R&I ANALYSIS REPORT

‘R&I for alternative protein sources: towards strategic autonomy and sustainability in EU protein production’

Geert Van Royen, Trine Kastrup Dalsgaard, & Louise Juul

04/2026

SCAR
Standing Committee on Agricultural Research

PROTEIN Task Force

Portfolio Analysis of EU-funded projects

Independent Expert Report by
Geert Van Royen*, Trine Kastrup Dalsgaard** & Louise Juul** (RefreSCAR project)

Commissioned and edited by the SCAR Protein Task Force

* Flanders Research Institute for Agriculture, Fisheries and Food, Belgium
** Aarhus University, Denmark

For citation purposes, please refer to the report using the following reference: Royen, G., Dalsgaar, T. & Juul, L. (2026). *R&I for alternative protein sources: towards strategic autonomy and sustainability in EU protein production"*. Independent expert report under the RefreSCAR project. Portfolio Analysis commissioned by the SCAR Protein Task Force.

Disclaimer

Supported by the RefreSCAR project:

Funded by the European Union

The RefreSCAR project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement no. 101060553

FIGURES

TABLES

Table of Contents

Abbreviations

EC	European Commission
EU	European Union
LCA	Life Cycle Assessment
PA	Portfolio Analysis
R&I	Research and Innovation
SCAR	Standing Committee on Agricultural Research
SCP	Single Cell Protein
SME	Small and Medium-sized Enterprises
TF	Task Force
TRL	Technology Readiness Level
VAT	Value Added Tax

1. Introduction

1.1 Background

The SCAR Protein Task Force (TF) is currently preparing a Policy Report titled *"R&I for Alternative Protein Sources: Towards Strategic Autonomy and Sustainability in EU Protein Production."* To inform this work, the TF commissioned this Portfolio Analysis (PA) of projects focused on alternative protein sources for food and feed. The analysis aims to map the existing research landscape, identify knowledge gaps, and strengthen evidence-based recommendations, ensuring alignment with European Union (EU) priorities.

Europe faces growing challenges in its agri-food systems, including climate change, market volatility, geopolitical tensions, and a dependence on imported protein. The EU strategic frameworks, such as the Vision for Agriculture and Food (2024), emphasise the need for sustainable, resilient, self-sufficient, and diversified protein production. Furthermore, the European Commission (EC) Food 2030 Pathways for Action 2.0 highlight alternative proteins for dietary shift as one of the key pathways towards sustainable healthy, climate-resilient and inclusive food systems[1]. Within this context, the SCAR Protein TF seeks to foster research and innovation (R&I) for alternative protein sources - including non-traditional plant sources, microbes, insects, marine biomass, cultured meat, and bioeconomy by-products - through a holistic food systems approach.

The TF aims to provide actionable policy guidance to enhance Europe's protein self-sufficiency, food security, and sustainability. The PA contributes to this objective by providing an overview of recent and ongoing projects, identifying knowledge gaps and overlaps in funded projects, and supporting the development of a future-oriented European protein research agenda.

1.2 Aim and scope

The aim of the PA was to provide an overview of existing research on alternative proteins funded by EU funding programmes, highlighting knowledge gaps and overlaps, and thereby strengthening the recommendation prepared by the TF.

The specific objectives were to:

- Identify EU funded R&I projects (ongoing or completed within the last five years) related to alternative proteins for food and feed;
- Highlight knowledge gaps and overlaps in the funded projects, thereby outlining future research needs

[1] https://research-and-innovation.ec.europa.eu/knowledge-publications-tools-and-data/publications/all-publications/food-2030-pathways-action-20-ri-policy-driver-sustainable-healthy-climate-resilient-and-inclusive_en

1.3 Alternative proteins - definition

Alternative proteins were defined as protein sources that differ from conventional animal-based proteins and offer sustainable solutions for food and feed systems. These include plant-based proteins, microbial proteins, insects, and cultured meat. Marine sources (with the exception of seaweed and microalgae) were excluded from the PA, as a previous PA focused on this area.

The different protein groups considered in this analysis (plant-based, microbial, insects, and cultured meat) are outlined below. The groups included, but were not limited to, the following:

- Plant-based proteins: Derived from crops such as legumes (e.g. soy, peas, beans, alfalfa), oilseeds (e.g. rapeseed, sunflower), and cereals, as well as associated by-products such as oilseed meals or by-products from the starch industry.
- Microbial proteins: Proteins or protein-rich biomass from bacteria, yeast, microalgae, and fungi, including proteins obtained from precision fermentation.
- Insects: Such as meal worms and black soldier fly larvae.
- Cultured meat

2. Methodology

The PA was conducted through the following three steps leading to this PA report:

- Project mapping – identification of relevant projects
    - Project information was collected from up-to-date and relevant sources, and all identified projects were mapped in an Excel database.
    - From the overall pool of projects, 30 projects were selected based on criteria such as outstanding scientific and practical results, strong co-creation and collaboration throughout the research process, and high-quality European or regional collaboration.
- Project overview analysis
    - Overview of the characteristics and achievements of the 30 selected projects.
    - Shortlisting of 10 illustrative projects, selected on the basis of research quality, availability of results, project progress, and relevance of the protein source within the defined scope.
- Project in-depth analysis and synthesis
    - Detailed review of the 10 selected projects
    - Analysis of project deliverables and synthesis of project development, results, trends, knowledge gaps, and overlaps across the selected projects.
    - Development of project fiches for the 10 projects, providing key project information, results and identified gaps and overlaps.

The methodology for each of the three steps is further explained below.

2.1 Identifying relevant projects – mining strategy

Based on keywords provided by the SCAR protein TF, the following search string formed the basis of the mining strategy:

"alternative AND protein AND sustainabl* AND (food OR feed)", additional filter: end date projects from 2020-01-01.*

Artificial intelligence (AI) tools (CoPilot and ChatGPT, GPT-5.3 standard versions) were used to screen the identified project homepages, extract aims and key highlights and summarise the results of individual projects, including realised activities, obtained results, achievements, research advancements, and identified gaps and needs, The outputs were subsequently reviewed and manually refined to ensure accuracy and validity. AI tools were also used for grammar correction.

As this search string was not compatible with all of the applied databases (Table 1), adjustments were made to ensure a sufficient number of relevant database hits. In practice, the full search string provided results in only two of the databases; therefore. simplified search strings or search terms were applied for the remaining databases. An overview of the databases, search terms used and the number of results (hits) is provided in Table 1. Database hits that did not focus on protein for food or feed, or that fell outside the defined time frame (projects ongoing or completed within the last five years) were excluded. Across all databases, a total of 80 projects were identified and retained as the basis for the further selection of the 30 projects included in the analysis.

Table 1: List of databases, the applied modified search string/search terms, number of hits and relevant hits.

Database	Search terms	Hits	Relevant hits
CORDIS	Original search string	202	46
CBE JU	Alternative AND protein	11	8
Keep.eu	Alternative AND protein	7	1
EIT	Protein diversification (tag)	23	5
OpenAIRE	Alternative AND protein	30	8
LIFE	Alternative AND protein	8	5
CNR-IRBIM	All projects screened	16	0
INTERREG	Protein	1	1
GFI	Alternative protein (tag)	66	13
Network Nature	Protein	3	0
*Erasmus+	-	-	-
*Susfood ERA-NET Cofund	-	-	-
FNSSA	Original search string	7	4
FOSC ERA-NET Cofund	All projects screened	22	1
ICT-AGRI-FOOD ERA-NET Cofund	All projects screened	40	0
BlueBio ERA-NET Cofund	Protein	8	2
Total		**444**	**94/80 (14 doubles)**

*Databases were not available

2.2 Selection and mapping of thirty R&I projects

An Excel database consisting of the 80 identified projects was established to support the selection process. The database included essential project information, such as title, acronym, funding source and contribution, project coordinator and contact details, start and end dates, number of participants and main project objectives. This database served as the basis for identifying the 30 most relevant projects.

2.2.1 Project selection criteria

In consultation between the independent experts and the TF, the following criteria were applied to identify the 30 projects:

A) Thematic criteria

The selection aimed to reflect the relative distribution of protein sources represented in the initial pool of 80 projects, ensuring a balanced overview of the EU funding landscape.

Protein sources were categorised as follows:

- Microbial protein
- Plant-based protein
- Insects
- Cultured meat
- Mix (protein sources from at least two of the other categories)

The relative distribution of protein sources among the selected project is illustrated in Figure 1.

Projects were excluded if their main focus fell outside the scope of protein for food or feed (e.g. proteins primarily targeting pharmaceuticals and fertilisers).

B) Technology readiness level

Projects primarily addressing Technology Readiness Levels (TRLs) 1-6 were selected to ensure a balance between research and innovation activities. Projects with TRL levels above 6 typically involved only one or two participants (often companies) and focused mainly on market readiness rather than broader R&I contributions (see excel file ANNEX 1_Project_screening_selection 30 projects.xlsx).

C) Project progress

Projects with a start date in 2024 and 2025 were excluded, as they did not yet provide sufficient information to assess project deliverables or allow for a meaningful evaluation.

2.2.2 Project mapping

The results of the project mapping are reported in an Excel file (see excel file ANNEX 1_Project_screening_selection 30 projects.xlsx) and further in a PowerPoint presentation format (see PowerPoint file ANNEX 2_Refrescar_PPT-30 selected projects.pptx) which includes essential project information, main objectives, and key results and outputs. The main findings for the overview of the 30 projects are covered in section 3.1.

2.3 Selection and analysis of ten R&I projects

The Excel database with the 30 selected projects provided the basis for identifying the most relevant projects for in-depth analysis.

2.3.1 Project selection criteria

Two selection criteria were applied to identify the 10 most relevant projects:

A) Thematic relevance

The selection was designed to reflect the relative distribution of protein sources represented within the pool of 30 projects, as well as to ensure a balance between food and feed as the main scope. This approach ensured consistency with the overall PA and provided a representative overview of the EU funding landscape.

B) Project output

Priority was given to projects demonstrating a high level of output, such as published scientific articles, deliverable reports, patents, and other tangible results. This ensured that sufficient information was available to support a meaningful in-depth analysis of activities, achievements, and impacts.

2.3.2 Projects in-depth analysis

The results of the in-depth project analysis are presented in Annex 3 (*ANNEX 3_RefreSCAR PA Project Fiches_10 selected projects*), which summarises the key findings from the 10 projects. The project fiches include essential project information (e.g. funding details, start and end dates, contact information, data sources etc.), a summary of project objectives and results, and a brief overview of identified overlaps and gaps in relation to the other projects included in the PA.

2.4 Limitations of the Study

Since some projects were still ongoing and only limited output documents were publicly available for some completed projects, this portfolio analysis is based on the documents (deliverables, public reports, scientific publications, etc.) available for the selected research projects.

3. Results

The results section is divided into three parts, focusing respectively on the initial project screening and the 80 projects identified through database searches (Section 3.1), the overview of the 30 selected projects (Section 3.2), and the in-depth analysis of the 10 selected projects (Section 3.3). In sections 3.1 and 3.2, illustrative figures and tables support understanding of the overall EU funding landscape for alternative protein, while section 3.3 presents insights into the knowledge generated by the selected projects and their performance in contributing to the EU protein policy framework, with a view to strategic autonomy and sustainability in EU protein production.

Gaps and future needs identified through the in-depth analysis are outlined in Section 4.

3.1 Initial project screening

The initial screening indicated that microbial and plant-based proteins were the main protein categories addressed by the projects, with a marked increase in EU-funded microbial protein projects observed in 2023. Projects focusing on insects and cultured meat were particularly funded during the period 2018–2023 and were also represented in the mixed category, which has received growing attention over the past five years (Figure 1).

Among the 80 projects, 17 countries were represented as project leaders or coordinators. Spain accounted for the largest share, followed by France, the United Kingdom, and Germany (Figure 2).

More than half of the identified projects targeted food applications as the primary use of the protein biomass or ingredients developed (Figure 3).

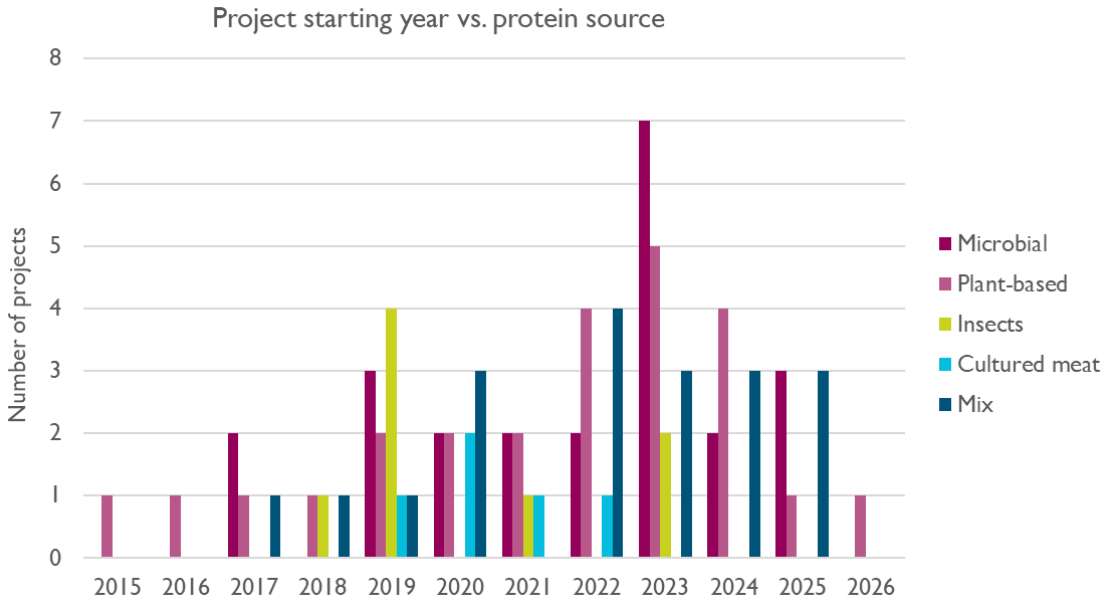

Figure 1: Illustration of the distribution of protein categories across the 80 projects identified in the initial screening, shown over time

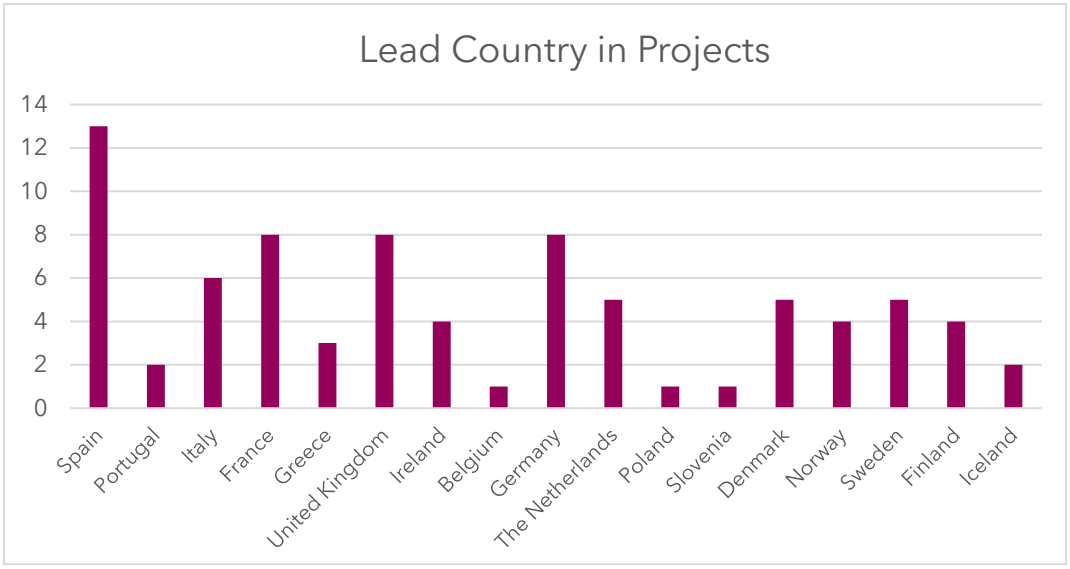

Figure 2: Country representation among the project leaders/coordinators in the 80 projects identified in the initial screening

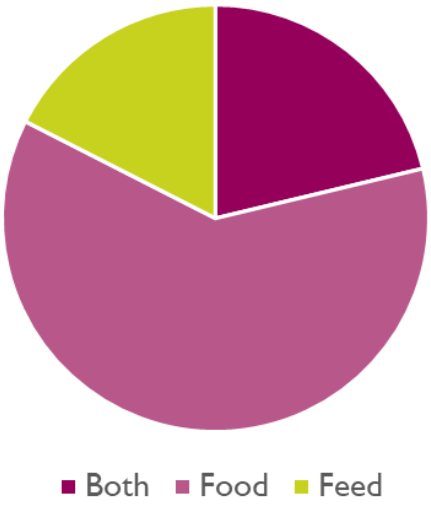

Figure 3: Relative distribution of the main application (food, feed or both) of protein biomass or ingredients across the 80 projects identified in the initial screening.

