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VALPRO path.

NEW VALUE LANDSCAPES FOR PLANT PROTEIN PATHWAYS

D5.4 Exploitation, IPR and Business Models Catalogue II

valpropath.eu

Co-funded by the European Union

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Abstract:	The Exploitation, IPR and Business Models Catalogue II represents the comprehensive overview of the VALPRO Path exploitation, IPR, business modelling and sustainability activities. Building on the first iteration of the Catalogue (D5.3), it consolidates the methodological approach, business modelling process, market assessments, exploitation plans for Key Exploitable Results (KERs) and other Exploitable Results (ERs), IP management considerations and pathways for long-term sustainability and uptake beyond the project lifetime. The document serves as a practical roadmap for the continued commercial and non-commercial use, replication and scale-up of VALPRO Path results after project completion.

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VALPRO Path

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4	NATIONAL TECHNICAL UNIVERSITY OF ATHENS - NTUA	NTUA	Greece
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9	AGRICOLUS S.R.L.	AGRICOLUS	Italy
10	WAGENINGEN UNIVERSITY	WU	Netherlands
11	BEOTANICS LIMITED	BEOTANICS	Ireland
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13	DIGNITY IDIOTIKI KEFALAIOUXIKI ETAIREIA	DNY	Greece
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17	FARMB DIGITAL AGRICULTURE PRIVATE COMPANY	FARMB	Greece
19	Fattoria Soidale del Circeo cooperativa sociale	FSDC	Italy
20	Antignano prodotto tipico di Tealdi Roberto	APT	Italy
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Table of Contents

1. Executive Summary 8
2. Introduction 9
2.1. Project Summary 9
2.2. Document Scope 9
3. VALPRO Path Exploitation and Business Modelling Approach 10
4. Business Case Complementarity 12
4.1. Complementarity of Business Cases in IPS1 Context 13
4.2. Complementarity of Business Cases with IPS2 context 13
4.3. Complementarity of Business Cases in IPS3 context 14
4.4. Complementarity of Business Cases in IPS4 Context 15
4.5. Complementarity of Business Cases in IPS5 Context 16
5. Exploitation Plans for KERs and Exploitable Results (ERs) 17
5.1. Production of Plant-Based Burgers 17
5.2. Developing the Peanut Industry in Europe 18
5.3. Varietal Selection Tool 19
5.4. Intercropping Field Peas and Faba Beans 21
5.5. Using Pulse Flours in Confectionery Products 22
5.6. More Informative Labelling for Plant-Protein Foodstuffs 23
5.7. The Nutrient Tracking Tool 24
5.8. Value-Added Production of Artisan Legume-Based Pasta 25
5.9. Hermetic Bagging Systems to Enable Cross-Regional Applications for Plant Proteins 26
5.10. Decentralised processing technologies 28
5.11. Strategic Knowledge Base on Plant Protein Value Chains 29
5.12. Methodology for Value-Chain Business Modelling 30
5.13. Protein Valorisation Pathways for Side-Streams and High Value Compounds 32
5.14. Advanced Fractionation and Functionalisation Technologies for Plant Protein Ingredients 33
5.15. Protein Crops Dataset 34
5.16. Digital Traceability Tool for Protein Crop Supply Chains 35
5.17. Automated Carbon Footprint Assessment Tool 36
5.18. MRV System for Carbon Accounting in Protein Crop Systems 38
5.19. Harmonised LCA & LCSA Framework for Plant Protein Value Chains 39
6. IP Assessment – Organisations' Analysis 40
7. Sustainability Plan 50
Conclusion 53

Annex 1. IPS1.2 Business Case Report 54
Annex 2. IPS3.2 Business Case Report 79
Annex 3. IPS4.2 Business Case Report 97
Annex 4. IPS5.2 Business Case Report 114
Annex 5. IPS5.3 Business Case Report 135
Annex 6. The Lupin Business Case 166
References 179

List of Tables

Table 1 List of Abbreviations and Acronyms 6
Table 2 VALPRO Path IPSs and Complementary Business Cases 12

List of Figures

Figure 1 VALPRO Path exploitation and sustainability approach 10

Table 1 List of Abbreviations and Acronyms

List of Abbreviations and Acronyms	
AI	Artificial Intelligence
API	Application Programming Interface
B2B	Business-to-Business
B2C	Business-to-Consumer
B2G	Business-to-Government
BMC	Business Model Canvas
BRC	Brand Reputation through Compliance / Global Standard for Food Safety
CA	Consortium Agreement
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CBM	Collaborative Business Model
CO_2e	Carbon Dioxide Equivalent
D2C	Direct-to-Consumer
DMIS	Data Management Information System
EFSA	European Food Safety Authority
ER	Exploitable Result
ERP	Enterprise Resource Planning
ESG	Environmental, Social and Governance
EU	European Union
FaaS	Farming-as-a-Service
FIBC	Flexible Intermediate Bulk Container
FMIS	Farm Management Information System
FTO	Freedom to Operate
GA	Grant Agreement
GHG	Greenhouse Gas
GMO	Genetically Modified Organism
GPS	Global Positioning System
HORECA	Hotels, Restaurants and Cafés/Catering
IP	Intellectual Property
IPR	Intellectual Property Rights
IPS	Innovative Production System
ISO	International Organization for Standardization
KER	Key Exploitable Result
KPI	Key Performance Indicator
KT	Knowledge Transfer
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
LCSA	Life Cycle Sustainability Assessment
ML	Machine Learning
MRV	Monitoring, Reporting and Verification
MVP	Minimum Viable Performance
NDVI	Normalised Difference Vegetation Index

OPEX	Operating Expenditure
PVP	Plant Variety Protection
QA	Quality Assurance
QR	Quick Response
R&D	Research and Development
S-LCA	Social Life Cycle Assessment
SOP	Standard Operating Procedure
TRL	Technology Readiness Level
TTO	Technology Transfer Office
USP	Unique Selling Point
UVP	Unique Value Proposition
PVP	Plant Variety Protection
QA	Quality Assurance
QR	Quick Response
R&D	Research and Development
S-LCA	Social Life Cycle Assessment
SOP	Standard Operating Procedure
TRL	Technology Readiness Level
TTO	Technology Transfer Office
USP	Unique Selling Point
UVP	Unique Value Proposition
WP	Work Package

1. Executive Summary

Deliverable 5.4 (D5.4) constitutes the final iteration of the Exploitation, IPR and Business Models Catalogue for the VALPRO Path project. Building on the methodological foundations, preliminary findings and exploitation activities established in D5.3, this deliverable consolidates the outcomes of the project's business modelling, market assessment, exploitation planning, IP management and sustainability activities into a comprehensive roadmap for the deployment and development of VALPRO Path results beyond the project lifetime.

The deliverable translates the technical validation of the project's business cases into a portfolio of exploitation plans covering 12 Key Exploitable Results (KERs) and a broader set of complementary Exploitable Results (ERs). These results reflect both commercial and non-commercial exploitation routes, including direct market deployment, licensing, technology transfer, consultancy, advisory services, knowledge transfer, research uptake and open dissemination.

The exploitation analysis is complemented by the project's IPR assessment, which addresses ownership, background and foreground knowledge, access conditions and suitable protection measures, including know-how and trade secrets, copyright, database rights, confidentiality and licensing. Finally, the Sustainability Plan defines how the project can remain operational, relevant and financially viable beyond its lifetime through integration into partners' regular activities, continued collaboration, follow-on funding and revenues from commercially mature results.

D5.4 also summarises the VALPRO Path business modelling process. Through the iterative CAPTURE–CO-CREATE–DELIVER methodology, the project assessed business opportunities across the five IPSs by combining market analysis, value proposition development, value chain innovation mapping, the Business Model Radar and the Business Model Canvas. In addition to the five business cases previously reported in D5.3, D5.4 provides a detailed analysis of five further business cases: Developing the Peanut Industry in Europe (IPS1.2, see *Annex 1. IPS1.2 Business Case Report*), Using Pulse Flours in Confectionery Products (IPS3.2, see *Annex 2. IPS3.2 Business Case Report*) as a partial substitute for cereal-derived flours, the Nutrient Tracking Tool (IPS4.2, see *Annex 3. IPS4.2 Business Case Report*), Hermetic Bagging Systems (IPS5.2, see *Annex 4. IPS5.2 Business Case Report*) and Decentralised Processing Technologies (IPS5.3, see *Annex 5. IPS5.3 Business Case Report*). These analyses are presented in Annexes 1–5, while *Annex 6. The Lupin Business Case* presents the business case for lupin protein isolate and examines the implications for the protein industry with lessons learnt as a result of the insolvency of a former SME project partner. Taken together with the business cases analysed in D5.3, these business cases, which are also considered among the project's KERs, demonstrate complementary exploitation pathways spanning crop production, agronomic practices, processing, storage and logistics, digital decision support, and market-oriented food applications.

Overall, D5.4 demonstrates how the technical, scientific and practical results generated across VALPRO Path can be converted into credible commercial and non-commercial exploitation pathways. By integrating business model blueprints, exploitation plans, IP management and sustainability measures, the deliverable provides a solid basis for maintaining and scaling the project's economic, environmental and societal value across European plant-protein value chains after project completion.

2. Introduction

2.1. Project Summary

The current European plant-protein landscape is flawed. Heightened societal awareness of the environmental impact of consuming animal-based protein is driving the public's awareness of alternative, sustainable sources of dietary protein. Yet, production systems are focussed heavily on the production of feedstock for direct transfer into animal sectors in an attempt to counter the EU's over-dependency on imported feed. In essence, there is an absence of premium supply chains - farmers miss out on added-value opportunities that exist within the crops they already grow across Europe. There is a need to increase resilience in farming systems to mitigate against increasingly volatile climate patterns and to support farming systems to meet Farm-to-Fork strategic objectives. Built on the principles of co-creation, innovation and demonstration, VALPRO Path will design, validate and deliver sustainable and competitive plant protein crop systems and value chains. Focussed on underpinning economic value for all actors in the supply chain, it will exploit beyond state-of-the-art innovations, demonstrating and evaluating potential across 5 multi-stakeholder 'living lab' Innovation Production Systems (IPSs). With strong industry involvement, the project will deliver a stronger ecosystem for plant protein production, supported with robust evidence of the social, economic, environmental, climate and health benefits. VALPRO Path delivers new, sustainable business models, showing how focussed research can come into practice. Sustainable diversification of rotations with grain legumes will support the transition to more environmentally sustainable farming. European agriculture is at a juncture in regard to the sustainable provision of dietary protein. It can embrace opportunities presented through existing innovations that are integrated into real-life scenarios to support stakeholders realise the new market opportunities that exist for indigenous, fully traceable plant protein.

2.2. Document Scope

D5.4 Exploitation, IPR and Business Models Catalogue II provides the roadmap for the exploitation, IP management, business development and long-term sustainability of the project's results. It consolidates the outcomes of the business modelling, market analysis, exploitation planning and IPR management activities implemented in the project. D5.4 aims to:

- **Define exploitation pathways for KERs and other ERs** through individual and joint exploitation plans covering both commercial and non-commercial routes, target users and beneficiaries, uptake mechanisms, partner responsibilities and further actions required for exploitation.
- **Identify appropriate IP protection and management measures** for the project results, considering ownership arrangements, access rights, the nature and maturity of each result, intended exploitation routes and the IP management capacities of the consortium partners.
- **Support the long-term sustainability and impact of VALPRO Path** by defining pathways for the continued use, maintenance, replication, scale-up and commercial or non-commercial uptake of project results beyond the project lifetime.
- **Consolidate the project's business modelling outcomes** by applying the validated methodology for the value chain business modelling across the five IPSs and integrating market analysis, value proposition development, value chain innovation mapping using the Business Model Radar and the Business Model Canvas as tools. The deliverable complements the five business cases previously reported in D5.3 with five additional cases analysed in detail in D5.4.

D5.4 should be read in conjunction with D5.3 Exploitation, IPR and Business Models Catalogue I and D5.2 Dissemination, Exploitation and Communication Plan II, where the corresponding Business Model Canvases are presented. Together, these deliverables provide a complementary and consolidated record of the project's business modelling, exploitation and market-uptake activities.

3. VALPRO Path Exploitation and Business Modelling Approach

The VALPRO Path exploitation approach was designed to support the systematic identification, validation and uptake of the project's commercial and non-commercial results. It combines the principles of the Lean Startup methodology with a multi-actor, value-chain-oriented business modelling process. Rather than developing business models around individual organisations, the approach focuses on collaboration among farmers, processors, technology providers, researchers, advisors, food manufacturers and other actors whose combined contributions are required to create and deliver value across plant-protein value chains.

The methodology follows an iterative **CAPTURE–CO-CREATE–DELIVER** process. These cycles are adapted to the implementation progress and maturity of each business case, allowing assumptions to be tested and refined through validated learning. The approach covers innovations positioned at different points of the plant-protein value chain, including on-farm processing, supply-chain applications and end-to-end solutions. It is applied to products, technologies, decision-support tools, advisory services, agronomic practices and business concepts developed through the IPSs.

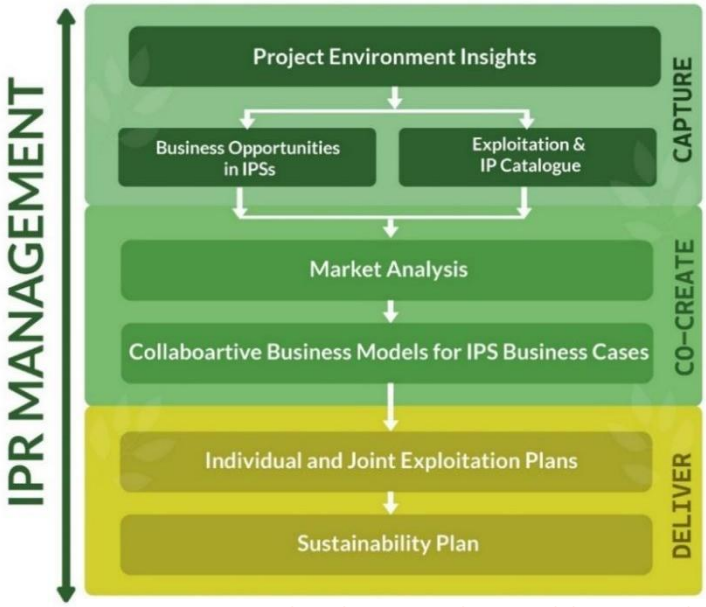


Figure 1 VALPRO Path exploitation and sustainability approach

CAPTURE Cycle: This cycle established the foundation for exploitation and business modelling. Its purpose was to identify viable business opportunities within the IPSs, define the results with exploitation potential and formulate the initial assumptions that were subsequently tested in WP3.

Commercial and non-commercial results are recorded in the VALPRO Path Exploitation and IP Catalogue, which was progressively updated throughout the project. For each result, the process considers its description, potential users and beneficiaries, ownership, contribution of individual partners, possible exploitation pathways and suitable IP protection measures. Joint results are addressed collaboratively, with the partners involved contributing to the definition of ownership and future exploitation arrangements.

In parallel, business cases were identified in cooperation with IPS leaders, technical and industry partners. Each business case is positioned within one or more of the three value-chain segments:

- **On-farm processing**, covering production, pre-processing, agronomic practices and technologies that create value at or before the farm gate;
- **Supply chain**, including logistics, traceability, sustainability monitoring and decision-support solutions; and
- **End-to-end**, covering market-oriented applications and final plant-protein products intended for industrial customers or consumers.

A Minimum Viable Performance (MVP) Business Validation General Questionnaire was used to capture the initial business opportunity. It defines the problem addressed, the proposed innovation, its position in the value chain, target beneficiaries, implementation objectives and the MVP indicators against which progress can be monitored.

CO-CREATE Cycle: This cycle transformed the initial opportunities into Collaborative Business Models (CBMs) since the development of VALPRO Path solutions required coordinated activities, resources and knowledge from several value-chain actors.

CBMs examine how the participating organisations jointly create, deliver and capture value. It considers not only the offer made to customers, target groups and revenue generation, but also whether the partners can cooperate sustainably, how their relationships support value delivery and how costs, benefits and risks are distributed across the network. The co-creation process is supported through a sequence of facilitated activities and tools:

- **Market analysis.** A Market Analysis Questionnaire was used to define the market context of each business case by addressing the intended geographical market, customer and user groups, demand drivers, competitors, market trends, potential by-products and barriers to market uptake. The partners' inputs were complemented by desk research and discussions to assess commercial potential, market positioning and relevant competitive advantages.

- **Collaborative business modelling.** IPS and WP leaders were introduced to the principles, objectives and expected outcomes of the methodology. This step helped align individual partner interests with the collective objectives of the business case and identify where further business support or clarification is required.

- **EXPLORE workshop.** The Value Chain Innovation Mapping Tool was used to map the main activities, stakeholders, information flows and value exchanges associated with the innovation. The workshop identified existing pain points, expected gains and the technical and organisational roles required to implement the proposed solution. Based on this analysis, a Value Proposition Statement was developed to clarify the target customer, the problem or need addressed, the proposed solution and its principal benefits.

- **DESIGN workshop.** Using the Business Model Radar to place the focal value proposition at the centre, business case participants mapped actors required to deliver it through a facilitated process. For each participant, the model defines its role, co-production activities, costs, expected benefits and value received. This enables the partners to agree on how the innovation will be implemented, which organisations will undertake specific activities and how value will be distributed within the collaborative network.

DELIVER Cycle: This cycle converts the collaboratively designed model into an actionable pathway for exploitation and market or non-market uptake. Evidence collected during implementation is used to validate or revise the main business assumptions, including the value proposition, customer segments, partner configuration, operational activities, costs and potential revenue streams.

The final model is presented through the **Business Model Canvas**, which consolidates the business case into nine interconnected elements: value propositions, customer segments, customer relationships, channels, key partners, key activities, key resources, cost structure and revenue streams. In VALPRO Path, the Canvas is developed using the information generated through the market analysis, value chain innovation mapping, value proposition statement and the Business Model Radar.

The DELIVER cycle also links business modelling with the wider exploitation and sustainability process. Individual and joint exploitation plans specify the intended use of each result, the responsible partners, target beneficiaries, exploitation route, required resources, IP considerations and post-project actions. Depending on the nature of the result, pathways include direct commercialisation, licensing, consultancy, subscription-based access, integration into existing products or services, further research, training, open access or dissemination to relevant practitioner communities.

Through this iterative methodology, VALPRO Path moved from the early identification of opportunities to evidence-based and partner-validated business cases. The combination of exploitation planning, market analysis, collaborative value creation and the BMC ensures that the final business models reflect both market conditions and the practical capacities and interests of the actors required to sustain the solutions beyond the project.

4. Business Case Complementarity

The VALPRO Path business cases are implemented within five IPSs, each addressing a distinct intervention point or enabling function within European plant-protein value chains. The IPSs provide multi-actor demonstration environments in which agronomic practices, processing technologies, digital tools, logistical solutions and market-oriented products are jointly developed and validated. Together, they support the project's objective of creating sustainable and competitive local and regional plant-protein systems through crop diversification, value-chain development, reduced environmental impacts and improved opportunities for farmers and other value-chain actors.

Table 2 VALPRO Path IPSs and Complementary Business Cases

IPS	IPS focus and topic	Related business case(s)
IPS1 – Realising the potential of on-farm technology and processing to deliver added value	Increasing the value retained at farm and primary-processing level through locally adapted crops, processing solutions, product development and side-stream valorisation.	IPS1.1 - Production of plant-based burgers IPS1.2 - Development of a sustainable European peanut industry
IPS2 – Varietal selection based on regional suitability and nutritional characterisation	Supporting the selection of protein-crop varieties suited to different European pedo-climatic conditions, production systems and downstream market applications.	IPS2 – Supporting varietal selection for different pedo-climatic regions (Varietal selection tool)
IPS3 – Agronomic practices that mitigate yield losses and create crop synergies	Improving the resilience, productivity and value of pulse-production systems through crop diversification, agronomic innovation and downstream food applications.	IPS3.1 - Intercropping field peas and faba beans IPS3.2 - Using pulse flours in confectionary products
IPS4 – Promoting new practices for farm-to-shelf nutrient tracking and sustainability	Using digital technologies, data and sustainability information to support decisions and communicate nutritional and environmental value across the plant-protein chain.	IPS4.1 - Development of more informative labelling for plant-protein foodstuffs IPS4.2 - Nutrient Tracking Tool
IPS5 – Demonstrating the value of building synergies through cross-regional applications	Connecting production regions, processing capacities, logistics and markets through technologies and business arrangements that enable regional and cross-regional plant-protein value chains.	IPS5.1- Value-added production of artisan legume-based pasta IPS5.2 - Hermetic Bagging Systems IPS5.3 - Decentralised processing technologies

The IPS structure enables complementarity between the business cases by connecting crop and varietal selection, agronomic production, post-harvest management, processing, digital decision support and final-product development. The following sections examine these relationships within each IPS, highlighting how the individual business cases reinforce one another and contribute to integrated pathways for the production, processing and market uptake of European plant proteins.

4.1. Complementarity of Business Cases in IPS1 Context

The IPS 1.1 and IPS 1.2 business cases fit within the broader VALPRO Path framework by demonstrating how **shortening supply chains** and utilising on-farm technologies can deliver significant added value to farmers. This approach transfers processing power back to producers, helping to bridge the gap between primary crop cultivation and premium end-product manufacturing while establishing cohesive, localised value chains.

IPS 1.1 – Production of plant-based burgers: This business case addresses the lengthy plant-based value chain that traditionally limits a farmer's ability to capture revenue from high-value end products. Upstream activities, such as the cultivation of lentils and chickpeas supported by precision farming and metadata collection, are connected to downstream manufacturing. By validating and employing decentralised, small-scale processing technologies directly on the farm, producers can independently process their crops into premium plant-based burgers. This end-to-end pathway creates a short, sustainable supply chain that allows farmers and cooperatives to capture the downstream added value and commercialise directly to health-conscious consumers and local catering businesses.

IPS 1.2 – Developing the peanut industry in Europe *(see Annex 1, p. 53):* This business case contributes to building a local, sustainable European peanut supply that reduces reliance on imported raw materials. It establishes a cohesive pathway connecting upstream varietal development, seed licensing and localised peanut cultivation to downstream regional processing steps like on-farm de-vining, shelling, roasting and oil pressing. This circular model channels the primary harvest into high-value food products (e.g. peanut butter). In addition, this model connects upstream production to downstream waste valorisation. The IPS 1.2 business case ensures maximum resource efficiency and added value for European farmers through the utilisation of side streams, such as transforming peanut shells into eco-packaging or using skins and pressed meal for livestock feed and birdseed.

Together, these two business cases create a coherent farm-to-fork pathway centred on shortening supply chains and delivering added value directly to producers. IPS1.1 strengthens the farmers' market position by utilising decentralised, small-scale on-farm processing technologies to turn locally grown lentils and chickpeas directly into premium, high-value plant-based burgers. IPS1.2 complements this approach by establishing a sustainable European peanut supply, connecting the cultivation of region-adapted peanut varieties with on-farm processing and the full valorisation of side streams into artisan snacks, oils and livestock feed. In this way, IPS1 links primary crop cultivation with decentralised food innovation and on-farm empowerment, supporting the broader VALPRO Path goal of creating new value landscapes for plant-protein pathways.

4.2. Complementarity of Business Cases with IPS2 context

The **IPS2 Varietal Selection Tool** is complementary to several VALPRO Path business cases because it provides an upstream decision-support layer, helping identify protein-crop varieties that are best suited to specific pedo-climatic conditions, production systems and downstream uses. By combining information on yield, resilience, nutritional composition and environmental performance, IPS2 can support better raw-material choices before crops enter agronomic, processing or product-development pathways as explored in other IPS business cases.

The IPS2 business case has strong complementarities with the following business cases:

IPS1.2 – Development of a sustainable European peanut industry *(see Annex 1, p. 53):* IPS2 connects with IPS1.2 through the regional testing and selection of suitable peanut varieties. The varietal performance evidence generated in the peanut business case feeds into the Varietal Selection Tool, while IPS2 provides a structured way to translate that evidence into recommendations on where particular varieties are best suited for deployment. This creates a feedback loop between varietal validation, regional recommendation and future market expansion, supporting the replication of European peanut production in additional regions.

IPS3.1 – Intercropping field peas and faba beans: The connection with IPS3.1 lies in the selection and validation of pea and faba bean varieties and combinations. IPS2 provides information on individual varietal performance under different pedo-climatic conditions, while IPS3.1 generates additional evidence on how these varieties perform when combined in intercropping systems, particularly in relation to lodging resistance and yield stability. The IPS3.1 findings enrich the varietal evidence base used by IPS2, while IPS2 supports the transfer of successful combinations to other regions by identifying where the underlying varieties are likely to be suitable.

IPS3.2 - Using pulse flours in confectionary products *(see Annex 2, p. 78):* IPS2 connects upstream varietal characteristics with the downstream processing work undertaken in IPS3.2. The nutritional composition and processing behaviour observed for pea and faba bean raw materials in IPS3.2 provide information on which varietal characteristics are desirable for flour production and confectionery applications. This enables IPS2 to go beyond agronomic suitability and consider downstream use as part of varietal selection, while IPS3.2 benefits from better identification of raw materials with the characteristics required for processing and formulation. The two business cases connect variety choice with ingredient functionality and end-use suitability.

IPS4.2 – Nutrient Tracking Tool *(see Annex 3, p. 95):* IPS2 generates and consolidates information on varietal yield, nutritional composition and regional performance, while IPS4.2 uses agronomic and compositional information as inputs for modelling nutrient flows through processing and food manufacturing. Data associated with selected varieties feeds into nutrient-tracking scenarios, allowing stakeholders to assess which variety performs well in a region and what value that variety may generate further down the chain. Results from nutrient-flow modelling can help identify which crop characteristics are most valuable for particular processing pathways and end uses, strengthening future varietal-selection criteria.

IPS5.3 – Decentralised processing technologies *(see Annex 5, p. 133):* The processing work in IPS5.3 provides practical evidence on how locally grown legume raw materials perform during cleaning, sorting, milling, separation and dry fractionation. These findings inform IPS2 on which varietal characteristics are relevant for successful cultivation and efficient downstream processing. At the same time, IPS2 can help identify regionally adapted crops and varieties that could provide suitable feedstock for decentralised processing facilities. The complementarity of these business cases lies in aligning what is grown locally with what can be efficiently processed locally, strengthening regional plant-protein value chains and reducing the disconnect between varietal choice and processing requirements.

4.3. Complementarity of Business Cases in IPS3 context

IPS3 focuses on **agronomic practices that mitigate yield loss and create crop synergies**, particularly through the combined use of field pea and faba bean within the VALPRO Path plant-protein value chains. It connects upstream agronomic innovation (IPS3.1) with downstream processing and food-product applications (IPS3.2).

IPS3.1 – Intercropping field peas and faba beans focuses on the production side of the value chain. The main challenge addressed is yield loss in field peas caused by lodging. This is becoming more problematic due to climate volatility with intense rain and/or heavy winds at the critical period ~3 weeks prior to harvest threatening yield returns. In the case where a pea crop is lodged it can lead to a complete crop loss scenario for the farmer and significant economic loss. In response, this business case explores intercropping field peas with more structurally stronger faba bean as a practical agronomic solution to improve field pea stability. As the pea intertwines its stems within the faba bean crop, this has the positive impact of reducing lodging risk and enhancing yield reliability as it widens the harvest window for the farmer due to a more stable crop in the field. If field peas and faba beans are intercropped, yield loss due to lodging can be significantly mitigated and field pea yield stability improved. The business case is positioned in on-farm processing with farmers, seed producers and breeders as key target users. Its MVP is the identification and characterisation of up to five high-performing pea-faba bean variety combinations with more than two potential uses. The innovation in IPS3.1 is concentrated in pre-farm gate activities, especially variety selection, mixed-seed sowing, crop management, harvesting and optimisation of mixed-crop harvesting. TEAGASC coordinates the work with AU supporting agronomic evaluation and data collection, CSIC contributing expertise in ingredient functionality and processability and Agricolus supporting crop data collection and lodging assessment.

IPS3.2 - Using pulse flours in confectionery products *(see Annex 2, p. 78)* like combinations of pea and bean flour builds on the outputs of IPS3.1 and shifts the focus downstream, from crop production to post-harvest processing, ingredient development and food manufacturing. It explores how pea and faba bean raw materials can be processed into pulse-flour blends and used in confectionery products, as a direct substitute for wheat flour. The business opportunity is based on developing optimised pea-faba flour blends and validated processing protocols that allow at least 30% wheat-flour substitution in mainstream confectionery products while maintaining taste, texture and industrial performance. In IPS3.2, the innovation is positioned at the interface between ingredient processing and product formulation. Key activities include soaking, germination, drying, milling, blending, formulation generation, testing and optimisation. These steps aim to reduce anti-nutritional factors and off-flavours, improve functionality and transform raw pulse materials into specification-ready ingredients for bakery and confectionery applications.

Together, IPS3 business cases create a coherent farm-to-fork pathway and links climate-resilient crop production with industrial food innovation while supporting the broader VALPRO Path goal of creating new value landscapes for plant-protein pathways.

4.4. Complementarity of Business Cases in IPS4 Context

IPS4 is positioned as an end-to-end innovation stream within VALPRO Path, focused on **promoting new farm-to-form practices for nutrient tracking and sustainability**. Its overall logic is to apply a systems engineering approach that integrates nutritional, environmental and economic data across the full plant-protein value chain, from raw material production, processing to formulation and environmental assessment. This responds to a key gap identified in the plant-protein sector: stakeholders often lack an integrated understanding of how nutrients move across the chain, where value is retained or lost and how production and processing choices influence ingredient yields and co-product potential.

IPS4.1 - The development of more informative labelling for plant protein foodstuffs focuses on the product innovation and consumer-facing dimension of IPS4. It demonstrates how advanced nutrient tracking, spectroscopy technologies, digital traceability and environmental assessment can be applied in the development of plant-protein food prototypes, including a plant-based beverage and an energy bar. These prototypes are intended to feature labels that go beyond standard nutritional information by also displaying environmental performance indicators, such as greenhouse gas emissions and

carbon-use efficiency. In this way, IPS4.1 addresses the growing need for more transparent and sustainability-oriented food labelling, enabling consumers and value-chain actors to better understand the nutritional and environmental profile of plant-protein products.

IPS4.2 - The Nutrient Tracking Tool *(see Annex 3, p. 95):* provides the digital and decision-support backbone for IPS4. It is designed as an interactive simulation tool linking agronomic data, compositional analysis, processing mass-balance models and sustainability analytics in order to quantify and model nutrient flows from farm to processing and food manufacturing. The tool supports producers, processors, food manufacturers and supply-chain coordinators in predicting nutrient flows, optimising protein and co-product recovery, reducing nutrient losses and identifying opportunities for circular valorisation. By connecting early-stage crop assessment with processing scenarios and LCA outputs, IPS4.2 helps address value-chain challenges that fragmented agronomic or processing tools cannot solve alone.

Taken together, the two IPS4 business cases are complementary because they connect the physical demonstration of sustainable plant-protein products with the digital modelling and assessment tools needed to support their development. IPS4.1 translates nutrient tracking and environmental assessment into tangible food product prototypes, while IPS4.2 enables upstream and midstream actors to generate, interpret and use the data behind those claims. Their complementarity is further reinforced by the fact that IPS4 operates in synergy with IPS1, IPS2 and IPS3, as the raw materials and data used for both product prototype development and modelling activities for the Nutrient Tracking Tool are derived from those innovation streams.

4.5. Complementarity of Business Cases in IPS5 Context

The IPS5.1, IPS5.2 and IPS5.3 business cases fit within the broader VALPRO Path framework by demonstrating how shortening supply chains and utilising on-farm technologies can deliver significant added value. These initiatives complement each other directly through a **cross-application model**, establishing a seamless logistical and processing flow (IPS5.3 to IPS5.2 to IPS5.1) from primary crop handling to final consumer product creation.

IPS5.3 - Decentralised processing technologies *(see Annex 5, p. 133):* The pathway begins with the regional application of local processing facilities capable of handling larger volumes of legumes. The IPS5.3 business case provides the essential decentralised technology required to prepare and process raw materials locally, complementing both storage and final food product applications. By utilising specific technologies for drying, cleaning, sieving, sorting, milling and separation, the raw harvested legumes are processed locally into high-quality, ready-to-use flour through dry fractionation.

IPS5.2 – Hermetic bagging systems to enable cross-regional applications for plant proteins *(see Annex 4, p. 164):* This business case contributes to the framework by providing a decentralised storage and transport solution that acts as the logistical bridge between the farms, regional processing facilities and downstream buyers. Following local processing, the product is packaged into 1-ton capacity hermetic bags featuring a controlled atmosphere system using CO2 injection. This enables pulse protein fractions to be stored at the farm level without requiring investments in expensive, centralised silos or storage facilities. The hermetic bagging technology guarantees that fractions retain quality, moisture stability and shelf life during storage and transport, while also achieving required pest control. Combined with a digital field-to-fork traceability platform, the system allows for the safe and flexible transfer of raw materials from small organic farmers to regional milling facilities and pulse protein fractions to downstream processors and buyers. The sealed packaging reduces the risk of physical cross-contamination and product mixing. The digital platform records product origin, handling conditions and movement through the supply chain. In this way, IPS5.2 ensures that raw materials and pulse ingredients retain their moisture stability, natural pest control and exact origin data during shipments.

IPS5.1 - Value-added production of artisan legume-based pasta: The IPS5.1 business case focuses on the downstream creation of premium, plant-based food products directly from locally sourced legume crops. The preserved, ready-to-use flour is transported in hermetically sealed bags to Antignano Prodotto Tipico (APT), an Italian milling and processing company. APT uses the identity-preserved flour to produce value-added artisan legume-based pasta. APT produces gluten-free pasta products and recipes using legume flour, including vegetable-enriched pasta and products tailored to specific consumer groups, such as athletes and health-conscious consumers. This step converts the safely stored and transported flour into differentiated, market-ready food products with higher commercial and nutritional value.

Together, these three business cases create a coherent farm-to-fork pathway centred on localised processing, safe cross-regional logistics and premium end-product manufacturing. Specifically, IPS5.3 provides the technology for processing plant proteins locally into ready-to-use flour. IPS5.2 provides the hermetic storage and transport solution needed to preserve product quality and move the flour safely across regions. IPS5.1 uses the preserved flour as a premium raw material to produce value-added artisan legume-based pasta. Overall, IPS5 bridges the gap between primary crop cultivation and high-value food production, supporting the broader VALPRO Path objective of shortening European supply chains and maximising value retention for regional stakeholders.

5. Exploitation Plans for KERs and Exploitable Results (ERs)

The VALPRO Path project has produced a portfolio of project results with strong potential for exploitation across the European plant-protein sector. Exploitation Plans have been developed per each project result following below. The project results are organised into two groups: **KERs**, representing the principal outputs with the strongest potential for continued uptake and impact, and **other ERs**, which complement the KER portfolio through enabling technologies, datasets, methodologies and supporting knowledge assets. The following sections present the corresponding individual and joint exploitation plans, defining how each result can be used, protected, maintained and developed beyond VALPRO Path.

5.1. Production of Plant-Based Burgers

KER #1	Production of Plant-Based Burgers
Description	An integrated **local production and market model for transforming European-grown lentils and chickpeas into premium plant-based burgers** through decentralised/ on-farm processing. The approach connects crop production with small-scale processing, product formulation, shelf-life improvement, sustainable packaging and direct market access, enabling farmers and social enterprises to retain a greater share of the value generated downstream. The resulting burgers are positioned as fresh, locally sourced and sustainable alternatives to conventional frozen plant-based products. The model supports both direct consumer sales and B2B supply to restaurants, catering companies and local food businesses, while demonstrating how shortened value chains can strengthen local food systems and create additional revenue opportunities for primary producers. The detailed business model and market assessment for IPS1.1 are presented in D5.3.
Type of result	Food product / Processing and value-chain model
Ownership	**Individual**
Partners involved	FSDC; Contributors: BEOTANICS, farmB, UNITO, AU
Exploitation pathway	**Commercial.** Identified exploitation pathways include: ● Direct sales of plant-based burgers to consumers (B2C/D2C) ● Supply to restaurants, catering businesses, street-food vendors and micro-SMEs ● Local retail and food-service partnerships ● Potential subscription and catering models

Target market/ potential users	Vegans, vegetarians, flexitarians and health-/environmentally conscious consumers, restaurants, catering companies, street-food vendors, local food businesses and micro-SMEs.
End-users' usage of result	• Purchase of locally produced plant-based burgers • Integration of food products into menus • Use of decentralised processing to capture more value from locally grown legumes
TRL	**TRL 7-8:** Product and processing approach validated in a relevant environment; further commercial scale-up required.
Channels	● Direct sales ● Local retail ● Restaurants and catering ● D2C/e-commerce ● Farmers' markets ● Local food networks ● Demonstrations and food events
Access to result	**Private/controlled access:** Detailed recipes, processing parameters, formulations, production SOPs and commercial information. **Publicly shareable results:** Demonstration results and general information on decentralised plant-based food production.
Suggested IP protection	● Trade secrets/ know-how for formulations and processing parameters. ● Trademark/ brand protection for marketed plant-based burgers.
Exploitation risks	● **Risk 1:** Limited consumer acceptance or product performance. **Mitigation:** Continue sensory, shelf-life and product optimisation. ● **Risk 2:** Production costs and operational complexity limit competitiveness. **Mitigation:** Optimise decentralised processing and short supply chains. ● **Risk 3:** Limited market reach. **Mitigation:** Combine B2C sales with catering, local retail and food-service partnerships.
Year of availability	At project end (M52), subject to final commercial validation and market arrangements.
Key message to target groups	***Locally grown legumes transformed into fresh, nutritious and sustainable plant-based burgers while creating more value for farmers and local food systems.***
Replicability/ Upscaling potential	**High** ● Transferable to other farms, social enterprises and local processors ● Adaptable to different legumes and product formulations ● Replicable through regional short supply chains

5.2. Developing the Peanut Industry in Europe

KER #2	Developing the Peanut Industry in Europe
Description	An integrated solution for establishing sustainable European peanut production based on IP-protected, climate-resilient peanut varieties adapted to European growing conditions, combined with agronomic guidance, seed licensing and know-how for decentralised/on-farm processing and side-stream valorisation. The solution connects variety development and seed supply with cultivation, harvesting, shelling, roasting, oil pressing and other local processing activities. It enables farmers and cooperatives to generate value from the primary crop through products such as fresh and roasted peanuts, peanut butter and peanut oil, while creating additional opportunities from shells, skins, vines and press cake through feed, bio-based materials and other circular applications. The detailed business case is presented in **Annex 1. IPS1.2 Business Case Report.**
Type of result	Plant genetics / Know-how
Ownership	**Individual**
Partners involved	BEOTANICS; Contributors: TEAGASC, CSIC, NTUA
Exploitation pathway	**Commercial.** Identified exploitation pathways include: ● Licensing of protected European-adapted peanut varieties,

	• Seed sales and royalty-based licensing agreements, • Agronomic advisory and technical-support services for farmers/cooperatives, • Transfer of know-how for small-scale/on-farm processing solutions, • Establishment of B2B supply-chain partnerships with processors, ingredient manufacturers and artisan food producers.
Target market/ potential users	European farmers, agricultural cooperatives and seed producers, artisan food companies and other food manufacturers, feed producers and companies developing circular/bio-based applications from peanut residues.
End-users' usage of result	• Use adapted varieties and agronomic recommendations to diversify crop rotations and establish viable European peanut production • Use decentralised processing to retain greater added value locally • Source traceable European-grown peanuts for peanut products • Valorise peanut side-streams in feed and bio-based applications • Use the model to establish new regional peanut supply chains
TRL	**TRL 6–7:** Peanut varieties have been validated under relevant farm and processing conditions, including pilot cultivation in the Netherlands and Portugal and production of various product prototypes.
Channels	• Direct seed sales and consultancy activities with farmers and cooperatives • Agricultural and farmer networks • Demonstration farms, field days and knowledge-transfer events • Direct B2B engagement with seed producers • Industry networks and trade fairs • VALPRO Path Varietal Selection Tool and associated advisory services
Access to result	**Private/controlled access:** protected genetics, germplasm, breeding know-how and proprietary technical information. **Publicly shareable results:** non-confidential validation findings, general agronomic recommendations, demonstration outcomes and good-practice guidance.
Suggested IP protection	• EU Plant Breeders' Rights / Plant Variety Protection for selected commercially promising peanut varieties, with applications to the CPVO. • Confidentiality/ trade-secret protection for proprietary germplasm, parental lines, breeding know-how, agronomic data and selected processing know-how.
Exploitation risks	• **Risk 1:** Limited agronomic knowledge and availability of adapted planting material. **Mitigation:** Regional demonstrations, advisory support, continued varietal validation, registration, seed multiplication and licensing. • **Risk 2:** Fragmented supply chains and weak market integration. **Mitigation:** Develop regional B2B partnerships, off-take arrangements and links between growers, processors and food brands. • **Risk 3:** Processing and scale-up barriers. **Mitigation:** Prioritise accessible value-added products and modular processing solutions.
Year of availability	At project end (M52), with progressive commercial scale-up thereafter.
Key message to target groups	***Build profitable European peanut value chains with locally adapted genetics, farmer-focused processing and multiple high-value product streams.***
Replicability/ Upscaling potential	**High** • Adaptable to additional European regions local varietal and agronomic validation • Scalable through seed multiplication and licensing of protected varieties • Replicable through farmer/cooperative-based regional production clusters • Modular processing solutions can be adapted to different farm and cooperative scales • Circular valorisation of shells, skins and press cake for additional revenue streams

5.3. Varietal Selection Tool

KER #3	Varietal Selection Tool
Description	A decision-support tool to support stakeholders shortlist protein-crop varieties best suited to different European pedo-climatic regions, production conditions and downstream

	applications. The tool combines information from national and breeding trials with project-generated data on crop yield, resilience, nutritional composition and environmental performance. By consolidating these data into region-specific recommendations, it supports farmers, breeders, seed suppliers and advisors in selecting well-adapted varieties and avoiding poorly performing options. The result is intended as a publicly accessible knowledge and advisory resource supporting sustainable protein-crop production, research and evidence-based agricultural decision-making. The detailed business model and market assessment for IPS2 are presented in D5.3.
Type of result	Decision support tool
Ownership	**Joint**
Partners involved	AU, TEAGASC, ZALF, UNITO, CSIC, BEOTANICS, AGRICOLUS, farmB
Exploitation pathway	**Non-commercial.** Identified exploitation pathways include: • Integration into agricultural advisory and knowledge-transfer services • Use by farmers, breeders and seed suppliers to support evidence-based varietal selection • Use in research, education and further scientific activities • Uptake by policymakers and public authorities to support regional crop-planning and protein-crop strategies • Dissemination through publicly available guidance, recommendations and platforms
Target market/ potential users	Farmers, breeders, seed suppliers, agronomists, agricultural advisors, food processors and manufacturers, researchers and policymakers.
End-users' usage of result	• Select varieties adapted to specific regions • Support crop and rotation planning • Improve yield, resilience and nutritional quality • Support advisory, breeding and policy decisions
TRL	**TRL 7-8:** Methodology and varietal data validated across different European pedo-climatic conditions, with further digital integration and scale-up possible.
Channels	• Agricultural advisory networks • Farmer and breeder networks • Digital platforms • Demonstration activities and field events • Research networks • Training and knowledge-transfer activities
Access to result	**Publicly shareable results:** Varietal recommendations, regional suitability information, agronomic and nutritional findings, validation results and guidance supporting informed varietal selection. **Controlled access:** Underlying datasets may remain restricted where required by data ownership, confidentiality or partner agreements.
Suggested IP protection	• Copyright for the tool interface, documentation and guidance materials. • Database rights, where applicable, for structured datasets. • Appropriate data-use and attribution conditions for underlying datasets.
Exploitation risks	• **Risk 1:** Insufficient or inconsistent data across crops and regions. **Mitigation:** Continue validation and harmonisation of regional datasets. • **Risk 2:** Limited uptake by farmers and advisors. **Mitigation:** Promote the tool through advisory networks, demonstrations and training. • **Risk 3:** Recommendations become outdated. **Mitigation:** Establish mechanisms for periodic data and varietal updates.
Year of availability	At project end (M52), with continued use and updating through research, advisory and knowledge-transfer activities.
Key message to target groups	***Science-backed support for selecting the right protein crop variety for the right region and market.***
Replicability/ Upscaling potential	**Very high** • Extendable to additional crops, varieties and regions • Scalable through integration with precision-agriculture platforms • Extension through new agronomic, nutritional and sustainability datasets

5.4. Intercropping Field Peas and Faba Beans

KER #4	Intercropping Field Peas and Faba Beans
Description	A **validated agronomic practice and associated advisory knowledge for intercropping field peas and faba beans** to reduce lodging risk, stabilise pea yields and improve the resilience of European pulse-production systems. The result combines knowledge on suitable varietal combinations, seed ratios, mixed-crop sowing, crop management, harvesting and post-harvest utilisation. Faba beans provide structural support to field peas under conditions where intense rain and wind can increase lodging, while the mixed crop creates additional opportunities for food and feed use. The result is designed primarily for deployment through agricultural advisory and knowledge-transfer services, enabling farmers and advisors to adapt the intercropping approach to local conditions while supporting more diversified and sustainable protein-crop production systems. The detailed business model and market assessment for IPS3.1 are presented in D5.3.
Type of result	Agronomic practice / Advisory service / Know-how
Ownership	**Individual**
Partners involved	TEAGASC; Contributors: AU, CSIC, AGRICOLUS
Exploitation pathway	**Primarily non-commercial/advisory with commercial service potential.** Identified exploitation pathways include: • Advisory and knowledge-transfer services • Farmer training and demonstrations • Integration into agronomic recommendations • Advanced personalised advisory/ consultancy
Target market/ potential users	Farmers, breeders, seed suppliers, agricultural advisors, agronomists, processors and food/ feed producers.
End-users' usage of result	• Apply validated intercropping combinations and crop ratios • Reduce lodging and stabilise pea yield • Improve crop management and harvesting • Use resulting crops/ fractions in food and feed applications
TRL	**TRL 7-8:** Agronomic practice validated under relevant field conditions, with further regional adaptation possible.
Channels	• TEAGASC advisory services • Field walks and demonstration days • Farmer training • Agricultural networks and events • Knowledge-transfer materials
Access to result	**Private/controlled access:** Detailed trial datasets, specific experimental protocols and customised advisory recommendations. **Publicly shareable results:** Validated agronomic recommendations, general crop ratios, field guidance and demonstration outcomes.
Suggested IP protection	• Know-how protection for detailed implementation and advisory protocols. • Copyright for guidance and training materials. • Confidentiality for non-public trial datasets.
Exploitation risks	• **Risk 1:** Variable performance across regions and seasons. **Mitigation:** Continue regional validation and adapt recommendations to local conditions. • **Risk 2:** Limited farmer uptake. **Mitigation:** Demonstration trials, field walks and advisory support. • **Risk 3:** Harvesting and separation complexity. **Mitigation:** Optimise crop ratios, harvesting and post-harvest practices.
Year of availability	At project end (M52), with continued advisory uptake thereafter.
Key message to target groups	***Reduce pea lodging and improve yield stability through a validated intercropping approach that strengthens the resilience of European protein-crop production.***

Replicability/ Upscaling potential	**High** • Adaptable to different European regions • Transferable through advisory networks • Variety and seed ratios can be adjusted to local production conditions

5.5. Using Pulse Flours in Confectionery Products

KER #5	Using Pulse Flours in Confectionery Products
Description	An integrated pulse-flour ingredient and processing solution for bakery and confectionery applications, combining specification-ready pea–faba bean flour blends with validated natural, food-grade processing and formulation protocols. The solution covers processing steps (soaking, germination, drying, dehulling, milling, sieving and blending), together with application-specific formulation know-how. It enables up to 30% substitution of wheat flour in confectionery and bakery products while maintaining sensory quality, texture, shelf life and compatibility with standard industrial processing equipment. The approach supports development of higher-protein, higher-fibre and clean-label products while reducing the technical and commercial risks associated with pulse-flour reformulation. The detailed business case is presented in **Annex 2. IPS3.2 Business Case Report.**
Type of result	Ingredient system / Know-how
Ownership	**Individual**
Partners involved	TEAGASC
Exploitation pathway	**Commercial.** Identified exploitation pathways include: ● Licensing and transfer of validated processing protocols and SOPs, ● Technical advisory and formulation-support services, ● Industrial trials and scale-up support, ● Co-development projects with food manufacturers, ● Framework agreements with ingredient suppliers, millers, bakeries and confectionery manufacturers.
Target market/ potential users	Food ingredient manufacturers, pulse processors, millers and functional-ingredient suppliers, industrial and mid-size bakeries and confectionery manufacturers, private-label manufacturers and co-packers.
End-users' usage of result	• Implementation of validated processing protocols and SOPs to produce pea–faba flour blends • Integration of pea-faba blends into existing production lines to reformulate products • Use formulation guidance, technical specifications, sensory and shelf-life evidence to reduce reformulation risk and accelerate product development
TRL	**TRL 6-7:** The processing protocols and blends have been developed and validated through multiple confectionary applications.
Channels	• Direct B2B engagement with ingredient and confectionery manufacturers • Technology-transfer and licensing agreements • Co-development and industrial validation projects • Trade fairs and industry events
Access to result	**Private/controlled access:** Validated processing protocols and SOPs, detailed formulation parameters, proprietary blend specifications, technical performance data and partner-specific processing know-how. **Publicly shareable results:** Validation findings, general processing recommendations, demonstration results, formulation guidance and good-practice information.
Suggested IP protection	● Know-how and trade-secret protection for processing parameters, formulations, SOPs and proprietary technical knowledge. ● Copyright for documented protocols and technical manuals. ● Confidentiality/NDAs for industrial trials and co-development projects.
Exploitation risks	● **Risk 1:** Insufficient industrial performance or consumer acceptance. **Mitigation:** Further industrial, sensory and shelf-life validation and formulation optimisation.

	• **Risk 2:** High processing costs or complexity limiting uptake. **Mitigation:** Prioritise CAPEX-light, industry-compatible processing, co-development with manufacturers. • **Risk 3:** Inconsistent raw-material supply or quality. **Mitigation:** Strengthen sourcing arrangements and quality specifications with farmers, cooperatives and processors.
Year of availability	At project end (M52), with industrial deployment thereafter.
Key message to target groups	***A validated ingredient-plus-know-how solution enabling higher-protein, clean-label confectionery products with at least 30% wheat-flour substitution and no major changes to existing production lines.***
Replicability/ Upscaling potential	**High** • Applicable across multiple bakery and confectionery products • Transferable to ingredient and confectionary manufacturers, millers and bakers through standardised specifications and SOPs • Adaptable to different pea-faba blends and industrial applications • Expansion beyond confectionery to adjacent food applications

5.6. More Informative Labelling for Plant-Protein Foodstuffs

KER #6	More Informative Labelling for Plant-Protein Foodstuffs
Description	A consumer-facing labelling approach for plant-protein food products that combines nutritional information with environmental performance indicators generated through nutrient tracking, spectroscopy technologies, digital traceability and environmental assessment. The approach is demonstrated through **plant-based beverage and energy-bar prototypes** featuring information beyond standard nutritional labelling, including indicators such as greenhouse-gas emissions and carbon-use efficiency. It supports greater transparency on the nutritional and environmental profile of plant-protein foods and enables consumers and value-chain actors to make more informed and sustainability-oriented decisions. The detailed business model and market assessment for IPS4.1 are presented in D5.3.
Type of result	Methodology
Ownership	**Joint**
Partners involved	PEPSICO, TEAGASC, KERRY, BEOTANICS, farmB, MTL
Exploitation pathway	**Commercial and non-commercial.** Identified exploitation pathways include: • Integration of enhanced nutritional and environmental information into plant-protein product labels • Application of the approach in future plant-based product development • Use by food manufacturers to support sustainability-oriented product communication • Dissemination of methodological findings to relevant food-sector stakeholders
Target market/ potential users	Plant-based food manufacturers and brands, ingredient manufacturers, retailers, sustainability and product-development teams and other plant-protein value-chain actors.
End-users' usage of result	• Support development of more transparent plant-protein products • Use validated information to support sustainability-oriented purchasing and product-development decisions • Communicate nutritional and environmental product information
TRL	**TRL 6-7:** The approach has been demonstrated through plant-based beverage and energy-bar prototypes using nutrient-tracking and environmental-performance data.
Channels	• Product packaging and labels • Food manufacturers and brand portfolios • Retail and distribution channels • Digital product information (QR codes) • B2B food-industry networks
Access to result	**Private/controlled access:** Detailed datasets, product-specific formulations, processing information and proprietary assessment inputs.

	Publicly shareable results: General labelling approach, non-confidential nutritional and environmental indicators, demonstration findings and methodological guidance.
Suggested IP protection	• Copyright for methodology and supporting documentation. • Confidentiality for proprietary product, processing and assessment data.
Exploitation risks	• **Risk 1:** Limited consumer understanding or trust in environmental information. **Mitigation:** Use clear, transparent and validated indicators. • **Risk 2:** Inconsistent availability or quality of underlying data. **Mitigation:** Harmonise nutrient, traceability and environmental data requirements.
Year of availability	At project end (M52), with further application in plant-protein products thereafter.
Key message to target groups	***Go beyond conventional nutrition labels by making the environmental performance of plant-protein foods visible, understandable and actionable.***
Replicability/ Upscaling potential	**High** • Applicable to a wide range of plant-protein food products • Extension to additional nutritional and environmental indicators • Integrable with nutrient-tracking, traceability and sustainability-assessment tools • Transferable to different food manufacturers and product categories

5.7. The Nutrient Tracking Tool

KER #7	The Nutrient Tracking Tool
Description	An interactive **end-to-end decision-support and simulation tool** designed to quantify and model nutrient flows across the plant-protein value chain, from crop production through processing to food manufacturing. The tool integrates agronomic and compositional data with processing mass-balance models and sustainability analytics to predict nutrient and co-product streams, compare alternative processing scenarios, optimise protein and ingredient recovery, reduce nutrient losses and identify opportunities for circular valorisation. The detailed business case is presented in **Annex 3. IPS4.2 Business Case Report.**
Type of result	Decision-support tool
Ownership	**Individual**
Partners involved	TEAGASC; Contributors: NTUA
Exploitation pathway	**Hybrid commercial/non-commercial.** ● **Commercial:** enterprise platform licensing by offering advanced/ customised versions to larger processors, ingredient manufacturers and food companies through paid licences, including proprietary-system integration, customised modules, dedicated technical support and data services. ● **Non-commercial**: advisory-led knowledge transfer by making the basic Nutrient Tracking Tool a free-to-use public asset, deployed through advisory services, training and knowledge-transfer activities for producers, SMEs, advisors and researchers.
Target market/ potential users	**Primary users:** Farmers and growers, processors and plant-protein ingredient manufacturers, food manufacturers and formulators. **Additional users:** agricultural advisors, researchers, supply-chain coordinators and logistics actors.
End-users' usage of result	• Assess crop nutrient potential and determine the most valuable use of crops • Model processing pathways, predict protein and co-product yields, optimise fractionation and reduce losses • Select raw materials with suitable nutritional and functional properties and reduce costly formulation trial-and-error • Forecast ingredient and co-product volumes and improve storage and processing planning • Interpret model outputs and translate them into practical recommendations
TRL	**TRL 6-7:** The decision-support tool has been validated through end-to-end scenarios and pilot-user testing in a plant-protein value-chain context using faba bean data.
Channels	• TEAGASC advisory and Knowledge Transfer (KT) services

	• Free/open-access platform for the basic tool model • Direct enterprise licensing • B2B engagement with processors, ingredient manufacturers and food companies • Research and innovation projects • Industry and stakeholder networks
Access to result	**Private/controlled access:** Proprietary algorithms, modelling logic, source code, non-public datasets, customised modules and enterprise integrations. **Publicly shareable results:** Basic tool functionality, non-confidential validation findings, general methodological guidance, demonstration results and case studies.
Suggested IP protection	• Copyright/software protection for the tool, user interface and source code. • Know-how and trade-secret protection for proprietary algorithms, modelling approaches, technical configurations and non-public processing models. • Licences/terms of use for open-access deployment. • Software/licensing agreements for enterprise users. • Confidentiality and data-sharing agreements for proprietary industrial datasets.
Exploitation risks	• **Risk 1:** Insufficient, inconsistent or fragmented data across the value chain. **Mitigation:** Harmonise data requirements, strengthen data-sharing arrangements and validate data quality. • **Risk 2:** Limited interoperability and trust in tool outputs. **Mitigation:** Improve integration with existing digital systems and continue validation in real processing environments. • **Risk 3:** Limited user uptake and long-term sustainability. **Mitigation:** Combine user-friendly, advisory-led deployment with training, technical support and enterprise licensing to support continued development.
Year of availability	At project end (M52), with continued development and expansion thereafter.
Key message to target groups	***Turn fragmented farm-to-factory data into actionable insights that optimise nutrient recovery, processing decisions and value creation across plant-protein value chains.***
Replicability/ Upscaling potential	**High** • Applicable to other plant-protein crops • Expansion to additional processing and fractionation routes • Scalable through an open-access digital platform • Enterprise versions integrated with different corporate ERP and supply-chain systems • Additional datasets can improve predictive accuracy • Extension with sustainability, economic, traceability and processing modules • Potential application beyond plant proteins to other agri-food value chains

5.8. Value-Added Production of Artisan Legume-Based Pasta

KER #8	Value-Added Production of Artisan Legume-Based Pasta
Description	A **premium artisan pasta solution based on locally and regionally sourced legume flours**, demonstrating how lentils, chickpeas and other European pulses can be transformed into nutritious, differentiated plant-protein foods through optimised milling, formulation and pasta-production techniques. The solution combines selected legume-flour blends with product-formulation know-how to deliver pasta with increased protein and fibre content and potential gluten-free applications while retaining desirable sensory and technological properties. It also demonstrates a cross-regional value chain in which legumes are produced, processed into identity-preserved flour and transferred to downstream artisan manufacturers for final product development. The approach creates higher-value market opportunities for European pulses while responding to consumer demand for nutritious, sustainable and locally sourced food products. The detailed business model and market assessment for IPS5.1 are presented in D5.3.
Type of result	Food product / Formulation know-how
Ownership	**Individual**

Partners involved	APT; Contributors: Molino Peila, KERRY, AU, UNITO
Exploitation pathway	**Commercial.** Identified exploitation pathways include: • Direct sales and e-commerce • Specialty and health-food retail • Restaurants and food-service supply • Farmers' markets and local-food channels • Distribution partnerships and potential private-label arrangements
Target market/ potential users	Vegans, vegetarians, flexitarians, gluten-free and health-conscious consumers, restaurants, specialty-food retailers, local food businesses and food-service operators.
End-users' usage of result	• Purchase nutritious legume-based pasta as an alternative to conventional pasta • Integrate premium legume pasta into restaurant and food-service menus • Use validated flour combinations and formulations for development of additional pasta products
TRL	**TRL 7-8:** Legume-pasta formulations and processing approaches developed and validated in relevant production conditions.
Channels	• D2C/e-commerce • Specialty food and health-food stores • Restaurants and food-service suppliers • Farmers' markets and local-food networks • Food fairs and promotional events
Access to result	**Private/controlled access:** Detailed recipes, flour combinations, formulation parameters, processing conditions and commercial specifications. **Publicly shareable results:** General formulation findings, nutritional and sensory validation results, demonstration outcomes and sustainability information.
Suggested IP protection	• Trade secrets/ know-how for formulations, flour combinations and processing parameters. • Trademark/ brand protection for marketed pasta. • Packaging design protection.
Exploitation risks	• **Risk 1:** Sensory or technological performance limits consumer acceptance. **Mitigation:** Continue formulation optimisation and sensory validation. • **Risk 2:** Cross-regional supply and logistics complexity. **Mitigation:** Strengthen supplier agreements and value-chain coordination. • **Risk 3:** Strong competition in the legume-pasta market. **Mitigation:** Differentiate through artisan quality, nutrition, sustainability and traceable European sourcing.
Year of availability	At project end (M52), with progressive market deployment thereafter.
Key message to target groups	***Transform European legumes into premium artisan pasta combining nutritional value, sustainable sourcing and differentiated food quality.***
Replicability/ Upscaling potential	**High** • Applicable to different legume crops and flour blends • Transferable to other artisan and industrial pasta producers • Scalable through specialty retail, food-service and wider distribution channels

5.9. Hermetic Bagging Systems to Enable Cross-Regional Applications for Plant Proteins

KER #9	Hermetic Bagging Systems to Enable Cross-Regional Applications for Plant Proteins
Description	An **integrated post-harvest preservation, storage, transport and traceability system** for identity-preserved legumes, plant-protein raw materials and processed fractions. The solution combines reusable 1-tonne hermetic FIBC/raffia bags, recyclable high-barrier liners, portable airtightness-testing and controlled-atmosphere equipment using CO_2, and bag-level QR-code traceability. It enables chemical-free pest control, moisture stability, extended shelf life, reduced contamination and product losses, preservation of crop identity and direct farm-to-processor logistics. The system is particularly suited to

	decentralised, organic, gluten-free, specialty and identity-preserved plant-protein value chains. The detailed business case is presented in **Annex 4. IPS5.2 Business Case Report.**
Type of result	Integrated storage and transport technology / Packaging system / Controlled-atmosphere technology / Digital traceability solution
Ownership	**Individual**
Partners involved	INTA; Contributors: UNITO
Exploitation pathway	**Commercial.** The integrated solution will be exploited through three core routes: ● Physical product and consumables sales – reusable external bags, replacement liners and treatment equipment; ● Equipment rental / treatment-as-a-service – seasonal rental or per-bag/per-tonne services for airtightness testing and controlled-atmosphere treatment; ● Digital traceability-platform access – subscriptions, licenses, user accounts or per-bag QR fees. **Additional routes** include maintenance and calibration contracts, training and validation services, technology licensing and consultancy/custom integration with customer logistics and quality-management systems.
Target market/ potential users	Farmers, agricultural cooperatives and producer organisations; processors and millers, ingredient manufacturers, organic, gluten-free and specialty food manufacturers, storage and logistics operators, buyers of identity-preserved raw materials.
End-users' usage of result	• Fill and store crops directly at farm level, preserve separate lots and avoid investment in centralised silos • Secure identity-preserved materials suitable for clean-label, gluten-free, organic and specialty applications • Handle palletised one-tonne units with digital records attached to each shipment • Use QR-linked records for verification, quality assurance, traceability and auditability
TRL	**TRL 7-8:** The system has undergone relevant-scale validation covering controlled-atmosphere treatment, modular storage, handling and QR-based traceability.
Channels	● Direct B2B sales – licensing and service agreements ● Agricultural equipment and packaging distributors ● Licensed equipment-rental and treatment-service providers ● Demonstration farms and pilot sites ● Field days and agricultural fairs ● Plant-protein industry events ● Direct engagement with processors and ingredient manufacturers ● Web-based traceability platform
Access to result	**Private/controlled access:** Detailed system design, controlled-atmosphere treatment protocols, airtightness-testing procedures, technical know-how, software components of the traceability platform and customer-specific operating data. **Publicly shareable results:** General operating principles, demonstration outcomes, user guidance, case studies and good-practice information.
Suggested IP protection	● Know-how and trade-secret protection for system integration, controlled-atmosphere treatment parameters, airtightness-testing protocols and technical operating knowledge. ● Copyright/software protection for the traceability platform and associated documentation.
Exploitation risks	● **Risk 1:** Cost and operational barriers to adoption. **Mitigation:** Use rental and treatment-as-a-service models and standardised supplier/service networks. ● **Risk 2:** Limited market differentiation and digital uptake. **Mitigation:** Position the system as an integrated preservation, controlled-atmosphere and traceability solution with simple QR-based access and system integration. ● **Risk 3:** Crop-specific performance and environmental concerns. **Mitigation:** Continue crop-specific validation and optimise protocols, while promoting reusable bags, recyclable liners and take-back/recycling schemes.
Year of availability	At project end (M52), with progressive commercial scale-up thereafter.

