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Alternative food and feed products

Dr. Eva Maria Binder, Senior VP Research & Development, ERBER AG, Austria

Introduction: the big picture

Globally, demand for traditional protein sources (livestock and fish) is expected to grow by 76% from 2007 to 2050 (Alexandratos and Bruinsma, 2012). This increase is due to not only a growing population, but also changing diets in developing countries compared to developed nations (Rosegrant *et al.*, 2012). Land that is not suitable for cultivation of crops can often efficiently be used to graze livestock. However, overgrazing and the creation of new pastures at the expense of natural ecosystems have detrimental environmental impacts. In addition, the projected increased meat production may also lead to a rise in greenhouse gas emissions, in addition to placing further pressure on natural resources (such as arable land and freshwater) and exacerbating the competition between humans and animals for grains and other high quality plant food/feed (OECD/FAO 2017). Thus, there is a critical need to provide additional food and animal feeds that are both safe and nutritious at the same time minimizing environmental footprints.

To fill this gap, **alternative food and feed products** are receiving growing attention worldwide.

Key issues

Livestock Feed additives

Livestock intensification requires producing more with fewer inputs. Advances in nutritional research and innovation are being leveraged to promote optimal animal health and production. Modern livestock production aims to understand the critical growth needs of the animals, the varying ability to absorb and effectively utilize dietary nutrients and should be increasingly allowing for the formulation of more balanced rations that provide the necessary feed components without over-supplying valuable nutrients. Feed additives, including probiotics, plant derived extracts as well as enzymes can support the maintenance of the intestinal barrier, reduce the variability of nutrient utilization and improve the animal's ability to cope with and recover from immunological challenges. Supplemental enzymes, like phytases, proteases, carbohydrases and xylanases can improve nutrient release and digestibility, while specific hydrolases are used to counteract undesirable contaminants, like mycotoxins, transforming them into non-toxic metabolites, allowing for the use of feeds that would otherwise be wasted. Well-nourished animals are also healthier. They are less prone to disease, and need less inputs (such as antimicrobials) to grow; this in turn, will result in reduced food safety risk due to zoonoses and carriage of antimicrobial-resistant bacteria. More efficient use of available feed stock has the

potential to reduce GHG emissions in ruminants. In addition, certain feed additives selectively inhibit microorganism in the rumen and lower the emission of methane from cattle. The inclusion of novel feed components in livestock and poultry feed carry with it new regulatory challenges that also must be addressed, notably safety and validation of labeling claims. Generally, many feed additives are of limited public health concern and regulatory hurdles for their inclusion in feed are not too burdensome. However, if specific label claims are made about specific additives to impact animal health or disease, in addition to product safety (for the animal and the food produced) then the efficacy claims should be based on science and appropriate oversight should be employed to avoid misleading both the producers and the consumers who purchase products raised with these products. Furthermore, the institutional responsibility should be defined for those overseeing impacts on the environment, or other aspects of regulation that have previously been unexplored.

Insect-based feed and food products

Insects have traditionally been consumed as a part of the normal diet in a number of regions in the world. However, with the expected global market value for insects as food and animal feed to cross \$1 billion USD by 2020, intensified insect farming is gaining traction. Indeed, in recent years there has been a growing interest in the possibility of using insect farming to meet the growing demand for protein in animal feeds and in the human diet due to the efficiency with which they can convert their feed into protein. Among the most promising species for industrial feed production are black soldier flies, common housefly larvae, silkworms and yellow mealworms. While limited available data so far show a low risk for transmission of zoonotic infections from consumption of wild-collected insects, detailed investigation is still pending to determine microbial hazards of consumption of farmed insects. At the same time, attention should be given to the possible bioaccumulation of undesirable chemicals from the environment that has been identified in farmed insects intended for animal feed (including pesticides residues and heavy metals) (Vijver et al., 2003; Charlton et al., 2015).

