Scoping paper

Biotechnology IPCEI with focus on Key Components for Food and Feed

1. DESCRIPTION OF THE INITIATIVE AND SCOPE

This initiative focuses on innovations in the production of consumable and nutritional products, tackling global challenges by harnessing advanced biotechnologies and expanding biomanufacturing capabilities. This includes alternative proteins to complement animal-based proteins, which may be plant-based, cell-based (e.g., cellular agriculture), or fermentation-derived (e.g., biomass or precision fermentation)[1]. Additionally, other bio-based components used as food ingredients, supplements or animal feed additives are considered. Moreover, any reference to 'food' should be understood to include both food and beverages.

Shortly, the global food system faces several challenges including climate change, increased demand for food, need to transition to more sustainable diets, challenges posed by new technologies and artificial intelligence and resource competition. The world population is expected to grow from the current 8 billion to nearly 10 billion by 2050.[2] Food production will have to increase, putting pressure on scarce resources such as land and water. It is expected that there will be a 56% gap between crop yields in 2010 compared to 2050 due to climate change and the increasing population[3].

Perspectives for advanced biotechnology: Advanced biotechnology offers transformative potential for food and feed production. Precision-fermented proteins and mycoprotein, derived from biomass fermentation, for example, can help lower emissions compared to conventional protein sources, while also reducing water consumption and land use.[4] Estimates show that fermented novel proteins could make up about 4 percent of total protein production by 2050, an annual market of $100 billion to $150 billion.[5] Another example is cellular agriculture, which involves using cell cultures to produce food, which might contribute to reducing the environmental footprint of food production, can enhance food security, and provide alternatives to animal-based products. Advanced biotechnology enables the design and engineering of biological systems for specific purposes, such as producing high-value food ingredients, enhancing nutritional content and developing novel food products. It can also allow for the use of non-traditional raw materials such as wood, grasses, algae, etc. in the production of food and feed. Marine biomass—such as algae, seaweed, and marine-derived enzymes—remains underexploited despite its strategic importance, particularly for coastal Member States. Integrating marine biotechnology across the scoping papers supports Europe's leadership in sustainable ocean-based bioeconomy applications.

By leveraging advanced biotechnology, industries can create tailored solutions to meet consumer demands for sustainable and healthy food options[6]. Combining these technologies with recent advances in artificial intelligence for high-precision design has the potential to address global

[1] https://proteindirectory.com/

[2] The future of food and agriculture – Alternative pathways to 2050

[3] https://www.pwc.com/gx/en/issues/business-model-reinvention/how-we-feed-ourselves/reconfiguring-global-food-system.html

[4] https://www.nature.com/articles/s43016-021-00418-2 and https://www.nature.com/articles/s41586-022-04629-w

[5] https://www.mckinsey.com/industries/agriculture/our-insights/ingredients-for-the-future-bringing-the-biotech-revolution-to-food

[6] https://knowledge4policy.ec.europa.eu/projects-activities/jrc-biomass-mandate_en

challenges and increase EU competitiveness through building this new industry. It is also of major interest regarding our food security and the prosperity of our farmers that an innovative and sustainable feed additives production takes place in Europe.

Robust bioprocessing infrastructure is critical to bridge the gap between laboratory-scale innovation, scale-up (at least in certain EU regions) and first industrial demonstration. Enhancing this capacity will empower SMEs and R&D centres to commercialise biotechnological advancements in biobased materials, chemicals, and food/feed ingredients.

Challenges in scaling up new technologies and first industrial deployment: Scaling up new technologies from laboratory to industrial scale presents several challenges[7]. Technical barriers, such as maintaining product consistency and quality, can be significant. The transition from pilot to demonstration scale to pre-commercial scale often encounters the "valley of death", where promising innovations struggle to secure the necessary funding and support for large-scale implementation. Additionally, integrating new technologies into existing industrial processes requires substantial investments in infrastructure and expertise. Pilot and demonstration plants play a crucial role in validating the technical, economic, and sustainable feasibility of new processes under industrial conditions. These plants help mitigate risks by providing a controlled environment to optimize processes and ensure consistent product quality.

Where feasible and justified, retrofitting existing industrial or agri-food facilities (“brownfield” projects) should be prioritized, as it may effectively lower CAPEX, shorten permitting times and accelerate first industrial deployment. Overcoming these challenges, with a special focus on enabling first industrial deployment, is essential to accelerate the commercialization of innovative biotechnologies and achieve the desired impact on food and feed production. Finally, the current lack of industrial-scale infrastructure poses a significant bottleneck that must be tackled to unlock the full potential of these sectors.

