



## Insect Meal in Poultry Nutrition: A Review

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### Abstract

Poultry industry in India is witnessing exponential growth yet faces challenges in meeting the nutritional demands of its populace. To bridge this gap sustainably, the exploration of alternative protein sources is imperative. Insect meal has emerged as a promising solution, offering high nutritional value and ecological benefits. This review examines the nutritional composition, safety considerations, and overall benefits of incorporating insect meal into poultry diets. Furthermore, it describes challenges and future prospects associated with scaling up insect production and navigating regulatory frameworks. Despite facing limitations, insect meal presents a viable and eco-friendly option to enhance poultry nutrition and support sustainable agricultural practices. With ongoing research and regulatory support, insect-based feeds hold the potential to revolutionize the poultry industry, ensuring food security and environmental stewardship.

**Keywords:** Insect Meal; Poultry; Alternative Protein Source; Cost-Effective; Food Security

### Introduction

The Indian poultry industry stands as a formidable force in both egg and meat production on the global stage. Ranked second worldwide in egg production and fifth in meat, it showcases a remarkable growth trajectory with egg production growing at a rate of 6-8% and meat production at 11-12% annually. With a staggering 138.38 billion eggs and 9.77 million tonnes of meat produced, (Department of Animal Husbandry and Dairy - DAHD, Basic Animal Husbandry Statistics - BAHS, Gov. of India, 2023) the industry significantly contributes to the country's food security. Despite these impressive figures, there remains a notable disparity in per capita availability compared to international recommendations. While the average Indian consumes approximately 101 eggs per annum and 7.10 kg of poultry meat per annum, (DAHD, BAHS, 2023), the Indian Council of Medical Research (ICMR) suggests a higher intake of 180 eggs and 11 kg of meat annually for optimal nutrition. Closing this gap presents an opportunity for the industry to not only meet domestic demands but also tap into the potential for increased exports and improved public health outcomes through enhanced nutrition.

Between the 19th and 20<sup>th</sup> Censuses in 2012 and 2019 respectively, the Indian poultry industry experienced significant growth across various parameters. The total poultry population surged

from 729.21 million to 851.81 million, marking a remarkable growth of 16.8%. Out of this total population, the majority share comprises birds from commercial farming, which increased from 511.72 million to 534.74 million, reflecting a growth rate of 4.5%. In contrast, backyard farming, while representing a smaller portion of the total population, saw a substantial increase from 217.49 million to 317.07 million birds, indicating a significant growth rate of 45.8%. (Livestock Census 2019, DAHD, Gov. of India). This data reinforces the dynamic nature of the Indian poultry sector, where commercial and backyard farming both contribute to meeting the nation's escalating demand for poultry products.

Soybean meal has earned widespread recognition as a high-quality protein feedstuff, as affirmed by Taliercio., *et al.*, 2014 [1]. Traditionally, both soybean meal and fishmeal have held central positions as the primary vegetable and animal protein sources respectively in poultry feeds. These protein sources play a crucial role in poultry diets, constituting the second largest component. As commercial and smallholder poultry enterprises continue to expand worldwide, as noted by Chisoro., *et al.*, 2018. [2] The demand for poultry feeds escalates accordingly. This growth indicates the essential role of protein-rich feeds in meeting the nutritional needs of poultry populations across diverse production systems, driving the continual evolution and adaptation of the poultry feed industry to meet increasing demands.

### Need for alternative protein sources

Researchers and industry experts are exploring various options, including alternative protein sources. The growing interest in alternative protein sources stems from a confluence of factors reshaping the landscape of poultry production. Firstly, the rapid expansion of poultry enterprises worldwide necessitates a diversified approach to feed formulation to meet the escalating demand for poultry products. Secondly, the inherent fluctuation in the production of traditional protein sources like soybean meal and fishmeal underscores the need for reliable alternatives that can offer stability in the supply chain. Furthermore, as global populations burgeon, traditional protein sources alone may fail to meet the ever-increasing demand for poultry feeds, necessitating the exploration of novel protein-rich ingredients to sustainably support poultry production. Lastly, the rising prices of conventional feedstuffs such as soybean meal pose economic challenges for poultry producers, prompting a quest for cost-effective alternatives without compromising on nutritional quality [3].