3.2 Thirty R&I projects overview

As described in Section 2.2, the selection of the 30 projects was designed to reflect the relative distribution of protein sources represented in the initial pool of 80 projects, thereby ensuring a balanced overview of the EU funding landscape. The distribution across protein categories is shown in Figure 4. The main categories represented were plant-based proteins, microbial proteins, and mixed sources. Within the mixed category, six of the eight projects involved microbial proteins, five included insects, and three focused on plant-based proteins. Microbial protein projects were evenly distributed across microalgae, fungi, and bacterial sources, while plant-based projects encompassed a wide range of feedstocks, including legumes, green biomass (e.g. clover, grasses, duckweed), grains, macroalgae, and agricultural side streams such as potatoes, rapeseed, sugar beets, and olives.

Of the 30 projects, 12 focused primarily on food applications, five on feed, and 13 on both food and feed. A recurring theme across the portfolio was a strong emphasis on sustainability and circularity in protein production. Many projects incorporated life cycle assessment (LCA) as part of their methodology, addressing circularity through the use of underexploited resources, agricultural and industrial by-products, biowaste and waste nutrients, as well as carbon capture - either directly as a protein source or as feedstock for protein production.

Common challenges identified across the projects included scaling, cost reduction, market readiness, and regulatory barriers. Addressing these issues will require continued efforts in process optimisation, regulatory adaptation, and increased consumer awareness, all of which are key drivers for advancing the alternative protein sector in EU.

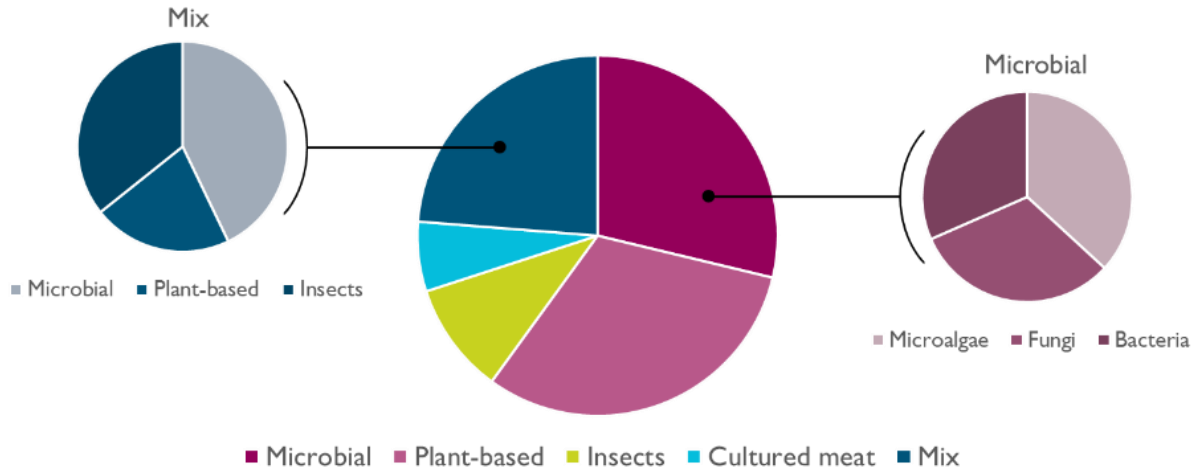

Figure 4: Relative distribution of the five main project categories in the 30 selected projects (central pie chart). The 'mix' category includes projects covering at least two other protein categories. The left pie chart shows the composition of the mix category, and the right pie chart shows the distribution of microbial protein sources.

Among the 30 projects, ten received EU funding contributions in the range of €4–6 million, while nine projects were awarded less than €4 million. Three projects secured €10–15 million, and two

projects exceeded €15 million in EU contributions (Figure 5). Excluding the two highest-funded projects, there was a general tendency for projects with a larger number of participants to receive higher levels of funding (Figure 6). Overall, funding was distributed across a range of programmes and actions, reflecting the diversity of EU instruments supporting research and innovation in alternative proteins (Figure 7).

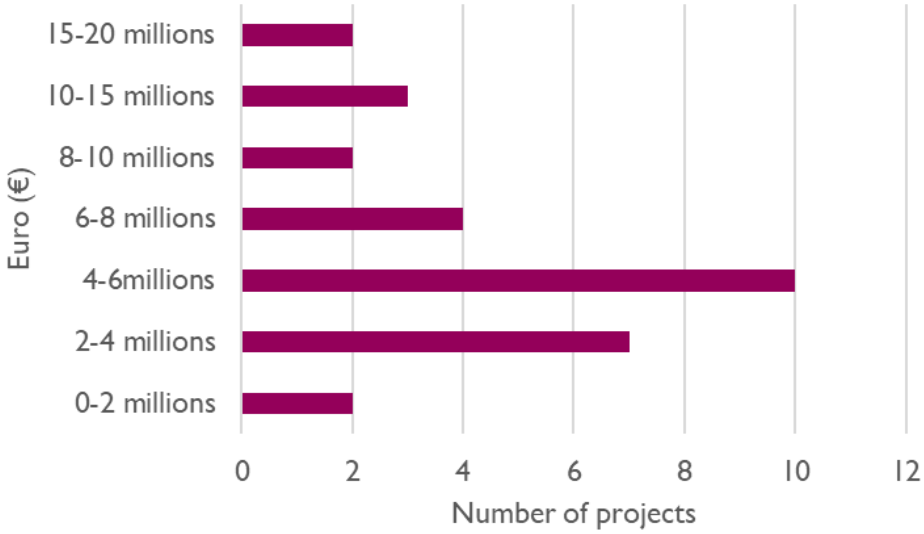

Figure 5: EU funding to the 30 projects

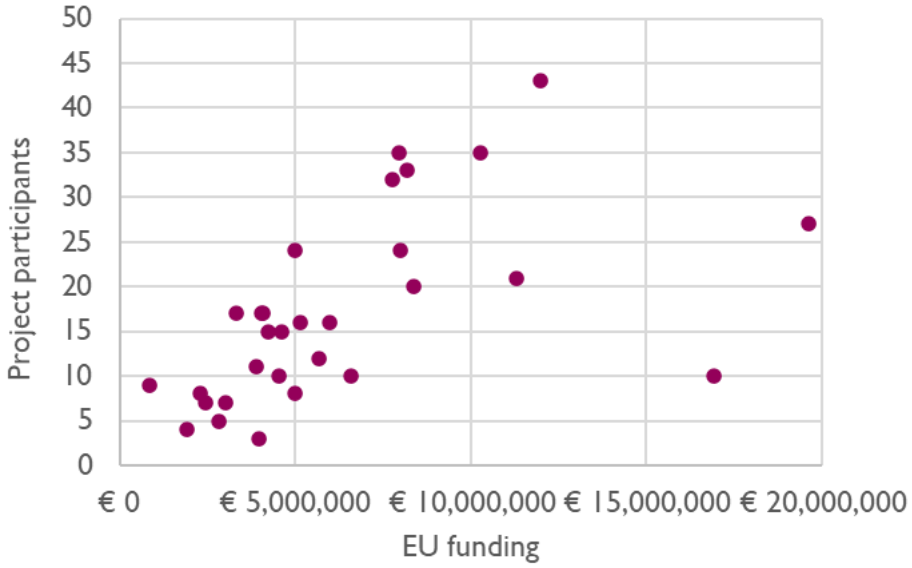

Figure 6: EU funding plotted against number of project participants

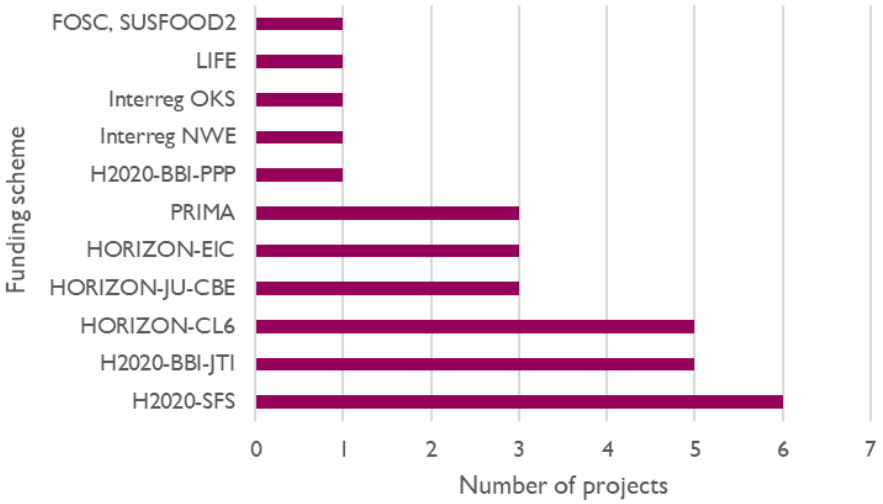

Figure 7: Number of projects per type of funding programme and action

3.3 Ten R&I projects overview analysis and synthesis

The ten R&I projects for in-depth analysis were selected based on thematic relevance and project outputs, i.e. the availability and accessibility of information. Table 2 lists the ten projects with title, acronym, protein source of scope, and main R&I goal.

Table 2: List of the ten R&I projects. SCP: Single cell protein

	Project title	Acronym	Protein source	Main R&I goal
1	Biorefineries for the valorisation of macroalgal residual biomass and legume processing by-products to obtain new protein value chains for high-value food and feed applications	ALEHOOP	Macroalgae and legumes	Valorise macroalgal residual biomass and legume by-products for food and feed applications
2	Microalgae protein ingredients for the food and feed of the future	ProFuture	Microalgae	Optimise the microalgae supply chain from cultivation to plate
3	Sustainable insect chain	SUSINCHAIN	Insects	Enhance scalability and economic feasibility of the EU insect protein value chain
4	Transition paths to sustainable legume-based systems in Europe	TRUE	Legumes	Promote legume-supported agri-food systems
5	Smart protein for a changing world: future-proof alternative terrestrial protein sources for human nutrition encouraging environment regeneration, processing feasibility and consumer trust and acceptance	SMART PROTEIN	Legumes and fungi	Develop alternative protein ingredients for food and build consumer trust and acceptance

6	Bioconversion of underutilised resources into next generation proteins for food and feed	NextGenProteins	Microalgae, fungi, insects	Optimise and validate SCP and insect production in industrially relevant settings
7	Development of novel functional proteins and bioactive ingredients from rapeseed, olive, tomato and citrus fruit side streams for applications in food, cosmetics, pet food and adhesives	PRO-ENRICH	Agricultural side streams from olive, rapeseed, tomato, citrus	Develop a flexible, sustainable biorefinery model to valorise agricultural side streams
8	Carbon capture from syngas to SCP and use as fish feed ingredient	SynoProtein	Bacteria	Develop and demonstrate a carbon-negative process that transforms sawmill by-products into bacterial SCP
9	From niche to mainstream – alternative proteins for everybody and everywhere	LIKE-A-PRO	Legumes, SCP, insects	Mainstream alternative proteins by making them available, accessible, and acceptable to all population groups
10	Printed symbiotic materials as a dynamic platform for living tissues production	PRISM-LT	Cultured meat	Develop a versatile platform for 3D bioprinting of living tissues

Together, these ten projects form a broad, complimentary portfolio across the alternative protein sector, covering single cell protein (SCP) sources (microalgae, fungi and bacteria), bioconversion/fermentation, insects, legumes, macroalgae, side-stream valorisation, and cultivated/bio-printed living materials (cultured meat). All ten projects include protein processing and product prototyping, developing either food or feed applications and performing consumer acceptance tests or animal feeding trials. Eight of the ten projects primarily focus on process optimisation, addressing cultivation, protein processing/extraction and product prototyping, with the goal of overcoming challenges such as economic viability and scalability. The remaining two projects (LIKE-A-PRO and SMART PROTEIN) place a stronger emphasis on building consumer trust and acceptance to promote mainstream adaption of alternative proteins, while also addressing protein processing and product prototyping. Figure 8 presents a word cloud of the top 50 most frequently mentioned words across the ten projects, highlighting key terms such as protein, sustainability, sustainable, feed, food, consumer, processing, and prototype.

Nine of the ten projects span the full value chain, from primary production to product prototyping, with many incorporating consumer insights and regulatory considerations. PRISM-LT, however, focuses on cultivated meat, which currently has a natural limit in the value chain due to its early developmental stage. As a result, the project concentrates primarily on upstream platform development, bio-fabrication, and prototype demonstration. Most projects progress from TRL 4-5 to TRL 6-7 through pilot-scale demonstrations and prototype validation, whereas PRISM-LT, being an EIC Pathfinder project, operates at an earlier stage, progressing from TRL 2 to TRL 4. Figure 9 illustrates the TRLs of the ten projects. TRLs were estimated based on the type of funding schemes and key wording in project descriptions and deliverables, as direct TRL statements were rarely available in the public documentation. Key phrases such as “pilot-scale demonstration”, “prototype validation”, or “proof-of-concept” were used to guide these estimates.