Key message to target groups	***Preserve plant-protein crops and ingredients from farm to processor through one modular solution combining chemical-free storage, controlled atmosphere and verified digital traceability.***
Replicability/ Upscaling potential	**High** ● Applicable beyond legumes to other dry identity-preserved commodities, particularly suitable for organic, gluten-free and premium supply chains ● Modular one-tonne units allow deployment without centralised silo infrastructure ● Rental and treatment-as-a-service models enable adoption by smaller and seasonal producers ● Authorised distributors and service operators can replicate the model regionally ● The traceability platform can scale through additional users and bags without equivalent physical-infrastructure growth ● Liner take-back/recycling schemes can strengthen circularity during scale-up

5.10. Decentralised processing technologies

KER #10	Decentralised processing technologies
Description	A **regional decentralised processing model for European plant-protein crops based primarily on dry fractionation**, including cleaning, dehulling, milling, sieving, sorting and air classification, complemented where appropriate by hybrid extraction. The solution enables locally grown chickpeas, peas, faba beans and lentils to be converted into traceable, identity-preserved protein-rich and starch-rich functional ingredients close to the production area. Compared with conventional wet fractionation, the approach requires less energy and avoids water and chemical solvents. The business model is based on commercial valorisation of both processing fractions: the fine protein-rich fraction as a premium plant-protein ingredient and the larger starch-rich fraction as a functional food ingredient for bakery, pasta, snacks and other applications. The detailed business case is presented in **Annex 5. IPS5.3 Business Case Report.**
Type of result	Processing technology / Know-how
Ownership	**Individual**
Partners involved	Molino Peila; Contributors: AU, UNITO, APT, Alpine
Exploitation pathway	**Commercial.** Exploitation will focus on: ● Sales of protein-rich concentrates and functional pulse flours ● Sales of starch-rich functional co-products ● Premium pricing for regional, traceable and sustainably processed ingredients ● Long-term B2B supply agreements with food manufacturers ● Licensing/technology-transfer agreements for processing know-how ● Operation or replication of regional decentralised processing hubs
Target market/ potential users	Artisanal and industrial food manufacturers using plant-protein ingredients, pulse processors and ingredient manufacturers, pasta, bakery, snack, nutritional and plant-based food manufacturers, food/feed producers and circular-economy actors seeking starch-rich or other functional co-products.
End-users' usage of result	• Establish or use decentralised dry-fractionation capacity to produce higher-value regional ingredients • Incorporate protein-rich concentrates and functional flours into pasta, bakery, snack, nutritional and plant-based products • Integrate the coarse fraction into bakery, cakes, biscuits, snacks and other formulated foods rather than treating it as low-value feed
TRL	**TRL 6-7:** Pilot trials have demonstrated relevant processing performance, but further commercial-scale optimisation and market validation are still required.
Channels	• Molino Peila's existing B2B sales network • Long-term supply contracts with food manufacturers • Ingredient distributors and specialist commercial agents • Customer samples and formulation trials

	• Food-ingredient and plant-protein trade fairs • Technical data sheets, application guides and digital product catalogues • Joint promotion with downstream manufacturers and regional supply-chain partners
Access to result	**Private/controlled access:** Crop-specific milling diagrams, processing parameters, optimisation protocols, equipment settings, detailed performance data and proprietary processing know-how. **Publicly shareable results:** Demonstration results, ingredient performance information, application examples and good-practice guidance.
Suggested IP protection	● Know-how and trade-secret protection for crop-specific milling diagrams, processing parameters, fractionation settings and operational optimisation. ● Confidentiality agreements for customer-specific application and processing data. ● Copyright for technical documentation, application guides and operating protocols. ● Licensing/technology-transfer agreements for processing know-how. Any proprietary dry-fractionation technology supplied by Alpine is subject to Alpine's underlying ownership and licensing arrangements.
Exploitation risks	● **Risk 1:** Insufficient or inconsistent raw-material supply. **Mitigation:** Use pre-sowing contracts defining crop variety, quality, volumes, delivery and purchasing conditions to secure viable processing campaigns. ● **Risk 2:** Limited commercial viability of the fractionation model. **Mitigation:** Commercialise both protein-rich and starch-rich fractions and differentiate through functionality, traceability, regional sourcing and lower-resource processing. ● **Risk 3: Variable processing performance and scale-up risk. Mitigation:** Optimise milling and fractionation settings by crop and variety, validate food applications with downstream manufacturers and secure commitments before scale-up.
Year of availability	At project end (M52), with further commercial scale-up thereafter.
Key message to target groups	***Turn locally grown European pulses into traceable, high-value protein and functional ingredients through lower-resource regional processing while creating value from the entire crop.***
Replicability/ Upscaling potential	**High** ● Replicability through regional processing hubs located near crop-growing areas ● Applicable to peas, faba beans, lentils, chickpeas and other crops ● Pre-sowing agreements provide a transferable model for securing regional raw-material supply ● Ingredient adaptation to artisanal customers through smaller packs and industrial customers through bulk supply ● Processing know-how transferred or licensed to additional processors ● The co-valorisation model improves scalability due to potential revenue generation both from protein-rich and starch-rich fractions ● Replication potential across European regions where sufficient crop volumes, processors and downstream food manufacturers can be connected

5.11. Strategic Knowledge Base on Plant Protein Value Chains

KER #11	Strategic Knowledge Base on Plant Protein Value Chains
Description	A structured and comprehensive **knowledge base consolidating strategic evidence on European plant-protein value chains** generated through project research, market and policy analysis, stakeholder engagement and implementation across the five IPSs. It brings together information on value-chain actors and activities, production and processing systems, markets, policy and institutional conditions, key gaps, bottlenecks and lock-ins, as well as transition pathways towards more sustainable and resilient plant-protein systems. The result provides an integrated evidence base that can support research, policymaking, strategic planning, innovation development and future initiatives across the European plant-protein sector.
Type of result	Advancement in knowledge

Ownership	**Joint**
Partners involved	All consortium partners
Exploitation pathway	**Primarily non-commercial with strong policy and strategic impact.** The knowledge base will be exploited through: • Scientific publications and dissemination, • Policy briefs and recommendations, • Use by stakeholders for strategic planning and decision-making, • Supporting further research, innovation projects, and funding proposals. Indirect commercial use includes: • Input for consultancy and advisory services, • Integration into training, capacity-building, and innovation support activities.
Target market/ potential users	Policymakers and public authorities, research organisations and academia, agri-food companies, agricultural and business advisors, NGOs, innovation-support organisations and other plant-protein value-chain stakeholders.
End-users' usage of result	• Inform policy design and strategic initiatives • Identify opportunities and barriers in plant protein value chains • Support investment and innovation decisions • Guide development of sustainable and resilient food systems
TRL	**TRL 4-5:** Knowledge has been generated, consolidated and validated through project analysis and implementation across different European plant-protein contexts.
Channels	• Scientific publications and reports • Policy briefs and recommendations • VALPRO Path website/Knowledge Point • Workshops and conferences • Stakeholder and policy-engagement activities • Research and innovation networks
Access to result	**Open access:** The knowledge base will be made publicly accessible through project dissemination channels, including the VALPRO Path Knowledge Point, reports, publications and policy-oriented materials. Reuse will be permitted with appropriate attribution to the project and contributing partners.
Suggested IP protection	• Copyright for publications, reports and structured knowledge outputs. • Attribution requirements for reuse. • Appropriate acknowledgement of contributing partners and project sources.
Exploitation risks	• **Risk 1:** Fragmentation of knowledge outputs. **Mitigation:** Consolidate findings into a coherent and accessible knowledge base. • **Risk 2:** Limited uptake beyond the project. **Mitigation:** Promote the result through policy, research and stakeholder networks. • **Risk 3:** Knowledge becomes outdated. **Mitigation:** Enable future updating through follow-up projects, research and new evidence.
Year of availability	At project end (M52).
Key message to target groups	***A comprehensive evidence base to understand, develop and accelerate sustainable plant-protein value chains across Europe.***
Replicability/ Upscaling potential	**High** • Applicable across regions and value chains • Expandable with new data and future research • Usable as a foundation for policy, innovation, and investment strategies • Transferable to other agri-food sectors

5.12. Methodology for Value-Chain Business Modelling

KER #12	Methodology for Value-Chain Business Modelling
Description	A structured, **collaborative methodology for developing and validating business models across complex agri-food value chains**, developed and tested within VALPRO Path for

	plant-protein applications. The methodology follows an iterative value-chain-oriented process that supports stakeholders in identifying business opportunities, understanding market conditions, defining customer value, mapping value-chain activities and stakeholder roles, and designing viable collaborative business models. Validated through the VALPRO Path business cases, the methodology enables farmers, processors, technology providers, researchers and food companies to jointly define how value is created, delivered and captured and to translate innovation into actionable exploitation and market pathways.
Type of result	Methodology / Service framework
Ownership	**Individual**
Partners involved	FSH
Exploitation pathway	**Commercial (service provision and consulting activities).** The methodology will be exploited through: • Business modelling and exploitation consultancy provided by FSH • Application in EU and other innovation projects • Integration into acceleration and incubation programmes • Tailored business-development support for agri-food organisations and consortia • Training and capacity-building services
Target market/ potential users	Farmers and farmer organisations, agri-food SMEs, food manufacturers and processors, technology providers, research and innovation consortia, innovation hubs, accelerators, clusters and advisory organisations.
End-users' usage of result	• Identify and validate market opportunities • Develop value propositions and collaborative business models • Define stakeholder roles, value exchanges and exploitation pathways • Design viable business and market-entry strategies • Support commercialisation and scale-up of innovations
TRL	**TRL 9:** Methodology validated through multiple business cases and ready for operational deployment through consulting, innovation and capacity-building services.
Channels	• Direct consulting services (B2B) • EU and international innovation projects • Acceleration and incubation programmes • Training workshops and capacity-building activities • Collaboration with innovation ecosystems and projects
Access to result	**Private/controlled access:** Full methodology, facilitation approach, detailed templates, implementation know-how and customised application through FSH consulting and training services. **Publicly shareable results:** Methodological approach, selected examples, non-confidential project applications and general information on the business-modelling process.
Suggested IP protection	• Know-how for methodology, facilitation process and implementation approach. • Copyright for templates, tools, training materials and methodological documentation. • Confidentiality provisions for client-specific applications and consulting assignments.
Exploitation risks	• **Risk 1:** Limited uptake by organisations unfamiliar with collaborative business modelling. **Mitigation:** Demonstrate practical value through validated cases and tailored facilitation. • **Risk 2:** Replication without FSH know-how reduces quality and differentiation. **Mitigation:** Protect detailed methodology and deliver it through controlled consulting, training and licensing arrangements.
Year of availability	At project end (M52), with immediate post-project deployment.
Key message to target groups	***Design profitable and scalable business models tailored to your position in the plant protein value chain.***
Replicability/ Upscaling potential	**Very high** • Applicable across different value chains and agri-food sectors • Adaptable to different geographic and market contexts • Scalable through training, digitalisation and standardised tools

	• Strong potential for integration into innovation programmes and advisory services

5.13. Protein Valorisation Pathways for Side-Streams and High Value Compounds

Project result	Valorisation Pathways for Side-Streams & High-Value Compounds
Description	A set of identified and validated pathways for the valorisation of side-streams and residues generated during plant protein processing (e.g. fibre-rich fractions, carbohydrate-rich streams, processing by-products). Through compositional characterisation and process analysis, the project identifies high-value components suitable for further utilisation, including applications in: ● Food ingredients, ● Biomaterials, ● Bio-based products (e.g. biochar, biofuels, agronomic inputs). The result enables the transformation of low-value residues into valuable products, contributing to circular and resource-efficient agri-food systems.
Type of result	Methodology
Ownership	Individual
Partners involved	CSIC; Contributors: MTL, MP, KERRY
Exploitation pathway	**Hybrid (commercial + research + industrial integration)** The valorisation pathways will be exploited through: ● Integration into existing processing chains to utilise side-streams ● Development of new value-added products from residues ● Licensing or transfer of valorisation approaches to industry Use in R&D and innovation projects for further development
Target market/ potential users	Food processing companies, ingredient manufacturers, bio-based industries (biomaterials, bioenergy, agri-inputs), R&D organisations and innovation actors.
End-users' usage of result	● Identify and exploit high-value components in processing residues ● Reduce waste and improve resource efficiency ● Develop new products and revenue streams ● Improve sustainability and circularity of production systems
TRL	**TRL 4-5:** Concepts and pathways validated at laboratory and early pilot level, requiring further development for industrial deployment.
Channels	● Industrial partnerships and collaborations ● Integration into processing and product development pipelines ● Research and innovation projects ● Knowledge transfer and technical dissemination
Access to result	**Partially restricted access.** ● General knowledge on pathways: Shareable ● Specific applications and process details: Restricted due to commercial sensitivity
Suggested IP protection	Know-how and trade secrets (primary protection); Potential patents for specific valorisation processes or applications; Licensing agreements for industrial uptake; Controlled dissemination of sensitive information
Exploitation risks	● **Risk 1:** Some applications may not be cost-effective at scale ● **Mitigation 1:** Focus on high-value applications and conduct techno-economic assessments ● **Risk 2:** Technical challenges in scaling up processes ● **Mitigation 2:** Further pilot testing and collaboration with industrial partners
Year of availability	At project end (M52) with further development required for commercial deployment
Key message to target groups	***Turn processing side-streams into valuable resources and unlock new revenue streams through circular innovation.***

Replicability/ Upscaling potential	**High.** ● Applicable across multiple crops and processing systems ● Adaptable to different industrial contexts ● Strong potential for integration into circular economy strategies ● Expandable with further research and innovation

5.14. Advanced Fractionation and Functionalisation Technologies for Plant Protein Ingredients

Project result	Advanced Fractionation & Functionalisation Technologies for Plant Protein Ingredients
Description	A set of advanced processing technologies for the fractionation and functionalisation of plant protein ingredients derived from legumes (e.g. chickpea, lupine). The result includes the evaluation and optimisation of techniques such as: ● Dry fractionation, ● Air classification, ● Supercritical fluid extraction (for delipidisation), ● Milling and pre-processing approaches. These technologies aim to enhance the functional, nutritional and techno-functional properties of plant protein ingredients, improving their suitability for food applications such as bakery, confectionery, and plant-based products at the same time reducing water use and saving energy.
Type of result	Product
Ownership	**Joint**
Partners involved	MTL, Molino Peila, Contributors: CSIC, KERRY, AU
Exploitation pathway	**Commercial.** The technologies will be exploited through: ● Integration into existing industrial processing lines, ● Licensing or technology transfer to food processing companies, ● Development of improved plant protein ingredients for commercial use, ● Use within industrial product development pipelines.
Target market/ potential users	Food ingredient manufacturers, food processing companies, plant-based food producers, technology providers and equipment manufacturers, R&D departments in the agri-food sector.
End-users' usage of result	● Improve functionality of plant protein ingredients (e.g. solubility, texture, stability, taste) ● Enable development of high-quality plant-based food products ● Optimise processing efficiency and product performance ● Increase value of protein crops through enhanced ingredient quality
TRL	**TRL 5-6:** Technologies validated at pilot scale with potential for further scale-up and industrial implementation.
Channels	● Direct industrial implementation by project partners ● Technology transfer and licensing agreements ● Collaboration with food and ingredient manufacturers ● Integration into commercial product development processes
Access to result	**Private / Restricted access** • Access limited to involved partners & industrial stakeholders • Results protected due to commercial sensitivity and competitive advantage • Shared under controlled agreements where relevant
Suggested IP protection	Trade secrets & confidential know-how (primary protection mechanism); Process optimisation knowledge retained within industrial partners; Potential for patents (depending on novelty of specific processes); Licensing agreements for controlled technology transfer
Exploitation risks	• **Risk 1:** Scale-up challenges from pilot to industrial level. **Mitigation 1:** Gradual scale-up and validation with industrial partners.

	• **Risk 2:** High investment costs for industrial adoption. **Mitigation 2:** Demonstrate economic benefits & efficiency gains.
Year of availability	At project end (M52)
Key message to target groups	***Unlock superior functionality and value from plant proteins through advanced, scalable processing technologies.***
Replicability/ Upscaling potential	**High** • Applicable to multiple legume crops and protein sources • Scalable from pilot to industrial level • Adaptable to different processing infrastructures • Strong potential for integration into diverse food production systems

5.15. Protein Crops Dataset

Project result	**Protein Crop Dataset**
Description	A comprehensive, harmonised dataset containing field-level and experimental data on protein crops collected across multiple regions and pedo-climatic conditions within the project. The dataset includes information on: • Crop performance (yield, stability, phenology), • Agronomic practices (cropping systems, intercropping, inputs), • Environmental parameters (soil, climate conditions), • Quality and compositional characteristics (e.g. protein content), • Sustainability-related indicators (where available). The dataset is structured to support modelling, decision-support tools, sustainability assessments, and future research on plant-based protein systems. In VALPRO Path, the dataset is a core enabling asset which feeds ML Yield Tool, Traceability Tool and Nutrient Tracking Tool.
Type of result	Dataset
Ownership	**Individual**
Partners involved	AGRICOLUS (lead developer and owner), with data inputs generated across project pilots and partner activities
Exploitation pathway	**Primarily non-commercial with selective commercial potential** The dataset will be exploited through: • Supporting development and validation of project tools (e.g. yield prediction, nutrient tracking, LCA models), • Enabling further scientific research and publications, • Providing input data for advisory services and decision-support systems. Selective commercialisation pathways may include: • Licensing access to curated datasets for agri-tech companies, • Integration into subscription-based digital services (e.g. VALPRO Path tools portfolio), • Use in consultancy and advisory services.
Target market/ potential users	Academia and research organisations; Agri-tech companies & digital solution providers; Agricultural advisors; Policy makers and public bodies
End-users' usage of result	• Develop and validate predictive models and decision-support tools • Support agronomic optimisation and crop management strategies • Inform sustainability assessments and policy development • Enable data-driven innovation in plant-based protein value chains
TRL	**TRL 5-6:** Data validated and demonstrated in relevant environment, but requiring further structuring and scaling for full commercial deployment.
Channels	• Research collaborations and scientific networks • Integration into digital platforms and tools developed within the project • Data-sharing platforms and repositories (controlled access) • Advisory services and knowledge transfer activities
Access to result	**Partially open / partially restricted**

	• Aggregated or anonymised datasets: Open access (or shared via research repositories) • Detailed/raw datasets: Restricted access under data-sharing agreements
Suggested IP protection	Data governance frameworks (ownership, access rights, usage conditions); Licensing agreements for commercial use; Anonymisation and aggregation to protect sensitive data; Protection of proprietary data processing methodologies (know-how)
Exploitation risks	• **Risk 1:** Data fragmentation and lack of standardisation. **Mitigation 1:** Harmonisation protocols and metadata standards. • **Risk 2:** Limited accessibility due to data ownership constraints. **Mitigation 2:** Clear data governance agreements and tiered access model.
Year of availability	At project end (M52).
Key message to target groups	***A unique, multi-regional dataset enabling data-driven innovation, modelling and decision-making for sustainable protein crop systems.***
Replicability/ Upscaling potential	**Very high** • Expandable with new datasets and additional regions • Applicable to other crops and agricultural systems • Can serve as a foundation for future digital services and AI-based tools • Enables long-term data infrastructure for plant protein innovation in Europe

5.16. Digital Traceability Tool for Protein Crop Supply Chains

Project result	**Digital Traceability Tool for Protein Crop Supply Chains**
Description	A digital traceability solution developed as an Application Programming Interface (API) that enables the collection, integration and provision of supply chain data for protein crops, with a primary focus on the primary production stage. The tool allows stakeholders to track key production parameters (e.g. origin, agronomic practices, environmental data), ensuring transparency, traceability and data interoperability across protein crop value chains. The tool will remain a distinct API-based service while providing the data integration and traceability layer within a broader sustainability pathway. It supplies structured farm and supply chain data to the Automated Carbon Footprint Assessment Tool and supports the ISO-aligned MRV System through transparent records, provenance and controlled evidence access. The tool also supports QR-enabled access to selected traceability and environmental indicators at product or batch level, enabling downstream communication with processors, retailers and consumers while preserving controlled access to sensitive farm-level data.
Type of result	Service
Ownership	**Individual** - The underlying software components, API logic, platform integration, QR-enabled interface and related know-how developed within the farmB FMIS environment remain farmB-owned.
Partners involved	farmB, Contributors: UNITO (data provision and validation through a use case)
Exploitation pathway	**Commercial** (integrated service offering): to be commercialised as part of an upgraded Farm Management Information System (FMIS) and/or as a standalone API service. Potential exploitation routes include: • Integration into existing digital agriculture platforms (e.g. farmB cloud solutions), • API licensing to agri-tech companies and food industry actors, • Embedding within certification and sustainability schemes (e.g. traceability for ESG compliance), • Bundling within the VALPRO Path integrated service portfolio, • Deployment of QR-enabled product and batch-level traceability services for downstream value chain communication, • Interconnection with complementary VALPRO Path results.

Target market/ potential users	Farmers and farm advisors, agri-food companies (processors, retailers), agri-tech companies and digital platform providers, certification bodies, policy makers and regulatory authorities.
End-users' usage of result	• Track and verify primary production data for protein crops • Enable supply chain transparency and traceability • Support compliance with sustainability, certification, and regulatory requirements • Facilitate data-driven decision-making and reporting • Provide processors, retailers and consumers with QR-enabled access to selected traceability and environmental indicators at product or batch level
TRL	**TRL 8:** System complete and qualified.
Channels	• Commercial sales channels (via FMIS providers and agri-tech platforms) • API integration partnerships • Direct B2B agreements with agri-food companies • Demonstrations within pilot farms and value chains
Access to result	**Restricted/controlled access.** Access will be controlled through: • Subscription-based or licensing models • API access keys and user authentication • Data governance and sharing agreements
Suggested IP protection	• Soft IP protection for confidential information, proprietary algorithms and data structures and company know-how. • Licensing agreements for API usage.
Exploitation risks	• **Risk 1:** Stakeholders may be slow to adopt traceability solutions. **Mitigation 1:** Demonstrate value through pilots • **Risk 2:** Incomplete or inconsistent farm-level data. **Mitigation 2:** Standardised data collection protocols and integration with IoT/remote sensing systems
Year of availability	Year 1 after project ends.
Key message to target groups	***Enable full transparency and trust in protein crop supply chains through seamless, real-time traceability of primary production data.***
Replicability/ Upscaling potential	**High** • Applicable to different crops and farming systems • Expandable beyond primary production to full value chain traceability • Integrable with sustainability assessment tools (e.g. LCA, carbon footprint tools) • Suitable for cross-regional and international deployment • Connectable with the Automated Carbon Footprint Assessment Tool and the ISO-aligned MRV System as part of a broader digital sustainability pathway

5.17. Automated Carbon Footprint Assessment Tool

Project result	Automated Carbon Footprint Assessment Tool
Description	A **farmB.log** extension that automates farm-level carbon-footprint assessment for protein crop production. It integrates heterogeneous data streams, including field boundaries, crop calendars, field operations, machinery parameters, input records, transport activities, yield data and protein-related information. By combining these data with relevant emission factors and modelling approaches, the extension calculates GHG emissions across different functional units, including kg CO_2e/ha, kg CO_2e/kg product and kg CO_2e/kg protein, while identifying the main emission sources. Integration with the Digital Traceability Tool provides structured and traceable inputs, while the resulting calculations and emissions-intensity indicators can support the ISO-aligned MRV System for transparent reporting and verification-readiness.

	The GHG analytical pathway is further supported by the VALPRO Path publication on interpretable machine learning for legume yield prediction using Sentinel-2 satellite data.[1] The research demonstrates the potential to integrate remote sensing, machine learning and explainable AI into protein crop analytics. Yield and productivity estimates derived from these approaches support future calculations of emissions intensity per kilogram of product and per kilogram of protein, subject to further technical integration and validation.
Type of result	Product / Digital tool
Ownership	**Individual**
Partners involved	farmB
Exploitation pathway	**Commercial** (platform-based service and integration into sustainability solutions) The tool will be exploited through: • Integration into the existing farmB.log commercial platform, • Offering as a subscription-based service to farmers and agri-food companies, • Licensing or white-label solutions for third-party digital platforms, • Integration into certification schemes and sustainability reporting systems, • Provision of GHG analytics and emission-source diagnostics
Target market/ potential users	Farmers and cooperatives, agri-food companies (processors, retailers), certification bodies, advisory services and sustainability consultants, policy makers and regulatory bodies.
End-users' usage of result	• Monitor and quantify farm-level carbon emissions • Support compliance with sustainability regulations and reporting requirements • Identify emission hotspots and optimise farming practices • Provide verified data for carbon footprint labelling and ESG reporting • Analyse the contribution of different field operations, machinery, inputs, transport activities and production outputs to total GHG emissions • Compare results across functional units, including emissions per hectare, per kilogram of product and per kilogram of protein
TRL	**TRL 8:** System complete and validated within an operational digital platform environment.
Channels	• Direct deployment via the farmB.log platform • Partnerships with agri-tech providers and advisory services • Integration into certification and carbon accounting schemes • B2B agreements with agri-food companies
Access to result	**Restricted/Private access.** Access provided via: • Subscription-based platform access • User authentication and data governance mechanisms • Tiered service levels (e.g. basic vs advanced analytics)
Suggested IP protection	• Proprietary algorithms and emission calculation models (know-how). • Software copyright (platform and codebase). • Data protection and controlled access mechanisms. • Licensing agreements for third-party use.
Exploitation risks	• **Risk 1:** Changes in carbon accounting methodologies or policies. **Mitigation 1:** Align tool with recognised standards and ensure flexibility for updates. • **Risk 2:** Limited willingness of farmers to adopt carbon monitoring tools. **Mitigation 2:** Provide user-friendly interfaces and demonstrate economic incentives (e.g. carbon markets, compliance benefits).
Year of availability	At project end (M52).
Key message to target groups	***Measure, manage and reduce your farm's carbon footprint with automated calculation and advanced GHG analytics, reliable and real-time or near-real-time insights (subject to data availability and completeness).***

[1] Petropoulos, T., Benos, L., Berruto, R., Miserendino, G., Marinoudi, V., Busato, P., Zisis, C. and Bochtis, D. (2025). Interpretable Machine Learning for Legume Yield Prediction Using Satellite Remote Sensing Data. Applied Sciences, 15(13), 7074. DOI: 10.3390/app15137074, https://www.mdpi.com/2076-3417/15/13/7074

Replicability/ Upscaling potential	**Very high** • Applicable across different crops, farming systems, and regions • Scalable through cloud-based platform deployment • Expandable to include additional environmental indicators (e.g. water, biodiversity) • Strong integration potential with the Digital Traceability Tool, the ISO-aligned MRV System and other digital sustainability solutions including LCA and decision-support systems

5.18. MRV System for Carbon Accounting in Protein Crop Systems

Project result	MRV System for Carbon Accounting in Protein Crop Systems
Description	An **ISO-aligned MRV framework** for quantifying and documenting GHG emissions and emission reductions in protein crop production systems. The framework builds on the Digital Traceability Tool and the farmB.log carbon footprint extension, using structured farm-level data and analytical outputs to support transparent carbon accounting, verification-readiness and credible sustainability claims. Its alignment with relevant GHG accounting principles, including ISO 14064-2, was assessed through an independent methodological review and validation activity within VALPRO Path. By integrating traceability, carbon-footprint calculation and sustainability assessment components, the MRV framework provides a consistent evidence base for climate-related reporting and the future development of emission-reduction schemes.
Type of result	Methodology/ MRV and verification-readiness framework
Ownership	**Individual**
Partners involved	farmB
Exploitation pathway	**Hybrid (policy-driven and commercial MRV implementation, verification readiness and advisory service opportunities).** The MRV system will be exploited through: • Adoption by certification bodies and standardisation initiatives as an ISO-aligned methodological framework, • Integration into carbon farming and emission reduction schemes, • Use by agri-food companies for ESG reporting and compliance, • Deployment via digital platforms, including integration with carbon footprint calculation tools and traceability systems, • Consultancy and advisory services supporting implementation and verification readiness.
Target market/ potential users	Certification bodies and standardisation organisations, policy makers and regulatory authorities, agri-food companies (for ESG and sustainability reporting), farmers participating in carbon farming schemes, advisory services and sustainability consultants.
End-users' usage of result	• Monitor and verify GHG emissions & emission reductions • Enable participation in carbon markets and carbon farming schemes • Support compliance with regulatory and reporting requirements • Provide credible, standardised data for sustainability claims • Link farm-level carbon footprint calculations and traceability data with transparent MRV reporting and verification processes
TRL	**TRL 6-7:** System demonstrated in relevant environment and aligned with recognised standards, with potential for further methodological validation, verification-readiness assessment, and scaling post-project.
Channels	• Collaboration with certification bodies and standardisation initiatives • Integration into digital tools and platforms (e.g. farm-level carbon footprint calculation and traceability tools) • Policy engagement and stakeholder workshops • Advisory and consultancy services supporting implementation and preparation for independent verification
Access to result	**Controlled / semi-restricted access.** • Methodology may be publicly available (to support adoption and standardisation)

	• Full system implementation and tools may be restricted or licensed • Access governed through partnerships and service agreements
Suggested IP protection	• Methodological know-how and system design (protected as know-how). • Copyright for documentation and implementation guidelines. • Licensing frameworks for commercial deployment.
Exploitation risks	• **Risk 1:** Changes in carbon accounting frameworks may reduce relevance. **Mitigation 1:** Continuous alignment with ISO standards, relevant GHG accounting principles, and policy developments. • **Risk 2:** Farmers and stakeholders may find the system difficult to apply. **Mitigation 2:** Integration with digital tools and simplified user interfaces. • **Risk 3:** ISO-aligned methodological validation may be incorrectly interpreted as formal certification. **Mitigation 3:** Clear communication that the system is ISO-aligned and not a formal certification.
Year of availability	At project end (M52), with further independent methodological validation and verification-readiness assessment post-project.
Key message to target groups	***A robust, standardised and ISO-aligned MRV system enabling credible carbon accounting, transparent evidence-based reporting and verification-readiness, and unlocking participation in carbon farming and sustainability markets.***
Replicability/ Upscaling potential	**Very high** • Applicable across regions, crops, and farming systems • Adaptable to evolving regulatory, verification, and certification frameworks • Strong potential for EU-wide and international deployment • Scalable through integration with the Automated Carbon Footprint Assessment Tool, the Digital Traceability Tool and other digital sustainability platforms

5.19. Harmonised LCA & LCSA Framework for Plant Protein Value Chains

Project result	**Harmonised LCA & LCSA Framework for Plant Protein Value Chains**
Description	A harmonised methodological framework for conducting Life Cycle Assessment (LCA) and Life Cycle Sustainability Assessment (LCSA) of plant protein value chains, covering environmental, economic, and social dimensions from primary production to end-of-life. The framework provides standardised system boundaries, indicators, data requirements, and calculation approaches, enabling consistent and comparable sustainability assessments across different crops, regions, and processing pathways. It is designed to support decision-making, policy development, and sustainability reporting in the agri-food sector.
Type of result	Methodology
Ownership	**Individual**
Partners involved	NTUA (result owner), Contributors: DNY, KPAD, farmB, AGRICOLUS
Exploitation pathway	**Primarily non-commercial with strong indirect commercial impact.** The framework will be exploited through: • Adoption by research organisations and sustainability analysts • Use by agri-food companies for sustainability assessment and reporting • Integration into digital tools (e.g. carbon footprint tools, traceability systems, labelling systems) • Contribution to policy development and standardisation initiatives Indirect commercialisation pathways include: • Embedding the framework into subscription-based digital services • Use in consultancy and advisory services • Integration into certification and sustainability labelling schemes
Target market/ potential users	Research organisations and universities, agri-food companies (processors, retailers), sustainability consultants and advisory services, policy makers and public authorities, certification bodies and standardisation organisations.

End-users' usage of result	• Perform harmonised sustainability assessments of plant protein value chains • Compare environmental and socio-economic impacts across systems • Support product development and value chain optimisation • Provide robust evidence for policy and sustainability claims
TRL	**TRL 6-7:** Methodology validated through real case studies and integrated with project tools, with potential for further standardisation and uptake post-project.
Channels	• Scientific publications and technical reports • Integration into digital tools and platforms developed within the project • Policy briefs and stakeholder engagement activities • Advisory services and consultancy applications
Access to result	**Partially open/ partially restricted access.** • Core methodology: Open access to promote adoption and standardisation • Implementation tools, datasets, and advanced applications: Restricted or licensed access
Suggested IP protection	• Open methodology combined with protected implementation (hybrid approach). • Copyright for framework documentation. • Know-how related to modelling approaches and integration. • Licensing for embedded use in commercial tools.
Exploitation risks	• **Risk 1:** High complexity of LCSA implementation. **Mitigation 1:** Provide simplified guidelines and integrate into user-friendly digital tools • **Risk 2:** Limited uptake by industry. **Mitigation 2:** Demonstrate business value (e.g. compliance, branding, efficiency gains) and link to labelling systems
Year of availability	At project end (M52).
Key message to target groups	***A harmonised framework to assess and compare the full sustainability performance of plant protein value chains with confidence and consistency.***
Replicability/ Upscaling potential	**Very high** • Applicable across crops, regions, and value chains • Adaptable to evolving sustainability standards and policies • Scalable through integration into digital tools and services • Strong potential for EU-wide and international adoption

6. IP Assessment – Organisations' Analysis

In order to identify the IP (Intellectual Property) and IPR (Intellectual Property Rights) considerations for each Project Partner, the results recorded in the context of the VALPRO Path IP (Intellectual Property) Internal Questionnaire were analysed. The information used concerns the following:

A. Project specific questions: In this part, WP5 investigated the intention of Project Partners on whether they are planning to develop IP during the project, as well as to provide specific information about this IP. Moreover, a brief description of the assets to be protected was asked (IP) and how these assets could be protected (IPR), as well if there is a case of mutual development of IP with other project's partners. Such insights enabled us to suggest potential IP protection measures.

B. Organization analysis: In this part, WP5 investigated the IP strategies, activities and capacities of the project partners. This part is strongly related to the preliminary IP Audit, including issues such as internal organization, IP security, IP status and type. We also asked partners to proceed to an internal IP assessment of their organization. Based on these findings, we acquired a clear picture about each partner IP current status. More specifically, two different aspects were examined including **Internal Processes**, and **IP and Security**.

TEAGASC - AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY (TEAGASC)

Internal processes: TEAGASC has a well-established and structured approach to intellectual property management, supported by a dedicated IP office/legal department and clearly defined in-house policies and procedures covering the creation, maintenance and enforcement of IPR. The organisation has dedicated personnel and/or access to legal expertise for handling IP-related matters, along with formal procedures for recording and disclosing new inventions. A comprehensive register of IP assets is maintained, and processes are in place for prioritising IP protection activities. Additionally, the presence of an internal IP & innovation review board ensures systematic monitoring of IP assets, innovation disclosures, and strategic portfolio development.

IP and security: TEAGASC has robust security and IP protection measures in place to safeguard intellectual property. Employees are trained to recognise and handle confidential information appropriately, and clear policies exist for reporting any potential misappropriation of IP or trade secrets. The organisation systematically uses non-disclosure agreements with third parties to ensure controlled sharing of sensitive information. TEAGASC applies a broad range of IP protection mechanisms, including patents, trademarks, industrial designs and confidential information, and has experience in managing jointly developed IP with external partners. While the organisation has not actively commercialised IP through licensing or sales, it demonstrates strong awareness of the strategic importance of IPR, with top scores assigned to its importance for future research and competitiveness. Overall, TEAGASC shows a high level of IP awareness and a very strong, well-implemented IP protection strategy.

AARHUS UNIVERSITET (AU)

Internal processes: AU demonstrates a strong and well-structured approach to intellectual property management, supported by established institutional frameworks, dedicated support functions, and clear internal procedures for the creation, maintenance, and protection of IP. The organisation maintains records of its intellectual property assets and follows formal processes for invention disclosure, reflecting a high level of organisational maturity. The consistently high internal assessment scores indicate that IP management is well integrated into AU's research and innovation activities, with a clear recognition of its strategic importance.

IP and security: AU has implemented solid IP protection and security practices, including safeguards against unauthorised disclosure and the use of confidentiality measures to protect sensitive information. The organisation applies a combination of patents and open-access mechanisms, such as Creative Commons licences, reflecting its dual focus on innovation and knowledge dissemination. While commercialisation and collaborative IP development have not been a primary focus, AU demonstrates strong awareness of the importance of IP for future research. The identification of legal and enforcement costs as key risks further highlights a realistic and informed approach to IP management, with a solid foundation for continued strategic development.

UNIVERSITA DEGLI STUDI DI TORINO (UNITO)

Internal processes: UNITO has a formal IP management structure supported by an institutional IP office/legal department and established procedures for recording and disclosing new inventions. The organisation maintains a register of its intellectual property assets, including patents and confidential information, indicating a structured approach to IP documentation and ownership. However, UNITO does not have dedicated internal personnel exclusively focused on IP management, nor does it rely on external legal services for this purpose. Additionally, there are no defined processes for prioritising IP protection activities. Overall, UNITO demonstrates a moderate level of maturity in internal IP processes, with solid foundational structures but some limitations in strategic IP management and resource allocation.

IP and security: UNITO has basic IP protection and security measures in place, including policies that allow employees to report potential misappropriation of intellectual property and the use of non-

disclosure agreements with third parties in certain cases. However, there is a lack of systematic training or awareness among employees regarding confidential IP, which may pose a risk in safeguarding sensitive information. The organisation primarily relies on patents and confidential information as protection mechanisms and has limited experience in IP commercialisation, with no history of licensing or joint IP development with external partners. Overall, UNITO shows a moderate level of awareness and implementation of IP protection practices, with room for improvement in employee awareness, security measures, and strategic use of intellectual property to enhance competitiveness.

ETHNICON METSOVION POLYTECHNION (NTUA)

Internal processes: NTUA has an established institutional framework for knowledge transfer and intellectual property management, supported by its Technology Transfer Office (TTO), which operates under the Special Account for Research Funding of NTUA. TTO provides support to NTUA researchers in relation to technology and know-how transfer, dissemination and exploitation of research results and the management and protection of intellectual property. NTUA has dedicated institutional capacity to guide researchers in identifying, protecting and valorising research-based assets. NTUA's TTO also provides services linked to entrepreneurship and innovation capacity building, including educational programmes, seminars on innovation and entrepreneurship, skills seminars for potential young entrepreneurs, innovation competitions and related activities. NTUA has practical experience in supporting spin-off creation and research commercialisation. Recent examples include the approval of NTUA spin-off companies such as GreenΔrasis and RedEdge in 2024, as well as earlier spin-offs such as R-AMS, TopoTronics, PRINSUS, EUCLIA and DATOPTRON. This demonstrates that NTUA has operational procedures and institutional mechanisms for assessing research results with commercial potential and supporting their transfer towards market-oriented exploitation pathways.

IP and security: NTUA demonstrates a mature awareness of intellectual property protection and research valorisation. The NTUA TTO provides information on different forms of IP protection, including patents, and refers to procedures for patent applications through the Hellenic Industrial Property Organisation, the European Patent Office or other patent offices. This indicates institutional knowledge of formal IP protection routes, particularly for inventions with industrial applicability. Given NTUA's role as an academic and research organisation, dissemination through scientific publications, technical reports, policy briefs and stakeholder engagement is expected to remain important. At the same time, where NTUA results are integrated into digital tools, consultancy services, certification approaches or commercial platforms, appropriate access conditions, licensing terms, data-sharing agreements and confidentiality measures should be considered.

FUTURE SYSTEMS HUB (FSH)

Internal processes: FSH has a structured approach to intellectual property management, supported by internal expertise and dedicated capacity to address IP-related matters. The organisation applies clear procedures for recording and disclosing new knowledge and innovations, ensuring that intellectual assets are properly identified and managed. Given its focus on consulting, innovation strategy and business model development, IP is primarily managed as know-how and proprietary methodologies. Overall, FSH demonstrates strong and well-organised internal processes, enabling it to effectively handle IP and IPR-related matters within its activities.

IP and security: To safeguard against unwanted disclosure of IP to third parties, FSH relies on NDAs. FSH employees are well educated about the kind of IP that is considered confidential so that they can protect this information accordingly. Also, in some cases third parties are required to agree, in writing, to non-disclosure agreements.

IP protection measures that have been applied within FSH so far include mainly copyrights and soft IP protection measures. There's high awareness of IPRs in FSH and all security measures are in place in

order to safeguard the IP generated. FSH's current strategy regarding protection of intellectual property rights is strong because FSH considers that IP protection is very important for increasing organisation's overall competitiveness.

LEIBNIZ-ZENTRUM FUER AGRARLANDSCHAFTSFORSCHUNG (ZALF)

Internal processes: ZALF operates primarily as a research-driven organisation where intellectual assets are generated through scientific knowledge, models, datasets, methodologies, experimental infrastructures and applied research outputs. The organisation demonstrates a well-structured internal approach to IP management, supported by an IP office/legal department, written in-house IP procedures, dedicated IP personnel, invention disclosure procedures and records of IP owned or used by the organisation. This indicates that IP management is formally embedded within ZALF's internal processes rather than handled on an ad hoc basis. ZALF also has security measures in place to prevent unwanted disclosure of IP. Employees are aware of the types of information considered confidential, and procedures exist for reporting potential misappropriation of IP or trade secrets. The presence of an IP and innovation review board further supports the structured assessment of potentially valuable research outputs and helps guide decisions on protection, disclosure and further exploitation. ZALF places strong emphasis on research data management and open research data. Its Research Data Policy covers rights and licences related to ZALF research data, as well as handling responsibilities, quality, integrity, long-term availability and reuse.

IP and security: ZALF's IP position is closely aligned with open science, responsible data governance and knowledge transfer. Through its Open Research Data platform, ZALF provides access to data and metadata, with DOI registration supporting traceability, citation and reuse. The organisation applies a balanced approach between openness and protection. Outputs intended for scientific or policy uptake may be disseminated through open-access channels, copyright and clear attribution requirements. ZALF protects IP mainly through patents and copyright, reflecting the nature of its research outputs, including publications, models, methodologies, datasets and software-related materials. The organisation shows a high level of IP awareness and a strong protection strategy, although prioritisation of IP protection activities may require further clarification when deciding between open dissemination, restricted access or formal protection.

AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS (CSIC)

Internal processes: CSIC has a well-established and formalised framework for intellectual property management, supported by a dedicated IP office/legal department and specialised personnel. The organisation operates under clearly defined in-house policies and procedures governing the creation, maintenance, and protection of IP, alongside structured processes for recording and disclosing new inventions. A comprehensive register of IP assets is maintained, and procedures are in place to prioritise IP protection activities. This reflects a strong institutional capacity and a systematic approach to managing intellectual property within a research-driven environment.

IP and security: CSIC has implemented solid IP protection and security practices, including measures to safeguard against unauthorised disclosure and ensuring that employees are aware of handling confidential information appropriately. Non-disclosure agreements are applied where relevant to manage interactions with third parties. The organisation primarily relies on open-access mechanisms such as Creative Commons licences to protect and disseminate its outputs, reflecting its dual role in research and knowledge sharing. While commercialisation of IP is not a primary focus, CSIC demonstrates a structured and responsible approach to IP management, with a foundation that can support further strategic development if needed.

CONFEDERAZIONE GENERALE DELL AGRICOLTURA ITALIANA (CONFAGRICOLTURA)

Internal processes: The organisation's IP-relevant assets consist mainly of knowledge-based outputs, advisory materials, policy positions, training content, stakeholder intelligence, communication materials and project-related results, rather than patentable technologies. However, IP management appears to remain relatively informal and not established as a separate internal function. Confagricoltura does not have a dedicated IP office or legal department, written in-house IPR procedures, or formal processes for prioritising IP protection activities. Procedures for recording inventions or maintaining records of IP owned or used by the organisation are also very limited, suggesting that IP-related matters are mainly handled through general organisational, administrative or project management processes.

IP and security: Confagricoltura does not rely on registered or formally protected IP as a central part of its current operations, and there is no active IP licensing, jointly developed patented IP or systematic use of licensed third-party IP products. Given its representative and service-oriented role, the main IP and security considerations are linked to copyrightable content, confidential stakeholder information, internal analyses, member-related data and dissemination materials. Confagricoltura operates through a broad organisational network and provides information and services to associated enterprises, which increases the importance of clear procedures for content approval, attribution, controlled sharing and confidentiality. Security-related procedures are currently limited, particularly in relation to preventing unwanted disclosure, identifying confidential IP, reporting possible misappropriation and systematically using NDAs with third parties. The organisation shows a moderate level of IP awareness and recognises IP infringement as a relevant risk.

AGRICOLUS S.R.L.

Internal processes: AGRICOLUS demonstrates a well-structured and mature approach to intellectual property management, supported by both an IP/legal function and dedicated internal or external expertise handling IP-related matters. The organisation has established procedures for recording and disclosing new inventions and maintains a comprehensive register of its IP assets. While formal prioritisation processes for IP protection are not defined, AGRICOLUS shows strong operational capacity in managing and developing IP, including experience in collaborative IP development and commercialisation. Overall, the organisation exhibits a solid and practical IP management framework aligned with its innovation-driven activities.

IP and security: AGRICOLUS has robust IP protection and security measures in place, including clear safeguards against unauthorised disclosure, employee awareness of confidential information, and formal mechanisms for reporting potential IP misappropriation. The consistent use of non-disclosure agreements with third parties further strengthens its IP protection approach. The organisation applies a diverse set of IP protection mechanisms, including patents, copyrights, trade secrets, and confidential information, and has experience in both licensing and collaborative IP development. Combined with a high level of awareness regarding the strategic importance of IP for future research and competitiveness, AGRICOLUS demonstrates a strong and well-balanced IP and security framework.

WAGENINGEN UNIVERSITY (WU)

Internal processes: WUR has a dedicated Knowledge Transfer Office (KTO), which serves as a central point of contact for licensing, collaboration and access to WUR technologies. WU has established institutional mechanisms for identifying, managing and transferring research-based intellectual assets towards external partners and users. WUR's KTO supports researchers, entrepreneurs and industry partners throughout the process from initial inquiry to final agreement through a structured internal

capacity for technology transfer, including collaboration support, licensing processes, partner engagement and valorisation of research outputs. WUR also publicly presents innovation and entrepreneurship as part of its broader impact strategy, showing that IP and knowledge transfer are integrated into the organisation's research valorisation approach. WUR has defined licensing principles for patents and offers patent licensing under fair and transparent conditions, aligned with Dutch and EU regulations and knowledge valorisation policies. Depending on the strategic relevance of a patent, companies may either purchase the patent for a fair market fee or license it under agreed fair market terms. WU has established processes for assessing commercially relevant research results and managing patent-based exploitation pathways. In addition to technology transfer and licensing, WUR demonstrates a structured approach to research data management. WUR Library provides infrastructure and support for managing data according to the FAIR principles.

IP and security: WU has a mature IP and knowledge-transfer environment supported by dedicated institutional functions, patent licensing principles and research data management infrastructure. The existence of a Knowledge Transfer Office and defined patent licensing terms indicates that WU has mechanisms for protecting and exploiting formal IP, including patents, licensing agreements, collaboration agreements and potential transfer of technology to external partners. WU demonstrates a strong and institutionally supported IP management profile, combining technology transfer, licensing, innovation support and research data management.

BEOTANICS LIMITED

Internal processes: BEOTANICS demonstrates a structured and strategically oriented approach to intellectual property management, supported by written in-house policies governing the creation, maintenance, and protection of IP. While IP responsibilities are not centralised within a dedicated department or specialised team, the organisation maintains a clear overview of its IP assets and has established practices for prioritising IP protection. The presence of a maintained IP portfolio and defined internal guidelines reflects a solid operational approach, aligned with the company's focus on innovation and plant breeding activities. Overall, BEOTANICS shows a strong awareness and practical implementation of IP management within its organisational context.

IP and security: BEOTANICS has implemented relevant IP protection and security measures, including safeguards against unauthorised disclosure, employee awareness of confidential information, and the systematic use of non-disclosure agreements with third parties. The organisation utilises a diverse set of IP protection mechanisms, incl. trademarks, trade secrets, confidential information and Plant Breeders' Rights, and has experience in both IP commercialisation and collaborative IP development. With a high level of awareness of the strategic importance of IP (particularly as a key component of its international competitiveness), BEOTANICS demonstrates a strong and proactive approach to IP management, despite recognising external challenges related to enforcement in the plant breeding domain.

PORTFOLIO CONCENTRATE SOLUTIONS UNLIMITED COMPANY (PepsiCo)

Internal processes: PepsiCo demonstrates a highly advanced and comprehensive approach to intellectual property management, supported by a dedicated IP/legal function and specialised personnel. The organisation operates under well-established internal policies and procedures governing the creation, maintenance, and enforcement of IP, along with structured processes for recording and disclosing new inventions and maintaining a detailed IP portfolio. The consistently highest scores across all internal IP assessment criteria reflect a very high level of organisational maturity, strategic alignment and integration of IP management within core business operations.

IP and security: PepsiCo applies robust and multi-layered IP protection and security measures, including strong safeguards against unauthorised disclosure, employee awareness of confidential information, formal reporting mechanisms for IP misappropriation, and systematic use of non-

disclosure agreements with third parties. The organisation utilises a wide range of IP protection mechanisms, including patents, utility models, industrial designs, copyrights, trademarks, and trade secrets, ensuring comprehensive coverage of its innovations. While collaborative IP development is not a current focus, PepsiCo demonstrates a highly strategic and proactive approach to IP management, with strong awareness of key risks such as the potential loss of IP value over time. Overall, the organisation exhibits an exemplary and forward-looking IP strategy fully aligned with maintaining competitiveness and long-term value creation.

KPAD LTD (KPAD)

Internal Processes: KPAD's intellectual assets are primarily concentrated in methodological know-how, LCA modelling expertise, process-analysis logic, data interpretation methods, eco-design recommendations, calculation assumptions and applied sustainability assessment workflows. Its LCA services are aligned with ISO 14040 and focus on assessing the complete life cycle of food products and production processes, which indicates that KPAD's internal IP is mainly methodology- and know-how-based rather than dependent on registered IP rights.

IP and Security: KPAD's most relevant IP protection route is a combination of copyright, confidential information, trade secrets, know-how protection, database rights where applicable, and licensing conditions. Copyright may apply to technical reports, framework documentation, guidelines, templates, software code, calculation sheets and other original written or digital outputs, while confidentiality and trade-secret protection are particularly relevant for internal methods, unpublished models, client-specific sustainability results, process optimisation logic and commercially sensitive partner data. Given the nature of KPAD's services, the main IP risks relate to uncontrolled disclosure of methodological know-how, unauthorised reuse of templates or models, unclear ownership of jointly developed outputs and accidental publication of sensitive data.

DIGNITY IDIOTIKI KEFALAIOUXIKI ETAIREIA (DIGNITY)

Internal processes: As a small research- and engineering-focused SME, DIGNITY's IP activities are managed through its senior management and R&D project functions, with IP-related decisions addressed on a project-by-project basis. Within collaborative EU-funded projects, DIGNITY operates under consortium-level procedures governing ownership of background and newly generated knowledge, confidentiality, publication, exploitation rights and potential licensing. Its current approach focus is primarily on the management and exploitation of technical know-how, process-development expertise, sustainability methodologies, digital tools and research outputs rather than on an established internal portfolio of registered patents, trademarks or designs.

IP and security: DIGNITY's publicly visible safeguards include the reservation of copyright over its website and communication materials, together with privacy and cookie policies addressing the collection, use, storage and protection of personal data. Its participation in European research consortia also indicates the use of contractual confidentiality requirements and rules controlling access to, dissemination of and exploitation of project-generated information. Technical methods, process designs, data, software tools and commercially sensitive research knowledge are protected principally through restricted disclosure, contractual arrangements, consortium agreements and the retention of confidential know-how.

MOOREPARK TECHNOLOGY LTD (MTL)

Internal processes: Moorepark Technology Ltd. does not operate a separate IP office or publish an MTL-specific IP policy. Instead, as a Teagasc-controlled joint venture and an integral part of Teagasc's food research and technology-transfer infrastructure, its IP-related activities are supported through Teagasc's central Technology Transfer and Commercialisation Office. This framework includes formal invention disclosure, technical and commercial assessment, patent evaluation and filing, portfolio

review, licensing and assignment negotiations, and the management of IP arising from collaborative or contract research. MTL's role is primarily focused on pilot-scale product development, process validation, technology demonstration and industry knowledge transfer, while formal decisions concerning ownership, protection and commercial exploitation are managed through Teagasc procedures and project-specific agreements. No evidence was identified of an MTL-only invention disclosure process, dedicated IP committee or internally managed registered IP portfolio.

IP and security: MTL protects IP and confidential business information primarily through contractual, procedural and regulatory safeguards. These include non-disclosure agreements for confidential know-how, data and material transfer agreements, research and development licences, supplier IP-assignment clauses, and collaboration or consortium agreements defining ownership, access rights, publication conditions and exploitation rights. MTL also maintains data-protection and privacy policies aligned with Irish and EU legislation and operates under recognised food-processing and quality-management standards, supporting controlled and documented handling of client projects and technical activities. Copyright notices protect its public-facing materials, while commercially sensitive process knowledge is retained as confidential know-how. However, no public evidence was found of an MTL-specific cybersecurity certification such as ISO/IEC 27001, a published trade-secret policy or detailed internal controls for secure data storage, physical access and document management.