It is important that the introduction of biotechnology-based agriculture should not be seen as a replacement for livestock production, but rather as a complementary source of income and food production to that of traditional livestock farming, where also hybrid products across conventional and traditional production are considered.

It’s also crucial to understand market barriers:

- , Challenges regarding regulatory approval of precision fermentation, cultivated cell-based products and other novel foods in the EU
- Need to improve public acceptance of modern protein production methods,
- High costs of research and implementation of new technologies,
- Its need to be highlighted that food and feed products produced with biotechnology could reduce the dependency on fossil resources.

Proposed key focus areas

This IPCEI scope focuses primarily on downstream biotechnological innovations for food and feed. Cross-cutting enabling technologies such as synthetic biology, New Genomic Techniques (NGTs), AI-driven bioprocess design, and advanced fermentation engineering are included insofar as they support downstream applications—such as production, processing, formulation, and optimization of food and feed components.

- **Alternative proteins:**

[7] https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.3002116

- **Plant-based proteins:** utilizing regional legume-based alternatives like soybean, pea, faba bean, lupin, lentil[8], water-lentils (duckweed) [9] and other plants to produce protein-rich foods.
- **Cell-based proteins:** cultivating plant cells, animal cells to create meat, dairy, and seafood products. Working on these technologies has to include additional studies on the impacts of this type of culture.
- **Fermentation-derived proteins:** using microbial fermentation to produce proteins, such as mycoprotein, and precision fermentation, for specific protein molecules.
- **Insect-based proteins:** rearing edible insects or producing insect meal for food and animal feed, providing high-quality proteins as well as functional lipids with a low land and water footprint.

Other bio-based components for Food and Feed:

- **Lipids and oils:** producing essential fatty acids and oils through microbial and algal fermentation.
- **Vitamins and amino acids:** using microorganisms to produce essential vitamins and amino acids for food and feed fortification.
- **Enzymes and biocatalysts:** microbial- or plant-derived catalysts, including both purified enzymes and whole-cell systems, for processing, nutritional enhancement, and flavour- or fragrance-generation.
- **Functional ingredients:** developing bioactive compounds that enhance the nutritional profile and functionality of food products, e.g. probiotics, post-biotics, prebiotic oligosaccharides, bioactive peptides and food-culture microorganisms for flavour development, bio-preservation and waste reduction.
- **Technological and sensory additives:** including fermentation derived flavour enhancers, sweeteners, colourants, emulsifiers, stabilisers and thickeners.

Additional considerations:

Feedstock: the choice of raw materials is broad and flexible, allowing for diverse resources based on Member States' varying interests and regional strengths. This includes primary agricultural biomass (e.g. grass), agricultural residues, forestry by-products, food and feed byproducts, and marine biomass. For fermentation these can be categorised into first generation (high purity, e.g. glucose or sucrose), second generation (organic waste/side streams) and third generation feedstocks (gases, such as CO_2). For cell-based production, first-generation feedstocks refer to the substitution of Fetal Bovine Serum (originating from pharma applications), while second-generation approaches involve the use of organic waste and side streams.

Technology readiness: more details on specific technologies and their readiness levels will be included during the upcoming industry mapping phase. At this stage, the visibility is limited, and it may not be necessary to narrow down technologies due to uncertainty about which innovations will reach industrial readiness within the next three years and the varying focus areas across Member States.

Design and optimization: leveraging rapid and disruptive advances in advanced biotechnology and other technologies, such as artificial intelligence, offers substantial opportunities to achieve set goals and alleviate challenges related to those. Immense computing power could be used for optimization

[8] https://www.sciencedirect.com/science/article/pii/S0959378024001444

[9] https://www.alphagalileo.org/en-gb/Item-Display/ItemId/254834/identifier/18733

of large-scale production processes[10] as well as design of cell factories[11] etc. One of the most recent highlights would be the Evo2 model from NVIDIA[12].

