Ref. Ares(2024)6166843 - 30/08/2024

VALPRO path.

NEW VALUE LANDSCAPES FOR PLANT PROTEIN PATHWAYS

D5.5 Practice Abstracts – batch I

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Co-funded by the European Union

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Work Package	WP5
Delivery Date (DoA)	31.08.2024.
Actual Delivery Date	30.08.2024.

Document Revision History			
Date	**Version**	**Author/Contributor/ Reviewer**	**Summary of main changes**
27.07.2024	V1	FSH Team	First version of the document
16.08.2024	V2	Ewen Mullins, Richard Lynch	Review and changes recommended
19.08.2024	V3	FSH Team	Update of the recommended changes
20.08.2024	V4	Ewen Mullins, Richard Lynch	Review and changes recommended
20.08.2024	V5	FSH Team	Update of the recommended changes

VALPRO Path

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22	**Antignano prodotto tipico di Tealdi Roberto**	**APT**	**Italy**
23	**Kerry Luxembourg S.á.r.l.**	**KERRY**	**Luxembourg**

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Co-funded by the European Union

Title: new VALue landscapes for plant PROtein Pathways
Type of action: HORIZON Innovation Actions ● Topic: HORIZON-CL6-2021-FARM2FORK-01-02
Start date of project: 01 September 2022 ● Duration: 48 months
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1. Executive Summary

This collection of Practice Abstracts offers an overview of five innovations currently being developed within the project to benefit end-users. This document serves several key purposes: providing essential information and practical recommendations, insights into the project's outcomes as well as highlighting some of the tangible results achieved and their applicability in real-world contexts.

Summary of the 5 Practice Abstracts Featured:

1. *Life Cycle Assessment (LCA) in fava beverage (Page 8)*
   The National Technical University of Athens is conducting a Life Cycle Assessment (LCA) to evaluate and reduce the environmental impacts of fava bean beverage production, focusing on key areas like greenhouse gas emissions, eutrophication, acidification, and freshwater consumption.

2. *Gap Analysis- Gaps in the EU plant protein value chain (Page 11)*
   Teagasc and ZALF developed a value-chain framework to identify and address the challenges that exist in meeting the growing demand for plant-based protein in Europe, integrating research and expert knowledge across five stages of the value chain to facilitate knowledge transfer and stakeholder communication.

3. *All-in-one farm information management system (Page 13)*
   The application of FarmB's all-in-one information management system integrates IoT, AI, Cloud, and Big Data technologies to overcome fragmented data issues in precision agriculture, ensuring data coherence, enhancing traceability, and facilitating accurate environmental assessments and Life Cycle Assessments (LCA) for crop production.

4. *Dry fractionation technologies for legumes as a proposition to add value for farmers (Page 15)*
   The current plant protein processing methods are outdated and inefficient, relying on techniques designed for dairy and meat. Dry fractionation provides an opportunity to develop less refined, more sustainable plant protein ingredients, which reduces environmental impact by eliminating water and heat use. However, challenges include optimizing the process for various seeds and improving separation yields. With improvements, this approach could lead to innovative, localized manufacturing near farms and create viable business models.

5. *Precision fermentation as a method of adding value to legumes (Page 17)*

Precision fermentation offers a significant advantage in enhancing the aroma profile of plant-based food products. This process can reduce or mask undesirable flavours commonly associated with legumes, resulting in products that are more appealing to consumers. By improving the sensory experience, precision fermentation makes plant-based foods more enjoyable and competitive with traditional animal-based products.

This document provides detailed analyses of the challenges addressed, the solutions implemented, and the practical benefits of each practice abstract. The summaries also include actionable recommendations and insights into the environmental impacts, all developed in accordance with the EIP AGRI abstract format as part of the VALPRO Path project.

2. Introduction

The practice abstracts compiled in this document serve as a resource within the VALPRO Path project. These abstracts refine complex research findings into practical, actionable insights aimed at bridging the gap between scientific knowledge and real-world application. By focusing on innovative technologies and methodologies, the abstracts not only highlight the progress made within the project but also offer clear guidance for end users, ranging from farmers to policymakers, on how to implement these advancements effectively.