MOLINO PEILA SOCIETA PER AZIONI SIGLABILE MOLINO PEILA SPA (MP)

Internal processes: Molino Peila does not currently have a dedicated IP office or written in-house policies and procedures covering the creation, maintenance and enforcement of IPR. IP management is handled through general management, operational decision-making or on a case-by-case basis. Valuable knowledge is embedded in production, quality control, product development and commercial activities, but may not yet be systematically identified, recorded or managed as an IP asset. At the same time, employees are aware of the type of information considered confidential, which represents an important basis for IP security. This is particularly relevant because MP's core intellectual value is closely linked to confidential know-how, production experience, milling parameters, product specifications, heat-treatment knowledge, customer-specific requirements and quality-control practices.

IP and security: MP's current IP protection approach is primarily based on confidential information and know-how rather than registered rights. The use of non-disclosure agreements with some third parties indicates that confidentiality is recognised as a relevant protection mechanism. However, IP management appears to remain largely informal, as the organisation does not currently have a dedicated IP office, written IP policies, an IP asset register, invention disclosure procedures, IP prioritisation processes or a dedicated IP review structure. MP has not sold or licensed any IP, although it does use licensed third-party products in its organisational processes. Employees demonstrate a moderate to good level of awareness of the importance of IP, particularly in relation to confidential information. To strengthen its current know-how-based protection model, MP could benefit from introducing simple internal safeguards, such as confidentiality marking, restricted access to sensitive files, controlled sharing of technical information, internal reporting channels and management-level review of potentially valuable knowledge before external disclosure.

GLOBAL NETWORKS GEMEINNUTZIGE UNTERNEHMERGESELLSCHAFT HAFTUNGSBESCHRANT (GN)

Internal processes: Global Networks is a Germany-based non-profit entrepreneurial company with limited liability, registered in Braunschweig. It operates in the field of scientific research and development. Based on this profile, GN's intellectual assets are likely to be mainly knowledge-based and project-driven, including research outputs, methodologies, reports, stakeholder engagement formats, analytical insights, project documentation, communication materials and network-based

know-how. As no detailed public information on a dedicated IP office, internal IP policy or formal technology transfer structure could be identified, GN's IP management appears to be relatively lean and likely handled through general management, project coordination and contractual arrangements. Internal IP-relevant procedures should therefore focus on clear documentation of outputs, authorship, ownership of materials, treatment of background knowledge and review of results before public dissemination.

IP and security: GN does not appear to rely on registered IP rights, such as patents, trademarks or industrial designs, as a central part of its public profile. Its IP position is more likely linked to copyright-protected outputs, confidential project information, stakeholder data, research-based know-how and dissemination materials. Given its participation in publicly funded research and innovation projects, the main IP and security measures should include confidentiality management, controlled sharing of sensitive information, clear attribution of contributors, publication review, and compliance with project-level access rights and dissemination rules. Where GN develops or contributes to reports, methods, databases, communication outputs or stakeholder engagement tools, copyright, database rights where applicable, confidentiality obligations and clear reuse conditions are likely to be the most relevant protection mechanisms. Overall, GN's IP profile can be described as knowledge- and project-output-based, with a need to balance open dissemination of non-sensitive results with appropriate control over confidential, unpublished or jointly developed materials.

FARMB PSIFIAKI GEORGIA IDIOTIKI KEFALAIOUCHIKI ETAIREIA (farmB)

Internal processes: As an SME, farmB follows a lean and pragmatic approach to IP management, relying on project-level governance, confidentiality agreements, access controls, software copyright, internal know-how protection, patent and trademark management where applicable, and controlled disclosure procedures. While farmB does not maintain a dedicated IP department, IP responsibilities are managed at the management and technical leadership level and are embedded in software development, project implementation and commercialisation activities. The organisation maintains a clear record of its IP assets, including patents and trademarks. This indicates an operational awareness of IP ownership and protection. The flexible internal setup allows farmB to remain agile in developing and deploying digital solutions, with IP considerations embedded within its broader innovation activities.

IP and security: farmB has established solid practical measures to safeguard its IP, including protections against unauthorised disclosure, employee awareness of confidential information, and clear mechanisms for reporting potential IP misappropriation. The consistent use of non-disclosure agreements with third parties further strengthens its IP protection framework. The organisation relies on a combination of patents and trademarks, complemented by software copyright, access controls, controlled disclosure procedures and internal know-how and confidentiality practices, to protect its innovations. Formal standalone IP licensing has not been the primary commercial route to date; however, farmB actively commercialises IP-embedded digital services through its platform, project deployments, B2B agreements and integration partnerships. This approach enables farmB to exploit its proprietary software, algorithms, platform functionality and technical know-how while retaining control over its core intellectual assets. FarmB demonstrates strong recognition of the strategic importance of IP for future research and competitiveness, indicating good potential for continued development and formalisation of its IP strategy.

Wide Open Agriculture (WOA)

Internal processes: Responsibility for IP is integrated into broader corporate governance, executive management and commercialisation activities. Wide Open Agriculture's Code of Conduct establishes that IP created by employees during their work belongs to the company and that any alternative use requires executive approval. WOA manages its IP portfolio primarily through licensing, acquisitions,

patent applications and commercial partnerships. Its current portfolio includes an exclusive global licence from Curtin University for patented lupin protein technology and associated know-how, patent and trademark assets acquired through Prolupin GmbH, the Buntine Protein® brand and a patent application covering a novel lupin protein milk formulation.

IP and security: WOA protects its IP and sensitive information through a combination of registered rights, contractual safeguards and internal governance controls. Its protection strategy includes patents, patent applications, trademarks, copyright, exclusive licensing arrangements and the retention of proprietary recipes, technical processes and know-how. The company's Code of Conduct requires confidential and commercially sensitive information to be disclosed only to authorised personal, while its governance and whistleblower policies contain confidentiality provisions for protected information and investigations. Public risk disclosures also indicate that it uses specialist IT support, current antivirus software, data backups and two-factor authentication, alongside requirements for sensitive physical materials to be stored securely when unattended.

FATTORIA SOLIDALE DEL CIRCEO COOPERATIVA SOCIALE DI PRODUZIONE E LAVORO (FSDC)

Internal processes: FSDC is a social agricultural cooperative whose principal activities concern organic crop production, product transformation, vocational training and the employment inclusion of disadvantaged people. It also participates in collaborative research and innovation initiatives, including EU and regional projects, where ownership, access rights, confidentiality, publication and exploitation of project results are governed through consortium agreements and project-specific contractual arrangements. FSDC's IP management therefore is integrated into its general management and project coordination activities, with its principal exploitable assets consisting of agricultural know-how, cultivation practices, product-processing experience, training methodologies and project-generated knowledge rather than a publicly documented portfolio of patents or registered technologies.

IP and security: FSDC's protection approach mainly relies on confidentiality, contractual controls and the controlled dissemination of operational and project information. In collaborative projects, sensitive data, technical knowledge and jointly generated results would ordinarily be safeguarded through consortium-level provisions defining permitted access, disclosure, publication and future exploitation. Its website and communication materials are also subject to copyright, while commercially relevant cultivation, processing and organisational knowledge are retained as confidential know-how. The cooperative holds recognised quality and organic-production credentials, including an ISO 9001-related certification for training activities and Bioagricert organic producer certification, which indicate the use of documented procedures and controlled records in relevant operational areas.

TEALDI ROBERTO (APT)

Internal processes: APT operates with a lean and flexible organisational structure, where intellectual property management is not formalised through dedicated departments or procedures. Instead, IP-related aspects are handled in an ad hoc and practice-oriented manner, aligned with the company's focus on production and product development. While there are currently no formal systems for recording, disclosing, or prioritising IP, this streamlined approach allows APT to remain agile and responsive to market needs. Their experience in commercialising products indicates practical know-how in bringing innovations to market, even without a structured internal IP framework.

IP and security: APT's approach to IP protection reflects its business model and market context, where product formulations (e.g. recipes) are not typically protected through formal IP mechanisms. The organisation relies on internal awareness of confidentiality among employees rather than formalised

security procedures. While structured IP protection measures and formal agreements with third parties are not systematically applied, APT has practical experience in commercial activities and demonstrates an operational focus on delivering products to the market. Overall, APT shows a pragmatic approach to IP, with potential to strengthen formal IP and security practices in the future should strategic needs evolve.

KERRY GROUP SERVICES INTERNATIONAL LIMITED (KERRY)

Internal processes: Kerry has a highly developed and comprehensive approach to intellectual property management, supported by a dedicated IP/legal department and specialised personnel handling IP-related matters. The organisation operates under well-defined in-house policies and procedures governing the creation, maintenance, and enforcement of intellectual property rights. It has established processes for recording and disclosing new inventions and maintains a detailed register of its IP assets. Overall, Kerry demonstrates a very high level of organisational maturity and strategic capability in managing intellectual property, fully aligned with its innovation-driven business model.

IP and security: Kerry implements robust and well-structured IP protection and security measures. These include safeguards against unauthorised disclosure, strong employee awareness and training on confidential information, formal mechanisms for reporting IP misappropriation, and systematic use of non-disclosure agreements with third parties. The organisation utilises a broad spectrum of IP protection mechanisms, including patents, trademarks, industrial designs, copyrights, and trade secrets, and has experience in collaborative IP development and integration of third-party technologies. With top scores across all indicators related to IP awareness and strategic importance, Kerry demonstrates an exemplary and highly proactive approach to safeguarding and leveraging intellectual property.

7. Sustainability Plan

The VALPRO Path Sustainability Plan was developed throughout the project and consolidated through the systematic identification, assessment and prioritisation of the project's commercial and non-commercial results. This process included mapping KERs, clarifying IP ownership, identifying target beneficiaries and assessing the replicability and scalability of the collaborative business models established across the five IPSs. These activities established a structured foundation for the continued uptake of project results by farmers, food-industry actors, researchers, advisors, policymakers and consumers.

The transition phase: During the transition phase between M48 and M52, the Sustainability Plan functions as a practical transition mechanism moving project results from validation to sustained application. This phase includes the final validation of ownership and access arrangements, specifically formalising Joint Ownership Agreements for collaboratively produced results. The consortium will confirm the responsibilities of specific partners involved in maintaining and updating each result after the formal project period.

- **VALPRO Path solution portfolio**: Flagship digital tools, such as the ML-Based Yield Prediction Tool and the API-based Digital Traceability Tool, will be sustained through a flexible, subscription-based access model integrated into the growing Farming-as-a-Service (FaaS) market.
- **Value chain business modelling:** This methodology will continue to generate value through consultancy and advisory assignments delivered to farmers, cooperatives, and plant-based food companies.

- **Open access and public goods**: Non-commercial results, such as the Harmonised LCA & LCSA Framework and open datasets, will remain freely available to support sector-wide impact, adhering to the *"as open as possible, as closed as necessary"* principle. Associated customisation and implementation services by partners will generate income to finance their continued maintenance.

Institutional sustainability and target beneficiaries: Institutional sustainability will be secured by embedding VALPRO Path results within the ongoing research, advisory, commercial, technological and stakeholder-engagement activities of the consortium partners. Sustainability will be achieved through a distributed model in which partners continue using, maintaining, adapting and promoting the results that correspond to their institutional mandates, technical capacities and exploitation interests. This approach reflects the multi-actor character of VALPRO Path, in which farmers, processors, technology providers, researchers, advisors and food manufacturers jointly contribute to value creation across plant-protein value chains.

Research, academic and advisory institutions: TEAGASC, AU, UNITO, NTUA, ZALF, CSIC and WU will integrate validated agronomic practices, analytical methods, processing protocols, sustainability assessment approaches, datasets and decision-support methodologies into future research projects, scientific publications, education, demonstration activities and knowledge-transfer programmes. **TEAGASC** is well positioned to incorporate intercropping recommendations, nutrient-tracking approaches and related digital tools into its advisory infrastructure, demonstration farms and FaaS activities. **AU, CSIC, ZALF, NTUA, UNITO** and **WU** will support further scientific validation, methodological development and application of the results to additional crops, regions and food products. Their institutional research and IP-management capacities will also support the responsible protection, dissemination and further development of jointly generated knowledge.
Agricultural, farmer and stakeholder networks: CONFAGRICOLTURA and FSDC will support continued engagement with farmers, cooperatives, rural enterprises and regional value-chain actors. **CONFAGRICOLTURA** will facilitate the dissemination and replication of validated practices through its agricultural and industry networks. **FSDC** will contribute practical farming and social-enterprise perspectives and support the local demonstration and replication of short, inclusive and sustainable plant-protein value chains. These organisations are particularly important for reaching farmers, cooperatives, advisors and local communities.

Digital agriculture and technology providers: AGRICOLUS and FARMB will support the continued technical development, maintenance, integration and deployment of the project's digital agriculture and sustainability solutions. **AGRICOLUS** will integrate validated agronomic data, crop-monitoring approaches and lodging and field-assessment methods into its digital agricultural services, supporting farmers and advisors with data-driven crop-management recommendations. **FarmB** will be positioned to maintain and expand digital traceability, automated carbon-footprint assessment and MRV-related applications, including their integration into farm-management, carbon-accounting and sustainability-reporting services. Both partners will support replication through software maintenance, platform integration, user onboarding, technical assistance, data services, subscriptions, licensing and customised implementation for farms, cooperatives, processors and agri-food companies.

Seed, crop and ingredient innovation partners: BEOTANICS, MTL, MP and WOA will contribute to the continued development and commercial uptake of crop genetics, processing technologies and plant-protein ingredients. **BEOTANICS** will be central to the further validation, protection and licensing of regionally adapted peanut genetics and to the establishment of European peanut supply chains. **MTL and MP** can continue testing, optimising and transferring processing, fractionation and ingredient-production approaches developed within the project. Target beneficiaries include seed companies, farmers, cooperatives, millers, ingredient manufacturers and regional processors.

Food manufacturers and market-oriented SMEs: PEPSICO, KERRY, APT and FSDC will support the transition of validated ingredients, formulations and product concepts into industrial or commercial applications. **PEPSICO and KERRY** may further assess the integration of nutrient tracking, eco-nutritional labelling, sustainable sourcing and plant-protein ingredients within product-development and corporate sustainability activities. **APT** will continue producing, testing and marketing value-added legume-based pasta and related artisan products, while **FSDC** will apply the results in locally embedded food-production and short-supply-chain models. These partners will provide routes to market and practical feedback from food manufacturing, product formulation, retail, HORECA and consumer-facing applications.

Business modelling, exploitation and innovation-support organisations: FSH will maintain and further apply the VALPRO Path Collaborative Business Modelling methodology through consultancy, training, mentoring and follow-on EU-funded projects. **FSH** will also support partners in refining exploitation strategies, ownership arrangements, funding pathways and collaborative business models after the project.

This distributed institutional model ensures that every consortium partner contributes according to its core capacity. In this way, the sustainability of VALPRO Path will be rooted in the regular operations and strategic interests of the consortium rather than being dependent on continued project funding.

Financial sustainability: To support the financial sustainability of VALPRO Path results, two dedicated **funding-opportunities webinars** were organised for consortium partners in M41 and M46. The first session provided a broad overview for industry, academic and research organisations, covering public and private funding sources at EU, national and regional levels and explaining how funding needs should be matched with the maturity and intended exploitation pathway of each result. It addressed opportunities for continued research, technical development, piloting, demonstration, farm-level uptake and commercial readiness, including Horizon Europe, the European Innovation Council, CBE JU, CAP and EIP-AGRI instruments, as well as thematic partnerships and national or regional programmes. The second webinar focused more specifically on industry and market-oriented alternative-protein innovations. It guided partners in selecting suitable instruments according to whether they require collaborative R&D, pilot and demonstration funding, rapid validation, farm-level deployment, protection of intellectual property or larger scale-up investment. The session covered grants, subsidies, loans, guarantees, equity and prizes, and presented relevant routes such as Horizon Europe, CBE JU, Eurostars, LIFE, EIC instruments and InvestEU. The webinars helped partners identify potential follow-up funding, understand eligibility and co-financing requirements and begin aligning individual and joint exploitation plans with realistic post-project financing opportunities.

The most viable approach for VALPRO Path is a **blended financial model** combining follow-on public funding with income generated through the exploitation of commercially mature results. Public funding should be used to reduce the remaining technical, demonstration and adoption risks, while longer-term continuity will rely on subscriptions and enterprise licences for digital tools, advisory and consultancy fees, technology-transfer and licensing agreements, customised sustainability assessments, ingredient and product sales, supply contracts and co-development services. This combination reduces dependence on a single funding source and allows each result to move progressively from project-supported development towards institutional or market-based sustainability.

Replicability and scalability: The VALPRO Path results have strong replication potential because they were developed and validated across different intervention points of the plant-protein value chain, including crop production, processing, storage, digital monitoring, sustainability assessment and food-product development. **Agronomic practices and business models** can be adapted to new crops, farming systems and pedo-climatic regions through local trials, advisory support and demonstration

activities. **Modular processing and storage solutions** can be transferred to other cooperatives, rural SMEs and regional processors by adapting equipment capacity, raw materials and operational protocols. **Digital tools, datasets and assessment frameworks** are particularly scalable because they can be expanded to additional users, crops and value chains through new datasets, software modules and platform integration. **Product formulations and ingredient-processing protocols** can also be replicated by other manufacturers through technical specifications, standard operating procedures, licensing and co-development. Scalability will depend on preserving the core validated methodology while allowing technical, regulatory, market and organisational adaptation to each new regional or commercial context.

Through the combined application of these financial, institutional, technical and collaborative approaches, the Sustainability Plan will successfully transition VALPRO Path results into lasting economic, environmental and societal impacts across the European plant-protein sector.

Conclusion

The publication of D5.4 Exploitation, IPR and Business Models Catalogue II marks the successful culmination of the exploitation, IP and business modelling activities conducted over the period of 48-months of the VALPRO Path project. Building upon the foundational framework established in the first iteration (D5.3), this final catalogue serves as the definitive roadmap for the commercialisation, management and long-term sustainability of the project's commercial and non-commercial results with significant exploitation potential outlined in individual and joint exploitation plans.

The exploitation plans clarify how individual and joint results can be taken forward by the responsible partners, while the IP assessment provides an appropriate balance between protection of commercially sensitive assets and wider access to knowledge-oriented results. The Sustainability Plan further anchors continuation in partners' regular activities, follow-on cooperation, additional funding and market-based exploitation where relevant.

Overall, VALPRO Path has established credible pathways for the continued use, adaptation and replication of its results beyond the project. The deliverable therefore provides partners with a practical basis for maintaining project outcomes and supporting their longer-term contribution to more resilient, sustainable and value-generating European plant-protein value chains.

Annex 1. IPS1.2 Business Case Report

VALPRO path.

NEW VALUE LANDSCAPES FOR PLANT PROTEIN PATHWAYS

IPS1.2 Business Case Report

Developing the Peanut Industry in Europe

valpropath.eu

Co-funded by the European Union

1. Developing the Peanut Industry in Europe (IPS1)

Business opportunity hypothesis
If proven peanut varieties are successfully cultivated across EU regions and supported by established waste and by-product value chains, the European peanut industry can expand to create additional value for farmers and local processors.

IPS	**IPS1 -** Realising the potential of on-farm technology and processing to deliver added value
Business-case focus	**B2B and B2C:** Empowering farmers to process premium locally grown peanuts and valorise agricultural side streams directly on the farms.
Lead geography	Europe
Target crops/ materials	European-grown peanut varieties Side streams (shells, skins and pressed cake)
Technology solution	IP-protected, climate-resilient peanut varieties seeds with on-farm processing equipment.
Expected outcome	Establishment of a sustainable, zero-waste European peanut value chain that creates multiple high-value revenue streams.

The business case focuses on the commercialisation of peanut seed from IP-protected genetics and the development of localised supply chains targeting various added-value propositions. The core business model, driven by **Beotanics**, relies on ***identifying agronomically adapted, IP-protected genetics, licensing them to farmers, providing technical production support and identifying viable supply chain opportunities.*** The successful development of peanut varieties adapted to EU regions, combined with validated waste and side-stream value chains, can support the establishment of a sustainable European peanut-growing industry that creates significant added value for local farmers and processors.

The innovation is an integrated genetic adaptation and decentralised processing system built around climate-resilient, high-protein European peanut varieties, coupled with small-scale, modular on-farm processing steps, such as de-vining, shelling, roasting and oil pressing, alongside the circular valorisation of agricultural side streams from shells, skins and press cake.

Commercial logic is strongest across both B2B and B2C supply chain models for farmers, regional processors, ingredient manufacturers and artisan food brands. The value comes from **shortening the supply chain** and **empowering primary producers**: farmers gain a validated pathway to capture maximum added value directly on the farm without relying solely on large industrial buyers, while processors and consumers gain access to a traceable, premium and locally sourced European peanut alternative that reduces reliance on imported commodities and enables clean-label, high-protein and lower-carbon product positioning.

1.1. Problem Statement

Peanuts present a unique opportunity as a highly resilient protein crop that is both drought-tolerant and nutrient-deficient-tolerant. Furthermore, as a nitrogen-fixing rotation crop, peanuts support diverse and sustainable farming systems. Currently, Europe lacks a structured, commercial-scale framework for peanut production, rendering the market highly dependent on imported raw materials. **Over 90% of European peanut demand is met through imports from non-European producers, leaving the massive potential for domestic cultivation largely underexploited.** This heavy reliance on imports exposes European processors to several challenges, including difficulties in securing consistent, controlled and specific seed sources that comply with EU ethical and regulatory codes. At the primary production level, European farmers face significant barriers due to a lack of agronomic

knowledge, limited technical transfer and a lack of established climate- and disease-resilient varieties suited to European climatic regions, ultimately leading to low yields. Furthermore, the current supply chain model lacks established solutions for fully valorising and processing waste and side streams, meaning producers do not take full advantage of potential secondary revenue opportunities.

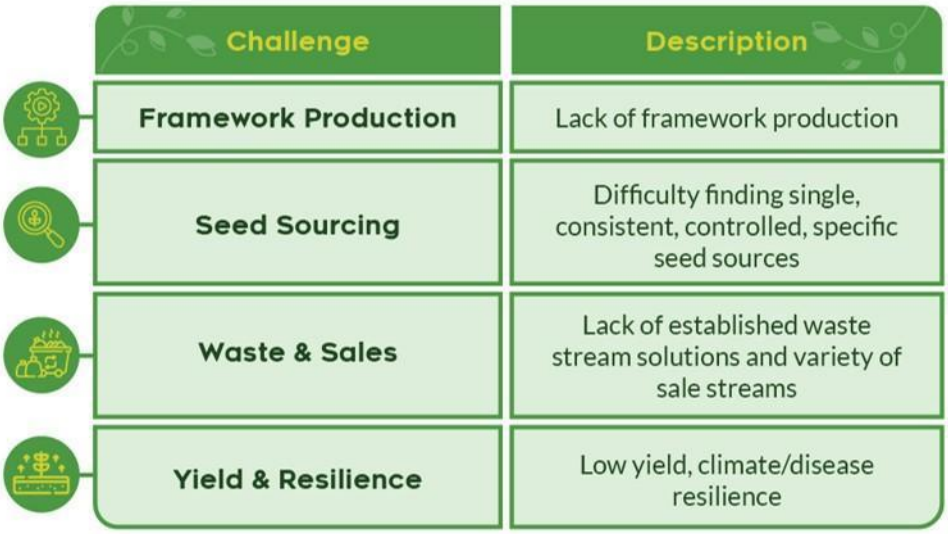


Figure 2 Peanut production challenges in Europe

To bridge this gap, there is a critical need to establish a sustainable, localised European peanut industry that shortens the supply chain and shifts processing power back to the farm. By introducing IP-protected, region-suited peanut genetics and implementing decentralised, small-scale on-farm processing technologies (such as shelling, roasting and oil pressing), European producers can independently transform raw crops into premium ingredients. This transition provides processors with a consistent, traceable and EU-compliant local supply, satisfies the growing consumer demand for sustainable, locally sourced peanuts, and enables the circular valorisation of by-products into eco-packaging and animal feed

1.2. Objectives of IPS1.2 Business Case

The IPS1.2 business case aims to establish foundations for a sustainable and commercially viable European peanut industry that reduces dependence on imports and maximises value creation for farmers. It provides integrated approaches to germplasm development and cultivation systems, and focuses on commercialising IP-protected, climate-resilient peanut varieties adapted to European growing conditions, providing reliable, traceable and regionally suitable planting material.

The business case also aims to establish a compliant European peanut supply chain aligned with EU regulatory requirements for agricultural production and minority crops. This provides processors and consumers with a consistent, traceable and sustainable source of European-grown peanuts while reducing exposure to import-related risks. Another objective is to support short supply chains and localised processing models that retain value within producing regions. This includes the use of decentralised and modular technologies and other on-farm processing solutions.

IPS1.2 further seeks to maximise the use of both primary peanut products and side streams. It targets at least two to three profitable revenue streams per production area, including peanut butter, peanut oil and peanut beverage and products derived from processing residues. Side streams such as shells, skins, vines, and other residues are assessed for applications including feed, bio-based products, soil amendments and other circular economy uses.

The business case aims to demonstrate the nutritional quality and market competitiveness of European-grown peanuts by validating protein, nutritional and fatty-acid profiles that meet processor and consumer requirements. For the model to be viable, the supply chain must remain compliant and traceable, processing technologies must be feasible on a small or regional scale and the selected varieties must consistently deliver quality profiles capable of competing with imported commodity peanuts.

To be commercially and technically viable, these goals must be met within several specific operational constraints. A core requirement is that the entire supply chain must strictly abide by EU ethical and regulatory codes regarding minority crops to provide processors with a consistent, compliant and traceable source. Additionally, the proposed solutions rely heavily on the feasibility of using small-scale, modular and decentralised on-farm processing technologies rather than requiring massive new centralised industrial facilities. Finally, the cultivated peanut varieties must consistently deliver specific nutritional and fat profiles that can compete with or outperform standard commodity imports, and the system must successfully implement low-input valorisation of waste materials to ensure the model is economically sustainable and viable for producers.

Characteristic	Description
Regulatory Environment	EU production environment
Minority Crops	EU regulations for minority crops
Regional Suitability	Varieties suited to different regions
Source	Single variety sources
Nutritional Profile	Specific nutrition and fat profiles
Farmer/Processor Value	Maximising value through local sources
Waste Valorisation	Valorisation of waste and side streams
Climate Resilience	Continuous improvement programmes
Infrastructure	Processing infrastructure investments

1.3. Market Analysis

The market analysis focuses on the development of the European peanut concept: a locally produced European peanut positioned as a sustainable alternative to imported peanuts, with the ambition to deliver higher nutritional value, a shorter supply chain and greater added value for European producers and processors. Emphasis is placed on assessing the market potential of peanuts in Europe, both in terms of primary production and in relation to processing and the development of higher-value products.

The analysis specifically examines market opportunities for peanuts in segments showing growing demand, including plant-based and protein-rich products aimed at health-conscious consumers. These include whole and processed peanuts, peanut butters and spreads, peanut protein powder as an alternative for dairy-free products and sports nutrition and peanut flour as a gluten-free, high-protein ingredient for the food industry.

Special attention is given to the market potential of products such as peanut butter and peanut oil, alongside consideration of the organic positioning of European peanuts. In addition, the analysis considers the potential valorisation of by-products and processing residues as an important component of a future circular and economically sustainable business model.

1. The European peanut as a raw material

The European peanut market, viewed as a source of raw material and as a basic food product, is large, well-developed and highly dependent on imports. Europe, considered as the EU-27, the UK and EFTA, does not commercially produce peanuts at a scale capable of meeting market demand, which is why it represents a significant import market.

Between 2018 and 2022, European peanut imports grew at an average annual rate of 2.6% by volume[2], while the total value of the import market rose to around €2.15 billion, with volume reaching approximately 1.24 million tonnes in 2022. The largest share of this trade consists of shelled, unprocessed peanuts, indicating that raw peanuts continue to serve as the key input for European processing, snack production and further positioning along the food value chain.

Where is demand and consumption the highest in Europe?

When the market is viewed through an apparent consumption approach, by looking at the difference between imports and exports, Germany, the United Kingdom and the Netherlands remain the three most important peanut markets in Europe.

The Netherlands primarily serves as Europe's main entry and distribution hub, while Germany and the UK represent the largest peanut consumer markets with around 164,000 and 137,000 tonnes of imports, respectively, in 2022.[3] CBI reports that in 2022, the Netherlands imported around 383,000 tonnes of peanuts, of which as much as 63% was subsequently re-exported to other European markets. France and Poland stand out as growing markets, with imports of around 101,000 and 93,000 tonnes, while Spain shows a strong combination of direct imports and a well-developed food industry.

Consumer profile and the main uses. In the European market, peanuts are predominantly used as a snack product and as a raw material for the food industry. Around 60–70%[4] of imported peanut kernels in Europe end up in the snack segment, primarily as roasted and salted peanuts. At the same time, demand is also growing for less processed variants, such as unsalted, dry-roasted and raw products, as consumers increasingly perceive them as a healthier alternative to conventional salty snacks.

In addition to direct consumption, peanuts are also used as an ingredient in the confectionery industry, bakery products, protein and snack bars, desserts, butters and spreads, as well as in home food preparation. Consumer profiles are not identical across all countries, but several patterns clearly recur:

- In the Netherlands, demand growth is driven by healthy snacking, convenient packaging and increasing interest in plant-based diets, while peanut butter represents a particularly well-developed subcategory.
- In Germany, important factors include price sensitivity, the dominance of private-label products and growing interest among younger consumers in vegan, plant-based and healthier snacking products.
- In the UK, peanuts also benefit from demand linked to ethnic cuisines and peanut-based products.

[2] What makes Europe an interesting market for groundnuts - https://www.cbi.eu/market-information/processed-fruit-vegetables-edible-nuts/groundnuts/market-potential

[3] CBI. (2023). *The European market potential for groundnuts*. Centre for the Promotion of Imports from developing countries. https://www.cbi.eu/market-information/processed-fruit-vegetables-edible-nuts/groundnuts/market-potential

[4] How is the end-market segmented - https://www.cbi.eu/sites/default/files/pdf/research/1260.pdf

- In France, growth is visible through the snack segment and rising peanut butter consumption, which has tripled over the last ten years to around 14,000 tonnes annually.[5]

It is important to emphasise that the market for raw and minimally processed peanuts in Europe is already shaped by consumer trends that are directly relevant to the concept of this IPS: growing interest in plant proteins, nutrient-rich snack products, more natural and less processed foods and products that can be positioned within the wellness, plant-based and clean-label narrative.

Demand trends and forecast. Regarding future demand, available sources indicate moderate but steady growth in the European peanut market. It is estimated that in the period from 2024 to 2026[6], the European market could grow by around 2% annually in volume and around 5% annually in value[7], provided that inflationary pressures remain under control. At the same time, publicly available and methodologically transparent projections for the European peanut market beyond 2026 remain limited. Long-term demand, however, is expected to be supported by expanding categories such as snacks, vegan products, natural/raw foods and broader consumer interest in functional and protein-rich products. In addition, when other nut categories become more expensive, some consumers shift toward peanuts as a more affordable alternative, which further supports demand.

Case studies

Across Europe and the wider European market, peanut cultivation is no longer limited to trials. Bulgaria, Spain, France, Italy, Portugal's Azores and Turkey all show evidence of domestic peanut cultivation, with several named companies or organised supply chains commercialising peanut seeds, roasted peanuts, peanut snacks, or peanut-based products.

Sadovo region domestic peanut varieties[8]: Bulgaria has a deeply rooted history in peanut research and commercial farming, centred around the Sadovo region in Southern Bulgaria. Bulgaria has developed its own registered domestic peanut varieties, including Kremena and Kalina. They are Valencia-type peanuts, which usually have three to four small, sweet kernels per pod and bright red skins. Bulgarian peanuts are highly valued in the EU because the local climate and farming practices produce crop yields virtually free of aflatoxin. Bulgarian peanut production is sought on the European market. Sadovo peanut seed production is largely sold outside Bulgaria, with markets including Italy, Spain, Portugal, Austria and Germany. In addition, brands like Detelina's and Rois (prominent Bulgarian snack companies) utilise domestic crops for their premium lines of blanched, oven-baked and flavoured snacking peanuts. Because Valencia peanuts are naturally sweet, Bulgarian-grown peanuts are frequently processed into high-quality nut pastes and confectionery fillings for regional European bakeries.[9]

[5] CBI. (2023). The European market potential for groundnuts. Centre for the Promotion of Imports from developing countries. https://www.cbi.eu/market-information/processed-fruit-vegetables-edible-nuts/groundnuts/market-potential

[6] The European market potential for groundnuts – https://www.cbi.eu/sites/default/files/pdf/research/1245.pdf

[7] What makes Europe an interesting market for groundnuts? – https://www.cbi.eu/sites/default/files/pdf/research/1245.pdf

[8] International Journal of Environment, Agriculture, and Biotechnology. (2018). *Assessment of Productive Potential of Peanut Varieties (Arachis hypogaea L.) from the Bulgarian Breeding Program and Opportunities for Genetical Improvement* https://ijeab.com/detail/assessment-of-productive-potential-of-peanut-varieties-arachis-hypogaea-l-from-the-bulgarian-breeding-program-and-opportunities-for-genetical-improvement/

[9] Common Agricultural Policy Science talks. (2022) Innovations in peanuts demonstrated by the Institute of Plant Genetic Resources "K. Malkov" – Sadovo https://cap.europe.bg/bg/category/1/node/2

Valencia region peanut production: Peanut production is officially recorded but on a very small scale, with 17 tonnes produced across 7 hectares in 2022, primarily in the Valencia region. Spain's Ministry of Agriculture table records 17 tonnes of peanuts on 7 hectares in 2022, including production in Valencia. Ca Climent's official site says it cultivates traditional Valencian peanut varieties and sells them locally/nationally; Cadena SER reports Ca Climent cultivates, roasts, packages and sells Valencian peanuts directly.[10]

Azores region peanut production: There are modern examples of peanut cultivation, and the Azores region possesses a highly valued domestic variety known as "amendoim do nosso". Agroportal/Voz do Campo reports that peanut production in São Miguel has traditional importance, that producers still cultivate and sell the crop, and that residual production is sold while still in the field. A 2025 MDPI agronomy paper identifies the local landrace "amendoim do nosso", purchased locally and used by local producers. Terra Verde lists a São Miguel producer whose crops include peanuts.[11]

Menguy's launched a French peanut supply chain with co-op Ocealia: France has recently shifted from the trial phase toward early commercial production, introducing the first "100% French peanuts" with plans for further expansion through contract farming. Menguy's launched a French peanut supply chain with Co-op Océalia in 2025, using five farmers over about 10 hectares, with roasting at Menguy's workshops. Agro-media and RIA report the first harvest in October 2025 and commercialisation of 100% French peanuts from early 2026.[12]

Italian peanut supply chain: Alongside Spain and Portugal, Italy has been conducting viable trials for locally produced, organic EU peanuts. Certified Italian peanut supply chain involving SIS, Bonifiche Ferraresi, Noberasco, and Coldiretti, with cultivation contracts, initial hectares in production and commercialisation as 100% Italia. Gambero Rosso reports expansion to about 100 hectares and products sold through Coop Italia. Noberasco-related reporting also describes 100% Italian peanut products, including peanut butter/spreads.[13]

Osmaniye region peanut production: Turkey has a very well-developed peanut sector. The Osmaniye region is particularly notable, producing a geographically protected product ("Osmaniye Yer Fıstığı") that was officially recognised at the EU level in 2024. Osmaniye Yer Fıstığı received EU PDO status in 2024. TÜRKPATENT also confirms EU registration. DOĞAKA reports more than 300 Osmaniye businesses that process and market peanuts, including branded packaged products.[14]

2. Peanut processed products in Europe

Among processed peanut products, the strongest interest in this IPS lies in peanut butter, peanut oil and peanut based beverages. More detailed breakdowns for each of these is presented in the following sections.

[10] SER (2025). Ana Climent, awarded by the Ministry of Agriculture for recovering the Valencian peanut https://cadenaser.com/comunitat-valenciana/2025/10/14/ana-climent-premiada-por-el-ministerio-de-agricultura-por-recuperar-el-cacahuete-valenciano-radio-xativa/

[11] MDPI (2025) Effect of Row Spacing in the Period Prior to Weed Interference in Peanut Cultivation Under Azorean Conditions https://www.mdpi.com/2673-7655/5/5/59

[12] Menguy's (2026) The Peanut Industry https://www.menguys.fr/filiere/la-filiere-cacahuete/

[13] Terra e Vita (2020) The Italian peanut supply chain is born. Four actors, all Oscar-winning, take the stage. https://terraevita.edagricole.it/economia/arachide-filiera-italiana/

[14] Delegation of the European Union to Türkiye (2024) First EU-Registered Peanut from Türkiye https://www.eeas.europa.eu/delegations/t%C3%BCrkiye/first-eu-registered-peanut-t%C3%BCrkiye_en

Peanut butter market overview. Peanut butter is currently the most mature and best-documented category among peanut-based products in Europe. European imports of peanut butter increased from 42,000 tonnes in 2018 to 60,000 tonnes in 2022, representing an average annual growth rate of 9.4%[15]. The most important European hub is the Netherlands, which exported around 44,000 tonnes of peanut butter to European buyers in 2022. In France, peanut butter consumption has risen to around 14,000 tonnes per year, which is approximately three times higher than ten years ago.

This indicates that peanut butter is already a well-developed category in Europe, with clearly established centres of consumption, processing and distribution. The European peanut butter market is expected to remain one of the most attractive and stable categories for peanut-based products, reaching approximately US$2.27 billion by 2028.[16]

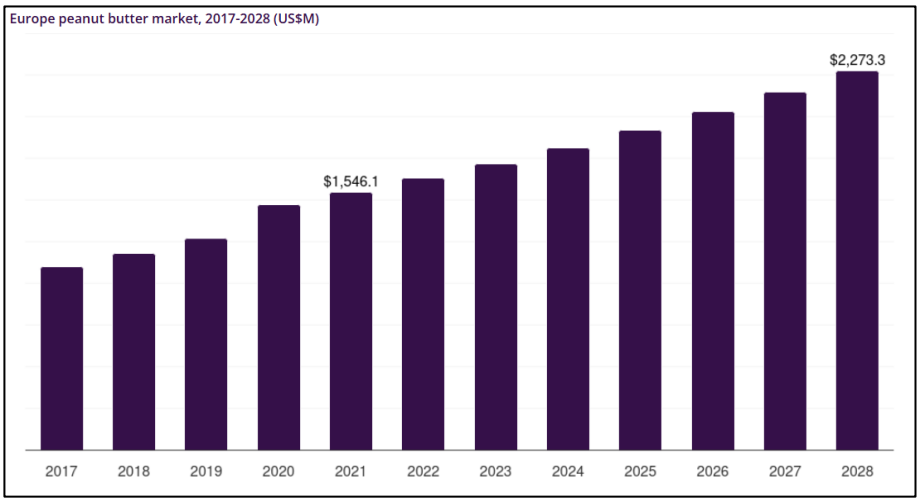


Figure 4 Europe peanut butter market, 2017-2028 (US$M)

Key market drivers. The main growth drivers of this category are rising demand for plant-based proteins and healthier snack options, product convenience and growing consumer interest in natural/ no added sugar/ clean-label formulations. Growth in peanut butter consumption in France has been linked to the broader trend of increasing interest in plant proteins. At the same time, leading peanut butter brands on the market position the product as a source of protein, fibre and "good fats. An additional driver is the product's versatility, as it can be used as a spread, in breakfast foods, smoothies, bakery products and functional nutrition.

Market challenges

- **Allergen labelling**[17,18]. Peanuts are among the allergens subject to mandatory declaration under European consumer information rules, which means that peanut butter faces a higher regulatory burden and potentially a narrower target group than some other plant-based alternatives.

[15] What makes Europe an interesting market for groundnuts? – https://www.cbi.eu/sites/default/files/pdf/research/1245.pdf

[16] Europe Peanut Butter Market Size & Outlook, 2021-2028 - https://www.grandviewresearch.com/horizon/outlook/peanut-butter-market/europe

[17] List of the 14 most common food allergens (2025) https://www.eufic.org/en/healthy-living/article/list-of-the-14-most-common-food-allergens

[18] Regulation (EU) No 1169/2011 of the European Parliament and of the Council https://www.legislation.gov.uk/eur/2011/1169/annex/II

- **Raw material safety,** due to the high risk of aflatoxin contamination associated with groundnuts, peanut butter and peanut paste.
- **Dependence on imported raw materials,** with supply heavily reliant on external sources, particularly from Argentina and the United States.

Market segmentation

- **By formulation** – smooth/creamy and crunchy, while commercial market reports also distinguish organic, flavoured and unsweetened variants.
- **By positioning** – mainstream/private-label products and premium/natural/artisanal offerings.
- **By channel** – supermarkets and retail remain the key channels, but vendor reports indicate that the online channel is growing faster than average, particularly among urban and health-oriented consumers.

Competitive landscape. This is not an empty market. Competition already exists at multiple levels.

- In the Netherlands, strong manufacturers and processors play an important role: Bredabest[19] positions itself as one of Europe's leading processors of peanut butter and peanut ingredients, while Calvé[20] It is a very strong domestic brand and presents itself on its official website as the favourite peanut butter in the Netherlands.
- In France, Nut Expert[21] is a relevant player, clearly positioned as a French producer of palm-oil-free peanut paste and peanut butter.
- In the UK, the most visible brands include Whole Earth[22] and Sun-Pat[23], while according to *The Times*, Pip & Nut[24] became the best-selling nut butter brand in the UK in 2025.

Indirect competition. Peanut butter does not compete only between peanut butter brands, but also with the broader category of nut-based spreads, as well as with conventional sweet spreads and other options.

- The nut-based spread market includes almond, hazelnut, cashew, walnut and mixed-nut spreads within the same competitive field.
- At the level of broader sweet spread consumption, peanut butter shares shelf space and consumer attention with jams, honey and other spreadable products.

For the European peanut concept, this is important because it shows that while peanut butter is a strong category, it is not the only option consumers consider.

Barriers to market entry. Barriers to market entry include mandatory allergen labelling requirements for peanut-based products and the need for strict aflatoxin monitoring and control throughout the supply chain. In addition, any new market entrant must establish a clear point of differentiation from existing products, for example through European or regional origin, superior nutritional characteristics, clean-label formulation, organic certification, or a distinctive craft and premium positioning.

[19] Breadabest https://www.bredabest.com/

[20] Calvé https://www.unilever.nl/brands/foods/calve/

[21] Nut Expert https://nut-expert.eu/en/our-products/

[22] Whole Earth https://www.wholeearthfoods.com/

[23] Sun-Pat https://www.sunpat.co.uk/

[24] Pip&Nut https://www.pipandnut.com/

Key takeaways. Peanut butter is currently the most strongly validated European peanut-based product category. The market already exists, it is growing, it has established processors, strong brands and clear core countries, above all, the Netherlands, the UK, France and Germany. At the same time, the category remains dependent on imported raw materials and is highly competitive, meaning that room for new entry does not lie in a generic product, but in a differentiated value proposition. For the European peanut concept, peanut butter appears to be a highly logical application, particularly if positioned through local origin, raw material quality, nutritional value, clean label, organic credentials and a premium story.

3. Peanut-based beverages market overview

As a distinct category, peanut-based drinks in Europe still represent an early and a relatively narrow niche, but they are developing within the much larger and growing plant-based drinks market. It is estimated that the European plant-based drinks market was worth around US$4.54 billion in 2024 and could grow at around 7.1% annually until 2030, with Germany identified as the market with the highest expected growth[25,26].

- In Spain[27], nearly 10% of all milk sold in 2024 was plant-based, and almost half of households purchased plant-based beverages at least once during the year.
- In Germany[28]37% of households bought plant-based beverages at least once in 2024, while in at UK that share stood at 31.8%.
- In France, the plant-based drinks category was the largest plant-based category by value, accounting for 42% of total plant-based sales in 2024[29].

This shows that the European market already has a well-developed consumer base for alternative drinks, even though peanut-based drinks are not yet among the dominant bases such as oat, almond or soy. Peanut-based drinks also offer additional differentiation potential – peanuts can be positioned through higher protein content, a creamier texture and broader usage scenarios as a beverage, a smoothie ingredient, a cooking ingredient or a functional product.

[25] Europe Plant-based Milk Market Size & Outlook, 2025-2030 - https://www.grandviewresearch.com/horizon/outlook/plant-based-milk-market/europe

[26] Plant-based retail sales in six European countries, 2022 to 2024 - https://gfieurope.org/european-plant-based-sales-data/

[27] Plant-based retail sales in six European countries, 2022 to 2024 - https://gfieurope.org/european-plant-based-sales-data/#spain

[28] Plant-based retail sales in six European countries, 2022 to 2024 - https://gfieurope.org/european-plant-based-sales-data/#germany

[29] France plant-based food retail market insights - https://gfieurope.org/wp-content/uploads/2025/06/France-plant-based-food-retail-market-insights-2022-2024.pdf?

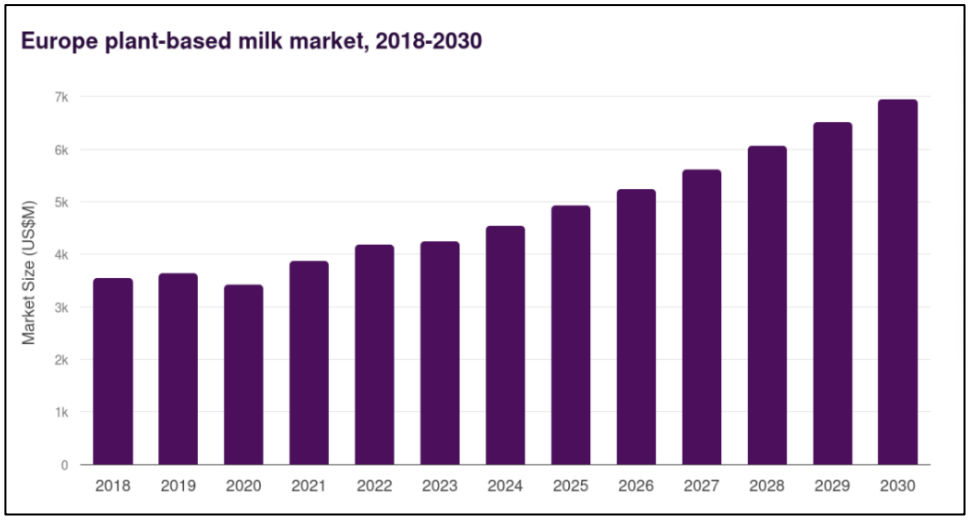


Figure 5 Europe plant-based drinks market, 2018-2030

Key market drivers. Rising demand for dairy alternatives, growing interest in health and wellness, consumption among flexitarians and demand for products that suit consumers with lactose intolerance or those seeking to reduce dairy intake, as well as broader concerns related to health, sustainability and animal welfare.

Market challenges. The biggest challenge is that peanut-based drinks are not entering a space, but rather a category already strongly shaped by several dominant bases. In Europe, almond-based drinks were the largest segment by revenue in 2024, while oat-based drinks are expected to be the fastest-growing segment in the coming years. A second major challenge concerns price, value perception and consumer habits. The average price per litre of plant-based beverages increased by 9%[30] between January 2022 and April 2024, and plant-based drinks were on average around two-thirds more expensive than cow's milk. For a new and niche base, this means the risk of a price barrier is even greater than for more established plant-based drinks. A third challenge is allergenicity. Peanuts are among the most sensitive food allergens in Europe and expert reviews indicate that the prevalence of peanut allergy has increased, reaching around 1.4–2% in Europe[31] and the United States.

Market segmentation. First, there is the mainstream plant-based drinks segment for everyday consumption, where affordability, private label and broad distribution dominate. Second, there is the functional/ high-protein /health-oriented segment, where peanut-based drinks may have their strongest argument. Here, the focus would be less on serving as a replacement for ordinary milk and more on products aimed at consumers seeking plant protein, satiety and sports or wellness applications. Third, there is the premium /organic /culinary-use segment, where peanut-based drinks can differentiate through taste, raw material origin, clean-label formulation or use in cooking and beverages.

Competitive landscape. Direct competition in this segment is still limited, but concrete product examples already confirm that peanut-based drinks are entering the market.

[30] Perspectives on the development of the UK's plant-based food market - https://gfieurope.org/wp-content/uploads/2024/10/EN-Perspectives-on-the-development-of-the-UKs-plant-based-food-market-October-2024.pdf

[31] White paper on peanut allergy - part 1: Epidemiology, burden of disease, health economic aspects – https://pubmed.ncbi.nlm.nih.gov/34603938/

- Particularly relevant is Bonneterre[32], a French organic brand, which launched an organic peanut-based drink with no added sugar, intended for use in both hot and cold beverages as well as in cooking. This example is important because it shows that peanut-based drinks already have a place in the European market as a differentiated, premium and health-oriented product.
- In addition, NIÚKE Foods[33] has launched a peanut-based drink in plain and cacao variants, which is a useful indication that this product concept is developing beyond Europe as well, and that there is broader market interest in peanut drinks as a distinct category.

For this reason, peanut-based drinks in the European context can be seen as an emerging category with a still limited number of direct competitors, but with clear signals that the market is testing this base.

Indirect competition. Although the number of direct competitors remains small, indirect competition is very strong. Peanut-based drinks are entering a category already dominated by oat, almond and soy drinks, supported by significant private-label presence and well-developed distribution channels. According to available market data, the almond-based drink was the largest segment by revenue in Europe in 2024, while the oat-based drink has been identified as the fastest-growing segment for the coming period. Beyond plant-based alternatives, indirect competition also includes cow's milk, lactose-free dairy products and the broader category of functional and protein drinks.

This means that peanut-based drinks compete not only with other plant-based beverages, but with a whole range of established solutions that already benefit from consumer purchasing habits, strong recognition and established shelf presence in retail.

Barriers to market entry. The first barrier is regulatory and communicational[34]. In the EU, a purely plant-based product cannot legally be marketed as "milk," so the market approach needs to rely on terms such as peanut drink, peanut-based beverage, or similar alternatives. This may sound like a small issue, but it is important for packaging, marketing and consumer understanding of the product. The second barrier is allergen labelling. The third barrier is gaining shelf access in an already crowded category. Market entry depends not only on innovativeness, but also on a clear value proposition and on identifying the channel in which the product can justify a higher price point or niche positioning.

Key takeaways. In the European context, the peanut-based beverage market currently provides a niche opportunity within a larger growth market. Its advantage is that it enters a category that is already large, familiar and expanding. Its weakness is that it must break through in a highly competitive space, while also facing additional obstacles related to allergen perception, regulatory terminology restrictions and the need for clear differentiation from oat, almond and soy. For that reason, in the European context, peanut-based drinks are unlikely to have the strongest initial logic as a mass-market product, but rather as a protein-forward, premium, culinary, or health-oriented niche.

4. Peanut-oil market overview

[32] New beverage launches (2024) https://www.beveragedaily.com/Article/2024/12/16/new-beverage-launches-zoa-stok-and-more/

[33] 6 of the Latest Product Launches in Dairy Alternatives That You Need to Know (2024) https://vegconomist.com/food-and-beverage/milk-and-dairy-alternatives/6-latest-product-launches-dairy-alternatives/

[34] Purely plant-based products cannot, in principle, be marketed with designations such as 'milk', 'cream', 'butter', 'cheese' or 'yoghurt', which are reserved by EU law for animal products https://curia.europa.eu/site/upload/docs/application/pdf/2017-06/cp170063en.pdf

Although peanut oil remains a niche segment in Europe compared to mainstream edible oils, the category shows continued market relevance, supported by its functionality in high-heat cooking, food processing and selected premium culinary applications.[35]

The European groundnut oil market is expected to grow at a CAGR of 4.5% from 2024 to 2030, due to the increasing demand for natural and healthy cooking oils, driven by the region's health-conscious consumers.[36] This is not a market that grows linearly from year to year.

Key market drivers. The strongest market logic for peanut oil in Europe lies not in everyday household use, but in specific functional and culinary applications. Groundnut oil is used for frying, as well as in sauces, mayonnaise, wok dishes and other Asian-inspired foods. Italy and France stand out as stronger markets, while for France, room is highlighted for premium, roasted, virgin and cold-pressed positioning.

Market challenges. In recent years, imports have declined, partly due to substitution by other oils, while in culinary use, sesame oil has emerged as a notable competitor. An additional challenge relates to food safety requirements, as EFSA notes that aflatoxins may occur both in groundnuts and in crude vegetable oils.

Competitive landscape. Illustrative European examples include:

- Elburg Global[37] from the Netherlands, which offers RBD groundnut/peanut oil in its portfolio.
- Henry Lamotte Oils[38] from Germany as a supplier for industry and trade.
- AAK Foodservice[39], which markets roasted peanut oil for high-heat cooking.
- In the premium and specialised retail segment, La Tourangelle[40] is an example of a brand positioning peanut oil as a flavour-driven, culinary product.

Indirect competition. Indirect competition is very strong in this category. Since peanut oil is not a dominant everyday household oil in Europe, in practice, it competes with a wide range of other vegetable oils that are more familiar to consumers, more widely available, or more affordable.

Barriers to market entry. Peanut oil in Europe does not have an equally broad everyday consumer base, so a new product must first explain its role and intended use. In addition, for less refined product streams, aflatoxins and quality control are particularly important, while for retail products, an additional challenge is justifying a higher price compared with more familiar alternatives.

Key takeaways. Peanut oil has a market in Europe, but it is primarily a speciality and import-dependent category, not a mass-market one. Italy is the key country for crude product flows, while France, the UK, the Netherlands and Belgium are important for finished products, processing and trade. The strongest market entry logic, therefore, does not appear to be a generic retail oil for broad consumption, but rather a product aimed at foodservice, high-heat cooking, ethnic and culinary use, or premium/speciality positioning.

[35] Europe Peanut Oil Market Size, Share & Trends - https://www.kbvresearch.com/europe-peanut-oil-market/

[36] Groundnut Oil Market (2025 - 2030) - https://www.grandviewresearch.com/industry-analysis/groundnut-oil-market-report

[37] Elburg Global - https://elburgglobal.nl/products/products/vegetable-oils/rbd-groundnut-peanut-oil/

[38] Henry Lamotte Oils - https://lamotte-oils.de/en/product/groundnut-oil/

[39] AAK Foodservice - https://aakfoodservice.com/eu/prep-premium/the-range/prep-premium-roasted-peanut-oil

[40] La Tourangelle - https://latourangelle.com/products/roasted-peanut-oil

Waste Streams and Circular Economy

Around 22% of the total mass of peanuts consists of shells[41], which at the global level amounts to more than 10 million tonnes of this by-product each year. Rather than remaining a low-value waste stream, these materials can be transformed into useful value-added products. Peanut shells can be used in the production of biodegradable polymers and sustainable composite materials, while research also highlights their potential to produce cellulose nanofibres, activated carbon and other functional materials. For this reason, they can justifiably be viewed as a basis for packaging, biomaterials and potentially disposable cutlery and similar products, rather than merely as waste.[42]
An important by-product also arises during peanut pressing, in the form of peanut cake/peanut meal residue, which contains approximately 47–55% protein. For this reason, this stream is already used or considered as an alternative protein ingredient in animal feed. This means that peanut processing residues are not merely secondary waste but can also represent a direct source of additional revenue through livestock feed and the broader valorisation of by-products.[43]

Recent validations within the VALPRO Path project have valorised the conversion of peanut shells into thermoplastic biocomposites. By milling the shells to create tailored fillers and blending them with thermoplastic biopolymers (such as PHBV and PBAT) via melt compounding and compression moulding, these residues can be transformed into sustainable materials that replace fossil-based plastics. Proper processing and the incorporation of surface-modifying additives further enhance the mechanical properties, processability and compatibility of the materials. This integrated approach allows peanut waste to be upcycled into high-value commercial applications, such as single-use packaging and agricultural materials, reducing dependence on fossil-based resources, advancing the circular bioeconomy and creating new, scalable economic opportunities within the European agri-value chain.

For the IPS concept, this is particularly important, as locally produced peanuts generate value not only through the main food product but also through additional processing outputs by converting peanut industry **by-products into value-added applications across food, feed, agricultural and bio-based markets**. Peanut shells, which account for 50-60% of total processing waste, could be used for biofuel production, agricultural mulch, soil amendments, activated carbon for water filtration, eco-packaging, and bioplastics. In addition, peanut skins could be valorised as a source of polyphenols and antioxidants for functional food ingredients, natural dyes, tannins and livestock feed additives. Peanut cake or meal from oil extraction, and their elevated protein content, may create additional value as a high-protein and high-fibre input for animal feed, organic fertilisers and peanut protein extraction for food industry applications. Harvest residues such as vines and leaves could also be used for livestock silage, composting, soil enrichment and bio-based biodegradable materials. This model would support a low-waste peanut value chain while creating additional revenue streams for farmers and processors. In this way, raw material utilisation is increased, product differentiation is strengthened, and the long-term sustainability and resilience of the overall business model are improved, in line with the principles of the circular economy.

[41] Upcycling of ligno-cellulosic nutshells waste biomass in biodegradable plastic-based biocomposites uses - a comprehensive review https://www.sciencedirect.com/science/article/pii/S2666682024000483

[42] From Waste to Strength: Unveiling the Mechanical Properties of Peanut-Shell-Based Polymer Composites https://www.mdpi.com/2504-477X/7/8/307

[43] Peanut Cake as an Alternative Protein Source to Soybean Meal on Performance, Nitrogen Utilization, and Carcass Trits in Feedlot Lambs https://www.mdpi.com/2504-3129/5/4/70

1.4. Practical Value-Added Processing Pathways for European Peanut Growers

Within the VALPRO Path project, the practical potential of three peanut-based products, peanut butter, peanut beverage and peanut oil, was examined using Life Cycle Assessment (LCA), Life Cycle Costing (LCC), product development activities and engagement with growers. The assessment was based on European cultivation trials in Portugal, which produced 204 kg of harvested peanuts. The modelling found that the peanut-based beverage had the lowest calculated carbon footprint, at 0.183 kg CO_2 eq./kg, and generated the highest modelled profit under the assessed conditions. Peanut butter recorded a higher carbon footprint of 2.196 kg CO_2 eq./kg and remained profitable, while peanut oil had the highest impact, at 4.358 kg CO_2 eq./kg, and generated a financial loss at the small scale assessed. While the environmental and economic modelling provided useful comparative results, the suitability of each product pathway also depends on processing requirements, shelf life, market access and the level of validation achieved during the project.

Peanut butter emerged as the most accessible value-added processing option for small-scale European growers. It has a relatively long shelf life, low perishability and a straightforward route to market compared with beverage products. Its production can also be integrated into decentralised or on-farm processing systems using roasting, milling and packaging equipment. These characteristics reduce logistical requirements and allow farmers to transform harvested peanuts into a recognisable, market-ready product with greater added value. Peanut butter also received the strongest practical validation and commercial interest during the project. Engagement with growers in Portugal and the Netherlands showed that it was their preferred processing pathway for adding value to peanut crops. Product development activities also focused more substantially on peanut butter and oil than on peanut-based beverages.

