**A SEMINAR PRESENTATION**

**ON THE TOPIC:**

**ALTERNATIVE PROTEIN SOURCES FOR MONOGASTRIC (POULTRY) NUTRITION**

**BY:**

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**SUMMARY**

*This work includes the economic importance and nutritional requirement of poultry, before further evaluation of the different types of conventional protein feedstuff for poultry nutrition. This work also critically evaluates the use of small invertebrates and insects such as; silk worm, earthworm, meal worm and maggot meal by considering it proximate composition and a review of its use in poultry and monogastrics as an alternative protein sources for their nutrition.*

**INTRODUCTION**

The price of the poultry feed has been increased due to the shortage and high price of feed ingredients especially protein. Due to the increase cost and high demand for conventional protein sources, it is very costly for the use for both human and animal population (Bovera *et al.,* 2015). This unremitting increase in the price of poultry feed items is a convincing factor to find out other alternatives for protein sources, which do not only have a good nutritional value but these must be cheaper and easily available than the other conventional protein sources (Cardoso *et al.,* 2012). Any effort towards finding cheap and easily available protein resources will definitely decrease the cost of monogastric livestock especially the cost of poultry production. The main constituents of poultry feed includes; proteins and energy. Cereal grains including barley, oats, corn, wheat and sorghum are used as source of energy in poultry ration. Along with energy, quality protein is also essential for the health of poultry birds. Soyabean meal and fish meal are the chief protein sources for poultry birds, but this meal fulfills the need and has increased environmental footprint and its mass scale production on sustainable bases is costly and leads to an increase poultry feed prices (Chand *et al.,* 2014). The level of soybean meal inclusion is 25% in chicks and 30-40% in breeders, laying hen and broilers depending upon the breed and type of birds as well as the ingredients availability. In the last decade increased feed prices make poultry farming out of the reach for small holder farmers. Thus, it is very important to search for local and easily available unconventional sources for protein to substitute soyabean meal in poultry ration (Chand *et al.,* 2014). Finding a cheap and easy alternative to replace soyabean has become imperative. Identification of such cheap protein alternatives like; silk worm, maggot meal, earthworm meal, meal worm and other insects including; fly larvae grasshoppers and crickets would help resource poor farmers not only to cut down their production costs, but also to improve their production efficiency (Van Huis *et al.,* 2013). A recent study has shown that it is technically feasible to produce insects on a large scale and to use them as an alternative sustainable protein rich ingredient in poultry ration, and the benefit is particularly high, if they are reared on substrates of biowaste and organic side streams (Heidari-Parsa, 2018). They have high nutritive value in proteins as well as in fats, vitamins, and minerals (Hassan *et al.,*2009). In poultry production, feed constitute almost 75% of the total cost or 70% of the total production cost (Anosike *et al.,* 2018). The demand for low cost poultry feed is high, due to the rising cost and limited supply of commercial feeds. Hassan *et al.,* (2009) contended that due to establishment of new compounding feed mills and growing poultry farm the cost of poultry feed ingredient is increasing day by day. The impact is and will continually be felt most in sub-Saharan Africa where animal protein contribute about 61% of the human protein intake (FAO, 2019). In addition, the population of sub-Saharan Africa is projected to more than double from the current 1.1 billion people by 2050 (Van Huis *et al.,* 2013), resulting in increased protein requirement. Hence, the Food and Agriculture Organization of the United Nations (FAO) recommended insects and small invertebrates as an alternative protein source in livestock feed (Van Huis *et al.,* 2013).

**ECONOMIC IMPORTANCE OF LIVESTOCK PRODUCTION**

Livestock production plays significant role in human economy through the provision of food while also creating wealth job provision for the teeming population (FAO, 2019). The livestock sector provides raw materials to industries as well as serves as a take-up industry for other industries (Anosike *et al.,* 2018). Livestock production provides economic support and development effect on the tourism sector as well as the fashion industries (Heinke *et al.,* 2015). Livestock production also provides nutrients in form of the supply of protein, vitamin, mineral and oil. It provides organic fertilizers in form of animal droppings. It provides affordable meat for the populace especially in urban areas (Anosike *et al.,* 2018). Livestock production industry serves as a means of foreign exchange as it has contributed about 25% of the total agricultural in the nations GDP (FAO, 2019).