Practice abstracts are essential tools in research dissemination, especially in Innovation Action type projects like VALPRO Path, where the ultimate goal is to ensure that scientific innovations translate into tangible benefits for the agricultural sector and beyond. These documents blend detailed research outputs into concise, user-friendly formats that are easily accessible to non-specialists. The abstracts also play a vital role in fostering knowledge exchange and promoting the adoption of best practices across different sectors of the value chain. They provide a platform for sharing lessons learned, innovative approaches, and practical recommendations that can drive sustainable development in plant protein agriculture and food production.

This introductory batch of practice abstracts covers a range of topics reflecting the diverse scope of the VALPRO Path project:

1. **Life Cycle Assessment (LCA) in fava beverage**
2. **Gap Analysis - Gaps in the EU plant protein value chain**
3. **All-in-one farm information management system**
4. **Dry fractionation technologies for legumes as a proposition to add value to farmers**
5. **?**

These practice abstracts represent a collaborative effort among project partners to share the knowledge and innovations developed within VALPRO Path. As more abstracts are created, this

repository will continue to grow as a valuable resource, guiding stakeholders in adopting practices that are both innovative and sustainable. The abstracts are not just a record of what has been achieved; they are a roadmap for future action, offering clear, practical steps for realizing the full potential of the VALPRO Path project. Each practice abstract will be readily accessible on the VALPRO Path website, ensuring that all stakeholders can benefit from these insights at any time. To further enhance engagement, every abstract will be individually featured and promoted across our social media channels, ensuring broad visibility and encouraging widespread adoption of these best practices.

3. Life Cycle Assessment (LCA) in fava beverage

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3.1.1. Problem Statement

The increasing popularity of plant-based beverages has highlighted the need to assess and focus on enhancing the environmental sustainability of the products. The environmental footprint of novel beverages like those made from various legumes, such as fava beans, remains underexplored, necessitating a comprehensive assessment of their life cycle impacts. The primary challenges include ensuring that greenhouse gas emissions as well as the potential for eutrophication, acidification, and freshwater consumption associated with their production are minimised, thereby ensuring the economic and environmental sustainability of plant-based beverages going forward

3.1.2. Solution

In response, this study employs a Life Cycle Assessment (LCA) of the production chain for a fava bean beverage from field to consumer. The assessment follows ISO 14040:14044 standards, focusing on identifying key impact categories and hotspots across the entire plant beverage production chain.

3.1.3. Benefits

The LCA provides a baseline for the environmental impacts of a fava-based beverage, highlighting the major contributors to the main environmental categories, including global warming potential, eutrophication, acidification, and freshwater consumption. The study identifies specific processes (e.g., cultivation of fava beans and their subsequent processing to produce fava protein isolate) that can significantly contribute to environmental impacts, allowing for targeted positive interventions. Scenario analysis reveals strategies for improvement (see below), leading to further potential reductions in emissions and resource use. The results will guide stakeholders, including farmers, food processors and indeed policymakers, towards the adoption of sustainable practices in the plant-based beverage industry.

3.1.4. Practical recommendations

1. **Fertilizer Optimization:** Ensure minimal fertilizer (potassium, (K) and phosphorous (P)) application rates to minimize potential runoff into waterways, thus reducing eutrophication and acidification potential. There is also a real possibility for zero fertilizer if the crop is produced on high-index soil, with sufficient P and K present already.
2. **Renewable Energy Sources:** Switch to renewable energy sources during post-harvest processing to decrease GHGs.
3. **Incorporation of novel technologies:** Implement novel and advanced processing technologies, such as pressurized liquid (PLE) or ultrasound/microwave-assisted extraction for the process of protein isolate production and high-pressure processing (HPP) for beverage pasteurization, to optimize process efficiency, energy consumption and resource use.
4. **Biodegradable Packaging:** Replace conventional plastic packaging with biodegradable materials thereby reducing waste and greenhouse gas emissions.

3.1.5. Environmental Impact

1. **Global Warming Potential (GWP):** Post-harvest processing contributes significantly to greenhouse gas emissions (GHGs), driven by energy consumption in the beverage production phase. Equally, cultivation and associated crop management practices produce GHG emissions, which can be reduced with tailored agronomy practices and robust soil management
2. **Eutrophication Potential (EP):** Runoff of fertilizers utilized during the cultivation stages is the primary driver of EP. Fava bean does not require nitrogen but dependent on soil profile, may necessitate phosphorous and/or potassium
3. **Acidification Potential (AP):** Emissions from both agricultural practices and beverage production (energy consumption) significantly influence AP.
4. **Freshwater Consumption:** Irrigation practices, particularly in regions with high water scarcity, dominate water consumption impacts.