Based on its practical feasibility, grower acceptance and level of project validation, peanut butter represents the most appropriate initial value-added pathway for small-scale European peanut producers. It was recognised as the most acceptable near-term option for farmers seeking a realistic entry point into value-added peanut processing. Peanut-based beverages show a promising longer-term opportunity, particularly where regional processing hubs can provide the required pasteurisation, packaging and cold-chain infrastructure. Peanut oil may complement the product portfolio where larger production volumes, efficient processing equipment and premium markets are available, but it should not be prioritised at the small scale examined.

1.5. Key Challenges Identified

During the VALPRO Path Annual General Assembly held in Athens, Greece, on 8 November 2024, a dedicated workshop was organised to identify challenges, explore potential solutions and discuss opportunities related to the development of VALPRO path business cases using a collaborative business modelling approach. The session brought together project partners and technical experts to refine and advance the development of the business cases by defining their scope, challenges, and additional expansion opportunities. Through this exchange, participants highlighted a set of key challenges spanning value chain development, processing, market adoption, traceability, competitiveness, regional suitability and the valorisation of peanut-derived products and side streams.

1. **Establishing value chains and processing:** Develop efficient processing technologies and value chains for peanuts and side streams to maximise value creation throughout the supply chain.
2. **Allergenicity:** Address concerns related to peanut allergies in product development and market acceptance.

3. **Industry buy-in:** Identify food companies interested in sourcing European-grown peanuts and understand the barriers limiting their adoption**.**
4. **Food fraud risks:** Prevent substitution of high-quality European peanuts with lower-grade imported products and ensure traceability systems.
5. **Pricing challenges:** Balance the cost of European-grown peanuts against lower-cost imported alternatives.
6. **Cultivation locations:** Identify the most suitable European regions for peanut farming based on agronomic, climatic and production factors.
7. **Nutrient valorisation:** Maximise the use of peanut nutrient fractions to create additional value-added products.

Additional business opportunities for developing a sustainable peanut industry in Europe include the valorisation of peanut shells and the diversification of peanut-based products. Peanut shells could be processed into peat-free growing media, animal feed ingredients, soil amendments and bio-based packaging materials, reducing agricultural waste while creating new revenue streams. Their use as organic soil inputs could also support soil health, nutrient cycling and more sustainable crop rotation systems. In parallel, novel food applications could expand the market for peanut-derived ingredients and products, further strengthening the economic viability and circularity of the European peanut value chain.

1.6. Customer Segmentation

This business case targets an integrated, localised value chain spanning primary producers adopting new genetics, B2B processors seeking traceable supplies and the health- and eco-conscious consumers driving the ultimate demand. The specific market pains addressed, and gains created for each of these three key segments are detailed below.

Table 3 Value proposition analysis for IPS1.2 business case customer segments

Customer/ Actor	Paid addressed	Gain created
Producers (farmers, agricultural cooperatives)	Lack of agronomic knowledge, low yields from unadapted varieties and lack of established solutions to monetise waste streams.	Access to IP-protected, region-suited genetics, new revenue streams through on-farm processing and monetisation of side streams like shells and skins.
Processors, ingredient manufacturers and artisan snack producers	Difficulty securing a consistent, controlled and traceable supply, heavy reliance on cheaper commodity, strict EU regulatory compliance risks and product differentiation challenging in a crowded market.	Access to a sustainable, low-food-mile local supply of premium peanuts tailored for functionality (e.g., high-protein, high-oleic). Strict EU compliance and traceability, “100% European" narrative enabling clean-label and organic positioning for high-value goods.
Vegan, health- and eco-conscious consumers	High carbon footprints are associated with imported commodities and a desire for transparent, ethical food sources.	Locally sourced, sustainable and organic, potential "good for you" peanut products that support local agriculture and biodiversity

1.7. Value Proposition Statements

For producers (farmers and agricultural cooperatives): For European farmers seeking to diversify their crops and increase farm profitability, the VALPRO Path peanut business case provides IP-protected, region-suited peanut genetics coupled with small-scale on-farm processing technologies. Unlike traditional models that rely on unadapted varieties, this solution mitigates agronomic risks through technical transfer and empowers farmers to capture maximum value directly on the farm by turning both their primary harvest and agricultural side-streams (like shells and skins) into premium, saleable goods.

For processors, ingredient manufacturers and artisan snack producers: For food processors, ingredient manufacturers and artisan snack brands who require consistent, high-quality and sustainable plant proteins to differentiate their products in a saturated market, the VALPRO Path localised European peanut value chain offers traceable, EU-compliant peanuts with targeted high-protein and high-oleic profiles. Unlike relying on cheap, mass-produced commodity imports that carry long-distance supply chains and food-safety risks, this short-supply-chain alternative significantly lowers food miles and provides a premium "100% European" ingredient narrative. Ultimately, this traceable and locally processed supply enables highly marketable clean-label, low-carbon and potentially organic positioning ideal for specialised plant-based products, artisan snacks, peanut butters, functional dairy-free beverages and sports nutrition.

For vegan, health- and eco-conscious consumers: For health, wellness and environmentally conscious consumers who want to incorporate more sustainable plant proteins into their diets, the VALPRO Path European-grown peanut products provide premium, nutritious and delicious artisan snacks and functional foods. Unlike standard peanut products made from distant, imported crops with high carbon footprints, the VALPRO Path solutions offer transparent local origins, lower environmental impact and superior nutritional profiles that align with ethical and ecological values.

1.8. MVP and Business Case Validation Metrics

The IPS1.2 business case aims to develop a sustainable and commercially viable European peanut industry by commercialising IP-protected, climate-resilient varieties adapted to European conditions, reducing dependence on imports and maximising value for farmers and processors. The minimum viable process (MVP) includes establishing regional pilot farms of approximately 250–500 hectares in selected regions, which validate agronomic performance, yield benchmarks, knowledge transfer, local processing feasibility and the creation of multiple value streams from both primary peanut products and side streams.

Table 4 Business case validation metrics for PS1.2

MVP dimension	Target value/ Validation requirement	Value reached in validation
Yield benchmarks	Proving the viability and yield performance of EU-suited peanut varieties benchmarks. Yield per hectare improvement over and above the yield values currently achieved by existing farmers.	European field harvests in the Netherlands and Portugal successfully demonstrated the viability of peanut production under both Northern European and Mediterranean growing conditions. Portuguese and Dutch pilot trials yielded well with a scaled predicted yield of between 2.5 and 3.2 tonnes/ha on small and identified five varieties with strong regional suitability and maturity characteristics. This was a significant increase on earlier pilot trials which yielded 1.2t/ha.

		Yield figures are expected to improve as farmer knowledge, crop management practices and access to specialised equipment continue to develop. In the Netherlands, varietal selection successfully identified genetics capable of germinating and reaching maturity under cooler early-season conditions, while in Portugal trials confirmed suitability for local production and processing.
On-farm processing	Demonstrating the technical feasibility of small-scale, modular processing systems to perceive added-value income streams	Peanut Butter from own-farm peanut crop was successfully produced and marketed in both regions. Peanut butter was preferred over beverage and oil products for initial on farm processing due to lower investment costs, shelf-life and proven marketability. Producers in both Portugal and Netherlands have invested in branding and aim to increase production in future as volumes increase and supply chains mature.
Multiple value streams	Generating at least 2-3 distinct value streams per farm, thereby successfully processing both the primary crop and its side streams into marketable products (e.g. peanut kernels, peanut oil, artisan snacks, and livestock feed).	Producers successfully demonstrated five viable value streams including fresh in-shell peanuts, roasted in-shell peanuts, peanut butter, peanut oil and coated peanut snack products, while additional products remain under development. Validation activities also identified opportunities for high-protein ingredients and bird feed products.
Waste and side streams	Manufactured products from waste and side streams (e.g. peanut press cake, biomaterials, packaging materials and tableware)	Biobased materials from protein crop waste**,** including integrating peanut lignocellulosic residues into high-performance applications to unlock the full potential of crop residues within circular bioeconomy models. VALPRO Path valorised peanut shells through an integrated approach into biocomposites and aerogels, demonstrating potential as high-value, sustainable materials.
Royalty income	Supply chain of new nutritionally and agronomically superior varieties protected with EU plant breeders' rights	Successful varieties have been identified for future protection and commercialisation based on their agronomic performance, regional adaptability and nutritional characteristics. Applications will be submitted to the CPVO to protect selected varieties under EU Plant Breeders' Rights, creating future opportunities for royalty income through seed licensing and commercial cultivation across the EU.

1.9. Business Modelling Workshop

The VALPRO Path methodology, presented in D5.3 Exploitation, IPR and Business Models Catalogue I, applies an iterative CAPTURE–CO-CREATE–DELIVER approach to support collaborative business model development across the plant-protein value chain. In M43, this methodology was applied in the business modelling workshop for IPS1.2 in close collaboration with Beotanics as IPS leader. The workshop focused on value chain innovation mapping for the European peanut business case. Participants outlined the main activities required to develop and scale locally adapted peanut production in Europe and the key stakeholders involved across the value chain. In addition, participants identified the information needed to assess business model viability. The workshop also

addressed market opportunity and awareness, particularly the need to communicate the suitability of peanut cultivation in regions where the crop is not traditionally grown, while developing a value proposition for locally adapted peanut varieties that can support small family farms, improve financial margins and contribute to more sustainable production agricultural systems. Finally, the session considered potential partnerships and cost-benefit aspects, including the roles of core partners such as Beotanics, Teagasc and CSIC, as well as the costs linked to trials, travel, seed build-up and processing equipment.



Figure 6 Business modelling workshop for IPS1.2 business case

1.9.1. Value Chain Innovation Mapping

The Value Chain Innovation Mapping tool demonstrated that the IPS1.2 business case spans the full pathway from genetic conception and seed breeding to decentralised on-farm processing and final product valorisation. At the upstream level, the chain begins with the breeding, selection and agronomic optimisation of peanut varieties to secure raw materials with high-protein and high-oleic characteristics that are well suited for European climates.

This is followed by rigorous varietal testing and pilot production across targeted regions, as well as the sourcing of agricultural equipment to prepare the crop for decentralised handling. This germplasm line development utilises seed bank sourcing, local variety breeding and micropropagation multiplication pipelines. The varietal screening funnel is highly rigorous: starting with 40 varieties screened in Year 1, narrowing down to 34 retained for trials in Year 2, advancing to 18 lines in Year 3, and ultimately resulting in 5 final candidate lines. These multi-region, on-farm trials map specific geographic testing clusters to assess regional suitability, distinguishing between regions with cool climate adaptability (Netherlands, Germany, France) and strong Mediterranean performers (Portugal, Spain, Italy).

The midstream stage covers a set of localised, post-harvest on-farm processing operations, including harvesting, de-vining, shelling, roasting and oil pressing, alongside the circular valorisation of side streams. To operationalise these value streams, specific step-by-step technological pathways have been mapped for farmers:

- **Peanut-based beverage:** Soaking, draining, cooking, grinding, filtration, homogenization and pasteurisation.
- **Peanut butter:** Soaking, draining, drying, roasting, dehusking and milling.
- **Peanut oil:** Grinding, roasting, mechanical processing, filtration and refining.

These operations are particularly important because they empower European producers to capture added value directly on the farm, reduce reliance on imported commodities by shortening the supply chain and maximise resource efficiency by transforming agricultural waste into profitable secondary products like livestock feed and eco-packaging.

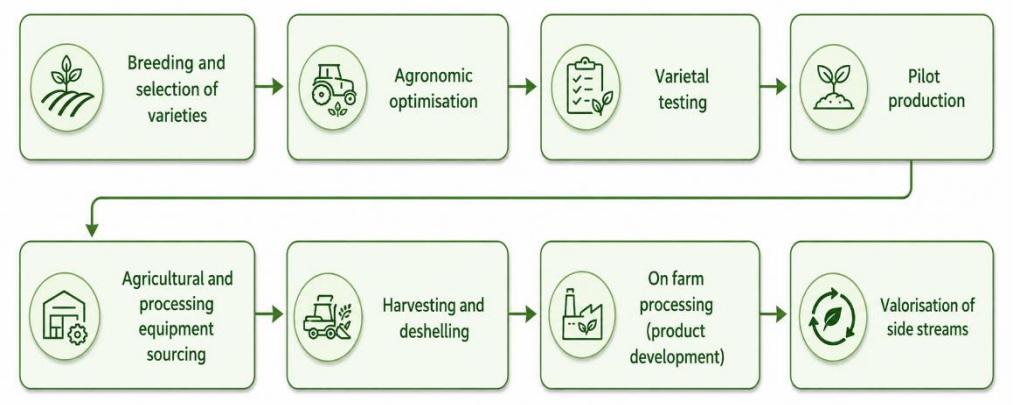


Figure 7 Value chain activities in IPS1.2 business case

Within the mapped value chain, the main innovation areas are focused on **variety breeding and selection** and **on-farm processing**. The breeding stage supports the development of IP-protected, climate-resilient peanut varieties adapted to European regions, with targeted high-protein and high-oleic profiles. On-farm processing converts these specialised crops into higher-value products and valorised side streams through small-scale, decentralised technologies such as shelling, roasting and oil pressing. By integrating these processing solutions, the business case aims to create a sustainable, low-waste supply chain that increases added value for producers while delivering products such as artisan snacks, peanut oil and animal feed that can compete with imported commodities. In this way, the IPS1.2 business case represents a combined pathway for genetic adaptation and decentralised processing to support the development of a sustainable, localised peanut industry in Europe.

The IPS1.2 value chain brings together a coordinated network of stakeholders from variety development through to final product use. This includes seed suppliers and breeders, researchers and academic partners, farmers, processing equipment suppliers, processors and packers, distributors and retailers, consumers, nutritionists and culinary experts. While this wider group of stakeholders supports the cultivation, processing, supply and market placement of European peanuts, the main stakeholder groups addressed are farmers and end users.



Figure 8 Stakeholders in IPS 1.2 business case

Farmers act as the central drivers of value creation in the midstream of the value chain. With support from seed breeders, researchers, and processing equipment suppliers, they are responsible for adopting IP-protected, climate-resilient peanut genetics and applying the key innovation of decentralised on-farm processing. Through processing activities at the farm level, farmers are able to

convert both the main peanut harvest and related side streams into higher-value products thereby increasing their overall profitability.

At the other end of the value chain, **consumers**, particularly those who are **health-conscious, environmentally aware and interested in vegan products**, act as the ultimate drivers of market demand. Distributors and retailers support market access. However, consumers ultimately determine the commercial viability of the value chain by choosing sustainable, low-food-mile, EU-compliant plant protein products.

Together, these two key stakeholder groups, **farmers** as value creators and **consumers** as demand drivers, form the foundation of the IPS1.2 innovation. Their combined role supports the shift from a localised, import-dependent commodity model towards a sustainable, localised, and commercially viable European peanut industry.



Figure 9 Information and value in IPS1.2 business case

The value chain innovation mapping illustrates how information and value are co-created and exchanged across the value chain through interactions among activities and stakeholders, from genetic conception to final product valorisation. At the upstream stages, seed suppliers, breeders, and researchers generate critical genetic and agronomic data, thereby determining varietal acceptance and suitability, as well as the nutritional density (protein, fat, fibre) of peanut crops tailored for European climates. This information flows directly to farmers and agricultural cooperatives, providing them with local agronomic opportunity awareness and ensuring food security (yield and rotation value) by proving the crop is a stable, resilient addition to their rotation. At the midstream and on-farm processing stages, farmers and processing equipment suppliers become the central actors in value creation. During harvesting, de-vining, shelling, roasting and oil pressing, they generate and track critical parameters related to operational efficiency and production costs by location. This data is essential for successfully implementing small-scale, modular technologies directly on the farm and accurately calculating the earning potential of both the primary peanut kernels and the valorised side streams. The information produced at this stage is transferred downstream to food processors, artisan snack producers and secondary market buyers (such as those for birdseed and eco-packaging), aligning local supply with downstream processing capacity without requiring massive new industrial infrastructure. At the downstream stages, B2B and B2C actors use these ingredient specifications to conduct product development, sensory validation and formulation optimisation, creating premium, EU-compliant plant-based foods while capturing maximum value within a shortened, sustainable supply chain.

1.9.2. Business Model Radar

The Business Model Radar for IPS1.2 presents the collaborative structure required to develop, validate and exploit a sustainable, localised European peanut value chain. It positions Beotanics as the focal

organisation and main source of IP-protected genetics, agronomic expertise and on-farm processing technologies, while showing how value is created through the coordinated involvement of actors across the value chain. Farmers and agricultural cooperatives cultivate region-suited peanut varieties and execute small-scale, modular on-farm processing; processors, artisan snack manufacturers and secondary market buyers then transform both the primary kernels and agricultural side-streams into premium, added-value goods such as peanut butter, peanut-based beverage, livestock feed and eco-packaging. Research and technology partners contribute to validation activities related to varietal suitability, yield benchmarks, nutritional density and optimal processing pathways, while end users benefit from premium, clean-label and sustainable peanut products with transparent local origins and enhanced high-protein and high-oleic profiles. The model demonstrates how IPS 1.2 can move from genetic adaptation and pilot-farm testing to a commercially viable European industry through seed licensing agreements, B2B supply chain partnerships, technical transfer and decentralised value capture directly on the farm.

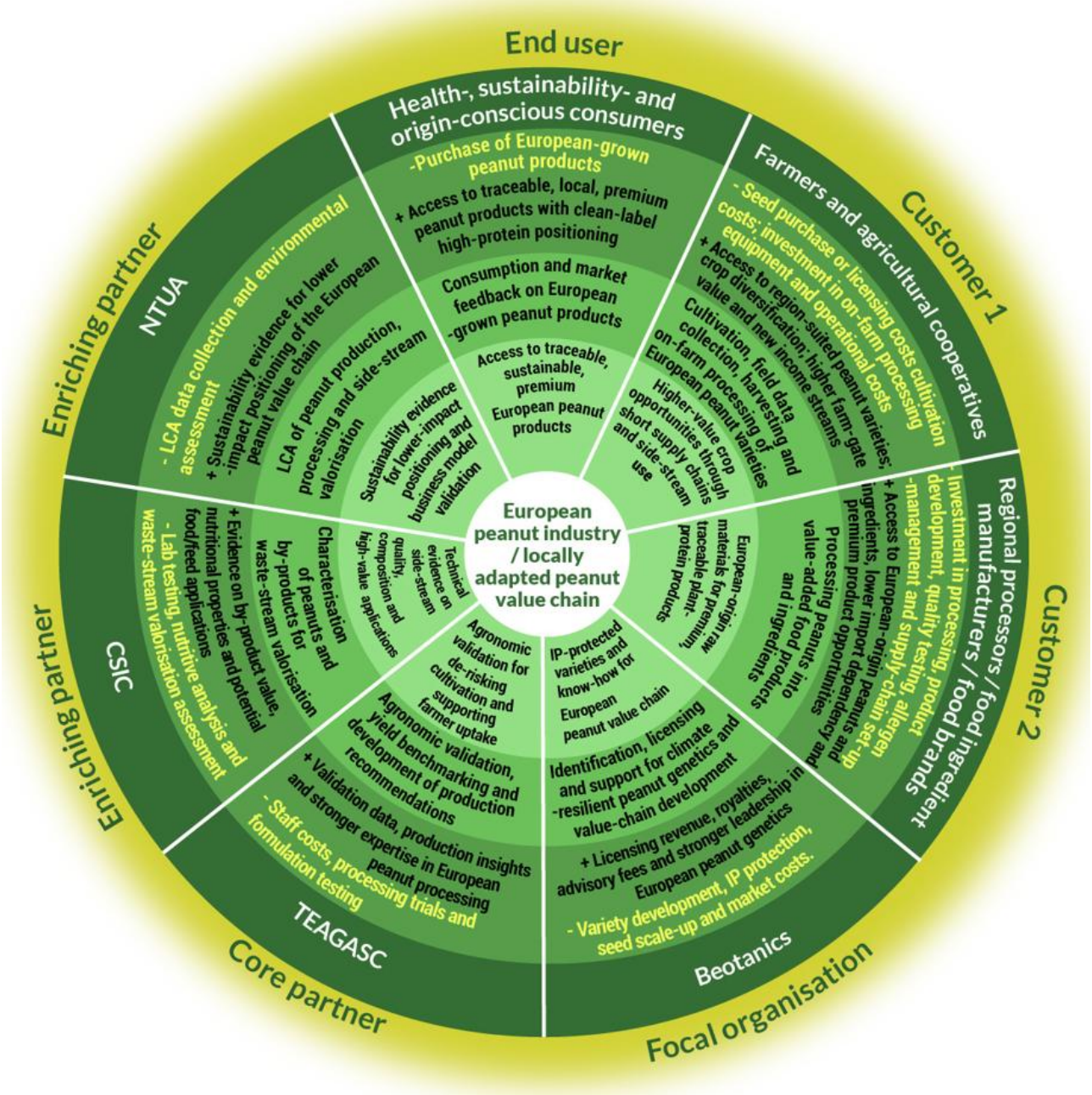


Figure 10 Business Model Radar for IPS1.2 business case

1.10. Business Model Analysis and Options Considered

Based on the broader IPS1 context, the business models for the downstream product development in IPS1.2 - *Developing the peanut industry in Europe* should also reflect the role of its upstream genetic and agronomic activities, as the two stages are closely connected. The upstream phase provides the agronomic foundation by introducing IP-protected, region-suited genetics, improving climate resilience and yield benchmarks, and creating a more reliable local supply of high-protein and high-oleic raw materials for downstream valorisation. The downstream phase builds on this by transforming the harvested peanuts and side streams into premium products and circular materials using validated, small-scale on-farm processing protocols. Therefore, the business model logic should not treat the downstream valorisation as an isolated food-innovation case, but as part of an integrated farm-to-fork pathway linking genetic conception, raw material cultivation, decentralised on-farm processing, product formulation and zero-waste supply chain development.

A suitable business model for IPS1.2 would be based on the development, protection and licensing of high-value peanut seed varieties adapted to European production conditions. The model would begin with genetic innovation, focusing on IP-protected varieties with strong market potential and varieties suited to low-input or organic farming systems. Revenue would be generated through **premium seed sales, licensing agreements with growers, cooperatives and seed companies and partnerships between private companies and research institutions.** This approach would give farmers access to differentiated varieties with improved yield, resistance, nutritional profiles and market premiums, while enabling breeders to capture value through seed commercialisation and licensing.

Another option could be the model focusing on the **technical service and advisory model**, which can be applied across the entire IPS1.2 value chain. At the upstream level, Beotanics and research partners can provide advisory support to farmers and agricultural cooperatives on agronomic optimisation, selection of best suited varieties, field data tracking and crop management. Downstream, this advisory role extends to on-farm processing and supply chain co-creation through technical support for small-scale modular technologies and identifying off-take opportunities for primary kernels and side streams. This model is particularly relevant because developing the European peanut industry requires significant technical guidance. Farmers need evidence-based agronomic recommendations and technical transfer to overcome historic barriers like low yields and poor climate resilience, while also needing tailored support to successfully operate decentralised processing equipment and establish zero-waste value chains. Revenue could come from **bundled seed licensing and agronomic support agreements, technical service fees, long-term supply chain partnerships, or project-based service contracts**.

Additionally, IPS1.2 can support a **training and knowledge-transfer model**. Upstream, this would include farmer-facing activities such as field demonstrations, advisory materials and knowledge-transfer events on European peanut cultivation and varietal performance. Downstream, training would target farmers, cooperatives and local processors interested in decentralised processing, circular valorisation of side streams and artisan product development. This model is suitable because the business case generates practical know-how that directly addresses the current lack of agronomy knowledge and technical transfer in Europe, supporting wider uptake of sustainable, low-food-mile peanut production. It could generate income through **technology transfer packages, bundled farmer service models, paid training or demonstration events**.

Integrated development across genetics, agronomy, processing and markets can successfully support the emergence of a viable European peanut industry. Pilot programmes have demonstrated that farmers have a strong desire to engage with peanuts where agronomic potential is proven and peer learning is enabled. Ultimately, European peanut production is not limited by farmer interest - it is

limited by the absence of coordinated systems. Future scale-up requires further steps in EU agricultural policy for the peanut to catch up to other established protein crops, necessitating coordinated legislation, seed systems, agronomy support and processor integration.

1.11. Recommended Business Approach

Overall, the most suitable approach for IPS1.2 is a ***hybrid farm-to-fork business model that combines upstream seed licensing and agronomic advisory logic with downstream technology transfer, decentralised processing support and supply chain development activities.*** Beotanics retains and exploits the core genetic IP, agronomic data and processing know-how, while providing licensed seed varieties, cultivation recommendations, technical guidance and knowledge-transfer services to farmers and cooperatives. Farmers and cooperatives would cultivate the tailored peanut crops and implement on-farm processing to produce premium kernels and valorised side streams. Local processors and artisan food brands would then integrate these outputs into high-value food products and circular economy applications.

This combined approach reflects the collaborative nature of IPS1.2, where value is co-created through the transfer of genetic innovation, agronomic expertise, processing knowledge and supply chain partnerships from seed development through to consumer uptake. For European farmers adopting this decentralised model, peanut butter represents the most suitable near-term value-added product stream. It offers a longer shelf life, lower perishability and a more accessible route to market than peanut-based beverages, while also receiving the strongest practical validation and commercial interest from growers during the project. Its production can be integrated into small-scale or on-farm processing systems using relatively straightforward roasting, milling and packaging technologies. To further enhance the sustainability of this model, future efforts must focus on strengthening local plant-based value chains, supporting peanut butter product development and market entry, promoting circular bioeconomy practices for by-product valorisation, optimising logistics and facilitating industrial scale-up via targeted funding and strategic partnerships.

Annex 2. IPS3.2 Business Case Report

NEW VALUE LANDSCAPES FOR PLANT PROTEIN PATHWAYS

IPS3.2 Business Case Report

Using Pulse Flours in Confectionery Products

valpropath.eu

Co-funded by the European Union

1. Using Pulse Flours in Confectionery Products (IPS2)

Business opportunity hypothesis
If optimised pulse-flour blends made from pea and faba bean, along with validated processing protocols, are developed and demonstrated across at least four mainstream confectionery products, then the confectionary and bakery industry can introduce a competitive and sustainable alternative to traditional wheat flour. This would enable a minimum 30% wheat flour substitution rate while meeting industrial standards for taste, texture and processing performance.

IPS	**IPS3** - Agronomic practices that mitigate yield loss and create crop synergies
Business-case focus	**B2B:** Know-how solution for using pea and faba bean pulse flours in mainstream confectionery and bakery reformulation.
Lead geography	Europe
Target crops/ materials	Field pea and faba bean fractions processed into pulse flours and blended with wheat flour for hybrid confectionery applications.
Technology solution	Optimised pea-faba flour blends combined with natural food-grade processing protocols, including soaking, germination, drying, dehulling, milling, sieving and product-specific formulation.
Expected outcome	Specification-ready pulse-flour blends and transferable processing protocols enabling at least 30% wheat-flour substitution in 4+ confectionery products while maintaining sensory, shelf-life and industrial performance.

The business case focusing on the use of pulse flours in confectionary products addresses a practical reformulation opportunity for food applications: ***how to replace a meaningful share of traditional wheat flour with locally relevant pulse flours while maintaining the taste, texture, shelf life and process performance expected by food processors and manufacturers.***

The innovation is an integrated ingredient and process system built around pea and faba bean flour blends, natural processing steps that reduce bitterness and anti-nutritional factors and application-specific formulation protocols for products such as biscuits, crackers, cakes, waffles and soda bread.

Commercial logic is strongest as a B2B ingredient-plus-know-how offer for ingredient manufacturers, industrial bakeries, confectionery producers, private-label suppliers and brand owners. The value comes from lowering reformulation risk: manufacturers gain a validated pathway to reach at least 30% wheat-flour substitution without major capital expenditure while preserving consumer acceptability and enabling clean-label, higher-protein and fibre-rich product positioning.

1.1. Problem Statement

The bakery and confectionery sectors are increasingly required to deliver products with improved nutritional profiles and sustainability performance. Pulse flours derived from legumes such as pea and faba bean offer significant potential in terms of higher protein and fibre content, clean-label positioning and reduced environmental footprint. However, their large-scale application in confectionery products remains limited due to a set of technical, technological and economic challenges.

Attempts to substitute wheat flour with pulse flours are constrained by the presence of anti-nutritional compounds and associated bitterness and off flavours which negatively affect sensory quality and consumer acceptance. In addition, differences in functional properties between wheat and pulse flours pose challenges in achieving desirable texture, structure, flavour and appearance in finished products. Uncertainty regarding technological functionality on standard industrial processing

lines further limits adoption, as manufacturers must ensure stable dough handling, machinability and baking performance without compromising product quality. These challenges are compounded by the need to rely exclusively on natural, food-grade processing techniques in line with clean-label requirements, as well as by concerns related to economic viability and the scalability of additional upstream processing steps (e.g. dehulling, sorting, soaking/germination, thermal treatments) which can increase costs and operational complexity.

1.2. Objectives of IPS3.2 Business Case

The primary objective of IPS3.2 business case is to enable the industrial uptake of pulse flours in confectionery applications by developing technically robust, nutritionally improved and economically viable alternatives to conventional wheat flour. To this end, IPS3.2 aims to identify and validate optimal pulse flour blends derived from pea and faba bean that can achieve at least 30% substitution of traditional wheat flour in confectionery formulations while maintaining processability on standard industrial equipment and preserving or enhancing the nutritional value of the final products.

In parallel, IPS3.2 seeks to optimise texture, sensory and techno-functional parameters of pulse-flour-based formulations to ensure that four or more confectionery end-products (e.g. biscuits, crackers, cakes, waffles, soda bread) meet established industry standards for taste, structure and processing performance. This includes achieving sensory parity with conventional products, ensuring stable dough handling and baking behaviour and delivering consistent product quality under industrial manufacturing conditions.

1.3. Market Analysis

Market analysis situates IPS3.2 within two closely connected commercial domains: the food-ingredient market for pulse flours and the bakery and confectionery product market for hybrid formulations combining pulse and wheat flours. Together, these markets define the primary pathways for industrial uptake of the VALPRO Path innovation addressed in IPS3.2, spanning upstream ingredient supply and downstream product reformulation. The analysis focuses on demand drivers, buyer requirements and competitive dynamics relevant to pea–faba pulse flours in mainstream confectionery applications, with particular attention to hybrid wheat–pulse formulations as a pragmatic route to achieving meaningful nutritional and sustainability improvements while maintaining sensory quality, shelf life and compatibility with existing industrial production lines.

The IPS3.2 business case is best positioned as a B2B “ingredient plus know-how” offer, combining validated pea-faba flour blends with transferable processing protocols that reduce anti-nutritional factors and deliver confectionery-ready functionality, thereby providing a CAPEX-light route to consistent industrial performance and competing effectively with both commodity pulse flours that lack application support and higher-cost functional ingredients. The most compelling market opportunity lies with bakery and confectionery manufacturers and ingredient suppliers seeking reliable substitution pathways and differentiated clean-label positioning within Europe’s broader protein-diversification context. In this setting, IPS3.2 focuses on hybrid confectionery systems targeting wheat-flour substitution at a level that is commercially meaningful yet operationally feasible, with market positioning anchored in sensory parity, compatibility with standard industrial processing lines and clean-label, higher-protein and fibre differentiation supported by robust technical data that help manufacturers secure reformulation opportunities in a large and growing European market.

1. Pulse flour market overview

Pulse flours sit within the broader “pulse ingredients” category (flours, proteins, fibres, isolates, starches). Across global pulse-ingredient markets, pulse flours represent a large share of ingredient

revenues (e.g., Mordor Intelligence reports pulse flours as the largest ingredient type by revenue share in 2024[44]). Multiple market research sources project solid growth for pulse flours, driven by mainstreaming of plant-based and healthier reformulations; for example, IMARC estimates the **global pulse flour market at USD 30.2B in 2024[45]**, growing to **USD 48.1B by 2033**. For Europe specifically, Market Data Forecast estimate places the **Europe pulse flour market at cc. USD 4.1B in 2024[46]**, with strong forecast growth rate (CAGR) of 5.06% during 2025-2033. European market forecasts project continued expansion in pulse flour usage across different food categories.

Key market drivers. The pulse flour market is experiencing sustained growth, driven by structural shifts in consumer demand, public health awareness and food industry reformulation strategies. Key drivers include the following:

- **Protein fortification and health positioning:** Food manufacturers increasingly use pulse flours to enhance protein content and support product positioning in mainstream categories.
- **Growth of gluten-free applications:** Rising awareness of celiac disease and gluten sensitivity is driving demand for naturally gluten-free ingredients, making pulse flours attractive for inclusive product development.
- **Clean-label demand and ingredient transparency:** Consumers' preference for simple, recognisable ingredients is encouraging manufacturers to adopt pulse flours as natural, minimally processed alternatives to functional additives.
- **Adoption of plant-based and flexitarian diets:** The shift toward plant-based eating patterns for health, environmental and ethical reasons is increasing demand for legume-based ingredients with high nutritional value.
- **Product innovation in bakery and snacks:** Ongoing innovation in baked goods, snacks, pasta and convenience foods is expanding application opportunities for pulse flours and accelerating market uptake through new product launches.

Together, these drivers create favourable conditions for the uptake of pulse flours in both ingredient supply and food applications.

Market segmentation. The European market can be segmented along multiple axes:

- **By raw material type:** pea flour, faba bean flour, chickpea flour, lentil flour, lupin flour.
- **By application:** bakery (bread, cakes, biscuits, crackers), confectionery (sweet and savoury snacks), pasta/noodles, snacks, meat analogues, beverages.
- **By functionality:** standard flours vs. functionalised flours (pre-treated for flavour/texture improvements).
- **By buyer:** ingredient manufacturers and compounders, industrial bakeries/confectionery producers, private-label and co-packers supplying retailers.

Competitive landscape. The key suppliers in the European hybrid pulse–wheat bakery and confectionery space include pulse protein and flour suppliers, wheat flour suppliers, hydrocolloid and texture-modifier suppliers, flavor maskers and packaging suppliers. The number of specialized pulse-

[44] Mordor Intelligence. (2024). Pulse ingredients market – Growth, trends, COVID-19 impact, and forecasts (2025–2030). https://www.mordorintelligence.com/industry-reports/pulse-ingredients-market

[45] IMARC Group. (2024). *Pulse flour market: Industry trends, share, size, growth, opportunity and forecast 2024–2033.* https://www.imarcgroup.com/pulse-flour-market

[46] Market Data Forecast. (2024). *Europe pulse flour market: Forecast to 2030.* https://www.marketdataforecast.com/market-reports/europe-pulse-flour-market

protein suppliers is **limited**, with companies such as BENEO,[47] Roquette,[48] Vestkorn, Ingredion, and others offering specialized pulse and plant-protein ingredients accompanied by application support. Formulators are technically dependent on these suppliers because they must provide **consistent protein functionality**, **sensory optimization** through maskers and flavor modifiers, and validated **application data** and **standard operating procedures** (SOPs).[49] Raw material price volatility for protein ingredients further strengthens supplier leverag. Switching costs are also significant, as changing protein suppliers often requires re-validation of formulations, new sensory testing and fresh shelf-life data, all of which raise the cost and complexity of switching. As a result, **specialized ingredient suppliers exercise moderate to high bargaining power**, particularly for those that need high-quality, consistent and application-supported pulse-protein systems.Competition is strong on price, formulation support and technical service, as global suppliers from North America and Asia-Pacific serve the European market, intensifying competition on price and technical support.

Indirect competition. Pulse flours also face indirect competition from a range of alternative ingredient categories that manufacturers can use to enhance texture, protein and fibre content in bakery and confectionery products. These include **other plant flours** such as oats, barley and sorghum which are widely adopted for nutritional uplift and familiar consumer positioning; **seed and nut flours**, including almond and sunflower which support high-protein and clean-label claims in premium and **specialty products and protein isolates and concentrates**, particularly soy and pea proteins, which enable high protein fortification but may conflict with clean-label expectations due to higher levels of processing. Together, these alternatives compete with pulse flours for reformulation budgets and shelf space, especially where manufacturers prioritise ease of formulation or established ingredient familiarity over the multifunctional benefits of pulse-based flours.

Barriers to market entry. Key barriers include the need for consistent raw material quality, investments in processing to reduce off-notes and variability and the ability to provide robust application support (e.g., formulation guidance, SOPs). Regulatory compliance with food safety and allergen labelling also increases entry complexity, particularly when targeting large industrial bakery and confectionery customers.

Entry barriers are differentiated by scale: **small-scale entrants** face *low to moderate capital barriers* and can enter relatively easily via contract manufacturers, private-label producers and co-packers, especially in bars, cookies and snack formats, often leveraging contract manufacturing and premium positioning to reach niche markets. In contrast, **industrial-scale**, **mainstream entrants** face *moderate to high barriers* to enter due to significant technical complexity, substantial sensory risk and the need for strong technical support and application data.[50] Achieving industrial-scale success requires the ability to consistently **control sensory outcomes** (off-notes, bitterness, and texture) because consumers reject poor taste even when products offer health benefits.[51] [52] It also demands **repeatable industrial processability** with tight specifications, deep formulation know-how and consistent

[47] Food Ingredients First. (2025). *Beneo Unveils €50M Pulse Processing Site to Unlock Faba Bean Potential* https://www.foodingredientsfirst.com/news/beneo-faba-bean-protein-site.html

[48] EIT Food. (2026) *Partner Network Profiles: Roquette* https://www.eitfood.eu/community/partners/roquette

[49] Cereals and Grains Association (2020) *Challenges and Opportunities in Formulating with Pulse Ingredients* *https*://www.cerealsgrains.org/publications/cfw/2020/March-April/Pages/CFW-65-2-0019.aspx

[50] IBIS World, (2025) *Bakery Goods Production in Europe, Industry Data and Analysis* https://www.ibisworld.com/europe/industry/bakery-goods-production/200407/

[51] Zoha Mohammadi, Anusha MB, (2025*), A Review of Plant-Based Bakery Products,* International Journal for Multidisciplinary Research https://www.ijfmr.com/papers/2025/4/49839.pdf

[52] Baking Business. (2025). *Boosting Protein Content Poses Challenges for Bakers* https://www.bakingbusiness.com/articles/63424-boosting-protein-content-poses-challenges-for-bakers

ingredient quality across lots.[53] Therefore, key buyers such as industrial bakeries, retailers, and private-label producers require strong application data, including sensory profiles, shelf-life evidence and functionality data, before adopting new ingredients or systems, which further raises the barrier for large-scale market entry.[54]

Key takeaways. Overall, the European pulse flour ingredient market is positioned for continued growth, supported by nutrition, plant-based and clean-label trends. However, successful commercial uptake depends heavily on delivering application-ready ingredients with validated performance in industrial processes, reliable sensory profiles and functional equivalence to traditional flour. For IPS3.2, this implies a strong strategic fit for hybrid formulations that offer compositional differentiation without compromising production performance, underpinned by technical data and industry partnerships.

2. Confectionery products combining pulse and wheat flour

Key market drivers. Hybrid wheat–pulse formulations are gaining traction in Europe because they offer a practical route to nutrition-led reformulation (more protein/fibre) without fully sacrificing wheat's processing functionality, within a very large and growing bakery market.[55,56] Demand is reinforced by clean-label momentum (preference for simpler, recognisable ingredients) and the broader shift toward plant-based protein diversification in Europe.[57] In addition, gluten-free and reduced-gluten innovation continues to influence bakery/snacking development (even when hybrid products still contain wheat, the trend accelerates interest in alternative flours and protein enrichment).[58, 59]

Market challenges. Adoption remains constrained by sensory risks, texture/structure impacts and process variability when pulse flours are introduced into wheat-based systems. These challenges are especially critical in sweet bakery and confectionery products where consumer expectations for flavour and mouthfeel are strict, making formulation "fail risk" high without validated processing and blending approaches. Cost-in-use can also be a barrier when extra steps are needed to improve flavour/functionality (e.g., dehulling, germination, thermal treatments), unless performance benefits are proven at industrial scale.

Market share. There is no standard, separately reported "pulse–wheat hybrid confectionery" market size; however, the opportunity sits inside Europe's large bakery products market and within a clearly expanding pulse-ingredient demand base. Europe's bakery products market is forecast to grow strongly through 2031–2033. On the ingredient side, bakery and confectionery are estimated to represent a major share of EU pulse-ingredient demand – an estimated 22% starting from 2025, rising

[53] Cereals and Grains Association (2020) *Challenges and Opportunities in Formulating with Pulse Ingredients* https://www.cerealsgrains.org/publications/cfw/2020/March-April/Pages/CFW-65-2-0019.aspx

[54] Andrea Bresciani, Alessandra Marti., (2019). *Using Pulses in Baked Products: Lights Shadows, and Potential Solutions,* National Library of Medicine https://pmc.ncbi.nlm.nih.gov/articles/PMC6835306/

[55] Market Data Forecast. (2024). *Europe bakery products market: Forecast to 2030*. https://www.marketdataforecast.com/market-reports/europe-bakery-products-market

[56] Mordor Intelligence. (2024). Europe bakery products market – Growth, trends, COVID-19 impact, and forecasts (2024–2030). https://www.mordorintelligence.com/industry-reports/europe-bakery-products-market

[57] Mordor Intelligence. (2024). *Europe clean-label ingredient market – Growth, trends, COVID-19 impact, and forecasts (2024–2030)*. https://www.mordorintelligence.com/industry-reports/europe-clean-label-ingredient-market

[58] Market Data Forecast. (2024). *Europe gluten-free products market: Forecast to 2030*. https://www.marketdataforecast.com/market-reports/europe-gluten-free-products-market

[59] Glanbia. (2024). *Bakery trends 2024*. Glanbia. https://www.glanbia.com/news/bakery-trends-2024

over time according to Future Market Insights[60], indicating that these categories are already central to pulse ingredient utilisation and are likely to continue absorbing hybrid flour solutions.

Market segmentation. The European hybrid pulse–wheat bakery/confectionery space can be segmented as follows:

- **By product type:** biscuits/cookies, crackers, cakes, waffles, sweet bakery snacks (and adjacent snack-bakery formats).
- **By pulse input:** pea flour, faba bean flour, chickpea/lentil flours.
- **By inclusion rate ("hybrid intensity"):** low-moderate substitution (e.g., 10–30% typically targeted for mainstream sensory/process stability) vs higher substitution (often requiring stronger functionalisation/processing).
- **By route to market:** branded "better-for-you" snack-bakery, private label and industrial reformulation.

Competitive landscape. Competition comes from both finished-product players and ingredient-system suppliers. The European competitive landscape for high protein snacks and bakery products is active and fragmented. In Europe, high-protein snack and bakery brands, as well as contract manufacturers, demonstrate active commercialisation of protein-enriched cookies, cakes, bars, flapjacks and other bakery-style snack formats for mainstream, weight-management and sports-nutrition channels.[61] Market coverage describes the protein-snack category is highly competitive, while high-protein bakery products in Europe are projected to continue growing.[62] Product-side examples include **Bulk™** in the UK high-protein snack segment and **Bariatrix Europe** in France, which offers contract manufacturing and private-label high-protein bakery/snack formats. On the ingredient side, European and global suppliers such as **BENEO** and **Roquette** are expanding pulse- and plant-protein ingredient portfolios with application support for bakery, snacks and related food categories.[63] Relevant examples include **Vestkorn**, which offers pea and faba ingredients including flours, proteins and starches; Ingredion, through its HOMECRAFT® pulse and faba flours for snacks, bread, cakes and other applications; BENEO, with faba bean protein concentrate, faba bean flour and starch-rich flour; and Roquette, with a broad plant-based ingredient portfolio including pea-protein solutions. Global suppliers from North America and Asia-Pacific also serve the European market, increasing the availability of functionalised pulse and plant-protein ingredients and intensifying competition on price, formulation support and technical service.[64]

Indirect competition. Hybrid pulse–wheat products compete with other reformulation routes that can deliver similar nutritional and clean-label benefits, such as **almond/coconut and other alternative flours** (common in gluten-free bakery launches) and broader "healthy grains" positioning; these alternatives can absorb innovation budgets and shelf space that might otherwise go to pulse-based reformulations. They also compete with **clean-label ingredient solutions** (e.g., fibres, proteins, texturisers) that can boost nutrition while keeping wheat flour unchanged.[65]

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[60] Future Market Insights. (2024). *Demand for pulse ingredients in the EU*. https://www.futuremarketinsights.com/reports/demand-for-pulse-ingredients-in-eu

[61] Future Market Research. (2025). *Protein Snacks Market. https://www.futuremarketinsights.com/reports/protein-snacks-market*

[62] Persistence Market Research. (2026). *Protein Snacks Market Size, Share, and Growth Forecast 2026 – 2033*. https://www.persistencemarketresearch.com/market-research/protein-snacks-market.asp

[63] Food Ingredients First. (2025). *Beneo Unveils €50M Pulse Processing Site to Unlock Faba Bean Potential.* https://www.foodingredientsfirst.com/news/beneo-faba-bean-protein-site.html

[64] HTF Market Intelligence. (2025). *Global Plant Sourced Protein Market Roadmap to 2030.* https://www.htfmarketinsights.com/report/3748112-plant-sourced-protein-market

[65] Meat Borsa. (2025). *Europe's Protein Powerhouses: Meat Snacks Surge and Chicken Stays King.* https://meatborsa.com/en/blog/europe-s-protein-powerhouses-meat-snacks-surge-and-chicken-stays-king

Barriers to market entry. Key entry barriers include (i) the ability to consistently control **sensory outcomes** (bitterness/off-notes) and **structure/texture** in wheat-based matrices, (ii) delivering **repeatable industrial processability** with tight specifications and (iii) providing robust **application data packs** (sensory, shelf life, functionality) that de-risk adoption for industrial bakeries and private-label producers. Regulatory/retailer expectations around clean-label substantiation and quality documentation further advantage suppliers that can pair ingredients with validated SOPs and technical support.

Key takeaways. In Europe, the commercial opportunity for IPS3.2-aligned hybrid products is best understood as **a reformulation pathway inside a large, growing bakery market**, with bakery/confectionery sectors as already a major demand for pulse ingredients. The winning propositions are those that deliver **mainstream sensory parity and stable industrial processing** while enabling meaningful nutrition and clean-label differentiation - precisely where validated pulse-wheat blend systems and transferable SOPs can outperform commodity pulse flour swaps or costly functional ingredients.

1.4. Key Challenges Identified

During the VALPRO Path Annual General Assembly held in Athens in M27, a dedicated workshop was organised to identify challenges, explore potential solutions and discuss opportunities related to IPS3.2 business case. The session brought together project partners and technical experts to examine critical technical and functional aspects of plant-based ingredient processing, including dehulling, functionalisation and application in bakery and confectionery formulations. Through this exchange, participants highlighted a set of key challenges that currently constrain the efficient processing, functional performance and industrial uptake of faba bean-pea mixes in food production.

1. **Dehulling of the combined faba bean and pea mix:** A major challenge is determining whether dehulling the combined faba bean - pea mix is feasible.
2. **Separation and sorting issues:** The difficulty in separating faba beans and peas due to their comparable size and colour may make sorting problematic.
3. **Economic considerations:** Understanding the economic impact of introducing dehulling and separation techniques.
4. **Impact on product quality and functionality:** The ratios of pea and faba bean in the final product may alter the texture and structural properties. Potential sensory and functional changes for confectionery applications due to the influence of hulled versus unhulled mixtures.
5. **Sustainability and scalability:** Roasting and high-shear drying technology could be explored as potential solutions for improving microbiological quality, generating flavour and enhancing functionality. The environmental and sustainability benefits of the processing method to be evaluated.

The identified opportunities extend beyond bakery and confectionery applications and include the use of pea- and faba bean-derived ingredients in animal feed, low-gluten and low-carbohydrate snacks and breads, plant-based beverages, meat alternatives and sports nutrition products targeting vegan and vegetarian consumers, such as protein bars. Additional opportunities include the development of mixed protein isolates and roasted pulse products, while hulls generated during processing could be valorised as a raw material for bio-based packaging. These applications could diversify revenue streams, improve the use of processing side streams and strengthen the circularity and commercial potential of the IPS3.2 value chain.

1.5. Customer Segmentation

The business case targets B2B actors that can commercialise or adopt the pulse-flour system in ingredient supply and finished-product reformulation. End consumers are important as the ultimate source of market demand, but the immediate purchasing and implementation decisions sit with ingredient and food-manufacturing actors.

Table 5 Value proposition analysis for IPS3.2 business case customer segments

Customer/ Actor	Paid addressed	Gain created
Food ingredient manufacturers, pulse processors and millers	Commodity flour competition, lack of application data, variability and limited differentiation.	Validated blends, stronger portfolio positioning, technical-service offer and higher-value ingredient sales.
Industrial and mid-size bakeries / confectionery manufacturers	Sensory failure risk, process uncertainty, shelf-life concerns and formulation time.	At least 30% substitution rate, sensory parity, better protein/fibre profile and compatibility with standard equipment.
Private-label manufacturers and co-packers	Need to meet retailer specifications, cost targets and scale-up deadlines.	Transferable protocols, faster product development and credible clean-label product claims.
Retailers and brand owners	Need claims with evidence and products acceptable to mainstream consumers.	Validated product formats, clearer sustainability narrative and reduced reformulation risk.
Health- and sustainability-conscious consumers	Healthy products can sacrifice taste, texture or familiarity.	Familiar confectionery products with improved protein/fibre content and clean-label positioning.

1.6. Value Proposition Statements

For food ingredient manufacturers: For food ingredient manufacturers seeking to expand their portfolio of clean-label, plant-protein ingredients for bakery and confectionery applications, the pulse-flour system offers a science-based, industrially validated ingredient and processing solution that provides specification-ready pea–faba flour blends and transferable processing know-how enabling at least 30% wheat-flour substitution while maintaining functional performance, sensory quality, shelf-life requirements and compatibility with standard industrial equipment without additional capital investment.

For bakeries, confectionery manufacturers and private-label producers: For industrial and mid-size bakeries, confectionery manufacturers, co-packers and private-label suppliers seeking to develop higher-protein, clean-label confectionery products without retooling, the validated pulse-flour confectionery system developed within VALPRO Path offers a science-based and industrially tested ingredient and process solution that enables up to 30% wheat-flour substitution while maintaining sensory quality, texture performance and a shelf life equivalent to that of wheat control counterparts.

For retailers and brand owners: For retailers and brand owners seeking differentiated mainstream bakery and snack products, the IPS3.2 solution enables credible clean-label, plant-protein and fibre-rich positioning in familiar formats such as cookies, crackers, cakes, waffles and soda bread, supported by technical evidence and validated shelf-life performance.

For end consumers: For health- and sustainability-conscious consumers seeking familiar treats with improved nutritional value, pulse-flour bakery and confectionery products offer great-tasting options formulated with pea and faba bean flours that maintain conventional flavour and texture while delivering higher protein and fibre content.

1.7. MVP and Business Case Validation Metrics

Minimum Viable Process (MVP): A minimally processed pulse-flour confectionery product line and accompanying formulation and process specifications that demonstrate the technical and commercial feasibility of substituting at least 30% of wheat flour with pea–faba pulse flour (no CAPEX), delivers acceptable consumer sensory performance maintaining an equal shelf-life to wheat control counterparts and matches classic taste/texture while improving protein and fibre content.

Table 6 Business case validation metrics for PS3.2

MVP dimension	Target value/ Validation requirement	Value reached in validation
Validated end products	≥4 confectionery or bakery-adjacent products successfully developed and validated using pulse flours at ≥30% wheat substitution	Four bakery products were successfully developed and validated using pulse flours at ≥30% wheat substitution: cake, cracker, soda bread and waffle.
Blend coverage	3 to 5 pea–faba pulse-flour blend formulations covering different product categories and functional requirements	Four pea–faba pulse-flour blend formulations (95.5:4.5, 85:15, 80:20 and 70:30 pea:faba bean) were evaluated across cake, waffle, soda bread and cracker applications, covering different functional and processing requirements.
Sensory performance	Sensory acceptance score across key attributes for pulse-flour confectionery products compared to wheat-based reference products, with an overall score of ≥7/10 and no individual attribute falling below the acceptable threshold	Large sensory trials were not conducted within the project timeframe. However, smaller in-house sensory acceptability testing was undertaken at points during the developmental process for each of the four products.
Shelf-life performance	Demonstrated ambient shelf life of pulse-flour confectionery products equivalent to wheat control counterparts, with no unacceptable degradation in texture, flavour or microbiological quality	Partially demonstrated – storage stability was assessed against wheat controls using moisture and texture measurements. Cake was evaluated over 1, 3 and 7 days; crackers at day 1, weeks 1, 4 and 8; and soda bread and waffles at days 0 and 1. Sensory and microbiological quality were not assessed.
Nutritional improvement	Relative increase in protein content of hybrid confectionery products compared to conventional wheat-based equivalents, achieving a ≥15% protein increase versus baseline formulations	Protein content increased by 29.7% in cake (40% substitution), 70.2% in cracker (50% substitution), 27.8% in soda bread (30% substitution), and 26.2% in waffle (30% substitution) compared with the corresponding wheat controls. All four products exceeded the ≥15% protein-increase target.

1.8. Business Modelling Workshop

As outlined in D5.3 Exploitation, IPR and Business Models Catalogue I, the VALPRO Path business modelling methodology follows an iterative **CAPTURE – CO-CREATE – DELIVER approach** designed to support the development of collaborative business models for IPS-related business cases. The methodology brings together several complementary tools, including the identification of viable business opportunities, definition of business validation metrics and MVP assumptions, market analysis, value proposition development, value chain innovation mapping, Business Model Radar and Business Model Canvas. Rather than focusing only on the business model of a single organisation, the approach aims to capture how different actors across the plant-protein value chain contribute to value creation, validation and future exploitation of business case results.

In M38, this methodology was applied to IPS3.2 in cooperation with TEAGASC. The workshop focused on exploring the commercial potential of pea–faba pulse-flour blends and validation of confectionery applications, including their positioning as a B2B "ingredient plus know-how" solution for food ingredient manufacturers, industrial bakeries and confectionery producers. Representatives of the IPS3.1 business case also attended the workshop to ensure alignment and synergies between the two business cases under the broader IPS3 umbrella, linking upstream intercropping and crop production activities with downstream ingredient processing and confectionery product development.



Figure 11 Business modelling workshop for IPS3.2 business case

1.8.1. Value Chain Innovation Mapping

The Value Chain Innovation Mapping demonstrated that the IPS3.2 business case spans the full pathway from crop production to ingredient development and final confectionery application. At the upstream level, the chain begins with the cultivation, intercropping and optimisation of pea and faba bean crops to secure raw materials with suitable quality and yield characteristics. This is followed by harvesting, drying, cleaning and sorting, which prepare the crop material for further processing. The midstream stage covers logistics and a set of post-harvest processing operations, including soaking, germination, drying, dehulling, aspiration, cutting, milling and sieving. These operations are particularly important because they improve the suitability of pulse materials for food applications by reducing anti-nutritional compounds and off-flavours, supporting microbiological stability and enhancing functional performance.

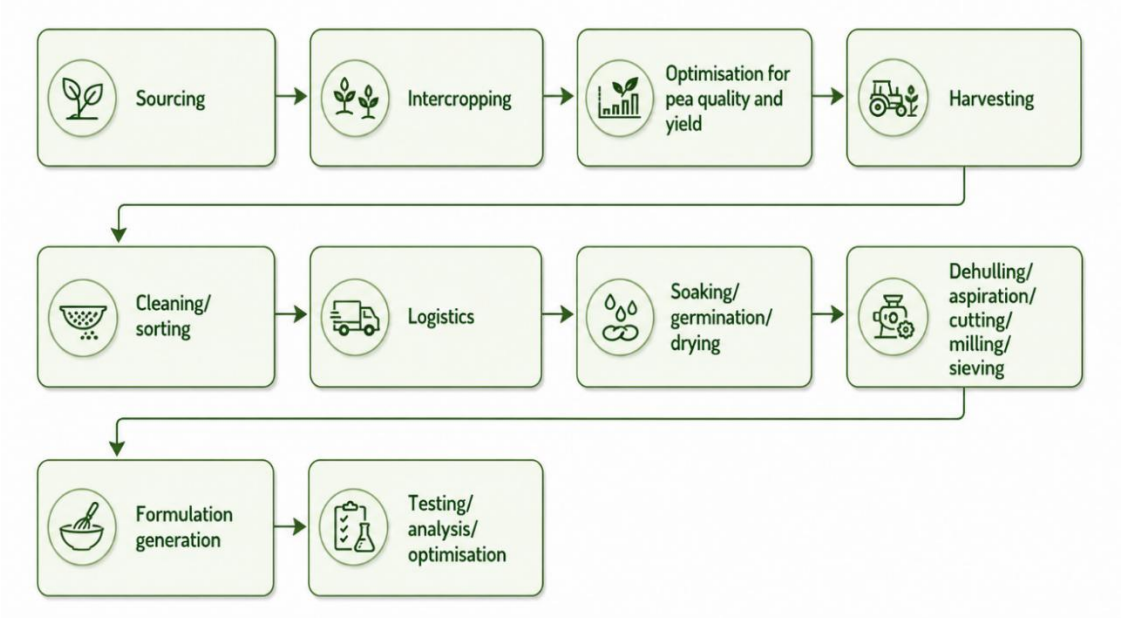


Figure 12 Value chain activities in IPS3.2 business case

Within the mapped value chain, the key innovation points are concentrated in the **soaking/germination/drying stage** and in **formulation generation**. The first enables the transformation of pea and faba bean raw materials into more stable, functional and confectionery-ready flour fractions while the second translates these improved ingredients into application-specific blends and recipes. Through formulation generation, the business case aims to achieve a meaningful level of wheat-flour substitution while preserving sensory quality, texture, processing behaviour and compatibility with industrial confectionery production. Thus, IPS3.2 is positioned as an integrated processing and formulation pathway for introducing pulse-flour blends into mainstream confectionery products.