The global poultry industry's competitiveness hinges on the ability to navigate cost challenges, prompting a search for alternatives to major feed ingredients, as highlighted by Batonon-Alavo, *et al.*, 2016 [4]. This quest extends to finding new feedstuffs with optimal nutritional value for poultry diets, a fundamental concern emphasized by Sogari, *et al.*, 2019 [5]. In anticipation of future protein demands, there is a growing imperative to explore novel protein sources. This proactive approach not only addresses current cost pressures but also positions the industry to meet evolving nutritional needs sustainably. By continually innovating and diversifying feed formulations, poultry producers can enhance efficiency, reduce reliance on traditional feed ingredients, and ensure the long-term viability of poultry production in a dynamic global market.

### Insect meal as an alternative

Among the various alternative protein sources (algae, single-cell protein (SCP), aquatic plants, etc.) to replace traditional ones, insect meal is gaining popularity. Insect meal, derived from insects like black soldier fly larvae, mealworms, and house fly larvae, is emerging as a promising high-protein feed ingredient for the poultry industry. This innovation comes at a crucial time, as the poultry sector grapples with the dual challenge of sustainability and cost-effectiveness in sourcing protein for feed. Despite being a relatively new concept in poultry production, insect meal has quickly gained traction as a sustainable solution to address these challenges. The vast abundance of insects, constituting about three-fourths of the total organisms on Earth [6] emphasize the potential of insect-based feeds to provide a scalable and environmentally friendly

protein source for poultry. As research and development in insect farming and processing continue to advance, insect meal holds promise as a viable alternative to traditional protein sources, offering both nutritional value and ecological benefits to the poultry industry.

### Why insect meal?

Insect meal presents a multifaceted solution to numerous environmental and nutritional challenges. Its appeal lies in its high nutritional content, offering a rich source of proteins and essential nutrients. Beyond its nutritional value, the production of insect meal significantly lowers emissions of greenhouse gases compared to traditional livestock farming [7]. This shift towards insect-based protein sources also tackle concerns about the loss of nutrients inherent in conventional animal agriculture. Moreover, insect farming requires far less land and water, making it a more sustainable option. The efficiency of resource utilization is further emphasized by the rapid growth rate of insects, facilitating swift production cycles. Additionally, insects possess the remarkable ability to consume organic waste, including animal manure and food scraps, thereby reducing pollution and waste accumulation. By minimizing total nitrogen excretion, odours, and methane emissions, insect farming contributes to a cleaner environment. Impressively, it can reduce waste mass by up to 80%, simultaneously providing valuable protein and fertilizers. In summary, the adoption of insect meal offers a compelling solution to the intertwined challenges of food security, environmental sustainability, and waste management [8,9].

Entomophagy, the consumption of insects, is a longstanding practice embraced by over two billion people globally [10]. Across different regions, a diverse array of insect species forms a crucial part of traditional diets. Africa leads with an estimated 524 edible insect species, followed by Asia with 349, the Americas with 679, Australia with 152, India with 298, and Europe with a relatively modest 41 species [11,12]. Mexico claims the title for the highest documented number of edible insect species, trailed by Thailand, Congo, India, Australia, China, and Zambia [12]. The integration of insects into poultry feeds is gaining momentum, attributed to their exceptional nutritional profile and rapid growth potential [13]. Notably, insects serve as an alternative protein source in poultry feed, boasting comparable fat and protein content to soybean meal or fish meal [14]. This highlights their viability as a sustainable and efficient means of meeting the nutritional demands of poultry production while reducing reliance on conventional feed sources.

