ID: 534

# Alternative Protein Sources Used in Poultry Nutrition: Insects

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**Abstract**

In animal nutrition, it is important to provide a balanced diet that is sufficient in terms of protein to ensure the continuity of vital activities. The protein composition of the feed given to the animal should be both economical and sustainable and environmentally friendly. When the protein given to the animal is sufficient, it strengthens the animal's immunity and reduces the risk of contracting diseases, but when it is insufficient, the animals' productivity decreases and if the insufficiency is not met for a long time, it can result in death. In broiler chicken production, where high live weight gain is targeted in a short time, it is important to meet the high protein and energy needs of the animals. In this context, animal and plant protein sources are used to meet the protein needs in poultry nutrition. Today, as a solution to the problems experienced in the supply of these resources as a result of their insufficiency and high cost, sustainable alternative protein and feed raw material searches continue. Insects, potentially requiring less space and water and also being able to be produced quickly on organic wastes, show that they are economically feasible alternative protein sources. In this review, the advantages and disadvantages of using insects in animal nutrition are discussed and studies conducted on poultry nutrition of some insects are mentioned.

***Key Words:*** *Animal nutrition, Insects, Protein source, Poultry, Sustainability*

## Introduction

Today, protein sources used in animal feeds are mainly soybean meal, fish meal and processed animal origin proteins. While an increase in resources is expected to meet the protein needs of animals, the decrease in soybean lands and fish stocks worldwide, as well as the last 10 years of information, has caused the price of soybean meal and fish meal to almost double (Jozefiak & Engberg, 2015). The reason for such a pricing increase is the imbalance between supply and demand. One of the main costs in poultry production is feed, and feed costs constitute 60-70% of the production cost. Reducing production costs and providing a cheap protein source that is nutritious for animals is important for sustainability and the environment, and it also provides an important step for people to access animal protein more cheaply (Özek, 2016).

It is important to identify economical and sustainable alternative raw material sources in animal nutrition and to conduct research in this direction. In broiler chicken production, where high live weight gain is targeted in a short time, it is important to meet the high protein and energy needs of the animals. Some protein sources used in broiler chicken rations for high protein requirements are soybean meal, sunflower seed meal, meat meal, meat-bone meal, fish meal. 25-35% of poultry rations contain full-fat soybean and soybean meal (Ergül, 2008; Işık & Kırkpınar, 2017). However, the inadequacy of plant protein sources in meeting the protein needs of broiler chickens has made it necessary to use animal-based protein sources. In our country, in this context, the use of slaughterhouse wastes causes problems due to Salmonella and the inability to fully determine feed values. Of the aforementioned slaughterhouse wastes, meat meal, meat-bone meal and blood meal carry the risk of Salmonella if they are not processed with appropriate methods (Aslantaş, 2004). Insects are thought to be potentially effective in reducing feed costs in broiler feeding. In addition, studies have shown that there is no significant difference in the nutrient composition of insects compared to fish meal and soybean meal, and therefore their use will have a positive effect on production profitability.

## Insects

Although they are in the Arhropoda phylum of the animal kingdom, insects (Insecta) constitute the richest class in terms of species diversity (Gillespie et al., 2018). There are almost 1 million insect species named so far, and it has been stated that approximately 2000 of them are suitable for use as human and animal food (Van Huis, 2013). Recently, the use of insects as animal feed in addition to human food has frequently come to the fore and many studies are being carried out in various parts of the world (Erwin, 2004; Sánchez-Muros et al., 2014; Van Zanten et al., 2015; Yüksel & Canhilal, 2018). Insects are natural protein and feed sources for poultry, fish and birds, which are rich sources of protein (Ssepuuya et al., 2017).