This comprehensive LCA underscores the importance of targeted interventions in fava beverage production, across the whole production chain, providing a roadmap for reducing environmental impacts and promoting sustainable plant-based beverage consumption.

3.1.6. Weblinks

https://www.ntua.gr/en/

https://valpropath.eu/practice-abstracts/

4. Gap Analysis - Gaps in the EU plant protein value chain

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4.1.1. Problem Statement

Commented [1]: Should this be section 1.2.1

While there is a growing demand for plant-based protein, challenges along the value chain from inputs to consumption mean that this demand is not currently being met by European farmers and food companies. Moreover, addressing challenges at one point in the chain does not necessarily lead to success. There is a need to integrate knowledge from research and practice to identify these gaps along the whole value chain.

4.1.2. Solution

To address this challenge, a value-chain framework was developed which considered five value-chain stages (farm inputs, cultivation & production, processing & packaging, marketing & distribution, sales & retail) along with the institutional context. Challenges at each stage were identified based on a literature review (including policy and strategic sectoral documents and reports) complimented by virtual expert interviews and an in-person stakeholder workshop. To ensure that key messages from the analysis were easily communicated, a story map was developed and made publicly available.

4.1.3. Benefits

A significant amount of knowledge was gathered from across European stakeholders with key messages effectively distilled and communicated. Focusing on high-value protein crops grown in the

EU like peas, lupins, chickpeas, fava beans, soybeans, and lentils, the insights aim to empower stakeholders involved in strategic planning, business case development, and transformative initiatives within the European food system.

4.1.4. Practical recommendations

Expert and practitioner knowledge needs to be integrated in a more efficient manner. Online platforms can facilitate this; however, in-person workshops are also a very important intervention to support knowledge transfer.

4.1.5. Environmental Impact

Legumes can offer many environmental benefits such as the ability to reduce inorganic nitrogen use, improve soil texture and increase the levels of biodiversity compared to cereal crops. By addressing the challenges identified in this GAP analysis a more supportive environment for legume production, processing and consumption can be established within Europe.

4.1.6. Weblinks

https://arcg.is/15Wb5T0

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5. All-in-one farm information management system

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5.1.1. Problem

Fragmented data in digital agriculture presents significant challenges, as stand-alone precision agriculture applications often fail to provide holistic solutions for crop production. This fragmentation leads to uncertainty in the traceability, especially, of protein-based agricultural products, complicating efforts to ensure transparency and accountability in the protein supply chain. Moreover, the lack of real data on field production hampers accurate environmental and social impact assessments, making it difficult to understand the true implications of farming practices on the protein supply chain. Additionally, processing and generating metadata for Life Cycle Assessment (LCA) in primary production is fraught with difficulties, further complicating efforts to measure and mitigate the environmental footprint of agricultural activities towards the design and validation of plant protein crop systems. These challenges underscore the need for integrated digital solutions to enhance data coherence and reliability as farmers leverage the added-value opportunities of protein crop production.

5.1.2. Solution



The farmB's all-in-one farm information management system overcomes the "fragmented information problem" in precision agriculture applications by combining IoT, AI, Cloud, and Big Data technologies providing data analytics and decision-making under a holistic assessment of the available information for protein crop production. farmB operates based on dynamic data collected in the field (by proximal and remote sensors, UAVs, agri-machinery, agri-robotics, and digital log of agricultural operations) throughout the cultivation season. In its database, it also incorporates all the information needed for real market products and machinery, in a way to ensure the quality of the data collected. farmB.log offers the inventory analysis mechanism that automatically prepares all the information needed for an LCA assessment in protein crop production, based on the inserted data, facilitating environmental assessment.

5.1.3. Benefits

farmB serves as a valuable decision-making tool promoting sustainability and circularity into the agricultural practice for protein products. All the primary production information is organized in a systematic manner within the platform, safeguarding the traceability of the final protein product. This benefits the standardization of the processes while enhancing the quality of the environmental assessment due to the originality of the collected data. Social impacts can also be addressed through the assessment of dedicated social indicators.

5.1.4. Practical recommendations

The users, insert agricultural practice data in farmB.log throughout the cultivation season. They then can extract the data needed for performing LCA with external software. Nonetheless, an instant environmental assessment is readily available with a calculation of the carbon footprint for each separate operation and for the entire cultivation altogether within the platform.

