



Possibilities of using insects in feeding turkeys – A review

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Abstract: Turkey meat is an essential part of a healthy human diet due to its nutritional, hypoallergenic and dietary properties (). The nutritional and biological value of this meat is determined by the content of essential amino acids, their good ratio, and also by its good digestibility. Problems in raising turkeys is the high price of obtaining turkey meat. This is related to the requirements for high protein nutrition (about 28% protein in the mixtures) in the early stages of raising the chicks. Various studies have found that insects can be an alternative protein source in poultry nutrition. In addition to their good nutritional qualities, insects are rich in bioactive substances. This review of the literature available to us examines the possibilities of using insects and insect products in turkey nutrition.

Keywords: turkeys, insects, alternative protein source, turkey nutrition

Introduction

Growing turkeys worldwide as a branch of poultry farming is a source of valuable dietary meat. Numerous studies have reported that turkeys are characterized by high growth intensity, good feed conversion and high slaughter yield from 70.08% to 81.35% (Lalev, 1993; Hristakieva, 2006; Olakova et al. 2008; Olakova et al. 2009; Al Hafiz Abdelrahman Hassan et al. 2014; Lalev et al. 2018; Chartrin et al. 2019). Turkey meat is known to be a very good source of protein of animal origin and also contains phosphorus, B vitamins and minerals, preventing anemia and cardiovascular diseases in consumers (Amirkhanov et al. 2017; Lisitsyn et al., 2018). Turkey meat is an essential part of a healthy human diet due to its nutritional, hypoallergenic, safe and dietary properties (Lisitsyn et al., 2018). The nutritional and biological value of this meat is determined by the content of essential amino acids, their good ratio, and also by its good digestibility. It contains a high amount of protein (up to 28% vs. 14-18% in other poultry meat) and a moderate amount of fat (1–5%), and has the lowest level of cholesterol compared to other types of meat (Jukna and Valaitienė, 2012; Oblakova et al., 2016; Okuskhanova et al., 2017). White meat from skinless turkey breast is low in fat, approximately 1.0% (Laudadio et al., 2009; Mikulski et al., 2012). Problems in raising turkeys is the high price of obtaining turkey meat. This is related to the requirements for high protein nutrition (about 28% protein in the mixtures) in the early stages of raising the turkey poults (Hristakieva, 2021).

This review article provides an overview of the possibilities of including some insects and their products in turkey feed as a protein source and their effects on animal growth, meat quality and overall health. Concerns about the safety of raising insects or feeding insect-based diets are also addressed.

Nutritional characteristics of some insects and their products used for feeding in poultry farming

The European Commission has authorized the use of insect meals in fish feeding ponds [Reg. (EU) 2017/893] The Regulation specifies the seven permitted insect species [Black soldier fly (BSF) Black soldier fly larvae(BSFL) - *Hermetia illucens* (HI), common house fly (HF) - *Musca domestica*; yellow mealworm (MW) - *Tenebrio molitor*; lesser mealworm - *Alphitobius diaperinus*; house cricket- *Acheta domesticus*; banded cricket - *Grylloblatta campodeiformis*; field cricket - *Gryllus assimilis*] by defining the permitted breeding substrates on which insects can be reared. As insects are "farmed animals", they can only be fed feed materials of animal origin listed in Regulation (EU) 2017/1017 (ie fishmeal, blood, non-ruminant products, hydrolysed proteins or gelatin and collagen from ruminants, eggs, dietary products). Insects cannot feed on manure, waste containing meat, fish from restaurants, pubs or catering. Among the aforementioned insect species, BSF and MW have the highest potential for production at a production scale (Veldkamp and Bosch 2015; Schiavone et al. 2017; Allegratti et al. 2018; Biasato et al. 2018) and would be successfully used as source of protein in poultry.

The nutritional value of insects depends on the species, the season, the life stages, the substrate and the way the insects are prepared before consumption (Yhoun-Aree, 2010; Jensen et al., 2011). Ghosh et al., 2016 studied the nutritional composition of five preferred insect species used as food and forage in Korea, *Allomyrina dichotoma* (Coleoptera: Dynastidae), *Protaetia brevitarsis* (Coleoptera: Cetoniidae), *Tenebrio molitor* (Coleoptera: Tenebrionidae), *Teleogryllus emma* (Orthoptera: Gryllidae) and *Gryllus bimaculatus* (Orthoptera: Gryllidae). The scientists found that most of these insect species were high in protein (53.2 to 58.3%), with the exception of *Protaetia brevitarsis* - (up to 44.2% protein). The fat content of insects varies widely (11.9 to 34.5%). A total of 17 amino acids (8 essential, 1 conditionally essential and 8 substitutable) as well as 26 fatty acids (12 SFA, 6 MUFA and 8 PUFA) were determined in the composition of the studied insects. With the exception of methionine, all other essential amino acids showed a protein level recommended by FAO / WHO / UNU (2007). The absorption of amino acids from the feed component is one of the key indicators that determine its quality (Dalibard et al. 1995).