Insects may need very different nutrients at different stages of their lives and can feed on a wide variety of waste (restaurant waste, post-harvest plant waste) (Van Huis, 2013). Raising them on biological waste (Khan et al., 2016) has a positive effect on preventing environmental pollution. The rapid growth and high reproductive power of some insect species under suitable conditions are important for the sustainability of production. Insect farming is much more economical when compared to the areas allocated for the cultivation of other protein sources such as forage crops and water requirements, as small areas are used in the cultivation of insects and they generally meet their water requirements from the food they consume. In addition, insect farming is more environmentally friendly when compared to cattle farming, as less greenhouse gas and ammonia are released into nature. In addition, the rate of benefiting from the food consumed by insects is also quite high (Van Huis, 2013). In addition to varying according to insect species and biological period, many insects have protein content ranging from 40-80% and important essential amino acids. Insects are also rich in some minerals (Van Huis, 2013; Sánchez-Muros et al., 2014; Barroso et al., 2014; Henry et al., 2015). The insect species with the highest potential for use as animal feed in the European Union (EFSA, 2015) are shown in Table 1.

Table 1. Insect species with the highest potential for use as animal feed and their information (EFSA, 2015).

| Scientific Name | English Name |
|---|---|
| Musca domestica L. (Diptera: Muscidae) | Common Housefly, |
| Hermetia illucens L. (Diptera: Stratiomyidae) | Black Soldier Fly |
| Tenebrio molitor L. (Coleoptera: Tenebrionidae) | Mealworm, |
| Zophobas atratus F. (Coleoptera: Tenebrionidae) | Giant Mealworm |
| Alphitobius diaperinus P. (Coleoptera: Tenebrionidae) | Lesser Mealworm |
| Galleria mellonella L. (Lepidoptera: Pyralidae) | Greater Wax Moth, |
| Achroia grisella F. (Lepidoptera: Pyralidae) | Lesser Wax Moth |
| Bombyx mori L. (Lepidoptera: Bombycidae) | Silkworm, |
| Acheta domesticus L. (Orthoptera: Gryllidae) | House Cricket |
| Gryllodes sigillatus L. (Orthoptera: Gryllidae) | Banded Cricket, |
| Locusta migratora migratorioides (Orthoptera: Acrididae) | African Migratory Locust, |
| Schistocerca Americana D. (Orthoptera: Acrididae) | American Grasshopper, |

**Advantages and Limitations of Using Insects in Animal Nutrition**

The ability to grow insects used in feed on manure and organic waste is important in terms of sustainability as well as preventing environmental pollution. Insects are used not only in their adulthood but also in developmental stages such as larvae and pupae. In addition to their very fast development, their feed utilization is very high. Approximately 2 kg of organic waste and 1 $m^2$ of area are sufficient to produce 1 kg of insect protein (Van Broekhoven et al., 2015). When considered from an environmental perspective, insects release much less greenhouse gas and ammonia into the atmosphere compared to cattle and pigs for the production of 1 kg of meat (Smith & Pryor, 2014). In addition, it is stated that the use of insects in feed will minimize the damage caused by insects to the product in the field, limit the use of pesticides and contribute to the reduction of environmental pollution (Odabaşı and Yeşilbağ, 2020).

Insects, in addition to their advantages, also bring some risks that need to be considered. These risk factors can be listed as microbial, chemical, toxicological and allergic risks (Odabaşı and Yeşilbağ, 2020). Insects can digest the food they consume thanks to the microbiota in their intestines, and this microbiota can vary depending on the type of insect, the food they feed on and the place where they are grown (El-Tabey, 1951). The microorganisms (bacteria, viruses, etc.) that insects host in their intestines and on their body surfaces can also be found in feeds by participating in the processing stage. These microorganisms can have a pathogenic effect on other insects and the animals that consume them. The most important point to note is that although there is a possibility of pathogenic effects that can reach humans within the food chain, there are few articles reported on this subject. There are studies showing that some microorganisms (Entomopathogens) that cause the death of insects can also be pathogenic for humans (Gerrard et al., 2003; 2004). Insects can contain heavy metals (cadmium and arsenic, etc.), pesticide residues, mycotoxins and plant toxins depending on the plants they feed on. In addition, it is known that some insects can produce their own toxins (Hogan & Razniak, 1991; Devkota & Schmidt, 2000; Zhuang et al., 2009). Although it is known that some insects contain various allergens, no allergic condition has been encountered in the literature as a result of feeding insects to farm animals or pets. (EFSA, 2015).



