NUTRITIONAL COMPOSITION OF HOUSEFLY LARVAE MEAL: A SUSTAINABLE PROTEIN SOURCE FOR ANIMAL PRODUCTION – A REVIEW

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Abstract
The United Nations reported that, human population will increase from 7.3 billion to 9.7 billion by 2050, indicating an urgent need to increase food production. Livestock and fish products provide food of high nutritional value but nutrition has been a major constraint affecting the productivity of animals in Nigeria. Feeds alone accounts for 70 to 75 % of the total cost of animal production. Therefore the need to find alternative good quality and sustainable protein source that can replace or substitute current protein sources used in animal nutrition. Such an alternative protein source can be provided by insects. Among insects, common housefly (*Musca domestica*) larvae are particularly promising because they can be produced cheaply and rapidly on organic waste materials thereby converting low value waste into a high value product. Housefly larvae have the potential as a sustainable future protein source for diets of production animals (poultry, fish, and pigs). It has good nutritional value, cheaper and less tedious to produce than other animal protein sources. The dry matter and crude protein contents of housefly larvae meal (HFLM) ranged between 83.47 and 94.79 %, and 28.63 and 63.99 %, respectively. While crude fibre, ether extract and ash ranged between 3.14 and 9.95 %, 14.08 and 37.78 % and 4.50 and 10.68 %, respectively. Housefly larvae meal has a well-balanced essential amino acid profile, similar to the amino acids of fishmeal, and can thus provide high-value feedstuff. A good knowledge of the nutrient composition of HFLM with regards to its protein and amino acid contents will equip diet formulators with more definite data for correct placement and replacement of feed ingredients in ration formulation. Therefore, the use of HFLM as alternative to the expensive protein sources will help reduce the cost of production and boost livestock and fish productivity in Nigeria.

Key words: Housefly, Larvae, Sustainable, Protein, Animal

Introduction

In Nigeria, the bulk of the feed used in animal production, especially for poultry and fish, is imported and this has led to a high production cost of these animals. The rising cost of feed ingredients, especially fish meal, has retarded the growth of the poultry and aquaculture industries in the country. With the ever increasing demand for fish meal globally, it is expected that its cost will continue to rise in the world market (Aniebo *et al*., 2009). Commercial poultry and aquatic feeds have traditionally been based on fishmeal as the main protein source because of its high protein content and balanced essential amino acid profile (Ossey *et al*., 2014). Fishmeal is also a good source of essential fatty acids, digestible energy, minerals and vitamins. However, fishmeal is relatively expensive; its supply is limited and quality variable (Ruhnke *et al*., 2018). In addition, fishmeal is one of the most expensive ingredients in formulated feeds. In order to reduce feed costs, farmers need to replace fishmeal with alternative protein source (Ossey *et al*., 2014), which is cheaper to produce and sustainable. Such an alternative protein source can be provided by insects. Among insects, common housefly (*Musca domestica*) larvae are particularly promising because they can be produced cheaply and rapidly on organic waste materials thereby converting low value waste into a high value product (Ogunji *et al*. 2006; Ruhnke *et al*., 2018).
Housefly larvae have the potential as a sustainable future protein source for diets of production animals (poultry, fish, and pigs).

Housefly larvae contain high amounts of energy, protein and essential amino acids, fatty acids and micronutrients (e.g. copper, iron, zinc). It is cheaper, has good nutritional value, and less tedious to produce than other animal protein sources. In general, HFLM contain high amounts of lysine, threonine and methionine, which are major limiting essential amino acids in low-protein cereal- and legume-based diets for livestock (Hwangbo *et al.*, 2009). The overall nutrient content viz: crude protein, lipid and essential amino acid content of HFLM are comparable with fishmeal. According to van Huis *et al*. (2013), rearing insect could be one way to enhance food and feed security considering that housefly larvae can feed on waste biomass including fruits and vegetable peels, food wastes, sewage, manure, slurry, etc transforming it into high value food and feed resources (Čičková *et al*., 2015). In addition to turning organic wastes into high quality feeds, residues from rearing insect larvae can be used as plant fertilizers (Oonincx *et al*., 2015, Lalander *et al*., 2015). Feeding HFLM to farm animals will not only contribute to animal feed security and a reduced competition between humans and animal farming for resources but will also have marked positive effects on environment, energy use and economy (Čičková *et al*., 2015). Therefore, this paper reviewed the nutritive value of housefly larvae meal as a sustainable protein source in the diets of production animals (poultry, fish and pigs).

Nutritional Composition of Housefly Larvae Meal

There are differences in nutrient composition of housefly larvae meal reported by various researchers. These variations may not be unconnected with the type of substrate used during the production process, age, processing, drying or storage methods used. Generally, housefly larvae meal has a well-balanced essential amino acid profile, similar to the amino acids of fishmeal, and can thus provide high-value feedstuff. A good knowledge of the nutritional composition of HFLM, with regards to its protein and amino acid contents will equip diet formulators with more definite data for correct placement and replacement of feed ingredients in ration formulation. The nutrient composition of HFLM as reported by various researchers is summarized in Table 1.

Table 1: Nutrient Composition of Housefly Larvae Meal

Nutrients (%)	A	B	C	D	E	F	G	H	I	J	K	L
DM	91.34	-	94.24	92.70	94.72	92.80	-	91.40	91.99	98.24	92.70	83.47
CP	39.16	37.20	28.63	47.10	63.99	51.30	60.38	42.50	42.00	59.97	55.40	33.29
CF	8.25	9.05	-	7.50	-	6.30	8.59	9.95	5.89	7.00	6.20	3.14
EE	20.76	35.50	23.30	25.30	24.31	23.40	14.08	31.50	28.95	22.27	20.80	37.78
Ash	6.15	7.15	9.65	6.25	5.16	6.24	10.68	8.15	8.10	8.50	6.83	4.50

A = Atteh and Ologbenla (1993); B = Adeniji (2007); C = Ogunji *et al*. (2008); D = Aniebo *et al*. (2008); E = Hwangbo *et al*. (2009); F = Aniebo and Owen (2010); G = Pretorius (2011); H = Jonathan (2012); I = Ossey *et al*. (2014); J = Obeng *et al*. (2015); K = Ukanwoko and Olalekan (2015); L = Arong and Eyo (2017).

