



International Journal of Veterinary Sciences and Animal Husbandry



ISSN: 2456-2912

NAAS Rating (2025): 4.61

VET 2025; SP-10(9): 16-19

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www.veterinarypaper.com

Received: 21-07-2025

Accepted: 24-08-2025

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Alternative feed ingredients in poultry diets: A review of nutritional potential, processing technologies, and challenges

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DOI: <https://www.doi.org/10.22271/veterinary.2025.v10.i9Sa.2555>

Abstract

The pressing need for sustainable feed options that lessen reliance on traditional components like maize and soybean meal is highlighted by the rising demand for poultry products worldwide. Agro-industrial by-products, crop leftovers, and new proteins from insects, algae, and single-cell organisms are examples of alternative feed resources that have intriguing opportunities to improve circularity, reduce feed costs, and diminish environmental effect. However, socioeconomic limitations pertaining to cost competitiveness and farmer acceptance, technical obstacles such as seasonal availability, storage, and processing demands, and nutritional challenges such as variability in composition, anti-nutritional factors, and poor digestibility are impeding their adoption. The potential of these resources can be unlocked with the aid of cutting-edge techniques including extrusion and fermentation, enzyme supplementation, digestible amino acid-based formulations, and synthetic amino acids. Looking ahead, alternative feeds can be positioned as a cornerstone of sustainable poultry production, guaranteeing profitability, bird health, and resilience against future challenges. This can be achieved through targeted use in broilers and layers, integration into organic and antibiotic-free systems, and the exploration of novel proteins.

Keywords: Poultry nutrition, alternative feed ingredients, sustainability, novel proteins, feed processing, gut health

Introduction

As the area of animal husbandry with the greatest rate of growth worldwide, poultry production is essential to maintaining food and nutritional security. Due to their low cost, superior protein, and advantageous nutritional profile in comparison to red meat, poultry meat and eggs have become extremely sought-after commodities, driven by increasing urbanization, population growth, and shifting consumer preferences (Makkar *et al.*, 2014; Alexandratos & Bruinsma, 2012) [8, 3]. Furthermore, with a comparatively smaller carbon footprint per unit of protein produced, poultry farming is sometimes regarded as being more ecologically friendly and resource-efficient.

However, the chicken industry's extraordinary expansion has also increased demand for traditional feed ingredients like soybean meal and maize. These feed ingredients, which make up the bulk of poultry diets worldwide, are under increasing pressure from rival businesses such as the production of biofuel and human food processing, in addition to the cattle industry. Due to this reliance on a limited selection of traditional feedstuffs, costs have increased, supply chains have fluctuated, and people are more susceptible to shocks from the global market (Fitches *et al.*, 2017) [6]. By 2027, the demand for chicken feed is expected to reach 890 million metric tons worldwide, with a compound annual growth rate (CAGR) of 7.1%. This highlights the critical need for feed diversity.

In this regard, alternative feed sources have drawn more attention as viable ways to lower production costs, improve sustainability, and lessen feed-food rivalry. Agro-industrial waste, agricultural waste, new protein sources including insects, algae, and single-cell proteins, and locally accessible non-traditional feed ingredients are some of these substitutes. In addition to

solving issues with cost and availability, many of these resources have useful qualities, such as bioactive chemicals that can improve immunity, gut health, and poultry performance in general.

The goal of this analysis is to present a thorough synthesis of the opportunities, challenges, processing technologies, and nutritional potential related to incorporating alternate feed sources into chicken diets. The article aims to support the global development of more resilient and sustainable chicken production systems by showcasing innovations and new viewpoints.

Alternative feed ingredient definition

Alternative feed ingredients are basic materials that are not frequently used in regular poultry diets. They are also known as non-traditional or novel feeds. In the past, their limited utilization has typically been ascribed to information gaps about their cost-effectiveness, availability, digestibility, and nutritional makeup (Dale, 2008) [5]. However, the scope and significance of alternate feed resources have significantly increased in tandem with the ongoing worldwide need for chicken feed. These days, it is becoming more widely acknowledged that these nutrients are essential to creating robust and sustainable chicken feeding systems.

A feed ingredient's designation as "alternative" is very contextual and depends on factors including geographic location, the availability of local resources, and accepted industry standards. For instance, other cereals like wheat or sorghum may be classified as alternative grains in nations like the USA, China, and Brazil where maize is the primary cereal grain in poultry diets. On the other hand, wheat is regarded as a traditional feed element in places like Europe and Australia. Similarly, the geographical heterogeneity in categorization is demonstrated by agro-industrial by-products. For example, palm kernel meal (PKM), which is often used in chicken diets in Southeast Asia, is considered a non-traditional feed resource in Africa.

