**A SEMINAR PRESENTATION**

**ON THE TOPIC:**

**ALTERNATIVE PROTEIN SOURCES IN POULTRY NUTRITION**

**BY:**

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**SUMMARY**

*Poultry are domesticated birds with economic value and it includes; chickens, pigeon, duck, goose, ostrich, guinea fowl, among others. Poultry production is a major sources of animal protein to humans, source of income, employment, raw materials for the industries and also a means of foreign exchange. Poultry production is faced with myriads of challenges and high cost of feed is a major challenge caused by high cost of conventional feedstuff such as; soybean, fish meal, groundnut cake, sunflower meal, etc. The objective of this seminar is to review the alternative animal protein sources such as; earthworm, crickets, meal worm, silk worm, maggot meal, black soldier fly, housefly, etc. in poultry 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 such as soybean and fish meal, 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, for example insects such as; grasshopper, mealworm, silkworm, earthworm, cricket, etc. which have a good nutritional value, cheaper and available than other conventional protein sources such as; soybean and fish meal (Cardoso *et al.,* 2012). Any effort towards finding cheap and easily available protein resources may decrease the cost of poultry production. Protein is one constituents of poultry feed. Quality protein is also essential for the health of poultry birds. Soyabean meal and fish meal are the chief protein sources used for the production of poultry feed which leads to increase poultry feed prices due to their high cost (Chand *et al.,* 2014). 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 and fish 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). The objective of this seminar is to review the alternative animal protein sources such as; earthworm, crickets, meal worm, silk worm, maggot meal, grasshopper, etc. in poultry nutrition.

**PROTEIN REQUIREMENT** **OF POULTRY**

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).

**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, sunflower 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 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 analyzed 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, crickets, maggots, earthworm, the Black Soldier Fly (*Hermetia illucens),* the common Housefly *(Musca domestica*) and the yellow Mealworm *(Tenebrio molitor*).

**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). Proximate analysis of maggot meal in a study by Odesanya *et al*., (2011) indicated 86.0% moisture content, 10.0% ash content, 5.89% Crude fibre, 48.0% Crude Protein, 31.76% crude fat, 3755 kcal/kg energy. Efforts to prevail over high cost of poultry feed 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. Sogbesan and Ugwumba (2008) reported that earthworms contain (on dry mass basis) 63.0% crude protein, 5.9% crude fat, 3% crude fibre, 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. 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). According to De Marco *et al.,* 2015, he reported that meal worm has 45-60.5% crude protein, 25-43.1 crude fat, 5.1-8.8% crude fibre, 2600-2700kcal/kg energy and 1-4.5% ash. 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 – (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 (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.

**CRICKET**

Recently, the use of edible insects as high-protein feed sources has increased, and cricket has shown economic production potential (Makkar *et al.,* 2014). Compared to other insects, the Field cricket occurs in dense in most areas of China and could be easily harvested in a considerable amount. Furthermore, it could be mass rearing under controlled condition and once harvested can be toasted, ground and incorporated into the diet of poultry (Dun Wang *et al.,* 2005). Cricket (*Gryllus bimaculatus*) contains 54.10% crude protein (CP), 6.90% crude ﬁber (CF), 26.90% fat, and 78.90% total digestible nutrient (TDN) (DM basis), as well as a variety of essential amino acids including methionine, lysine, histidine, valine, and leucine (Jayanegara *et al.,* 2017). Crickets are also considered an excellent source of other macro minerals such as Mg, Fe, Ca, K, and Na (Jayanegara *et al.,* 2017).

Cricket *(Gryllus bimaculatus)*, fed as a partial replacement for soybean meal in the diet of 8–20-day broilers, resulted in no negative effects on growth, weight gain, or feed intake (Wang *et al.,* 2005), while Permatahati *et al.,* (2019) found that replacement of ﬁsh meal by cricket meal resulted in increased egg production and egg quality of layer quails.

According to Dun Wang *et al.,* (2005), cricket meal was replaced partial protein supplement on an equal of CP percentage and total metabolizable energy basis, broilers growth was not significantly affected among diets with up to 15% insect meal.