Three projects developed decision-support tools to facilitate sustainable and efficient protein production along the value chain, demonstrating how digital solutions can enhance process optimisation, guide sustainable production choices, and provide insights for stakeholders. ProFuture created a tool integrating sustainability and economic data to optimise microalgae production. SUSINCHAIN developed a tool to identify optimal insect production chains based on variations in species, feed, production scale, and location. TRUE developed a decision-support system for sustainability assessment and scenario modelling across a legume-based agri-food chain supporting operational decisions.

Four of the projects launched a webinar series under the Horizon4Proteins cluster, starting in 2021. In 2023, the series was joined by a fifth project from the selected ten, along with additional projects outside this selection. The five projects collaborating in Horizon4Proteins are NextGenProteins, ProFuture, SMART PROTEIN, SUSINCHAIN, and LIKE-A-PRO. The cluster was established to foster collaboration on key topics such as consumer acceptance of alternative proteins, safety and regulatory challenges, food applications, and sustainability. Through these webinars, the projects shared knowledge, showcased results, and discussed best practices, with the goal of creating synergies across different protein platforms and accelerating the development and market readiness of alternative proteins in Europe.

Further information on each of the ten projects can be found in Annex 3 (RefreSCAR PA Project Fiches_10 selected projects).

Figure 8: Word cloud of the top 50 most frequently mentioned words across the ten projects.

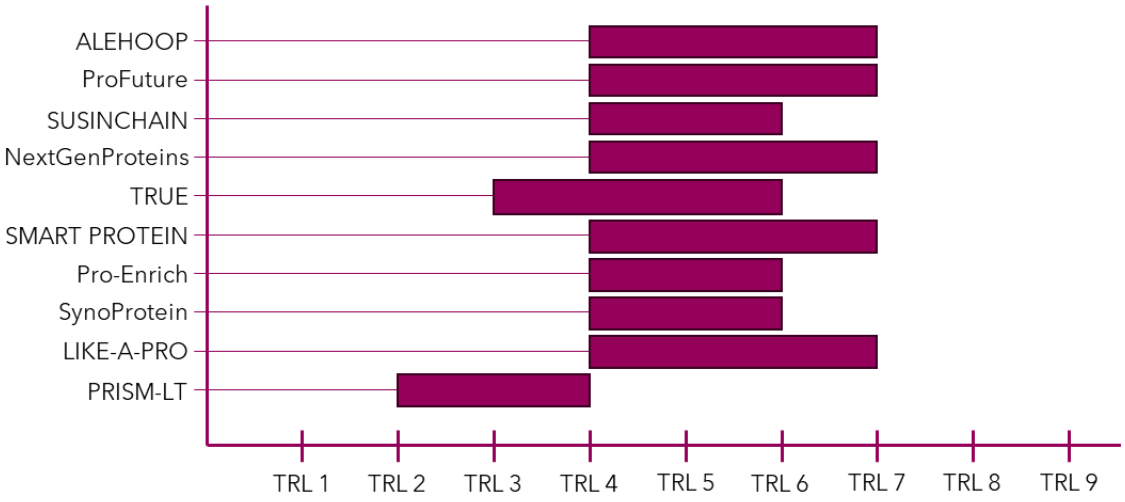

Figure 9: Estimated Technology Readiness Levels (TRLs) of the ten projects

4. R&I Gaps and Needs

In the project fiches of the ten selected projects for in-depth analysis (Annex 3 RefreSCAR PA Project Fiches_10 selected projects), overlaps and gaps in projects relative to the other projects are described for each project individually.

The ten selected projects - ALEHOOP, ProFuture, SUSINCHAIN, TRUE, SMART PROTEIN, NextGenProteins, PRO-ENRICH, SynoProtein, LIKE-A-PRO, and PRISM-LT - collectively address the development and commercialisation of alternative proteins. However, each project contributes **unique strengths.** These are summarised in Table 3.

Table 3: Overview of the unique aspects per project.

	Project title	Acronym	Unique aspects
1	Biorefineries for the valorisation of macroalgal residual biomass and legume processing by-products to obtain new protein value chains for high-value food and feed applications	ALEHOOP	Focus on valorising macroalgal residual biomass and legume by-products to develop sustainable, low-cost protein sources for food and feed applications, primarily focusing on protein extraction, product prototyping, digestibility studies, safety and toxicology tests, sustainability assessment, regulatory mapping and consumer testing.
2	Microalgae protein ingredients for the food and feed of the future	ProFuture	Microalgae-centric, with focus on optimising the microalgae supply chain from cultivation to plate, with particular attention to improving microalgae cultivation efficiency and achieving sustainable and affordable production of protein rich ingredients from microalgae biomass, as well as the development of foods and feeds and the scale-up of production and market for micro-algae based foods and feeds.
3	Sustainable insect chain	SUSINCHAIN	Uniquely addresses insect-specific challenges to enhance the economic feasibility and scalability of the European insect protein value chain, with a particular focus on the development of business models for commercialisation of insect proteins, upscaling, feed applications, consumer acceptance and trust, safety (e.g., allergenicity, contaminants) and sustainability.
4	Transition paths to sustainable legume-based systems in Europe	TRUE	The only project fully centred on legumes in this portfolio, highlighting field and experimental work (agronomic trials, feeding trials and legume-based

			products), stakeholder engagement, tool and framework development (LCA methodology, sustainability indicators) and policy analysis.
5	Smart protein for a changing world. Future-proof alternative terrestrial protein sources for human nutrition encouraging environment regeneration, processing feasibility and consumer trust and acceptance	SMART PROTEIN	Focus on protein products sourced from plants and microbial biomass, including organic and generative farming methods, fractionation of plant-based proteins, solid-state fermentations using food and processing wastes, identification of food applications, addressing regulatory, food-safety and sustainability challenges and studying consumer acceptance and trust.
6	Bioconversion of underutilised resources into next generation proteins for food and feed	NextGenProteins	Demonstrates suitability of three protein sources (Spirulina, single cell protein (SCP) and insects) in food and feed value chains, with attention to the regulatory and safety landscape, the production of sustainable proteins for food and feed applications, market and consumer readiness and sustainability analysis.
7	Development of novel functional proteins and bioactive ingredients from rapeseed, olive, tomato and citrus fruit side streams for applications in food, cosmetics, pet food and adhesives	PRO-ENRICH	A unique dedicated focus on valorisation of agricultural side streams through the development of biorefinery models, producing ingredients for food, pet food, cosmetics and adhesives, including novel extraction technologies, piloting and analysing sustainability and socio-economic aspects.
8	Carbon capture from syngas to SCP and use as fish feed ingredient	SynoProtein	Develops and demonstrates a carbon-negative process to transform sawmill by-products into bacterial SCP for fish feed and biochar for animal feed, with attention to life-cycle analysis, public awareness and a business model for market entry.
9	From niche to mainstream – alternative proteins for everybody and everywhere	LIKE-A-PRO	Aims to make alternative proteins available and acceptable to all population groups and across diverse European settings through consumer research, stakeholder engagement, product innovation, impact, safety and regulatory alignment.
10	Printed symbiotic materials as a dynamic platform for living tissues production	PRISM-LT	A unique focus on engineered living materials, with attention for biomedical and food applications, cell engineering, bioprinting and bioinks, testing, regulatory engagement and training.

Despite their diverse approaches of qualifying different type of biomass (e.g., microalgae, insects, legumes, syngas fermentation, engineered living materials) into food and feed applications,

several **common gaps and challenges** emerge. These gaps and challenges are organised per stage in the value chain (primary production, downstream processing for food and feed applications, product development (feed and food), consumer), supplemented with identified sustainability, regulatory and policy related gaps and challenges. Related **needs** to overcome the described gaps and challenges are also included.

1. Primary production

The primary production of protein rich crops (e.g. legumes) remains limited due to insufficient breeding programmes for high-protein cultivars, unstable yields due to climatic variability, and a lack of sufficient regional agronomic knowledge to grow new protein crops. The development of tailored transition pathways that integrate agronomy, genetics and socio-economic context across different EU-climatic zones is needed. In addition, further development of farmer decision-support tools, as well as increased engagement, training and education is needed.

Microalgae production faces challenges related to strain optimisation, high production costs, immature supply chain structures, fragmented producers and scaling constraints. Insect production shows knowledge gaps in relation to nutrition, disease control, storage and batch-to-batch inconsistency, as well as concerns regarding the potential accumulation of contaminants (PFAS, microplastics). SCP production derived from side streams or (industrial) gasses struggles to balance productivity with sustainability constraints. A key gap identified across several projects in this part of the value chain, is inconsistency of the available feedstock, as seasonal variability of agrifood side streams, along with insufficient infrastructure for collection, preprocessing and transport, remains a major bottleneck.

2. Downstream processing for food and feed applications

Across projects, (downstream) processing gaps primarily relate to scaling, process optimisation and cost competitiveness. While pilot processes demonstrate feasibility, the transition to cost competitive industrial production remains challenging, especially for novel proteins derived from microalgae, insects and single cell sources. Flexible biorefinery concepts for processing heterogeneous side streams require further optimisation of both processes and infrastructure. This highlights the need for increased investment, improved funding tools and a stronger follow-on investment for scale-up. In relation to protein extraction and refinement, achieving high purities and yields without compromising sustainability remains a key challenge. This emphasises the need to find a balance between ingredient performance and minimal processing principles. Cost competitiveness compared to established proteins such as soy and pea also remains a significant challenge.

3. Product development (food and feed)

For the development of food applications, sensory (taste, texture, colour) and functionality constraints are reported. Many alternative proteins exhibit suboptimal solubility, emulsification, foaming or gelation properties compared to more 'traditional' ingredients, such as soy and animal proteins. Off flavours - such as marine notes in (micro)algae or earthy flavours in insects or SCP – further reduce their applicability in food products. This highlights the need to improve (mild) processing technologies that retain functionality while removing undesired flavours and ensuring food safety and nutritional value. In addition, product formulation remains a key challenge as,

many novel protein-based food formulations do not yet match consumer expectations for taste, texture or price. Even small additions of alternative proteins can affect consumer acceptance substantially. Addressing flavour and off-flavour compounds, both in raw biomass and during processing, is essential.

Gaps in feed applications relate to further validation regarding digestibility, as well as long-term impacts on animal health and performance. Novel protein sources require broader feed trials across different species, life stages and longer duration periods. Current inclusion of these novel protein sources in feed can result in performance issues, indicating the need for improved formulations combined with supportive technologies, such as enzymatic treatments. Safety considerations also remain important. Allergenicity of insect proteins raises concerns, as well as contaminant accumulation. For SCP, risks related to waste-contaminated feedstocks have also been identified. These challenges require optimised risk assessment methodologies and validated processing methods to ensure safety.

4. Consumer

Food products containing alternative proteins (insects, microalgae and microbial proteins) encounter consumer scepticism regarding taste, texture, safety, perception and cultural appropriateness. Plant-based proteins may also encounter sensory drawbacks, such as bitterness and astringency. Unfamiliarity and misinformation further contribute to consumer mistrust of these products. Overall, consumer acceptance remains a universal bottleneck.
Another aspect that restricts mainstream adoption and slowing broader market diffusion is the high price of these products, which are often positioned in premium market segments. The gaps identified in this section of the value chain highlight the need for clearer and more transparent communication with consumers, as well as further product reformulation, culinary integration, increased product visibility and availability and deeper behavioural insights to align these innovations with everyday consumption patterns and to support broader consumer adoption.

5. Sustainability

LCAs conducted within the selected projects of this PA demonstrate potential reductions in greenhouse gas emissions, land use and water consumption compared to the conventional livestock proteins. However, comparisons across feedstocks and technologies remain challenging because of the heterogeneity of the methodologies applied. This highlights the need for a more harmonised LCA framework, particularly one that accounts for co-products, circularity benefits and soil carbon effects.

High energy consumption during (micro)algae and microbial protein production is identified as a limiting factor in relation to sustainability benefits. In addition, limited data availability (on farm level and on industrial scale) restricts the ability to perform accurate assessments. Besides environmental sustainability, economical sustainability remains a key bottleneck as many innovations currently depend on subsidies or premium pricing to remain viable. Social sustainability (amongst others, rural development impacts and public health implications) deserves more attention in relation to sustainability analysis. These gaps clearly indicate the need

for integrated sustainability analysis combining environmental, economic and social aspects to support credible sustainability claims.

6. Regulatory and policy

Across the selected projects in the PA, regulatory barriers and complexity are systematically identified as a challenge for market entry. Concrete, Novel Food (and feed) regulations create delays, high costs and uncertainty (e.g. for investors and Small and Medium-sized Enterprises (SMEs)). For microalgae, only a small fraction of the many strains has been approved, while proteins derived from waste streams lack clear regulatory frameworks. In addition, existing regulations are not well adapted to emerging fields such as engineered living materials. This stresses the need for reviewing and adapting the Novel Food regulation to facilitate innovation. Labelling and discussions on terminology make market positioning difficult, certainly for hybrid or fermentation-based products. To boost transparency, innovation and consumer acceptance, clear and harmonised approaches are needed.

Embedding protein diversification in public procurement criteria could increase stimulation to include sustainable proteins in school catering or hospital meals. Similarly, implementing Value Added Tax (VAT) incentives could boost sustainable proteins. Fragmented policy support, trade dependencies, and limited domestic support measurements may negatively affect the adoption of legumes and other novel protein crops. Overall, there is a clear need for co-creation approaches involving producers, processors, retailers, chefs and consumers to integrate the entire value chain to close the gap between supply and demand.

5. Concluding remarks

Europe's agri-food systems face mounting challenges, including climate change, geopolitical tensions, and continued reliance on imported protein. In response, the EU aims to enhance protein self-sufficiency through sustainable, diversified, and resilient production systems. Alternative proteins (plant-based, microbial, insects and cultured meat) are a key component of this system.

In this portfolio analysis, 80 projects were initially screened, of which 30 were selected for further review. Finally, ten projects were analysed in depth. These projects cover full value chains - from production to prototyping and consumer testing - and span diverse protein sources and applications (food, feed, or both), with a strong emphasis on sustainability, circularity and LCA. Most of the selected projects focus on process optimisation and product prototyping to address challenges such as economic viability and scalability, while a few projects place a stronger emphasis on consumer trust and the mainstream adoption of alternative proteins.

The TRLs of nine of the ten projects range from TRL 4-5 to TRL 6–7. Combined with the identified gaps and needs, this highlights the importance of further fundamental research to better understand key bottlenecks and enable targeted, effective solutions along the value chain.

The main gaps identified in the ten projects relate to primary production (e.g. producing protein rich crops and novel biomass streams, inconsistent feedstock, lack of infrastructure), downstream processing for food and feed applications (e.g. scaling and process optimisation issues, cost competitiveness), food product development (e.g. sensory and functionality constraints, product formulation and safety challenges, price), feed product development (e.g. digestibility, long-term animal health and performance impact, safety), consumer acceptance (e.g. sensory issues, 'processed' perception, cultural appropriateness, misinformation, product availability), sustainability (e.g. methodology inconsistency, energy consumption, limited data, economic and social sustainability) regulatory bottlenecks (e.g. complexity and cost for approval, labelling and terminology) and policy bottlenecks (e.g. support and stimulation tools, value chain development), .