Black soldier fly larvae (BSFL; *Hermetia illucens*) are a rich source of fat (7–39% DM) and protein (37–63% DM), with a better amino acid profile than soybean meal (Dabbou et al. 2018; Barragan-Fonseca et al. 2017). In a study by Lalev et al.2020 on the amino acid composition of Silkworm meal (SW), Black soldier fly defatted (BSFd) and Black soldier fly whole larvae (BSFw) meals using the *HPLC Waters AccQ Tag method*, the following composition presented in Table 1 was found .

Table 1. Chemical composition of insect meal

Parameters	SWM**	BSFd **	BSFw**
Fat content, %	24.50	7.79	13.48
Protein content, %	57.14	56.16	44.76
Moisture content, %	11.50	1.03	0.83
Gross energy, kcal/kg	5831	2090	2325
Calcium, %	0.55	0.84	0.18
Phosphorus,%	0.75	0.67	0.43
Amino acid content, %			
Valine	5.60	4.79	4.35
Isoleucine	6.90	4.93	4.00
Leucine	7.24	1.00	0.82
Lysine	3.83	8.04	6.92
Methionine	3.70	1.88	6.41
Methionine+ Cystine	4.65	11.22	13.32
Threonine	5.20	5.19	4.32
Phenylalanine+Tyrosine	10.70	7.91	5.75
Arginine	4.50	7.16	5.81
Glycine	4.70	2.71	1.94
Histidine	2.90	11.25	10.90

*Source: Lalev et al. 2020;

**Silkworm meal- SWM, Black soldier fly defatted -BSFd and Black soldier fly whole larvae -BSFw meals

The protein and its composition of amino acids (AA) in the feed must meet the requirements of the birds. Amino acids, in particular those that cannot be synthesized in the body and are therefore called essential AAs (EAAs), play a key role in regulating homeostasis throughout the biological system, including body maintenance, growth, immunity and reproduction. Most poultry feeds are based on soybean meal (SBM), which is a well-balanced source of protein in terms of AA composition (Ross et al. 2019). It can be seen from Table 1 that the values of these AAs- lysine (Lys) was highest in BSFd and BSFw, arginine (Arg) again higher in BSFd and BSFw and methionine in BSFw (Met) compared to SWM.

The fatty acid profile of BSF larvae depends on the fatty acid composition of the medium on which they are reared (Nguyen et al. 2015; Spranghers et al. 2017). Insect larvae are rich in lauric acid (20–40% of all lipids), palmitic acid (11–16% of all lipids) and oleic acid (12–32% of total lipids) (Gariglio et al. 2019).

To date, the majority of research papers have been on the use of housefly larvae meal as an alternative source of protein in broiler feed. The results of these studies showed a positive influence on weight gain, feed intake and FCR. Thus, it can be predicted that larvae can be an alternative protein source in poultry nutrition. In addition to their good nutritional qualities, insects are rich in bioactive molecules with various pharmacological properties, including anticancer, antitumor, antiviral and antimicrobial properties. In addition to their good nutritional qualities, insects are rich in bioactive molecules with various pharmacological properties, including anticancer, antitumor, antiviral and antimicrobial properties. Insect meal (or live larvae) included in bird feed may offer a multi-level system of antimicrobial mechanisms to prevent the development of resistant

pathogens. Among the many components found in insect products, the group of polysaccharides, antimicrobial peptides, lauric acid, as well as antioxidants clearly show such antimicrobial potential (Petrova et al. 2021).

Potential inclusion of insects in the nutrition of production turkeys

Recently, there has been increased interest in the use of insects as a source of highly digestible feed protein, fat with antioxidants and immunostimulating properties in turkey farming. In the wild, wild turkeys start feeding on insects in the first days of their development, which is in contrast to commercial feeding in intensive farming. Insects are one of the most promising sources of protein for feed production (Tomotake et al. 2010; Secci et al. 2018; Altmann et al. 2020). There are few studies regarding metabolizable energy ME when feeding turkeys with insects. Zuidhof et al., 2003 reported optimal values of gross energy, metabolizable energy and crude protein when feeding chicks with *M. domestica* - dehydrated larvae (MDL) of 23.1, 17.9 MJ/kg and 593 g/kg, respectively, and in CD (control diet) 17.0, 13.2 MJ/kg and 318 g/kg, respectively ($P < 0.05$). Apparent digestibility coefficients throughout the tract were high at MDL. The authors concluded that dehydrated fly larvae (MDL) could successfully replace soybean meal as a protein supplement in turkey diets. Many researchers confirm the good absorption of amino acids by insects when they are included in poultry nutrition (Schiavone et al. 2017; Hall et al. 2018; Dabbou et al. 2020; Hristakieva et al. 2021). Milby and Penquite (1940) also reported that fattening turkeys willingly consumed feed containing whole grasshoppers as a protein source. Healy (1985) described that when rearing chicks, they prefer and search for insects in the litter. Despins and Axtell, 1994 conducted experiments to determine the effects of feeding larvae of the dark beetle (smaller mealworm), *Alphitobius diaperinus* (Panzer) [Coleoptera: Tenebrionidae], to turkeys on growth and feed consumption. The authors found that young turkeys willingly feed on the larvae and show reduced growth in the absence of other food. Turkeys aged from 3 days old to 5 days old, fed only larvae have a significantly lower weight than chicks fed only standard feed during the same period. After returning to standard feed for 16 days after feeding only larvae for 3 days, the chicks did not compensate for the weight loss, although weight gain was normal. The scientists concluded that if some young turkeys were fed only larvae there would be adverse effects on weight gain, a long-lasting and perhaps permanent effect for these individuals. In another experiment by the same scientists, it was reported that turkeys actively searched for beetle larvae in the litter even in the presence of age-appropriate standard feed. Larvae consumption by turkeys from 2 days of age to 10 days of age was high, and at 11 to 13 days of age there was a drastic drop in larval consumption. The inclusion of dark beetle larvae in the diet does not negatively affect the growth of turkeys. From 5 days of age to 22 days of age, turkeys fed litter beetle larvae and standard feed had significantly higher live weight compared to control turkeys fed only standard feed.