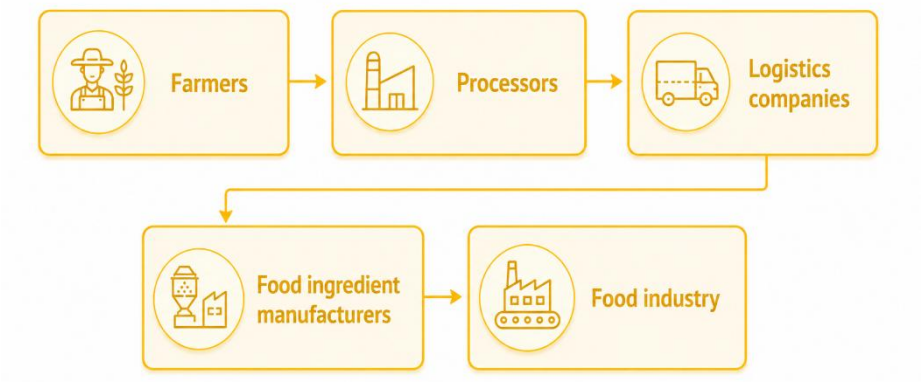


Figure 13 Stakeholders in IPS3.2 business case

The value chain for IPS3.2 involves a coordinated set of stakeholders spanning primary production to industrial food manufacturing, including farmers, processors, logistics companies, ingredient manufacturers and the food industry. Farmers supply pea and faba bean raw materials produced under intercropping systems, while primary processors and logistics operators ensure cleaning, sorting, storage and transport to downstream processing stages. These upstream actors enable the provision of raw pulses but are not the primary locus of innovation in IPS3.2. The central innovation in IPS3.2 is driven by the active participation of **ingredient manufacturers and the food industry**, which jointly operationalise the validated processing and formulation solutions. Ingredient manufacturers implement the soaking, germination, drying, milling and blending protocols to produce

specification-ready pulse-flour ingredients with reduced anti-nutritional factors and improved functional performance. The food industry (industrial and mid-size bakeries and confectionery manufacturers) integrates these ingredients into existing production lines and co-develops formulations for multiple confectionery applications, validating sensory quality, shelf life and process compatibility at industrial scale. Together, these two stakeholder groups act as the **primary adopters** of the IPS3.2 innovation, translating upstream crop synergies into higher-protein confectionery products.

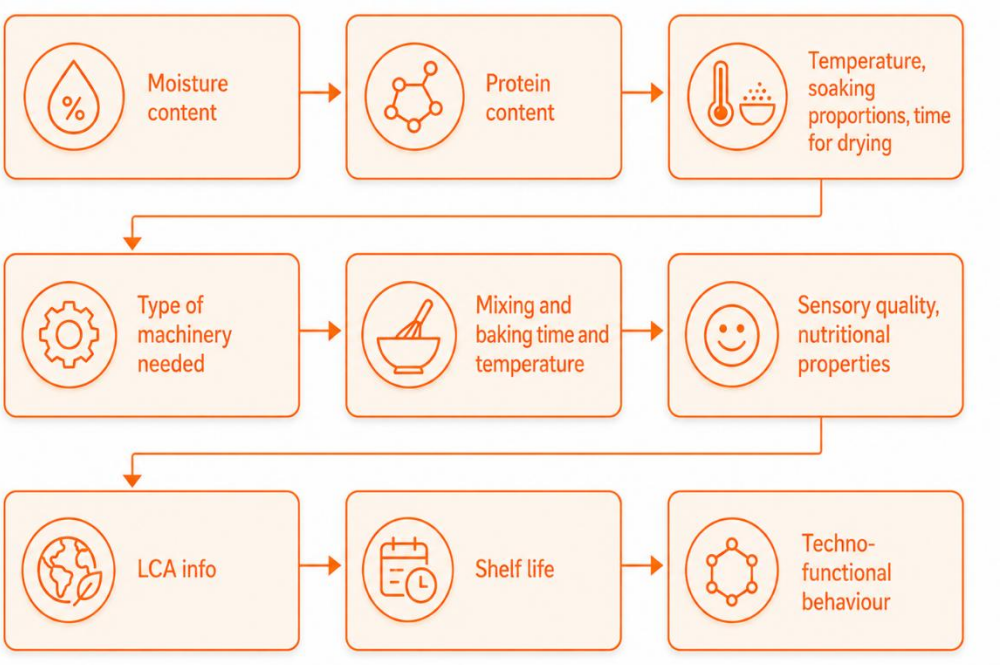


Figure 14 Information and value in IPS3.2 business case

The figure illustrates how information and value are co-created and exchanged across the value chain through the interaction of activities and stakeholders, from primary production to food manufacturing. At the upstream stages, farmers and primary processors generate quality-related information such as moisture levels and protein content, which directly determines the suitability of pea and faba bean raw materials for further processing and sets the baseline value of the crop for food applications. This information flows to processors, ingredient manufacturers and logistics operators, who use it to manage drying, cleaning, sorting, storage and transport conditions, thereby preserving raw material quality and reducing variability and losses along the chain. At the midstream processing stages, ingredient manufacturers become the central actors in value creation. During soaking, germination, drying, dehulling, milling and sieving, they generate and control critical process parameters such as temperature, soaking proportions, time, particle size distribution and equipment requirements. These data are essential to reduce anti-nutritional factors, improve functional properties and ensure that the resulting pulse flours meet specification for confectionery use. The information produced at this stage is transferred to the food industry and logistics and sourcing partners, aligning supply, processing capacity and quality expectations without requiring additional capital investment. At the downstream stages, the food industry uses the ingredient specifications and process data to carry out formulation generation, testing, analysis and optimisation. Here, new information is created in the form of mixing and baking parameters, processing times and temperatures and product performance data such as sensory (organoleptic) quality, nutritional properties, shelf life, techno-functional behaviour and sustainability indicators.

1.8.2. Business Model Radar

The Business Model Radar for IPS3.2 presents the collaborative structure required to develop, validate and exploit pulse-flour solutions for confectionery applications. It positions TEAGASC as the focal organisation and main source of processing know-how, formulation expertise and transferable SOPs, while showing how value is created through the coordinated involvement of actors across the value chain.

Farmers and cooperatives provide food-grade pea and faba bean raw materials produced through intercropping systems; processors, millers and ingredient manufacturers transform these inputs into specification-ready pulse-flour ingredients and industrial bakeries, and confectionery manufacturers integrate the blends into existing production lines to develop nutritionally enhanced products. Research and technology partners contribute to validation activities related to sensory quality, shelf life, techno-functional performance, packaging and industrial standards while end users benefit from healthier, clean-label and more sustainable confectionery products that maintain familiar taste and texture. The model demonstrates how IPS3.2 can move from research outputs to industry-ready ingredient systems through B2B technology transfer, co-development, technical services and partnerships with the food and food-ingredient industry.

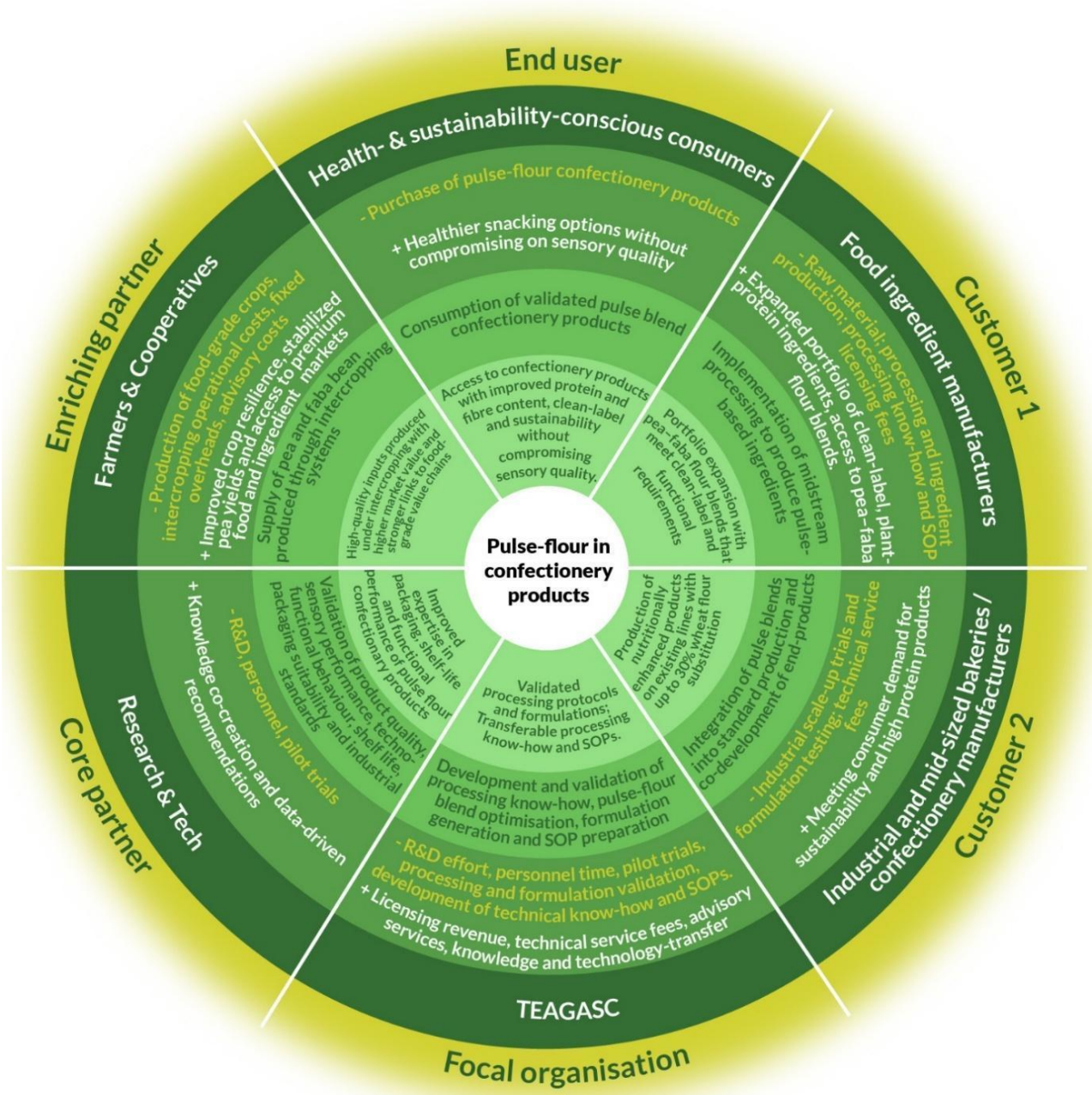


Figure 15 Business Model Radar for IPS3.2 business case

1.9. Business Model Analysis and Options Considered

Based on the broader IPS3 context, the business models for IPS3.2 - Use of pulse flours in confectionery products should also reflect the role of IPS3.1 - Intercropping field peas and faba beans, as the two business cases are closely connected. Therefore, the business model logic should not treat IPS3.2 as an isolated food-innovation case, but as part of an integrated farm-to-fork pathway linking intercropping, raw material quality, ingredient processing, formulation and industrial product development.

Licensing of validated processing know-how and SOPs. In this model, TEAGASC acts as the knowledge owner and technology-transfer actor, providing food ingredient manufacturers, millers and industrial bakeries with access to validated protocols for treating, processing and formulating pea-faba pulse flours. The licensed know-how could include guidance on soaking, germination, drying, milling, sieving, formulation generation and quality-control parameters needed to achieve at least 30% wheat-flour substitution in confectionery products. The connection with IPS3.1 strengthens this model by ensuring that the processing protocols are linked to raw materials produced through intercropping systems, where crop quality, yield stability and agronomic performance are considered from the start.
Revenue options: Licence fees, annual access fees or use-based royalties.

The technical service and advisory model. For IPS3.1, TEAGASC can provide advisory support to farmers, seed producers, breeders and agricultural advisors on intercropping practices, crop-management optimisation, variety selection, sowing ratios and lodging reduction. For IPS3.2, this advisory role extends downstream to ingredient manufacturers and confectionery producers through formulation support, troubleshooting, sensory optimisation, shelf-life testing, techno-functional analysis and industrial trial support. This model is particularly relevant because both intercropping adoption and pulse-flour application require technical guidance.
Revenue options: Consultancy fees, service contracts, pilot-trial support, technical workshops or long-term advisory agreements.

Co-development model with food manufacturers. Under this approach, TEAGASC works directly with industrial bakeries, confectionery manufacturers and brand owners to adapt pea–faba pulse-flour blends to specific product lines and market requirements. The manufacturer contributes production knowledge, consumer insight, processing facilities and scale-up capacity, while TEAGASC contributes validated processing and formulation know-how. IPS3.1 contributes by strengthening the credibility and sustainability narrative of the raw material supply, demonstrating that the ingredients originate from crop systems designed to reduce lodging, stabilise yields and improve production resilience.
Revenue options: Co-development contracts, shared IP arrangements, royalties linked to commercialised products.

The ingredient system supply model. In this case food ingredient manufacturers or millers produce and commercialise specification-ready pea-faba pulse-flour blends based on validated IPS3.2 protocols. In this model, TEAGASC transfers or licenses the processing know-how, while the ingredient manufacturer becomes the market-facing supplier of pulse-flour systems for bakery and confectionery manufacturers. The link with IPS3.1 is important because a reliable ingredient system depends on stable access to suitable pea and faba bean raw materials. The ingredient supplier could offer different blends adapted to specific confectionery applications, supported by technical data sheets, sensory evidence, shelf-life results and processing recommendations.
Revenue options: Ingredient sales with potential licensing or royalty arrangements for the underlying know-how for TEAGASC.

The training and knowledge-transfer model. For IPS3.1, this would include farmer-facing activities such as field demonstrations, intercropping guidelines, advisory materials, workshops and knowledge-transfer events on pea-faba bean cultivation, lodging reduction and variety/ration selection. For IPS3.2, training would target ingredient manufacturers, food processors, bakeries and cooperatives interested in pulse-flour processing, formulation, sensory optimisation and industrial validation. This model is suitable because both business cases generate practical know-how that can be disseminated beyond one commercial partnership, supporting wider uptake of sustainable plant-protein production and use.
Revenue options: Paid training, industry workshops, technical manuals, demonstration events or participation in further R&D and innovation project.

1.10. Recommended Business Approach

Overall, the most suitable approach for IPS3.2 **is a hybrid B2B "ingredient plus know-how" business model** combining the licensing and transfer of validated processing protocols with technical advisory services, industrial co-development and the commercial supply of specification-ready pea–faba bean flour blends. This approach reflects the collaborative structure of the business case, in which TEAGASC acts as the focal knowledge and technology-transfer organisation, while farmers, cooperatives, processors, ingredient manufacturers, research partners and food manufacturers jointly contribute to the development and delivery of the final solution.

Under this model, TEAGASC would retain and exploit the validated processing and formulation know-how generated through IPS3.2, including SOPs covering soaking, germination, drying, dehulling, milling, sieving, quality control and product formulation. This knowledge could be transferred to millers and ingredient manufacturers through licensing agreements, technical-service contracts, training and industrial trial support. Ingredient manufacturers would subsequently become the principal market-facing actors, producing standardised pea–faba bean flour blends tailored to specific bakery and confectionery applications and supplying them together with technical data sheets, formulation guidance, sensory evidence, shelf-life results and processing recommendations. Revenue could therefore be generated through licence or annual access fees, consultancy and pilot-support services, co-development contracts, royalties and sales of the resulting ingredient systems.

The recommended approach should initially prioritise co-development with selected food manufacturers and industrial bakeries. Working with a limited number of application partners would enable the pulse-flour blends and processing parameters to be adapted to specific product categories, validated under industrial conditions and supported by credible evidence on sensory quality, shelf life, nutritional improvement and techno-functional performance. Once the formulations and SOPs have been sufficiently validated, the model could be scaled through licensing and partnerships with established ingredient manufacturers that already possess production capacity, quality-management systems, customer networks and market access. This reduces the need for TEAGASC to invest in ingredient-production infrastructure while allowing the project knowledge to reach a broader industrial market.

The approach should also remain closely connected to IPS3.1 rather than treating IPS3.2 as an isolated product-development activity. Farmers and cooperatives would provide food-grade peas and faba beans produced through validated intercropping systems, while processors and ingredient manufacturers would translate these raw materials into consistent, application-specific flour blends. Linking agronomic performance, raw-material quality, ingredient functionality and final-product formulation would create an integrated farm-to-fork pathway and strengthen the sustainability, traceability and resilience claims attached to the ingredients.

In the near term, the strongest commercial opportunity lies in bakery and confectionery products in which at least 30% of wheat flour can be replaced without substantial investment in new production equipment. These applications offer manufacturers a comparatively accessible route to introduce higher-protein, higher-fibre and clean-label products while maintaining familiar taste, texture and production performance. Future scale-up should therefore focus on completing industrial validation, defining reproducible ingredient specifications, confirming production economics, establishing reliable raw-material supply arrangements and securing strategic partnerships with millers, ingredient manufacturers and food producers. The same validated ingredient platform could subsequently be

extended to adjacent markets such as snacks, breads, beverages, meat alternatives, mixed protein ingredients and vegan sports-nutrition products.

Annex 3. IPS4.2 Business Case Report

NEW VALUE LANDSCAPES FOR PLANT PROTEIN PATHWAYS

IPS4.2 Business Case Report

The Nutrient Tracking Tool

valpropath.eu

Co-funded by the European Union

1. The Nutrient Tracking Tool (IPS4)

Business opportunity hypothesis
If an integrated Nutrient Tracking Tool is applied across the plant-protein value chain, linking field-level data with compositional analysis and processing parameters, stakeholders will be able to predict nutrient flows, optimise processing decisions, and improve valorisation outcomes, resulting in increased efficiency, reduced waste, and higher-value ingredients and food products.

IPS	**IPS4** - Promoting new practises for farm-to-shelf nutrient tracking and sustainability
Business-case focus	**End-to-end:** Know-how solution for using pea and faba bean pulse flours in mainstream confectionery and bakery reformulation.
Lead geography	Europe
Target crops/ materials	Concept applicable to all crops - tool designed with data for faba beans generated within the VALPRO Path project.
Technology solution	An interactive simulation tool linking agronomic data to processing mass-balance models, enabling quantification of fractionated protein and co-products.
Expected outcome	A tool that enables informed decisions around processing and adding value to protein crops, acting as an interactive simulation model for the prediction of protein and co-product streams.

The business case focuses on developing the Nutrient Tracking Tool as a practical data-integration opportunity for the plant-protein sector. It addresses the need ***to connect fragmented information across production, processing and product development to predict nutrient flows and identify leverage points*** for further valorisation across the supply chain.

The proposed innovation is a **decision-support tool** built around agronomic data, mass-balance processing models and sustainability analytics. Through interactive scenario-planning steps and application-specific forecasting protocols, it supports the optimisation of ingredient yields for end-products while reducing the need for costly trials. Linking field-level data with processing and formulation models via this tool helps stakeholders move from reactive measurement to proactive nutrient-flow management. Instead of assessing losses, yields or ingredient suitability only after processing has taken place, users are enabled to compare alternative scenarios in advance and identify the most efficient route for each crop batch or processing stream. This predictive capability supports better allocation of raw materials, more efficient processing choices and improved recovery of valuable protein and co-product fractions.

The strongest commercial logic is a dual-pronged model combining advisory-led support with platform licensing for farmers, ingredient manufacturers, food formulators and supply chain coordinators. The value comes from lowering operational and formulation risk by providing stakeholders with a validated digital pathway to simulate processing scenarios and optimise protein and co-product recovery, while supporting raw material consistency and efficient, sustainable and transparent plant-protein positioning.

1.1. Problem Statement

Current plant-protein value chains still face a significant information gap in relation to how nutrients, resource inputs and environmental impacts are generated, transformed and communicated from farm to fork (the consumers). While different actors may collect relevant data at specific points of the chain, such as crop production, processing, formulation, logistics or environmental assessment, this information is often used in isolation and is not sufficiently connected to support coordinated

decision-making. As a result, stakeholders may have limited visibility over how raw material quality, processing choices and product development decisions affect nutrient retention, ingredient functionality, by-product generation, environmental performance and final product positioning.

This creates a challenge for both upstream and downstream actors. Farmers and primary producers may not fully capture the value of high-quality protein crops if the relationship between crop characteristics, nutrient composition and downstream applications is not clearly demonstrated. Processors and ingredient manufacturers may miss opportunities to optimise fractionation, reduce losses or identify higher-value uses for co-products. Food manufacturers, in turn, may face difficulties in substantiating nutritional and sustainability claims in a way that is transparent, evidence-based and meaningful for consumers. Without a shared farm-to-form framework, the full value of plant-protein crops can remain underexploited, and promising product innovations may lack the robust data basis needed for commercial uptake and market differentiation.

The problem is also linked to the growing demand for food products that combine nutritional quality, sustainability performance and credible communication. Consumers, retailers and food companies increasingly expect more transparent information on the origin, composition and environmental footprint of food products, but the current tools and processes do not always provide a clear basis for connecting technical value-chain data with consumer-facing product claims. This limits the ability of plant-protein products to demonstrate their added value beyond standard nutrition panels, particularly where carbon-use efficiency, greenhouse gas emissions, resource use, nutrient stability or circular use of by-products could become part of the product's value proposition.

Therefore, IPS4 addresses the need for a more integrated, data-driven and application-oriented approach to nutrient tracking and sustainability assessment in plant-protein value chains. By connecting upstream production data, processing and formulation parameters, environmental assessment outputs and final product information, IPS4 can support better decisions on crop use, processing efficiency, product development and labelling. In this way, the business case responds to a clear need to move from fragmented measurement towards coordinated value-chain intelligence, enabling stakeholders to improve transparency, reduce inefficiencies and create plant-protein products with stronger nutritional, environmental and commercial value.

1.2. Objectives of the IPS4.2 Business Case

The first objective of IPS4.2 is to support the development and future uptake of a specialised **Nutrient Tracking Tool** that can improve decision-making across plant-protein value chains. The tool is intended to move beyond fragmented data collection by creating a more integrated way to follow nutrient mass balance from crop input, through processing, to final output streams. In practical terms, this means helping stakeholders understand how nutrients are transformed, retained or lost during processing, and how these changes influence ingredient yields, product quality and co-product opportunities. This objective is particularly relevant for crops such as faba bean, where several valuable fractions and by-products may be generated, but their full value can remain under-recognised without a clear overview of nutrient flows.

A second objective is to validate the usefulness of an **interactive, scenario-based simulation model** that can compare outcomes under different production and processing conditions. Instead of relying only on post-processing assessment, the tool should enable users to test alternative scenarios in advance and evaluate how different crop characteristics, processing choices, or resource-use decisions may affect protein recovery, nutrient losses, process efficiency and value creation. This gives the tool a practical decision-support function for actors involved in production, processing and logistics, helping them translate technical data into clearer operational choices.

The third objective is to position the Nutrient Tracking Tool as a commercially relevant bridge between technical analysis, sustainability assessment and business model development. By linking agronomic

data, processing mass-balance models and sustainability analytics, the tool can support producers, processors and food manufacturers in identifying leverage points for value creation, optimising protein yields, reducing nutrient losses and supporting circular business models through by-product identification and valorisation. In addition, by connecting early-stage crop assessment with processing scenarios and LCA outputs, the Nutrient Tracking Tool can help address challenges that cannot be solved by isolated agronomic, traceability or process-modelling tools alone.

1.3. Market Analysis

This market analysis situates the IPS within two closely connected commercial domains: the digital solutions market for food traceability, formulation and manufacturing decision-support, and the emerging plant-protein value-chain market centred on the processing and valorisation of pulse crops. Together, these domains define the principal pathway for industrial uptake of the VALPRO Path innovation addressed in this business case, linking upstream crop production and logistics with downstream processing, ingredient development and end-use applications. The analysis focuses on demand drivers, buyer requirements and competitive dynamics relevant to a nutrient tracking and simulation tool that can quantify nutrient mass balance, model fractionation outcomes and support decision-making across production and processing scenarios for plant protein products.

This business case is best positioned as a B2B digital decision-support tool, combining nutrient mass-balance logic, scenario simulation and process-informed valorisation insights for plant-based crop streams. Rather than functioning as a conventional traceability or nutrition-labelling solution, the proposed tool is intended to support more informative operational and strategic decisions around the use of protein crops by modelling how nutrients and valuable fractions move across the chain from crop input to processed ingredients (in this case, pulse flour, protein concentrate, protein isolate) and co-products. In this sense, the strongest market opportunity lies with actors that need better visibility over yields, losses, co-product streams and processing trade-offs, particularly producers, processors and logistics actors handling plant protein crops, as well as downstream ingredient developers and end users seeking more efficient and data-based reformulation and sourcing decisions. This positioning aligns with wider European momentum around protein diversification, plant-based innovation and the creation of new value chains for crops.

Digital solutions market overview

The business case sits at the intersection of several already established but only partially overlapping digital solution categories: food traceability platforms, recipe and nutrition calculation tools, specification and product lifecycle management systems and process simulation/digital twin approaches for manufacturing optimisation. Existing commercial solutions demonstrate strong demand for software that improves visibility, compliance, formulation control and manufacturing efficiency in food systems, but no clearly positioned off-the-shelf solution was identified that integrates nutrient mass-balance tracking with scenario-based simulation of processing outcomes and co-product valorisation for plant protein value chains. Public market offerings therefore suggest the presence of a commercially relevant white space rather than a saturated direct-competition environment.

Key market drivers. The market opportunity for this type of tool is driven by several structural developments in the agri-food and plant-protein sectors. First, there is increasing interest in plant-based value chains and in improving the efficiency and economic viability of protein crop utilisation. Second, producers and processors are under growing pressure to reduce losses, improve resource efficiency and identify higher-value applications for side streams and co-products. Third, the complexity of modern food supply chains is increasing the need for better traceability, transparency and evidence-based decision-making. Finally, innovation in ingredient processing is creating demand

for tools that can simulate different production and processing scenarios before costly operational decisions are made.

- **Growth of plant-protein value chains:** The expansion of plant-based food systems is increasing the need for better tools to understand, optimise and valorise protein crop processing pathways.
- **Pressure to improve resource efficiency and reduce losses:** Producers and processors are under growing pressure to minimise nutrient losses, improve material efficiency and create more value from side streams and co-products.
- **Need for better traceability and transparency:** Increasing value-chain complexity is creating demand for tools that provide clearer visibility of material and nutrient flows across production, processing and logistics stages.
- **Demand for evidence-based process optimisation:** Companies need better decision-support tools to test production and processing scenarios before making costly operational or investment decisions.
- **Growing interest in co-product valorisation:** The search for additional revenue streams is increasing interest in solutions that help identify where nutritional and economic value can be retained, recovered or redirected.

Market challenges. Existing digital solutions are typically fragmented, with many tools focusing on only one part of the problem, such as traceability, nutritional data management or industrial process simulation. This makes it difficult for users to obtain an integrated view of nutrient flows from raw crop input to processed ingredients and co-products. The practical adoption of new digital tools can be slowed by limited data availability, variability in raw material composition, differences in processing conditions across sites and the need to translate technical outputs into business-relevant insights for diverse user groups such as producers, processors and logistics actors.

Market segmentation. The relevant market can be segmented along several dimensions:

- **By solution type:** Traceability and compliance tools, food-data and nutritional management tools, process simulation and optimisation tools and integrated decision-support systems.
- **By value-chain stage:** Primary production, post-harvest handling, ingredient processing, logistics and downstream product application.
- **By target user:** Producers, processors, logistics actors, business decision-makers, end users (food industry, food manufacturers).
- **By crop and application focus:** Broad agri-food software solutions versus specialised tools tailored to plant-protein crops and fractionation processes.

Competitive landscape. At present, several digital solutions operate in the market. Existing platforms support functions such as traceability, recipe formulation, product carbon footprinting, life-cycle assessment, ERP-based production control, supplier data management or waste-stream valorisation. These solutions, however, do not appear to provide a single integrated, off-the-shelf platform tailored specifically to plant-protein value chains that connects nutrient mass-balance tracking, scenario-based processing simulation, environmental assessment and co-product valorisation from farm to fork. This indicates a clear market gap for a specialised Nutrient Tracking Tool that can translate fragmented value-chain data into coordinated decision-support for producers, processors, food manufacturers and consumer-facing product communication.

Foodsteps[66]***:*** Foodsteps is a sustainability platform for food companies. It helps calculate product-level carbon footprints, Scope 3 emissions, recipe impacts and consumer-facing carbon labels. The Ella's Kitchen case shows that Foodsteps calculated emissions for more than 200 products across the company's UK and international portfolio, helping identify hotspots and support reformulation, supplier engagement and packaging decisions. This is relevant because it connects product data with sustainability decision-making, but it does not appear to track nutrient mass balance or co-product valorisation through plant-protein processing. Foodsteps also worked with Azzurri Group to assess recipe carbon footprints, identify supply-chain hotspots and support recipe reformulation. The case describes the use of Foodsteps data to support menu reformulation and lower-impact product decisions. The focus remains on carbon and LCA, and lacks information on nutrient flows, protein retention, fractionation yields or by-product valorisation.

Kezzler[67]***:*** Kezzler provides digital traceability and connected product solutions. Its FrieslandCampina "grass-to-glass" case shows how FRISO infant formula was tracked from farms in the Netherlands through production, quality checks, export, distribution and retail. The system uses unique digital IDs and integrates with ERP, manufacturing, warehouse and distribution systems. This is highly relevant for transparency and value-chain data connection, but it focuses on origin, authenticity, logistics and quality verification rather than nutrient transformation, processing simulation or co-product valorisation.

beCPG[68]**:** beCPG is a Product Lifecycle Management (PLM) and formulation software for food and consumer product development. It supports recipe formulation, nutrition calculation, allergens, costs, claims, quality data, yields and product versions. This is relevant for the formulation and final-product side as it can support recipe design and nutritional calculation. However, it does not appear to offer a full farm-to-fork nutrient mass-balance model or plant-protein processing simulation from crop input to ingredient fractions and co-products.

CSB-System[69]**:** CSB-System provides ERP software for food companies, covering areas such as production, traceability, quality management, controlling and operational workflows. This type of system could provide the operational backbone for processors because it records batches, recipes, suppliers, production data and quality information. However, ERP systems usually manage transactions and production records. They do not normally act as nutrient-flow simulation tools that predict protein, starch, fibre or mineral retention across plant-protein processing routes.

SimaPro[70]**:** SimaPro is a life-cycle assessment tool used for environmental impact assessment in the food and beverage sector. It can model supply chains, ingredients, processing, packaging, logistics and environmental scenarios. This makes it very relevant for the sustainability assessment part of the Nutrient Tracking Tool. However, it is an LCA platform, not a dedicated nutrient tracking tool related to plant-protein processing. It can compare environmental scenarios, but it does not provide a ready-made framework for nutrient mass-balance tracking and co-product valorisation across plant-protein value chains.

Indirect competition. Indirect competition also comes from non-digital or partially digital approaches currently used by companies to make processing and valorisation decisions. These include spreadsheet-based internal models, consultancy-led process assessments, laboratory yield testing and stand-alone ERP or quality management systems. Although these approaches may partially address

[66] Foodsteps. https://www.foodsteps.earth/

[67] Kezzler. https://kezzler.com/

[68] beCPG. https://www.becpg.net/

[69] CSB-System. https://www.csb.com/

[70] SimaPro. https://simapro.com/

decision needs, they are often time-consuming, difficult to scale and limited in their ability to simulate multiple scenarios or provide a holistic overview of nutrient and mass flows across the full chain.

Barriers to market entry. Key barriers to market entry include the need to access reliable and sufficiently granular data across multiple stages of the value chain, from crop production and composition to processing parameters and output streams. Additional barriers arise from the complexity of translating scientific and technical knowledge into a user-friendly tool that can support decision-making for diverse stakeholder groups, including producers, processors and logistics actors. Entry is further complicated by the need to build trust in model assumptions and outputs, demonstrate practical value in real processing environments and ensure compatibility with existing data practices, workflows and digital systems already used by companies.

Key takeaways. Overall, the market opportunity for the Nutrient Tracking Tool lies in a growing but still fragmented space for digital tools that support traceability, optimisation and value creation in agri-food systems. However, successful market uptake will depend less on offering generic software functionality and more on delivering a specialised, application-relevant tool with validated outputs, clear usability and demonstrable decision-support value for plant-protein processing. For this business case, it implies a strong strategic fit for a farm-to-fork nutrient tracking and simulation tool that can help stakeholders better understand nutrient flows, predict ingredient and co-product outputs and identify leverage points for further valorisation, initially in faba bean processing and potentially later across a wider range of protein crops.

1.4. Technology Solution: The Nutrient Tracking Tool

The Nutrient Tracking Tool is an interactive end-to-end decision-support and simulation system designed to quantify and model nutrient flows from the farm to processing and food manufacturing. The tool architecture is built to address the highly fragmented flow of information across the plant-protein value chain. It functions as a unified farm-to-fork model as it links early-stage crop data with downstream processing parameters to accurately predict how nutrients move across the supply chain, moving the sector from reactive measurement to proactive management.

The tool acts as a bridge between the field and the factory by integrating compositional considerations much earlier in the production cycle.

- **Pre-harvest integration:** It utilises modelling, drone imaging, and NDVI (Normalised Difference Vegetation Index) alongside predictive modelling to map crop density and forecast nutrient potential early in the growing cycle.
- **Compositional analysis:** It characterises dynamic nutrient profiles, such as protein, starch, and lipids, at various stages of the value chain.
- **Aligning practices:** By combining this field-level data with processing parameters, producers gain upstream visibility into the quality characteristics of raw materials, ensuring that agronomic choices align closely with strict processor requirements.

A core capability of the tool is its capacity to perform mass-balance calculations and simulate processing scenarios before users commit to costly physical resources or operational trials.

- **Processing path simulation:** The tool architecture allows stakeholders to build and test models for different processing pathways, such as comparing the outcomes of wet versus dry fractionation and milling.
- **Yield and economic calculations:** By modelling nutrient mass balances across processing steps, the tool calculates the expected weight of protein and starch, allowing processors to predict ingredient yields, assess costs and optimally allocate crop batches for the highest financial return.

The tool does not solely focus on economic optimisation; it is built with integrated sustainability analytics which verifies the accuracy of environmental data.

- **Life Cycle Assessment (LCA):** NTUA provides specialised LCA data and analytics to simulate the environmental impact of various scenarios.
- **Resource tracking:** The tool simulates energy calculations, water usage and overall environmental footprints (such as carbon impact) for different processing configurations and agronomic decisions.
- **Circular economy:** By identifying where nutritional value can be recovered rather than lost, the tool supports circular business models by transforming waste streams into valorised co-products.

Feature	Tool Type	Integration	Modelling	Analytics	Functionality
Description	Interactive end-to-end decision-support and simulation system	Integrates compositional considerations early in production	Performs mass-balance calculations and simulates scenarios	Integrated sustainability analytics supported by NTUA	Links field data, runs scenario comparisons

Figure 16 Nutrient Tracking Tool features

The core required functionality of the tool (defined by its Minimum Viable Performance) is to successfully link field data with processing outcomes, run alternative scenario comparisons and demonstrate this applicability on at least one representative crop, with the project initially focusing heavily on faba beans. Specific functional use cases include:

- **Product development & R&D:** The tool provides traceable ingredient profiles that link upstream decisions to final product suitability. For example, it can predict if a specific process will yield an 85% protein isolate suitable for a nutritional beverage or a 75% protein concentrate. Because the 75% concentrate has higher starch and different solubility, it would fail in a beverage but could be successfully channelled into a protein bar, thereby reducing R&D trial-and-error.
- **Logistics & Supply chain planning:** By forecasting the exact volumes of ingredients and co-products, the tool helps logistics coordinators proactively manage storage, transport and processing schedules, reducing supply bottlenecks.
- **Post-harvest crop allocation:** Producers can use the tool's predictions on protein content to transform simple crop sorting into a profitability exercise, deciding whether a specific harvest is best suited for high-value food ingredients or animal feed based on predicted composition.

1.5. Key Challenges Identified

The key challenges identified for the commercialisation of the Nutrient Tracking Tool are derived from the problem definition, market opportunity and stakeholder segmentation analysis:

- **Data access:** The first challenge is the need to access reliable and granular data across multiple value chain stages. The tool depends on the integration of information from crop production, compositional analysis, processing parameters, logistics and output streams. However, these data are often generated separately by different actors and may vary in format, quality and level of detail. Without reliable and sufficiently granular inputs, the tool's ability to model nutrient flows, estimate ingredient and co-product streams and support meaningful scenario analysis would be limited.
- **Digital fragmentation:** The second challenge is the fragmentation of existing digital solutions. Current tools may support traceability, nutrient calculation or process modelling in isolation, but they generally do not connect these functions into a single farm-to-fork framework

tailored to plant-protein processing. This fragmented digital landscape reinforces the wider information gap in the sector and prevents stakeholders from understanding how field-level variability influences processing efficiency, ingredient quality and valorisation potential.

- **Technical complexity:** The third challenge relates to technical complexity and user adoption. The Nutrient Tracking Tool is based on scientific models, nutrient mass-balance logic and scenario-based simulations. While these capabilities are central to its value, they also create a risk that the tool may be difficult for non-technical users, particularly primary producers, to interpret and apply directly. For this reason, advisors, consultants and researchers are expected to play an important intermediary role by translating complex model outputs into practical recommendations and actionable insights.

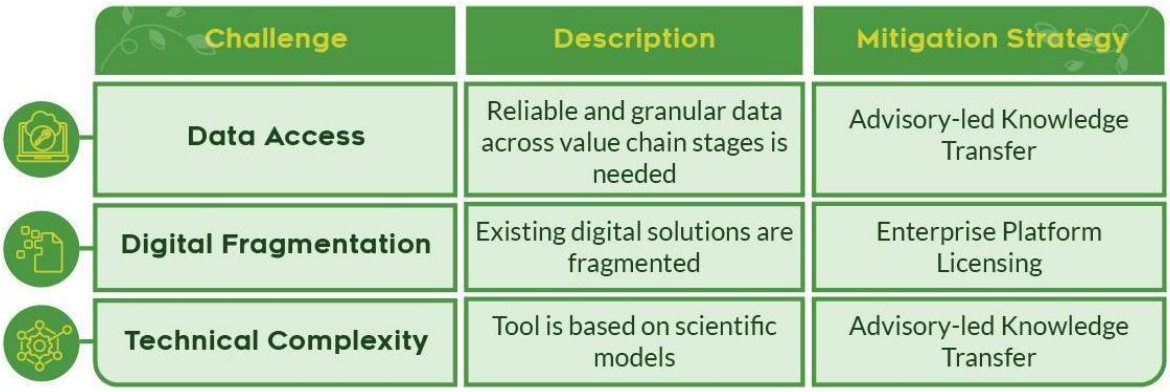


Figure 17 Challenges and Mitigation Strategies for The Nutrient Tracking Tool

The mitigation strategy should align the tool's deployment model with its intended purpose, target users and long-term adoption goals. An advisory-led Knowledge Transfer approach can help reduce adoption barriers by positioning the tool as a free-to-use public-good asset supported through advisory services. This removes cost barriers for producers and SMEs, while allowing organisations to support interpretation, training and practical application. Widespread use can also contribute to a data flywheel, where anonymised data generated through use helps improve the tool's predictive accuracy over time.

In parallel, an Enterprise Platform Licensing model can help address the needs of larger, vertically integrated food manufacturers and ingredient processors. These actors may require deeper integration with proprietary supply chain, processing or ERP systems, as well as dedicated technical support and custom functionality. This model can help reduce systemic fragmentation within larger corporate environments while creating a sustainable revenue stream to support the tool's ongoing development, maintenance and expansion.

1.6. Customer Segmentation

The Nutrient Tracking Tool is designed for a diverse set of stakeholders whose decisions are closely interconnected across the "end-to-end" plant-protein value chain. While the goal is to improve the efficiency and valorisation of the entire plant-protein sector, the immediate users and adopters of the system are the actors involved in primary production, processing, product formulation, supply chain logistics and agricultural advisory services. Identifying these distinct segments allows the tool to deliver targeted, data-driven recommendations that translate technical outputs into compelling business value for each group.

Table 7 Value proposition analysis for IPS4.2 business case customer segments

Customer/ Actor	Paid addressed	Gain created
Producers (farmers, growers)	Conventional agronomic tools focus only on yield or biomass;	Quantified understanding of crop nutrient potential; data-driven post-

	lack of visibility into how field decisions affect downstream ingredient value and variable crop pricing.	harvest allocation (e.g., high-value food vs. feed) to maximise financial returns.
Processors, ingredient manufacturers	Reliance on costly physical trials; unpredictable ingredient yields; isolated processing models that ignore raw material variability.	Mass-balance visibility to predict yields before processing; scenario simulation (e.g., wet vs. dry milling) to optimise protein/fibre recovery and reduce waste.
Food manufacturers (ingredient and end-product developers)	High R&D formulation risk and trial-and-error; traditional supplier specifications offer limited visibility into upstream nutrient variability.	Source-to-ingredient insights for consistent performance; ability to precisely select raw materials matching end-product needs.

1.7. Value Propositions Statements

The success of the Nutrient Tracking Tool depends on its ability to deliver distinct and tangible benefits to each stakeholder group. A strong value proposition translates the tool's technical features into compelling business solutions that solve specific problems for each stakeholder group.

Producers (farmers and growers): The Nutrient Tracking Tool helps producers and growers understand and increase the protein and nutrient value of their crops, moving beyond a narrow focus on total yield. By quantifying how field conditions, crop density and management practices influence nutritive potential, the tool supports earlier assessment of crop quality, reduction of antinutritive compounds and management of low-value variability through scenario modelling. Unlike conventional agronomic tools that primarily focus on yield or biomass, it links field-level decisions to downstream ingredient value and supports more informed crop management for plant-protein value chains.

Processors and ingredient manufacturers: The Nutrient Tracking Tool helps processors and ingredient manufacturers predict ingredient yields and optimise processing efficiency before committing to costly production trials. By modelling nutrient mass balances across processing steps, the tool supports improved recovery of protein, fibre and valuable co-products, while helping to reduce antinutritive compounds and processing losses through scenario-based optimisation of key processing parameters. Unlike isolated processing models or spreadsheets that overlook raw material variability, the tool connects field-level crop characteristics with factory-level processing outcomes, enabling more accurate and integrated decision-making across the plant-protein value chain.

Food manufacturers (ingredient and end-product developers): The Nutrient Tracking Tool helps ingredient and food manufacturers select raw materials that deliver consistent nutritional and functional performance in final products. By providing source-to-ingredient nutrient insights, the tool supports improved nutritive quality, greater formulation predictability and more reliable product development. It also helps reduce antinutritive effects and formulation risk by anticipating ingredient behaviour before costly development work begins. Unlike traditional supplier specifications or lab-only testing, it offers stronger visibility into upstream nutrient variability and links raw material characteristics to final product performance.

With the tool's value clearly defined for its key stakeholders, the next step was to outline a plan for its initial development and validation through a Minimum Viable Performance (MVP).

1.8. MVP Definition and Business Case Validation Metrics

Minimum Viable Performance: The MVP for the Nutrient Tracking Tool was defined as a functional decision-support tool with a specific and targeted scope. Its core required capabilities include:

- Functionality to link field-level data with processing and fractionation outcomes for plant-protein crops.
- Demonstration of its applicability through at least one representative plant-protein value chain.
- Capability for stakeholders to compare alternative production and processing scenarios and assess their impact on ingredient yields and valorisation potential.

The following table represents the quantitative business validation metrics. These metrics capture the tool simulation targets needed to track the Nutrient Tracking Tool's adoption and operational success.

Table 8 Business case validation metrics for IPS4.2

MVP dimension	Target value/ Validation requirement	Value reached in validation
Scenario testing	Number of full end-to-end mass-balance scenarios run	8
Data integrity	Completeness of data inputs required for successful simulations	Complete
System integration	Number of value-chain stages connected in a single model run (e.g., field-processing-formulation)	4-6
User adoption	Number of active pilot users across different stakeholder groups	10

Business validation approach: The business validation approach for the Nutrient Tracking Tool is centred on the successful demonstration of the capabilities defined in the MVP scope. These capabilities allow the tool to confirm the technical feasibility of the business opportunity hypothesis, proving that the tool can successfully predict nutrient flows, optimise processing decisions and improve valorisation outcomes across the supply chain. Validation is achieved by demonstrating the tool's ability to link the value chain, provide actionable, scenario-based insights and deliver on the core promise of integrating data from the field to the factory.

1.9. Business Modelling Workshop

As outlined in D5.3 Exploitation, IPR and Business Models Catalogue I, the VALPRO Path business modelling methodology follows an iterative **CAPTURE – CO-CREATE – DELIVER approach** designed to support the development of collaborative business models for IPS-related business cases. The VALPRO Path business modelling methodology was applied to the IPS4.2 Nutrient Tracking Tool business case in cooperation with TEAGASC. The workshop organised in M40 focused on the development of a decision-support tool designed to optimise the plant-protein value chain from farm to fork, with particular attention to crops such as faba bean. The objective was to explore how nutrient-flow data, processing information and sustainability considerations could be connected into a practical framework capable of supporting better decisions across production, processing and end-use applications.

Participants applied the **VALPRO Path Business Modelling Methodology** to define the main activities, stakeholders, relationships and value propositions associated with the Nutrient Tracking Tool. The discussion covered several stages of the value chain, including pre-harvest monitoring, cultivation, post-harvest handling, processing and end-user application. This helped clarify where the tool could create value, how different actors would contribute data or expertise, and how the resulting insights could support improved nutrient tracking, processing optimisation and co-product valorisation.

Several technical and operational methods were discussed during the workshop. These included the use of drones, mapping and early-stage crop monitoring to support yield estimation, crop density assessment and nutrient-potential prediction before harvest. Participants also considered the role of interactive simulations in analysing supply-chain scenarios, comparing different processing configurations and assessing the implications of alternative technologies, such as wet versus dry

milling. These simulation capabilities were seen as important for helping stakeholders evaluate potential outcomes before committing resources to physical trials or full-scale processing decisions.

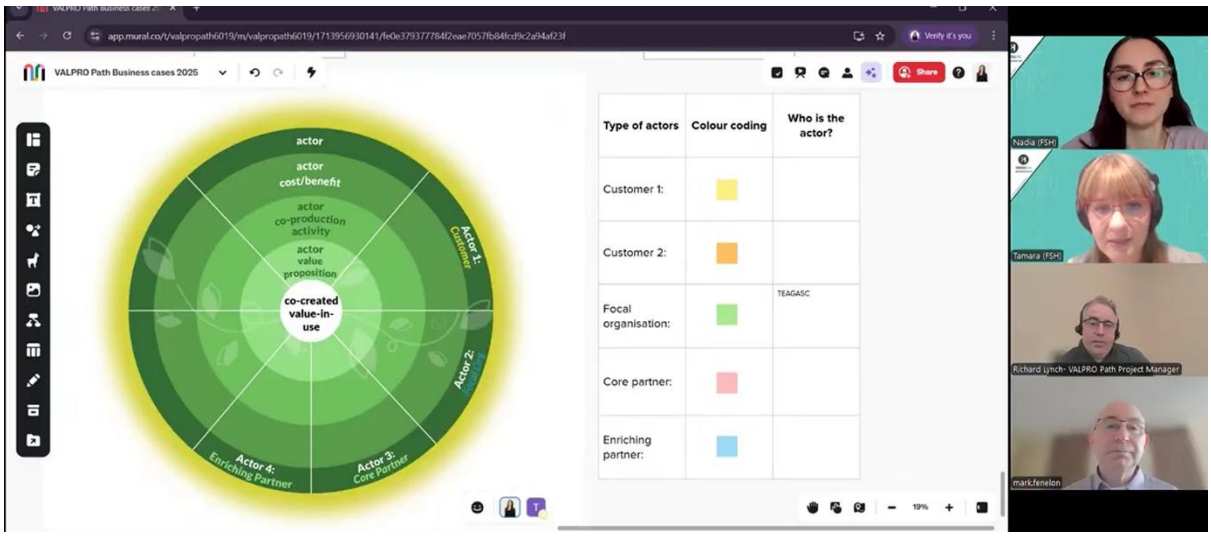


Figure 18 Business modelling workshop for IPS4.2 business case

The workshop also identified key partners and stakeholder groups needed to support the development and validation of the tool. TEAGASC was positioned as a central actor in guiding the nutrient tracking and advisory dimension of the business case, while the National Technical University of Athens (NTUA) was identified as an important partner for data integration and Life Cycle Assessment (LCA) activities. In addition, producers, ingredient manufacturers, processors, food companies and supply-chain stakeholders were recognised as important users and contributors, as their data, feedback and operational needs would be essential for validating the tool's relevance.

This workshop helped refine the business model logic for IPS4.2 by linking technical development with practical stakeholder needs. It confirmed the importance of an integrated nutrient tracking approach that can support decision-making across the value chain, improve visibility of nutrient and co-product flows and provide practical insights for producers, ingredient manufacturers and food companies seeking to optimise plant-protein value creation.

1.9.1. Value Chain Innovation Mapping

To ensure this innovation delivers maximum impact, it is important to define its precise position within the value chain and clearly identify its primary stakeholder segments. This strategic clarity ensures that tool development aligns directly with user needs and that value is created at the points where it is most needed.

The Nutrient Tracking Tool is strategically positioned as an "end-to-end" solution, providing a continuous, data-driven framework that links crop production, processing and end-use applications.

It introduces specific innovation and adds value at each stage. The tool supports decision-making across the full value chain, from pre-harvest monitoring to final product development. At the pre-harvest and field monitoring stage, it integrates drone imaging with predictive modelling to assess crop density, estimate nutrient potential and evaluate the impact of agronomic choices. This enables early-stage analysis of varietal selection and provides insights into the downstream economic implications and environmental footprint of decisions made in the field. During cultivation and harvest, the tool combines crop sampling data with simulation models to bring compositional considerations much earlier into the production cycle. In this way, producer practices can be better aligned with processor requirements, while providing upstream visibility into the quality characteristics of incoming raw materials. In the post-harvest handling and allocation phase, the tool

calculates the expected weight of protein and starch within a crop batch. This allows producers to better determine the economic value of the batch and make data-driven decisions on its most suitable application, such as high-value food ingredients or animal feed, in order to maximise financial returns.

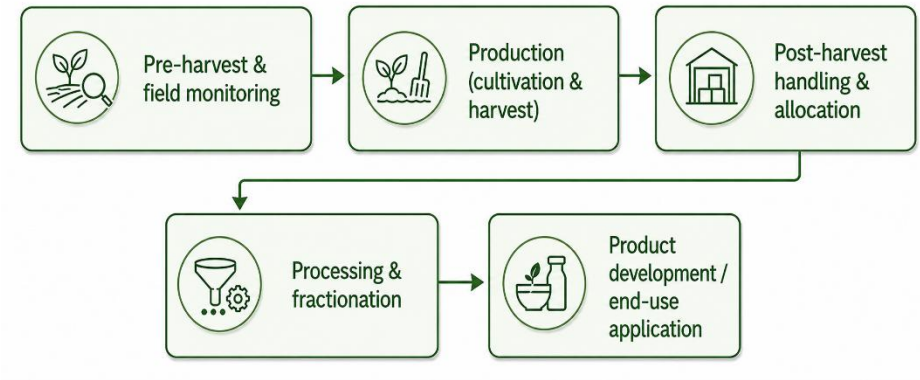


Figure 19 Value chain activities in IPS4.2 business case

At the processing and fractionation stage, the tool applies mass-balance modelling and process simulations to predict yields, assess costs and support the valorisation of co-products. It also enables processors to simulate energy requirements, water use and the overall environmental impact of different processing configurations. As a result, processing pathways can be optimised against both economic and sustainability objectives before physical resources are committed. Finally, in product development and end-use applications, the tool provides traceable ingredient profiles that link upstream decisions directly to final product suitability. This creates a clearer understanding of how field-level, post-harvest and processing decisions influence the quality, functionality and potential application of ingredients in final food products.

The tool is designed to serve a diverse set of stakeholders whose decisions are interconnected across the value chain. The primary customer segments for the tool span the agricultural, processing, food manufacturing and advisory parts of the value chain.

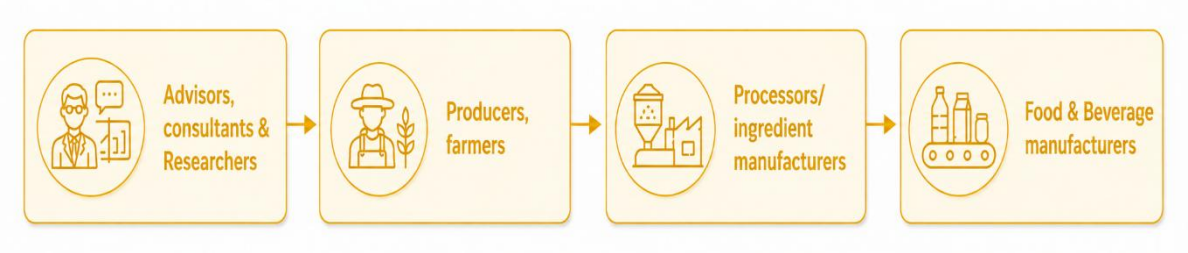


Figure 20 Stakeholders in IPS4.2 business case

Producers, including farmers and growers, represent an important user group, as they are responsible for crop cultivation and harvesting and are primarily focused on optimising yield, improving quality and maximising the market value of their crops. **Processors and ingredient manufacturers** form another key customer segment. These are companies that convert raw agricultural commodities into refined ingredients, such as protein isolates, protein concentrates and flours. For this group, the tool can support better planning, yield prediction, cost assessment and decision-making around the most suitable processing and fractionation pathways. **Food and beverage manufacturers,** particularly R&D teams and product formulators, are also relevant users. They rely on plant-based ingredients to develop consumer products and therefore require reliable information on ingredient composition, functionality, quality and suitability for specific end-use applications. By providing traceable ingredient profiles, the tool can help these users connect upstream production and processing decisions with final product development needs. Finally, **advisors, consultants and researchers** are a critical

intermediary segment. Given the technical complexity of the tool, these experts can help interpret its outputs and translate them into practical, actionable insights for producers and other value-chain actors. In this way, they may serve not only as direct users, but also as an important channel for wider adoption and implementation.

Identifying these distinct stakeholder segments necessitates the development of targeted value propositions that address the unique challenges and goals of each group.

The value chain innovation mapping also shows how **information and value are generated, exchanged and used** across the full crop-to-product pathway. At the upstream stage, producers, breeders, agronomists and researchers generate key data on varietal characteristics, crop density, expected yield, nutrient potential and agronomic performance. This supports better decisions on varietal selection, cultivation practices and harvest planning, while helping producers understand the economic and environmental implications of their choices. During cultivation, harvest and post-harvest handling, crop and compositional data are translated into practical indicators of raw material quality and value. By estimating protein, starch and other relevant fractions, the tool helps determine the most suitable use of each crop batch. It also gives processors earlier visibility into incoming raw materials and supports better planning. At the processing and fractionation stage, processors and ingredient manufacturers use mass-balance modelling and process simulations to predict yields, assess costs, estimate energy and water use and evaluate co-product valorisation. Further downstream, food and beverage manufacturers use traceable ingredient profiles to support product development, formulation and end-use application. These profiles link ingredient quality and functionality back to upstream and processing decisions, helping manufacturers assess suitability, nutritional value, sustainability potential and market positioning.

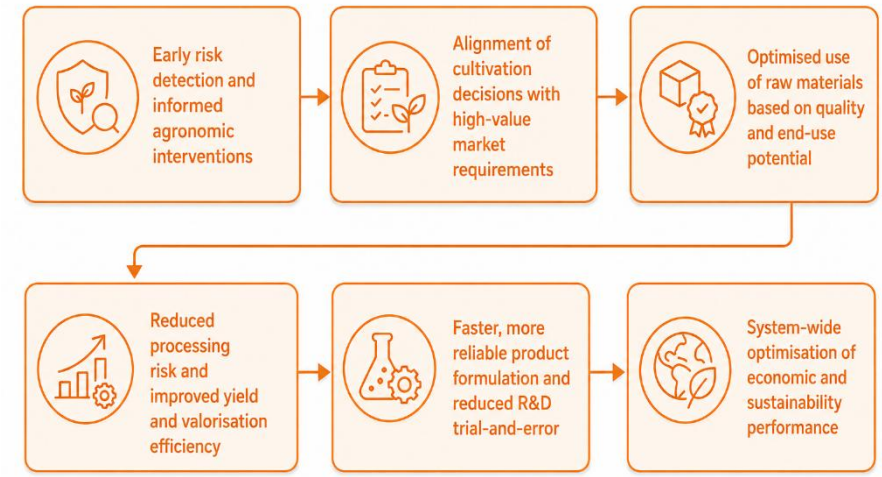


Figure 21 Information and value in IPS4.2 business case

Overall, the figure shows that the tool creates value by improving transparency, coordination and decision-making across the value chain, enabling stakeholders to capture higher value from crops, ingredients and co-products.

1.9.2. Business Model Radar

The Business Model Radar for the IPS4.2 presents a collaborative, co-creation system designed to optimise the plant-protein value chain by mapping out the roles of various stakeholders around a shared central value proposition: a validated decision-support tool for nutrient tracking, processing optimisation and sustainability assessment. The focal organisation, TEAGASC, leads the model's development, validation, tool maintenance and knowledge transfer. This is directly supported by core partners, such as plant-protein ingredient producers and processors, who provide real-world

processing data and validate model outputs in true operational contexts. Enriching partners, including NTUA and industry supply-chain stakeholders like PepsiCo, contribute specialised data analysis, LCA integration and practical industrial validation feedback. This coordinated effort delivers actionable value to the primary customers, food and beverage manufacturers and product developers, who can leverage the tool's predictive capabilities for more reliable ingredient selection, optimised product formulation testing and significantly reduced R&D trial-and-error costs.

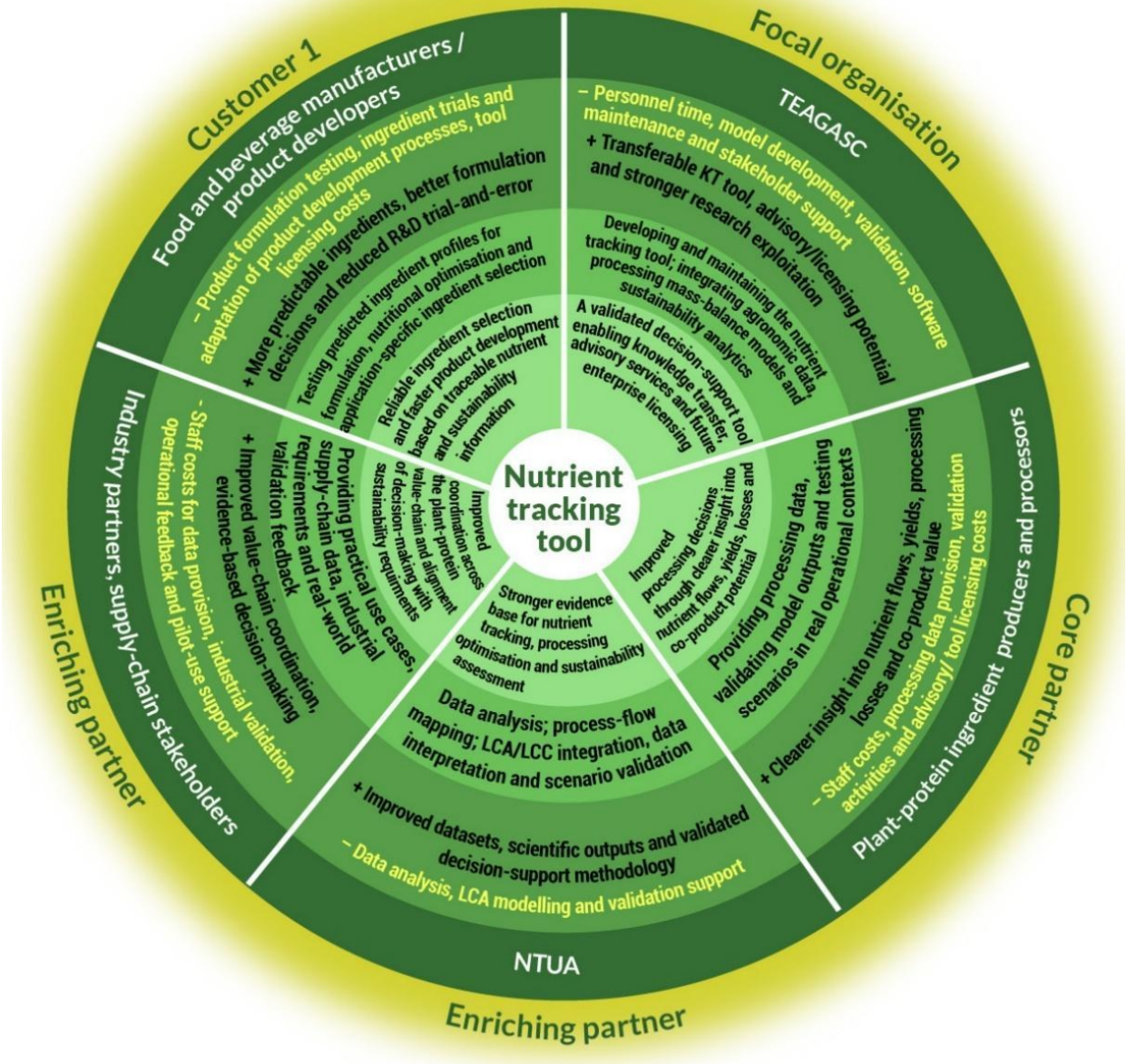


Figure 22 Business Model Radar for IPS4.2 business case

From a Business Model Radar presents a collaborative value-creation system with TEAGASC acting as the focal organisation, coordinating tool development, validation and knowledge transfer, while core partners, enriching partners, industry stakeholders and customers contribute data, expertise, testing environments and real-world feedback. In return, each actor receives tailored value. Overall, the tool's business potential depends on this ecosystem approach, where value is co-created through shared

inputs, mutual benefits and coordinated decision-making across the plant-protein ingredient value chain.

