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Evaluation of Worms as a Source of Protein in Poultry

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ABSRACT

Continuous improvement of the genetic potential through breeding studies in poultry has led to an increase in the nutrient density of the feed rations given to these animals. In poultry farming, approximately 70% to 75% of the operating costs constitute feeding costs, of which about 15% are animal proteins. The protein requirement of poultry is provided by feed stuff rations and usually by soy bean meal or fish meal. Limited production opportunities and price increases have led to the need to use alternative feed additives that can be substituted for these products. Research conducted to date suggests that worms, rich in essential amino acids and a high digestible protein source can be used as substitutes. As a source of alternative protein, worms are consumed by their poultry in their natural habitat, while intensive and extensive studies are needed to be used as a sustainable feed additive. In this review, research on the usability of worms as an alternative protein source in poultry diets has been compiled and evaluated.

1. Introduction

The fast increase in the population of the world has caused that the problems in nutrition also increased (Özen *et al*., 2005), and brought with it the difficulties in covering the animal protein needs, which are important for human nutrition (Makkar *et al*., 2014).

Eggs and chicken meat, which are among the animal protein sources, are inevitable products for human nutrition. Egg contains nearly all of the energy, fat acids, protein, vitamin, and minerals needed by human body at suitable amounts and rates. Chicken meat, on the other hand, is preferred more than red meat because of its ease in production and consumption, low cholesterol, calorie and fat amounts, high protein and calcium rates, and because of its cheap price. When compared with other nutrients, egg protein ranks the first in biological availability with 95% digestibility. Chicken meat, on the other hand, contains the amino acids that are not synthesized by human body in a sufficient amount and rate, and has proteins with high biological availability (Öztürk, 2016).

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Poultry husbandry is more economic than the other farm animals due to better food conversion ratios and short production periods. Poultry husbandry has been performed in cages where animal comfort has been provided and the most poultry husbandry amounts are achieved with lowest costs per unit with traditional and modern organic methods and with backyard poultry husbandry (Öztürk, 2016). The biggest cost in all systems applied in poultry husbandry is the feeding. Nearly 70-75% of the total poultry husbandry activities consist of feeding costs, and 15% of this rate consists of proteins (Özen *et al*, 2005; Banerjee, 1992). Soybean meal and fish meal, which are used as protein sources in poultry rations, being costly increases poultry husbandry costs (Adeniji, 2007). For this reason, it has been reported that worms and insects may be used as protein sources to ensure that poultry animals are fed in a balanced and sufficient manner and poultry husbandry activities are sustained (Van Huis *et al*., 2013).

Worms are natural nutrient sources for poultry animals. For example, chicken can pick up the earth worms and their larvae in and on the surface of the soil. When the natural role of worms in some farm animals as nutrients is considered, they may be re-evaluated for the purpose of being used as nutrients for certain poultry (Van Huis *et al*., 2013). Studies conducted so far have shown that it is technically possible to grow insects in large scales, and several authors have claimed that these insects may be used as alternative and sustainable nutrients that are rich in protein in poultry rations (Veldkamp *et al*., 2012; Khan *et al*., 2016). It was also reported that the plant wastes and other organic wastes of worms that have less hard crusts or chitosan and which are lower in digestion when compared with insects may be converted into protein with high value, and be used in feeding poultry. They may also be used in recycling of organic substances (Harword and Sabine, 1978; Prayogi, 2011). When suitable conditions appear, earthworms pass the soil through their stomach at a rate of 60% of their own live weights and make the soil become organic thus contributing to sustainable agriculture at an important rate. Including the worms, which constitute an important place in natural lives of poultry animals, again in poultry husbandry activities may create an important potential in terms of the comfort of animals, ensure quality protein at reasonable prices, and protection of the environment. In this compilation, the possibility of using worms as alternative protein sources in feeding poultry will be summarized.

2. Nutrient Composition of Worms

Worms include protein in dry matter at a rate of 64.5% and 72.9% (Table 1), and are very precious protein sources (Lieberman, 2002). The level of the proteins, which are accepted as structural elements and which take part almost in every physiological function, is directly related with the growth of worms (Hatti Shankerappa, 2013). In addition, worms contain carbohydrates at a rate of 8-20% of the dry matters of their bodies (Edwars, 1985; Ghatnekar *et al*., 2000).

