Matching protein ingredients and processing strategies to food application requirements

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Summary for practitioners

Objectives

Many alternative-protein foods underperform because ingredient choice and processing are not sufficiently aligned with the requirements of the final product. GIANT LEAPS investigated how different protein sources, ingredient combinations and processing strategies can be matched to specific food applications, including meat analogues, dairy alternatives and egg replacers, in order to improve texture, stability, flavour and nutritional value.

Results

GIANT LEAPS showed that there is no single alternative protein that performs well across all food applications. Product quality depends on selecting ingredients with the right functionality for the intended food and combining them with suitable processing methods.

Across different applications, the project demonstrated that tailored processing can substantially improve performance. Enzymatic treatment of faba bean proteins improved binding, emulsification and gelation, supporting their use as egg replacers in cakes. Deflavouring also reduced undesirable earthy and beany notes, making bakery applications more feasible. In meat analogue development, extrusion and enzymatic pre-treatment improved structure formation, while fermentation of chickpea-based ingredients reduced off-flavours and supported the development of meatball-type products with higher cooking yield. In dairy alternatives, legume proteins performed well in milk and yoghurt alternatives, while rapeseed protein showed limitations linked to low solubility and phase separation. Fermentation and ingredient blending also supported the development of cheese spread analogues with improved functionality and nutritional value.

A consistent finding across applications was that ingredient functionality cannot be assessed in isolation. Interactions with starches, fats, hydrocolloids, flavour systems and processing conditions strongly influence final product quality. The work also showed that scaling up from laboratory to pilot production can change fermentation behaviour, texture and stability, even when the general product concept remains valid.

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Practical implications

Food manufacturers should begin by defining the technical requirements of the final product, such as gelation, emulsification, foaming, water-holding, texture and stability, before selecting protein ingredients. Complementary protein sources should be screened early, and processing conditions should be optimised for the complete formulation rather than for isolated ingredients.

Pilot-scale validation is essential before industrial scale-up. It should include technological, sensory and nutritional assessment, as well as manufacturability and batch-to-batch consistency. Manufacturers should also expect variability between alternative protein ingredients depending on source, extraction method and processing history.

The main implementation costs include pilot trials, access to extrusion, fermentation or enzymatic processing, sensory testing and scale-up validation. The main benefits are improved product performance, fewer reformulation cycles, greater formulation flexibility and better use of a wider range of sustainable protein sources.

Additional dissemination and exploitation materials

www.giant-leaps.eu

www.linkedin.com/company/giantleapseu

Geographical location

The research was carried out across the GIANT LEAPS consortium, including work in Finland, Ireland, Spain, Iceland and other European countries. Product development and validation covered several food applications relevant to European food manufacturing.

Additional information

One of the strongest lessons emerging from GIANT LEAPS is that successful alternative protein products are developed through an integrated approach rather than by optimising individual ingredients in isolation. Throughout the project, food technologists, nutrition scientists, sensory researchers and processing experts worked together to evaluate ingredients under realistic manufacturing conditions. This interdisciplinary approach made it possible to understand how ingredient selection, processing technology and final product formulation interact to determine product quality.

A major challenge for manufacturers remains the natural variability of alternative protein ingredients. Functional properties such as solubility, water-holding capacity, emulsification and gel formation can vary considerably depending on the protein source, extraction method and production batch. Processing technologies can compensate for some of these limitations, but they cannot eliminate them entirely. As a result, formulations that perform well at laboratory scale may require further optimisation during pilot production or industrial manufacturing.

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GIANT LEAPS also demonstrated that improving one characteristic may negatively affect another. For example, processing conditions that enhance texture may influence flavour development, while nutritional improvements may alter technological performance. Product development should therefore balance functionality, nutrition, sensory quality, sustainability and manufacturing feasibility throughout the innovation process rather than addressing these aspects sequentially.

Future research should focus on expanding the range of commercially available alternative proteins, improving predictive methods for ingredient functionality, developing scalable processing technologies and evaluating performance under industrial production conditions. Digital tools that combine functionality, nutritional and sustainability data could further support evidence-based formulation decisions.

Key messages for practitioners: There is no single "best" alternative protein. Start from the characteristics required by the final product, combine complementary ingredients, optimise processing for the complete formulation, and validate performance under realistic production conditions before commercial scale-up.

About this practice abstract and GIANT LEAPS

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