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Insects as Alternative Feed Materials for Poultry Nutrition

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ABSTRACT

As the population of this world is gradually increasing, the requirement of cheap and economic protein source rendered by poultry meat and eggs is also increasing. In near past, the insects have attained great attention as an important and alternative feed source to substitute raw materials for animal nutrition and are considered good alternate for important ingredients. The insects, with estimated 1.5 to 3 million, are regarded as the most utilized species and among these are black soldier fly, yellow mealworm and domestic fly. Maggots are larvae of domestic fly have capability to grow on large scale of substrate and can recycle the waste into biomass rich in protein and fats. These insect species provide more sulphur containing amino acids and protein components for poultry birds. This review presents contemporary research studies of using insects, mealworms, grasshoppers, locust, crickets, katylids, black soldier fly, housefly, etc as an alternative feed stuff for poultry birds. However, there have been still technical, financial, regulatory and particularly legislative constraints in the European Union are there in order to smoothly utilize these insects on large scale as a substitute of feedstuff for the nutrition of monogastric animals.

Introduction

The human population has been constantly increasing along with the need of cheap protein source in the form of poultry meat. Therefore, the feed ingredients, necessary for poultry birds, from agricultural sources can decrease as well. The poultry production is thought to be comparatively eco-friendly in respect to other livestock animals. Throughout the world the poultry production is exponentially increasing and this requires high amount of protein contents necessary for optimum production in the form of eggs and meat (Hossain and Blair, 2007). The plant-based protein sources for poultry production e.g. various cereal by-products, legumes, rape seed, soybean meal, etc are being used extensively. However, the composition of amino acids of ingredients from plant meals has been not actually fulfilling the demand particularly in respect to the sulphur containing amino acids. The important protein source of poultry feed, fishmeal, has been still being used in poultry feeds but due to the market price hike, its usage is dwindling now-a-days diets. In this scenario, the alternative protein sources having almost same nutritive value should have replaced the existing protein sources, from vegetable origin,

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for optimum poultry production. So, the usage of insect-derived protein sources in poultry feeds in the next level of fulfilling the protein requirements of poultry birds and this phenomenon has already attracted much attention. In rural poultry production, we often see that the poultry birds when wandering outdoors they voluntarily pick and consume the insects of almost all life stages to fulfill their nutritional requirements. This, also, indicates that the insect feeding is natural for poultry (Bovera et al., 2016). Therefore, it is quiet rationale that utilising insects as an important protein will be alternative protein source in commercial feed manufacturing for poultry. In this regard, the ideal insects should be of short reproduction cycle, nutritious, provide high concentration of protein and sulphur containing amino acids and should be easy to rear for its intensive farming in order for its constant supply (Hossain and Blair, 2007).

Insects as nutritive material

Protein is present in nearly all life stages of insects (Bovera et al., 2016). So far, studies have been only focused on mealworm, maggot and pupae of the housefly, black soldier fly, and insect families of order Orthoptera which includes locusts, crickets, katylids, etc. However, insects of order Blattodea, like American, German, and Asian insects are also focused on (Helm et al., 1990). Makkar et al.(2014) and Sanches-Muros et al.(2014) mentioned the important information about the nutritive composition of various insects in their publications. The living insects may contain average DM up to 30% which may be problematic during feed milling operations and this need to be standardized for processing to obtain standard required quality of raw materials. In this regard, the process of oxidation and microbial deterioration should effectively be considered (Awoniyi et al., 2004). Chitin is most abundantly present polysaccharide, found in the cuticle of many insects, invertebrates, nematodes, and, also, found in fungal cell wall (Kramer et al., 1995; Nation, 2018).

Up to now, the majority of research articles are published on the usage of meal of common house fly as an alternative feed source for broilers. The results depicted good effects on weight gain, feed intake and FCR when the dietary concentration of larvae of common house fly remained up to 25% DM (Pretorius, 2011). In this way it can be predicted that the larvae or maggot meal can become an alternative feed resource for the poultry. However the regarding the ME, small number of research data is present, while the values of 17.9 MJ/kg DM for turkeys, reported by (Zuidhof et al., 2003) and for broilers 14.2 MJ/Kg DM is documented by (Bovera et al., 2016). The larvae of black soldier fly as a replacement of soybean meal did not Show any considerable weight gain as well as lowering feed intake (Makkar et al., 2014).

