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Edmore Bumhira

ebumhira@gzu.ac.zw

Great Zimbabwe University

Ngavaite Chigede

Great Zimbabwe University

Tonderai Mutibvu

University of Zimbabwe

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Nutritional Composition of Housefly (*Musca domestica*) Larvae Meal Reared on Poultry Manure as Potential Feed for Broilers

Edmore Bumhira[1*], Ngavaite Chigede [1], Tonderai Mutibvu[2]

1 – Great Zimbabwe University, Department of Livestock, Fisheries and Wildlife, Gary Magadzire School of Agriculture and Engineering, Masvingo, Zimbabwe.

2 – University of Zimbabwe, Department of Animal Science, Faculty of Agriculture, Environment and Food Systems, Harare, Zimbabwe

Corresponding Author – ebumhira@gzu.ac.zw or bumhiraedmore@gmail.com

Tonderai Mutibvu ORCID Number: 0000 – 0002 – 7319 - 9167

Ngavaite Chigede ORCID Number: 0000 – 0002 – 0161 - 2995

Abstract

The shortage of soybean meal for broiler feed production in Zimbabwe stems from competition between humans and animals for this vital protein feed source, as well as persistent droughts across Southern Africa, highlighting the need to explore alternatives to soybean meal. Housefly larvae, which are ubiquitous and can be cultivated inexpensively using organic waste, are a promising substitute for soybean meal. This study assessed the proximate composition and amino acid profile of housefly larvae raised on poultry manure using the natural oviposition method. The rearing substrate was replicated three times. Proximate analysis revealed that housefly larvae meal contains 10.9% moisture, 38.5% crude protein, 15.3% ether extract, 8.66% crude fiber, and 8.54% ash. Amino acid analysis indicated that housefly larvae meal contains 2.54% methionine, 4.10% lysine, 1.07% tryptophan, 4.72% isoleucine, 5.41% leucine, 3.81% phenylalanine, and 1.29% histidine. Calculations of the amino acid ratios in housefly larvae meal relative to lysine showed that these ratios meet or exceed the established ideal amino acid ratio standards for broiler chickens. Consequently, housefly larvae can serve as a viable and sustainable protein source in broiler diets, offering an alternative to the much-sought-after soybean meal.

Keywords: Alternative protein source, amino acid profile, broilers, Housefly larvae meal, proximate composition

1. Introduction

The United Nations (2024) stated that the global population was 8.2 billion in 2024 and estimated it would rise by about 82 million people annually until it reaches 10.3 billion by the mid-2080s. This anticipated population growth will increase demand for protein-rich animal products, since one-third of a human body's daily protein needs (0.66g per kg body weight) is recommended to come from animal products (Baldi and Gottardo, 2017). Demand for broiler meat is increasing because it is relatively cheaper than beef and pork. Broiler meat is not affected by religious and cultural beliefs, and it is highly digestible. Environmentally, chicken production has a lower global warming potential than other livestock. The poultry industry is responsible for 8% of the overall greenhouse gas (GHG) emissions generated by the worldwide livestock sector (Goswami *et al*., 2026). The same authors reported that feed production accounts for an estimated 60% of the total GHG emissions per kilogram of chicken meat produced. Soybean, the main source of dietary protein in broiler diets, is linked to excessive land clearing and deforestation, energy use, and global warming (Yalcin *et al*., 2025).

Researchers are exploring housefly larvae meal as a viable alternative protein source to traditional options like soybean and fish meal, which are currently limited because humans and livestock compete for these conventional protein sources (Hamani *et al*., 2022). Insects, such as houseflies, are a natural feed resource for poultry, giving researchers confidence that they can replace some costly traditional protein sources in poultry diets without adversely affecting growth performance or meat quality (Josefiak *et al*., 2016).

The nutritional profile of housefly larvae meal (HFLM) is comparable to that of soybean meal (Khan *et al*., 2024). Crude protein levels in HFLM range from 37% to 63%, similar to the 44% found in soybean meal. HFLM has a more balanced amino acid profile than soybean meal. HFLM contains essential amino acids in higher amounts than plant-based proteins (Kawasaki *et al*., 2026). The key limiting amino acids in poultry diets, specifically lysine and methionine, are generally more abundant in HFLM (6.0g / 100g protein and 2g / 100g protein, respectively) than in soybean meal (2.8g / 100g protein and 0.71g / 100g protein, respectively) (Gadzama *et al*., 2019).