To address these challenges, coordinated action across the entire value chain is essential to drive the breakthrough innovations required to enhance the overall competitiveness of the European bio-based industries ecosystem. This includes fostering collaboration between research institutions, industry stakeholders, farming organisations and cooperatives and policymakers to accelerate the development and adoption of sustainable food and feed production technologies. There is an urgent need to create such new value chains, for example:

1) the microbial protein value chain involves several key steps, starting with the raw materials, followed by fermentation and purification, after which the microbial proteins are incorporated into food products by the food industry,

2) cultivated cell-based value chains involve stable cell-line and feedstock material, and the harvested biomass is often used as ingredient or as a hybrid product combined with e.g. plant material,

3) hybrid value chains which blend plant, microbial or cultivated inputs (e.g., cultivated fats or fermentation-derived proteins, flavour enhancers etc.) with conventional food components to deliver products that have lower reliance on animal ingredients while meeting taste and texture expectations.

This IPCEI intentionally concentrates on the downstream end of the food-and-feed chain—novel ingredients and functional components—while noting that upstream agri-inputs (biocontrols, bio-fertilisers, biostimulants, etc.) rely on similar fermentation and would still benefit from the same infrastructure. Their exclusion simply preserves focus on the elements most directly linked to food innovation, without dismissing their strategic importance to the wider bioeconomy.

Current initiative is closely linked with two other scopes prepared for one or more potential IPCEI candidates in biotechnology – bio-based chemicals and bio-based materials. We see huge opportunity for synergies with the other scopes as described below:

Bio-based chemicals: both bio-based chemicals and key components for food and feed can utilize similar bio-based feedstocks, such as agricultural residues, forestry by-products, and marine biomass. This shared feedstock base can streamline supply chains and reduce costs through economies of scale. The biochemical processes used to convert biomass into chemicals can also be adapted to produce **food and feed components**. For example, fermentation processes used to produce bio-based chemicals can be optimized to produce alternative proteins, nutritional ingredients or additives such as thickeners, stabilizers, and emulsifiers. Bio-based chemicals can also supply inputs to the agri-food sector, further strengthening their overlap with the food and feed value chains.

Bio-based materials: bio-based materials can be used, for example, in food packaging, edible films, and coatings, enhancing the shelf life and safety of food products. **Bio-based chemicals**, on the other hand, serve as building blocks for bio-based materials used in the food and feed industries.

Sustainability and reduction of reliance on fossil-based or high-emission resources and production methods are the overarching goals of all three planned areas of intervention.

Integrated approach

By integrating the development of bio-based chemicals, bio-based materials, and key components for food and feed, industries can create synergies that enhance overall efficiency and sustainability.

[10] https://www.leadventgrp.com/blog/ai-and-machine-learning-optimizing-bioprocesses

[11] A *cell factory* is a living microorganism—usually a bacterium, yeast, filamentous fungus, or cultured animal/plant cell etc—that has been engineered to behave like a miniature production line. Through metabolic-engineering and synthetic-biology tools, its natural pathways are rewired (or new ones are inserted) so the cell converts inexpensive feedstocks—sugars, CO_2, methane, waste streams—into high-value molecules at industrial scale

[12] https://blogs.nvidia.com/blog/evo-2-biomolecular-ai/

For example, a biorefinery could produce chemicals, bio-based materials and food/feed ingredients from the same biomass feedstock, maximizing resource utilization and minimizing waste. This integrated approach aligns with the EU's strategies on biomass biochemical valorisation and supports the transition to a circular bioeconomy. This is also in line with other relevant strategies, such as the Vision for Agriculture and Food, and Food2030 Strategy. It also addresses global challenges related to food security, environmental sustainability, and resource efficiency (please see chapter 2 for specifics).

2. POLICY OBJECTIVES

The world is facing several large global challenges, for example:

- Increase in human population and decrease in fertile agricultural land

- Reducing greenhouse gases and improving human health and the related need for protein diversification

Also, there are challenges for the European Union, like competitiveness in the global food and feed market, strategic autonomy, the Green Deal etc.

Several EU strategies specifically address the need to develop biotechnology and biorefining:

- EU Bioeconomy Strategy[13]
- EU Biotech Communication[14]
- European Biotech Act, Bioeconomy Strategy and Life Science Strategy (announced in the Competitiveness Compass [15])
- European Union's Farm to Fork Strategy[16]
- Vision for Agriculture and Food[17]
- Ensuring global food supply and food security[18]
- Common agricultural policy[19]
- Food 2030[20]

These strategies outline several key objectives for the EU:

1. **Sustainable food production:** Implement sustainable agricultural practices to minimize environmental impact.
2. **Food security:** Ensure access to sufficient, safe, and nutritious food while maintaining affordability and ensuring the resilience of production chains and security of supplies.
3. **Promoting sustainable consumption:** Facilitate the shift to healthy, sustainable diets.
4. **Reducing food loss and waste**: Implement measures to minimize food waste throughout the supply chain.
5. **Environmental and climate impact:** Mitigate climate change and reverse biodiversity loss by ensuring that food systems have a neutral or positive environmental impact.
6. **Animal health and welfare**: Ensure animal health and welfare in food production with the goal of making food systems fair, healthy, and environmentally friendly.