Maggot meal in poultry feed

According to a study trial by Elizabeth and Adeniji (2007), the maggot meal could be substituted for

groundnut oilcake meal in poultry diets without posing any negative impact of DMI. In this regard, Hwangbo et al.(2009) supplemented the maggot meal in broiler chicken diets to test their production. They planned a study and added 0% (control), 5%, 10%, 15%, and 20% maggot meal to various treatment groups. Their diet was isocaloric and isonitrogenous. They found out that the differences in live weight gain and CP digestibility could be due to the presence of essential amino acids in maggot meal. The maize gluten level, in the control diet, was about 8% and this could have affected the low performance (Afshar and Moslehi, 1997). In another trial the results were not significant of supplementing maggot meal in diets to check different performance parameters of broilers (Awoniyi et al., 2004; Teguia et al., 2002). Awoniyi et al. (2004) conducted an experiment and mixed maggot meal at the concentration of 25%, 50%, 75%, and 100%, respectively, and found no significant effect on weight gain. However, impact of maggot meal was more pronounced when the birds became 3 weeks old possibly due to the fact that after three weeks of age the birds efficiently utilized the maggot meal (Awoniyi et al., 2004). Teguia et al. (2002) conducted a research trial to find the impacts of supplementing maggot meal in the feed to investigate various performance parameters in different physiological phases of broilers. The treatment diets contained maggot meal whoever there was no addition of maggot meal in the diets given to control treatment group. At the end of trial the results depicted in respect of weight gain when 10% maggot meal was added in the starter phase of broiler chicks. This may be due to lower CP contents (22.65%), however weight gain was significantly higher when maggot meal was supplemented 5% and 15% in starter phase. In another trial, Teguia et al.(2002) added maggot meal 50% and 100% and could not found any significant results. However, live weight gain was better in 100 % maggot meal supplemented group. Okah and Onwujiariri (2012) added maggot meal at the concentration of 0%, 20%, 30% 40%, and 50% in the diets of broilers of 0-35 days old. The authors observed 50% added maggot meal was economically good and resulted in high performance as well as 25% addition gave better live weight, feed intake and weight gain in growing phase. In another trial performed on 50 weeks old layer hens, maggot meals was added at the level of 50% gave no negative effects of egg production and egg shell strength while 100% supplementation was fatal for laying hens (Agunbiade, 2007). Akodiete et al. (1998) replaced fish meal with maggot meal and found no negative effects on performance characteristics of layer hens and suggested that maggot meal could be used an as alternative feedstuff for layer hens. However, they found significant declines in respect of egg yolk cholesterol and calcium concentration with the increased level of maggot meal supplementation. Awoniyi et al.(2004) observed no significant effect on dressing status of breast and muscle weight when they added maggot meal in the diets of broilers. Their results were similar to that of Teguia et

al.(2002) and different from that of Hwangbo et al.(2009).

Legislation on insect usage in poultry

Insect meal can be used as an alternative feed resource in poultry nutrition but there are some obstacles which are prohibiting the addition of this sources in poultry as well as livestock feeds because these are defined as processed animal protein (PAP) (Council, 2009). The insects are divided into category 3 materials which designate these items although are fit but should not be meant for human consumption. Council (2009) and EC(2001) banned insect feeding to farm animals, approval is given to feeding insects to aquaculture species. Insect feeding of poultry and pigs will be allowed in near future after reconsideration. In this regard a dossier is made public recently in which all the relevant information is mentioned (EFSA, 2015). The obstacles include a constant and considerable supply of insects is not always available for this purpose, prices of insects and their meals are very high making it economically not viable to use insect for this purpose. The way out of this is the identification and industrial level massive production of most suitable insect species which not only are economically viable but also contain required amount of nutritional significance. For the industrial level production of these insects, the pre-requisites should be development of state of the art automated system for rearing, harvesting and post-harvesting procedures (Rumpold and Schluter, 2013).