The reported dry matter content of HFLM varied from as high as 95 % (Hwangbo *et al*., 2009) to as low as 84 % (Arong and Eyo (2017). Similarly, Hwangbo *et al*. (2009) reported the highest (64 %) crude protein content in HFLM but Ogunji *et al*. (2008) reported the lowest value of 29 % CP. Crude fibre, ether extract and ash varied from as high as 10 % (Jonathan, 2012), 38 % (Adeniji, 2007) and 11 % (Pretorius, 2011), respectively. While the lowest values 3, 14 and 5 % for CF, EE and Ash were recorded by Arong and Eyo (2017), Pretorius (2011) and Arong and Eyo (2017), respectively. The differences observed in the nutrient composition of HFLM may not be unconnected with the type of substrate used during the production process, age, processing, and drying or storage methods used. However, the content of the essential fatty acid linoleic acid was between 16% (Hwangbo *et al*., 2009) and 26 % (Pretorius, 2011) of the total fat content for the housefly larvae.

Amino Acid Profile of Housefly Larvae Meal

Protein is a very important ingredient required for nutrition and for decades a lot of emphasis has been placed on the quality of proteins especially its composition of amino acid. Housefly larvae meal has a well-

balanced essential amino acid profile, similar to the amino acids of fishmeal, and can thus provide high-value feedstuff. In general, housefly larvae meal contain high amounts of lysine, threonine and methionine, which are major limiting essential amino acids in low-protein cereal- and legume-based diets for livestock (Hwangbo *et al.*, 2009). According to Veldkamp *et al*. (2012), HFLM contains 9 essential amino acids with higher Cystine and similar levels of Lysine, Methonine, Threonine and Tryptophan as marine fishmeal. Table 2 summarizes the different amino profiles reported by different authors.

Table 2: Amino Acid Profile of Housefly Larvae Meal

Parameters (%)	A	B	C	D	E	F	G	H
Essential Amino Acids								
Arginine	4.20	4.60	5.80	3.63	2.18	6.06	4.90	3.17
Histidine	2.60	5.10	3.09	1.98	1.03	3.01	2.80	1.59
Isoleucine	3.50	1.70	3.06	1.46	1.82	3.05	3.20	1.84
Leucine	5.30	5.60	6.35	2.90	2.93	6.35	5.70	3.28
Lysine	5.20	4.40	6.04	5.22	3.03	4.23	6.90	3.85
Methionine	2.60	-	2.28	2.34	0.67	1.82	2.20	4.03
Phenylalanine	4.20	10.20	3.96	3.57	2.12	3.53	5.00	3.82
Threonine	3.40	7.60	2.03	2.27	2.09	2.09	3.30	-
Tryptophan	-	1.50	-	3.17	-	3.17	3.20	0.69
Valine	3.40	1.30	3.61	2.92	2.34	1.91	4.40	2.59
Non-Essential Amino Acids								
Alanine	2.86	4.40	2.86	4.85	2.70	3.84	-	2.91
Aspartic Acid	8.25	4.50	8.25	2.21	4.37	4.31	-	5.18
Cystine	0.52	-	0.52	0.42	-	1.20	0.70	0.78
Glutamic Acid	15.30	6.80	15.30	5.71	6.08	3.87	-	8.38
Glycine	4.11	0.90	4.11	3.27	2.24	2.76	-	2.22
Proline	2.85	-	2.85	1.58	-	1.58	-	2.44
Serine	3.23	3.30	3.23	5.63	1.99	3.14	-	2.25
Tyrosine	-	2.50	-	4.55	2.07	2.47	5.10	3.51

A = Calvert *et al*. (1969); B = Ogunji *et al*. (2006); C = Aniebo *et al*. (2008); D = Hwangbo *et al*. (2009); E = Akpodiete *et al*. (2011); F = Jonathan (2012); G = Veldkamp *et al*. (2012); H = Hussein *et al*. (2017).

Jonathan (2012) reported higher values of Arginine (6.06%) followed by Aniebo *et al*. (2008). Highest values of Histidine (5.10%) were reported by Ogunji *et al*. (2006), while the lowest (1.03%) was reported by Akpodiete *et al*. (2011). Calvert *et al*. (1969), Veldkamp *et al*. (2012) and Hussein *et al*. (2017) reported higher Isoleucine, Lysine and Methionine (3.50, 6.90 and 4.03%), respectively compared to reports of other researchers. The differences observed in the essential amino acids could probably be due to differences in either the analysis procedures employed or the medium used to produce the HFLM. Both Aniebo *et al*. (2008) and Ogunji *et al*. (2006) hydrolysed the samples before analyses, but Ogunji *et al*. (2006) used high performance liquid chromatography (HPLC) equipment and Aniebo *et al*. (2008) used Technicon Sequential Multi sample amino acid analyser to determine the specific amino acid content. The high level of essential amino acids makes HFLM a potential replacement for fish meal in poultry diet and other monogastrics.

Conclusion

Judging from the nutritional composition and amino acid profile, housefly larvae meal is a potentially attractive alternative for use as a sustainable protein-rich feed ingredient for livestock and aquaculture operations. Additional research is recommended on its feeding value and inclusion levels in the diets of production animals.

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