Table 1.

Comparison of Worms with Fish Meal and Soybean Meal (Ghatnekar *et al*., 1995; 2000; Rumpold and Schlüter., 2013).

Protein source	Crude protein (%)	Ether extract (%)
Worm	64-73	7-10
Fish meal	61-77	11-17
Soybean meal	49-56	3

When the energy contents and nutrients of some worms are examined, it is observed that worms have high nutrient values in terms of protein, fat and mineral contents (Table 2).

Table 2.

Nutrient and Energy Contents of Worms (Bernard *et al*., 1997).

Worm Species	Dry matter (%)	Crude protein (%)	Ether extract (%)	Ash (%)	Acid detergent fiber (%)	Gross Energy (kcal/g)
Black worm	18.4	47.8	20.1	4.5	0.7	5.57
Blood worm	9.9	52.8	9.7	11.3	*	*
Earth worm	20.0	62.2	17.7	5.0	9.0	4.65
Night worm	16.3	60.7	4.4	11.4	15.0	4.93
Tubifex worm	11.8	46.1	15.1	6.9	*	*

*: Value not determined.

Watson (1957) show that approximately 80% of the cuticle consists of a protein component, which contains a high proportion of hydroxyprolyl and glycyl residues. The remainder of the cuticle is chiefly composed of polysaccharide, which when hydrolysed yields galactose and small amounts of both pentoses and hexosines. He also reported that the remaining part consisted of galactose, pentose and hexose-giving polysaccharides at smaller amounts. Edward (1985) conducted a study and reported that the muscle tissue of 100 kg worm consisted of protein at a rate of 60-70%, ether extract (EE) at a rate of 6-11%, carbohydrates at a rate of 5-21%, minerals and vitamins at a rate of 2-3%. Sabine *et al*. (1986) analyzed the protein content of 3 worm species in South Africa, and determined the CP content at 66.1%, 58.4% and 61.6% for Eisenia fetida, Eudrilus eugeniae and Perionyx excavatus respectively with 61% for fish meal. Ghatnekar *et al* (1995; 2000) reported that the dry matter of worm consisted fat 60-70% protein, 7-10% of fat, 8-20% carbohydrates, 2-3% minerals and various vitamins. Zhenjun *et al*. (1996) reported that the earthworm had a CP content at a rate of 54,7-71% in dry matter. Bernard *et al*. (1997) determined that the earthworm contained in 1.72% Ca, 0.90% total P, 0.14% Mg, 0.02% Na, 0.06% K. Paoletti *et al*. (2003) reported that the earthworm contained in

64.5% and 72.9%. Sogbesan and Ugwumba (2008) reported that the earthworm contained in 63.0% CP, 5.9% EE, 1.9% crude fiber (CF), 8.9% ash, 11.8% nitrogen free extracts (NFE), 0.43% Na, 0.53% Ca, 0.62% K, 0.94% P and 1476 kJ/100g metabolic energy. In addition, the same authors found out that the essential amino acids composition (g/16gN) for the earthworm they analyzed as arg 2.83%, his 1.47%, iso 2.04%, leu 4.11%, lys 6.35%, met 5.30%, phe 6.26%, thr 4.43% and val 4.43%. Hasanuzzaman *et al.* (2010) reported that Perionyx excavatus worm contained 46.57% CP and 8.03% EE. Hatti Shankerappa (2013) determined that Polypheretima elongata species contained 63.1% CP, 7.3% EE and 15.4% glycogen.

It has been reported in studies conducted so far that the differences between the mineral contents of worms occur due to the mineral content of the soil. The mineral composition in the bodies of the worms may vary depending on the components of the soil (Ouachem *et al*., 2015). Since the lifecycle of worms occurs in soil, the existence of minerals in the soil affects the composition of the worms. For this reason, this situation should be considered in feeding animals.

It is estimated that poultry kept in open air consume 10g soil, 7g plant and 20g insects and worms a day (Ouachem *et al*., 2015). It is observed that the soil and worm consumption of the chicken kept in free systems is not in rates that can be underestimated. It has been reported in the literature that the differences in the mineral compositions may be affected by these two sources at high levels. For this reason, this situation must be considered in using worms in feeding animals.