**GRASSHOPPER**

Grasshoppers can be grown within their natural habitats, such as farms, grasslands, paddocks, and wetlands (Khusro *et al.,* 2012). Harvesting grasshoppers from these habitats can decrease the use of effective elements to control insects. In this way, these hurtful insects can be used in an economical and self­sustaining way, especially in developing countries, as a protein source in animal feed (Makkar *et al.,* 2014). The grasshopper body has three main components: the head contains sensory structures, such as eyes, antennae, and mouth parts; the thorax has structures associated with mobility, such as the legs and wings; and the abdomen contains the digestive and reproductive structures (Ojewola *et al.,* 2003). On average, grasshoppers consist of dry matter (35.00%), crude protein (CP, 50.50%), crude fiber (CF, 15.30%), ash (6.40%) on dry matter basis. Furthermore, a grasshopper’s average mineral concentrations are as follows: calcium (Ca) 146.0 parts per million (ppm), phosphorous (P) 153.0 ppm, magnesium (Mg) 56.40 ppm, potassium (K) 344.0 ppm, zinc (Zn) 22.50 ppm, copper (Cu) 05.30 ppm, manganese (Mn) 01.40 ppm, and iron (Fe) 32.20 ppm. Many scientists have estimated the nutrients in grasshopper meal. As noted by Makkar *et al.,* (2014) and Khan (2018), this nutritional information is extremely unpredictable. The CP concentration fluctuates between 29% to 77.1% depending on species, developmental phase, and processing technique. Ojewola *et al.,* (2003) found that grasshoppers contained ash (9.97%), CF (2.38%), CP (28.13%), ether extract (EE, 4.18%), and gross energy (GE, 1,618 kcal/g), noted respectively on basis of DM. Alternatively, Makkar *et al.,* (2014) and Khan, (2018) found the contents of grasshopper: ash (4.31%), CF (9.21%), CP (53.58%), EE (26.52%), and nitrogen­free extract (6.40%), noted respectively on basis of dry matter.

The inclusion of grasshopper meal into the diet of chickens has enhanced feed conversion and protein digestibility. Adding grasshopper meal to the diet did not change the meat’s physical properties, but the sensory properties appear to improve with vision (Brah *et al.,* 2018). On the other hand, the following is an alternative to eating a fish meal with grasshoppers at rates of 0, 25, 50, 75, and 100 of in the broiler diet during the early and growing period. Replacing fish meal with grasshoppers significantly reduced feed intake, growth efficiency, and body production. During the growing phase of broilers, feed efficiency was not significantly affected (Patterson *et al.,* 2021). In Nigeria, researchers studying broilers (1 to 28 days) replaced desert grasshopper meal with fish meal; replacing 50% fish protein with grasshopper meal (1.7% in diet) resulted in increased weight gain, feed intake, and feed conversion ratios (Arango *et al.,* 2004).

**BLACK SOLDIER FLY**

Black soldier fly larvae originate in cattle, pig, and poultry manure, but they can mature on organic waste materials, such as catsup, coffee beans pulp, caribou, and vegetables (Cullere *et al.,* 2016). Adult Black soldier fly have a wasp­like shape, are blue or black, and have two translucent “windows” on the first part of the abdomen. Adult BSFs range from 15 to 20 mm in length. Different researchers have reported different nutrients in feeds made from Black soldier fly larvae. On average, Black soldier fly consist of DM (27.40%), CP (56.10%), CF (23.20%), ash (9.85%), Ca (2.14%), P (1.15%), Mg (0.39%), K (1.35 %), Zn (13.10 mg/kg), Cu (11.20 mg/kg), Mn (23.20 mg/kg), and Fe (20.40 mg/kg) on the basis of DM. Black soldier fly larvae are used directly or are dried, chopped, and ground into shapes. The dry matter substance in fresh Black soldier fly larvae is much higher (34.9% to 44.9%), which makes Black soldier fly larvae easier and less expensive than other fresh products. Black soldier fly larvae are ahead of significance in the diet of livestock ability to accelerate products through the low­cost agricultural industry in high­protein biomass. The required nutritional content of Black soldier fly larvae for use as protein­rich biomass in feed for poultry raised for food has not been met. In addition, insect digestibility depends not just on the insect species and breeding substrate but also on processing techniques and regulations (e.g., time and temperature) (Jayanegara *et al.,* 2016). Some differences in indigestion may be associated with the different percentages of larvae among studies. When raising quail (Jayanegara *et al.,* 2015), three diets were tested as controls, 10% nonstandard Black soldier fly larvae feed (soybean oil 28.4% and SBM 16.1% substitute) and 15% Black soldier fly larvae feed (soybean oil 99.9% and SBM substitute 24.8%). The quail showed the same body weight gain, feed intake, feed conversion ratio, and mortality rates in every experimental group. The evident nutrient digestibility (i.e., CP, DM, EE, OM, and starch) was similar in the three groups, except for EE, which had the maximum digestibility at 92.9% for the control and 89.6% for the 15% BSFL feed. Upon examination the quail showed no preference for the control. Hence, recommended for use in poultry nutrition.