Cross-cutting recommendations across the projects to accelerate the sustainable adoption of alternative proteins in Europe include; strengthening value chain integration to bridge supply and demand gaps; development of integrated transition pathways (agronomy, genetics, socio-economic context) in different EU-climatic zones; increasing farmer engagement, training and education; expanding investment and funding tools for scale-up regarding downstream processing; improving (mild) processing technologies; enhancing food and feed formulations; fostering consumer-centric innovation; investing in consumer education and broader food product diffusion; implementing a holistic and integrated sustainability evaluation; promoting harmonised regulation and policy alignment; improving economic viability; and supporting collaborative platforms and shared data resources.

Annexes

ANNEX 1_Project_screening_selection 30 projects.xlsx

An Excel file was created for the results of the mapping of the thirty most relevant R&I projects. The file is included in attachment to this report (see file "ANNEX 1_Project_screening_selection 30 projects.xlsx").

ANNEX 2_Refrescar_PPT-30 selected projects.pptx

A PowerPoint was created with essential project information, main objective, key results and outputs of the thirty most relevant R&I projects. The file is included in attachment to this report (see file "ANNEX 2_Refrescar_PPT-30 selected projects.pptx").

ANNEX 3_RefreSCAR PA Project Fiches_10 selected projects

The results of the findings of the 10 selected projects for in-depth analyses are summarised in this annex.

ANNEX 3 – PROJECT FICHES

SCAR Protein Task Force

Title: **PORTFOLIO ANALYSIS – PROJECT FICHES**

September | 2025

Authors:

- Geert Van Royen
- Louise Juul

List of 10 in-depth analysed projects

1. Biorefineries for the valorisation of macroalgal residual biomass and legume processing by-products to obtain new protein value chains for high-value food and feed applications - **ALEHOOP**
2. Microalgae protein ingredients for the food and feed of the future – **ProFuture**
3. SUStainable Insect CHAIN - **SUSINCHAIN**
4. Transition paths to sustainable legume-based systems in Europe - **TRUE**
5. Smart protein for a changing world. Future-proof alternative terrestrial protein sources for human nutrition encouraging environment regeneration, processing feasibility and consumer trust and acceptance – **Smart Protein**
6. Bioconversion of underutilised resources into next generation protein for food and feed - **NextGenProteins**
7. Development of novel functional proteins and bioactive ingredients from rapeseed, olive, tomato and citrus fruit side streams for applications in food, cosmetics, pet food and adhesives – **PRO-ENRICH**
8. Carbon capture from syngas to Single Cell Protein (SCP) and use as fish feed ingredient - **SynoProtein**

9. From niche to mainstream - alternative proteins for everybody and everywhere – **LIKE-A-PRO**
10. PRInted Symbiotic Materials as a dynamic platform for Living Tissues production – **PRISM-LT**

1. Biorefineries for the valorisation of macroalgal residual biomass and legume processing by-products to obtain new protein value chains for high-value food and feed applications – ALEHOOP

PROJECT INFORMATION

Source(s)

CORDIS website: https://cordis.europa.eu/project/id/887259

Project website: https://alehoop.eu/

Funding details

Source of funding: H2020-BBI-JTI-2019

Type of project (+ cluster if relevant): Innovation Action

Contract number: Grant agreement ID: 887259

Project total budget (€): 6718370,00

Start and end date of the project

01/06/2020 | 28/02/2025

Project summary

The ALEHOOP project aimed to valorise macroalgal residual biomass and legume by-products to develop sustainable, low-cost protein sources for food and feed applications. Key activities included:

- Raw Material Analysis: Nutritional, physicochemical, microbiological, and toxicological assessments of green, brown, and red seaweeds, and second choice legume by-products (lupin, lentil, pea, bean).
- Protein Extraction Development: Lab- and pilot-scale protocols for extracting high-purity proteins (>80%) from legumes and algae, including debittering of lupin protein extracts and removal of mineral contaminants from green seaweed.
- Product Prototyping: Development and testing of food products such as meat analogues, snack bars, jams, sports drinks, meal replacement shakes, and smooth food for elderly nutrition.
- Techno-functional Characterisation: Evaluation of solubility, emulsification, gelling, and foaming properties of protein isolates.
- In Vivo Digestibility Studies: Animal trials to assess bioavailability, metabolic effects, and safety of lupin and lentil proteins.

- Safety and Toxicology Testing: Extensive assessments of contaminants, allergens, and toxicological risks to validate the safety of the extracts.
- Sustainability Assessment: Development of a Life Cycle Sustainability Assessment (LCSA) framework integrating environmental, economic, and social metrics.
- Regulatory Mapping and Standardisation: Identification of applicable EU regulations, drafting of Product Category Rules (PCRs) for protein isolates to address gaps in existing LCA standards, and engagement with standardisation bodies.
- Consumer Testing: Sensory evaluations and acceptability studies across Europe and Latin America to validate product concepts and guide reformulation.

Project results

The ALEHOOP project delivered significant results in developing sustainable protein sources from macroalgal and legume by-products. Key outcomes include:

- High-Quality Protein Extracts: Legume-derived proteins, particularly lupin, achieved >80% purity with excellent amino acid profiles and very low levels of anti-nutrients. Red seaweed epiphytes showed the highest protein content among algae (~25%) and were identified as the most suitable fraction for extraction.
- Functional Performance: Lupin protein demonstrated strong gelling, emulsifying, and solubility properties, suitable for diverse food applications. Seaweed proteins required pH adjustment for optimal functional performance and flavour masking.
- Product Development: Eight meat analogue prototypes reached TRL 5–6, with high consumer acceptance. Additional products - snack bars, jams, sports drinks, and meal replacement shakes - were validated through sensory testing.
- Safety Validation: Toxicological assessments confirmed no mutagenicity, cytotoxicity, or genotoxicity. Allergenicity were low but require clear labelling, particularly for lupin.
- Digestibility and Bioavailability: In-vivo studies showed positive metabolic effects (lower final body weight, maintaining of lean, fat and mass distribution) and improved hematological parameters in rats fed lupin and lentil proteins.
- Sustainability Assessment: A Life Cycle Sustainability Assessment (LCSA) framework confirmed environmental, economic, and social viability of ALEHOOP processes.
- Regulatory and Standardisation Progress: Draft Product Category Rules (PCRs) were developed, and regulatory mapping aligned with EU food safety standards.
- Animal Feed Trials: Ulva macroalgae concentrate demonstrated no adverse effects on fish growth, indicating potential for feed applications.

Output: Six documents/reports, six peer reviewed articles, five book chapters, one review article, newsletters, website

Lead partner

Contactica, *Spain*, Consulting and innovation

Other partners

- Isanatur, *Spain*
- Biozoon, *Germany*

- Biosurya, *Spain*
- Centiv, *Germany*
- Garlan, *Spain*
- Alginor, *Norway*
- Nuscience, *Belgium*
- Indukern, *Spain*
- EV-ILVO, *Belgium*
- Anfaco, *Spain*
- Tecnalia, *Spain*
- Technological University Dublin, *Ireland*
- Universidad de Cadiz, *Spain*
- Veterinary Research Institute, *Czech Republic*
- Universidad de Vigo, *Spain*

Contacts

- Contactica, Spain;
  - mailto:alehoop@contactica.es

Relevant links

- Deliverables and newsletters: https://alehoop.eu/documents/
- Alehoop brochure: https://zenodo.org/records/5725042
- Peer reviewed articles, book chapters: https://cordis.europa.eu/project/id/887259/results

Relation to SCAR Protein TF PA scope

The project focusses on legume and macroalgal proteins for food and feed applications, applied research (processing up to pilot scale, safety, nutritional, sustainability, zero-waste, food technology, consumer acceptance, regulatory). Project completed in 2025.

Overlaps and gaps of the project content compared to the other projects in the portfolio

Gaps and challenges were identified within the ALEHOOP project:
1. Scaling to Industrial Levels: Transition from lab/pilot scale to full industrial production is still in progress and requires further investment, optimisation, and process integration.
2. Cost and Market Competitiveness: Economic scalability and price competitiveness remain to be demonstrated.
3. Wider Market Penetration: Although consumer testing showed positive results, more data is needed towards commercial launch or large-scale market availability.

4. More need for Animal Feed Trials: Promising feed applications in gilthead sea bream, but further trials across other species and under commercial farm conditions are needed.
5. Regulatory Bottlenecks: While regulatory frameworks are being followed, challenges linked to Novel Food or feed authorisation pathways could hinder commercialisation.

ALEHOOP highlights several common challenges in protein value chains observed by projects across the portfolio, including scaling up, cost barriers, regulatory hurdles, and market acceptance. ALEHOOP's primary uniqueness towards the other projects in this PA lies in its strong focus on agricultural by-products and their application in food and feed.

SCAR
Standing Committee
on Agricultural Research

2. Microalgae protein ingredients for the food and feed of the future – ProFuture

PROJECT INFORMATION

Source(s)

CORDIS website: https://cordis.europa.eu/project/id/862980

Project website: https://www.pro-future.eu/

Funding details

Source of funding: H2020-SFS-2019-1
Type of project (+ cluster if relevant): Innovation Action
Contract number: Grant agreement ID: 862980
Project total budget (€): 9.448.451,25 (EU contribution: 7.775.109,01)

Start and end date of the project

01/10/2019 | 31/12/2023

Project summary

ProFuture followed a multilevel strategy from lab to large scale, where 31 partners worked together to optimise the microalgae supply chain from cultivation to plate. The four main objectives and key work performed were:

1) Make microalgae cultivation more efficient, sustainable, and affordable.
- Scaled *Chlorella vulgaris* strains with enhanced protein content and improved sensory attributes.
- Developed and implemented heterotrophic and mixotrophic growth strategies for *Chlorella vulgaris* and *Galdieria sulphuraria*
- Deployed innovative systems such as direct air-capture CO_2 prototypes, side-stream valorisation (e.g., insect frass, recycled water), and off-grid photobioreactors to improve cost and energy efficiency

2) Improve the production of protein-rich ingredients from microalgae biomass.
- Evaluated drying approaches including solar drying (batch) and pulsed combination/thin film drying (continuous) for single cell proteins and used electrostatic spray drying for protein isolate recovery.
- Extracted protein isolates from *Tetraselmis chui* and Spirulina, identifying high-value co-products suitable for food or feed application.

3) Create nutritious and tasty foods and feeds using microalgae proteins.
- Reformulated seven food products (e.g., soups, pasta, breadsticks, meat analogues, sports bars, meal replacements) and scaled them industrially for consumer testing.

- Developed five feed formulations for poultry, piglets, catfish, carp, and shrimps—replacing up to half the soy protein with microalgae—and conducted successful animal trials validating performance and meat quality.

4) Scale up production and seize the market for microalgae-based foods and feeds.

- Combined Life-Cycle Cost (LCC) and Life-Cycle Assessment (LCA) to quantify reductions in water (–40%) and energy (–50%) consumption; developed a decision-support tool integrating sustainability and economic data.
- Conducted consumer surveys and market segmentation, revealing low familiarity with microalgae-enriched foods and key acceptance drivers.
- Performed preliminary regulatory assessment for novel-food authorisation

Project results

- Cultivation and processing innovation lowered resource demand
  - Under oxygen-balanced mixotrophy, *Galdieria sulphuraria* doubled biomass productivity compared to photoautotrophic growth, while maintaining protein content.
  - Insect frass proved a sustainable nutrient source for *Chlorella vulgaris,* although it encouraged growth of algae-associated bacteria.
  - Indirect hybrid solar drying offered a sustainable, cost-effective drying alternative to freeze drying, maintaining macronutrient profiles for *Tetraselmis chui* and *Nannochloropsis oceanica*, although with significant pigment loss. Microbial safety and functional properties were found to be adequate for feed and food formulations.
- Protein extraction efficiency and product quality were strongly strain- and condition-dependent. Innovations such as bead milling optimisation, agitated thin film drying, and electrostatic spray drying improved techno-functional properties, digestibility, and overall performance compared to conventional methods.
- Microalgae biomass ingredients were successfully incorporated into food and feed formulations at industrial scale. The products had a lower environmental footprint than animal-derived sources, although still higher than mature plant-based alternatives.
  - Microalgae enrichment in various food products enhanced protein density and quality and micronutrient content, without compromising *in vitro* digestibility. Sensory properties were affected to varying degrees depending on product, inclusion level and species.
  - Five feed formulations replaced 50% of soy protein with microalgae. Animal trials indicated that microalgae could compete with soy-based diets in terms of growth performance and meat quality parameters.
- Consumer acceptance depends on matching the sensory profile of microalgae with the food matrix, while regulatory simplification and broader public awareness could further support market uptake. Product positioning as "innovative," "sustainable," and "healthy" helped positively influence consumer attitudes.

Project output: 19 peer reviewed articles, one conference proceeding, and a range of infographics, videos, press releases and conferences.

Lead partner

Institut de Recerca I Tecnologia Agroalimentaries (IRTA, Institute of Agrifood Research and Technology), *Spain*

Other partners

- Dil Deutshes Institut fur Lebensmitteltechnik EV, *Germany*
- Wageningen University, *Netherlands*
- Eigen Vermogen van Het Instituut voor Landbouw- en Visserijonderzoek, *Belgium*
- Universiteat Gent, *Belgium*
- Universiteit Twente, *Netherlands*
- Zentrum fur Soziale Innovation GmbH, *Austria*
- NORCE Research AS, *Norway*
- Necton-Companhia Portuguesa de Culturas Marinhas SA, *Portugal*
- Allmicroalgae Natural Products SA, *Portugal*
- Associacao Oceano Verde Laboratorio Colaborativo Para o Desenvolvimento de Technologias e Produtos Verdes do Oceano, *Portugal*
- Algosource Technologies, *France*
- Givaudan Nederland BV, *Netherlands*
- Viva Maris GmbH, *Germany*
- Tradizioni Padane SRL, *Italy*
- Cale – Industria e Comercio, LDA, *Portugal*
- Alver World SA, *Austria*
- Enervit Spa, *Italy*
- Conservas Hijos de Manuel Sanchez Basarte SA, *Spain*
- Centro Nacional de Technologia y Seguridad Akimentaria, *Spain*
- Nutrition Sciences, *Belgium*
- INVE Technologies NV, *Belgium*
- Vitafort Elso Takarmanygyarto es Forgalmazo Zartkoruen Mukodo RT, *Hungary*
- COOP Italia – Societa' Cooperativa SCRL, *Italy*
- Apexagri SAS, *France*
- Wiise SRL Societa' Benefit, *Italy*
- Civitta Eesti AS, *Estonia*
- Axia Innovation GmbH, *Germany*
- RDC Informatics S.A., *Greece*
- ESU-Services GmbH, *Switzerland*
- Foodcompanions Holding BV, *Netherlands*
- European Food Information Council, *Belgium*
- Foodcompanions BV, *Netherlands*

Contacts

- IRTA, Spain;

- Communication contact: Marie-Christine Thurm/Nina McGrath – comms@pro-future.eu
- Project coordinator: Massimo Castellari – info@pro-future.eu

Relevant links

- Peer reviewed articles (19) and documents: https://cordis.europa.eu/project/id/862980/results
- Project infographics and videos: https://www.pro-future.eu/resources
- Project leaflet: https://assets.ctfassets.net/jki1kwy7fqkv/65Kt2oaJ58PtoL2WPgOinn/32f070897f623c68c6c03523a35ad6e5/ProFuture-leaflet-English_digital.pdf
- Popular paper project summary: https://www.greatitalianfoodtrade.it/en/innovazione/il-ruolo-delle-microalghe-in-alimenti-e-mangimi-lo-stato-dellarte-profutureeu/

Relation to SCAR Protein TF PA scope

The project developed microalgae-based proteins as sustainable, nutritious alternatives for food and feed. The project included optimisation of cultivation, processing, and biorefinery methods to reduce resource use and costs, and support industrial-scale reformulation of foods and feeds. The project assessed consumer acceptance, EU regulatory requirements, and environmental impact, paving the way towards scalable, market-ready alternative proteins. The project was completed in 2023.