3. Using Worms in Poultry Nutrition

The main limiting factors in feeding poultry are the protein and energy contents of the rations. Generally, fish meal and soybean meal are used as protein sources in poultry rations in today's conditions. However, the increases in the prices of fish meal and soybean meal due to various reasons also because some increases in the prices of the rations of poultry (Tacon and Metian, 2008). Continuous increase in the prices of these products gave rise to the need for the search for new protein sources as alternatives to these two previous agents. Worms are among the alternatives that may be used as protein sources for this purpose (Zhenjun *et al*., 1996; Guerrero, 1983; Kostecka and Paizka, 2006).

When the compositions of the nutrients are analyzed it is observed that worms contain amino acids, lipids, carbohydrates and minerals that are necessary for poultry animals at high levels (Paoletti *et al*., 2003; Dedeke *et al*., 2010). As a matter of fact, since worms contain protein and amino acids at adequate levels, it has been reported that they may be used as protein sources in poultry (Akiyama *et al*., 1984; Mason *et al*., 1992).

Fisher (1988) determined that the rates of making use of the rations in poultry for which worms were used as being higher. It was also reported that the essential amino acid structure of the earthworms that will be added to the rations of poultry was suitable and could be covered with earthworms that would be added to the ration at a rate of 15% (Taboga, 1980).

Zhenjun *et al*. (1996) conducted a study and concluded that earthworms could be used as animal feed with the protein levels they contained, and added that they had a high nutritional value that was higher than that of the fish meal and soybean meal in terms of protein rate and amino acid structure.

Ali (2002) conducted a study and reported that the Perionyx excavatus epige worm in Bangladesh among the many earthworms had a potential to be used in feeding poultry because it stayed in ecological conditions nearly all year round.

Hatti Shankerappa (2013) reported that the chemical contents like protein, lipid and glycogen of Polypheretima elongata, Peronyx sansibaricus and Dichogaster bolaui worms, and the changes in their weights were at the highest levels in summer months, at the middle levels in monsoon rains, and at the lowest values in winter months. The author claimed that these worms could be used as nutrients in human consumption with fish, poultry animals and pigwash due to the high protein, lipid and glycogen contents.

Ton *et al*. (2009) determined that adding 2% worms to broiler rations caused increases in the live weight of broilers in the 10th week, and this did not have any negative effects on meat quality.

Prayogi (2011) conducted a study to determine the rate of replacing the fish meal with worm meal in quails, and reported that using 10% worm meal in the mixture was possible to use in the rations instead of fish meal without any detrimental effect; however, when the rate was increased to 15%, the consumption of feed decreased. Son and Jo (2013) reported that adding 0.4% worm meal to the broiler rations improved the feed consumption and live weight, and increased the digestibility of the nutrients.

Sharma *et al*. (2005) defended that heavy metals and other pollutants could be received by worms and they might be transferred to the poultry that consumed these worms. Son (2009) reported that there were as (4.41 ppm), Cd (1.23 ppm), Cr (1.18 ppm), Hg (0.00 ppm) and Pb (3.39 ppm) heavy metals in worm meal. However, Son also reported that these metals were not transferred to the meat or egg, and did not affect the quality. The findings show that the environment where worms are fed affect the body compositions of these worms; however, the compounds of the worms is not reflected in the poultry at the same rate.

In this context, it may be concluded according to the data reported in this study that some toxic minerals may not be transferred to products through worms;

however, further studies are needed to make sound conclusions in this topic.

4. Results

Studies conducted so far show that earthworms have nutrient contents that are close to those of the fish meal and more valuable than those of soybean meal; and for this reason, they may be used as alternative potentials for fish meal and soybean meal.

Earthworms pass soil through their stomach each day and make the soil become organic at a rate of nearly 60% of their body weights thus contributing to sustainable agriculture. With these properties, and by including worms, which have an important place in the natural lives of poultry animals and which are important elements in the ecosystem of the soil, in poultry husbandry again, the comforts of animals will be improved and the protein will be provided at a cheaper price, and an environmental protection effect may be achieved with the help of recycling of animal and plant wastes.

Using worms in feeding poultry animals as protein sources may not be accepted immediately in some societies. However, this must be kept in mind that poultry animals naturally consume worms in their natural habitats, and this situation may be accepted by societies in time.

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