**NUTRITIONAL REQUIREMENT OF POULTRY**

* **Protein Requirement**

Proteins are polymers that are composed of α-amino acids, which are linked together by peptide bonds. They are broken down and hydrolyzed in the digestive system into amino acids. Following absorption, the amino acids will be assembled and metabolized to form proteins that are used in the building of different body tissues (Aviagen, 2009). They also serve vital metabolic roles as blood plasma proteins, enzymes, hormones, and antibodies, each of which has a specific role in the body (Aviagen, 2009). When formulating broiler diets, main emphasis is placed on the crude protein, because protein is the critical constituent of poultry diets, and together with the other main nutrients such as carbohydrates, fat, water, vitamins, and minerals, is essential for life (Cardoso, 2012).

Poultry chickens require about 18-24% of protein for it starter, grower and finisher phase (Adedeji *et al.,* 2011). The protein requirement of broilers is mostly obtained from animal and plant source (Adeyemo and Longe, 2007). Plant sources of protein include; Soybean, legumes, cereal by-products, etc., while animal protein sources is obtained from; fish meal, blood meal, feather meal, etc. Plant proteins are usually cheaper than animal proteins; however, there is a limitation to their use because of their content of anti-nutritional factors which can be destroyed by thermal processing that causes an increase in the nutritional value sometimes by freeing the protein in the plant protein products (Adeyemo and Longe, 2007). The anti-nutritional factors such as; trysin inhibitors, phytate, lectins, polyphenolic compounds, glucosinolates, saponin etc. and the processing methods of these protein sources can drastically limits the digestibility rate of protein generally (Adeyemo and Longe, 2007).

* **Energy Requirement**

Simple carbohydrates, some complex carbohydrates and fat in the feed are the main energy supplying summation of the energy requirement for growth and maintenance (Singh, 2015). The importance of energy feedstuff in poultry feeding cannot be over-emphasized because increasing or decreasing the dietary energy has been reported to affect feed intake in addition to promoting or undermining efficient feed utilization and growth rate (Ndams *et al.,* 2009). Dietary energy is measured by metabolizable energy, which is the amount of energy used for growth maintenance and other activities in the animal (Gheisar *et al*., 2015; Singh*,* 2015). From researches, it is deducted that birds usually eat with the aim of satisfying their energy requirement, and once this aim is achieved, the birds will stop eating irrespective of the fact that other key nutrient requirements such as protein, minerals, and vitamins have not been met (Gheisar *et al*., 2015). Energy feed stuff are feedstuff are feedstuff that is high in energy, low in fibre and protein content less than 18-20%. The use of cereals (especially maize) as an important energy feedstuff in broiler diets has been drawing much attention recently, because these ingredients contain considerable amounts of non-starch polysaccharides substances that may impair nutrient utilization (Ndams *et al.,* 2009). Poultry chickens requires about 3000-3200kcal/kg for growth and body maintenance (Ndams *et al.,* 2009).

**Table 1: Nutritional Requirements of Poultry Chickens**

|  |  |
| --- | --- |
| **Nutrients** | **Requirements** |
| Metabolizable Energy (ME) | 3000-3200 kcal/kg |
| Crude Protein (CP) | 18-24% |
| Crude Fat | 6% (max) |
| Crude Fibre (CF) | 8% (max) |
| Calcium | 0.80% (min) |
| Phosphorus, available | 0.45% (min) |
| Lysine | 0.95% (min) |
| Methionine | 0.30% (min) |
| Methionine + Cystine | 0.74% (min) |
| Threonine | 0.65% (min) |
| Tryptophan | 0.17% (min) |
|  |  |