Despite their longstanding use as a food source there are very few laws and limited harmonization across national borders that address insect farming as food or feed, considering: procurement of 'seed' insects to start colonies, required farm infrastructure, and standards for trading of the final products (Lahteenmaki-Uutela A. et al., 2017). While regulations for insects exist in some regions (e.g. in Europe) the lack of defined regulations in other parts of the world has allowed for a multitude of substrates being used for insect farming ranging from chicken feed to various waste streams including from animal sources, such as offal from slaughter houses, with various possible food safety implications. Moving forward, it will be important that policy-makers are provided with science and evidence on which to develop guidelines and regulations covering all aspects of insect entomoculture and entomopathy from primary production through processing and distribution and labelling to establish standards for safety and trade.

Algae

Macro marine algae (e.g. seaweeds) and their extracts such as carrageenan are consumed worldwide. Because of the potential of micro-algal species to be harnessed for energy; as pharmaceuticals and nutritional supplement; and for food and feed purposes; and as fertilizers; interest in their cultivation has gained momentum. Compared to corn or soybeans, one hectare of land used for algaculture can yield over 30 times the amount of food energy, making it an ideal crop for intensification. Rich in protein, carbohydrates and unsaturated fatty acids, the primary species that are cultivated and sold dried include *Spirulina* and *Chlorella*. Currently, it is estimated that the global market for microalgae is between \$5 to US\$7 billion, with food and nutrition applications currently accounting for US\$2 billion of annual sales and US\$0.7 billion for fish meal, with that number expect to continue to grow by 5% annually. Because of the benefits of intense

solar input and warm temperature, micro-algae production can potentially be expanded into tropical and subtropical regions, contributing to both food security and livelihoods. Two, production systems-open and closed- have been described. The former having a much lower investment cost, but are far more susceptible to contamination. Use of micro-algae in foods and feeds may introduce new hazards into the food chain. In addition to previously unrecognized allergens, protection from microbiological and chemical contamination and methods to validate strain identification are imperative. Similar to plant and animal agriculture, there is potential to genetically modify algal strains that may not be detectable. Legislation that protects consumers from misleading advertising claims and fraudulent or adulterated products is critical. Policies that facilitate financing and credit for emerging farmers to protect production sites from contamination would be valuable. Algae production will be dependent upon water use and re-use policies.

Circular bio-economy: recycling of food waste for feed

Approximately one-third of all food produced for humans is either lost (not suitable for consumption) or wasted. Food loss and waste is an economic, environmental and social burden as well as a threat to food security. Prevention and reduction of these losses, combined with alternate uses of food waste, including food recycling can help to reduce these negative impacts. For example, a young Dutch innovator developed a process to “upcycle” stale, but safe, bread products into a tasty 3D printed snack. Feed recycling strategies are more advanced in the animal feed industry: Feeding food losses to animals is a sustainable solution and brings more co-benefits by reducing waste streams, greenhouse gas emissions and supporting circular bio-economy. It comes with some threats such as risks of introduction, dissemination and persistence of animal disease agents, chemical residues, and zoonotic pathogens in the food chain. To ensure the safe use of food wastes and loss and their traceability, it is essential to develop innovative technology, retailer standards and policies to frame their collection, treatment and usage. These innovations can be supported by incentives and investment to develop infrastructure for food wastes and loss treatment and the education of consumers and retailers to separate food wastes and loss from other wastes. For instance, some national authorities have put in place laws to regulate food wastes and loss recycling and have developed incentives for farmers and retailers such as a premium market for “eco-feed” animal products produced using food wastes and loss.

Conclusions

New food and feed technologies have to include approaches to improve utilization of by-products, increase nutritional values, monitor and prevent hazards, while at the same time evaluating trade-offs related to the whole product life cycle process, including farm management, feed and water related activities, logistics, as well as full value chain traceability. Some of the alternatives presented in this brief might be able to offer valuable solutions, if accompanied by an adequate oversight and control to ensure their safety and appropriate application.

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