Various types of insect meals are commonly utilized in animal feeds, each offering unique nutritional profiles and benefits. These include black soldier fly larvae meal, mealworm meal, silkworm pupae meal, housefly larvae meal, earthworm meal and orthoptera

meal, etc. Comparatively, the nutritional value of soybean meal, a conventional protein source, is well-documented, containing 44% crude protein, 0.9% crude fiber, 2.95% lysine, 0.65% methionine, 0.32% calcium, and 0.65% phosphorus [15]. While soybean meal remains a staple in animal feeds, the emergence of insect meals offers a promising alternative, often with comparable or superior nutritional profiles. Additionally, insect meals contribute to the diversification of feed sources, reducing reliance on monoculture crops and promoting sustainable farming practices. As research into insect farming and utilization continues to expand, the integration of insect meals into animal feeds is expected to play a significant role in enhancing feed efficiency, supporting animal health, and advancing the sustainability of livestock production systems. Moreover, a comparative analysis of alternative protein sources to soybean meal reveals a spectrum of nutritional compositions among insect meals. Black soldier fly larvae meal, with a protein content of 42.3% and substantial fat content of 33.5%, along with notable levels of lysine (5.7%) and methionine (2.1%) [16]. Housefly larvae meal offers even higher protein content at 52%, with a lower fat content of 18%, while exhibiting significant levels of lysine (6.1%) and methionine (2.2%) [17]. Mealworm meal, with 45% protein and 30% fat, presents moderate levels of lysine (5.4%) and methionine (1.5%), [18]. Silkworm pupae meal emerges with a very rich protein content of 54%, accompanied by a lower fat content of 12%, and notable levels of lysine (7%) and methionine (3%) [19]. Orthoptera meal showcases an impressive protein content of 57.3%, with a lower fat content of 8.5%, alongside substantial lysine (5.8%) and methionine (2.3%) levels [20]. This highlights the diverse nutritional profiles of insect meals, underscoring their potential as viable alternatives to conventional protein sources in animal feeds, with attention to protein, amino acids, calcium (Ca%) and phosphorus (P%) content as essential components for animal nutrition.

### Safety Issues of Insects as Poultry Feed

Safety concerns regarding the utilization of insects as poultry feed encompass various aspects, as highlighted by Khalifah *et al.*, 2023. [21]. Microbiological risks include the presence of bacteria, viruses, fungi, and parasites, which can potentially contaminate insect-based feed. However, simple processing techniques like blanching can effectively mitigate these contaminants [22]. Furthermore, treating insects similarly to other animal-origin feedstuffs, such as washing and thorough heating, helps reduce the risk of bacteria-borne diseases [23]. Chemical contamination, including heavy metals, pesticides, and toxins, poses another concern. However, research suggests that the concentration of heavy metals decreases during insect molting and metamorphosis, resulting in lower concentrations in adults [23]. Moreover, residues of pes-

ticides, toxins, and heavy metals naturally break down as insects develop, although more research in this area is warranted. Allergies are also a potential issue; as insect proteins can trigger allergic reactions. Innovative processing procedures may help mitigate this risk [24]. Additionally, anti-nutritional substances found in some insect species, such as oxalates, tannins, and alkaloids, may affect protein digestion and mineral absorption [25]. Addressing these safety concerns is essential for ensuring the viability of insects as a sustainable and safe source of nutrition for poultry.

### Overall benefits of insect meal for poultry health and performance

Insect meal offers a myriad of benefits for poultry health and performance, enhancing overall productivity and feed conversion efficiency [26]. It has positive effects on poultry production, including improved body weight [27] for broilers and increased egg production [28] in layers. Additionally, the presence of antimicrobial peptides, chitin, medium-chain fatty acids and lauric acid in insect meal presents a promising solution to combat bacterial antibiotic resistance, offering optimism in the face of this widespread problem. These components contribute to improved gut health and function, promoting better food digestion and nutrient absorption in poultry [29]. Overall, the incorporation of insect meal into poultry diets represents a sustainable and effective strategy to enhance poultry health, performance, and resilience against bacterial challenges.