---

[13] https://environment.ec.europa.eu/strategy/bioeconomy-strategy_en

[14] https://ec.europa.eu/commission/presscorner/detail/en/ip_24_1570

[15] https://commission.europa.eu/document/download/10017eb1-4722-4333-add2-e0ed18105a34_en

[16] https://www.fao.org/agroecology/database/detail/en/c/1277002/

[17] https://agriculture.ec.europa.eu/vision-agriculture-food_en

[18] https://agriculture.ec.europa.eu/common-agricultural-policy/agri-food-supply-chain/ensuring-global-food-supply-and-food-security_en

[19] https://agriculture.ec.europa.eu/common-agricultural-policy_en

[20] food-2030_Research-and-Innovation-Pathways-for-action-2.0.pdf

The biotechnology IPCEI candidate areas will be described through the goals that need to be achieved. This will ensure a more systematic approach while also aligning the scope of the potential IPCEI candidate with the strategic goals of the EU.

Please describe briefly how the initiative would contribute to the listed policy objectives.

1. **Sustainable food production**:
    - **Biotechnology role**: advanced biotechnology particularly through New Genomic Techniques (NGTs), could offer potential to enhance crop resilience and nutritional content. This could reduce the need for external inputs like pesticides and fertilizers, aligning with sustainable agricultural practices.
    - **Example**: engineered crops or engineered microorganisms can have enhanced nitrogen fixation capabilities, reducing synthetic fertilizer use and environmental impact.
2. **Food security**:
    - **Biotechnology role**: by improving crop yields and resilience to climate change, advanced biotechnology helps ensure stable food supplies. Additionally, it can enhance nutritional content, contributing to better public health. With the global population continuing to grow, the demand for protein is set to rise, while the EU is heavily reliant on imports for animal feed, in particular for vitamins and amino acids. In this context, alternative proteins and additives produced through advanced biotechnology can play an important role in strengthening food security and building a more resilient food system in Europe.
    - **Example**: biofortified crops can provide essential micronutrients, improving nutrition in vulnerable populations. Cellular agriculture and modern fermentation techniques could contribute to food security as they allow for faster protein production, with some processes yielding results in just days or weeks, compared to the longer timelines required by conventional methods. An IPCEI tool could enable to overcome market failures for the production of feed additives in particular, which are crucial for a prosperous food system.
3. **Promoting sustainable food consumption**:
    - **Biotechnology role**: by creating alternative protein sources (e.g., cell-based or fungi-based proteins), advanced biotechnology supports shifts towards more sustainable diets. **Example**: companies like Funki Foods[21] use advanced biotechnology to produce fungi-based protein products, offering sustainable alternatives to traditional meat.
4. **Reducing food loss and waste**:
    - **Biotechnology role**: advanced biotechnology can convert food waste into valuable products. This approach minimizes waste disposal and environmental impacts.
    - **Example**: fermentation technology can convert side streams from the food and beverage industry into proteins or other functional ingredients.
5. **Environmental and climate impact**:
    - **Biotechnology role**: advanced biotechnology for food and feed components helps mitigate climate change by reducing greenhouse gas emissions through lowering environmental impacts associated with livestock production or other types of food production.
    - **Example**: advanced biotechnology can lead to reduced methane emissions, for example by using cellular agriculture.

[21] https://www.funki.ee/

6. **Animal health and welfare**:
   - **Biotechnology role**: by providing local and sustainable feed with biobased additives, advanced biotechnology supports better animal health and welfare.
   - **Example**: production of biobased vitamins and amino acids for feed is a way to improve resilience and better breeding practices at scale.

Please present the relevance of an intervention at EU level (as opposed to national) in the proposed area.