A new wave of innovative protein sources is emerging as possible substitutes for traditional soybean meal, in addition to regional by-products. Single-cell proteins (derived from bacteria, fungi, and yeast), algae (both micro and macroalgae), and insects like the larvae of the black soldier fly (*Hermetia illucens*) are all receiving more and more attention as sustainable and nutrient-dense feed sources (Makkar *et al.*, 2014; Veldkamp & Bosch, 2015) [8, 12]. In addition to providing protein security, these innovative ingredients also support the circular bioeconomy by minimizing environmental impact and repurposing waste streams.

As a result, the definition of substitute feed items cannot remain constant. It needs to take into consideration local customs, changes in the use of feed resources over time, and the dynamics of the global poultry market. Because chicken nutrition is flexible in response to changing sustainability issues and resource availability, what is deemed non-traditional in one area or era may become standard in another.

Requirements for Using Other Raw Materials

A number of nutritional, technological, and socioeconomic obstacles still prevent the widespread use of alternative feed ingredients in chicken diets, despite their potential to lessen reliance on traditional feed supplies (Ravindran & Blair, 1991) [11]. These restrictions have an impact on the practicality and economic viability of using such resources in commercial production systems, in addition to the

effectiveness of nutrient consumption.

Limitations in nutrition

Constitute one of the most significant obstacles. The nutritional makeup of many substitute products varies greatly, making feed formulation and animal performance inconsistent. Their use is further restricted by the presence of anti-nutritional factors (ANFs), including lectins, tannins, phytates, and protease inhibitors. Furthermore, a number of substitute feedstuffs have significant fiber content, which leads to poor digestibility and unbalanced amino acid (AA) profiles, especially those that lack critical amino acids like methionine and lysine. In addition to lowering voluntary feed intake, poor palatability further lowers their usefulness.

Technical limitations

This is just as important. It is difficult to guarantee year-round availability since the supply of many alternative feed alternatives is seasonal or unpredictable. Their widespread use is constrained by handling and storage problems, including as bulkiness, dustiness, and spoiling vulnerability. Furthermore, in order to enhance their nutritional quality and safety, some by-products need further processing stages like dehulling, drying, fermentation, or extrusion, which can be costly and energy-intensive. Accurate diet design is hampered by the lack of comprehensive research data on digestible amino acid levels and metabolizable energy (ME), which exacerbates these problems.

Another important factor restricting the usage of alternate feeds is socioeconomic restraints. These resources frequently directly compete with human consumption, especially when it comes to grains, pulses, and oilseed derivatives. Due to their poor profitability, farmers could be hesitant to grow crops that produce these by-products, which would limit the supply of raw materials on a large scale. Additionally, certain alternative ingredients have high nutritional costs per unit that are frequently higher than those of traditional feedstuffs, which deters commercial adoption.

Table 1: Key Limitations of Alternative Feed Ingredients

Category	Examples of Issues
Nutritional	Variable composition, ANFs, poor protein quality
Technical	Processing needs, logistics, lack of standard evaluation methods
Socio-economic	Competition with food industry, inconsistent supply

Techniques for Overcoming Nutritional Obstacles

Targeted solutions to overcome the inherent nutritional constraints of alternative feed ingredients are necessary for their effective usage in poultry diets.

Assessment of feed

It is essential to this procedure. More accurate nutritional profiles and precision diet design are made possible by the introduction of standardized techniques for calculating digestible amino acids (AA) and apparent metabolizable energy (AMEn) (Mateos *et al.*, 2018) [10]. Frequent feed evaluation reduces formulation mistakes by ensuring that nutritional matrices are updated with the most recent values.

The transition from crude protein to digestible AA-based formulations has been a significant advancement. This method lowers nitrogen excretion and increases the effectiveness of protein use. For example, when diets are designed on a digestible AA basis, broiler diets may safely incorporate up to 16% palm kernel meal (PKM) without

experiencing negative effects (Abdollahi *et al.*, 2016) [1].

The nutritional balance of meals is further improved by the addition of synthetic amino acids such as lysine, methionine, and threonine. These are especially crucial for maintaining growth performance and resolving amino acid imbalances in low-protein diets or when fibrous substances are employed.

Another effective method to improve nutrient consumption is the use of exogenous enzymes. In addition to increasing food digestibility, enzymes like xylanases, glucanases, and phytases also lessen the adverse effects of anti-nutritional factors (ANFs). Higher inclusion rates of substances rich in non-starch polysaccharides (NSP), such as canola meal and wheat bran, are made possible by this (Adeola & Cowieson,

2011) [2].