Overlaps and gaps of the project content compared to the other projects in the portfolio

Gaps and challenges identified in the ProFuture project:
1. Cost & Scalability: High production and processing costs still hinder large-scale commercialisation. Protein isolates, while functionally viable, remain expensive and energy consumption (from LCA results) is still higher compared to plant proteins.
2. Regulatory Barriers: The EU Novel Foods Regulation can be complex and costly, particularly for SMEs and startups. Few microalgae strains are currently approved (~72,500 strains exist, but few are authorised).
3. Market Maturity: Immature supply chain: fragmented producers, lack of scale, weak interconnection. Limited market penetration: microalgae still considered niche; consumer products not widely available in mainstream retail.
4. Consumer Education/awareness and Sensory Acceptance: Despite positive perception, lack of scientific understanding and organoleptic limitations (e.g., taste, colour) pose hurdles. Products face difficulty balancing nutrition and consumer taste preferences.

5. Investment & Knowledge Gaps: SMEs lack access to investment planning tools, expertise, and market data. Greater institutional and financial support is needed to advance the growth of the sector.
6. Policy Integration: Novel food approval pathways are not fully integrated into publicly funded R&D pipelines. Need for regulatory reform and strategic alignment between research and market implementation.

In general, ProFuture identifies some key challenges in protein value chains that are shared with other projects of this portfolio, in terms of cost, scalability, regulatory hurdles, market maturity, and consumer acceptance. ProFuture stands out for its microalgae focus and optimising the microalgae supply chain from cultivation to plate.

3. SUStainable INsect CHAIN – SUSINCHAIN

PROJECT INFORMATION

Source(s)

CORDIS website: https://cordis.europa.eu/project/id/861976

Project website: https://susinchain.eu/

Funding details

Source of funding: H2020-SFS-2019-1
Type of project (+ cluster if relevant): Innovation Action
Contract number: Grant agreement ID: 861976
Project total budget (€): 8,685,296.78 (EU contribution: 7,952,547.16)

Start and end date of the project

01/10/2019 | 30/09/2023

Project summary

The SUSINCHAIN project sought to enhance the economic feasibility and scalability of the European insect protein value chain. The overall objective was to test, pilot and demonstrate recently developed technologies, products and processes, in order to advance them to Technology Readiness Level 6 or higher, emphasising safety, consumer acceptance, and sustainability.

Key objectives for the project were to:

- Develop robust business models to support the commercialisation of high-quality insect proteins.
- Enable large-scale insect rearing, transport, and processing technologies across industrial settings.
- Validate animal performance and product quality through targeted research, ensuring efficacy when insects are used in feed.
- Integrate insect-based diets into daily European meals, fostering consumer acceptance and real-world uptake.
- Develop tools to ensure safety and sustainability, including improved decision-support systems for environmental and industry oversight.
- Raise awareness and build consumer trust through strategic exploitation and dissemination of project outcomes

Project results

The project established a conceptual framework to analyse supply- and demand-side barriers for insect-based feed and food, supporting commercialisation through risk management, consumer insights, and best practice identification. Results provide knowledge for scaling up production, guiding industry innovation, and informing evidence-based policymaking. Key results include:

- A stakeholder platform was created and a roadmap for sectorial transformation was developed.
- Insect rearing and health
    - Database of substrate pre-treatments developed; feed experiments conducted.
    - Studies on transport, pest species, and disease transmission improved rearing safety and welfare.
    - Nutritional requirements and chemical composition were compiled by insect species to identify gaps and guide sustainable production.
- Processing and preservation
    - Techniques optimised for industrial implementation: including preservation (nitrogen storage, water immersion), decontamination (low-energy electron beam), prolonged shelf-life (dielectric drying, tricanter centrifugation).
- Animal feed applications
    - Low consistency of insect batches led to different digestibility results which remain a challenge to be solved.
    - Results were dependent on animal species, insect source, and age of the animals, though in general show that insect meals are suitable protein sources to sustain animal growth.
- Food applications and consumer perception
    - Six insect-based dinner products developed; consumer studies in Denmark and Portugal highlighted sensory qualities and individual values as critical for acceptance.
- Feed and food safety
    - Results suggested that contaminants do not accumulate, except for some PFAS compounds and microplastics.
    - Insects have the potential to cause allergic reactions in persons with an existing seafood allergy. Enzymatic treatment could reduce allergenicity.
- Sustainability
    - Systematic overview of environmental impact of several insect species, performed with a single methodology for multiple scenarios, allowing for the selection of optimal sustainable production chains.
    - Online DSS tool developed, which allows to define the optimal production chains according to the variations in insect species, feeds, scale of production and potential location.

Output: 55 peer reviewed articles, one dissertation, 30 reports/documents

Lead partner

Stichting Wageningen Research, *Netherlands*

Other partners

- INAGRO, *Belgium*
- Katholieke Universiteit Leuven, *Belgium*
- Universita Degli Studi di Torino, *Italy*
- Københavns Universitet, *Denmark*
- Dil Deutsches Intitut fur Lebensmitteltechnik EV, *Germany*
- Sociedade Portuguesa de Inovacao (SPI), Consultadoria Empresarial e Fomento da Inovacao SA, *Portugal*
- Civic Consulting GmbH, *Germany*
- Insect technology Group Holdings UKLTD, *United Kingdom*
- Bioflytech SL, *Spain*
- Universidade Catolica Portuguesa, *Portugal*
- DSM Nutritional Products Ltd, *Switzerland*
- DYMOTEC, *Belgium*
- Forfarmers Corporate Services BV, *Netherlands*
- Hermetia Baruth GmbH, *Germany*Hipromine Spolka Akcyjna, *Poland*
- Havforskningsinstituttet, *Norway*
- Acondicionamiento Tarrasense Associacion, *Spain*
- Sense Test, Sociedade de Estudos de Analise Sensorial a Produtos Alimentares, LDA, *Portugal*
- Universidade do Porto, *Portugal*
- Technische Universitat Berlin, *Germany*
- Medizinische Universitaet Wien, *Austria*
- Universita Politecnica Delle Marche, *Italy*
- Eidgenoessische Technische Hochschule Zuerich, *Switzerland*
- Meam Holding, *Belgium*
- Hellenic Centre for Marine Research, *Greece*
- Institut National de Recherche Pour L'Agriculture, L'Alimentation et L'Environment (INRAE), *France*
- Danmarks Tekniske Universitet, *Denmark*
- EWOS Innovation AS, Cargill, *Norway*
- Nutrition Sciences, *Belgium*
- NGN Pro-active BV, *Netherlands*
- Bühler Insect Technology Solutions AG, *Switzerland*
- Bestico BV, *Netherlands*
- Bugging Denmark (Rukov Jakob Lewin), *Denmark*
- Ynsect NL R&D BV, *Netherlands*

Contacts

Wageningen University and Research, *Netherlands*
- Project coordinator Dr. Teun Veldkamp: teun.veldkamp@susinchain.eu

- Other contacts can be found at: https://susinchain.eu/contact/

Relevant links

- Project brochure: https://susinchain.eu/wp-content/uploads/2023/01/susinchain_brochure.pdf
- List of publications incl. peer reviewed articles: https://cordis.europa.eu/project/id/861976/results
- Best practice sheets: https://susinchain.eu/project-outcomes/best-practice-sheets/
- SUSINCHAIN tool for calculating economic impact: https://susinchain.eu/project-outcomes/susinchain-tool/
- Reports on WP deliverables: https://susinchain.eu/project-outcomes/deliverables/

Relation to SCAR Protein TF PA scope

The project focuses on various insect species to contribute to novel protein provision for feed and food in Europe by overcoming the remaining barriers for increasing the economic viability of the insect value chain.

Overlaps and gaps of the project content compared to the other projects in the portfolio

Gaps and challenges identified in the SUSINCHAIN project:

1. Regulatory Barriers: Existing rules around novel foods, feed materials, and substrate categories are fragmented and complex; unified legislation is needed
2. Industry Coordination: Few national-level sector platforms or working groups exist to align stakeholders; stakeholder collaboration remains limited
3. Knowledge & Data Sharing: Low consistency of insect batches led to different digestibility results which remain a challenge to be solved. Results suggested that contaminants such as some PFAS compounds and microplastics could accumulate. Insects have the potential to cause allergic reactions in persons with an existing seafood allergy. Enzymatic treatment could reduce allergenicity. Information (e.g., veterinary protocols, best practices) is scattered and insufficiently shared; a centralised EU resource centre is recommended
4. Market Acceptance & Awareness: Consumer knowledge and societal acceptance of insect-derived products remain low, and more transparent communication and standardisation are needed
5. Financing & Economic Incentives: Inadequate economic support, subsidies, and policy incentives limit scaling and investment readiness

In general, SUSINCHAIN highlights key challenges in the protein value chain, similar to other projects in this portfolio, such as regulatory barriers, market acceptance, fragmented supply

chains, and limited investment. Its unique focus is on insect-specific issues and to enhance the economic, feasibility and scalability of the European insect protein value chain.

4. Transition paths to sustainable legume-based systems in Europe – TRUE

PROJECT INFORMATION

Source(s)

CORDIS website: Transition paths to sustainable legume-based systems in Europe | TRUE | Project | Fact Sheet | H2020 | CORDIS | European Commission

Project website: Home - TRUE Project

Funding details

Source of funding: H2020-SFS-2016-2017
Type of project (+ cluster if relevant): Research and Innovation action
Contract number: Grant agreement ID: 727973
Project total budget (€): € 4,999,927.50

Start and end date of the project

01/04/2017 | 30/09/2021

Project summary

TRUE aimed to promote legume-supported agri-food systems. The work was structured into nine work packages and involved more than 24 case studies across diverse European agro-climatic zones.

Field & Experimental Work:

- Conducted agronomic trials on legume varieties, intercropping, and soil health.
- Performed feeding trials for poultry, pigs, and aquaculture using legume-based diets.
- Developed and tested legume-based food products (e.g., pasta, snacks, spirits).

Stakeholder Engagement:

- Established the Legume Innovation Network (LIN) to connect farmers, researchers, policymakers, and industry.
- Hosted regional workshops, roundtables, and transdisciplinary reflection sessions.
- Engaged with SMEs, NGOs, and public institutions to co-design solutions.

Knowledge Dissemination:

- Produced 40+ practice abstracts, multiple policy briefs, and technical reports.
- Created plain-language summaries and infographics for broader accessibility.
- Disseminated findings via Zenodo, ResearchGate, and the TRUE website.

Tool & Framework Development:

- Developed Pathfinder, a web-based decision support system for sustainability modelling.
- Created a tailored LCA methodology integrating environmental and nutritional metrics.
- Designed sustainability indicators for legume-based quality chains.

Collaborations & Legacy:

- Partnered with EU projects like LEGVALUE, DIVERFarming, and DIVERSify within the Crop Diversification Cluster
- Initiated legacy platforms such as the Digital Innovation Hub and continued LIN activities post-project.

Policy Interface:

- Applied co-design, co-production, and co-dissemination principles to shape policy analysis.
- Developed tools for scenario planning and governance evaluation.

Project results

Agronomic & Environmental Outcomes:

- Legumes demonstrated strong performance in improving soil health and reducing nitrogen input.
- Intercropping with cereals enhanced pest control, weed suppression, and biodiversity.
- Legume integration into dairy and aquaculture systems reduced greenhouse gas emissions and ammonia output.
- Validated elite rhizobia strains for enhanced nitrogen fixation.

Feed & Food Innovations:

- Legumes successfully replaced soybean meal and fishmeal in poultry, pig, and aquaculture diets.
- Developed novel legume-based food products: climate-positive spirits, protein-rich snacks, and pasta.
- Nutritional profiling showed high protein, fibre, and omega-3 content with low added sugars.

LCA Results:

- Legume crops and products had lower carbon footprints and eutrophication impacts than conventional cereals and animal-based foods.
- Created a public LCA database covering 16 environmental impact categories.
- Introduced nutrient density environmental impact (NDEI) indices to link health and sustainability.

Behavioural & Market Insights:

- Farmer adoption of legumes was influenced by diversification, agri-environmental schemes, and technology investment.
- Consumers showed strong interest in pulse-based products, especially flexitarians and vegetarians.
- Willingness to pay increased with labels like “organic”, “low fat” and “British”.

Value Chain Mapping:

- Mapped legume value chains across Europe, identifying key actors and successful business models.
- Highlighted market trends: rising demand for plant-based diets, PGI/PDO certification, and ready-to-eat formats.

Policy-Relevant Findings

- Identified barriers and drivers for pulse consumption to inform dietary and procurement policies.
- Demonstrated potential for legumes to support Common Agricultural Policy (CAP) reform, protein self-sufficiency, and climate goals.

Decision Support Tools

- Developed Pathfinder DSS for sustainability assessment and scenario modelling.
- Enabled bottom-up and top-down analysis of agri-food chain sustainability.