5.1.5. Environmental Impact

farmB provides directly to the user a variety of environmental assessment indicators. Carbon footprint is calculated for each operation separately, allowing for the identification of hot spots in the cultivation process of protein products so that interventions for improvements can take place. The calculation tool is certified according to the GHG protocol for agricultural production.

5.1.6. Weblinks

https://farm-b.com/

https://valpropath.eu/practice-abstracts/

6. Dry fractionation technologies for legumes as a proposition to add value to farmers

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6.1.1. Problem Statement

The current landscape for plant protein ingredients is built based on old paradigms, mostly derived from decades of practical knowledge on dairy, baking and meat processing. However, the nature of plant raw materials is different, and processes should be designed based on their characteristics, for example, the raw seed architecture. Furthermore, a design thinking approach is needed, whereby supply chains are developed closer to the farm and focused on delivering higher value to the farmers compared to that of the well-established and less sustainable ones they are engaged with today. Only by providing a value proposition to the farmers, we will be able to encourage a shift in production to protein-rich crops and ultimately undergo a transition to a more sustainable food system in Europe.

The current established manufacturing of foods is based on highly purified protein isolates. The production of such isolates is designed for liquid streams, and for plant proteins, this involves an initial water dilution with acids or bases, extensive energy input and the addition of chemicals, to obtain high extraction yields. Essentially, the flour or meal is extracted with water, and protein is more or less selectively precipitated, then resuspended again, and sufficiently diluted to be dried in spray driers. The result of this process on, for example, soy or pea protein is that of powders with high purities, with a mild flavour, low in antinutritional or coloured components, appealing and consistent. However, this is creating substantial aqueous side streams, in addition to being a resource-intensive process (Schutyser et al. Trends in Food Science & Technology, 2015).

6.1.2. Solution

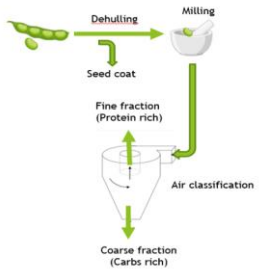


Figure. Schematic of the process of dry fractionation where a fine and coarse fraction are separated based on air classification.

Dry fractionation technologies, well known in cereal technology, are based on air classification of the various particles after dehulling and grinding. The main reason for their lower environmental footprint with respect to aqueous processes is the lack of water use, which in turn eliminates the need for a spray drier at the back end. Furthermore, no heat is applied, and the structural features of the protein present in the original seed are therefore maintained. These technologies show great potential for the creation of flexible, scalable, and diverse plant protein processing facilities.

6.1.3. Benefits

With the growth in demand for plant proteins as ingredients for food, we are faced with the opportunity to create new solutions, including ingredients which are less refined, but still nutritionally and technologically functional. This will not only bring innovative solutions, based on differences in composition and processing performance but also could drive the creation of different types of manufacturing facilities, closer to the production source, creating less centralized, shorter value chains.

Furthermore, an in-depth understanding of the process performance will create viable business models based on the utilization of both the starch-rich and protein-rich fractions and will develop novel, innovative functional ingredients. These facilities, when built for flexibility, may be well suited for milling and separation facilities closer to the farm gate.

6.1.4. Practical recommendations

- Yields, composition, and processing and post-processing improvements are needed to provide unique value propositions for these innovative less refined ingredients.
- While this technology, as designed today is a highly promising alternative, for oil-containing legumes (>3%) this is still a challenge. However, the lipid concentration limits may be improved.
- The development of appropriate varieties more suited for this process could improve the economy.
- Although protein isolates are necessary in high-end formulations (i.e. beverages), their high purity is not always needed, and these ingredients could be used in formulated foods.

- The financial viability of the processes based on economy of scale and short supply chains needs to be based on the efficiency of the process and supply chain models analysis.

6.1.5. Environmental Impact

The shift from traditional aqueous protein extraction methods to dry fractionation technology offers significant environmental benefits. Dry fractionation eliminates the need for water, energy-intensive processes, and chemical inputs, resulting in a much lower environmental footprint. This method also preserves the natural structure of proteins, reducing the need for further energy-consuming processing steps. By developing processing facilities closer to farms, this approach promotes shorter, more localized supply chains, reducing transportation-related emissions and supporting sustainable agricultural practices.