Last but not least, different feed processing methods might raise the nutritional content of substitute components. In fibrous diets, pelleting improves feed efficiency and nutritional availability. Extrusion has been demonstrated to enhance digestibility and lower ANFs, particularly in legumes (Hejdysz *et al.*, 2016) [7]. Conversely, fermentation can increase the functional value of feed ingredients, lower the amount of fiber, and improve the quality of the protein.

When combined, these nutritional, biochemical, and technical approaches help to overcome the drawbacks of alternative feed sources, making it possible for chicken production to employ them in a sustainable and safe manner.



Fig 1: Flowchart showing strategies to overcome limitations

Prospects for the Future

In the upcoming years, it is anticipated that the use of alternative feed components in chicken nutrition will increase dramatically due to changes in customer preferences, welfare, and sustainability. The difference in tolerance between layers and broilers is one crucial factor to take into account. According to Abdollahi *et al.* (2016) [1], broilers can usually only handle around 10% of fibrous feedstuffs, but layers may safely incorporate up to 30% of such feeds by using layers. This emphasizes the necessity of feeding plans tailored to the species and stage of development in order to optimize the use of substitute ingredients without sacrificing effectiveness.

The management of gut health and wellbeing represents a second promising field. By encouraging good bacteria populations and facilitating better digesta transit, high-fibre substitute components may improve intestinal functioning. These compounds may offer a natural way to lower the risk of enteric illnesses while promoting bird welfare in production systems without antibiotics, where issues with gut health are a big worry.

Opportunities for the wider use of alternative diets are also created by the growth of free-range and organic chicken

production methods. Naturally occurring, varied, and locally accessible feed supplies are more suitable with these systems by nature. Adoption of non-traditional feed additives is also financially motivated by customer demand for welfare-friendly and organic goods.

Lastly, a new horizon in sustainable poultry nutrition is represented by novel protein sources including insects (Paramasiva I *et al.*, 2024) [8], algae, and single-cell proteins. By lowering dependency on water- and land-intensive crops like soybeans, these ingredients not only offer premium proteins with advantageous amino acid profiles, but they also support environmental sustainability. According to life cycle evaluations, these additives can encourage circular resource use and reduce greenhouse gas emissions (Bosch *et al.*, 2014) [4]. Their effective incorporation into commercial chicken diets will depend on increasing their production and obtaining regulatory approval.

All of these opportunities point to a change toward more robust and sustainable feeding systems, where new technology, gut health, production system compatibility, and precision nutrition come together to reshape the chicken industry's future.

Table 2: Promising Alternative Feed Resources for Poultry

Category	Examples	Potential Inclusion
Agro-industrial by-products	Rice bran, PKM, maize DDGS, canola meal	10-30% (depending on species)
Insects	Black Soldier Fly larvae, mealworms	5-25% protein replacement
Algae	Spirulina, Chlorella	2-10% in broiler diets
Single-cell proteins	Yeast, bacteria	Up to 20% protein replacement

Conclusion

The pressing need for sustainable feed options is highlighted by the rising demand for chicken products worldwide. Problems with traditional reliance on maize and soybean meal include growing expenses, competition from human food, and environmental issues. There are hopeful ways to lessen this reliance by using other feed materials, such as fibrous wastes, insects, algae, and single-cell organisms, as well as agricultural byproducts. However, socioeconomic limitations, processing challenges, anti-nutritional effects, and nutritional diversity prevent their broad acceptance.

Strategies include accurate feed evaluation, formulations based on digestible amino acids, supplementing with synthetic amino acids, and using exogenous enzymes are crucial to overcoming these obstacles. Pelleting, extrusion, and fermentation are examples of processing methods that further improve the safety and nutritional content of unusual substances.

Going forward, there is room for a wider integration of alternate feeds due to species-specific strategies, particularly the higher fiber tolerance in layers, as well as chances in organic and free-range systems. Sustainable nutrition gains a new dimension with the introduction of novel proteins.

In conclusion, the thoughtful integration of alternate feed sources may improve poultry production's resilience, sustainability, and profitability while advancing the objectives of global food security.

Conflict of Interest

Not available

Financial Support

Not available

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How to Cite This Article

Kumar D, Rathod KD, Kale SM, Maurya R, Bhosale TR. Alternative feed ingredients in poultry diets: A review of nutritional potential, processing technologies, and challenges. International Journal of Veterinary Sciences and Animal Husbandry. 2025; SP-10(9): 16-19.

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