Building circular alternative protein systems from side streams

Authors and affiliations: Jasper van Puffelen, Wageningen University & Research; Laura Malinauskaite and Birgir Örn Smárason, Matís; Jakob Lewin Rukov, Bugging Denmark; Sergiy Smetana and Beatriz Silva, DIL Deutsches Institut fur Lebensmitteltechnik.

Summary for practitioners

Objectives

Circular production is often presented as a major opportunity for alternative proteins, especially where side streams, by-products or food waste can be converted into new protein ingredients. However, circularity benefits are not automatic. GIANT LEAPS examined how alternative protein systems can retain nutrients within the food system, reduce resource losses and make better use of organic side streams, while also identifying the technical, environmental and regulatory conditions needed for these approaches to be viable in practice.

Results

GIANT LEAPS identified substantial untapped potential for using biowaste and side streams as feedstocks in alternative protein production. The results showed that circular approaches can reduce pressure on land, water and imported inputs while creating more regional and resilient value chains. At the same time, the project confirmed that circularity performance differs significantly between systems and depends on feedstock quality, logistics, traceability, pre-treatment needs and processing technology.

In insect production, side streams and former foodstuffs can support more circular protein production, and GIANT LEAPS found that food-waste feed substitution can reduce the environmental impacts of cricket production at higher substitution levels. In microalgae systems, nutrient recirculation, reuse of water, and the use of industrial side streams or biogenic carbon sources offer additional circularity opportunities, although wider substitution with circular inputs can also increase impacts where extra processing is required. In rapeseed-based systems, integrated biorefinery approaches can improve resource efficiency by valorising multiple fractions rather than only the main protein output. Overall, the project showed that not every waste-to-protein pathway produces a net sustainability benefit, and that circularity must be assessed case by case.

Co-funded by the European Union

Practical implications

Practitioners should start circular protein development with a side-stream mapping exercise covering local availability, seasonal stability, transport distance, traceability, nutrient content, pre-treatment needs and likely regulatory constraints. Circularity claims should be supported by measurable indicators such as nutrient recovery, waste-to-feed ratios, bioconversion yield, and effects on greenhouse gas emissions and energy use.

Where waste-derived or novel substrates are involved, regulatory planning must begin early. Producers should clarify substrate legality, likely evidence requirements, and traceability expectations before scale-up. In some cases, stepwise validation may be needed, beginning with research use or non-food-chain applications before progression to food uses.

Additional dissemination and exploitation materials

www.giant-leaps.eu

www.linkedin.com/company/giantleapseu

Geographical location

Europe. The findings draw on GIANT LEAPS circularity and sustainability assessments across alternative protein systems relevant to European production, including case-study work on insect production in Denmark, microalgae in Portugal, rapeseed processing in Poland, and wider EU-level analysis of side streams, waste valorisation and regional partnerships.

Additional information

GIANT LEAPS showed that more circular alternative protein systems are feasible, but their benefits depend on local conditions and careful system design. Facilitating elements include access to stable and traceable side streams, regional partnerships between side-stream providers and protein producers, and better tools to measure nutrient recovery, waste-to-feed ratios and wider environmental trade-offs. Important obstacles remain, including the lack of consistent primary data, limited infrastructure for side-stream processing and biorefinery development, and uncertainty around the use of waste-derived substrates under current food safety and novel food rules. The results also show that circularity should not be pursued in isolation. Additional pre-treatment, transport or drying can increase energy use and emissions and may offset expected gains.

Future research should therefore focus on low-impact pre-treatment technologies, clearer circularity metrics, and stepwise validation routes for new substrates that support safe innovation and scale-up.

Key message for end-users: circularity is promising, but not automatic. Start with local feedstock availability and safety, assess nutrient recovery and environmental trade-offs from the outset, and address traceability and regulatory requirements before commercial scale-up.

Co-funded by the European Union

About this practice abstract and GIANT LEAPS

This practice abstract was elaborated in GIANT LEAPS project based on the EIP AGRI abstract format.

GIANT LEAPS is a project that has received funding from the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement No 101059632

Project website: *www.giant-leaps.eu*

Co-funded by the European Union