1.10. Business Model Analysis and Options Considered

Selecting a sustainable business model is needed to ensure the tool achieves its intended impact. The model should align with the tool's purpose, the nature of its target users and the project's overarching knowledge-transfer objectives. Two primary business models were considered for the Nutrient Tracking Tool.

Primary model: Advisory-led knowledge transfer (KT)

This model positions the tool as a "public-good asset" that is free to use and leveraged primarily through advisory services and knowledge transfer (KT) departments. The strategic focus is on maximising sector-wide impact and adoption rather than on direct revenue generation.

The strategic advantages of this model include:

- **Rapid adoption and impact:** By removing cost as a barrier, this model encourages widespread use by producers, SMEs and advisors, accelerating the tool's positive influence on the sector's efficiency and sustainability.
- **Reinforces core mission:** A free-to-use KT model aligns perfectly with the public service and knowledge transfer mandate of a research-focused organisation like TEAGASC, reinforcing its role as a central innovation hub.
- **Creates a data flywheel:** Widespread use generates a continuous flow of anonymised data. As this dataset grows, the tool's predictive accuracy improves, creating a compounding value proposition that builds a strong, defensible competitive advantage.

Alternative model: Enterprise platform licensing

This complementary model targets large, vertically integrated food manufacturers or ingredient processors who require deeper integration and dedicated support. It involves licensing the tool's platform for use within a single corporate ecosystem for a fee.

The potential benefits of this model include:

- **Revenue generation:** A licensing fee structure would create a direct revenue stream to fund the tool's ongoing development, maintenance and expansion into new functionalities or crop types.
- **Deep integration:** This model would facilitate the custom integration of the tool with a company's proprietary systems (e.g., ERP, supply chain management), maximising its value within that specific operational context.
- **Dedicated support:** Enterprise clients could be offered premium services, including dedicated technical support, user training and the development of custom features tailored to their unique needs.

This analysis of both primary and alternative models provides the foundation for a final, synthesised recommendation.

1.11. Recommended Business Approach

Based on a thorough analysis of the tool's purpose, target audience and long-term strategic goals, the final recommendation is a hybrid business model. This approach is designed to maximise both sector-wide impact and long-term financial sustainability, synthesising the strengths of both models considered.

The recommended strategy is a two-pronged approach:

First, TEAGASC as the business case owner should proceed with the **primary advisory-led knowledge transfer (KT) model**. This ensures the tool remains a free-to-use public asset, serving the broad community of producers, SMEs, advisors and researchers. This approach will drive rapid adoption, fulfil the project's knowledge-transfer mission, and build a powerful data flywheel that enhances the tool's value over time.

Second, in parallel, the project should actively **explore enterprise licensing opportunities** with large commercial partners. For vertically integrated companies seeking a more bespoke, deeply integrated solution with dedicated support, a paid licensing model offers a clear value proposition and creates a sustainable revenue stream to fund the tool's continuous improvement and expansion.

This dual-pronged strategy ensures the Nutrient Tracking Tool acts as both a public-good catalyst for sector-wide innovation and a commercially sustainable platform, cementing its role as the foundational data infrastructure for the future of the plant-protein industry.

Annex 4. IPS5.2 Business Case Report

VALPRO path.

NEW VALUE LANDSCAPES FOR PLANT PROTEIN PATHWAYS

IPS5.2 Business Case Report

Hermetic Bagging Systems to Enable Cross-Regional Applications for Plant Proteins

valpropath.eu

Co-funded by the European Union

1. Hermetic Bagging Systems to Enable Cross-Regional Applications for Plant Proteins (IPS5)

Business opportunity hypothesis

If a hermetic bagging system is used for transporting identity-preserved legumes (e.g., peas, lentils, chickpeas) and protein fractions (flour, concentrate and isolate), then nutrient stability, shelf-life and pest protection will improve, enabling waste reduction, improved traceability and access to new markets, while supporting future integration with on-farm processing for added value and farmer engagement.

IPS	**IPS5** - Demonstrating the value of building synergies with cross regional applications
Business-case focus	**B2B:** Targeting post-harvest preservation, localised storage and field-to-fork traceability for producers, processors and logistics actors.
Lead geography	Argentina (initial development and trials) and Italy (coordination of trials)
Target crops/ materials	Legumes (peas, lentils, chickpeas), soybeans, specialty grains, organic products and food-grade flours.
Technology solution	A modular hermetic bagging system using 1-ton capacity reusable raffia big bags with high-barrier plastic liners, integrated with controlled atmosphere (CO2) treatment, airtightness testing and digital QR-code traceability.
Expected outcome	A chemical-free, modular storage and transport system that minimises product loss, preserves product identity and quality, reduces packaging waste, reduces storage costs and connects physical products to digital field data across the supply chain.

The business opportunity for IPS5.2 assumes that specialised hermetic bagging systems can significantly improve the storage and cross-regional transport of identity-preserved legume-based raw materials and processed fractions. Rather than competing as a conventional packaging product, the proposed solution combines **physical packaging through reusable one-tonne bags and high-barrier liners, chemical-free preservation through controlled-atmosphere and anoxic conditions, automated airtightness verification and digital supply-chain visibility through bag-level QR-code traceability.** The solution creates value for farmers and cooperatives by enabling crops and flours to be treated, packaged and stored close to the point of production without requiring investment in expensive centralised silos. Its modular and palletised format also supports smaller batches, seasonal volumes and direct farm-to-processor deliveries, making it particularly suitable for decentralised, organic, gluten-free and identity-preserved supply chains. For processors, millers, specialty food manufacturers and logistics operators, the system offers more consistent raw-material quality, reduced exposure to moisture fluctuations, insects, oxidation, fungal contamination, product mixing and gluten cross-contamination. Controlled-atmosphere treatment can also reduce reliance on chemical fumigants, while the traceability platform provides verified information on product origin, production practices, storage conditions, handling and shipment movements.

IPS 5.2 can be positioned as **an integrated B2B preservation and traceability solution** comprising reusable packaging, specialised liners, portable sealing and gas-injection equipment, airtightness testing, digital traceability services, technical support and potentially liner take-back or recycling arrangements.

1.1. Problem Statement

Current storage and transport practices for plant-protein raw materials and pulse-derived ingredients, including flours, concentrates and isolates, do not always provide adequate protection for product quality, identity and traceability throughout the supply chain. When legumes, pulses and processed fractions are handled in bulk, stored in shared facilities or transported in conventional packaging, they are **exposed to multiple risks, including moisture fluctuations, pest infestation, oxidation, microbial contamination, physical damage, product mixing and loss of lot identity.** These risks are particularly significant for food-grade, organic, gluten-free and identity-preserved materials, where nutritional quality, functional properties, purity and documented origin directly influence commercial value and market acceptance. Inadequate moisture and temperature control may also encourage fungal growth and increase the risk of mycotoxin development, while oxygen exposure can contribute to rancidity and deterioration, particularly in higher-fat crops and ingredients.

Beyond product deterioration, **conventional storage infrastructure creates important operational and economic barriers.** Traditional silo systems are capital-intensive, fixed and centralised, making them less accessible to small-scale farmers, cooperatives and regional processors handling limited, seasonal or differentiated volumes. Producers may therefore need to transport materials over longer distances immediately after harvest, increasing logistics costs, handling requirements and exposure to quality losses. Conventional bulk systems are also poorly suited to smaller identity-preserved batches and cross-regional shipments, as they may require the commingling of products from different farms, crop varieties, production systems or quality categories.

Traceability represents an additional challenge. Information on crop origin, production practices, harvest conditions, storage parameters and transport history is often managed separately from the physical product, using paper documentation or fragmented digital systems. This can create data gaps and make it difficult to verify sustainability claims, production protocols, pesticide use, geographical origin or environmental indicators such as carbon and water footprints. Limited bag- or lot-level traceability also reduces the ability to respond quickly to quality incidents, recalls, contamination events or customer complaints. Shared storage and transport infrastructure may further increase the risk of cross-contamination with allergens or gluten-containing materials, potentially compromising the requirements of gluten-free and specialised food production.

Conventional post-harvest preservation may also rely on **chemical fumigation treatments,** such as phosphine, to control storage pests. While effective, these treatments may be unsuitable for organic production, residue-sensitive markets or buyers seeking reduced-chemical supply chains. Their use can also involve additional operational requirements related to worker safety, treatment control and regulatory compliance. At the same time, non-chemical alternatives are not always available in a modular and economically accessible format for individual farms, cooperatives or regional processors.

Existing commercial solutions typically address only individual parts of this problem. Hermetic bags and liners focus mainly on physical protection, controlled-atmosphere systems on pest control and preservation, monitoring tools on storage conditions and digital platforms on traceability and documentation. These functions are rarely integrated into a single, user-friendly system designed specifically for plant-protein raw materials and ingredients moving through decentralised and cross-regional value chains. A clear gap therefore remains for an accessible solution that combines airtight packaging, controlled or modified atmospheres, condition monitoring, chemical-free preservation and field-to-fork traceability, while remaining compatible with existing farm, processing and logistics operations.

1.2. Objectives of IPS5.2 Business Case

The primary objective of the IPS5.2 business case is to develop and implement a modular hermetic bagging system for identity-preserved legume-based protein raw materials and ingredients. The system combines reusable, large-capacity hermetic bags with controlled-atmosphere treatment, airtightness assessment and an integrated field-to-fork traceability platform. The IPS5.2 business case addresses current post-harvest and supply chain challenges through the following core objectives:

- **To preserve product quality and extend shelf life:** Maintain the nutritional, functional and commercial properties of pulses and plant-based ingredients through an airtight, controlled atmosphere based on anoxic conditions and CO_2 treatment. By limiting exposure to oxygen and moisture fluctuations, the system reduces lipid oxidation and rancidity and may extend the shelf life of stored materials by up to 50%.
- **To enable chemical-free pest and moisture control:** Provide a natural alternative to conventional chemical fumigation treatments. The hermetic seal and CO_2 injection stabilise storage conditions, limit mould and mycotoxin development and support effective pest control, including the targeted elimination of storage pests. This approach preserves product quality without requiring chemical treatments during storage and transport.
- **To implement integrated field-to-fork traceability:** Prevent the loss of product identity, cross-contamination and commingling with gluten-containing materials that may occur in conventional bulk-storage systems. Unique QR tags connect each physical bag with digital field-level information, including fertiliser and pesticide use, harvest season, production location and geolocation data. This supports product purity, origin verification and compliance with the requirements of premium and specialised markets.
- **To improve logistics and reduce product and packaging waste:** Reduce post-harvest and transport-related losses by replacing multiple small conventional bags with reusable, large-capacity hermetic bags. The packaging model supports circularity through a reusable external raffia big bag and a recyclable high-barrier polyethylene liner. The larger format also improves the efficiency of storage, handling and cross-regional transport.
- **To ensure operational feasibility and decentralised application:** Provide a modular storage solution that enables primary producers and regional processors to treat and store pulses or ingredients close to the point of production without investing in expensive centralised silo infrastructure and transport logistics (e.g. dedicated trucks for transport). The system is designed for straightforward operation, with the inflation, filling, sealing and CO_2 injection process completed in under 15 minutes per ton.

1.3. Market Analysis

The market analysis situates the business case within two connected components: a storage unit with controlled atmosphere treatment and a traceability system from field to fork. Therefore, the business case should not be understood only as a packaging innovation, but as a broader post-harvest preservation and supply-chain visibility solution. The business opportunity assumes that hermetic bagging systems can improve nutrient stability, shelf-life and pest protection during the transport of identity-preserved pulses and plant-based ingredients.

From a market perspective, IPS5.2 sits at the intersection of several existing but only partially overlapping solution categories: hermetic crop storage bags[71], FIBC/big-bag liner systems[72], controlled

[71] PICS Hermetic Bags - https://picsglobal.com/new-home/

[72] FIBC Hermetic Liner - https://www.grainpro.com/solutions/transport/grainpro-fibc-hermetic-liner

or modified-atmosphere storage[73], post-harvest monitoring[74,75] and food traceability[76] platforms. These markets show that there is already demand for better storage, preservation and supply-chain visibility. However, available market examples suggest that these solutions are usually offered separately, rather than as one integrated system tailored to plant-protein raw materials and flours.

1. Hermetic storage and controlled-atmosphere solutions market overview

As mentioned, hermetic storage and controlled-atmosphere solutions already exist on the market, but they are mostly developed as separate product or technology categories, rather than as fully integrated systems. Existing market solutions can generally be grouped into several related categories:

- hermetic bags for grains, pulses and other dry agricultural products;
- hermetic big-bag or FIBC (Flexible Intermediate Bulk Container) liner systems;
- controlled or modified-atmosphere storage and transport solutions;
- post-harvest monitoring tools;
- digital traceability systems for food and agricultural supply chains.

This means that the IPS5.2 business case concept is not entering a completely undeveloped market. The basic market need is already visible: producers, processors and logistics actors require better ways to protect product quality, reduce pest and moisture risks, limit chemical treatment and improve visibility across storage and transport.

These needs are particularly relevant for:

- food-grade legumes and pulse-based raw materials;
- flours and other more sensitive processed materials;
- organic and specialty crops;
- gluten-free materials;
- identity-preserved supply chains;
- smaller or cross-regional shipments between farmers and processors.

However, available market examples suggest that existing solutions are usually fragmented. Fewer solutions appear to combine these functions into one integrated system specifically designed for plant-protein raw materials and ingredients moving through cross-regional, identity-preserved supply chains. This is where the IPS5.2 concept can be differentiated. For this reason, the IPS5.2 innovation should be positioned as a specialized integration of existing market categories. Its distinctive value lies in combining:

- a hermetic storage unit;
- controlled atmosphere treatment;
- airtightness verification;
- post-harvest quality preservation;
- field-to-fork traceability.

Key market drivers. The market opportunity for hermetic controlled-atmosphere storage systems is driven by several connected trends:

[73] MAP - https://id.airliquide.com/modified-atmosphere-packaging-map

[74] Centaur - https://centaur.ag/

[75] Review of monitoring systems for stored grains in a modified atmosphere - https://www.sciencedirect.com/science/article/pii/S2405844025007273

[76] European Commission – General Food Law / Traceability - https://food.ec.europa.eu/horizontal-topics/general-food-law/food-law-general-requirements_en

- **Need to reduce post-harvest losses and quality deterioration:** Storage losses remain a relevant issue for grain and pulse value chains, especially where products are exposed to insects, moisture variation, mold or poor storage conditions.
- **Demand for chemical-free pest control:** Hermetic and modified-atmosphere systems can reduce reliance on chemical fumigation by creating low-oxygen or CO_2-enriched environments that limit insect survival.
- **Growth of plant-protein and pulse-based value chains:** As Europe seeks to reduce its plant-protein deficit and increase the use of pulses and legumes, there is growing need for reliable storage and logistics systems that can preserve quality from producer to processor.
- **Greater need for traceability and supply-chain transparency:** EU food law requires food and feed business operators to have systems that identify both suppliers and customers, supporting the "one step back, one step forward" traceability principle[77].
- **Reduction of packaging waste and improved circularity:** This supports the IPS5.2 logic of replacing many smaller bags with larger hermetic bags, potentially with reusable external structures and recyclable liners.

Market challenges. Existing solutions are still **fragmented**, with some products focused mainly on hermetic storage, others on controlled atmosphere, and others on traceability or monitoring. This makes it difficult for users to access one integrated solution that protects product quality, verifies storage conditions and maintains product identity across the full chain.

Another challenge is **product-specific validation**. Plant-protein raw materials and flours may behave differently during storage and transport depending on moisture content, fat content, particle size, microbial load and sensitivity to oxidation. Therefore, the benefits of controlled atmosphere and hermetic storage need to be demonstrated separately for different product types, such as whole pulses, chickpeas, lentils, soybean, peanuts and pulse-based flours.

A further challenge is **operational adoption**. Farmers, processors and logistics actors will only adopt the system if it is compatible with existing equipment, does not create excessive manual work and provides measurable benefits in terms of shelf-life, pest control, reduced waste or easier shipment.

Market segmentation. The relevant market can be segmented along several dimensions:

- **By solution type:** hermetic storage bags, hermetic big-bag or FIBC liners, controlled or modified-atmosphere systems, post-harvest monitoring tools, traceability platforms and integrated preservation-traceability systems.
- **By value-chain stage:** post-harvest handling, storage, transport, logistics, processing and delivery to food or feed industry users.
- **By target user:** producers, farmers, cooperatives, processors, millers, logistics actors, food ingredient manufacturers and buyers of identity-preserved raw materials.
- **By crop and product focus:** grains, pulses, oil-rich crops, organic products, gluten-free materials, specialty grains, food-grade flours and plant-protein ingredients.
- **By use case:** long-term storage, short-term transport, cross-regional shipments, farmer-to-processor logistics, small-batch identity-preserved supply chains and reduced-chemical storage systems.

Competitive landscape. The competitive landscape is best described as **adjacent rather than direct**.

[77] Regulation (EC) No 178/2002 of the European Parliament and of the Council - https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX%3A32002R0178

Hermetic storage bags / farm-level hermetic bags: These are smaller hermetic bags or liners used for basic storage of grains and pulses, often intended for farmers and smaller quantities. This category includes:

- **PICS Bags**[78] - positioned as a triple-layer hermetic storage solution for protecting crops from insects, moisture and mould without the use of pesticides.
- **GrainPro Hermetic Bag Farm**[79] - primarily intended for farmers and dry commodities such as maize, wheat, rice and soybean.

Hermetic FIBC / big-bag liner systems: These solutions are closer to the physical format of IPS5.2: liners or external hermetic bags for big bags/FIBCs.

- **GrainPro FIBC Hermetic Liner/Pouch**[80] is designed for FIBC/big-bag transport and semi-bulk storage of dry agricultural commodities, offering moisture protection and gas-barrier properties.
- **PIWA Hermi Bag**[81] also works with the BigBag/FIBC system and adds optional valves for measuring O_2/CO_2, as well as the option of CO_2 insertion.

Modified/controlled-atmosphere FIBC systems: These are also essentially FIBC/big-bag solutions, but with an additional level of functionality: vacuuming, gas flushing, nitrogen/CO_2 injection, active oxygen reduction and controlled or modified atmosphere.

- **United Bags**[82] describes MAP as the vacuuming of an airtight high-barrier liner inside an FIBC and the injection of nitrogen or CO_2 to achieve residual oxygen levels below 1%.
- **LC Packaging**[83] also refers to an FIBC liner with a valve, vacuuming and the addition of N_2/CO_2.
- **vQm**[84] uses an FIBC big bag with a hermetic, vacuum-proof barrier liner and high CO_2 concentration.

2. Post-harvest monitoring and traceability solutions

- **Centaur Analytics**[85] provides post-harvest storage monitoring, including data such as in-grain CO_2, moisture, grain volume, phosphine and oxygen. This type of solution is relevant because it addresses the monitoring and quality-control layer that could support controlled-atmosphere storage.
- **iFoodDS**[86] provides food-traceability software supporting supply-chain visibility and compliance with regulatory frameworks such as the US FSMA 204 Food Traceability Rule.
- **FoodChain ID**[87] also provides technology and services for food safety, product certification, regulatory compliance and supply-chain support.

[78] PICS - https://picsglobal.com/new-home/

[79] GrainPro - https://www.grainpro.com/solutions/bags/grainpro-hermetic-bag-farm

[80] GrainPro FIBC Hermetic Liner - https://grainprousa.com/products/grainpro-fibc-hermetic-liner

[81] PIWA - https://piwaco.com/products

[82] UNITED BAGS - https://www.unitedbags.com/modified-atmosphere-packaging/

[83] LC Packaging MAP Big Bags - https://www.lcpackaging.com/en/industries-products/product-categories/big-bags-fibc/map-big-bags/

[84] VQM - https://www.vqmpackaging.com/

[85] Centaur - https://centaur.ag/

[86] iFooDS - https://www.ifoodds.com/software-solutions/food-traceability-software/

[87] FoodChain ID - https://www.foodchainid.com/

These tools show that traceability and compliance are commercially relevant, but they are not directly integrated with hermetic packaging and controlled-atmosphere treatment.

Indirect competition. Indirect competition comes from **conventional storage and transport practices** that are already familiar to farmers, processors and logistics providers. These include standard 25 kg bags, non-hermetic big bags, bulk transport, silos, warehouse storage, conventional fumigation and manual or spreadsheet-based traceability systems.

Although these alternatives may be cheaper or easier to adopt in the short term, they do not necessarily provide the same combination of product identity preservation, moisture and pest protection, reduced chemical use and traceability. For food-grade legumes, flours, organic products and gluten-free materials, this limitation may become increasingly important where buyers require stronger quality assurance and documentation.

Barriers to market entry. Key barriers to market entry include the need to prove that the system works under **real storage and transport conditions**, not only in controlled trials. This includes demonstrating airtightness, stable atmosphere conditions, pest control, moisture stability, reduced spoilage and preserved product quality during cross-regional transport.

Another barrier is **cost**. The system may require specialised liners, sealing equipment, gas treatment, monitoring devices and traceability infrastructure. Adoption will depend on whether these costs can be justified by lower product losses, reduced handling time, improved shelf-life, access to higher-value markets or reduced need for chemical fumigation.

Additional barriers include **integration with existing farm and processor workflows, user training, data reliability, recyclability of packaging components and the ability to demonstrate clear added value** for different customer groups. For smaller producers, the business case will need to show that the solution is not only technically effective, but also practical and economically accessible.

Key takeaways. Overall, the market opportunity for IPS5.2 lies in a growing but still fragmented space for post-harvest preservation, controlled-atmosphere storage and traceability systems. Existing technologies show that the market already values hermetic storage, quality preservation, chemical-free pest control and supply-chain visibility. However, these functions are usually offered separately.

For IPS5.2, the strongest opportunity is therefore not to compete as a generic packaging product, but to offer a specialized B2B solution for plant-protein supply chains. Its value lies in combining hermetic big-bag storage, controlled-atmosphere treatment, airtightness verification and field-to-fork traceability in one integrated system.

Case studies

The European market already includes several commercial solutions that incorporate individual elements of the IPS5.2 concept. However, the available evidence suggests that few existing systems combine all these functions with bag-level digital field-to-fork traceability in a single integrated offer, which remains an important point of differentiation for IPS5.2.

Nox Storage, France – Hermetic Big Bags with CO_2 Treatment[88]: Nox Storage is a French company specialising in modified-atmosphere storage and transport solutions for grains and seeds. Its Nox® Big Bag system closely resembles the physical preservation component of IPS5.2. The system consists of a strong reusable external bag and a heat-sealable internal liner that creates a hermetic storage environment. Integrated non-return valves allow air to be removed and carbon dioxide or nitrogen to be injected into the bag.

[88] Nox® (2026) *Discover the Nox® Big Bag System*, https://www.noxstorage.com/solutions/big-bag

The company markets the solution for grains, seeds, flours, powders and other dry commodities. Its commercial packages include hermetic big bags, gas-injection equipment, heat-sealing devices, gas analysers, portable CO_2 alarms and start-up support. The bags can be filled and treated within the storage facility, monitored without opening, moved using standard forklifts and reused when the internal liner remains intact.

Nox Storage offers different entry packages, including small test packages and larger systems for commercial users. This demonstrates the commercial viability of a modular business model combining consumable bags, gas-treatment equipment, monitoring instruments and technical support. The company also states that its patented process is eligible for credits under the French Ecophyto 2+ plan, showing how chemical-free post-harvest technologies can be aligned with European pesticide-reduction policies.

Nox Storage is the closest identified European commercial comparison. IPS5.2 could differentiate itself by placing greater emphasis on automated airtightness testing, farm-level agronomic data, QR-code traceability and integration with the wider plant-protein supply chain.

Control Union EcO2, the Netherlands – Commercial Controlled-Atmosphere Pest Treatment[89]: Control Union EcO2 is a Dutch company providing controlled-atmosphere pest-management systems for dry agricultural and food commodities. Its technology creates an oxygen concentration below 0.5% by flushing sealed treatment chambers, containers, silos, or bulk cargo spaces with nitrogen. The low-oxygen environment eliminates insects at all stages of development without leaving chemical residues on the treated product.

The system is used for products including flour, seeds, rice, nuts, cocoa, coffee, dried fruit, spices and tobacco. EcO2 offers both fixed and mobile treatment options and records treatment data, making the technology applicable to organic production and quality-assured food supply chains.

This case shows that European food and agricultural markets already accept controlled-atmosphere treatment as a commercial alternative to conventional fumigation. It also demonstrates that the value proposition extends beyond storage: users pay for verified pest elimination, residue-free treatment, product-quality protection, worker safety and documented process control.

EcO2 validates the chemical-free controlled-atmosphere component of the business case. Unlike EcO2's treatment chambers and containers, IPS5.2 applies the treatment to individual 1-ton bags at farm level. This would make controlled-atmosphere preservation more decentralised, modular and accessible to farmers handling smaller or variable quantities.

GrainPro and Neumann Kaffee Gruppe, Germany – Hermetic Bags in a European Identity-Preserved Supply Chain[90]: As mentioned in the competition section above, GrainPro supplies commercial hermetic bags, liners, cocoons and transport systems for dry agricultural commodities. Its hermetic bags use high-barrier polyethylene materials to restrict air and moisture exchange, prevent insect infestation, inhibit fungal contamination and preserve products without chemical fumigants.
An important example of European market incorporation is GrainPro's partnership with Neumann Kaffee Gruppe. Through NKG Kala in Hamburg, Germany, European coffee roasters can return used GrainPro hermetic bags for recycling. GrainPro reported that the European and US recycling programme collected approximately 93,000 hermetic bags in 2025.

Although this application focuses on coffee rather than legumes, it illustrates how hermetic liners are already embedded in a European high-value, identity-sensitive agricultural supply chain. Specialty

[89] Control Union EcO2 (2026) *EcO2 Solutions*, https://www.eco2.nl

[90] Grain Pro (2026) https://www.grainpro.com

coffee requires protection of origin, moisture stability, aroma, quality and lot identity during long-distance transport and storage. The recycling arrangement also shows that the environmental impact of specialist liners can be managed through coordinated collection and circular-economy partnerships.

This case validates the use of hermetic bags for premium, traceable commodities entering the European market. It also highlights the importance of end-of-life liner management. IPS5.2 could incorporate a similar take-back or recycling scheme for polyethylene liners while extending the model to European legumes, protein crops, gluten-free grains, seeds and flours.

1.4. Hermetic Bagging System Features

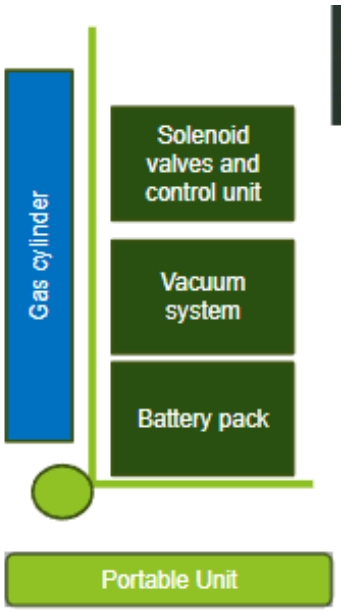
The hermetic bagging system presented is a comprehensive post-harvest storage and transport solution that combines physical product preservation with digital traceability.

Modular and sustainable packaging - The system is based on sealable, fully hermetic big bags with a capacity of approximately 1 ton. Each unit combines a reusable external bag with an innovative, recyclable internal liner, creating a more sustainable packaging solution. The bags can be filled directly in the field, reducing intermediate handling and allowing the product to be protected from the point of origin.



Figure 23 Liner design

Controlled atmosphere and portable equipment - Product preservation is supported by a portable Controlled Atmosphere and Airtightness Test Device. The unit includes a battery pack, vacuum system, solenoid valves and gas cylinder. The device first performs an automatic Pressure Decay Test to confirm that the bag is properly sealed. Once airtightness is verified, it creates a controlled, low-oxygen atmosphere inside the bag through gas injection.



Natural pest control and quality preservation - The controlled atmosphere provides several preservation benefits without the use of artificial or chemical treatments. The low-oxygen environment acts as a natural pest-control method, eliminating the need for toxic fumigants. The hermetic seal also stabilises moisture levels and helps prevent mould and mycotoxin development during storage and transport. The system limits oxygen exposure, which reduces fat oxidation and rancidity while helping maintain the nutritional

properties of the stored material. For products with a higher fat content, the system may extend shelf life by up to 50%.

Field-to-fork digital traceability - Each storage unit is connected to a digital traceability platform through a QR code attached directly to the bag. The system records and links agronomic data, including information on the producer, field geolocation and crop production protocols. It can also capture harvest conditions, storage parameters, trading documentation, transport information and shipment tracking. Because the product is sealed at the source and monitored throughout the supply chain, the system supports identity preservation and reduces the risk of contamination, fraud, product mixing and gluten cross-contamination that may occur during conventional bulk transport.



Figure 25 Digital traceability system

Operational and logistical efficiency - Unlike conventional bulk-storage systems, the 1-ton bags function as independent and stackable storage units that can be placed on pallets. This reduces the need for silos or other specialised storage infrastructure. The palletised format also supports direct farm-to-processor deliveries with standard trucks and provides greater flexibility for less-than-truckload shipments. Mechanical handling of 1-ton units can significantly reduce labour requirements, operator fatigue and handling time compared with the manual movement of traditional 25-kilogram bags. Although the business case focuses primarily on legumes, including peas, lentils and chickpeas, as well as processed flours, the system can also be adapted for organic products, speciality grains, gluten-free crops, spices, and nuts.

1.5. Key Challenges Identified

Implementing and scaling the hermetic bagging system for plant proteins involves navigating several technical, operational and market barriers. While the technology offers a robust solution for preserving quality and traceability, the following key challenges must be addressed to ensure successful adoption across the value chain:

- **Technical consistency (hermeticity and atmosphere maintenance):** Ensuring complete, foolproof airtight sealing in everyday farm environments is critical for maintaining the benefits of hermetic storage. If the seal is compromised, the low-oxygen (controlled) atmosphere cannot be sustained, which is essential for natural pest control, preventing oxidation and extending shelf life.
- **Operational adoption and handling:** There is a challenge in balancing the need for automated, scalable packaging processes with the reality that many small-scale farmers and processors

rely heavily on manual labour. For the system to be widely adopted, it must integrate seamlessly with existing handling equipment and not create excessive manual work or require significant new infrastructure investments.

- **Product-specific validation:** Plant-protein raw materials and flours behave differently during storage and transport depending on variables like moisture content, fat content, particle size and microbial load. The efficacy of the controlled atmosphere and hermetic storage must be validated separately for different commodities, such as whole pulses, high-fat legumes and specialised pulse-based flours.
- **Validation under real-world logistics:** It is necessary to prove that the system works reliably under actual cross-regional transport conditions, not just in controlled pilot trials. The system must demonstrate that the 1-ton bags can withstand physical loading stresses during transit while maintaining airtightness, stable gas concentrations and complete product protection.
- **Market fragmentation and integration:** The current market offers isolated solutions. The challenge lies in successfully integrating all separate functions into a single, user-friendly workflow that farmers and logistics actors can easily operate.
- **Cost justification and economic accessibility:** The IPS5.2 system requires investments in specialised high-barrier liners, sealing equipment, gas cylinders (CO2), monitoring devices and traceability software. Widespread adoption will depend on successfully proving to users that these upfront costs are economically justified by reductions in product loss, elimination of chemical fumigation costs, extended shelf-life and access to premium identity-preserved markets.

To effectively mitigate these implementation barriers, the IPS 5.2 business case relies on a highly integrated and actively validated approach. Technical consistency is guaranteed by the portable Anoxia Engine, which automatically performs a pressure-decay test to verify complete airtightness prior to gas injection. Operational and cost barriers are addressed by utilising modular, palletized 1-ton bags that seamlessly fit into standard logistics, drastically reducing manual labour compared to traditional 25 kg bags and eliminating the need for expensive fixed silos. Furthermore, the system justifies its initial investments and overcomes market fragmentation by combining physical preservation and digital field-to-fork QR traceability into one cohesive B2B platform, allowing producers to capture premium value for chemical-free, identity-preserved crops. Finally, to ensure product-specific efficacy and real-world logistical reliability, the system is undergoing comprehensive cross-regional pilot trials between Argentina and Italy to validate atmosphere stability, pest mortality, and packaging durability across different pulses, peanuts, and flours under actual transport conditions.

1.6. Customer Segmentation

Given that IPS 5.2 focuses on post-harvest preservation and supply chain optimisation, the business model is primarily oriented toward **business-to-business (B2B) customer segments** rather than direct retail consumers. The most relevant target groups are those involved in storing, transporting, processing or purchasing identity-preserved plant-protein raw materials and ingredients. Below is the customer segmentation outlining the specific pains addressed and gains created for each customer group in the value chain.

Table 9 Value proposition analysis for IPS5.2 business case customer segments

Customer/ Actor	Paid addressed	Gain created
Farmers, cooperatives, and producer organisations	Infrastructure barriers, reliance on expensive, centralised silos. High risk of crop spoilage from moisture fluctuations and fungal growth.	A low-cost, on-farm modular storage solution using 1-ton bags that eliminates the need for expensive silo facilities.

	Chemical dependency, the need to use toxic pesticides for pest control. Inability to easily store, track and prove the identity of small-batch or organic crops.	Complete chemical-free pest and moisture control and natural preservation. Direct traceability via QR codes linking the physical product to field data, allowing farmers to capture premium prices for identity-preserved crops.
Processors, millers and specialty food manufacturers	Quality degradation, moisture instability, oxidation and shelf-life limitations of high-fat legumes and ingredients. High risk of gluten contamination and loss of product origin during conventional bulk transport. Difficulty ensuring raw materials meet strict food safety and pesticide-residue-free standards.	Access to better-preserved raw materials with up to 50% extended shelf life due to anoxic, controlled atmospheres. Verifiable origin data and verified storage conditions that prevent commingling and guarantee the absence of chemical pesticide residues.

1.7. Value Proposition Statements

For producers (farmers and agricultural cooperatives): For farmers and cooperatives seeking to maximise the value of their identity-preserved legumes, the IPS 5.2 hermetic bagging system offers a modular, low-cost on-farm storage and packaging solution. Unlike traditional models that require investments in expensive, centralised silos and rely on chemical fumigants for pest control, this system transforms legume storage from a risky, chemically dependent process into a secure, fully trustworthy and sustainable operation. By utilising controlled atmospheres and QR-code traceability, it empowers farmers to independently preserve crop quality, prevent moisture-driven spoilage and prove product origin, allowing them to capture higher premium prices in the market.

For processors, millers and specialty food manufacturers: For processors and food manufacturers who require consistent, high-quality and pesticide-free plant proteins, the hermetic bagging system provides a traceable, premium supply of raw materials and pulse ingredients with up to 50% extended shelf life. Unlike conventional bulk shipments that carry high risks of gluten commingling, moisture fluctuations and fungal growth, this integrated system guarantees product purity and verifies that the grain was kept in optimal condition throughout transit. Ultimately, this field-to-fork digital transparency and chemical-free preservation enable highly marketable clean-label, gluten-free and organic positioning.

1.8. MVP and Business Case Validation Metrics

The MVP validation assess the performance of the IPS5.2 hermetic bagging system across six key dimensions, including shelf-life extension, sustainability, pest control, operational efficiency, modular storage, and traceability. The results demonstrate that the system has already achieved several important technical and operational targets.

Table 10 Business validation metrics for IPS5.2

MVP dimension	Target value/ Validation requirement	Value reached in validation
Shelf-life extension	Increase shelf life by up to 50% under controlled atmosphere (anoxia) conditions without spoilage,	Up to 4 months of storage without any quality and quantity loss for the pulses stored inside the big-bags.

	oxidation (rancidity) or contamination.	
Waste reduction and sustainability	Significantly reduce post-harvest/transport losses (spoilage) and replace non-recyclable 25kg bags with 1-ton recyclable and reusable packaging.	Successfully implemented innovative packaging utilising a reusable external raffia big bag structure paired with a fully recyclable internal plastic liner.
Pest and moisture control	Guarantee no mould or mycotoxin development and avoid chemical fumigation for insect control by using a modified atmosphere that blocks external moisture.	Real-scale trials demonstrated that maintaining a>20% CO2 concentration for 10 days achieved 100% mortality in adult Sitophilus Oryzae.
Operational efficiency (manpower)	Reduce handling time (Min/ton) and operator fatigue required to download two 500 kg big bags (1 ton) compared to handling forty conventional 25kg bags.	Enabled mechanised, palletised handling of 1-ton big bags, effectively eliminating highly manual loading/unloading processes.
Compatibility and modular storage	Ensure direct filing from the field and modular storage without the need for additional investments in centralised silo facilities or specialised equipment.	Proven feasibility of utilising bags as independent storage containers that can be stationed at the farm level without silos.
Cross-regional transport and traceability	Achieve direct farm-to-processor transport with at least 95% of bags arriving intact, successfully transport 4 types of flour and ensure field-level traceability while preventing gluten commingling.	Traceability system successfully integrated via QR codes linking physical bags to geolocation and field data, ensuring identity preservation and preventing intentional contamination/ fraud and using standard truck type, with the possibility to combine pallet with pulse products and pallet with other food materials.

1.9. Business Modelling Workshop

In M45 the Business modelling workshop was conducted for IPS5.2 following the VALPRO Path methodology for collaborative business model development in cooperation with the National Institute of Agricultural Technology (INTA) and the University of Turin (UNITO) to map this process. The workshop focused on value chain innovation mapping for the hermetic bagging system, outlining the main activities, stakeholders and the information and value captured across the value chain to assess business model viability.

Participants relied on the collaborative Mural board to work through several frameworks, including the Value Chain Innovation Mapping tool, the Value Proposition Statement and the Business Model Radar. The primary goal of the workshop was to define the target customers (primarily farmers and processors), outline the main activities across the value chain and identify the specific costs and benefits of the innovation used.

A significant portion of the discussion focused on mapping the step-by-step post-harvest activities, which include filling the bags at the farm, testing their hermeticity, injecting CO2 to create a modified atmosphere and uploading information to a traceability system before storage or transport. The participants detailed how this traceability platform works using QR codes attached to the bags. Farmers can upload critical field data such as seed variety, fertiliser and pesticide use, harvest dates, moisture content and geolocation directly to the system. This field-to-fork transparency is designed to help farmers secure higher prices for their crops while guaranteeing processors that the grain was kept in optimal condition.

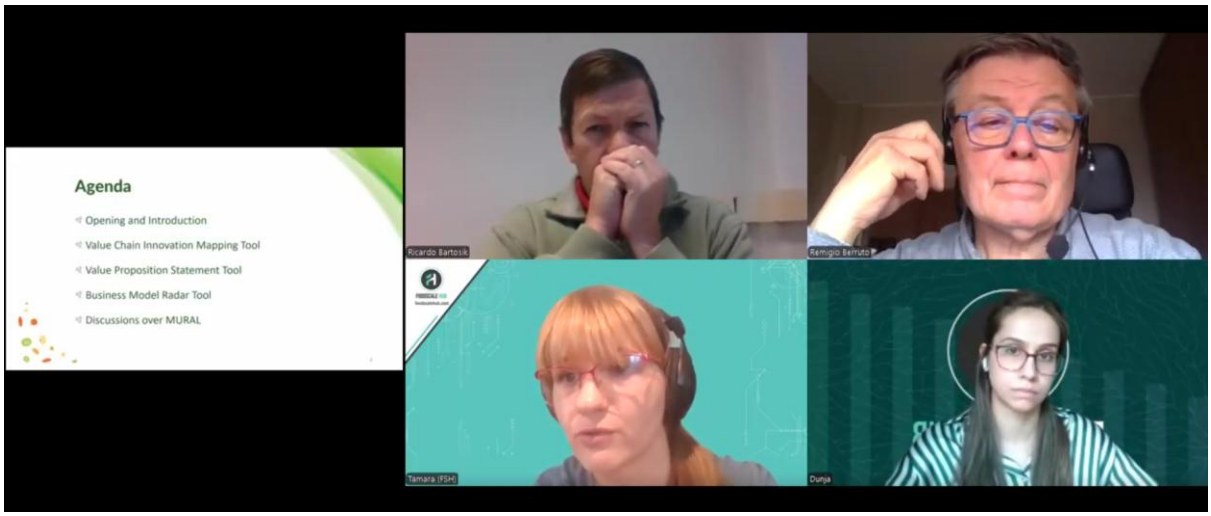


Figure 26 Business modelling workshop for IPS5.2 business case

The group also discussed the financial and operational benefits that would make up the core value proposition. The costs of the system include the recyclable plastic liners, gas for the modified atmosphere and service fees for the traceability platform and hardware. To keep these costs modular and accessible for smaller farms, the partners suggested that the CO2 injection equipment could be rented or hired as a service rather than purchased outright. Ultimately, the workshop highlighted that the system's greatest benefits are extending shelf life by up to 50%, naturally preventing spoilage and insects without chemical pesticides and enabling flexible, palletised transport without the need for expensive silos or specialised bulk trucks.

1.9.1. Value Chain Innovation Mapping

The Value Chain Innovation Mapping tool demonstrated that the IPS5.2 business case spans the post-harvest pathway, acting as a crucial logistical and informational bridge between primary production (the farm) and downstream manufacturing (the processor). To operationalise the hermetic bagging value chain, a specific step-by-step technological pathway has been mapped:

- **Filling the bags at farm level**: The process begins directly at the farm (or local granary/shelter), where 1-ton capacity bags are filled without the need for expensive, centralised industrial infrastructure. Each bag is reusable and is equipped with specialised high-barrier, recyclable polyethene liners.
- **Testing the hermeticity of the bags**: Once filled, the bags are sealed. Each bag undergoes a pressure decay test to ensure that it is completely airtight.
- **Creating a modified atmosphere**: After airtightness is confirmed, a portable device is connected to the bag through the integrated valve system. A precise quantity of carbon dioxide or nitrogen is injected to reduce the oxygen concentration and create an anoxic or modified atmosphere. This environment protects the stored crop against pests, oxidation, moisture-related deterioration and spoilage.
- **Uploading information in the traceability system:** A unique QR code links each bag to a digital record. Farmers or operators upload information relating to crop origin, production practices, harvest conditions, bag treatment, storage conditions and location.
- **Storage and transportation:** The sealed and digitally registered bags can be stored as independent modular units or placed on pallets for transport. They can be shipped directly from the farm to processors through standard logistics services, including less-than-truckload transport, without requiring specialised bulk vehicles.

Within the mapped value chain, the main innovation areas are focused on the specialised integration of modular hermetic big-bag storage, controlled-atmosphere treatment, airtightness verification and a field-to-fork digital traceability platform.

Unlike traditional methods that treat physical storage, chemical fumigation and documentation as separate, disconnected processes, the IPS5.2 innovation combines them into a single, decentralised post-harvest system. By shifting these capabilities directly to the farm level, the innovation eliminates the need for expensive, centralised silos and mandatory chemical pesticides. It enables primary producers to independently preserve the quality and identity of their high-value crops while providing downstream processors and logistics actors with a verified, low-waste, and highly traceable supply of premium plant proteins.

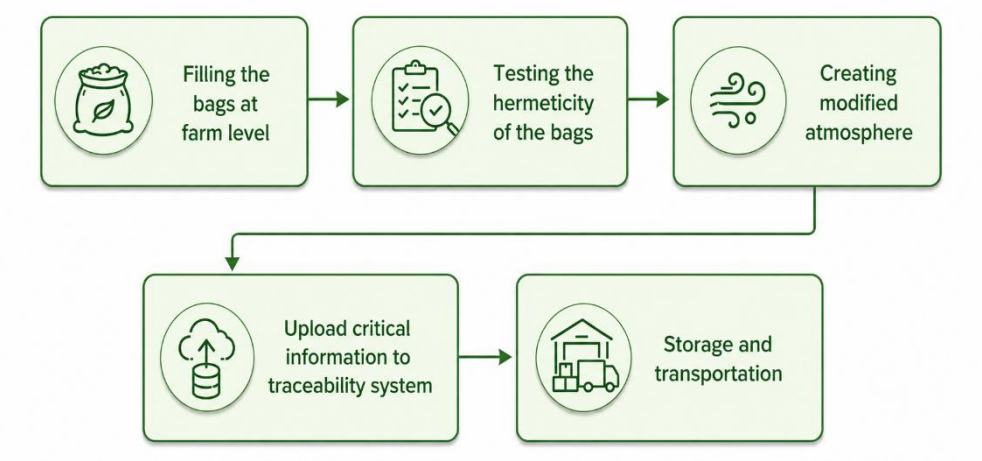


Figure 27 Value chain activities in the IPS5.2 business case

The IPS5.2 value chain is centred on two primary stakeholder groups, farmers and processors:

- **Farmers**: Farmers act as upstream value creators by carrying out bag filling, hermeticity testing, controlled-atmosphere treatment and data entry directly at the farm level. Through these activities, raw bulk crops are converted into secure, traceable and identity-preserved storage units.
- **Processors**: Processors act as downstream buyers and users of the preserved raw materials and ingredients benefiting from improved moisture stability, chemical-free pest control, extended shelf life and verified traceability.

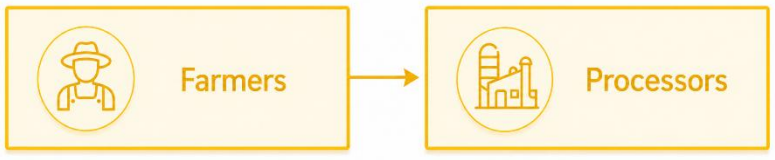


Figure 28 Stakeholders in IPS5.2 business case

Together, these stakeholders form the foundation of the IPS5.2 innovation. Farmers use large-capacity hermetic bags for post-harvest handling, temporary storage, and direct shipment, while processors receive better-preserved and fully traceable legumes and other plant-protein raw materials. Their combined role supports the transition from a chemically dependent bulk commodity model to a secure, decentralised, and traceable farm-to-processor supply chain that protects product quality and identity without relying on expensive centralised silos.

The innovation mapping demonstrates how each data point captured throughout the IPS5.2 process contributes to traceability, product preservation, quality assurance and commercial value.

Production and crop information: Farmers input vital field-level data into the system, including variety information and fertiliser type, pesticide use, harvest season dates, and moisture content.

- **Variety information:** The crop or seed variety is recorded to preserve the identity of the raw material and provide processors with information on its specific characteristics.
- **Fertiliser type:** The type of fertiliser used during cultivation is entered into the system as part of the crop production record, supporting greater transparency regarding farming practices.
- **Pesticide use:** Information on pesticide application is documented to support quality assurance, compliance and verification of production methods.
- **Harvest season:** The harvest date or season is recorded to provide information on crop age, origin and the likely duration of storage before processing.

Product condition and storage readiness: During the on-farm packaging phase, specific intervention data is captured, including treatment and oxygen level, CO2 level, and geolocation (via GPS in the testing device).

- **Moisture content:** The moisture level of the crop is measured and recorded because it directly influences storage stability, mould development and overall product quality.
- **Traceability:** Each bag is assigned a unique digital record linked through a QR code allowing the crop to be followed from the farm through storage, transport and delivery to the processor.
- **Geolocation:** The location of the crop and the treatment process is captured through the GPS-enabled device, strengthening origin verification and the reliability of the traceability record.
- **CO_2 level:** The carbon dioxide concentration inside the bag is measured to confirm that the required controlled atmosphere has been established.
- **Oxygen level:** The oxygen concentration is monitored to verify that a low-oxygen or anoxic environment has been achieved.
- **Treatment conditions:** Details of the controlled-atmosphere treatment are recorded to document how and when the crop was preserved.

Value creation: The synthesis of this data within the digital platform provides full field-to-fork traceability for processors. Meanwhile, the physical execution of the modified atmosphere translates directly to an increase of shelf life and protection against pests and spoilage.

- **Increase in shelf life:** The combination of hermetic storage and controlled-atmosphere treatment helps extend the shelf life of the stored crop, particularly for high-fat legumes which can extend its shelf life for up to 50% by reducing oxidation, rancidity, pest activity and spoilage.

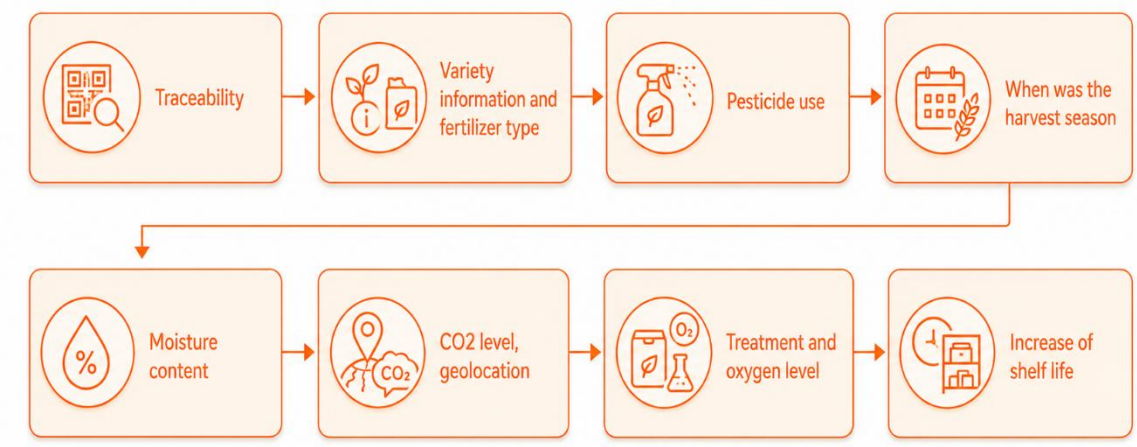


Figure 29 Information and value in IPS5.2 business case

The IPS5.2 business case presents a transformative approach to the post-harvest management of plant proteins by integrating modular hermetic bagging, controlled atmosphere technology and digital field-to-fork traceability into a single, cohesive system. By shifting storage capabilities directly to the farm level, this innovation eliminates the reliance on expensive centralized infrastructure and mandatory chemical pesticides, offering a highly sustainable and cost-effective solution for primary producers. Furthermore, it empowers farmers to capture premium value for their identity-preserved crops while providing downstream processors and logistics actors with a secure, easily transportable and quality-assured supply of raw materials and ingredients with significantly extended shelf lives. Ultimately, IPS5.2 bridges the critical post-harvest gap between primary crop cultivation and final processing, establishing a resilient, decentralised and transparent European plant-protein supply chain that strongly supports the broader farm-to-fork objectives of the VALPRO Path project.

1.9.2. Business Model Radar

The Business Model Radar for the IPS5.2 hermetic bagging system maps the collaborative ecosystem required to deliver cross-regional, modified-atmosphere preservation for plant proteins. INTA serves as the focal organisation, taking responsibility for the technical development, atmosphere-treatment protocols and field validation of the system. They are supported by core partners (the packaging, monitoring and traceability technology providers) who produce the bags and liners while configuring the integrated QR tracking, alongside an enriching partner (UNITO) that contributes logistics expertise, business-modelling resources and knowledge transfer. This collaborative structure delivers co-created value to two primary customer groups: farmers, cooperatives and producer organisations (Customer 1), who execute the on-farm bagging and provide crucial field data, and processors and ingredient manufacturers (Customer 2), who secure a reliable, traceable and pesticide-free supply of ingredients. Ultimately, these coordinated efforts provide safe, identity-preserved plant-protein ingredients to the food manufacturers and industrial buyers.

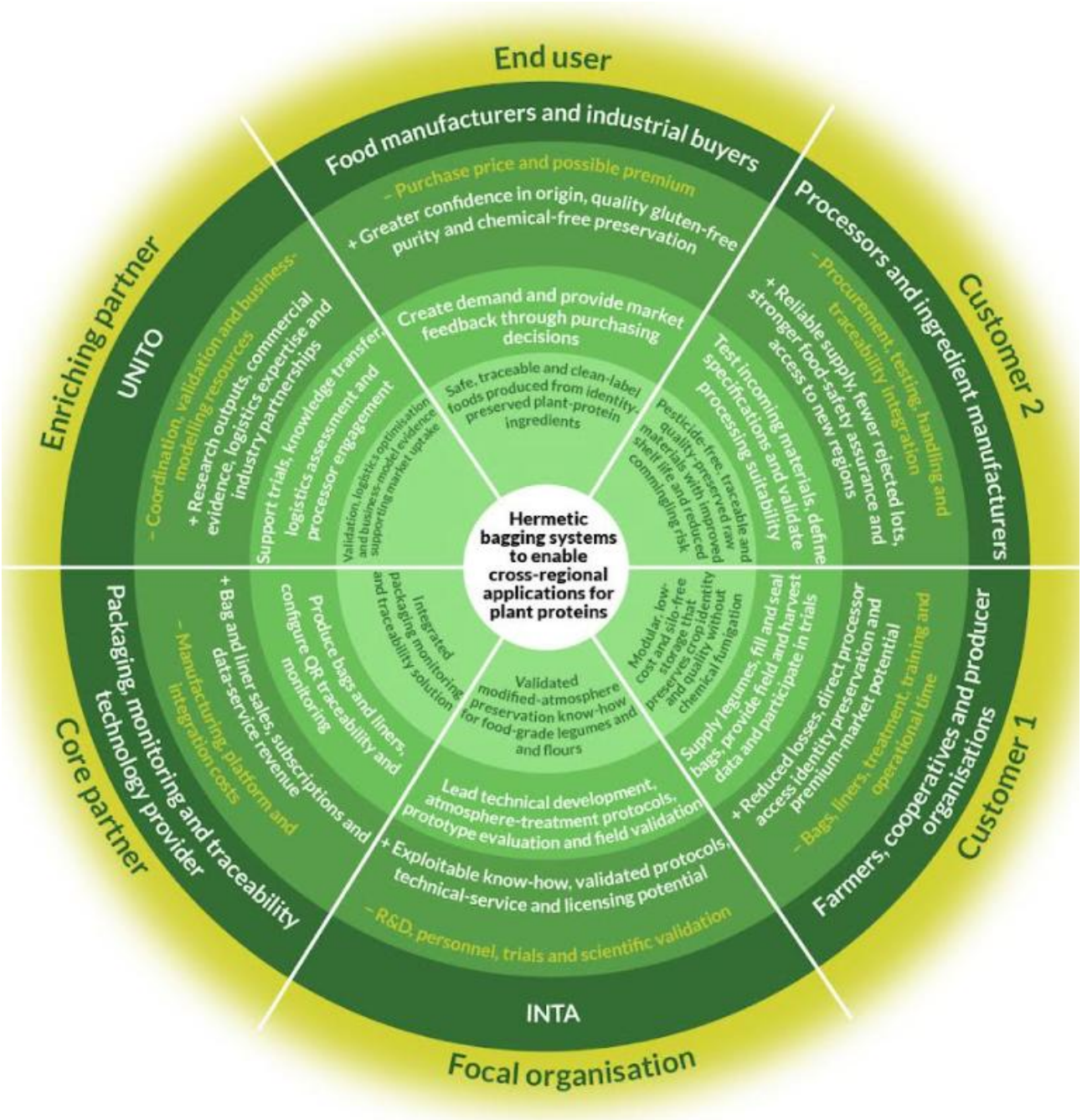


Figure 30 Business Model Radar for IPS5.2 business case

1.10. Business Model Analysis and Options Considered

Based on the market analysis and the specific structure of the IPS5.2 value chain, the business model for the hermetic bagging system should reflect its role as an integrated post-harvest preservation and supply-chain visibility solution, rather than a standalone packaging product. The strongest market opportunity for this business case lies in serving plant-protein supply chains through a specialised B2B solution that combines reusable hermetic big bags, controlled-atmosphere treatment, airtightness verification and field-to-fork traceability within one coordinated system. These features enable it to successfully compete with generic packaging products through added value.

To support market uptake across different customer groups, several potential business model options have been considered:

Direct equipment and consumables sales model: This traditional approach involves selling the physical components of the system directly to farmers, cooperatives, storage operators or processors. This includes the reusable 1-ton raffia bags, the recyclable high-barrier polyethylene liners and the automated portable device for airtightness testing and gas injection. This model is most suitable for larger farms, cooperatives and processors that handle sufficient volumes to justify purchasing the equipment outright. It provides users with full operational control and supports repeated use across several storage cycles. However, the initial capital requirement may limit adoption among smaller producers or users with seasonal and variable volumes.

Service-based and equipment rental model: To lower the barriers of adoption and reduce the initial cost, the hardware can be provided through rental agreements or operated by a third-party service provider. In this model, farmers or cooperatives pay for access to the equipment or for an on-site treatment service covering bag preparation, airtightness testing and controlled-atmosphere injection. This approach is suitable for small and medium-sized farmers, organic producers, specialty crop growers and cooperatives that may not require permanent ownership of the equipment. It converts a high fixed investment into a flexible operating cost linked to the number of bags or tonnes treated during each season. The model also offers an alternative to investing in silos or specialised storage infrastructure. Users can increase or reduce the service according to actual production volumes, making the system more accessible for seasonal crops, small harvests, pilot production and geographically dispersed farming operations.