Experimental studies were conducted in the conditions of one of the largest turkey breeding enterprises in Russia, in the Tula region, with BIG-6 turkeys on the influence of the inclusion of 5-7.5% dried whole larvae of *Lucilia* spp. in turkey fattening diets. The authors found that the inclusion of *Lucilia* spp fly larvae in an amount of 5.0 and 7.5% in the diet of fattening turkeys increased growth, reduced feed costs and improved meat quality, due to the content of highly effective protein, essential amino acids and unsaturated fatty acids (Romanenko and Istomin, 2020).

The effect of live BSFL supplementation on performance has not been extensively studied in turkeys. Veldkamp and van Niekerk, 2019 investigated the effect of including live Black soldier fly larvae (BSFL) in the diet of turkeys-poults on their behavior and in particular on harmful pecking. The control groups were fed with standard mixtures adapted to the species and age of the birds, and the BSFL groups received live BSFL in the feed. The scientists found that the daily feed intake and body weight gain of the BSFL groups were significantly higher compared to the control groups with a significantly lower feed conversion ratio. During the first week, a tendency for greater feed consumption was noted in the groups fed with live BSFL, but in the third and fifth weeks, the groups fed with live BSFL showed a decrease in the consumed feed compared to the control groups. Provision of live BSFL reduces aggressive pecking, at 5 weeks of age. The incidence of feather and skin damage was lower in the BSFL groups. Ognik et al. 2020 conducted an experiment with turkeys fed with an increased content of *Hermetia illucens* HI meal - BSF in the feed (first group - 5%, second group - 10% and third group - 15%) and a control group (HI - 0%) without insect meal. The scientists found that the inclusion of 10% or 15% HI in the diet of young turkeys favorably increased the levels of P, Fe, Zn $\mu\text{mol/L}$ and Hb g/L (haemoglobin) in the blood, having a negative effect on lipid metabolism, increases TC (total cholesterol) levels, lipid oxidation and fat deposition in the liver. Inclusion of 5% HI in the diet of young turkeys had no adverse effect on lipid status and liver histology, but did not improve antioxidant status. These scientists conclude that the level of HI meal in the diet of turkeys should not exceed 5%. As the researchers recommend for more such studies, but general conclusions cannot be drawn from the results of this study.

The results from study at Lalev et al. 2021 that 10% inclusion of insect meal have positive effects on turkey meat, especially on technical parameters, such as water holding capacity and cooking loss. Breast and thigh meat responded differently to the diets. Breast meat had significant physicochemical responses to the new diets (improved water holding capacity, cooking loss), but lacked nutritional—no change in protein, lipid, or mineral content. In contrast, in the thigh, both BSF diets increase the level of lipids and Iron. Authors reported that insect diets also improve omega-3 and omega-6 fatty acid levels.

In study at Jankowski et al. 2021 the ull-fat *Hermetia illucens* larvae meal (HM) content of turkey diets was 50, 100 and 150 g/kg in groups HM50, HM100 and HM150, respectively. The authors reported that the highest inclusion rate of HM did not affect IgA levels, but it increased IgY levels in the small intestinal tissue compared with the control treatment. Increasing inclusion levels of HM did not affect the final body weight (BW) or body weight gain (BWG) of birds, but induced a linear decrease in the feed conversion ratio (FCR). The results of this study indicate that HM can be included in diets for young turkeys at up to 150 g/kg without compromising the immune status or growth performance of birds, intestinal development and function.

Conclusions

Based on the review of the available literature, we can make the following summary: Insect products have a high protein content and high nutritional value, so they can have a beneficial effect on the growth, digestibility of nutrients and health of poultry. They have a good amino acid and fatty acid profile and a rich composition of bioactive molecules (with immunostimulating and antioxidant properties and antimicrobial peptides in insects). The

studies shows that the inclusion of insects and their products have beneficial effects on the performance and health status of turkeys. Further studies could be aimed at confirming these effects, since turkeys require a high-protein diet, especially in the first few weeks of life.

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