Housefly larvae meal has a crude protein digestibility of 69% across the total tract, with essential amino acid digestibility averaging 92%. HFLM metabolizable energy is 14.23 MJ/kg, higher than soybean meal at 12.53 MJ/kg (Khan *et al*., 2024). Crude fat digestibility in HFLM ranges from 94% to 98%, generally exceeding that of soybean meal, which falls between 70% and 85% (Tancharoenrat *et al*., 2013). Nonetheless, its fiber includes chitin, a polysaccharide that limits digestibility to 58%-62% (Pretorius, 2011).

The nutritional composition of housefly larvae meal reported by earlier studies varies significantly, and these discrepancies could be linked to factors such as the age at which the larvae were collected, the drying methods used, the nutrient profile of the growth medium, and the laboratory techniques employed to analyse the chemical composition of HFLM (Ochoa *et al*., 2025).

Due to the differences in the nutritional composition of HFLM noted by several researchers, this study aimed to analyse the nutrient composition of housefly larvae meal derived from larvae raised on poultry waste. It is hypothesized that the nutritional composition and amino acid profile of housefly larvae raised on poultry manure are comparable to, or potentially superior to, those in soybean meal.

1.1 **Materials and Methods**

1.1.1 **Study Site**

Housefly larvae used to produce housefly larvae meal were cultivated using the natural oviposition technique at Cold Storage Company Pvt Ltd, located in Kadoma District, Mashonaland West Province, Zimbabwe. The Cold Storage Company is positioned at geographic coordinates of 18° 19' 57.0" S, 29° 54' 50.4" E and stands at an elevation of 1183 meters above sea level. The wet season spans from November to March, while the dry season lasts from April to October. Temperatures in Kadoma range from 7.7°C to 34.4°C, and the region receives an average annual precipitation of 738.6mm. Houseflies prefer 28°C–33°C for optimal survival and reproduction (Ajayi *et al*., 2022). According to the same authors, houseflies struggle to survive below 15 °C and above 36 °C, with mortality happening due to chilling and heat exhaustion, respectively.

1.1.2 **Housefly Larvae Rearing and Drying**

Poultry manure was combined with a fly attractant (cattle gut contents) and placed in concrete tanks with a surface area of 1.16 m², following the procedures described by Hussein *et al*. (2017). A mixture of ten kilograms of poultry manure and 12 litres of water was prepared and introduced into the rearing tank to a depth of 7 cm (Kone *et al*., 2017). Each kilogram of dry manure produced 427 grams of fresh larvae or 106 g of dry larvae (Kone *et al*., 2017).

The maggots were collected after reaching maturity in 4 to 5 days using the flotation method described by Hussein *et al*. (2017). The live housefly larvae were immersed in hot water at 50°C to kill them and make them float. The water containing the dead maggots was then poured through a 3 mm sieve. The collected maggots were subsequently sun-dried and ground to produce housefly larvae meal following the guidelines established by IIeke *et al*. (2020).

1.1.3 **Analytical Methodologies**

Zimvet Laboratories and Aglab PVT LTD in Harare conducted proximate analysis and amino acid profiling of the housefly larvae meal, respectively, as shown in **Table 1**.

Table 1. Analytical Methods used to determine the Proximate Composition of HFLM

Analysis	Method	Reference
Moisture / Dry Matter	Oven-dry at 105^{O}C until a constant weight is attained.	Latimer (2023)
Crude Protein	Micro Kjeldahl method of digestion, distillation and titration	Latimer (2023)
Ether Extract	SOXHLET Method	Latimer (2023)
Crude Fiber	Boiling the defatted sample in dilute acid and dilute sodium hydroxide to dissolve starch and protein, leaving fiber.	Latimer (2023)
Ash	Incineration in a muffle furnace at 550^{O}C to burn all organic matter, leaving inorganic mineral residue.	Latimer (2023)

Analytical Methods Used to Measure the Amino Acid Profile of HFLM.

The amino acid profile of housefly larvae was analysed according to the standard methods outlined by Nsevolo Miankeba *et al*. (2022). The dried housefly larvae were ground into a fine, uniform powder, and the resultant meal was defatted with petroleum ether. Three samples of housefly larval meal, each weighing 50g, were combined with 6 M hydrochloric acid in a hydrolysis tube. Nitrogen gas was flushed through the tube to inhibit oxidation. The sealed hydrolysis tube was heated in an oven at 110°C for 24 hours to decompose proteins into their constituent free amino acids. Sulphur-containing amino acids, such as methionine and cysteine, were isolated using performic acid. Conversely, sodium hydroxide extracted tryptophan. The free amino acids were then reacted with phenylisothiocyanate to enable fluorescence detection. The prepared sample was introduced into an amino acid analyzer, where the distinct amino acids were isolated using the organic solvent acetonitrile.