**HOUSEFLY**

The housefly (HF) head has eyes, antennae, and mouthparts. Housefly increase food digestion by using saliva deposited from the mouthparts. Antennas provide housefly with their primary source of smell and often vary among males and females. The widespread housefly larvae (HFL) can breed on cattle, pig, and poultry manures, and HFL can be raised on public waste material. The life­cycle of the HF has multiple stages: eggs; larvae of first, second, and third instar; pupa; and adult. The duration from egg to adult is approximately 7 to 10 days in warm temperatures and 40 to 49 days in cooler weather (Boushy, 1991). The HFL is ready to create maggots of food. They are stored for fast reproductive tempo, high food cost, and simple to process and durable utilize (Campbell *et al.,* 2020). Housefly larvae have high amounts of energy, protein, micronutrients (e.g., Cu, Fe, Zn), essential amino acid, and fatty acid. Housefly larvae are inexpensive, have high quality nutritional value, and are less troublesome to make from other sources of animal protein. In general, HFL meals have high amounts of Lys, Thr, and Met and can be added to low­protein cereals and legume­based diets for livestock (Moreki *et al.,* 2012). Different researchers have reported different nutrient levels for feeds using HFL. On average, Housefly larvae include ash (6.25%), DM (83.47%), CP (33.29%), CF (6.20%), Ca (0.49%), P (1.09%), Mg (0.23%), K (1.27%), Zn (10.39 mg/kg), Cu (32.40 mg/kg), Mn (42.50) mg/kg, and Fe (47.50 mg/kg) on DM basis. There are two studies of apparent digestion of dried HF feed that were tested in broiler chickens. Hwangbo *et al.,* (2009) fed four weeks’ older broilers are fed 30% dry HF larvae or a diet for 7 day with SBM and three weeks older broilers are fed corn meal diet which contains 50% dry HFL feed. The consequences show that the apparent importance in the first study, the concentration of CP (98.5%) for HF larvae, was higher than in the 2nd study (69.5%) and the final study showed that CP fecal digestion was higher for HF pupae than for larvae. According to Pieterse and Pretorius (2013), found that the significantly better visible fecal digestibility standards for individual amino acids than crude protein, hence recommended for poultry nutrition.

**Table 1: Comparison of the nutritional composition of conventional and alternative protein sources.**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Nutritional composition** | **Conventional Protein Sources** | | | | **Alternative Protein Sources** | | | | | | |
|  | **SBM** | **GC** | **SM** | **FM** | **EW** | **SW** | **HF** | **BF** | **CRT** | **MW** | **MM** |
| Crude protein (%) | 49-52 | 45-60 | 40 | 65-71 | 63 | 49-60 | 60.4-76.2 | 44.1-45 | 56.4-63.8 | 45-60.5 | 48 |
| Energy (kcal/kg) | 4100 | 3000 | 4117 | 4890 | 1476 | 2290 | 2400 | 2200 | 2150 | 2700 | 3755 |
| Ether Extracts (%) | 3.3 | 5 | 2.0 | 10 | 5.9 | 14.5-30.3 | 16-26 | 15-35 | 16.8-23.8 | 25-43.1 | 31.78 |
| Crude fibre (%) | 4 | 7.5 | 17 | 0 | 3.0 | 0.05 | 14-15.7 | 7-9 | 7-9.4 | 5.1-8.8 | 5.8 |
| Ash (%) | 1.0 | 4 | 2.5 | 18.2 | 8.9 | 1.5 | 1.73-5.5 | 14.6-28.4 | 5.4-6.4 | 1.0-4.5 | 10 |

**\*SBM - Soybean meal; GC – Groundnut Cake; SM – Sunflower Meal; FM – Fish Meal; EW – Earthworm; SW – Silk worm; HF – Housefly; BF – Black Fly; CRT – Cricket; MW – Mealworm; MM – Maggot meal**

***Sources; De Marco et al., 2015;******Bukkens, 2015; Odesanya et al., 2011;******Sogbesan and Ugwumba, 2008***

**CHALLENGES OF USING ALTERNATIVE PROTEIN SOURCES**

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

**CONCLUSION**

Protein is one of the most important nutrients in poultry feed. Protein is costly compared to other nutrients leading to high cost of poultry feed. High cost of poultry feed is anchored on high prices of conventional protein sources especially; soybean and it’s a major challenge which require attention. Conclusively, from this review, alternative protein sources such as; earthworm, maggot meal, meal worm, silk worm, housefly, black soldier fly, crickets have sustainable and high nutritional composition. These nutritional composition is similar and it lower cost compared to the conventional protein feedstuff (soybean, groundnut cake, fish meal, sunflower meal); hence can be utilized to mitigate the challenge of high poultry feed cost.

**RECOMMENDATION**

Exploring the benefit of poultry 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 protein feedstuffs (soybean, groundnut cake, fish meal, sunflower meal) by employing the use of alternative protein sources (earthworm, maggot meal, meal worm, silk worm, black fly, crickets). From the review, it is could be recommended that earthworm, maggot meal, meal worm, silk worm, grasshopper, black fly, crickets should be employed for poultry nutrition as it is a better alternative to reduce high cost of poultry feed caused by conventional protein sources.

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