Integrated traceability platform subscription model: Because a core component of the IPS5.2 innovation is the digital link between the physical bag and field data, the digital traceability platform software represents a distinct business mechanism. The digital traceability platform creates a separate and recurring source of value within the IPS5.2 business model. Each bag is connected to a unique digital record through a QR code, enabling users to access information on crop origin, variety, fertiliser and pesticide use, harvest timing, moisture content, treatment conditions, oxygen and CO_2 levels and geolocation. Because the platform is web-based, users can access it without purchasing dedicated IT infrastructure. Access could therefore be monetised through annual subscriptions, user licences, per-bag fees, or processor-level platform agreements. This model is especially relevant for processors, ingredient manufacturers and supply-chain coordinators that require reliable information on product identity, treatment history, storage conditions and origin. The platform supports procurement decisions, quality assurance, compliance, auditability and claims related to chemical-free treatment, organic production, gluten-free integrity, or identity preservation.

1.11. Recommended Business Approach

The most suitable strategy for IPS5.2 is a **hybrid B2B business model** that combines physical product sales, equipment rental service and digital platform access. Rather than competing as a generic agricultural packaging product, the system should be marketed as **a specialised, integrated post-harvest preservation and supply-chain visibility solution.** Under this approach, the technology providers would retain the core IP and technical know-how, commercialising the solution through three interconnected revenue streams:

1. **Consumables sales:** The first revenue stream would come from the direct sale of the physical storage components. These include the reusable 1-ton external raffia big bags and the recyclable high-barrier polyethylene liners. This model provides recurring income because the external bag can be reused, while the internal liner may need to be replaced depending on use and condition. The main customers are farmers, cooperatives, processors and storage operators that require secure and identity-preserved post-harvest storage.
2. **Flexible access to treatment equipment:** The portable device used for airtightness testing and controlled-atmosphere treatment should be offered through more than one access model. Large cooperatives, processors, or storage operators handling high volumes may purchase the

equipment directly. Smaller farmers and seasonal users, however, should be able to rent the device or access the treatment through a third-party service provider that carries out airtightness testing and gas injection on-site. This flexible structure lowers the barrier to adoption and allows users to pay according to the volume treated. It also replaces the need for major investment in centralised silos or other fixed storage infrastructure with a modular cost that can be adjusted to seasonal production levels.

3. **Digital traceability platform access:** The third revenue stream would come from access to the web-based traceability platform. Each bag would be linked to a unique QR code containing information on crop origin, variety, production practices, harvest conditions, moisture content, treatment data, oxygen and CO_2 levels, geolocation, storage and transport. Because the platform is web-based, users would not need to invest in specialised IT infrastructure. Access could be offered through annual subscriptions, processor licences, user accounts, or per-bag fees. The platform would be particularly valuable for processors, ingredient manufacturers and supply-chain coordinators that require verified information on product identity, treatment history, quality, and origin.

The recommended model should focus initially on higher-value market segments where product identity, chemical-free preservation and traceability are commercially important. These may include organic products, gluten-free crops, specialty grains, premium legumes and other differentiated plant-protein materials.

For farmers, the system provides the ability to store crops safely at farm level, preserve individual lots, and dispatch partial loads directly to processors. This reduces dependence on centralised storage and specialised bulk transport while creating opportunities to access premium markets.

For processors, the system offers a more reliable supply of preserved and traceable raw materials with documented production and treatment conditions. This can reduce procurement risk, support quality assurance and improve confidence in product origin and integrity.

Overall, the recommended approach combines **one-time equipment sales with recurring revenues from consumables, rental services, treatment services and digital platform access.** Integrating modular storage, controlled-atmosphere preservation, airtightness verification and digital traceability into one commercial offer enables IPS5.2 to support a more resilient, decentralised and low-waste European plant-protein value chain.

Annex 5. IPS5.3 Business Case Report

NEW VALUE LANDSCAPES FOR PLANT PROTEIN PATHWAYS

IPS5.3 Business Case Report

Decentralised Processing Technologies

valpropath.eu

Co-funded by the European Union

1. Decentralised Processing Technologies (IPS5)

Business opportunity hypothesis

If decentralised, small-scale processing technologies are implemented at the regional level, then high-value plant-based can be produced locally, reducing the reliance on resource-intensive centralised processing, lowering environmental footprints and building more resilient local supply chains.

IPS	**IPS5** - Demonstrating the value of building synergies with cross regional applications
Business-case focus	**B2B:** Targeting pulse processors, ingredient manufacturers and food manufacturers, such as artisanal high-end pasta producers, looking for traceable, functional plant-protein ingredients
Lead geography	Italy (with pilot trials based in Turin), Europe
Target crops/ materials	Chickpeas, peas, fava beans and lentils
Technology solution	Decentralised dry fractionation (dehulling, milling, and air classification) and hybrid extraction. This provides an energetically less demanding alternative to wet extraction, requiring no water or chemical additions.
Expected outcome	The creation of locally certified protein ingredients and the valorisation of coarse starch side-streams into bakery and food applications.

The IPS5.3 business case explores how **decentralised processing technologies** can support shorter, more resilient and higher-value European plant-protein supply chains. Led by Molino Peila, it focuses on moving activities such as **dehulling, milling, sieving, sorting and air classification** closer to crop-growing regions. The main technological solution is **dry fractionation**, complemented by hybrid extraction. Compared with conventional wet processing, these methods require less energy, avoid water and chemical solvents and help preserve the functionality of proteins. The approach responds to the current dependence on centralised, resource-intensive processing and the limited availability of traceable, regionally sourced pulse ingredients for premium food applications.

The business case follows a **B2B model** targeting pulse processors, ingredient manufacturers and artisanal or industrial food producers. Dry fractionation generates a protein-rich fine fraction and a larger starch-rich coarse fraction, both of which must be commercially valorised for the model to be viable. The fine fraction can be positioned as a premium, identity-preserved protein concentrate for pasta, bakery, snack, nutritional and plant-based food applications, while the coarse fraction can be developed as a functional food ingredient rather than downgraded to low-value feed. Pilot trials demonstrated fine-fraction yields of around 27–28%, protein recovery of 54–70% and protein contents of approximately 41.6–55.8%, although performance varies depending on the crop and processing conditions.

Securing consistent raw-material volumes, estimated at a minimum of around 30 tonnes per processing campaign, is essential for reliable and profitable operations. By combining local sourcing, lower-impact processing, traceability and the high-value use of all output fractions, IPS5.3 can retain more value within producing regions, reduce transport and processing impacts, improve circularity and strengthen the resilience of European plant-protein supply chains.

1.1. Problem Statement

Current plant-protein production is largely **optimised for high-volume commodity and animal-feed markets** and remains heavily dependent on large, centralised processing facilities. High-purity protein isolates are typically produced through wet fractionation, a resource-intensive process requiring substantial quantities of water and energy, as well as chemical inputs. In addition to its environmental burden, wet extraction can alter the native structure of proteins and potentially reduce the functional properties needed for specialised food applications.

The heavy reliance on **centralised processing** also creates significant logistical and supply chain barriers. Shipping raw crops across long distances to centralised plants increases transportation costs and significantly inflates the overall environmental footprint of the final product. This model fails to exploit regional synergies between Europe's fastest-growing locations and local consumption needs. There is a distinct lack of decentralised processing infrastructure, such as localised drying, cleaning, milling and dry fractionation facilities, located near farms. This disconnect prevents the creation of shorter, resilient supply chains and stops local farmers and processors from capturing the added economic value of premium ingredients.

A further challenge is the **insufficient valorisation of processing side-streams**. Dry fractionation generates substantial volumes of coarse, starch-rich fractions that are often directed towards low-value feed applications or treated as residual material. This reduces the economic attractiveness of decentralised processing and limits its contribution to circularity. Commercially viable models must therefore identify suitable higher-value applications for these fractions, particularly as functional ingredients in bakery, pasta, snack and other formulated food products, thereby creating additional revenue streams and improving the use of the full crop.

At the same time, the centralised and bulk-oriented market creates **a supply gap for regional and premium food manufacturers**. Artisanal and industrial producers often struggle to source functional, identity-preserved and locally certified pulse ingredients in formats suited to their production needs. Smaller businesses may require manageable quantities, such as 5 kg bags, while larger manufacturers need consistent industrial volumes supported by verified origin, traceability and quality credentials. An integrated local processing model is therefore needed to provide differentiated ingredients while reducing dependence on resource-intensive and less transparent supply chains.

The development of such a model is, however, **constrained by limited commercial data and practical experience with small-scale decentralised fractionation**. Processing performance varies according to crop variety, composition, moisture and fat content, requiring technology settings and milling configurations to be adapted to each raw material. Regional facilities also need sufficient and consistent crop volumes to operate economically, yet local production is often fragmented and poorly aligned with processor and buyer requirements. Without advance sourcing agreements, common quality specifications, validated food applications and committed customers, processors face significant technical, investment and market risks.

These challenges reveal a broader coordination gap across the value chain. Farmers require predictable demand and clear production specifications, processors need stable throughput and consistent raw-material quality, and food manufacturers require reliable ingredient performance and supply. Closing this gap is essential to move decentralised processing beyond pilot-scale technical validation and towards a scalable, commercially viable regional model capable of producing traceable ingredients, valorising all processing fractions and strengthening European plant-protein supply chains.

1.2. Objectives of IPS5.3 Business Case

The primary goal of the IPS5.3 business case is to assess the feasibility and implementation of decentralised, small-scale processing technologies for plant proteins. By shifting these technological capabilities to a regional or community level, the initiative aims to build a more sustainable and adaptable plant-protein industry. The key objectives for of the business case include:

- **To enable localised value creation and resilient supply chains**: By processing plant proteins closer to their agricultural source, the business case aims to bypass large, centralised processing facilities. This localised approach drastically reduces transportation distances and associated environmental emissions while improving the overall efficiency and resilience of regional supply chains.
- **To produce traceable, high-value ingredients**: The system converts raw, regionally grown legumes into ready-to-use, identity-preserved and functional protein ingredients. A specific commercial objective is to create locally certified ingredients tailored to different market segments, offering smaller quantities (5 kg bags) of artisanal protein concentrate for premium food applications, alongside 1-ton big bags for larger industrial food processors.
- **To maximise circularity through side-stream valorisation:** Because dry fractionation inherently produces large volumes of coarse starch fractions that lack the protein content to be used as high-quality animal feed, another objective is to valorise these starch side-streams into human food applications, such as bakery products. Finding profitable uses for these side fractions is essential for improving circularity, reducing waste and making the decentralised processing model economically viable.
- **To validate ingredient functionality and market application:** The business case also emphasises detailed ingredient characterisation and practical food application testing. This involves evaluating different milling diagrams and partnering directly with downstream food manufacturers to test product formulations, ensuring that the locally processed ingredients meet the strict sensory, nutritional and performance expectations required for commercial food production.
- **To optimise regional crop sourcing**: To ensure a profitable and consistent raw material supply for the processing facility by selecting the best crop varieties suited to the region's climate and establishing secure procurement pipelines.

1.3. Market Analysis

1. Pea and chickpea concentrate market overview

The market analysis focuses on dry-fractionated legume ingredients, with particular attention to **pea protein concentrate** and **chickpea protein concentrate** as lower-processing alternatives to protein isolates. The analysis considers their current market presence in Italy and Southern Europe, identifies relevant competitors and provides an indicative price benchmark based only on publicly available information.

The main conclusion is that **pea protein concentrate is already commercially available in Italy and in the broader European market**, including dry-fractionated yellow pea concentrates with around 51–55% protein content[91]. In Italy, MartinoRossi offers yellow pea protein concentrates such as HTP PRO 55 and NATIVA PRO 60[92], both positioned as naturally processed ingredients without water or

[91] Wageningen. *Dry fractionation for production of functional pea protein concentrates.* https://research.wur.nl/en/publications/dry-fractionation-for-production-of-functional-pea-protein-concen/

[92] MartinoRossi. *Natural Proteins Concentrates*. https://www.martinorossispa.com/natural-proteins/

solvents. In Southern Europe, Ebro Ingredients, part of the Spain-based Ebro Group, offers PisumPRO, a dry-fractionated yellow pea protein concentrate containing 55% protein[93].

By contrast, **chickpea protein concentrate appears to be a more niche and less locally established segment**. In Italy, chickpea concentrate is present through the ATURA range, distributed by Alesco[94], with organic chickpea protein concentrates positioned for plant-based and gluten-free applications. However, available public information indicates that ATURA chickpea proteins are manufactured in the UK by Deltagen, with chickpeas sustainably grown in Turkey[95], rather than Italy.

Product and processing context. Dry fractionation is highly relevant because it can produce protein-rich fractions with less intensive processing than wet extraction. Compared with isolates, concentrates generally have lower protein purity, but they may retain more native functionality, fibre and starch fractions, while being **less processed and potentially more clean-label**. Ingredion explicitly positions pea protein concentrates as dry-milled ingredients that can support more natural claims, lower cost-in-use and functional properties such as viscosity, gelling, solubility and creamy texture[96].

Table 11 Legume ingredient types: Processing intensity and market relevance

Ingredient type	Typical positioning	Processing implication	Market relevance
Legume flour	Whole or milled legume ingredient with lower protein concentration.	Lowest processing intensity.	Relevant for bakery, pasta, snacks and gluten-free formulations, but less suitable when high protein claims are required.
Protein concentrate	Intermediate protein enrichment, commonly around 40-65% protein depending on crop and process.	Often produced through dry fractionation or mechanical concentration.	Relevant because it balances protein enrichment, lower processing, functionality and clean-label positioning.
Protein isolate	High-protein ingredient, often above 80% protein.	Usually more intensive processing, often wet extraction.	Strong benchmark in sports nutrition and high-protein products, but less aligned with the lower-processing strategy.

For pea, dry fractionation is already technically and commercially aligned with concentrates around 55% protein. For chickpea, dry separation is technically possible but more challenging: published research notes that chickpea air-classified concentrates often show lower separation efficiency than other starch-rich pulses and that de-oiling or process aids may be needed to improve flowability and enrichment.[97]

Market drivers. The demand for pea and chickpea protein concentrates is primarily driven by the growing need for **plant-based, clean-label and less intensively processed protein ingredients**. Food manufacturers increasingly look for ingredients that can improve nutritional value while still supporting simple formulations, recognisable raw materials and reduced processing intensity. Dry-fractionated concentrates are relevant in this context because they can provide protein enrichment

[93] Ebro Ingredients. *PisumPRO.* https://www.ebroingredients.com/ingredients/pulse/pisumpro-pea-protein-concentrates/

[94] Pharmanutra. *Atura plant origin proteins*. https://www.pharmanutra.it/en/atura-plant-origin-proteins-alesco-signs-the-distribution-agreement/

[95] ATURA Proteins. *Chickpea Protein 40%* - https://aturaproteins.com/plant-proteins/chickpea-protein/

[96] Ingredion. *VITESSENCE Prista proteins.* https://www.ingredion.com/emea/en-uk/ingredients/ingredient-product-families/vitessence-prista-proteins

[97] Science Direct. *Dry fractination of chickpea flour: Impact of de-oiling and flow aids.* https://www.sciencedirect.com/science/article/pii/S0032591024008246

through mechanical separation routes such as milling and air classification, without relying on wet extraction.[98]

A second important driver is the need for **functional plant ingredients**, not only high-protein ingredients. Pea and chickpea concentrates can support applications where texture, viscosity, emulsification, water/oil binding and product structure are important, including pasta, bakery, snacks, sauces, emulsions, plant-based meat alternatives and plant-based dairy alternatives. This makes them relevant for manufacturers seeking ingredients that combine nutritional value with technological functionality.

The category is also supported by broader European interest in **local and diversified plant-protein value chains**. The EU continues to address its plant protein deficit and dependence on imported protein sources, which creates a favourable context for ingredients based on European legumes such as pea and chickpea.[99]

Competitive landscape for pea protein concentrates. The European pea protein concentrate market includes a diverse group of established ingredient manufacturers and specialised regional suppliers offering products typically containing around 55-60% protein. Most competitors position their concentrates as lower-processed alternatives to protein isolates, highlighting mechanical or dry fractionation, the absence of chemical solvents, and, increasingly, regional sourcing and organic certification. The companies presented below provide relevant benchmarks for IPS5.3 in terms of protein content, processing approach, sustainability claims, application range and market positioning.

Table 12 Key competitors and market benchmarks for pea protein concentrates

Company	Country	Product evidence	Relevance
MartinoRossi	Italy	Offers yellow pea protein concentrates **HTP PRO 55** and **NATIVA PRO 60**, with applications in bakery, biscuits, pasta, drinks, plant-based products and snacks.[100]	Direct Italian competitor and key benchmark
Ebro Ingredients	Spain	Offers **PisumPRO**, a dry-fractionated yellow pea protein concentrates with 55% protein.[101]	Direct Southern European benchmark
Nuverta	Belgium	**Produces pea protein concentrate 55** in Belgium through a mechanical, chemical-free and water-free process, using peas grown in Belgium and neighbouring countries.[102]	Strong European competitor with sustainability and local-sourcing claims
Ingredion	Global/ Europe	**VITESSENCE Prista P155** is a pea protein concentrate with 55% protein on a dry basis.	Important global ingredient benchmark for functionality and market positioning
Bunge/ Golden Fields	Latvia/ Baltics	Bunge expanded into pea and faba protein concentrates through Golden Fields; the range is based on dry fractionation without water or solvents and contains 55-70% protein.	Important European scale competitor

[98] Wageningen. Dry fractionation for production of functional pea protein concentrates. https://research.wur.nl/en/publications/dry-fractionation-for-production-of-functional-pea-protein-concen/

[99] Reducing the plant protein deficit of the European Union - https://agriculture.ec.europa.eu/farming/crop-productions-and-plant-based-products/cereals/reducing-plant-protein-deficit-eu_en

[100] MartinoRossi. *Natural Proteins Concentrates*. https://www.martinorossispa.com/natural-proteins/

[101] Ebro Ingredients. *PisumPRO.* https://www.ebroingredients.com/ingredients/pulse/pisumpro-pea-protein-concentrates/

[102] Nuverta. *Human Nutrition: pea protein.* https://nuverta.eu/en/nuverta-pea-protein-for-food-innovation/

Ceresal	Germany/ Europe	Offers pea protein concentrate 55, mechanically concentrated from yellow split peas, with organic and conventional quality.	Strong EU benchmark, including organic option
Multiflour	Netherlands	Offers yellow pea protein concentrate 55 produced through dry air separation with organic option available.	Relevant for organic pea concentrate benchmarking
Aloja Starkelsen	Latvia/ Europe	Offers organic brown pea protein concentrate with typical 55% protein on dry matter produced through a dry system.	Useful direct organic concentrate benchmark
Helvet Ingredients	Hungary/ Europe	Offers pea protein concentrate 55 produced by dry fractionation without chemical extraction.	Relevant Central/ South-Eastern European supplier benchmark
Austrion	Austria/ Europe	Offers pea protein concentrate powder with average 55% protein available in conventional and organic form.	Relevant European supplier benchmark

Conclusion: The competitive landscape confirms that pea protein concentrate is already a well-established European ingredient category, with multiple suppliers offering products at around 55% protein and increasingly emphasising dry, mechanical, water-free or chemical-free processing. Organic options and regional sourcing claims are also becoming common, meaning that these attributes alone may not provide sufficient differentiation. A new IPS5.3 pea protein concentrate should therefore combine several advantages, such as verified local or Mediterranean origin, full traceability, consistent functional performance, an improved sensory profile and credible sustainability data. Competitive positioning should also demonstrate clear value for specific applications, including bakery, pasta, snacks and plant-based foods, supported by evidence of formulation performance and cost-in-use compared with existing concentrates and isolates.

Competitive landscape for chickpea protein concentrates. The chickpea protein concentrate market is less developed than the pea protein concentrate segment, but several established suppliers already offer products with protein contents ranging from approximately 45% to 70%. Competitors typically differentiate their products through mechanical or solvent-free processing, European sourcing, organic availability, neutral sensory properties and functionality in applications such as dairy alternatives, bakery, snacks, beverages and meat alternatives. The companies below provide relevant benchmarks for IPS5.3 in terms of protein enrichment, processing approach, functional performance, geographic positioning and access to the Italian market.

Table 13 Key competitors and market benchmarks for chickpea protein concentrates

Company	Country	Product evidence	Relevance
ATURA[103]	UK-linked manufacturing, Italy distribution	ATURA lists chickpea protein concentrate with organic availability, neutral taste, creamy texture, emulsifying properties and applications in dairy alternatives, bakery and snacks. **Alesco/ PharmaNutra** distributes ATURA products in Italy.[104]	Key Italy-relevant chickpea concentrate benchmark, but not Italian manufacturing.
Ceresal	Germany/ EU sourcing	Offers chickpea protein concentrate around 45% and 60%, mechanically concentrated from European chickpeas, with organic and conventional quality.[105]	Strong EU-origin chickpea concentrate benchmark.

[103] ATURA Proteins. *Chickpea Protein 40%* - https://aturaproteins.com/plant-proteins/chickpea-protein/

[104] Pharmanutra. *Alesco distribution of Atura proteins.* https://www.pharmanutra.it/en/atura-plant-origin-proteins-alesco-signs-the-distribution-agreement/

[105] Ceresal. *Chickpea protein 45% or 60%*. https://ceresal.de/en/products/plant-based-proteins/chickpea-protein-45-60/

InnovoPro[106]	Israel	Ingredion describes InnovoPro's solvent-free processing as enabling a 70% chickpea protein concentrate, positioned for neutral flavour, emulsification and creamy mouthfeel in dairy alternatives, meat alternatives, bakery and beverages.[107,108]	Important global benchmark, but not local Italian/ Southern European production.

Chickpea ingredients with protein contents of around 70% may be positioned as either high-protein concentrates or isolate-like products, depending on the supplier and processing method. They should not be considered directly comparable to dry-fractionated chickpea concentrates containing approximately 40–60% protein unless the production route, ingredient composition and technical specifications have been confirmed.

Conclusion: The comparison indicates that chickpea protein concentrate remains a more specialised and less crowded category than pea protein concentrate, creating potential space for a regionally produced IPS5.3 ingredient. However, existing suppliers already compete on protein content, organic certification, neutral flavour, emulsification and creamy texture. A new product would therefore need to differentiate through a combination of Italian or Mediterranean sourcing, verified traceability, chemical-free processing, consistent functionality and application-specific validation. Added value could be created by demonstrating performance in pasta, bakery and other regional food products, supported by sensory data, sustainability evidence and a competitive cost-in-use proposition.

Indicative price benchmark. Public pricing for **pea and chickpea protein concentrates is limited.** Most suppliers publish product specifications, protein content, applications and certification information. Therefore, the pricing benchmark should be treated as indicative and should be validated through direct supplier quotations.

Table 14 Pea protein concentrates price benchmarking

Product/ Source	Product type	Public price evidence
Expana - Pea Concentrate EXW Europe	Conventional pea concentrate	Expana's November 2024 Plant-Based Protein Market Insight lists **Pea Concentrate EXW Europe** at **€1.09/kg** for the October assessment, with a month-on-month increase of €0.04/kg / 4%.[109]
Aloja Starkelsen - Organic Brown Pea Protein Concentrate	Organic pea protein concentrate, 55% protein	1-2-Taste lists Aloja Starkelsen Organic Brown Pea Protein Concentrate at a visible price range of **€83–€2,400 excl. VAT**; the product is described as an air-classified organic brown pea concentrate with 55% protein.[110]

For **chickpea concentrate**, public price transparency is weaker than for pea. For **conventional pea concentrate**, the only clear public market price identified is Expana's €1.09/kg EXW Europe benchmark. This can be used as a low/reference market signal, but not as a final procurement price because it is not supplier-specific, not organic and not Italy-specific.

[106] EIT Food. *InnovoPro*. https://www.eitfood.eu/community/startups/innovopro

[107] Ingredion. *Ingredion and InnovoPro Sign Exclusive Commercial Distribution Partnership to Scale Next Generation Chickpea Proteins for North America*. https://www.ingredion.com/na/en-us/news-events/news/ingredion-and-innovopro-sign-exclusive-commercial-distribution-partnership

[108] Knowde marketplace. *CP-PRO 70*. https://www.knowde.com/stores/innovopro/brands/cp-pro-70

[109] Plant-Based Protein *(PowerPoint Presentation, slide 3)* - https://shorturl.at/AQOGD

[110] Aloja Starkelsen. *Organic Brown Pea Protein Concentrate.* https://www.12taste.com/product/aloja-starkelsen-organic-brown-pea-protein/

For **organic pea concentrate**, Aloja Starkelsen provides the most relevant public reference because the product is clearly identified as **organic brown pea protein concentrate** with 55% protein. However, the visible price range cannot be safely converted into a single €/kg benchmark without confirming the pack-size mapping and bulk conditions.

Application areas and market relevance. Pea and chickpea protein concentrates are particularly relevant for **food applications** requiring a balance between protein enrichment, functional performance, clean-label positioning and moderate processing intensity, rather than maximum protein purity. Compared with isolates, concentrates can offer sufficient protein content while retaining valuable functional and sensory characteristics and supporting lower-processed product positioning.

The most relevant application areas include pasta, bakery, biscuits, crackers, snacks, sauces, emulsions, dressings, plant-based meat alternatives, meat extenders, egg replacement, plant-based dairy alternatives, beverages and general protein enrichment.[111,112]

For chickpea concentrates, the main application potential appears to be in plant-based dairy alternatives, bakery, snacks, sauces, emulsions and plant-based meat alternatives, especially where neutral taste, creamy texture and emulsifying properties are important.[113,114]

The main **commercial opportunity for protein concentrates does not lie in replacing isolates** across all applications. Instead, concentrates are most attractive in products where moderate protein enrichment is sufficient and where texture, water- and oil-binding capacity, emulsification, sensory quality, clean-label credentials and cost-in-use are more important than achieving the highest possible protein percentage.

Market challenges. Despite their growing relevance in food applications, pea and chickpea protein concentrates face several market and commercialisation challenges that must be considered when assessing the viability of a new product. These challenges relate primarily to limited price transparency, differences in market maturity, established competition and the need to evaluate concentrates according to their application performance rather than protein content alone. The table below summarises the main issues and their implications for market positioning and financial validation.

Table 15 Key Market challenges for pea and chickpea protein concentrates

Challenge	Implication
Price opacity	Most concentrate suppliers do **not publish B2B prices**. RFQs are necessary before final financial modelling.
Pea market competition	Pea concentrate already has several established European suppliers, including **direct Italian and Spanish benchmarks**.
Chickpea market immaturity	Fewer visible chickpea concentrate suppliers may indicate an opportunity, but also **lower market maturity and higher validation risk**.
Concentrate vs isolate comparison	**Concentrates should not be compared with isolates on protein percentage.** The comparison should be application-specific: functionality, clean label, sensory profile, processing intensity and cost-in-use.

Overall, pea protein concentrate represents a relatively mature and competitive European market, requiring a new entrant to demonstrate clear differentiation and application-specific value. **Chickpea**

[111] MartinoRossi. *Natural Proteins Concentrates*. https://www.martinorossispa.com/natural-proteins/

[112] Ebro Ingredients. *PisumPRO.* https://www.ebroingredients.com/ingredients/pulse/pisumpro-pea-protein-concentrates/

[113] ATURA Proteins. *Chickpea Protein 40%* - https://aturaproteins.com/plant-proteins/chickpea-protein/

[114] Ceresal. *Chickpea protein 45% or 60%*. https://ceresal.de/en/products/plant-based-proteins/chickpea-protein-45-60/

concentrate may offer greater market space, but its lower maturity also increases the need for technical, sensory and commercial validation. In both cases, reliable financial modelling will depend on direct supplier quotations, while product comparisons should focus on functionality, processing intensity, clean-label potential, sensory performance and cost-in-use rather than protein percentage alone.

Key takeaways. The pea protein concentrate market is already developed. A new pea concentrate would enter the competitive field with established players in Italy, Spain, Belgium, Germany, the Netherlands, Latvia, Hungary and Austria.
The chickpea protein concentrate market appears more specialised and less saturated. Products are available through ATURA/Deltagen, Ceresal and InnovoPro, but visible evidence of Italian or Southern European manufacturing remains limited.

This suggests that the strongest differentiation opportunity may be a **dry-fractionated chickpea concentrate**, especially if it can be positioned around:

- organic production,
- Mediterranean or European sourcing,
- lower-processing/ clean-label production,
- validated functionality in pasta, bakery, snacks, sauces and plant-based applications,
- improved sensory profile and
- traceability and sustainability data.

For pea concentrate, the business case should be more cautious. Since direct competitors already exist, differentiation would need to be based on organic status, cost-in-use, local sourcing, specific functional performance or integration into regional legume value chains.

2. Legume starch market analysis

The market analysis focuses on **legume-derived starches**, with particular emphasis on pea starch and, where relevant, the broader category of pulse starches. Within legume processing, starch is commercially significant because it represents a major output of dry fractionation. This process mechanically separates crops such as peas, beans and faba beans into a protein-rich fine fraction and a **starch-rich coarse fraction** without the use of water or chemical solvents. The starch-rich fraction should therefore not be regarded merely as a **processing by-product**, but as a potentially valuable ingredient stream whose effective valorisation can strengthen the economic viability, resource efficiency and circularity of legume-processing systems.[115]

This is particularly important because starch constitutes a substantial share of pulse composition. According to Pulse Canada, starch typically accounts for **approximately 40–50% of the dry weight** of crops such as peas, lentils, beans and chickpeas. Consequently, legume fractionation inevitably generates a significant starch-rich output, making its effective valorisation essential to the economic viability, resource efficiency and circularity of the processing model.[116]

Product definition: Starch-rich side-stream vs Purified pea starch

A key distinction shpuld be made between purified native pea starch and a dry-fractionated starch-rich side-stream. Commercial pea starch products, such as **Roquette's NUTRALYS® N-735**, are

[115] HEISS MSP. *Sustainable protein concentrates from dry fractionation.* https://heiss-msp.de/en/sustainable-protein-concentrates-from-dry-fractionation/
[116] Pulse Canada. *Pulse Starches.* https://pulsecanada.com/processing/pulse-starch

described as **99% pure pea starch**[117] produced through a wet process and positioned as clean-label ingredients for food applications.

By contrast, research on dry fractionation shows that the coarse pea fraction may be a **pea starch concentrate**, but not necessarily a purified starch product; one study reported a coarse fraction with approximately **67 g starch per 100 g dry matter**, meaning that it still contains other components such as protein and fibre.[118]

This distinction is commercially important. If the side-stream is not further purified, it should probably be positioned as a **functional starch-rich ingredient** or **starch concentrate**, rather than as a direct equivalent to purified native pea starch. If, however, the producer can achieve consistent purity, functionality and food-grade specifications, the product can move closer to the higher-value native starch market.

Market context in Europe. The European starch industry is large and well established, but it is still dominated by traditional raw materials such as **wheat, maize and potato**. Starch Europe reports that the EU starch industry produces around **9.8 million tonnes of starch and starch derivatives**, using primarily EU-grown agricultural raw materials, while peas are mentioned as one of the additional starch sources alongside wheat, maize, potatoes, barley and rice.[119]

This means that **legume starch is still a niche segment within a much larger starch market**. However, it benefits from the broader demand for clean-label, plant-based and gluten-free ingredients. Market estimates vary significantly depending on the source, but they generally point to growth. Mordor Intelligence estimates the **global pea starch market** at around **USD 194 million in 2025 (~ EUR 170 million)**, growing to around **USD 302 million by 2031**[120] **(~ EUR 264.5 million)**, and **identifies Europe as the largest regional market**. Data Bridge Market Research estimates the **European pea starch market** at around **USD 128.7 million in 2025 (~ EUR 112.8 million)**, with growth expected toward **USD 206.8 million by 2033 (~ EUR 181.2 million)**.[121]

Because these market estimates differ, the safest interpretation is that pea/legume starch should be viewed as a **growing specialty ingredient market**, not as a commodity-scale market comparable to maize or potato starch.

Main applications in the food industry. Legume starch, especially pea starch, is used because of its **gelling, thickening, binding, texturising, film-forming and coating properties**. Roquette describes native pea starch as having good gel and film-forming properties after cooking, with applications in bakery, savoury products, noodles, processed meat, dairy, sports nutrition and confectionery.[122] Cosucra's NASTAR pea starch is also positioned as a clean-label, high-amylose ingredient for gelling and thickening, with applications in **meat/fish products, plant-based meat, bakery, extrusion, instant soups, sauces and cheese alternatives.**[123]

Emsland also positions pea starch in several technical food applications, including plant-based meat, coatings, and noodles. In **noodle applications**, Emsland notes that mung bean starch can be expensive,

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[117] Roquette. *Roquette pea starch N-735.* https://www.roquette.com/food-nutrition/resources/roquette-pea-starch-n-735

[118] Science Direct. *Functional analysis of mildly refined fractions from yellow pea.* https://www.sciencedirect.com/science/article/abs/pii/S0268005X14002999

[119] Starch Europe. https://starch.eu/the-european-starch-industry/

[120] Mordor Intelligence. *PEA STARCH MARKET SIZE & SHARE ANALYSIS - GROWTH TRENDS AND FORECAST (2026 - 2031).* https://www.mordorintelligence.com/industry-reports/pea-starch-market.

[121] Data Bridge. *Europe Pea Starch Market Size, Share and Trends Analysis Report – Industry Overview and Forecast to 2033.* https://www.mordorintelligence.com/industry-reports/pea-starch-market

[122] Roquette. *Roquette pea starch N-735.* https://www.roquette.com/food-nutrition/resources/roquette-pea-starch-n-735

[123] Cosucra. *NASTAR pea starch.* https://www.cosucra.com/our-ingredients/nastar/

while pea starch has a similar composition and can be used as a more cost-effective alternative in glass noodles.[124]

Market drivers. The first major driver is **the growth of plant-based food**. In Italy, the plant-based food market reached approximately **EUR 669 million in 2025**, with sales value growing by **4.5%** and volume by **5.8%**.[125] Plant-based meat volumes also grew, while prices declined, which suggests that affordability and functionality are becoming increasingly important for ingredient suppliers. This is relevant for legume starch because plant-based meat, cheese alternatives, sauces and convenience foods require functional ingredients that can bind, stabilise and improve texture.
The second driver is the demand for **clean-label and minimally processed ingredients**. Pea starch suppliers such as Roquette and Cosucra explicitly position their products as clean-label ingredients, while Cosucra highlights features such as non-GMO, local sourcing and physical extraction.[126,127] For a dry-fractionated starch-rich side-stream, this can be an important advantage because the process itself avoids water and chemical solvents, which supports a more natural and resource-efficient positioning.[128]

The third driver is the broader shift toward **European plant protein and pulse value chains**. Although protein is usually the main target of legume fractionation, starch valorisation is necessary to make the overall processing model economically viable. In other words, as more legumes are processed for protein concentrates and isolates, more starch-rich fractions will be generated and will need to find market outlets.

Competitive landscape for legume-derived starch. The European legume-starch market includes several established ingredient manufacturers offering native, instant and modified pea-starch solutions for a wide range of food applications. Leading suppliers differentiate their products through purity, clean-label positioning, functional properties such as gelling and thickening, and suitability for bakery, noodles, confectionery, dairy alternatives, meat analogues and other formulated foods. Dry-processing specialists also demonstrate the potential to market starch alongside protein concentrates as part of an integrated ingredient portfolio. At the same time, lower-priced imports from Asian suppliers create competitive pressure, although headline export prices may not reflect the additional costs associated with EU compliance, logistics, duties, certification and technical support.

Table 16 Key competitors and market benchmarks for pea starch

Company	Country	Product evidence	Relevance
Roquette	France	**NUTRALYS® N-735** is positioned as 99% pure native pea starch with food applications across bakery, savoury, dairy, noodles and confectionery. [129]	Major pea ingredient producer; offers native pea starch
Cosucra	Belgium	Positioned around high amylose, gelling/thickening, clean-label and plant-based applications.[130]	Offers NASTAR native and instant pea starch

[124] Emsland Group. *Dry Textured Vegetable Proteins (TVP) & High Moisture Meat Analogues (HMMA).* https://www.emsland-group.de/en/your-products/food/meat-analogues/
[125] Gfi Europe. *Plant-based retail sales in six European countries, 2023 to 2025.* https://gfieurope.org/european-plant-based-sales-data/#italy
[126] Roquette. *Roquette pea starch N-735.* https://www.roquette.com/food-nutrition/resources/roquette-pea-starch-n-735
[127] Cosucra. *NASTAR pea starch.* https://www.cosucra.com/our-ingredients/nastar/
[128] HEISS MSP. *Sustainable protein concentrates from dry fractionation.* https://heiss-msp.de/en/sustainable-protein-concentrates-from-dry-fractionation/
[129] Roquette. *Roquette pea starch N-735.* https://www.roquette.com/food-nutrition/resources/roquette-pea-starch-n-735
[130] Cosucra. *NASTAR pea starch.* https://www.cosucra.com/our-ingredients/nastar/

Emsland Group	Germany	Active in noodles, coatings, meat analogues, confectionery, vegan cheese and industrial uses.[131]	Offers pea starch and modified pea starch solutions
Vestkorn	Norway	Produces dry-processed pea/faba protein concentrates and pea/faba starches, including organic options. [132]	Dry-processing specialist for pea and faba ingredients
Asian starch suppliers	China/Asia	Chinese pea starch listings show very low indicative export prices, although these do not necessarily include EU certification, logistics, duties or technical support. [133]	Low-cost competitive pressure

Overall, the table confirms that pea starch is already a commercially established and sellable ingredient category, supported by existing products, technical benchmarks and established European competitors. For an Italian or European producer, this means that **the market is not empty** and that a new entrant would need to differentiate through clear product specifications, consistent functional performance and a credible value proposition rather than price alone. Relevant positioning opportunities include regional sourcing, traceability, organic certification, clean-label functionality, application-specific validation and verified sustainability benefits. At the same time, based on publicly available information, **no clear direct Italian competitor specialising in legume starch or pea starch as a standalone B2B ingredient was identified**, which may create an opportunity for a locally positioned supplier. For IPS5.3, the strongest approach may therefore be to market the starch-rich fraction as a resource-efficient, regionally sourced co-product of plant-protein processing, supported by technical evidence and a clear cost-in-use advantage.

Price positioning. Publicly available starch prices provide an initial reference point for assessing the potential market positioning and commercial viability of legume-derived starch ingredients. The benchmarks below cover a branded food-grade pea starch, indicative low-cost export offers and an established European commodity starch. Together, they help illustrate the price environment faced by a new pea or legume starch product and the extent to which specialised ingredients may achieve a premium over conventional starches. However, these figures are not directly comparable because they reflect differences in product specifications, order volumes, packaging formats, certification requirements, supply conditions and levels of technical support. They should therefore be treated as indicative market signals rather than definitive transaction prices, with final financial modelling based on comparable supplier quotations and clearly defined product requirements.

Table 17 Indicative price benchmarks for pea and commodity starches

Benchmark	Indicative price	Interpretation
NASTAR native pea starch	cc. **EUR 41.85 / 25 kg**, or **EUR 1.67/kg**	Useful benchmark for branded food-grade pea starch sold in smaller B2B packs.[134]
Chinese pea starch export listings	cc. **USD 0.35 -1.20/kg**	Low-cost export benchmark; not directly comparable to certified EU food-grade supply because logistics, duties, documentation and quality assurance may differ. [135]
Native potato starch, EU B2B benchmark	cc. **EUR 1.28–1.36/kg** depending on volume	Commodity starch comparison; shows price pressure from established starches.[136]

[131] Emsland Group. *Noodles and fluten free pasta*. https://www.emsland-group.de/en/your-products/food/noodles/

[132] Vestkorn. *Protein and other sustainable ingredients.* https://vestkorn.com/

[133] Made in China. *Pea Starch.* https://www.made-in-china.com/products-search/hot-china-products/Pea_Starch.html

[134] Ehlert shop. Nastar – native pea starch, bag 25kg - https://www.ehlert-shop.de/en/nastarnativepeastarchbag25kg-zid35625

[135] Made in China. *Pea Starch.* https://www.made-in-china.com/products-search/hot-china-products/Pea_Starch.html

[136] FDCM. *Native Potato Starch*. https://fdcm.eu/products/native-potato-starch/

The commercial implication of the analysis confirms that **purified, food-grade pea starch can potentially be sold at a specialty ingredient price**, but a dry-fractionated starch-rich side-stream will not automatically achieve the same value. If the material is closer to a starch-rich concentrate than to purified starch, its price will depend on **starch content, purity, flavour, colour, microbiological quality, functional performance** and whether it can replace existing starches in a formulation.

Therefore, the most realistic positioning is not to compete directly with cheap maize, potato or tapioca starch, but to position legume starch as a **European, clean-label, functional and circular ingredient** for selected applications. A new European legume starch should therefore not rely on price competition alone, but should demonstrate added value through regional sourcing, traceability, consistent functionality, food-grade certification, sustainability credentials and validated performance in specific applications.

Market challenges. The main challenge is **competition from established commodity starches** such as **maize, wheat, potato and tapioca starch.** These starches are widely available, technically familiar to food manufacturers and often cheaper. The broader European starch industry has also faced pressure from weaker demand and cheaper Asian imports.
The second challenge is **quality consistency**. A starch-rich side-stream from dry fractionation is not automatically equivalent to purified pea starch. Since dry fractionation separates starch and protein mechanically, the resulting fractions may still contain mixed components, and their functionality may vary depending on raw material, moisture, milling, air classification and process settings.

The third challenge is **market education and formulation support**. Established competitors already provide application-specific ingredients and technical guidance. For a new supplier, simply offering "legume starch" may not be enough; the product needs to be linked to specific use cases, such as crisp coatings, glass noodles, plant-based meat binding, gluten-free bakery or vegan cheese texture.

Finally, there is a **positioning challenge**. If sold as a commodity starch, legume starch will face price pressure. If sold as a specialty circular ingredient, it needs proof of functionality, sustainability and reliable supply.

Key takeaways. Starch from legumes is a commercially relevant but still niche ingredient category. The strongest existing market reference is pea starch, which is already produced and sold by established European ingredient companies for applications in bakery, coatings, noodles, sauces, plant-based meat, dairy alternatives and confectionery. This confirms that legume starch can be sold, but only if it is technically well-defined and positioned for the right applications.
For dry fractionation processes, the starch-rich fraction should be treated as a **valuable side-stream** rather than as waste. Its commercial value will depend on whether it can be standardised as a food-grade functional ingredient, and whether it offers **advantages compared with conventional starches**. The strongest positioning is likely to be: **European, clean-label, pulse-based, allergen and GMO free, certified, functional and circular**.

3. Dry Fractionation Technology Market Analysis

Dry fractionation is a mechanical processing technology used to separate the main components of legumes without using water or chemical solvents. In the most common industrial configuration, legumes are cleaned and dehulled, finely milled and then separated by air classification.

The process relies on the physical difference between relatively small protein particles, typically around 3 µm, and larger starch granules, commonly around 15-40 µm[137]. After controlled milling releases these particles from the cellular structure, an air classifier separates the flour into:

- a fine protein-enriched fraction,
- a coarse starch-rich fraction and
- a separate fibre-rich stream (where dehulling is included).

The most important technological step is not simply fine grinding, but **controlled liberation of protein bodies without excessive damage to starch granules**.[138]

Main applications of the technology. Dry fractionation is primarily used to process legumes into a fine, protein-enriched fraction and a coarser fraction enriched in starch and/or fibre. The technology is particularly suitable for peas, faba beans, lentils, chickpeas, lupins and other grain legumes, although its performance depends on the structure, starch content and oil content of the selected raw material.[139]

Although legumes represent the most established application, the same combination of fine milling and air classification can also be applied to wheat, rye, oats, barley, quinoa and selected oilseed-derived materials.[140]

The commercial attractiveness of dry fractionation increases when viable applications and market outlets are available for both the protein-rich fraction and the resulting starch- or fibre-rich co-products.

- **Peas, faba beans and lentils** are among the most suitable feedstocks because their protein bodies and starch granules can be effectively separated after milling.
- **Chickpea** is more challenging because of its higher fat content and different particle structure. Oil increases powder cohesion and can reduce dispersion in the air classifier.
- **Lupin and soybean** require different process optimisation because they contain less starch. Separation is more dependent on differences between protein, fibre and residual oil, rather than conventional protein-starch separation.[141,142]

Price and cost structure. No reliable public benchmark in EUR per tonne could be identified for the commercial use of dry-fractionation technology. The price paid to an external processor should be treated as a **service price**, which may be quoted per batch, per operating day, per pilot campaign or per tonne processed. It should not be confused with CAPEX or OPEX.
Where service prices are unavailable, CAPEX and OPEX can provide an indication of the financial requirements associated with owning and operating a dry-fractionation plant.

[137] Hosokawa Alpine. *Protein shifting (Dry fractionation).* https://www.hosokawa-alpine.com/powder-particle-processing/industries/food-and-feed/protein-shifting/
[138] Hosokawa Alpine. *Protein shifting (Dry fractionation).* https://www.hosokawa-alpine.com/powder-particle-processing/industries/food-and-feed/protein-shifting/
[139] Wageningen. *Dry Fractionation for Sustainable Production of Functional, Nutritional and Palatable Grain Legume Protein Ingredients.* https://edepot.wur.nl/687298
[140] Hosokawa Alpine. *Protein shifting (Dry fractionation).* https://www.hosokawa-alpine.com/powder-particle-processing/industries/food-and-feed/protein-shifting/
[141] MDPI. *Developments in the Dry Fractionation of Plant Components: A Review*. https://www.mdpi.com/2297-8739/11/12/332
[142] Springer Nature Link. *Dry Fractionation for Sustainable Production of Functional, Nutritional and Palatable Grain Legume Protein Ingredients*. https://link.springer.com/article/10.1007/s12393-024-09394-2

- **CAPEX – Capital expenditure** represents the initial investment required to establish the processing facility. It includes the purchase and installation of equipment, as well as supporting infrastructure such as piping, instrumentation, electrical systems, storage, site development, engineering, contingencies and working capital.
- **OPEX – Operating expenditure** represents the recurring annual cost of running the facility. It includes raw materials, electricity and other utilities, labour, maintenance, supervision, insurance, taxes, overheads, administration and other production expenses.

A 2024 peer-reviewed techno-economic study modelled an industrial facility processing **40,000 tonnes of yellow peas per year**, operating for approximately 8,000 hours annually. The baseline process included dehulling, coarse milling, air-classifier milling and air classification, without an additional thermal pre-treatment stage. All financial values in the study were expressed in Canadian dollars and reflected conditions assumed for a facility in Saskatchewan, Canada.[143]

Table 18 Indicative CAPEX and OPEX for the baseline processing plant

Cost indicator	Modelled value	Interpretation
Total CAPEX	CAD 8.4 mill (~ EUR 5,1 mill)[144]	Initial investment required for the complete baseline plant.
Total annual OPEX	CAD 35.3 mill/year (~ EUR 21.7 mill)[145]	Total annual cost of purchasing raw materials and operating the facility.

The estimated CAD 8.4 million CAPEX is not merely the purchase price of a mill or air classifier. It represents the study's estimated total capital investment for the complete industrial facility. Equipment costs were based partly on vendor quotations and then expanded to include installation, engineering, electrical systems, storage, site development, contingencies and working capital.

The CAD 35.3 million annual OPEX should also be interpreted carefully. It does not mean that operating the dry-fractionation equipment alone costs CAD 35.3 million per year. Approximately CAD 18.86 million[146], was attributed to the purchase of 40,000 tonnes[147] of peas. Utilities represented approximately 5%[148] of the total, while the remainder included labour, maintenance, financing and general operating expenses.

These values can be included as an **indicative investment and operating-cost benchmark**, but they should not be presented as European market prices or as a benchmark for the price of dry-fractionation services. Actual investment costs in Italy or elsewhere in Europe would depend on plant capacity, existing infrastructure, equipment supplier, level of automation, food-safety requirements,

[143] NRC Publications. *Techno-eco-environmental assessment of dry fractionation of protein concentrates from yellow peas with different pre-treatment methods: an eco-efficiency approach.* https://nrc-publications.canada.ca/eng/view/ft/?id=7235feb4-1ed6-4e15-83d1-753f6462adf5

[144] NRC Publications. *Techno-eco-environmental assessment of dry fractionation of protein concentrates from yellow peas with different pre-treatment methods: an eco-efficiency approach.* https://nrc-publications.canada.ca/eng/view/ft/?id=7235feb4-1ed6-4e15-83d1-753f6462adf5

[145] NRC Publications. *Techno-eco-environmental assessment of dry fractionation of protein concentrates from yellow peas with different pre-treatment methods: an eco-efficiency approach.* https://nrc-publications.canada.ca/eng/view/ft/?id=7235feb4-1ed6-4e15-83d1-753f6462adf5

[146] NRC Publications. *Techno-eco-environmental assessment of dry fractionation of protein concentrates from yellow peas with different pre-treatment methods: an eco-efficiency approach.* https://nrc-publications.canada.ca/eng/view/ft/?id=7235feb4-1ed6-4e15-83d1-753f6462adf5

[147] NRC Publications. *Techno-eco-environmental assessment of dry fractionation of protein concentrates from yellow peas with different pre-treatment methods: an eco-efficiency approach.* https://nrc-publications.canada.ca/eng/view/ft/?id=7235feb4-1ed6-4e15-83d1-753f6462adf5

[148] NRC Publications. *Techno-eco-environmental assessment of dry fractionation of protein concentrates from yellow peas with different pre-treatment methods: an eco-efficiency approach.* https://nrc-publications.canada.ca/eng/view/ft/?id=7235feb4-1ed6-4e15-83d1-753f6462adf5

ATEX compliance and whether the project covers only milling and classification or a complete turnkey facility.

Market drivers

Lower water and energy requirements: Dry fractionation eliminates the water-based extraction and subsequent spray-drying stages associated with conventional wet protein separation. This reduces water consumption, wastewater generation and thermal-energy demand. It also helps preserve relatively native protein functionality.[149]

Development of European protein-crop value chains: The European Commission's 2026 Protein Action Plan aims to strengthen domestic protein production, processing capacity and supply-chain resilience. Growth in European pulse production would increase demand for local and regional fractionation infrastructure.[150]

Side-stream valorisation: Dry fractionation generates multiple dry streams rather than a large liquid waste stream. Protein-, starch- and fibre-rich fractions can each be directed towards different applications, supporting circular processing and improved raw-material utilisation.[151]

Competitive landscape for dry fractionation technology. The European dry-fractionation landscape includes a mix of specialised equipment manufacturers, pilot and research centres, toll processors and contract-processing providers. These should not be treated as identical competitors. The organisations presented below cover different stages of technology development and deployment, from laboratory and pilot-scale testing to the supply of complete industrial milling and air-classification systems. Their capabilities are relevant for assessing equipment options, scale-up pathways, processing capacity and access to external food-grade processing services without requiring immediate investment in a dedicated facility.

Table 19 European dry-fractionation technology providers and processing services

Organisation	Country	Role and technological position
Hosokawa Alpine[152]	Germany	Major specialised supplier of mills, air classifiers and complete protein-shifting systems; offers standard and precision process configurations
NETZSCH[153]	Germany	Supplies classifier mills and high-efficiency air classifiers, with systems published at capacities of approximately 0.5–4 t/h
Atritor[154]	United Kingdom	Offers simultaneous milling and classification technology, pilot testing and systems with published capacities from approximately 50 to 5,000 kg/h

[149] Science Direct. *The potential of dry fractionation processes for sustainable plant protein production*. https://www.sciencedirect.com/science/article/abs/pii/S0924224410002645

[150] European Comission. *Reducing the plant protein deficit of the European Union.* https://agriculture.ec.europa.eu/farming/crop-productions-and-plant-based-products/cereals/reducing-plant-protein-deficit-eu_en

[151] Anual Reviews. *Mild Fractionation for More Sustainable Food Ingredients.* https://edepot.wur.nl/629014

[152] Hosokawa Alpine. *Protein shifting (Dry fractionation).* https://www.hosokawa-alpine.com/powder-particle-processing/industries/food-and-feed/protein-shifting/

[153] NETZSCH. *Case study.* https://grinding.netzsch.com/_Resources/Persistent/4/5/5/7/45579fb88c34b1b53e1f0c9b14c078fed5401f6d/NETZSCH_CaseStudy_Protein%20Shifting_e.pdf

[154] Atritor. Dry Fractionation of Pulses to Produce High-Quality Protein Concentrate. https://atritor.com/dry-fractionation-of-cereals-and-pulses-to-produce-high-quality-protein-concentrate/

IMPROVE[155]	France	Specialised pilot and R&D centre for dry and wet plant-protein processing
Heiss MSP[156]	Germany	Toll processor offering micronisation, separation and dry fractionation in food-grade facilities
Castle Group[157]	Belgium	Contract processor offering dry fractionation and related ingredient-processing services
Separ Micro System[158]	Italy	Italian manufacturer of micronisers and precision turbo-separators
CIMMA Morandotti[159]	Italy	Italian supplier of grinding, classification and microseparation equipment

Hosokawa Alpine and **NETZSCH** are the most visible direct specialised technology competitors, particularly for integrated milling and air-classification systems, while **Atritor** provides a broad capacity range and pilot-testing support. **IMPROVE, Heiss MSP** and **Castle Group** offer opportunities to validate processes or outsource production before committing to full-scale investment, and Italian suppliers such as **Separ Micro System** and **CIMMA Morandotti** may facilitate local sourcing, technical assistance and integration into a regional processing model. Competition among suppliers is driven primarily by proven performance with specific crops, the level of protein enrichment achieved at an acceptable yield, the ability to process fatty or cohesive materials, temperature control during milling, flexibility across feedstocks and pilot-to-industrial scale-up capability. Cleaning and allergen management, energy and maintenance requirements, and the integration of dehulling, conveying, filtration and packing are also important selection criteria. The final technology choice should therefore be based on crop-specific performance, required throughput, food-safety requirements and total investment and operating costs.

Market challenges

Raw-material variability: The efficiency of dry fractionation depends strongly on the characteristics of the selected crop, including particle size and shape, composition, powder cohesion and milling behaviour. Process parameters therefore need to be adjusted to the specific raw material to achieve the desired protein enrichment and yield. Changing raw material may require repeated process optimisation, which increases development costs.[160]

Powder cohesion and fat content: Moisture and oil can cause particles to agglomerate, reducing dispersion and classification efficiency. Chickpea and oilseed meals are therefore more difficult to process than conventional starch-rich peas or faba beans.[161,162]

[155] Hosokawa Alpine. *IMPROVE tests protein shifting with multiprocessing system.* https://www.hosokawa-alpine.com/powder-particle-processing/customer-stories/protein-shifting-with-multiprocessing-system

[156] HEISS MSP. https://heiss-msp.de/en/

[157] Castle Group. *Dry Fractionation/Air Classification*. https://www.castle-group.eu/dry-fractionation

[158] Separ Micro System. https://www.separmicrosystem.com/

[159] CIMMA Morandotti. *Air classifier mills pavia.* https://cimma.it/en/air-classifier-mills-pavia/

[160] Science direct. *Metrics to assess pulse grains for protein enrichment potential in air classification.* https://www.sciencedirect.com/science/article/pii/S0963996925008439

[161] Science Direct. *Dry fractionation of chickpea flour: Impact of de-oiling and flow aids.* https://www.sciencedirect.com/science/article/pii/S0032591024008246

[162] Food Engineering Reviews. *Dry Fractionation for Sustainable Production of Functional, Nutritional and Palatable Grain Legume Protein Ingredients.* https://edepot.wur.nl/687298

Starch damage: If milling is too aggressive, starch granules break into smaller particles and enter the protein-rich fraction. If milling is insufficient, protein remains attached to starch-containing cell fragments. The operating window must be determined experimentally.[163]

Limited price transparency: The absence of public service and equipment prices makes early financial assessment difficult. Comparable quotations require a common specification covering throughput, target enrichment, recovery, process boundaries and food-safety requirements.

Key takeaways. Dry fractionation is a **commercially available but highly application-specific technology.** Its main advantages are substantially lower water and energy requirements, fewer processing stages and the absence of water-intensive protein extraction and drying operations. It can therefore offer a considerably lower environmental footprint than conventional wet fractionation while also preserving the relatively native functionality of the separated components.

However, this environmental advantage is accompanied by an important trade-off. Dry fractionation generally achieves lower protein purity and lower recovery of the targeted protein-rich fraction than wet fractionation. Consequently, a larger proportion of the processed raw material remains in starch, fibre- or mixed-component fractions. These streams should not automatically be classified as waste, since they can be used as food ingredients, feed materials or inputs for further processing. Nevertheless, where suitable applications and buyers are not available, their relatively large volume may become a significant low-value side stream or waste-management challenge.

The commercial feasibility of the technology therefore depends not only on the value of the protein-rich fraction, but also on the processor's ability to valorise all resulting fractions. For Italy and Europe, dry fractionation appears particularly suitable for peas, faba beans and lentils, while chickpeas and higher-fat materials require more extensive process optimisation.

Case studies

Several European companies already produce pulse flours and protein concentrates using dry milling and air-classification technologies comparable to the IPS5.3 approach. These cases demonstrate that dry-fractionated pulse ingredients have an established B2B market, although IPS5.3 places stronger emphasis on regional sourcing, pre-sowing contracts, decentralised processing and the high-value use of both resulting fractions.

Vestkorn[164], Norway: Vestkorn is a major European producer of pea- and faba-bean ingredients manufactured through dry processing. Its portfolio includes protein concentrates, starch-rich ingredients, fibres, flours and textured proteins for food, pet-food and feed applications, with organic options also available. Vestkorn demonstrates the commercial potential of separating legumes into several functional ingredient streams and selling them into different markets rather than relying on a single protein product. This is particularly relevant to IPS5.3 because it confirms that both protein- and starch-rich fractions can form part of a diversified B2B ingredient portfolio.

Müller's Mühle[165], Germany: Müller's Mühle has expanded from conventional pulse milling into the production of high-protein flours and concentrates from peas, faba beans, lentils and chickpeas. At its facility in Gelsenkirchen, Müller's Mühle uses air separation to divide milled pulses into protein-rich and starch-rich fractions, which are supplied to food manufacturers or further processed into textured

[163] Wageningen. Dry fractionation for production of functional pea protein concentrates. https://research.wur.nl/en/publications/dry-fractionation-for-production-of-functional-pea-protein-concen/

[164] Vestkorn, *Protein and other sustainable ingredients* https://vestkorn.com/

[165] Smart Protein Project EU, *Providing the plant-based foods of today and tomorrow with legumes and cutting-edge technology*, https://smartproteinproject.eu/plant-based-foods-of-tomorrow-muellers-muehle/

vegetable proteins. This case closely reflects the IPS5.3 processing concept and shows how an established regional pulse processor can move from commodity flour production towards higher-value B2B ingredients for plant-based foods.