**Source: BIS, 2007**

**CONVENTIONAL PROTEIN SOURCES**

The protein requirement of broilers is mostly obtained from animal and plant source (Adeyemo and Longe, 2007). Plant sources of protein include; Soybean, legumes, cereal by-products, etc., while animal protein sources is obtained from; fish meal, blood meal, feather meal, etc. Plant proteins are usually cheaper than animal proteins; however, there is a limitation to their use because of their content of anti-nutritional factors which can be destroyed by thermal processing that causes an increase in the nutritional value sometimes by freeing the protein in the plant protein products (Adeyemo and Longe, 2007).

**ALTERNATIVE PROTEIN SOURCES FOR POULTRY NUTRITION**

According to Vander Poel *et al.,* (2013) the short list of potentially interesting protein sources to increase feed protein production includes;

* Oil seeds - Proteins of defatted soybeans, cotton seed cake, groundnut cake, rapeseed and sunflower seed
* Grain legumes Peas, Vicia faba, lupines and their concentrates, chick peas
* Forage legumes - Lucerne (alfalfa)
* Cereals and pseudo cereals - Proteins from oat and quinoa or cereal co-products
* Leaf proteins - Grass, sugar beet leaves
* Aquatic proteins - Algae, both macro- (seaweed) and microalgae, duckweed Mussel meal
* Insects - Mealworm, housefly, black soldier fly Microbial proteins Bacterial protein meal

**Oil seed by-products and grain legumes**

Proteins derived from oil seeds are very useful for application in pig and poultry diets, while there is already a widespread use of soybean meal, cotton seed cake, sesame seed meal, groundnut cake, rape seed, and sunflower seed meal in these diets. These protein sources are well known in terms of chemical composition and nutritive value. Less information is available with respect to concentrates of these protein sources (Vander Poel *et al.,* 2013). Results of one experiment showed that rape seed (canola) protein concentrate can be used up to 10% in piglet diets (Jung *et al.,* 2009). The processing of ingredients, thereby reducing the level of anti-nutritional factors and increasing the protein content to levels of 65% or higher, would fulfil the need for high quality proteins for application in all kind of organic diets and in conventional diets for young animals (piglets, broilers, rearing hens). The processing of the selected feed resources to enhance their protein content is generally still in development and not yet well established (Jung and Batal, 2009).

**Aquatic proteins**

Aquatic protein include small aquatic organisms with protein capacity. Some of aquatic proteins, e.g. micro algae and duckweed, might be valuable protein sources for pigs and poultry, whereas intact seaweed seems less suitable (Overland *et al.,* 2010). In addition to the necessary development regarding protein extraction from these sources, more research is required to determine the nutritional characteristics of these ingredients, cell wall degradation characteristics, feed safety, and legislative aspects. Processing to enhance the protein content of the aquatic resources algae and duckweed is still in its infancy. They may offer new opportunities on the long term (> 10 years) (Hellwing *et al.,* 2006).

**Insect and other invertebrate protein**

The use of insects, invertebrates or its protein fraction as a sustainable protein rich feed ingredient in poultry diets is technically feasible. Insects can be reared on low-grade bio-waste and can turn bio-waste into high quality proteins, but opinions differ whether this is possible within 5 years (Jung *et al.,* 2009). They can be an interesting link in the animal feed chain to fulfill the globally increasing demand for protein. Cultivation and processing insects or invertebrates and their inclusion in feeds for poultry production seems a promising innovation because of their high efficiency in making valuable nutrients (Solomon and Yusuf, 2005). Insects have a well-balanced nutrient content; they have the same or an even better amino acid profile compared to soybean meal and fishmeal for use in pig and poultry diets. A rich content of polyunsaturated fatty acids, micronutrients and vitamins can be attained too (Ullah *et al.,* 2017). Furthermore, one must not forget the beneficial properties of the polysaccharide chitin, which is also found in insects. The use of insects and invertebrates has already been analysed for poultry because insects are already part of their natural diet and poultry is the second mostly eaten meat in the world (Jung *et al.,* 2009). Most insect and invertebrate species are most suitable to use in poultry diets due to their high amount of protein and their ability to degrade organic waste. These species are; silk worm, maggots, earthworm, the Black Soldier Fly (*Hermetia illucens),* the common Housefly *(Musca domestica*) and the yellow Mealworm *(Tenebrio molitor*).