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**The Use of Different İnsects in Poultry**

The need for animal protein is increasing day by day and it is predicted that the need for animal protein will increase by 45% between 2010 and 2030 (İpçak & Alçiçek, 2015). However, the scarcity of protein-rich raw materials used in animal nutrition may pose a significant threat to the sector.

Our country faces difficulties in both domestic and foreign markets due to its dependence on imports of some protein-based feed raw materials. Considering that almost 70-80% of the costs in poultry production are feed-based and that primarily rendering products and soybeans are rich in essential amino acids used in feed, changes in the prices of these raw materials can lead producers into financial difficulties. Therefore, it is of critical importance to identify sustainable alternative raw material sources in animal feeding, as well as being economical (Odabaşı & Yeşilbağ, 2021).

The maintenance protein requirement in chickens is low. In other words, a large portion of the protein consumed is used to meet the yield protein requirement. When looking at broiler diets; it is known that the crude protein (CP) rate is 22-25% in the starter period, 21-23% in the grower period, and 19-23% in the finisher period (Ross Broiler Handbook, 2014). Meeting these high levels of crude protein requirements is only possible with animal protein sources. In addition, the protein amount calculated according to the survival and yield period must be balanced with essential amino acids (Odabaşı & Yeşilbağ, 2021).

The protein sources mainly used in broiler nutrition in poultry nutrition are divided into vegetable protein sources (such as soybean meal, sunflower meal, cottonseed meal and canola meal) and animal protein sources (such as fish meal, meat-bone meal, bone meal). Vegetable protein sources are found in lower amounts and have restrictive properties compared to animal protein sources in terms of essential amino acid content, especially lysine and methionine. Animal protein sources can pose a potential risk to animals and humans in terms of contamination with pathogenic bacteria such as Salmonella spp. For this reason, the European Union banned the use of animal protein in food animal husbandry with regulation 999/2001. In Turkey, the use of poultry rendering products in poultry nutrition has been terminated as of January 1, 2017 (Odabaşı & Yeşilbağ, 2021). This review includes studies on the use of different insect species in poultry nutrition.

In order to determine whether maggots can be used as an alternative to fish meal, they used them in broiler feeds at different rates (25-50-75-100%) and it was reported that the most effective maggot usage rate was 25%. As a result, they reached the conclusion that maggots are a cheap feed raw material that can be used instead of fish meal (Awoniyi et al. 2003).

It has been stated that adult field grasshoppers can be used in broiler feeds and that grasshopper meal used up to 15% as an alternative to fish meal did not have any negative effects on live weight gain, feed consumption and feed conversion ratio and can be evaluated especially in disadvantaged regions to fill the protein gap (Wang et al. 2005).

In a study conducted to evaluate Cirina forda larvae as a raw material for poultry feed, 50% and 100% Cirina forda larvae were substituted for fish meal in broiler feeds. As a result of the trial, it was observed that Cirina forda larvae did not significantly change the weight gain and growth rate of the animals. As a result, it was stated that C. forda larvae could be an alternative to traditional fish meal as a protein source (Oyegoke et al. 2006). In another study conducted on Westwood (Crina forda), they conducted a study to determine the effects of using its larvae in laying hen diets as an alternative to fish meal in tropical regions at different rates (0, 25, 50, 75 and 100%) on egg-laying performance and egg quality. As a result of the study, a significant decrease was observed in daily egg production when 100% (Crina forda) larvae were substituted for fish meal in laying hen feeds, and it was concluded that other egg quality parameters, such as egg yolk score, shell thickness and Haugh unit, were not significantly affected. However, it was concluded that Crina forda larvae can be used as up to 75% of fish meal in laying hen diets (Amao et al., 2010).