Output: 38 documents/reports, 29 peer reviewed articles, one non peer reviewed article, newsletters, website, workshops, databases, webtool, conference proceeds, two trademarks

Lead partner

The James Hutton Institute, *United Kingdom*

Other partners

- COVENTRY UNIVERSITY, *United Kingdom*;
- STC RESEARCH FOUNDATION, *United Kingdom*;
- SRUC., *United Kingdom;*
- KENYA FORESTRY RESEARCH INSTITUTE, *Kenya;*
- UNIVERSIDADE CATOLICA PORTUGUESA*, Portugal;*
- UNIVERSITÄT HOHENHEIM*, Germany;*
- GEOPONIKO PANEPISTIMION ATHINON, *Greece;*
- IFAU APS*, Denmark;*
- REGIONALNA RAZVOJNA AGENCIJA MEDIMURJE REDEA DRUSTVO S OGRANICENOM ODGOVORNOSCU ZA REGIONALNI RAZVOJ I POSLOVNE USLUGE, *Croatia;*
- BANGOR UNIVERSITY, *United Kingdom*;
- THE PROVOST, FELLOWS, FOUNDATION SCHOLARS & THE OTHER MEMBERS OF BOARD, OF THE COLLEGE OF THE HOLY & UNDIVIDED TRINITY OF QUEEN ELIZABETH NEAR DUBLIN, *Ireland;*
- PROCESSORS & GROWERS RESEARCH ORGANISATION LBG*, United Kingdom;*
- INSTITUT JOZEF STEFAN, *Slovenia;*
- IGV INSTITUT FUR GETREIDEVERARBEITUNG GMBH*, Germany;*
- ESSRG NONPROFIT KFT*, Hungary;*
- AGRI KULTI NONPROFIT KORLATOLT FELELOSSEGU TARSASAG*, Hungary;*
- ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FUR POLAR- UND MEERESFORSCHUNG*, Germany;*
- SLOW FOOD DEUTSCHLAND EV*; Germany;*
- ARBIKIE DISTILLING LIMITED*, United Kingdom;*
- TEAGASC - AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY*, Ireland;*
- SOCIEDADE AGRICOLA DO FREIXO DO MEIO LDA*, Portugal;*
- EUREST (PORTUGAL)-SOCIEDADE EUROPEIA DE RESTAURANTES LDA*, Portugal;*
- SOLINTAGRO SL, *Spain;*
- JAVNA USTANOVA ZA RAZVOJ MEDIMURSKEZUPANIJE REDEA*, Croatia*

Contacts

- The James Hutton Institute, *United Kingdom*;

- TRUE@hutton.ac.uk

Relevant links

- Deliverables, peer reviewed papers: Transition paths to sustainable legume based systems in Europe | TRUE | Project | Results | H2020 | CORDIS | European Commission
- LIN network: TRUE Legume Innovation Network (LIN) Workshops - TRUE Project
- Newsletters, recipes, video's,...: Resources - TRUE Project
- Brochure TRUE, e-book TRUE case studies: Home - TRUE Project

Relation to SCAR Protein TF PA scope

Identified and enabled transition pathways to realise successful legume-supported production systems and agri-feed and food chains. Applied research including agronomic trials, feeding trials, food products development, nutritional analysis, sustainability evaluation, farmer and consumer adoption studies. Project completed in 2021.

Overlaps and gaps of the project content compared to the other projects in the portfolio

Gaps and challenges identified in the TRUE project:

1. Low Adoption & Land Use: Legumes occupy only ~2% of EU arable land, despite their agronomic and environmental benefits. Limited uptake is due to historical underrepresentation in agricultural policy and market structures.
2. Policy Fragmentation: CAP has traditionally favoured cereals and livestock, offering inconsistent support for legumes. Legume-related policies are often absent, unclear, or poorly implemented across Member States.
3. Trade Dependencies: Europe relies heavily on imported soybeans for feed, undermining protein self-sufficiency. WTO constraints and global trade agreements limit flexibility in promoting domestic legume production.
4. Technical Barriers: Inconsistent legume quality and presence of anti-nutritional substances affect feed and food applications. Lack of small-scale processing infrastructure hinders commercialisation and supply chain development.
5. Cultural & Behavioural Challenges: Legumes are often perceived as "poor man's food," reducing consumer appeal. Limited cooking knowledge and convenience barriers restrict household consumption. Farmers may lack awareness, training, or incentives to adopt legume cultivation.
6. Market & Certification Issues: Fragmented supply chains and high compliance costs for certification (e.g., organic, PGI/PDO) exclude small producers. Legumes are often misclassified in procurement systems, limiting visibility and demand.
7. Data & Modelling Limitations: Gaps in farm-level data and rotation effects complicate LCA modelling. Consequential LCA faces uncertainty due to indirect effects and global market dynamics.

In general, the TRUE project highlights challenges in the protein value chain in common with other projects in the portfolio, such as fragmented policies, supply chain issues, technical barriers, and low consumer acceptance. However, TRUE is unique in its focus fully on legumes and related experimental work, stakeholder engagement, sustainability indicators and policy analysis.

5. Smart protein for a changing world. Future-proof alternative terrestrial protein sources for human nutrition encouraging environment regeneration, processing feasibility and consumer trust and acceptance – Smart Protein

PROJECT INFORMATION

Source(s)

CORDIS website: https://cordis.europa.eu/project/id/862957

Project website: https://smartproteinproject.eu/

Funding details

Source of funding: H2020-SFS-2019-1
Type of project (+ cluster if relevant): Innovation action
Contract number: Grant agreement ID: 862957
Project total budget (€): 9.630.342,73 (EU contribution: 8.179.214,26)

Start and end date of the project

01/01/2020 | 30/06/2024

Project summary

The Smart Protein project aimed to develop alternative protein ingredients and products for humans which have a positive impact on bioeconomy, environment, biodiversity, nutrition, food security and consumer trust and acceptance. The project focused on validating and demonstrating innovative, cost-effective, and resource-efficient protein products sourced from plants (fava bean, lentil, chickpea, quinoa) and microbial biomass (edible fungi), the latter derived through up-cycling side streams from the pasta, bread, and beer industries. A major part of the project was advancing resource-efficient protein production by enhancing the soil–plant–microbe "holobiome" through regenerative practices like cover cropping, reduced tillage, and organic amendments to improve crop resilience, nutrient uptake, and sustainability.

Key objectives included:

- Evaluating crop suitability, profitability, and yields across Europe using organic and regenerative farming methods.
- Developing novel plant-based protein isolates and concentrates through fractionation.
- Producing fungal biomass and edible mycelium via solid-state fermentation using food and processing waste as growth media.
- Characterising protein properties (nutritional, sensory, techno-functional) and identifying the most promising food applications.

- Preparing for commercialisation of plant-based alternatives to cheese, yogurt, meat, and seafood, and in baked goods, sauces, infant foods, and sports drinks.
- Addressing regulatory, food-safety, allergenicity, and sustainability challenges.
- Assessing business viability and studying consumer acceptance and trust.

Project results

The SMART PROTEIN project developed protein products from legumes (fava bean, lentil, chickpea, quinoa) and microbial proteins (yeast, fungi). Field trials across seven European pilot farms assessed crop adaptability, yields, and quality, with public guides supporting farmers in regional protein crop cultivation.
Industrial and pilot-scale trials validated protein extraction and fractionation methods, while fermentation using food side-streams created novel, sustainable ingredients. Optimised extrusion and high-shear mixing enhanced plant protein functionality for meat substitutes, while new formulations included:

- Meat and seafood analogues
- Dairy alternatives (yogurt, soft cheese)
- Sauces and baked goods

Key achievements include:

- Cultivation and sustainability:
  - Series of leaflets, that summarised the best climatic conditions and best agricultural practices for each of the four crops (chickpeas, fava beans, lentils, quinoa) validated by geographical region.
- Processing and innovation:
  - Protocols for new products and processes were delivered to industrial partners to accelerate commercialisation and market entry. Different processing investigated to increase properties of the protein varieties, e.g.:
    - High-shear mixing increased techno-functional properties of lentil protein isolate.
    - Fungal solid-state fermentation of quinoa flour improved nutritional (protein increased by 35%) and sensory properties, with mixed effects on functional properties.
  - Upcycling food by-products (bread, pasta, brewery yeast) reduced waste and improved resource efficiency.
- Consumer Engagement:
  - Pan-EU surveys (2021, 2023) and behavioural studies provided insights into plant-based adoption, with evidence of rising consumer interest.
- Social & Economic Benefits:
  - Support for European pulse production and reduced dependency on imports.
  - Greater variety of plant-based choices with improved taste and texture.
  - Contribution to EU policies on alternative proteins and regenerative agriculture.

Output: 31 peer reviewed articles, one dissertation, 13 leaflets on best agricultural practices, videos, press releases and more

SCAR
Standing Committee
on Agricultural Research

Lead partner

University College Cork – National University of Ireland, *Ireland*

Other partners

- TEAGASC - agriculture and food development authority, *Ireland*
- Tirlán limited, *Ireland*
- Beotanics limited, *Ireland*
- CC Academy Designated Activity Company, *Ireland*
- Soguima Comercio Industria Alimentar SA, *Portugal*
- Instituto Navarro de Technologias e Infraestructuras Agroalimentarias SA, *Spain*
- Control de Porciones SA, *Spain*
- Universiteit Gent, *Belgium*
- Anheuser-Busch Inbev, *Belgium*
- Delphy BV, *Netherlands*
- Danone Global Research & Innovation Center BV, *Netherlands*
- Københavns Universitet, *Denmark*
- Chr. Hansen AS, *Denmark*
- SiccaDania A/S, *Denmark*
- Novozymes A/S, *Denmark*
- Fraunhofer Gesellschaft zur Forderung der Angewandten Forschung EV, *Germany*
- ProVeg, *Germany*
- EurA AG, *Germany*
- Dohler GmbH, *Germany*
- Müller's Mühle GmbH, *Germany*
- Gebruder Woerle Gesellschaft M B H, *Austria*
- Universita Degli Studi di Udine, *Italy*
- UNIBZ - Libera Universita di Bolzano, *Italy*
- SQIM SRL, *Italy*
- Barilla G. E R. Fratelli Spa, *Italy*
- Arca Societa' a Responsabilita' Limitata Societa' Benefit, *Italy*
- Quinoa Marche SRL Semplificata, *Italy*
- Equinom LTD, *Israel*
- Haute Ecole Specialisee de Suisse Occidentale, *Switzerland*
- Thai Union Group Public Company Limited, *Thailand*
- Agresearch Limited, *New Zealand* (no EU funding)
- The Good Food Institute, *United States* (no EU funding)
- Endori Food GmbH & Co KG, *Germany*

Contacts

- University College Cork, *Ireland*
  - Project coordinator: Dr. Emanuele Zannini, e.zannini@ucc.ie

Relevant links

- Peer reviewed articles: https://cordis.europa.eu/project/id/862957/results
- Project newsletters: https://smartproteinproject.eu/news/
- Policy brief: https://smartproteinproject.eu/policy-brief/
- Farming leaflets: https://smartproteinproject.eu/farmers/

Relation to SCAR Protein TF PA scope

Identified and communicated best agricultural practices for four plant protein crops. Industrially validated and demonstrated innovative, resource-efficient, EU-produced nutritious plant (fava bean, lentil, chickpea, quinoa) and microbial biomass protein processing and products.

Overlaps and gaps of the project content compared to the other projects in the portfolio

Gaps and challenges identified in the SMART PROTEIN project:

1. Regulatory Barriers: Complex and inconsistent rules delaying approvals for novel alternative proteins, including requirements for labelling and novel food authorisation.
2. Funding Limitations: Current R&I funding (€32 M under Horizon Europe) is insufficient to reach scale. Support for European pulse production and reduced dependency on imports.
3. Cost & Scale Constraints: Existing production methods remain too costly for price competitiveness without further optimisation and upscaling.
4. Consumer Trust Gaps: Need to strengthen consumer confidence, address sensory quality barriers and establish transparent labels to build acceptance
5. Value Chain Integration: Scaling requires co-ordination among farmers, processors, manufacturers, and policymakers. These structures are still under development.

In general, Smart Protein highlights some similar challenges in the protein value chain to other projects in the portfolio, such as regulatory barriers, high costs, funding gaps, and the need for value chain integration and consumer acceptance. It is unique in its focus on protein products sourced from plants and microbial biomass and their applications in food.

6. Bioconversion of underutilised resources into next generation proteins for food and feed – NextGenProteins

PROJECT INFORMATION

Source(s)

CORDIS website: https://cordis.europa.eu/project/id/862704

Project website: https://nextgenproteins.eu/

Funding details

Source of funding: H2020-SFS-2019-1
Type of project (+ cluster if relevant): Innovation action
Contract number: Grant agreement ID: 862704
Project total budget (€): 9.257.320,41 (EU contribution: 7.985.149,77)

Start and end date of the project

01/10/2019 | 30/09/2023

Project summary

NextGenProteins aimed to optimise and validate, in industrially relevant settings, the production of three alternative protein sources: microalgae (Spirulina), single-cell proteins (Torula yeast, filamentous fungi), and insects (black soldier fly larvae, crickets). The project demonstrated their suitability as additions or replacements in food and feed value chains, reducing strain on resources and strengthening EU self-sufficiency.

Key Project Objectives:

- Regulatory & Safety Landscape: Assess current food and feed regulations and identify innovation barriers to support and contribute to future EU policy on alternative proteins.
- Production & Bioconversion: Deliver safe, high-quality, sustainable proteins by upcycling industrial waste streams via bioconversion
- Food Applications: Demonstrate usage in ready meals, bakery products, meat analogues, and functional supplements
- Feed Applications: Validate application potential in poultry and fish through targeted trials
- Market & Consumer Readiness: Explore market potential in co-creation with consumers and stakeholders; boost trust and acceptance
- Sustainability Assessment: Analyse environmental and economic impacts including GHG emissions, land, water, energy use, production efficiency, and value-chain risks
- Responsible Research & Innovation (RRI): Implement an RRI framework to engage researchers, policymakers, industry, and society to facilitate consumer acceptance, effective dissemination, and exploitation of results

Project results

NextGenProteins optimised three next-generation protein sources: microalgae, single-cell proteins, and insects, by scaling production, validating safety, and demonstrating applications in food and feed.

Key results:

- Production & Safety: Industrial-scale production was achieved, supported by comprehensive databases on nutritional value, digestibility, allergens, and toxins. Functional and sensory properties were tested and improved.
    - All protein sources provide essential amino acids, though with varying profiles., typically limited in methionine or tryptophan. Can complement traditional protein sources.
    - Spirulina showed the best functional properties, followed by filamentous fungi and Torula yeast.
    - Torula yeast showed a strong umami/yeast flavour with slight bitterness, Spirulina had grassy, grainy and metallic notes with a bitter aftertaste, while cricket flour presented mild grain- and mushroom-like flavours with umami and slight bitterness.
- Food Applications: New prototypes were developed, including breads, snacks, drinks, ready meals, emulsions, and supplements. Sensory evaluations showed potential for broad consumer acceptance.
- Feed Applications: Poultry, seabream, and salmon trials confirmed suitability, identifying optimal inclusion levels and feeding strategies.
    - Early inclusion of alternative proteins reduced broiler growth performance, but during grower and finisher phases they can be safely included (~3% microalgae, 2–6% SCP Torula, 9% insect meal) without negative effects on health, welfare, or meat quality. Insect meal (*H. illucens*) showed the most promising.
- Regulatory and consumer Insights: Focus groups in seven EU countries revealed increasing openness toward alternative proteins, with sustainability benefits highly valued.
    - Barriers include taste, transparency, and regulatory clarity.
    - Industrial partners identified knowledge gaps, highlighting the need for transparent labelling, stronger consumer education, and scientific evidence on health impacts.
- Sustainability & Economics: Assessments showed that while global production volumes remain modest, regional benefits include job creation, reduced imports, and lower environmental impact (land, water, GHG).