### Challenges

According to the International Platform of Insects for Food and Feed (IPIFF), the insect protein industry will have to face three main challenges to reach its full potential. First, the insect industry will need to considerably scale up to meet the growing demand for insect-based protein sources in poultry diets. This entails overcoming logistical, infrastructural, and investment challenges associated with expanding production operations. Second, insect producers must focus on producing nutritious and high-quality products to meet the evolving demands of the market. Factors such as insect species, feed substrate, and processing methods play crucial roles in determining the nutritional quality of insect meal. Therefore, optimizing rearing conditions and processing techniques is essential to ensure that insect-derived feed products meet the nutritional requirements of poultry. Lastly, strict adherence to general feed laws and regulations is imperative for insect producers. Variability in regulations across regions and countries poses challenges for compliance, highlighting the need for clear and consistent regulatory frameworks. By addressing these challenges, the insect protein industry can unlock its full potential as a sustainable protein source for poultry diets [5].

## Limitations

Incorporating insects into animal feed faces several limitations that need to be focused. One significant barrier is the limited number of reared insect species suitable for mass production. Another challenge lies in the presence of specific anti-nutritional compounds such as protease inhibitors, oxalates, tannins, lectins, and alkaloids in insect meal, which can affect nutrient absorption and animal health. Additionally, to gauge the economic feasibility of integrating insects into poultry feeding, regular cost-benefit analyses are necessary. These analyses would delve into how the inclusion of alternative ingredients, like insect meal, influences overall production costs. By addressing these limitations and conducting further research, the potential benefits of incorporating insects into animal feed can be better understood and utilized [5].

## Future Outlook

Looking ahead, the future outlook for insect meal as a protein source in poultry diets holds considerable promise, driven by several key factors

- **Advancements in Production Technology:** Continued advancements in insect production technology and efficiency are anticipated to increase the scale of production while decreasing costs. This improvement in scalability and cost-effectiveness will enhance the competitiveness of insect meals compared to traditional protein sources in the poultry industry.
- **Regulatory Developments:** Regulatory developments regarding alternative protein sources could open up new market opportunities for insect-based feeds in the poultry industry. Clearer regulations and standards may facilitate broader acceptance and adoption of insect-derived products within the feed market.
- **Need for Further Research:** Despite the potential benefits, more research is needed to fully understand the nutritional value of insect meals, identify any potentially harmful components, develop effective decontamination techniques, and establish optimal storage conditions. This ongoing research is crucial for ensuring the safety, quality, and efficacy of insect-based feed ingredients.
- **Promising Future Prospects:** Overall, the future prospects of insect meal as a protein concentrate for poultry diets are promising. With continued research and development efforts, there is a greater probability of fulfilling the growing demand for economical and sustainable protein sources in the poultry industry. By leveraging technological advancements, regulatory support, and ongoing research initiatives, insect-based feeds have the potential to play a significant role in addressing the protein needs of the poultry sector while contributing to sustainable agricultural practices.

## Conclusion

In conclusion, the mass production of insects using waste materials presents a promising opportunity to generate a sustainable novel feed ingredient for the poultry-feed sector while simultaneously addressing the environmental impact of food waste. Applied research has demonstrated encouraging results, highlighting insect-derived products as one of the most intriguing and sustainable sources of nutrients for animal feed. However, it is important to acknowledge that the insect protein industry is still in its early stages of development. Further research is needed to fully explore the potential of insect-based feed ingredients, optimize production processes, and ensure product safety and quality. Additionally, a clear legal framework is essential to provide guidance and regulations for the industry's growth and integration into mainstream animal feed markets. With continued innovation, collaboration, and regulatory support, the insect protein industry has the potential to make significant contributions to sustainable agriculture and food security.

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