Application of edible insects in western food products (EntomoFood)

(CORNET)

Coordination: Forschungskreis der Ernährungsindustrie e. V. (FEI), Bonn (Research Association of the German Food Industry)

National Agencies:
- AiF - German Federation of Industrial Research Associations, Germany
- IWT - Institute for the promotion of Innovation by Science and Technology, Flanders/Belgium

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- KU Leuven R&D, Leuven/Belgium
- Flanders' Food, Brussels/Belgium

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Industrial Branch: Food Processing and Packaging Machinery

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Initial Situation:

Insects are foreseen as a potential more efficient and more sustainable source of biomass for food and feed purposes. The need in research of processing potential of their application for food products is triggered with the lack of protein sources in EU and around the world.

The future protein supply from conventional food sources is continuously predicted to be insufficient. Therefore, the need for the new protein sources and their extensive technological research is of the great value for modern food industry. Insects are recognized as the most effective transformers of vegetable biomass into valuable proteins, which highlights ecological benefits of their application. They are known as human food for centuries and yet their application in western diets is limited due to the number of established cultural attitudes.

Insects could serve as a source of essential amino acids (proteins up to 80 % of dry matter) and fatty acids (fat fraction are up to 70 % of dry matter), chitin applicable for bio-based plastic production and bioactive compounds. 60-80 % of western populations indicated that they would be willing to consume insect-based products, provided they would have more information on benefits and would not be able sensually recognize insects in products.

The aim of the interdisciplinary research project ENTOMOFOOD was the development of high quality intermediate insect-based pro-

ducts for food industry based on industrially relevant high-moisture extrusion technology which combined thermal, pressure and shear processing effects. Two model insect species, legally allowed for food application, *Tenebrio molitor* and *Alphitobius diaperinus* were selected to be tested for the structural functionality and level of economic and environmental sustainability in meat substitutes applications. Furthermore, insect-based matrices for texturized food products should be assured for the nutritional relevance, microbiological and chemical safety.

Such approach should uncover the intermediate texturized insect matrices for industrial innovation and market penetration as meat substitutes. It provides innovative technological solutions, such as energy-efficient processing and reduced processing intensity, but also texturize formation for meat structure imitation.

The interdisciplinary approach in ENTOMOFOOD integrating innovative protein source from insect biomass with combined-effect processing technologies was intended to demonstrate a concept of insect-based innovative products on a pre-competitive basis.

Research Results:

ENTOMOFOOD is an interdisciplinary project, which relied on application of existing and effective technologies for the production of new media suitable for innovative food development. Larvae of two model insects (mealworm, *Tenebrio molitor* and buffalo beetle, *Alphitobius diaperinus*) were applied for product processing through the use of defatted meals and frozen whole insects. High-moisture extrusion (HME) of insect protein concentrates performed with the application of a twin-screw pilot scale extruder (Model Berstorff ZE 25x33D) allowed for the testing and optimization of temperature, pressure and water setting profile of insect biomass processing. Optimal processing conditions were defined according to the requirements of texture and hardness formation of meat substitutes (and chicken meat). The conditions were successfully established and led to the formulation of intermediates with meat-like texture with 40 % of insect protein concentrate content (dry matter), which is the highest concentration comparing to the reference products on the market (5-20 % of insect biomass). It was shown that increase of insect protein concentrate content is overall decreasing the hardness of the extrudates. However, optimization in temperature profile (increase to 170 °C) and reduction of water content (by 5-10 %) allowed to preserve the fibrous texture of insect-based intermediates (with up to 40 % of dry matter content). Protein concentrate powders from both species performed similarly during HME without significant difference in physical, chemical or microbiological parameters. Particle size reduction of insect protein concentrates with milling did not significantly affect the texturizing properties of extrudates. Similarly, fiber additives did not improve the binding properties of insect proteins.

Life-cycle assessment (LCA) allowed identification of environmental impact hotspots and recommendations for more sustainable product development. It defined that high-moisture extrudates composed of insect-biomass are more environmentally friendly than meat products but are not beneficial than plant-based texturized products. Furthermore, LCA defined the possibility to use fresh insect biomass for HME instead of protein concentrate, which reduced the number of processing stages eliminating defatting and drying, consequently reducing price, energy consumption and environmental impact of intermediates by 30 %. It made the HME based on fresh insect biomass extrusion more environmentally and economically competitive alternative than meat and plant-based meat substitutes on the market. Texture, chemical and microbial properties of intermediates processed with fresh insects were not significantly different than those based on insect powder concentrates.

Insect processing with high-moisture extrusion offered solutions to industry for the exploitation of insects as an alternative source of sustainable proteins for human nutrition and delivered innovative technological breakthroughs for more efficient processing technologies for protein-rich insect biomass. Fresh-insect based HME was proven as an economically and environmentally viable technology for the processing and production of intermediate burger matrix instead of existing technology of milled frozen insects.
In parallel, the project investigated the possi-

bilities for market penetration of produced insect-based food products and assured its microbiological safety and sensual suitability. The results indicated that consumers are mostly willing to eat insect-based products but would not so far do it on a regular basis in Germany. Industries should rely on initial interest of the consumers and develop the tradition of insect product consumption.

The use of several innovative products and effective processing technologies in new combinations underlined the interdisciplinary approach of ENTOMOFOOD and contributed to the pre-competitive character of the entire concept for insect-based matrices utilization in food.

Economic impact:

Insect market for food is developing quite dramatically considering introduced insect products to German and EU food market such as energy bars and snacks, burgers, pasta and bread, and food and feed additives. European market of insect-based products is rapidly progressing. A few "Novel Food" applications are being submitted by the companies (including those in User Committee of ENTOMOFOOD) for *Tenebrio molitor* and *Alphitobius diaperinus*). There are a few reasons for such a rapid market progression, which roots into a single strategy, which works for innovative products in European market. Novel and exotic foods, aimed to satisfy consumers needs for pleasure rather than for need, show the best progression results. Numerous insect-based products appearing on the markets of Europe follow this red line and are sold as premium products in luxury stores, restaurants and only recently in supermarkets.

New market application of developed intermediate product could not only compensate high cost of insect proteins (7-8 € for kg of dry weight), but also profit for premium product account. Considering an infancy level of breeding and processing technologies development the highest profitability of the processing could be reached within a few years. ENTOMOFOOD analyzed the potential of producing the meat-like product with the cost of 3-4 for kg, when whole fresh insects were applied for HME and intermediates with 40 % insect biomass content were produced. It was estimated that global market of edible insects would reach 600 mln. Euro revenue by 2025 with compound annual growth of 6,9 % (Persistence Market Research, 2018).

ENTOMOFOOD aim to adapt existing processing technologies for the development of new business models by the time European market allows for insect-based products is very actual. Multiple cases of insect products "tolerance" or allowance is observed in many countries of EU including Germany. That's why the developed practical solutions of insect biomass transformation into safe and sustainable intermediate industrial matrices (powder and texturized paste) are forcing innovation and product development of SMEs. Application of innovating processing technologies (microwave drying and high moisture extrusion) allow additional benefits creation comparing to the traditional technologies as the emerging technologies are more efficient and cost effective. Their application would make foods based on edible insects more competitive.

Publications (Choice):

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