Output: seven peer reviewed articles, five dissertations, one book chapter, several datasets, conference presentations and reports.

Lead partner

Matis OHF, *Iceland*

Other partners

- Teknologian Tutkimuskeskus VTT OY, *Finland*
- Alma Mater Studiorum – Universita di Bologna, *Italy*
- RISE Processum AB, *Sweden*
- RISE Researh Institutes of Sweden AB, *Sweden*
- Verein zur Forderung des Technologietransfers an der Hochschule Bremerhaven EV, *Germany*
- SP/F Syntesa, *Faroe Islands*
- Circular Solutions EHF, *Iceland*
- Gesco Societa Cooperativa Agricola, *Italy*
- VRM SRL, *Italy*
- Vaxa Technologies LTD, *Israel*
- ARBIOM, *France*
- Grimur Kokkur EHF, *Iceland*
- Biozoon GmbH, *Germany*
- Mutatec, *France*
- Entocube OY, *Finland*
- Aktiebolaget Herbert Karlssons Charkuterifabrik, *Sweden*
- Waitrose Limited, *United Kingdom*
- Aquscot Limited, *United Kingdom*
- Mowi Feed AS, *Norway*
- Fazer Sweden AB (Fazer Bageri AB), *Sweden*
- Sjokovin, *Faroe Islands*
- Peas of Heaven AB, *Sweden*
- KPMG EHF, *Iceland*

Contacts

Matis, *Iceland*

- Project general email address: nextgenproteins@matis.is
- Project manager: Birger Örn Smárason, birger@matis.is
- Contact persons for each project work package: https://nextgenproteins.eu/our-work/

Relevant links

- Project documents (papers, newsletters, fact sheets etc.): https://nextgenproteins.eu/project-documents/
- Peer reviewed articles, datasets etc: https://cordis.europa.eu/project/id/862704/results
- Presentations and papers collection: https://zenodo.org/communities/nextgenproteins/records?q=&l=list&p=1&s=10&sort=newest

Relation to SCAR Protein TF PA scope

Optimised three next-generation protein sources: microalgae, single-cell proteins, and insects, by scaling production, validating safety, and demonstrating applications in food and feed.

Overlaps and gaps of the project content compared to the other projects in the portfolio

Gaps and challenges identified in the NextGenProteins project:

1. Cost Competitive Production: High production and processing costs remain barriers compared to conventional protein sources.
2. Regulatory Uncertainty: Ambiguity over pre-market approvals may delay commercialisation.
3. Sensory & Formulation Constraints: Texture, taste, nutritional and functional properties of alternative proteins require further optimisation
4. Feed Performance Issues: Early inclusion levels in poultry trial diets impacted growth performance negatively; solutions like enzyme addition and pelletisation are being tested.
5. Consumer Acceptance & Market Trust: Broader uptake depends on enhancing transparency (i.e. labelling), trust, awareness (consumer education) and scientific evidence on health impacts.
6. Funding & Value Chain Risks: Uncertainty around continued investment and scaling could impede sustained development.

In general, NextGenProteins highlights some challenges identified by the other nine projects in the portfolio, in particular high costs, regulatory hurdles, sensory limitations, and the need for consumer acceptance and value chain integration. It is unique in its detailed focus on demonstrating the suitability of three protein sources coming from Spirulina, SCP and insects for application in food and feed value chains.

7. Development of novel functional proteins and bioactive ingredients from rapeseed, olive, tomato and citrus fruit side streams for applications in food, cosmetics, pet food and adhesives – PRO-ENRICH

PROJECT INFORMATION

Source(s)

CORDIS website: Development of novel functional proteins and bioactive ingredients from rapeseed, olive, tomato and citrus fruit side streams for applications in food, cosmetics, pet food and adhesives | Pro-Enrich | Project | Fact Sheet | H2020 | CORDIS | European Commission

Project website: https://www.pro-enrich.eu/ (not available anymore)

Funding details

Source of funding: H2020-BBI-JTI-2017
Type of project (+ cluster if relevant): Research & Innovation Action
Contract number: Grant agreement ID: 792050
Project total budget (€): € 3,956,640.86

Start and end date of the project

01/05/2018 | 31/10/2021

Project summary

The PRO-ENRICH project aimed to develop a flexible, sustainable biorefinery model to valorise agricultural side streams–specifically rapeseed, olive, tomato, and citrus residues–into high-value functional ingredients for food, pet food, cosmetics, and adhesives.
Key activities included:

- Developed a flexible, sustainable biorefinery model to valorise agricultural side streams from:
  - Rapeseed (press cake)
  - Olive (pomace and mill wastewater)
  - Tomato (pomace and seeds)
  - Citrus (peel and pulp)
- Targeted production of high-value ingredients for:
  - Food
  - Pet food
  - Cosmetics
  - Adhesives
- Conducted:
  - Feedstock mapping and quality assessment
  - Lab-scale and pilot-scale extraction trials

    - Enzymatic and mechanical processing optimisation
- Developed novel extraction technologies:
    - Magnetic particle-based polyphenol recovery from olive mill wastewater
    - Enzyme-assisted protein and carotenoid extraction
- Delivered pilot and demonstration batches to industrial partners for real-world testing
- Integrated:
    - LCA
    - Socio-economic analysis
    - Safety and regulatory compliance
- Organised business model workshops and exit strategy

Project results

- Produced and delivered:
    - Rapeseed protein isolates (up to 92% purity)
    - Tomato carotenoid-rich oleoresins and powders
    - Citrus hesperidin extracts (60–90% purity)
    - Tomato seed protein hydrolysates (35.9% protein)
- Validated:
    - Magnetic nanoparticle-based polyphenol extraction from OMWW
    - Enzymatic hydrolysis for protein and carotenoid recovery
- Standardized analytical protocols for:
    - Phenolics (HPLC-DAD-qTOF-MS)
    - Proteins (Dumas, SDS-PAGE)
    - Flavonoids and carotenoids
- Identified key exploitable results and aligned stakeholders on commercialization
- Assessed:
    - TRLs (4–7): Citrus hesperidin closest to market
    - Market potential and economic feasibility
    - Consumer acceptance through perception studies
- Delivered business model canvases and exploitation plans
- Supported industrial testing in food, pet food, adhesives, and cosmetics

Lead partner

TEKNOLOGISK INSTITUT, *Danmark*

Other partners

- GEA WESTFALIA SEPARATOR GROUP GMBH, *Germany;*
- G. C. HAHN AND COMPANY LIMITED LONDON, United Kingdom;
- CHIMAR (HELLAS) AE - ANONYMI VIOMICHANIKI KAI EMPORIKI ETAIREIA CHIMIKON PROIONTON THERMI THESSALONIKI, Greece;
- ANECOOP SOCIEDAD COOPERATIVA Valencia, Spain;

- FBCD AS Tjele, Denmark;
- TAILORZYME APS HERLEV, Denmark;
- INNORENEW COE CENTER ODLICNOSTI ZA RAZISKAVE IN INOVACIJE NA PODROCJU OBNOVLJIVIH MATERIALOV IN ZDRAVEGA BIVANJSKEGA OKOLJA Izola, Slovenia;
- NATAC BIOTECH SL Hervas, Spain;
- UNIVERZA NA PRIMORSKEM UNIVERSITA DEL LITORALE Koper, Slovenia;
- EMMELEV AS OTTERUP, Denmark;
- JAENCOOP, S.COOP AND Villanueva Del Arzobispo, Spain;
- ACONDICIONAMIENTO TARRASENSE ASSOCIACION Terrassa, Spain;
- EURIZON SL Madrid, Spain;
- FRANKA MARZI SMARJE PRI KOPRU, Slovenia;
- MARS GMBH Verden, Germany;
- BANGOR UNIVERSITY Bangor, United Kingdom;
- UNIVERZA NA PRIMORSKEM UNIVERSITA DEL LITORALE; Slovenia

Contacts

- TEKNOLOGISK INSTITUT, *Denmark*;
  - Anne Christine Steenkjær Hastrup (https://www.dti.dk/testing/biosolutions-technology-center/44422) ; +45 72 20 16 02

Relevant links

- Documents, reports, peer reviewed articles and workshops: Development of novel functional proteins and bioactive ingredients from rapeseed, olive, tomato and citrus fruit side streams for applications in food, cosmetics, pet food and adhesives | Pro-Enrich | Project | Results | H2020 | CORDIS | European Commission

Relation to SCAR Protein TF PA scope

The PRO-ENRICH project aimed to develop a flexible, sustainable biorefinery model to valorise agricultural side streams into high-value functional ingredients (including proteins) for food, pet food, cosmetics, and adhesives. The project's interdisciplinary approach—combining chemistry, engineering, food technology, economics, and policy—enabled a holistic understanding of side-stream valorisation and its industrial relevance. Life cycle, socio-economic, and safety assessments were integrated to support regulatory compliance and policy development. The project was completed in 2021.

Overlaps and gaps of the project content compared to the other projects in the portfolio

Gaps and challenges identified in the Pro-Enrich project:

1. Feedstock variability: Seasonal, cultivar, and processing differences affect consistency
2. Application-specific hurdles: Rapeseed protein isolates unsuitable for pet food
3. Patentability issues: Natural compounds like lycopene and hesperidin are hard to protect
4. Regulatory barriers: Novel food approval, REACH (EU's registration, evaluation, authorisation and restriction of chemicals regulation), and cosmetics regulations
5. Enzymatic methods: Costly and lower yield compared to chemical extraction
6. OMWW (olive mill wastewater) challenges: High variability and degradation complicate polyphenol recovery
7. Safety concerns: Allergenicity of rapeseed proteins requires labelling and risk management
8. Operational constraints: need for funding and alignment for post-project continuation

In general, the PRO-ENRICH project highlights common challenges with the other nine projects in the portfolio in terms of cost, scalability, regulatory hurdles, feed validation, and funding gaps. It is unique in its focus on valorisation of agricultural side streams in food, pet food, cosmetics and adhesives.

8. Carbon capture from syngas to Single Cell Protein (SCP) and use as fish feed ingredient – SynoProtein

PROJECT INFORMATION

Source(s)

CORDIS website: https://cordis.europa.eu/project/id/101112345

Project website: https://synoprotein.eu/

Funding details

Source of funding: HORIZON-JU-CBE-2022
Type of project (+ cluster if relevant): Innovationaction
Contract number: Grant agreement ID: 101112345
Project total budget (€): 6.025.738,00 (EU contribution 4.995.504,75)

Start and end date of the project

01/09/2023 | 29/02/2028

Project summary

SynoProtein aims to develop, mature, and demonstrate a carbon-negative process that transforms abundant, low-value sawmill by-products into bacterial (hydrogen-oxidising bacteria (HOB)) single-cell proteins (SCP), for fish feed and biochar for animal feed. By combing pyrolysis, syngas conditioning and fermentation processes, SynoProtein will convert forest residues into proteins. By pyrolysis, saw-mill by-products will be converted into syngas, which will be fermented by a natural microbial consortium, converting syngas to biogenic hydrogen and acetic acid, which is to be used by HOB creating a protein-rich biomass.

Objectives:

- Develop a zero-emission production chain combining thermochemical (pyrolysis) and biological (fermentation) methods
- Scale production of SCP and biochar to pilot scale and assess their suitability for aquaculture and agriculture feed
- Quantify carbon capture and environmental benefits through life-cycle analysis, evaluating impacts from forestry through to feed production
- Disseminate findings, raise public awareness, and craft a business model for market entry

By 2033, SynoProtein aims to:

- Capture 200,000 tonnes of CO_2 annually, recover 160,000 t/year of forest residues, and produce 120,000 t/year of feed worth approximately €175 million
- Deliver environmental savings: 458,000 t CO_2, 147 km² of land, and 630,700 m³ of water, compared to soybean-based feed

- Generate 260 new jobs in the EU, halve production and sale prices of SCP, and reduce reliance on imported feed ingredients

Project results

The SynoProtein project is ongoing, and therefore few final results have been published. However, the first reporting period indicates that the project has advanced on several key technical and analytical fronts:

- Process development (lab scale):
  - Alternative protein production processes were tested and optimised under laboratory conditions, showing performance close to targeted levels, providing a basis for scale-up.
  - Demonstrated a chemical-free strategy for syngas fermentation by optimising inoculum selection, pretreatment, and environmental conditions, achieving enhanced H_2 production with complete CH_4 inhibition
  - Developed a hybrid biological–inorganic (HBI) system that efficiently recovered nitrate from contaminated groundwater and upcycled it into protein-rich microbial biomass using *C. necator* H16.
  - A universal agar-based hydrogel coating to commercial electrodes enhanced *C. necator* H16 growth and SCP yield by improving gas dissolution, reducing metal ion leaching, and limiting ROS diffusion, advancing the HBI system.
- Engineering and economic assessments:
  - Pre-engineering designs for a potential full-scale plant were completed.
  - Techno-economic models were developed to evaluate feasibility and guide future decision-making.
- Product evaluation:
  - Initial investigations into the suitability of single-cell protein (SCP) and biochar for aquaculture and agricultural feed were carried out.
- Environmental assessment:
  - A preliminary LCA was conducted, identifying environmental hotspots and areas where process improvements would be most beneficial.

Output: Four peer review articles (incl. one review), two webinars, two newsletters

Lead partner

WAI Environmental Solutions, *Norway*

Other partners

- Danmarks Tekniske Universitet (DTU), *Denmark*
- Hoegskolan i Boras, *Sweden*

- SINTEF AS, *Norway*
- SINTEF Energy AS, *Norway*
- NORSUS Norsk Institutt for Baerekraftsforsknings AS, *Norway*
- NOFIMA AS, *Norway*
- RISE Research Institutes of Sweden AB, *Sweden*
- Bergene Holm AS, *Norway*
- Skretting Aquaculture Research Centre AS, *Norway*
- DECHEMA Gesellschaft fur Chemischetechnik und Biotechnologie, *Germany*

Contacts

- WAI Environmental Solutions, *Norway*
  - Project email: contact@synoprotein.eu
  - Project manager: Long Lin, long@waies.no

Relevant links

- Public documents (peer reviewed articles, newsletters etc.): https://synoprotein.eu/public-documents/
- Project overview: https://synoprotein.eu/project/

Relation to SCAR Protein TF PA scope

SynoProtein aims to develop and demonstrate a carbon-negative process that converts residues from sawmills into single-cell proteins for fish feed, as well as producing biochar for animal feed. By transforming low-value by-products into high-value bio-products, SynoProtein will provide a sustainable alternative protein source to soybean.

Overlaps and gaps of the project content compared to the other projects in the portfolio

Gaps and challenges identified in the SynoProtein project:

1. Hydrogen Supply Limitations: In systems relying on hydrogen-oxidising bacteria, insufficient H_2 production at lower voltages (3–4 V) was a bottleneck for microbial growth and SCP yield.
2. Complexity of Real Groundwater: The variable composition and presence of competing anions in real groundwater pose challenges for consistent nitrate recovery and SCP production.
3. Regulatory and Safety Barriers: Safety and regulatory approval for using SCP derived from waste streams (e.g., nitrate-contaminated groundwater) is still pending, which could delay commercialisation.