According to Ravindran and Blair (1991),the factors limiting the use of novel feed resources in poultry feed formulation can be considered under two categories and these include;

**Nutritional aspects**

* Variability in nutrient level and quality
* Presence of naturally occurring anti-nutritional and/or toxic factors
* Presence of pathogenic micro-organisms
* Need for supplementation

**Technical aspects**

* Seasonal and unreliable supply (need for storage)
* Bulkiness, wetness and/or powdery texture
* Processing requirements
* Lack of research and development efforts

**MAGGOT MEAL**

Maggot meal is a potent alternate protein source and its use in poultry feed playing two major roles; poultry waste recycling and environment friendly sustainable management of poultry wastes (Khan *et al.,* 2016). Efforts to prevail over this is to include reasonably inexpensive feed ingredients for example the costly soybean meal would be replaceable by the locally inexpensive available maggot meal which has a reasonably similarity in the amino acid profile (Khan *et al.,* 2016). The egg production over the trial period endorses that maggot meal as protein supplement was better for laying hen (Makkar *et al.,* 2014). It is also found that egg production increases with increase in maggot meal replacement up to 70% and then decreases beyond this limit, may be due to some digestibility factors, which may affect further utilization of maggot meal (Khan *et al.,* 2016). Similarly, Makinde, (2015) study supported that in poultry production, there is a declined with increasing level of insect source proteins ingredients replacing in a diet.

**SILK WORM**

Among many alternative protein sources, silkworm pupae (*Bombyx mori*) are considered as an important dietary protein source for poultry after proper processing at a reasonable cost (Ullah *et al.,* 2017). Utilizing silk worm as a livestock or poultry feed would partly meet the protein feed deficiency. Silk worm generates vast resources of nutrients for livestock and poultry. Silk worm (*Bombyx mori*) is one of the unconventional good ranked protein (65-75% Crude protein) and lipid feeds which is a waste product of the silk industry and is obtainable four times in a year (Ullah *et al.,* 2017).

Solomon and Yusuf (2005) explored the utilization of silkworm meal as feed ingredient due to its high nutritional value of protein as a substitute to reduce feed cost. It is a waste material of silk industry and contain high quality protein (49.4-60% CP), lipids (14.5-30.3 % crude fat), and amino acid profile is as close to fish meal. The lipid composition of *Bombyx mori* includes; palmitic, oleic, palmitoleic, linoleic, stearic (24.6% of lipid), myristic, linolenic, lauric (14% of lipid) and arachidic acids that are present in a segment of neutral lipids (Solomon and Yusuf, 2005). One third of the total fatty acids constituted of unsaturated fatty acids. Cholesterol is found along with trace amount of campesterol in an oily fraction of sterols (Ullah *et al.,* 2017). Due to limited resources on the use of silk worm meal in poultry nutrition, Ullah *et al.,* (2017), concluded in his studies that silkworm meal is a potential alternative of soybean meal and other conventional protein sources without adverse effect on layers or poultry performance, nutrient digestibility, blood profile and egg quality. Replacement of soybean meal with silkworm meal at 50% replacement in the ration achieved better results. It is suggested to conduct more studies on silkworm meal as feed ingredient.

**EARTHWORM**

The use of earthworms as an alternative protein source for fish and poultry feeding is an opportunity for providing environmental services via cleaner technologies (Marco *et al.,* 2013). Thanks to earthworms, organic wastes and by-products generated by livestock activities can be valorised and become a resource for animal feeding in a circular perspective (Marco *et al.,* 2013).

