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Review Article

Effects of Extrusion on Insect-Based Feeds: Nutritional Enhancement and Processing Challenges

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Abstract: The global demand for sustainable protein necessitates alternatives like insect-based feeds, such as Black Soldier Fly Larvae (BSFL) meal and cricket flour, which offer high protein content and a lower environmental footprint than conventional sources; however, their high lipid and chitin content present significant challenges for extrusion processing. This review examines the effects of extrusion parameters, including temperature (cold extrusion <70°C vs. hot extrusion >130°C), moisture content, and the use of defatting or blending strategies, on the nutritional quality and physical properties of the resulting feed. Findings indicate that while hot extrusion ensures microbial safety, it can degrade heat-sensitive amino acids, and high lipid levels reduce kibble expansion, increasing bulk density. Chitin, though a potential prebiotic, impedes pellet expansion at high inclusion levels. It is concluded that strategic processing adjustments, such as partial defatting, optimized temperature control, and careful chitin management, are critical to enhancing the quality of extruded insect-based feeds. Future research should focus on long-term digestibility trials and cost-effective production methods to facilitate broader industry adoption.

Keywords: Black Soldier Fly Larvae (BSFL), Insect-based feeds, Cricket flour, Chitin, Sustainable protein sources.

Introduction

The increasing global demand for sustainable protein sources has spurred interest in insect-based feeds as viable alternatives to conventional protein ingredients such as fishmeal, soybean meal, and poultry by-products. Black Soldier Fly Larvae (BSFL) meal and cricket flour are among the most studied insect-derived proteins due to their high protein content (40–65% dry matter (DM)), balanced amino acid profiles, and lower environmental footprint compared to traditional feed sources [1,2]. However, their successful incorporation into extruded feeds presents unique challenges, including high lipid and chitin content, which influence extrusion performance, kibble quality, and nutrient bioavailability. This paper critically examines the effects of extrusion on insect-based feeds, focusing on nutritional implications, processing modifications, and strategies to optimize feed quality.

Nutritional and Functional Properties of Insect-Based Feeds

Protein Quality and Amino Acid Profiles

Insect proteins exhibit a well-balanced amino acid composition, often comparable to fishmeal and soybean meal [1]. For instance, BSFL meal contains essential amino acids such as lysine and methionine, which are crucial for muscle development in livestock [3]. However, high-temperature extrusion (>135°C) can degrade heat-sensitive amino acids, reducing protein digestibility [4]. In contrast, cold extrusion (<70°C) preserves amino acid integrity but may compromise microbial safety [5].

Lipid Content and Fatty Acid Stability

BSFL meal typically contains 20–35% lipids (DM basis), with lauric acid (C12:0) being a predominant fatty acid that enhances shelf-life and exhibits anti-inflammatory properties [2,3].

However, excessive lipid content (>15% inclusion) reduces kibble expansion during extrusion, leading to denser pellets [1]. Defatting insect meal prior to extrusion mitigates this issue while maintaining energy density [5].

Chitin and Its Functional Role

Chitin, a structural polysaccharide found in insect exoskeletons (5–10% in BSFL), acts as a prebiotic, promoting the production of short-chain fatty acids (SCFAs) in the gut [6]. However, high chitin levels (>30% inclusion) can impede nutrient absorption and reduce pellet expansion [7] (Table 1). Partial replacement strategies (e.g., blending with plant proteins) help mitigate these effects while retaining chitin's prebiotic benefits [8].

Impact of Extrusion Parameters on Feed Quality

Temperature and Moisture Optimization

Hot extrusion (>130°C) enhances protein digestibility and microbial safety but may degrade essential amino acids [4]. Conversely, cold extrusion (<70°C) is suitable for probiotic-enriched feeds but requires post-processing drying to prevent microbial contamination [5]. Optimal moisture content (28–30%) improves kibble texture and expansion, particularly for high-fat insect meals [9] (Table 1).

Physical Properties of Extruded Insect Feeds

Expansion and Bulk Density

High lipid content reduces kibble expansion, increasing bulk density [1]. Defatted BSFL meal at 10–20% inclusion improves floatability, making it suitable for aquaculture feeds [5].

Texture and Water Absorption

Chitin increases pellet hardness but reduces water absorption, necessitating adjustments to moisture levels [7]. The inclusion of cricket flour (15–20%) enhances water solubility but may reduce oil-binding capacity [10].

Table 1: Effects of Extrusion on Insect-Based Feeds

Property	Effects on Extrusion	Optimal Conditions	Nutritional Implications	References
Fat Content	High fat reduces expansion but improves floatability.	30% moisture, 120–130°C barrel temperature.	Higher energy density but risk of lipid oxidation.	[5,9]
Protein Content	Improves pellet durability & floatability (BSFL).	Blend with plant proteins (e.g., soy/corn).	Comparable digestibility to fishmeal but lower at >25% inclusion.	[6,12]
	Higher protein retention in crickets but hard texture (>20%).	10–20% inclusion; defatting recommended.	Improved AA profile but reduced lysine/methionine at high temps.	[11,13]
Chitin	Reduces expansion & digestibility; binds water (BSFL).	Defatting or ≤30% inclusion.	May stimulate immune response; lowers fiber digestibility.	[7,8]
Processing	Lower SME & bulk density vs. fishmeal; higher flowability.	Increase screw speed to compensate for lipids.	Similar fecal output but altered microbiota (higher SCFAs).	[1,14]
	Compact structure, high hardness (crickets).	Low moisture (32%) + high screw speed (100 rpm).	Comparable digestibility to soy but lower starch availability.	[15]
Functional Properties	Enhanced selenium retention (crickets).	Optimized screw speed & moisture.	Improved mineral bioavailability but potential texture issues.	[11]

BSFL = black soldier fly larvae, SME = specific mechanical energy, SCFAs = short-chain fatty acids, AA = amino acids, rpm = revolutions per minute

Challenges and Future Perspectives

Microbial Safety and Allergenicity

Insects may harbour foodborne pathogens, requiring high-temperature extrusion (150°C) to ensure microbial safety [1]. Additionally, cross-reactivity with crustacean allergens necessitates careful formulation for sensitive species [11].

Economic and Regulatory Considerations

Despite their sustainability benefits, high production costs and evolving regulations limit the widespread adoption of these technologies [1]. Standardised processing protocols and life-cycle assessments are needed to validate environmental claims and improve market viability.

Conclusion

Insect-based feeds offer a sustainable alternative to conventional protein sources, with extrusion playing a critical role in optimizing their nutritional and functional properties. Strategic processing adjustments such as defatting, temperature control, and chitin management can enhance feed quality while mitigating challenges. Future research should focus on long-term digestibility trials, cost-effective production methods, and regulatory harmonization to facilitate industry adoption.

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