4. Energy Efficiency and Cost: High energy costs, especially for electrolysis, remain a challenge. Integration with renewable energy sources is needed to improve sustainability and economic viability.
5. Nitrogen Transformation Pathways: There is a need for further exploration of nitrogen transformation, particularly the roles of ammonium and nitrite, to optimise nutrient recovery and minimise losses.
6. Reactive Oxygen Species (ROS) Management: In hydrogel-coated electrode systems, ROS inhibition remains a critical issue, especially at higher voltages, affecting microbial viability and system performance.
7. Gas Bubble Trapping in Hydrogel Layers: Three-layer hydrogel coatings were found to trap gas bubbles, reducing gas transfer efficiency and SCP productivity.
8. Mass Transfer Limitations in Syngas Fermentation: Low gas-to-liquid mass transfer limits microbial access to syngas substrates, affecting conversion rates and scalability.
9. Microbial Interaction Complexity: Incomplete understanding of microbial interactions in mixed cultures hinders optimisation of fermentation processes.
10. Syngas Impurities: Impurities such as NOx, H_2S, and NH_4^+ in syngas streams inhibit microbial growth and reduce productivity.
11. Scalability and Reactor Design: Limited scalability due to reactor design constraints and operational costs remains a barrier to industrial deployment.
12. Public Acceptance: Consumer and stakeholder acceptance of SCP from unconventional sources (e.g., waste streams or syngas) is uncertain and requires attention.

In general, SynoProtein highlights some common challenges identified by other projects in the portfolio with regard to high costs, regulatory hurdles, feed validation, and market acceptance. It is unique in its focus on the development and demonstration of a fermentation process to transform sawmill by-products into bacterial SCP for feed applications.

9. From niche to mainstream – alternative proteins for everybody and everywhere – LIKE-A-PRO

PROJECT INFORMATION

Source(s)

CORDIS website: https://cordis.europa.eu/project/id/101083961

Project website: https://www.like-a-pro.eu/

Funding details

Source of funding: HORIZON-CL6-2022-FARM2FORK-01
Type of project (+ cluster if relevant): Innovation action
Contract number: Grant agreement ID: 101083961
Project total budget (€): 13.693.753,92 (EU contribution: 11.999.659,64)

Start and end date of the project

01/11/2022 | 31/10/2026

Project summary

The goal of LIKE-A-PRO is to mainstream alternative proteins by making them available, accessible, and acceptable to all population groups (from children to the elderly) and across diverse European settings (urban, peri-urban, and rural).

Key components include:

- Consumer Research & Ecosystem Governance: Investigation of consumer behaviours, needs, and behavioural drivers, alongside the design of food-environment governance mechanisms to boost acceptance and integration of alternative proteins.
- Stakeholder Engagement & Social Innovation: Co-design of practical solutions with citizens through 11 living labs and four real-life food environments. Direct involvement of middle food systems actors through capacity building and co-creation.
- Product Innovation: Development of 16 novel alternative-protein food products derived from seven sustainable, healthy, and novel protein sources: rapeseed, mealworm, krill, microbial biomass, mushrooms, fermented fungal protein, and pea protein. Extraction/fractionation optimisation, determination of functionality, and products formulation.
- Impact, Safety & Regulatory Alignment: Ensuring health, sustainability, regulatory, ethical, and safety compliance of all developments. This includes risk assessment and alignment with EU frameworks.
- Communication & Outreach: Launch of innovative communication campaigns across six European countries to engage approximately eight million citizens over four years.

Project results

The LIKE-A-PRO project is still ongoing but has made significant project progress in mainstreaming alternative proteins across Europe through scientific, technological, and social innovations. Published results so far only include consumer behaviour and food environments.

Key achievements include:

- Consumer Behaviour & Food Environments: Identification of key determinants, motivations, and demographic factors shaping consumer choices
    - Level of intention to eat/buy alternative protein food (AFP) are low-to-moderate. Patterns of APF consumers' choices highlighted regional variations across the EU, but no indication of rural-urban differences.
    - Psychosocial determinants (familiarity, gender, age etc.) differ to some extent between different APF choices (e.g. plant-based vs. insect-based).
    - Retail and food environment practices strongly shape consumer choices. Factors such as perceived availability, food presentation, shopping habits, and social norms act as key barriers/facilitators depending on the type of APF.
- Protein & Food Innovation
    - Optimisation of protein extraction and processing, and progress in scaling up ingredient production, with improved protein quality.
    - Evaluation of technological properties and small-batch development of new food products.
- Living Labs & Stakeholder Engagement
    - Operational framework for Food Environment Citizen Innovation Living Labs in 11 EU countries, with strategies for citizen recruitment and engagement.
    - Creation of 17 system maps across 13 EU countries with stakeholders to locate leverage points for encouraging alternative protein uptake.
- Policy, Safety & Impact Assessments
    - Review of EU food safety regulations and creation of methodologies to assess allergenicity, toxicity, and digestibility of novel proteins.
    - Socio-environmental assessment of conventional proteins is a benchmark for alternative proteins.
    - Monitoring of economic impacts, market penetration, and pricing strategies.

Output: Four peer reviewed articles, five stakeholder briefs/recommendations, 10 reports, one trademark, multiple news and events.

Lead partner

CNTA - Centro Nacional de Technologia y Seguridad Alimentaria, *Spain*

Other partners

- Fraunhofer Gesellschaft zur Forderung der Angewandten Forschung EV, *Germany*

- Ynsect NL R & D BV, *Netherlands*
- Moreforsking AS, *Norway*
- Rimfrost AS, *Norway*
- Calidris Bio, *Belgium*
- Asociacion Profesional de Productores de Sustratos y Hongos de la Rioja Navarra y Aragon, *Spain*
- Kinoko - Tech Ltd, *Israel*
- Celabor SCRL, *Belgium*
- Biozoon GmbH, *Germany*
- Revo Foods GmbH, *Austria*
- Flowfood AS, *Norway*
- Carnes de Teruel SA, *Spain*
- Naturuel SL, *Spain*
- Collaborating Centre on Sustainable Consumption and Production GmbH, *Germany*
- Uniwersytet SWPS, *Poland*
- Amerikaniko Kollegio Ellados, Kentro Ereynas, *Greece*
- ITC - Inovacijsko Tehnoloski Grozd Murska Sobota, *Slovenia*
- Zeytince Ekolojik Yasami Desteklemedernegi, *Türkiye*
- Demos Helsinki OY, *Finland*
- Foodlab Proef, *Belgium*
- Basque Culinary Center Fundazioa, *Spain*
- Stichting Food Valley, *Netherlands*
- FBCD AS, *Denmark*
- Spread European Safety and Sustainability Geie, *Italy*
- Association Nationale Des Industries Alimentaires, *France*
- Syndesmos Ellinikon Viomichanion Trofimon Somateio, *Greece*
- Lebensmittelversuchsanstalt, *Austria*
- Gospodarska Zbornica Slovenije, *Slovenia*
- Federacao Das Industrias Portuguesas Agro-Alimentares, *Portugal*
- Potravinarska Komora Ceske Republiky, *Czechia*
- Federazione Italiana Dell Industriaalimentare Associazione, *Italy*
- Federacion Espanola De Industrias De La Alimentacion Y Bebidas, *Spain*
- Turkiye Sut Et Gida Sanayicileri Veureticileri Birligi Dernegi, *Türkiye*
- Eurizon SL, *Spain*
- Green Food Lab B.V., *Netherlands*
- Alma Mater Studiorum - Universita Di Bologna, *Italy*
- Fundacion Gaiker, *Spain*
- Alimentos Sanygran SL, *Spain*
- Safe Food Advocacy Europe, *Belgium*
- 21 Markets B.V., *Netherlands*
- Stichting Nationale Week Zonder Vlees, *Netherlands*
- Ynsect, *France*

Contacts

- CNTA, *Spain*

- Project coordinator: Morena Silvestrini, msilvestrini@cnta.es
- Food & Bio Cluster Denmark, *Denmark*
  - Dissemination and communication manager: Britt Sandvad, bs@foodbiocluster.dk

Relevant links

- Project objectives: https://www.like-a-pro.eu/about/objectives/
- Project news: https://www.like-a-pro.eu/news-events/
- Peer reviewed articles, stakeholder briefs, and project reports: https://www.like-a-pro.eu/results-publications/

Relation to SCAR Protein TF PA scope

LIKE-A-PRO aims to facilitate sustainable and healthy diets by mainstreaming alternative proteins and products, making them more available, accessible, and acceptable to all population groups (from children to elderly) and everywhere (across Europe, in urban, peri-urban, and rural areas).

Overlaps and gaps of the project content compared to the other projects in the portfolio

Gaps and challenges identified in the LIKE-A-PRO project:

1. Sensory & Functional Quality: Limitations in taste, texture, gelling, and emulsification currently constrain product appeal
2. Food Environment Barriers: Products remain hard to find or poorly integrated in retail and catering settings, hindering visibility and uptake
3. Labelling & Communication: Ambiguous or segmented labelling (e.g., vegan-only labels) can confuse consumers; transparency and trust needs improvement
4. Consumer Motivation & Norms: Deep-rooted meat traditions, neophobia, and distrust in highly processed foods slow down adoption. Level of intention to eat/buy alternative protein food (APF) are low-to-moderate. Retail and food environment practices strongly shape consumer choices. Factors such as perceived availability, food presentation, shopping habits, and social norms act as key barriers/facilitators depending on the type of APF.
5. Value-Chain Coordination: Scaling requires stronger collaboration among producers, processors, retailers, and regulators - currently fragmented

In general, LIKE-A-PRO highlights challenges also identified by some of the other nine projects in the portfolio in terms of sensory limitations, consumer acceptance, labelling, and value chain fragmentation. It is unique in its deep focus on alternative protein availability and acceptability for all population groups and across diverse European settings.

10. PRInted Symbiotic Materials as a dynamic platform for Living Tissues production – PRISM-LT

PROJECT INFORMATION

Source(s)

CORDIS website: PRInted Symbiotic Materials as a dynamic platform for Living Tissues production | PRISM-LT | Project | Fact Sheet | HORIZON | CORDIS | European Commission

Project website: Complex tissue manufacturing using engineered living materials – PRISM-LT

Funding details

Source of funding: HORIZON-EIC-2021-PATHFINDERCHALLENGES-01
Type of project (+ cluster if relevant): HORIZON EIC Grants
Contract number: Grant agreement ID: 101070913
Project total budget (€): 2,805,403.82

Start and end date of the project

01/11/2022 | 31/10/2028

Project summary

The core objective of the project is to develop a versatile platform for 3D bioprinting of living tissues using Engineered Living Materials (ELMs), integrating synthetic biology, bioprinting, and ethical foresight.

- Biomedical & Food Applications:
  - Organoids for in vitro biomedical research.
  - Cultured marbled meat for food innovation.
- Cell Engineering:
  - Engineered bacterial (E. coli) and yeast helper cells to secrete growth factors for bone, muscle, and fat tissue formation.
  - Developed minicells—non-dividing bacterial cells—for safe co-culture with stem cells.
  - Introduced lactic acid and stiffness-responsive systems for dynamic cell support.
- Bioprinting & Bioinks:
  - Two strategies: direct cell mixing of stem cells with bioinks and encapsulation in microcapsules.
  - Created tuneable bioinks optimised for mechanical and biological properties.
  - Developed software tools for precise patterning of soft/hard regions.
- Mechanical Testing:
  - Implemented Brillouin microscopy for non-invasive, high-resolution mechanical characterisation.
- Regulatory & Ethical Engagement:
  - Led structured dialogue with EMA (European Medicines Agency), contributing to Horizon Scanning Reports.

- Merged ELSA (ethical, legal, social aspects) and Regulation working groups for cohesive governance.
- Initiated training programmes (e.g., Autumn School on Biodesign and Ethics).

Project results

- Synthetic Biology:
  - Helper cells engineered to respond to biochemical and biophysical cues.
  - Enabled dynamic interaction with stem cells during tissue formation.
- Bioprinting Innovations:
  - Developed bioinks with tuneable stiffness and biological compatibility.
  - Advanced patterning techniques for heterogeneous tissue structures.
- Regulatory Leadership:
  - Organised the first EMA (European Medicines Agency)–ELM developer workshop.
  - Contributed to EMA's Horizon Scanning Report with biosafety and classification insights.
- Ethical Governance:
  - Developed a five-dimensional ethical framework: naturalness, progress, prudence, autonomy, justice.
  - Planned a Summer School and white paper to disseminate best practices.
- Cross-Sectoral Impact:
  - Demonstrated versatility across biomedical and food domains.
  - Positioned PRISM-LT as a benchmark for future ELM initiatives.

Lead partner

In society, *Italy*

Other partners

- CHALMERS TEKNISKA HOGSKOLA AB, *Sweden*;
- STICHTING RADBOUD UNIVERSITEIT, *The Netherlands*;
- CELLINK BIOPRINTING AB, *Sweden*;
- UNIVERSIDADE DE AVEIRO, *Portugal*
- UNIVERSITY OF GLASGOW, *United Kingdom*

Contacts

- In society, *Italy*;
  - Laura Martinelli - https://prism-livingtissues.eu/contact/

Relevant links

- Reports/deliverables, thesis, peer-reviewed articles: PRInted Symbiotic Materials as a dynamic platform for Living Tissues production | PRISM-LT | Project | Results | HORIZON | CORDIS | European Commission
- Project website: Complex tissue manufacturing using engineered living materials – PRISM-LT

Relation to SCAR Protein TF PA scope

The PRISM-LT project (Printed Symbiotic Materials for Living Tissues) is a pioneering EU-funded initiative under the EIC Pathfinder Challenge on Engineered Living Materials (ELMs). Its core activity is the development of a versatile platform for 3D bioprinting of living tissues that mimic natural biological complexity. The project spans biomedical and food applications, focusing on two symbiotic materials: organoids for in vitro biomedical research and marbled cultured meat for food innovation. Basic research, interdisciplinary (cell engineering, bioprinting, regulatory, ethical). The project started in 2022 and is still ongoing.

Overlaps and gaps of the project content compared to the other projects in the portfolio

Gaps and challenges identified in the PRISM-LT project:

1. Regulatory Uncertainty: Existing frameworks (advanced therapy medicinal products, Novel Foods) may not fully accommodate Engineered Living Materials (ELMs). Ambiguity in approval pathways and labelling standards.
2. Public Perception: Cultured meat faces scepticism around GMOs, unnaturalness, and corporate control. Media analysis shows limited stakeholder diversity and risk of misinformation.
3. Technical Limitations: Variability in bioink performance and stiffness measurement. Need for robust cell morphology analysis tools.
4. Scalability Issues: Spheroid/organoid production constrained by cost and complexity.

PRISM-LT highlights some challenges that are in common with the other nine projects in the portfolio, namely regulatory uncertainty, public perception, funding gaps, and technical limitations. It is unique in its focus on engineered living materials with attention on biomedical and food applications, cell engineering, bioprinting and bioinks.