Studies conducted

One trial was conducted to replace black soldier fly (BSF) larvae meal with soybean meal (SBM) and mixed in napier grass to check various performance parameters. Two different age categories of BSF larvae were added: larvae of BSF 1 were of one week old while larvae of BSF 2 were two weeks old. The dietary treatments were formulated as follows on dry matter basis: T1 included 100% napier grass; T2 was composed of 60% napier grass + 40% SBM; T3 contained 60% napier grass + 40% BSF 1; T4 was comprised of 60% napier grass + 40% BSF 2; T5 had 60% napier grass + 20% SBM + 20% BSF 1; and T6 was composed of 60% napier grass + 20% SBM + 20% BSF 2. The samples were subjected to check their chemical composition and, then, incubated *in vitro* by mixing buffer rumen fluid for 48 hours at 39°C. EE, NDF, ADF, insoluble CP contents of treatment 3 to 6 was increased when BSF 1 and BSF 2 were supplemented. However, treatment 3 and 4 significantly decreased ammonia concentration of rumen, in vitro digestibility of DM and OM as compared to those parameters of treatment 2. There was significantly lowered methane gas production detected as well as in vitro lower nutritional value was observed when diet mixed with BSF was given as compared to that supplemented with soybean meal. However, the low level of methane was detected when diet composed of BSF 1 was given as compared to that which had

BSF 2 (Jayanegara et al., 2017).

The trials conducted in near past have shown the importance of using maggots in poultry diets to increase their overall performance. The impact of maggot addition in feed was conducted to evaluate meat standards and growth of broilers. For this, 600, day old broiler chicks were randomly divided into 5 groups which were composed of 40 replicates each containing 3 birds. The broilers were given the diets mixed with 5%, 10%, 15% and 20% maggots. The overall growth of broilers was affected by amino acids; high protein (63.99%), essential amino acid content (29.46%) and high protein digestibility (98.50%) of the maggots which increased live weight gain but didn't affect FCR. The weight gain of 4-5 weeks old broilers was significantly increased when 10% and 15% maggots were added in diets, resulted in significantly increased dressing percentage, breast and thigh muscles was observed that might be due to increased levels of lysine and tryptophan. However, fats of liver and abdomen, meat color and the CP contents of breast muscle remained unaltered (Hwangbo et al., 2009).

Another experimental trial was performed to find out the effect of adding maggot meal in the diet of broilers and for this 120, day old broiler chicks were randomly divided in different treatment groups. Maggot meal was supplemented at the rate 0%, 40%, 50% and 60% to the treatment groups namely A, B, C and D respectively. In group D, body weight gain, dressing percentage, ME were significantly higher, while FI and FCR were significantly lower as compared to group A and B. On the other hand significantly higher digestibility of DM, CP, EE and ash was observed, and CF was significantly lower in group D as compared to that of group A. the final findings showed that 60% soybean meal could safely be substituted by maggot meal during the starter phase (Khan et al., 2018).

An experiment was performed on 150 days old broilers to check the effect of replacing silkworm caterpillar meal (SCM) with fish meal (FM) on growth and digestibility of nutrients in starter phase. The broilers were divided into 5 treatment groups containing 30 birds each and each treatment group was composed of two replicates comprised of 15 birds each. There were 5 iso-caloric and iso-nitrogenous diets formulated in such a way that diet 1 (control) had 100% FM: 0% SCM whereas rest of the diets, 2, 3, 4 and 5, contained 75% FM: 25% SCM; 50% FM: 50% SCM; 25% FM: 75% SCM and 0% FM: 0% SCM, respectively. No significant difference was observed regarding FI (29.51 - 31.66 g), body weight gain (16.56 - 19.03 g), FCR (1.60 - 1.72), protein efficiency ratio (PER) (2.67 - 2.77) and nutrient digestibility of the chicks between different treatment groups. The trial was economically good as cost per kg weight gained slowly decreased with ascending dietary level of SCM. It was concluded that SCM meal could be an economic and effective alternative feedstuff in formulating diets for starter broiler chicks leading to increased economic benefits (Ijaiya and Eko, 2010).

Conclusion

The substitution of insect meal in poultry diet can boost the performance and health of broilers as well as it is economically viable by minimizing the cost of buying feeds. However, the degree of impact depends on nutrient profile of insect being used in diets. In future, more studies should be conducted to determine the level at which replacement is done and to explore other insects being viable on growth performance for poultry, on economic perspective for its mass applicability and on health perspectives for being used for human consumption.

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