6.1.6. Weblinks

https://international.au.dk/

https://valpropath.eu/practice-abstracts/

7. Precision fermentation as a method of adding value to legumes

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7.1.1. Problem Statement

Consumer interest in increasing protein intake from alternative sources, particularly plant-based proteins such as those derived from legumes, has grown significantly. This shift is driven by the legume's high protein content and quality nutritional profile, along with a relatively low carbon footprint. However, legumes contain a portion of their nutritional compounds in non-bioavailable forms and also possess several antinutritional factors (ANFs) that can reduce nutrient digestibility and cause physiological discomfort. Additionally, legumes often exhibit poor technological and sensory attributes, limiting their broader application in food products. Therefore, to fully exploit the nutritional and functional potential of legumes, it is crucial to identify and implement suitable sustainable processing methods.

Fermentation has long been recognised for its ability to enhance the nutritional, technological and sensory properties of legumes. However, traditional fermentation methods are often managed empirically, using rudimentary equipment and relying on the activity of endogenous microorganisms. The quality of raw materials and the biotechnologies employed are not standardised, leading to inconsistencies in product quality.

7.1.2. Solution

Precision fermentation is an advanced biotechnological process that utilises carefully selected microorganisms or enzymes to convert target compounds into specific desired products. Unlike traditional fermentation, which relies on naturally occurring microbes, precision fermentation offers a highly controlled environment where desired outcomes can be precisely engineered.

Utilising precision fermentation can enhance the nutritional and sensory attributes as in the traditional approach while ensuring consistency and safety. This evolution from traditional practices to more controlled fermentation processes opens the door to developing high-quality, innovative legume-based products and ingredients for commercial applications.

7.1.3. Benefits

Precision fermentation offers a significant advantage in enhancing the aroma profile of plant-based food products. This process can reduce or mask undesirable flavours commonly associated with legumes, resulting in products that are more appealing to consumers. By improving the sensory experience, precision fermentation makes plant-based foods more enjoyable and competitive with traditional animal-based products.

In addition to flavour enhancement, precision fermentation can allow for more efficient protein extraction from legumes. By targeting specific components like starch, for degradation, the protein entrapped in the starch matrix can be more easily released, leading to higher protein yields without relying on harsh chemical treatments. This results in higher-quality and more sustainable plant-based protein ingredients.

However, the application of precision fermentation comes with challenges that require careful consideration. Identifying the correct conditions for successful fermentation is crucial. This includes understanding the characteristics of the substrate (chemical composition), optimising fermentation conditions (temperature, time, and pH), and selecting the right starter culture (specific strains, inoculum concentration, and the use of single or mixed cultures).

7.1.4. Practical recommendations

- Optimise and standardise fermentation processes: Tailor fermentation conditions and select microbial strains suited to specific legume varieties based on their composition to enhance nutrient bioavailability, improve sensory attributes, or enhance functional properties.
- Develop Decentralised Facilities: Explore small-scale, local fermentation facilities to reduce costs, support local economies, and enhance sustainability.
- Expand Product Applications: Promote the use of fermented legumes in diverse food products.
- Optimise Supply Chains: Conduct thorough supply chain analyses to ensure efficiency, sustainability, and cost-effectiveness in fermentation-based production.

7.1.5. Environmental Impact

Precision fermentation has the potential to increase the consumption of plant-based products by reducing the need for additives, enabling the creation of clean-label products that meet the growing demand for natural, minimally processed foods, offering a unique value proposition.

Moreover, the use of fermentation for protein extraction offers a more sustainable alternative to traditional methods like alkalisation-acid precipitation (wet extraction). This conventional process relies heavily on chemicals, water, and energy, contributing to environmental degradation. Precision fermentation, by contrast, could achieve high protein yields with fewer resources and without the need for harsh chemicals, reducing the environmental burden of production.

7.1.6. Weblinks

https://valpropath.eu/practice-abstracts/

8. About this Practice Abstracts and VALPRO Path

These practice abstracts were elaborated in the VALPRO Path project based on the EIP AGRI abstract format. VALPRO Path, a Horizon Europe project, spanning 4 years, from September 2022 until August 2026. With the participation of 22 partners from 9 countries, VALPRO Path is developing fresh possibilities, validating and showcasing ways to enhance plant protein production for food and feed in the EU.



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101059824 and co-funded by UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding guarantee.

Project website: **https://valpropath.eu/**