Evaluation the proximate composition of earthworms, it dry matter (16-20% of fresh matter) contains from 55 to 70% of proteins (Mohanta *et al.,* 2016), with a higher content of essential amino acids, such as lysine and methionine, compared to meat or fishmeal. The other constituents of earthworms are 6-11% fat, 5-21% carbohydrate, 2-3% minerals and a range of vitamins, including niacin and vitamin B12. Sogbesan and Ugwumba (2008) reported that earthworms contain (on dry mass basis) 63.0% crude protein, 5.9% crude fat, 8.9% ash, 0.43% Na, 0.53% Ca, 0.62% K, 0.94% P and 1476kJ/100g of metabolizable energy. Furthermore, they determined the essential amino acid composition of earthworm meal and found that it contained arginine 2.83 g/kg, histidine 1.47g/kg, isoleucine 2.04 g/kg, leucine 4.11 g/kg, lysine 6.35 g/kg, phenylalanine 6.26 g/kg, tryptophan 4.43 g/kg and valine 4.43 g/kg on a protein basis. Similar results were reported by Finke (2002), who showed that earthworm meal included 10.5% of crude protein, with arginine 0.61%, methionine 0.19%, lysine 0.66%, threonine 0.47%, tryptophan 0.09%, crude fat 1.2% and ash 0.6%.

Although, the studies investigating the earthworm meal use are quite old above all those carried out in Europe; however, some general indications can be drawn: for broiler and other manogastrics, the parameters usually evaluated are body weight gain, growth rate, feed intake and feed conversion rate, the acceptability level of earthworm meal in broiler diet is lower than 15% -30% (Marco *et al.,* 2013).

The inclusion of earthworm meal in diets with an inclusion level lower than the acceptability threshold allows good productive performances without affecting the quality of the final food products (Finke, 2002).

**MEAL WORM**

*Tenebrio molitor* larvae, known as mealworm, have been considered a good and alternative protein source for monogastric animals. This is because the production eﬃciency of *Tenebrio molitor* larvae is higher than that of the adults (Jinsu *et al.,* 2020). The ingredient of *Tenebrio molitor* larvae is produced by drying and grinding and larvae meal is produced from a by-product of oil extraction for *Tenebrio molitor* larvae (Jinsu *et al.,* 2020; Lee *et al.,* 2019).They have a high quantity and quality of protein content and amino acid proﬁle (Heidari-Parsa, 2018). The crude protein content of *Tenebrio molitor* larvae shows an average of 52.4% and ranges from 47.0% to 60.2%, which is greater than that of conventional soybean meal (49.4%) and less than that of ﬁsh meal (67.5%) (Ravzanaadii *et al.,* 2012).

The inclusion of *Tenebrio molitor* larvae in broiler diets improved the growth performance without having negative eﬀects on carcass traits and blood proﬁles in broiler chickens, or had no inﬂuence on the growth performance and carcass yield of broiler chickens (Jinsu *et al.,* 2020). The supplementation of *Tenebrio molitor* larvae improved the growth performance and protein utilization of monogastric animals – pigs (Jinsu *et al.,* 2020). Furthermore, the replacement of ﬁshmeal with *Tenebrio molitor* larvae resulted in no diﬀerence in the growth performance and nutrient digestibility of weaning pigs (Jinsu *et al.,* 2020). However, there are some challenges regarding biosafety, consumer’s acceptance, and price for the use of *Tenebrio moiltor* larvae in animal feed (Jinsu *et al.,* 2020). Consequently, *Tenebrio molitor* larvae could be used as an alternative or sustainable protein source in monogastric animal feed.

**CONCLUSION**

Exploring the benefit of livestock production and it contribution to human diet and finances, it is imperative to consider the sector growth by mitigating the major challenge of high feed cost caused by raising prices and competition of conventional feedstuffs by employing the use of alternative protein sources. From the review, it is could be concluded that maggot meal, silk worm, earthworm and mealworm should be employed for poultry and other monogastric nutrition as it is a better alternative for conventional protein sources.

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