Interventions at the EU level are crucial when developing breakthrough technologies and first industrial deployment, particularly in areas like sustainable food systems and biotechnology. Here's why EU-level interventions are more effective than national ones in these matters:

1. **Access to diverse expertise**:
   - **EU-level collaboration**: an IPCEI provides a platform for collaborations across member states, allowing researchers and companies to access a broader pool of knowledge and skills. This is essential for developing complex technologies that require interdisciplinary approaches.
   - **Example**: collaborative projects bring together experts from different sectors and countries, ensuring that projects benefit from a wide range of expertise, from biotechnology to engineering and from academia to industry.
2. **Cost sharing and Coordination**:
   - **Role of Member States**: while the Member States fund the projects with State Aid, the collaborative nature of IPCEI helps share the financial burden of developing breakthrough technologies. This is particularly important since large-scale development can be prohibitively expensive for individual countries, and particularly in areas where private investment alone is insufficient due to high risks or uncertain returns.
   - **Example**: Member States provide support to IPCEI projects by offering funding to participating companies or research organizations (if engaged in economic activities) based on the funding gap analysis. The Commission supports the Member States in coordination among them, as well as assesses whether the State aid notified by Member States aligns with State aid rules and does not distort competition.
3. **Scalability and market access**:
   - **EU-level market**: the EU's single market provides a large and integrated market for innovative technologies, allowing them to scale more effectively than if developed solely for a national market. This scalability is crucial for achieving economies of scale, new value chains and making disruptive technologies viable.
   - **Example**: EU-level collaborative projects often aim to develop solutions that can be deployed across the EU, ensuring that innovations can reach a broader market and achieve greater impact.
4. **Regulatory framework**:
   - **EU-level regulation**: The EU provides a harmonized regulatory framework that facilitates the development and deployment of new technologies across member states. This consistency reduces regulatory barriers and costs associated with navigating different national regulations, ensures safety and enhances European competitiveness.
   - **Example**: Recognizing the promise of New Genomic Techniques (NGTs), the EU is working to update its regulatory framework to accommodate these innovations. On March 14, 2025, representatives of the EU member states endorsed the Council's

negotiating mandate on a proposed regulation for plants developed using NGTs and their derived food and feed products.[22]

5. **Risk management and innovation support**:
    - **EU-level risk sharing**: by pooling resources and expertise, the EU can better manage the risks associated with developing disruptive technologies. This includes supporting innovative startups and SMEs through various funding instruments and programs.
    - **Example**: An EIC-funded biotech startup developing a novel fermentation process for alternative proteins could transition into a potential CBE JU project and subsequently an IPCEI project when moving toward industrial deployment. EU-funded research on precision fermentation under Horizon Europe could later be applied to develop scaling up processes in an IPCEI first industrial deployment project.
6. **Synergies with EU strategies:**
    - **Alignment with ongoing initiatives:** An EU-level intervention enables strategic alignment with existing EU policies and initiatives, enhancing impact and coherence.
    - **Example:** This initiative can generate/exploit synergies with strategies outlined in the "Policy Objectives" section of this document, reinforcing broader EU sustainability and innovation goals.

In summary, EU-level interventions support developing innovative technologies due to their ability to facilitate cross-border collaboration, share costs, provide access to a large market, and offer a harmonized regulatory environment. These factors are critical for overcoming the challenges of high development costs and the need for diverse expertise, making it more feasible to develop and deploy innovative technologies across the EU.

3. Conclusion of Scoping Phase

Based on the above, which takes on board the consultation with stakeholders at EU level, the working group considers that a possible IPCEI candidate on biobased key components for food and feed may be suitable.

It is therefore proposed to enter an in-depth phase analysis to confirm the suitability, desirability and feasibility of a possible IPCEI candidate on biobased key components for food and feed.

Disclaimer

This scoping paper was drafted by the Working Group for **Biotechnology** of the Joint European Forum for Important Projects of Common European Interest (JEF-IPCEI). The objective of this document is to contribute to pre-screening of whether certain technologies, infrastructures, value chains or sectors could be suitable candidates for potential new IPCEIs. It should facilitate exchanges with representatives of industries and/or academia about potential IPCEIs in the pre-screened technology and/or infrastructure areas. This exchange does not prejudge whether an IPCEI will subsequently be pursued. It does not indicate a commitment, or approval by the participating Member States or by the European Commission on certain technologies, infrastructures or value chains, or an available budget and it does not bind any participant in this exchange.

[22] https://www.consilium.europa.eu/en/press/press-releases/2025/03/14/new-genomic-techniques-council-agrees-negotiating-mandate/