(Awoniyi, 2007) stated in the study maggots are a good source of protein that can be used in egg production as well as in poultry meat production.

In a study conducted using different rates (5, 10, 15 and 20%) of house fly maggots in broiler diets, the effects of house fly maggots on broiler performance and meat quality were investigated and it was determined that the most effective dose level for broilers was 10-15% of house fly maggots in the diet. It was found that the mentioned dose levels significantly increased carcass yield, breast muscle and thigh muscle ($P<0.05$) (Hwangbo et al., 2009). In a different study, it was reported that Musca domestica (house fly) larvae significantly increased weight gain and feed consumption in broilers when compared to soybean meal containing diets and it was determined that the larvae did not cause any toxicity in the gizzard. It was observed that the carcass and breast muscle ratio increased significantly in the groups receiving 10% house fly larvae compared to the group receiving soybean meal, however, it was concluded that the breast, thigh muscle color and pH parameters were not significantly affected (Pretorius, 2011).

In a study evaluating the meat of chickens raised in pastures with a predominantly locust population in Tibet, it was determined that chickens raised in such pastures had a stronger antioxidant potential and a longer preservation period (Sun et al., 2012).

Jacob (2013) stated that the nutritional components of poultry meat and eggs may differ depending on the type of insect consumed, and it was also determined that the fat content of eggs increased as a result of insect consumption. It has been stated that Hermetia illucens (Soldier Fly), a fly species belonging to the stratiomyidae family of the order of insects (insecta), diptera (Robinson, 2005), can be used for poultry feeding due to its nutrient content (more than 40% protein and more than 30% fat) (Newton et al., 2005). At the same time, it has been determined that thanks to the insect production system combined with chicken coops, it significantly reduces environmental pollution caused by manure (50-60%) and reduces the development of harmful bacteria (Erickson et al., 2004).
Musca domestica (Housefly) is found in the diptera order of insects, in the muscidae family, and it has been stated that it can be evaluated as an excellent protein source, especially in the nutrition of poultry (Işık and Kırkpınar, 2017). When housefly larvae meal was used by replacing fish meal in rations containing 25% fish meal in poultry and when a comparison was made, it was concluded that housefly larvae meal provided a better live weight (Awoniyi et al., 2003).
(Wang et al., 2005) prepared 4 different formulation groups containing different proportions of meadow crickets (0%, 5%, 10% and 15%) in a study conducted with castrated roosters and determined the amino acid properties of meadow crickets and the actual metabolizable energy values accordingly and compared them with fish meal. As a result, the actual digestible amino acid levels of meadow crickets and the actual digestible amino acid levels of fish meal were determined as 92.9% and 91.3%, respectively. As a result of the experiment, no significant difference was observed between the groups when live weight gain, feed consumption and feed utilization rates were taken into consideration in roosters.
In a study conducted by Açıkgöz and Tolon, they stated that silkworm chrysalis flour has the potential to be applied in poultry nutrition (Açıkgöz & Tolon, 2003).

**Conclusion and Recommendations**

As a result of the predictions of the International Feed Industry Federation (IFIF) and the Food and Agriculture Organization (FAO) that the need for animal protein will increase further by 2050, it is estimated that the cost of animal product production and consumption will be negatively affected. The need for protein sources in the poultry sector, which is among the advanced sectors of our country, will also cause insects, which are among the alternative protein sources, to be considered as a potential protein source in this field. While it has many advantages such as being economical as well as being environmentally friendly, it is one of the alternative protein sources, and it increases concerns due to issues such as the microbial, chemical, toxicological and allergic effects caused by insect production and the lack of standardization in production. It should not be forgotten that more research is needed on the use of different insects in broiler feeds, and it is evaluated that the use of insect-origin protein sources in poultry feed should be implemented within the scope of legislation to be prepared based on scientific data.

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