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Insect Protein Sources in Animal Nutrition: Economic Viability, Farming Practices, and Regulatory Considerations

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Insects are emerging as a promising alternative protein source for both human food and animal feed due to their high nutritional value and low environmental impact. Insects such as black soldier fly (BSF), mealworms and housefly larvae are rich in essential amino acids, fats, and minerals, and can efficiently convert organic waste into high-protein biomass. Their benefits include low greenhouse gas emissions, reduced land use, and minimal feed food competition.

Research shows that insect-based feeds can enhance animal growth, gut health, and immunity, especially in poultry and aquaculture. Insects also contain bioactive compounds like antimicrobial peptides and lauric acid. With growing demand for animal protein, especially poultry, insect farming is expected to rise, with the market projected to reach 3 million tons by 2030 (Barroso *et al.*, 2013). However, nutritional composition varies among insect species and life stages. Despite their advantages, there is limited research on insect protein source.

Economical assessment of insect protein as compared to other protein sources

Insect protein has potential as a sustainable feed source, but its economic viability compared to traditional protein sources like soybean meal (SBM) and fish meal (FM) remains a challenge. Current prices for insect protein are significantly higher than SBM. Adjusted for nutritional value (protein, lysine, methionine), insect protein is still costlier.

To become competitive, production costs must decrease. Strategies include scaling up production, using low-cost biowaste as feed, improving breeding and processing efficiency, and enhancing nutrient extraction. While FM may be replaceable by insects from an economic standpoint, replacing SBM with insects like BSF, housefly (HF), or mealworms (MW) could drastically increase feed costs for farmers. Insect protein is not yet economically competitive with SBM, but improvements in production efficiency and nutrient utilization could narrow the gap in the future.

Current insect farming production status

Insect farming is rapidly growing as a sustainable source of protein for animal feed and, to a lesser extent, human food. While insect consumption (entomophagy) is common in many regions, especially in Asia and Africa, it is still gaining acceptance in Western countries. Currently, most edible insects come from deforestation and semi-breeding, with only a small fraction (2%) from formal farming, which is now expanding globally, especially in developed countries (Yen *et al.*,2015). Insect farming offers several advantages: it requires less land, has lower start-up costs, uses simple technology, offers fast financial returns, and is easy to manage. The industry is growing, with the insect feed market valued at $687.8 million in

2018 and projected to double by 2025. Aquaculture is the largest consumer of insect feed, with companies like Protix, EnviroFlight, and Agro Protein leading the sector.

Despite the potential, insect farming is not yet cost-effective due to high feed costs and limited economies of scale. However, black soldier fly (BSF) and housefly (HF) are cheaper alternatives to fish meal (FM), especially for poultry and aquaculture. Studies show that insect meal can provide a 25% higher return on livestock investment due to better feed conversion rates and raw material utilization. The sector presents economic opportunities, especially in developing countries, but faces challenges such as scaling production, ensuring quality standards, and reducing costs to compete with traditional protein sources.

Advantage and limitation of insects use in animal diets

Insects are emerging as a sustainable and efficient alternative protein source for animal diets, offering several advantages over traditional feed ingredients like fish meal (FM) and soybean meal (SBM). They require significantly less land, water, and feed input, making them more environmentally friendly. Insects such as black soldier fly (BSF), housefly larvae, mealworms, and silkworms have been identified by the FAO as among the most promising species for industrial feed production. Their high nutritional value and comparable amino acid digestibility (89–95% in poultry) to FM make them suitable for inclusion in animal diets. Insects also promote animal health by enhancing immunity and potentially slowing age-related health issues, particularly in young animals and aquatic species vulnerable to pathogens.

Beyond feed, insects have notable medical uses. Bee venom, for example, has shown promise in treating rheumatoid arthritis by triggering apoptosis in harmful cells and may also help combat HIV by breaking down the virus structure using melittin nanoparticles. Additionally, maggot therapy is an established medical practice used to clean chronic wounds and ulcers, as maggots consume dead tissue and release antimicrobial substances that support healing. Despite the current higher costs of insect farming, innovations and scaling efforts are expected to reduce production expenses, making insect protein a competitive and multifunctional solution for animal nutrition and health in the future.

Regulatory of insect uses by the governments

Regulations and safety policies concerning edible insects are essential for both developing and developed nations to ensure a safe, low-risk food supply from production to consumption. With increasing consumer awareness about food quality and safety rights, there is growing demand for stricter oversight this includes edible insects and their derived products. Therefore, it is important that insects intended for human consumption be clearly marketed as such and meet current Good Manufacturing Practices (CGMP) related to processing, packaging, and transportation. Additionally, to safeguard consumers, especially those with allergies, insect-based food products should include warning labels for potential shellfish allergens (Hanboonsong *et.,al,* 2013).

Conclusion

Insects offer a promising solution to the growing global demand for sustainable and efficient protein sources in both human food and animal feed. Their high nutritional content, low environmental impact, and potential to convert organic waste into valuable biomass make them an attractive alternative to conventional protein sources like soybean meal and fish meal. While insect farming is gaining momentum globally and shows considerable economic and environmental benefits, especially in aquaculture and poultry sectors, challenges such as high production costs, limited large scale infrastructure, and consumer acceptance still persist. Continued investment in research, innovation, and scaling up production along with supportive regulatory frameworks will be essential to making insect protein economically viable and widely accepted. As awareness grows and technology advances, insects are likely to play a significant role in future food and feed systems, contributing to food security, sustainability, and improved animal and human health.

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