Ebro Ingredients[166], Belgium and the Netherlands: Ebro Ingredients produces dry-fractionated pea and faba-bean protein concentrates, including **PisumPRO** and **ViciaPRO**, for applications such as meat alternatives, bakery products, beverages, sauces and other protein-enriched foods. Ebro Ingredients also uses locally grown specialised faba-bean varieties for some of its concentrates and offers both protein concentrates and textured products. This case demonstrates the market value of combining regional crop sourcing, clean-label dry processing and application-specific ingredient development, which closely supports the premium and identity-preserved positioning proposed for IPS5.3.

These examples confirm that dry-fractionated pulse ingredients are already commercially established in Europe. IPS5.3 can differentiate itself through a more decentralised regional-hub model, advance supply agreements with farmers and deliberate co-valorisation of both protein-rich and starch-rich fractions for human-food applications.

1.4. Decentralised Processing Technology Solutions

Dry fractionation is a promising technology for the localised processing of plant proteins. The process generally combines dry milling with air classification: milling releases protein-rich particles from the surrounding seed structure, after which air classification separates the smaller protein-rich particles from the coarser starch-rich fraction. Compared with conventional wet extraction, dry fractionation requires substantially less water and energy and helps preserve proteins in a relatively native state, supporting functional properties relevant to food formulation.[167, 168,169]

The composition and recovery of the resulting fractions depend strongly on the crop and processing conditions. For **yellow peas**, dry milling and air classification have produced protein concentrates containing approximately **51–55% protein**, with a maximum reported **protein recovery of 77%.**[170] The protein-rich fine fraction may therefore provide a moderately enriched and functional alternative to highly refined isolates, while the coarse fraction is primarily enriched in starch and requires a suitable commercial application.

Chickpea is more challenging to process through air classification because its higher fat content and smaller starch granules can reduce powder dispersibility and separation efficiency. Published research reported **protein enrichment to approximately 45%,** with initial protein yields below 25%. Extensive de-oiling increased protein yield to approximately 70%, while the resulting **de-oiled fraction**

[166] Ebro Ingredients, *Producing innovative solutions from rice and pulses* https://www.ebroingredients.com/ingredients/pulse/pisumpro-pea-protein-concentrates/

[167] Pelgrom, P. J. M., Vissers, A. M., Boom, R. M., & Schutyser, M. A. I. (2013). Dry fractionation for production of functional pea protein concentrates. Food Research International, 53(1), 232–239. https://doi.org/10.1016/j.foodres.2013.05.004

[168] Schutyser, M. A. I., & van der Goot, A. J. (2011). The potential of dry fractionation processes for sustainable plant protein production. *Trends in Food Science and Technology*, *22*(4), 154-164. https://doi.org/10.1016/j.tifs.2010.11.006

[169] Schutyser, M. A. I., Pelgrom, P. J. M., van der Goot, A. J., & Boom, R. M. (2015). Dry fractionation for sustainable production of functional legume protein concentrates. *Trends in Food Science and Technology*, *45*(2), 327-335. https://doi.org/10.1016/j.tifs.2015.04.013

[170] Pelgrom, P. J. M., Boom, R. M., & Schutyser, M. A. I. (2015). Functional analysis of mildly refined fractions from yellow pea. Food Hydrocolloids, 44, 12-22. https://doi.org/10.1016/j.foodhyd.2014.09.001

contained 51% protein and was further enriched to 56% through electrostatic separation.[171,172] These results demonstrate that chickpea processing may require additional optimisation or pre-treatment to obtain commercially relevant protein concentrates.

1.5. Key Challenges Identified

The key challenges for the IPS5.3 business case were identified during the co-creation workshop held at the VALPRO Path General Assembly in Athens in M27. Using Mentimeter and facilitated group discussions, project partners contributed real-time feedback on the technical, economic and operational barriers to decentralised plant-protein processing. The objective of the workshop on was to explore the challenges and opportunities related to the business case, focusing on technologies like drying, cleaning, sieving, sorting, milling and separation. Discussions covered the technical feasibility of these methods, economic considerations for their implementation and the valorisation of processing by-products. The goal was to identify mitigation measures for the identified challenges making production more efficient and adaptable to local needs. Some of the key challenges identified include:

1. **Sustainability and processing efficiency:** Ensuring efficient and sustainable processing methods to maximize ingredient functionality. Balancing environmental impact with economic viability in production.
2. **Removal of anti-nutritional factors:** Need for effective techniques to remove anti-nutritional factors in dry concentrates. Evaluating the impact of different processing methods on nutritional quality.
3. **Infrastructure and technological scaling:** Challenges in establishing local processing plants to reduce transportation costs. Develop scalable extraction and fractionation technologies for starch, fibre and other crop side streams.
4. **Economic and capital expenditure considerations:** Capital costs associated with dry fractionation technologies. Optimization of protein yield and economic assessment of different processing approaches.
5. **Side stream valorisation:** Identify alternative uses for waste streams generated during processing. Explore commercial opportunities for secondary metabolites and hybrid fractionation techniques.

The workshop also identified several **additional business opportunities** that could broaden the scope and commercial potential of the business case. These include the extraction of secondary metabolites with potential **value for food, nutraceutical, cosmetic or other specialised applications**, as well as the valorisation of processing residues in both food and non-food markets, including their possible use as **natural fertilisers**. **Hybrid fractionation techniques** were also highlighted as a promising pathway for combining dry and other mild processing methods to improve ingredient functionality, increase the recovery of valuable components and reduce overall resource use. Together, these opportunities could create additional revenue streams, strengthen circularity and improve the economic viability of decentralised plant-protein processing.

Table 20 Key challenges in using dry fractionation technology

[171] Wetterauw, K., Spitzer, M., Nafingah, R., Wilms, P., Boom, R., Venema, P., & Schutyser, M. (2024). Dry fractionation of chickpea flour: Impact of de-oiling and flow aids. Powder Technology, 446, Article 120180. https://doi.org/10.1016/j.powtec.2024.120180

[172] Xing, Q., Utami, D. P., Demattey, M. B., Kyriakopoulou, K., de Wit, M., Boom, R. M., & Schutyser, M. A. I. (2020). A two-step air classification and electrostatic separation process for protein enrichment of starch-containing legumes. Innovative Food Science and Emerging Technologies, 66, Article 102480. https://doi.org/10.1016/j.ifset.2020.102480

Key challenge	Mitigation measure
Sustainability and processing efficiency	Optimise processing conditions through pilot trials that compare energy use, ingredient yield, functionality and environmental performance. Select the processing configuration that achieves the best balance between technical efficiency, product quality and economic viability.
Removal of anti-nutritional factors	Evaluate suitable pre-treatment and processing options, such as dehulling, controlled heating, roasting or hybrid fractionation, and assess their effects on anti-nutritional compounds, nutritional quality, digestibility and ingredient functionality.
Infrastructure and technological scaling	Apply a phased scale-up approach, progressing from pilot to demonstration and commercial operation. Use modular and flexible equipment, assess toll-processing options and validate the scalability of technologies for separating protein, starch, fibre and other crop fractions before investing in dedicated local facilities.
Economic and capital expenditure considerations	Conduct detailed CAPEX, OPEX, break-even and sensitivity analyses based on verified pilot data. Optimise protein yield, throughput and equipment utilisation and compare alternative processing configurations before selecting the most commercially viable option.
Side-stream valorisation	Characterise starch-, fibre- and metabolite-rich fractions and identify suitable higher-value applications through collaboration with research and industry partners. Assess opportunities in food, feed, fertilisers, biomaterials and secondary-metabolite extraction.

1.6. Customer Segmentation

As IPS5.3 is centred on the localised processing and commercialisation of plant-protein ingredients, the proposed business model follows a **B2B approach**. The target market comprises two principal customer groups - **pulse processors and ingredient manufacturers** seeking to adopt decentralised processing technologies, and **downstream artisanal and industrial food manufacturers** purchasing the resulting functional protein- and starch-rich ingredients.

Table 21 Value proposition analysis for IPS5.3 business case customer segments

Customer/ Actor		Paid addressed	Gain created
Pulse processors and ingredient manufacturers		Dependence on centralised, resource-intensive processing methods (wet extraction). Conventional protein supply chains are strictly optimised for high volumes and low-value commodity feed markets, limiting local value creation.	Access to localised processing models (dry fractionation) that require lower resource intensity (no water/chemicals). Increased value creation through the production of functional protein fractions and improved, profitable use of side-streams.
Food manufacturers	**Artisanal and premium food manufacturers**	Reliance on highly refined protein isolates that require resource-intensive supply chains and lack transparent, cross-regional sourcing. Difficulty sourcing appropriate, manageable quantities of regional ingredients for small-batch production.	Access to sustainable, highly functional European pulse fractions with verified regional traceability. Provision of practical 5kg bags of locally certified protein concentrate, ideal for high-end, gluten-free artisan pasta production.
	Industrial food manufacturers and bakery sector	Need for scalable, traceable and sustainable raw materials. Lack of functional, circular ingredients derived from processing side-streams.	Access to 1-ton big bags of certified regional protein concentrates. Access to upcycled, food-grade coarse starch fractions specifically tailored for food applications.

1.7. Value Proposition Statements

Processor-focused value proposition: The decentralised processing technologies and models help pulse processors and ingredient producers who want to create higher-value plant-protein ingredients from European crops by reducing dependence on centralised, resource-intensive processing and increasing value creation through functional protein fractions, improved side-stream use and better alignment between crop origin, processing pathway and market application (unlike conventional protein supply chains that primarily optimise for volume, centralised processing and commodity feed markets).

Food manufacturer-focused value proposition: Pulse ingredients help food manufacturers who want to develop sustainable, functional and market-relevant plant-protein products by enabling access to European pulse fractions with improved functionality, traceability and circularity, while reducing reliance on highly refined isolates and resource-intensive ingredient supply chains (unlike conventional plant-protein ingredients that may require wet extraction, high resource use and less transparent cross-regional sourcing).

1.8. MVP and Business Case Validation Metrics

For IPS 5.3, the Minimum Viable Performance (MVP) is defined as the minimum level of demonstrated performance required to prove that decentralised, cross-regional protein supply chains can create tangible economic, environmental and market value. The success of this business case is measured through a combination of broader project-level KPIs and specific technological benchmarks.

Table 22 Business case validation metrics for IPS5.3

MVP dimension	Target value/ Validation requirement	Value reached in validation
Value creation and technology	**Up to 10% increase in value creation** through the exploitation of innovative post-harvest technologies and optimised production. **Technical validation:** Operating dry milling and separation with an energy consumption benchmarked between **130 and 200 kWh/t**.	The technical evaluations confirmed that the operational energy consumption typically ranges between 130 and 200 kWh/t.
	Achieving a fine fraction (protein concentrate) yield of around 27-28%, successfully recovering 54-70% of total protein from the raw crop.	During the best pilot trials, the system successfully produced fine fraction (protein concentrate) yields of 27% and 28%. These trials also validated the targeted protein recovery rates, successfully capturing 54% and 70% of the total protein from the raw crop. The resulting fine fractions achieved a highly concentrated protein content of 41.6% and 55.8%.
Circularity and by-product valorisation	**20% improvement in circularity** through the successful exploitation of milling side-streams.	The pilot trials confirmed that the coarse starch fractions make up the remaining bulk of the yield (approximately 72-73%) and contain around 15.9% to 16.6% residual protein.
	Technical validation: Finding profitable uses for the low-protein coarse starch fractions, which make up approximately 70% of the processing yield. This includes evaluating them for animal	Food-grade coarse fractions have been analysed and sent to the downstream food manufacturer - APT. Premium pasta is produced from these low-protein flours. The end-products have undergone a

	feed applications or successfully upcycling them into food applications.	nutritional value and cost analyses to validate commercial profitability.

1.9. Business Modelling Workshop

The VALPRO Path methodology, described in ***D5.3 Exploitation, IPR and Business Models Catalogue I***, was used to support collaborative business model development across the plant-protein value chains tackled in the VALPRO Path IPSs. In M47, this methodology was applied to IPS5.3 during the Value Chain Development Workshop, in cooperation with Molino Peila and partners from Aarhus University.



Figure 31 Business modelling workshop for IPS5.3 business case

The workshop focused on outlining the IPS5.3 business case tackling decentralised processing technologies for legumes (e.g., chickpeas and peas). The discussion centred on developing a collaborative business model that brings together farmers, processors, technology providers, research organisations and downstream food manufacturers. The value proposition focuses on locally produced pulse flour or protein concentrate whose value is based on regional origin, traceability and premium quality rather than direct price competition with imported commodity ingredients. A key challenge identified was the limited availability of local raw materials to support a fully decentralised processing model. To address this, pre-sowing agreements with farmers would be needed to secure the required quantities and quality in advance. This would ensure the division of the financial and market risk between farmers and processors, making the model dependent on strong demand for the final product and on achieving a premium market position. The possible role of public incentives or policy support was therefore also discussed to encourage farmers and reduce the initial risk for local processors.

Workshop discussions identified dry fractionation as the principal processing technology for IPS5.3, while emphasising that its commercial viability depends on the effective use of all resulting fractions. Participants noted that the process generates both a protein-rich fine fraction and a larger starch-rich coarse fraction; consequently, revenues from the protein concentrate alone may be insufficient to support a viable business model. The starch-rich fraction should therefore be developed for higher-value food applications, including bakery products, cakes, snacks and other formulated foods, rather than being directed primarily to low-value animal-feed markets. The workshop concluded that the strongest commercial pathway combines premium food-market positioning with coordinated regional

sourcing, secure agreements with farmers, efficient processing and full valorisation of both output streams.

1.9.1. Value Chain Innovation Mapping

The Value chain innovation mapping tool helped to **map activities** beginning with agronomic crop and variety selection, ensuring the chosen pulse varieties are well-adjusted to the local climate conditions. Following this, raw material sourcing secures locally produced crops in sufficient volumes, typically requiring at least 30 tons to establish a commercially profitable run. Post-harvest handling, storage, and logistics rely heavily on establishing pre-sowing contracts with farmers the year prior to guarantee material availability and utilizing localised storage solutions. Finally, pre-processing and milling preparation define the initial physical requirements, such as dehulling and moisture control, before the materials move into the extraction phase.

The core technological innovation takes place during the processing stage, which focuses on dry fractionation and the hybrid extraction of ingredients. This decentralised processing step eliminates the need for centralised, resource-intensive wet-extraction plants, successfully producing functional, protein-rich fractions with significantly lower energy and water requirements. Following this innovative extraction, ingredient characterisation and functionality testing are conducted to analyse the nutritional profile, precise protein content and functional properties of these newly milled fine fractions.

The final activities focus on market application and circularity, starting with food product formulation and application testing. Here, the locally processed and certified protein concentrates are validated by integrating them into premium consumer products like high-end, gluten-free artisanal pasta. (connection with IPS5.1 business case). Concurrently, side-stream and coarse fraction valorisation identifies profitable human food applications for the leftover low-protein coarse starch fractions. This final step ensures improved circularity and generates additional revenue streams from materials that would otherwise be downgraded to low-quality animal feed.

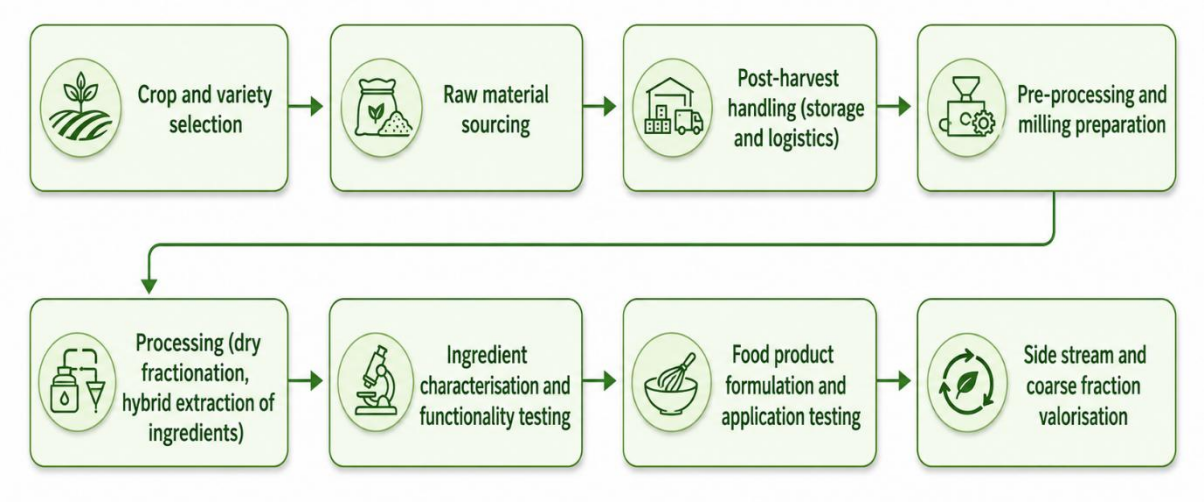


Figure 32 Value chain activities in IPS5.3 business case

The workshop discussions have identified a **highly collaborative network of stakeholders** involved in the business case consisting of traditional agricultural actors, commercial processors and research organisations to operationalise the decentralised model. At the upstream level, farmers, agronomists and agricultural cooperatives are essential for crop and variety selection and securing raw material sourcing. As the crops move to post-harvest handling and storage, storage providers and logistics

operators take over. IPS5.2 Hermetic bagging system is complementary to IPS5.3 business case supported by expertise from INTA evaluating sealable bag storage solutions focusing on cross-regional applications.

During the midstream processing phase, the focus shifts to technology providers and technical operators who manage pre-processing, dry fractionation and hybrid extraction. Molino Peila acts as the focal organisation and business case owner for the technical stage working closely with Hosokawa Alpine as the core technology provider running the milling pilot trials and Aarhus University (AU) for analysing the extraction yields and evaluating the dry fractionation.

Finally, the downstream market application and circularity activities involve ingredient manufacturers, food manufacturers, processors and end users. Antignano Prodotto Tipico (APT) serves as the key food manufacturer in this network, formulating and testing the locally processed ingredients in premium pasta products for end users. Concurrently, food and feed producers, circular economy actors and research partners - including the National Technical University of Athens (NTUA) handling LCA analysis and AU managing the starch streams – have collaborated to valorise the processing side-streams.

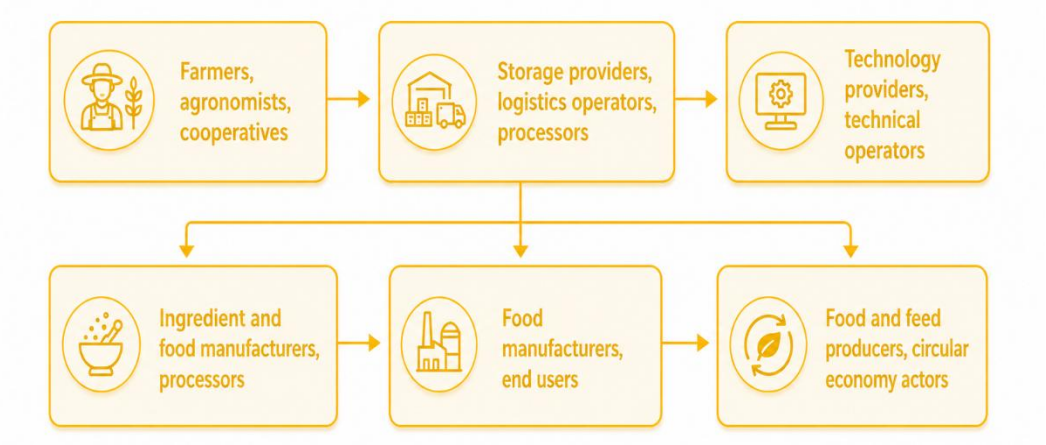


Figure 33 Stakeholders in IPS5.3 business case

The value chain innovation mapping reveals important **information gathered and value created** at each stage of the value chain incorporating the decentralised processing model. During crop and variety selection, data on suitable crops categorised by pedoclimatic region, quality parameters, protein content and expected yield is gathered to create a better match between the crop, the growing region and its final end-use. For raw material sourcing, insights into crop availability, the required volumes for profitability and procurement conditions establish a predictable material supply and a transparent link between agricultural regions and downstream processing. As crops move into post-harvest handling, storage and logistics, monitoring storage conditions, transport distances and potential waste points results in reduced post-harvest losses, maintained product identity and an improved environmental footprint due to shortened transport distances.

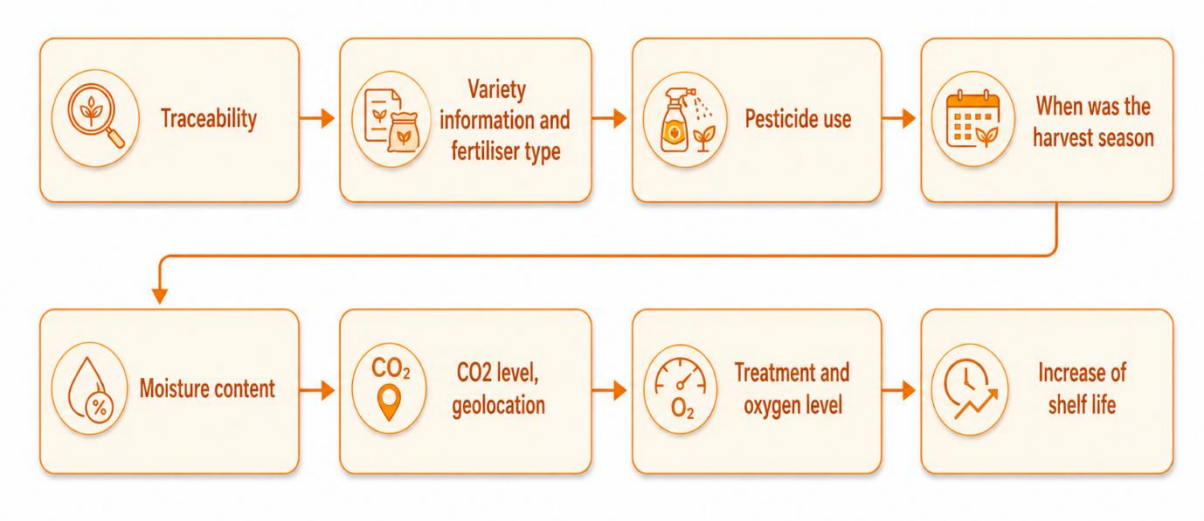


Figure 34 Value created in IPS5.3 business case

In the pre-processing and extraction phases, technical data drives efficiency. During pre-processing and milling preparation, information regarding dehulling requirements, moisture levels and lipid content helps identify crop-specific processing constraints, ultimately defining which specific varieties are most suitable for the equipment. The core processing stage gathers operational metrics including milling diagrams, specific energy consumption benchmarks and yield percentages to enable the physical production of functional, protein-rich ingredients using significantly lower resource intensity. Following extraction, ingredient characterisation and functionality testing provides an analysis of the newly milled fractions' nutritional profile, moisture levels and functional properties, delivering a clearer understanding of which protein fractions are best suited for specific food applications.

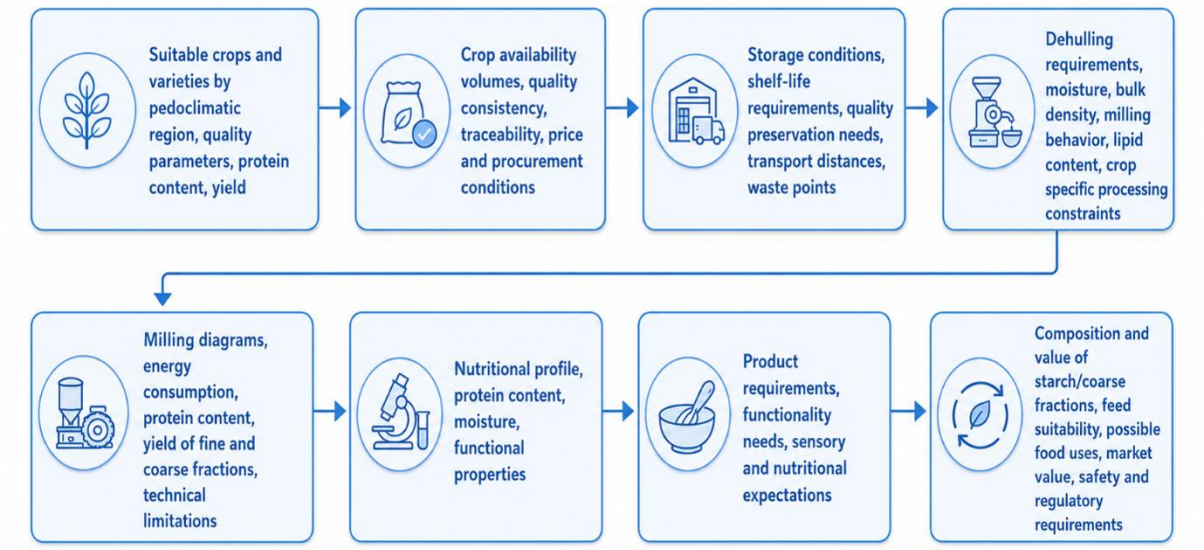


Figure 35 Information created in IPS5.3 business case

The final stages focus on market validation and maximising circularity. During food product formulation and application testing, consumer and manufacturer data detailing functionality needs and strict sensory expectations is gathered to validate the locally processed ingredients used to create premium artisanal pasta. Finally, side-stream and coarse fraction valorisation evaluates the composition, market value and food applications of the coarse starch fractions. By upcycling these starch side-streams into bakery applications rather than low-quality animal feed, the system significantly improves circularity, reduces waste and generates additional revenue streams to support the overall economic viability of the business case.

1.9.2. Business Model Radar

The IPS5.3 Business Model Radar illustrates the collaborative ecosystem required to commercialise decentralised processing technologies for European plant-protein ingredients. At the centre of the model is the shared value proposition: producing functional, traceable and regionally sourced protein-rich and starch-rich ingredients through decentralised processing. The radar shows that this value cannot be created by a single organisation, but depends on coordinated contributions from farmers, processors, technology providers, research organisations and downstream food manufacturers.

Molino Peila acts as the focal organisation and coordinates the core business activities, including raw-material sourcing, processing, quality control and commercial positioning. **Farmers, cooperatives and crop suppliers** provide suitable pulse varieties and secure reliable volumes through pre-sowing agreements, while also benefiting from more predictable demand and access to higher-value markets. **Alpine** contributes the dry-fractionation technology, equipment validation and technical adaptation, while **UNITO** supports varietal selection, regional sourcing, storage and transport analysis. **AU** contributes scientific evidence, ingredient characterisation, process optimisation and the valorisation of starch-rich side-streams.

Downstream, **food manufacturers using plant-protein ingredients** represent the primary customer group. Their role is to test the resulting fractions in food applications, provide feedback on functionality, sensory quality and market suitability and validate their use in products such as pasta, bakery goods and other premium formulations. **Health-conscious consumers** form the final end-user segment, benefiting from nutritious, clean-label and traceable European pulse ingredients. Overall, the radar demonstrates how IPS5.3 combines complementary capabilities, shared risks and co-production activities to create a commercially viable regional value chain in which both the protein-rich and coarse starch fractions are fully valorised.

The model also highlights how **value is distributed across the network** rather than captured only by the focal processor. Farmers gain stronger market access and more stable buyer relationships; technology and research partners generate validation evidence, application knowledge and scale-up know-how; processors diversify their ingredient portfolios and improve the use of all output fractions; and food manufacturers gain access to differentiated regional ingredients. This shared-value structure is essential for reducing investment and market risks, supporting long-term collaboration and enabling the regional processing model to move from pilot validation towards commercial scale-up.

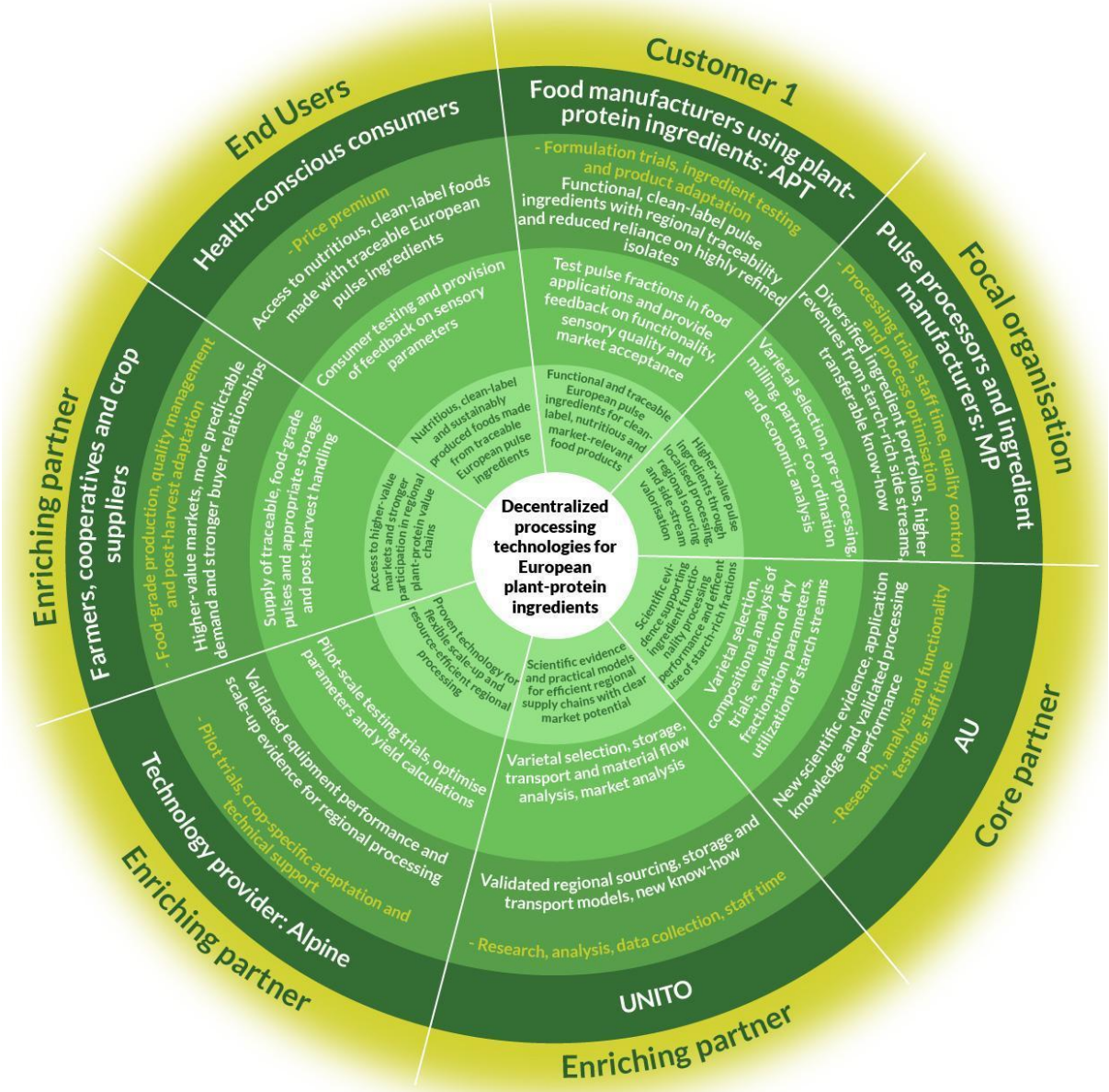


Figure 36 Business Model Radar for IPS5.3 business case

1.10. Business Model Analysis and Options Considered

Based on the market analysis and the pilot trials conducted by Molino Peila, the business model for IPS5.3 must navigate a fundamental shift from volume-driven commodity processing to value-driven, regional identity preservation. Because decentralised dry fractionation typically produces a protein concentrate representing only around 30% of the total yield, the business model's commercial viability depends on capturing premium market value, securing consistent raw material supplies and achieving total circularity of its processing outputs.

To operationalise these decentralised processing hubs, several business model options and processing strategies were considered:

Decentralised protein-concentrate model: This option focuses primarily on establishing regional dry-fractionation hubs that produce identity-preserved protein concentrates from locally sourced crops. The protein-rich fine fraction would be sold to food manufacturers as a higher-value ingredient, while the remaining coarse starch fraction would be directed to the animal-feed market. Although this model is relatively simple to implement, its commercial potential is limited. Once protein is concentrated in the fine fraction, the remaining starch-rich material contains less protein and may have reduced value as animal feed. As approximately 70% of the total processing output would therefore enter a low-value market, revenues from the protein concentrate alone may not be sufficient to cover the costs of decentralised processing. For this reason, the model is considered economically unsustainable unless stronger markets for the coarse fraction can be identified.

Integrated food-ingredient co-valorisation model: Under this model, both processing fractions are treated as commercial food ingredients rather than separating the protein fraction for food use and downgrading the remaining material to feed. The fine fraction is marketed as a locally sourced protein concentrate, while the coarse starch-rich fraction is developed for applications in bakery, cakes, snacks, pasta or other food products. This approach improves the economics of decentralised processing by generating revenue from the full volume of material processed. It also supports a zero-waste model, as the larger coarse fraction becomes a valuable co-product rather than a low-value side stream. The success of this model depends on identifying food applications that match the functional properties of each fraction and establishing relationships with manufacturers willing to incorporate both ingredients.

Pre-sowing contract and regional hub model: This option addresses the need for a reliable and consistent raw-material supply. It involves processing hubs entering into pre-sowing agreements with farmers, defining the crop variety, required quality, expected volume and purchase conditions before cultivation begins. A minimum processing volume, estimated at around 30 tonnes of a single raw material, is required to operate efficiently and maintain consistent ingredient quality. Contracting production in advance reduces supply risk, supports batch consistency, and gives farmers greater certainty regarding market access. It also enables processors to plan production schedules and secure sufficient volumes for commercial processing runs.

Premium identity-preserved ingredient model: This option focuses on obtaining a higher market price by preserving and verifying the regional origin, crop variety and chemical-free processing characteristics of the ingredients. The protein concentrate is sold in different formats according to customer needs. The commercial value is based not only on protein content but also on local sourcing, traceability, functionality and the absence of water or chemical solvents in the processing method. These attributes allow the ingredient to achieve a premium positioning over standard commodity products, particularly in markets for regional, sustainable, organic, or speciality foods.

1.11. Recommended Business Approach

The recommended business approach for IPS5.3 is an **integrated B2B co-valorisation model** built around regional processing hubs, pre-sowing supply agreements and the commercial use of both outputs generated through dry fractionation. Rather than treating the protein-rich fraction as the only valuable product, this model creates revenue from the full processing yield and avoids the economic weakness of directing most of the output into low-value animal feed markets. Under this approach, a regional processing hub works directly with local farmers and cooperatives to secure sufficient quantities of a specific crop before sowing. These pre-sowing agreements define the required crop variety, expected quality, production volume, delivery period and purchase conditions. Advance contracting ensures that the hub receives a consistent and traceable supply while reducing uncertainty for both farmers and processors.

Once the crop is delivered, it is processed through decentralised dry fractionation or another suitable chemical-free extraction method. This generates two main ingredient streams. The fine fraction, containing a higher concentration of protein can be marketed as an identity-preserved protein concentrate. The coarse fraction is starch-rich and can be developed as a functional food ingredient. The protein-rich fraction can be supplied to food manufacturers operating in higher-value markets, including pasta, bakery, snack, nutritional and plant-based food production. Its commercial positioning is based on verified regional origin, traceability, consistent functionality and the absence of water and chemical solvents during processing. This fraction can be supplied in smaller formats, such as 5-kilogram bags for artisan producers, or in 1-ton bulk bags for industrial manufacturers. These differentiated characteristics support a substantial price premium compared with conventional commodity protein ingredients. At the same time, the starch-rich coarse fraction can be commercialised in sectors where its functional properties can create value, such as bakery products, cakes, biscuits, snacks and other formulated foods. Developing reliable markets for this larger fraction is central to the business model because it provides an additional revenue stream, improves the economics of each processing run and supports the objective of zero-waste processing.

The fractions and approach depend on several closely connected conditions: securing sufficient raw material volumes, maintaining consistent crop and ingredient quality, validating food applications for both fractions and establishing long-term relationships with buyers. It also requires strong coordination between farmers, processors, food manufacturers, researchers and logistics providers.
This integrated B2B co-valorisation model offers the strongest route to commercial viability because it combines secure regional sourcing with the high-value use of all processing outputs. By creating markets for both the protein-rich and starch-rich fractions, the IPS5.3 business case improves processing profitability, reduces waste, strengthens regional plant-protein value chains and supports the development of traceable, locally produced food ingredients.

VALPRO path.

NEW VALUE LANDSCAPES FOR PLANT PROTEIN PATHWAYS

The Lupin Business Case: From Insolvency to Scale-up

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1. The Lupin Business Case: From Insolvency to Scale-up

The Prolupin-Wide Open Agriculture business case provides a useful example of how promising food-tech innovations can face significant commercialisation barriers, even when supported by strong scientific expertise and relevant market trends. Prolupin GmbH was a German company specialised in lupin protein isolate production and acted as VALPRO Path project partner until it filed for insolvency in June 2023. Prolupin was founded in 2010 as a spin-off of the Fraunhofer Institute and was one of the global market leaders in the production of lupin protein isolates. After insolvency Wide Open Agriculture acquired selected Prolupin assets, including production facilities, technical infrastructure and IP-related assets, through a German subsidiary.[173]

The acquisition enabled WOA to strengthen its position in the plant protein sector and establish a European production base more rapidly than through a greenfield investment. The business case is therefore relevant for analysing the links between innovation, IP, production scale-up, market demand and business model viability in the alternative protein industry.[174]

1.1. Market Analysis

The market opportunity for **lupin protein isolate** is supported by three wider demand drivers: rising global protein needs, growth of plant-based food markets and increasing demand for more sustainable and diversified protein sources. According to the Deloitte, global population growth and changing diets are expected to increase protein consumption by **32%–78% by 2050**[175], while the global population is projected to reach around **9.7 billion people by 2050** by the UN.[176] This creates a strong long-term demand for alternative protein ingredients, including plant-based proteins such as lupin.
The **plant-based food market** is also expected to expand significantly. According to Bloomberg Intelligence, the global plant-based foods market could reach **USD 162 billion by 2030**, up from **USD 29.4 billion in 2020**, potentially representing up to **7.7% of the global protein market** by 2030.[177] This suggests that plant-based ingredients are moving from niche applications into a larger commercial market, creating opportunities for ingredient suppliers that can offer scalable, functional and differentiated proteins. **Consumer demand** is another important driver. According to EAT and GlobeScan's *Grains of Truth 2* report, **22% of respondents reported eating vegetarian or vegan food most or all of the time in 2022, while 42% believed that most people would be eating plant-based food instead of meat within the next ten years**.[178]

Within this context, **lupin protein isolate has a clear market positioning opportunity**. It can serve as a **non-soy, non-GMO, plant-based protein ingredient** for manufacturers seeking alternatives to established proteins such as soy and pea. The most relevant market applications are **plant-based**

[173] KPMG Law, KPMG Law advises Wide Open Agriculture on the acquisition of assets of Prolupin GmbH, 8 November 2023. https://kpmg-law.de/en/kpmg-law-advises-wide-open-agriculture-on-the-acquisition-of-assets-of-prolupin-gmbh/
[174] Listcorp / WOA announcement, WOA agrees to acquire assets of Prolupin GmbH, 10 October 2023. https://www.listcorp.com/asx/woa/wide-open-agriculture-ltd/news/woa-agrees-to-acquire-assets-of-prolupin-gmbh-2938216.html
[175] Deloitte. (2021). *The future of protein*. Deloitte Switzerland. https://www.deloitte.com/ch/en/Industries/consumer/perspectives/food-future-of-protein.html
[176] United Nations Department of Economic and Social Affairs. (2019, June 17). https://www.un.org/development/desa/en/news/population/world-population-prospects-2019.html
[177] FHT Bali (2021) *Plant-based foods market to hit $162 billion in next decade, projects Bloomberg Intelligence*. https://www.fhtbali.com/plant-based-foods-market-to-hit-162-billion-in-next-decade-projects-bloomberg-intelligence/https://www.fhtbali.com/plant-based-foods-market-to-hit-162-billion-in-next-decade-projects-bloomberg-intelligence/?utm
[178] EAT & GlobeScan. (2022). *Grains of Truth 2: EAT–GlobeScan global consumer research on a sustainable food system*. https://eatforum.org/wp-content/uploads/2025/09/EAT-Forum-Report-2022.pdf

dairy, bakery, snacks, beverages, nutrition products and potentially meat alternatives. WOA illustrates application potential through examples such as protein-enhanced oat milk, cookies and noodles, which suggests that lupin protein isolate can be positioned across both mainstream and specialised product categories. For the B2B market, this is important because ingredient suppliers must show versatility across multiple formulations rather than rely on a single end-use category.

However, the market remains challenging. Lupin protein isolate must **compete with soy and pea proteins**, which are more established, widely available and familiar to food manufacturers. It also needs to overcome the typical barriers faced by alternative protein ingredients: price competitiveness, consistent supply, sensory performance, processing functionality and customer validation. In addition, lupin is a recognised allergen in the EU, which means that its use requires appropriate labelling and may influence product positioning.

Overall, the market for lupin protein isolate can be described as **high-potential but still emerging**. The demand side is supported by global protein growth, the expansion of plant-based foods and increasing consumer openness to plant-based diets. The supply side, however, requires commercial-scale production capacity, strong B2B partnerships and proof that lupin protein can deliver reliable performance at competitive cost.

1.2. Company Background

Prolupin GmbH was a German food-tech company specialised in the development and production of lupin-based protein ingredients and plant-based food products. The company was founded in 2010 by researchers from **Fraunhofer IVV** and used a patented process to extract protein from sweet lupins for food applications. This positioned Prolupin as a science-based company emerging from applied research and focused on transferring lupin protein technology into commercial markets.

The company's development was closely linked to Fraunhofer expertise in food process engineering and plant protein functionality. Fraunhofer IVV describes sweet lupin as a regionally relevant protein crop and explains that its research focused on using lupin proteins in milk alternatives, meat alternatives, fat substitutes and egg substitutes.[179] As a result Prolupin commercialised a wide range of dairy substitute products under the **MADE WITH LUVE** brand.

Prolupin's activities covered both **B2B ingredient production** and **consumer-facing product development**. On the ingredient side, the company produced lupin protein isolates and customised food ingredients intended to substitute animal protein functions in industrial food applications. On the consumer side, Prolupin developed the **MADE WITH LUVE** brand, including dairy alternatives such as plant-based yoghurt, ice cream, milk alternatives and soft cheese alternatives, which became available to consumers from 2015.

From an innovation perspective, Prolupin followed a typical research-to-market pathway. Fraunhofer's work on lupin protein focused on producing protein-rich, flavour-neutral ingredients for food, and Fraunhofer scientists together with Prolupin GmbH were recognised with the **German Future Prize 2014** for their work on food made from lupins.[180] This recognition underlined the technological novelty and applied research strength behind the company's core processing approach.

[179] Fraunhofer Institute for Process Engineering and Packaging IVV. (n.d.). *Plant-based foods with lupine protein*. https://www.ivv.fraunhofer.de/en/food/lupine-protein.html

[180] Fraunhofer-Gesellschaft. (2014). *Food made from lupins*. https://www.fraunhofer.de/en/media-center/videos/videos-2014/food-made-from-lupins.html

The company was based in **Grimmen, Germany**, and was considered as a market leader in lupin protein isolate production. WOA's investor presentation states that Prolupin's manufacturing facilities had an initial capacity of approximately **500 tonnes per annum**, with potential to reach **1,000 tonnes per annum** with further investment. It also refers to the acquisition of Prolupin's manufacturing assets, software assets, technical infrastructure, seven patent families related to lupin protein and a B2B pipeline of more than 100 tonnes.[181]

Despite its strong technological basis and relevance to the growing plant-based food market, Prolupin entered insolvency in **June 2023** with WOA later acquiring selected Prolupin assets through an asset deal, enabling WOA to establish an immediate operational presence in Europe and strengthen its position in lupin protein production.[182]

The Prolupin case therefore illustrates both the potential and the vulnerability of research-based food-tech companies. Its technology, production infrastructure and IP were valuable enough to attract acquisition interest, but the company's insolvency shows that scientific credibility and patented processing technology are not sufficient on their own. Commercial success also depends on customer adoption, production economics, access to scale-up capital, raw material supply, operational resilience and the ability to grow in line with real market demand.

1.3. Problem Statement

The central challenge in the Prolupin business case is the gap between technological potential and commercial scalability. Lupin protein has several attractive characteristics as a plant-based ingredient, but producing it at industrial scale requires specialised infrastructure, technical optimisation and sufficient market demand to justify investment.[183] The challenge was therefore not only to **develop a technically viable lupin protein isolate**, but to **establish a commercially sustainable operating model** around it.

Prolupin's insolvency was a result of several interconnected scale-up barriers rather than a single mistake. The company had developed relevant lupin protein isolate technology and had built a position in the plant-based dairy replacement market through its LUVE brand. However, the uptake of lupin protein isolate by food manufacturers was slower than expected, while the move into branded consumer products increased marketing costs and exposed the company to retailer pressure. At the same time, lupin protein faced strong price competition from soy and pea protein, both of which benefit from larger supply chains, lower costs and greater market familiarity.

The company also faced the typical scale-up funding gap experienced by many food-tech businesses. While R&D and pilot-stage innovation may attract support, industrial scale-up requires much larger and longer-term investment. Prolupin had to maintain production capacity, build market demand, secure raw material supply and compete with established multinational ingredient suppliers at the same time. These challenges were further complicated by the limited lupin supply base and the allergen-related constraints associated with lupin processing. In this context, Prolupin's insolvency can be understood as a case of technology-market mismatch during the scale-up phase: the technology existed, but the surrounding market, supply chain, financing and adoption conditions were not yet strong enough to support sustainable growth.

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[181] WOA investor presentation, *The new global leader in lupin-based protein*, November 2023. https://newsfile.futunn.com/public/NN-PersistNoticeAttachment/7781/20240223/ASX-2924-02726941-6A1174800.PDF

[182] KPMG Law, KPMG Law advises Wide Open Agriculture on the acquisition of assets of Prolupin GmbH, 8 November 2023. https://kpmg-law.de/en/kpmg-law-advises-wide-open-agriculture-on-the-acquisition-of-assets-of-prolupin-gmbh/

[183] WOA investor presentation, *The new global leader in lupin-based protein*, November 2023. https://newsfile.futunn.com/public/NN-PersistNoticeAttachment/7781/20240223/ASX-2924-02726941-6A1174800.PDF

1.4. Acquisition Rationale

For Wide Open Agriculture, the acquisition of Prolupin's assets represented a strategic opportunity to accelerate growth in the alternative protein sector. Instead of building a new production facility from the beginning, WOA gained access to an existing European asset base. WOA announced that the acquisition of Prolupin included an advanced manufacturing facility, patents to produce Prolupin protein isolate, the LUVE trademark, inventory and raw material supply.[184]

The acquisition addressed several strategic needs. First, it gave WOA a physical production presence in Europe, a key market for plant-based food innovation. Second, it allowed the company to move more quickly towards commercial-scale operations. Third, it added technical knowledge and intellectual property that could support further development of WOA's lupin-based ingredient portfolio. WOA also refers to software assets, technical infrastructure, seven patent families related to lupin protein and a B2B pipeline of over 100 tonnes.[185]

This makes the business case an example of asset-based scale-up. WOA was not only acquiring equipment, but also accumulated knowledge, market credibility and business development opportunities. For companies operating in capital-intensive sectors, such acquisitions can reduce development time and help bridge the gap between technology development and commercial production.

1.5. Value Proposition

The value proposition is based on offering sustainable and functional lupin protein ingredients to food manufacturers. These ingredients can support the development of products that respond to several market needs at once: **higher protein content, plant-based formulation, ingredient diversification and sustainability positioning.** WOA describes its lupin-based ingredients as clean, functional and nutritious solutions for the global food and beverage industries.[186]

For food manufacturers, lupin protein can be relevant because it offers an alternative to more established plant proteins. **It may help companies differentiate their products, reduce dependence on soy or pea and explore new formulations in categories such as plant-based dairy, bakery, snacks and nutrition.** From WOA's perspective, the Prolupin acquisition strengthened this value proposition by adding production capacity, technical expertise, IP assets and European market access.

The sustainability dimension is also important. Lupin can be linked to regenerative and legume-based agriculture narratives, which may be attractive to food companies seeking stronger environmental claims. However, the value proposition must remain grounded in practical industry needs. Sustainability alone is unlikely to be enough unless the ingredient also performs well in terms of functionality, sensory quality, cost and supply reliability.

1.6. Target Customers and Applications

The business case is primarily **B2B**. The main customers are:

[184] DGWA (n.d.) *Wide Open Agriculture*. https://www.dgwa.org/wideopenagriculture

[185] WOA investor presentation, *The new global leader in lupin-based protein*, November 2023. https://newsfile.futunn.com/public/NN-PersistNoticeAttachment/7781/20240223/ASX-2924-02726941-6A1174800.PDF

[186] Wide Open Agriculture, company website, lupin-based ingredient positioning. https://wideopenagriculture.com.au/

- Food manufacturers,
- Plant-based food companies,
- Ingredient distributors,
- Nutrition brands and
- Companies developing protein-enriched products.

These customers are not simply buying a raw material; they are looking for ingredients that can solve formulation challenges and support commercially viable end products. Also, it is important that they provide taste and texture in line with consumer preferences.

Plant-based dairy represents one of the most relevant early application areas. In December 2023, WOA reported its first sale of lupin protein isolate from WOA Germany following a design win in the non-dairy category.[187] The company also referred to design wins in products such as cheeses, spreads and creamers, although the first sale was not described as material to overall turnover.[188]

Bakery and snack applications are also relevant, particularly where manufacturers want to increase protein content or differentiate products with alternative plant-based ingredients. Nutrition brands may use lupin protein in high-protein formulations, while plant-based meat producers may explore it as part of broader ingredient systems. Ingredient distributors can play an important role in the route to market by expanding customer access, supporting market testing and reducing the burden of direct sales.

The **business model** can be described as a **B2B ingredient production and commercialisation model**. Its core logic is to produce lupin-based protein ingredients and sell them to food industry customers that integrate them into finished products. **Revenue** can come from:

- Ingredient sales,
- Recurring supply agreements,
- Distribution contracts and
- Valorisation of co-products such as lupin fibre.

The model depends on several key resources. The acquisition materials identify the manufacturing facility, patents, trademark, inventory and raw materials as part of the asset base,[189] while WOA investor materials also refer to a customer pipeline and technical infrastructure.[190]

Key activities include ingredient production, facility upgrading, quality control, customer testing, formulation support, B2B sales and distributor management. The formulation support element is particularly important because food manufacturers often need technical assistance when integrating novel proteins into their products. The **business model** therefore **combines production with customer development and technical service.**

[187] Listcorp / WOA announcement, WOA reports first lupin protein sale from WOA Germany, 14 December 2023. https://www.listcorp.com/asx/woa/wide-open-agriculture-ltd/news/woa-reports-first-lupin-protein-sale-from-woa-germany-2971834.html

[188] Small Caps, *Wide Open Agriculture secures breakthrough European lupin protein deal*, 14 December 2023. https://smallcaps.com.au/article/wide-open-agriculture-secures-breakthrough-european-lupin-protein-deal

[189] Listcorp / WOA announcement, WOA agrees to acquire assets of Prolupin GmbH, 10 October 2023. https://www.listcorp.com/asx/woa/wide-open-agriculture-ltd/news/woa-agrees-to-acquire-assets-of-prolupin-gmbh-2938216.html

[190] WOA investor presentation, *The new global leader in lupin-based protein*, November 2023. https://newsfile.futunn.com/public/NN-PersistNoticeAttachment/7781/20240223/ASX-2924-02726941-6A1174800.PDF

1.7. Risk Analysis

The case includes several interconnected risks.

- **Commercial risk**: Food manufacturers may be interested in testing lupin protein, but this does not guarantee large-volume adoption. Product development cycles in the food industry can be long and companies may require extensive testing before committing to regular supply. WOA's first German lupin protein sale is a useful example: it confirmed market traction, but the company noted that the sale was not material to turnover and did not guarantee ongoing volumes.[191]
- **Operational risk:** The acquired production assets in Germany may require upgrades, maintenance, process optimisation or adaptation to new product specifications. Integrating this facility in the WOA system may involve additional complexity, including staff retention, supplier relationships, quality systems and production continuity.
- **Financial risk:** Linked to the capital-intensive nature of ingredient production. The Prolupin facilities might require investment not only to purchase or acquire assets, but also to upgrade, operate and optimise them. The business must generate enough volume to cover fixed costs and justify continued investment.
- **Regulatory and market risks** Lupin is included among substances or products causing allergies or intolerances under EU food information legislation, meaning it requires clear allergen labelling when present in food products.[192] This does not prevent its use, but it may affect product positioning and application choices.

1.8. Lessons Learned

Start-ups and scale-ups developing novel food ingredients often face a difficult transition from technical validation to commercial success. A technology may work at laboratory or pilot scale, but this does not mean that it can be produced consistently, affordably and in sufficient volumes for industrial customers. The scale-up phase is therefore one of the most vulnerable stages, as companies need to invest heavily in production capacity before stable demand and revenue are fully secured.

One major challenge is **slow market adoption by food manufacturers**. Large food companies are often cautious when introducing new ingredients because they must consider taste, texture, shelf life, labelling, processing compatibility, consumer acceptance and the risk of replacing existing products. Even when a new ingredient is promising, customer validation can take a long time. Samples, product trials and design wins are important milestones, but they do not automatically lead to large recurring contracts.

Another important lesson is that **price competitiveness is critical**. Novel ingredients often compete with established alternatives that benefit from mature supply chains, high production volumes and lower costs. Start-ups may initially rely on sustainability, health or innovation claims, but many customers and consumers are not willing to pay a significant premium unless the product also delivers clear functional or sensory benefits. A cost-reduction strategy should therefore be built into the business model from the beginning.

[191] Listcorp / WOA announcement, WOA reports first lupin protein sale from WOA Germany, 14 December 2023. https://www.listcorp.com/asx/woa/wide-open-agriculture-ltd/news/woa-reports-first-lupin-protein-sale-from-woa-germany-2971834.html

[192] European Commission. (2026). *Allergies*. Food Safety. https://food.ec.europa.eu/food-safety/campaign-2026/allergies_en

Start-ups and scale-ups also face a **funding gap between R&D and industrial scale-up**. Public funding and investor interest are often more accessible during research, piloting and proof-of-concept phases. However, the later stage of building, operating and optimising commercial-scale production requires much larger and longer-term financing. Without sufficient capital, companies may struggle to maintain facilities, reduce production costs and survive the period before the market matures.

A further challenge is **supply-chain development**. Novel ingredient businesses depend not only on processing technology, but also on a reliable raw material base. Farmers and suppliers need predictable demand before committing to new crops or production systems. If market uptake is uncertain, the upstream supply chain may remain weak, which can then limit the company's ability to scale. Successful market entry therefore requires parallel development of the ingredient, the production process and the raw material supply base.

Companies should also be cautious about **expanding too early into consumer-facing brands**. When B2B uptake is slow, creating branded products can seem like a way to demonstrate market potential. However, this requires marketing budgets, retail relationships, packaging development, consumer communication and promotional activities. These costs can quickly divert resources away from technology development, production optimisation and B2B sales.

Finally, novel ingredient companies need to manage **regulatory, allergen and operational risks** from the beginning. New ingredients may require specific labelling, dedicated production lines, quality systems or additional customer assurances. These requirements can affect production flexibility and customer adoption. For this reason, technical development should always be linked to practical market-entry planning, including target applications, regulatory positioning, customer requirements and route-to-market strategy.

Overall, the key lesson is that success in novel ingredient markets depends on more than having a strong technology. Start-ups and scale-ups need a realistic scale-up pathway, committed customers, reliable supply chains, sufficient financing, cost competitiveness and a business model that connects innovation with real market demand.

1.9. Recommendation for Future Implications

For future projects developing novel plant protein ingredients, this business case highlights the importance of starting commercialisation planning early. Technical development should be accompanied by market validation, customer segmentation, cost analysis, regulatory assessment and route-to-market planning. Projects should avoid assuming that sustainability or novelty alone will be enough to drive adoption.

Recommendations for companies entering the plant protein market:

- **Validate B2B demand before scaling production:** Companies should secure clear evidence of customer demand before investing heavily in commercial-scale facilities. Samples, trials and design wins are useful, but they should be converted into letters of intent, offtake agreements or recurring supply commitments wherever possible.
- **Avoid moving too early into expensive consumer branding:** Developing a consumer brand can create visibility, but it also requires high marketing budgets, retail negotiations and promotional spending. For ingredient companies, it may be safer to prioritise B2B partnerships first and enter B2C markets only when production volumes and financing are strong enough.
- **Start in premium or regional markets:** It is suggested that companies should consider starting in regional or higher purchasing-power markets, such as Nordic markets, where consumers may be

more willing to pay for sustainable and premium plant-based products. This can provide time to improve production economics before entering larger price-sensitive markets.

- **Build the raw material supply chain early:** A reliable crop base is essential. Companies should work with farmers from the beginning and create predictable demand for lupin, not only for protein isolate production but also for other applications. This can reduce supply risk and make lupin more attractive as a crop.
- **Develop multiple uses for lupin and its co-products:** The business model should not depend only on protein isolate. Companies should explore fibre, feed, side streams and other applications to improve total crop valorisation and reduce pressure on isolate margins.
- **Use shared scale-up infrastructure:** Create shared scaling hubs that can be used by several companies. This would reduce the need for each small company to build its own facility and could lower the risk of underutilised infrastructure.
- **Plan for price reduction from the start:** Lupin protein cannot rely only on sustainability claims if the price gap with soy and pea remains too high. Companies should include a clear cost-reduction roadmap covering process efficiency, facility utilisation, raw material sourcing, co-product valorisation and partnerships.
- **Address allergen management clearly:** Since lupin is allergenic, companies must build allergen management into their market strategy. This includes clear labelling, dedicated or well-controlled production lines, and careful selection of customers and applications where allergen constraints are manageable.
- **Combine IP protection with partnership strategy:** Protected IP gives value to start-ups and scale-ups, but it can also force them to build proprietary facilities, which increases investment risk. A better approach may be to combine IP protection with licensing, joint ventures or strategic partnerships with larger food or ingredient companies.
- **Align funding with the full commercialisation journey:** Funding should not stop at R&D and piloting. Companies entering the market need financing for demonstration, industrial scale-up, market development, working capital and supply-chain building. This should be reflected in both public support schemes and private investment strategies.

Overall, the Prolupin–WOA business case is valuable because it shows both sides of innovation commercialisation. It demonstrates the potential of lupin protein as a sustainable alternative ingredient, but also the difficulty of scaling specialised food technologies in competitive and cost-sensitive markets. The main takeaway focuses on the fact that **scientific innovation must be matched with customer demand, economies of scale and market access.**

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