Statistical analyses

The arithmetic mean of the three replicates of the proximate composition and three amino acid profiles was calculated to obtain the average proximate composition and amino acid profile of housefly larvae, respectively.

1.1.4 **Results**

Proximate Composition of Housefly Larvae Meal

The results obtained in this study show that housefly larvae raised on poultry manure have adequate crude protein, optimal crude fibre, and enough ash content, as shown in **Table 2**

Table 2. Nutritional Composition of Housefly Larvae Meal

Component	Mean (%)
Moisture	10.9
CP	38.5
EE	15.3
NDF	17.6
ADF	11.8
CF	8.66
Ash	8.54
Ca	0.82
P	0.89
Na	0.36

CP – Crude protein, EE – Ether extracts, NDF – Neutral detergent fibre, ADF – Acid detergent fibre, CF – Crude fibre, Ca – Calcium, P – Phosphorous, Na – Sodium

Amino Acid Profile of Housefly Larvae Meal

Table 3 outlines the amino acid profile of the housefly larvae meal used in this research.

Table 3. Amino Acid Profile of Housefly Larvae Meal

Amino Acid	Mean (%)
Methionine	2.539
Lysine	4.147
Tryptophan	1.074
Isoleucine	4.723
Leucine	5.405
Phenylalanine	3.809
Histidine	1.291

Calculated Amino Acids to Lysine Ratios in Comparison to the Ideal Amino Acid Ratio of Broiler Chickens

This study assessed amino acid composition in housefly larvae meal relative to lysine levels to derive amino acid-to-lysine ratios. These ratios were then compared with the established ideal amino acid profile for broiler chickens to determine whether they adequately meet broiler chickens' nutritional needs (**Table 4)**.

Table 4. Calculated Amino Acid to Lysine Ratios in Comparison to the Ideal Amino Acid Ratio of Broiler Chickens

Amino Acid	**Calculated HFLM Amino Acid Ratios Relative to Lysine**	**Ideal Amino Acid Profile For Broiler Chickens**
Lysine	100	100
Methionine	61	40 – 46
Tryptophan	26	14 – 20
Isoleucine	114	63 – 71
Leucine	130	107 – 126
Phenylalanine	92	55 – 75
Histidine	31	27 – 39
		Ref 1;2;3

Ref 1 – Baker (2003); Ref 2 – Wu (2014); Ref 3 – Macelline *et al.* (2026).

1.1.5 **Discussion**

Proximate Composition of Housefly Larvae Meal

Understanding the nutrient composition of animal feed is crucial for Nutritionists to create balanced diets. Crude protein (CP) supports tissue development and repair, enzyme and hormone production, and immune function. The crude protein levels in this study fall within the range (33% CP–64% CP) reported by other researchers (Adeniji, 2007; Hwangbo *et al*., 2007; Pretorius, 2011; Abraham *et al*., 2015; Arong and Eyo, 2017). The CP content of Housefly larvae meal identified in this study is lower than that reported by Hwangbo *et al*. (2007) and Obeng *et al*. (2015) but higher than that reported by Adeniji (2007) and Arong and Eyo (2017). Differences in CP content of housefly larvae (HFLM) can be explained by variations in drying techniques, larval age at collection, processing methods, and analytical techniques used (Gadzama and Ndudim, 2019). Aniebo and Owen (2010) noted that housefly larvae (HFL) collected at 2 days of age had an average CP content of 53.35%, while larvae harvested at 4 days of age had a CP content of 44.7%. Additionally, the same researchers reported average CP contents of 50.9% and 47.0% for oven-dried and sun-dried HFL, respectively.

The ether extracts found in this study are similar to those reported by Pretorius (2011) but are lower than those reported by other researchers (Atteh and Olobgbenla, 1993; Aniebo *et al*., 2008; Arong and Eyo, 2017). HFL collected later in metamorphosis, when they form pupae, exhibit higher levels of ether extracts than those collected at earlier life stages (Gadzama and Ndudim, 2019). Ether extracts play an important role in broiler diets because they provide a rich supply of concentrated energy and essential fatty acids that broilers cannot synthesize (Obeng *et al*., 2025). The crude fiber levels of HFLM in this study are similar to those reported by Atteh and Olobgbenla (1993) and Aniebo *et al*. (2008). The crude fiber levels identified in this study are consistent with those reported by Atteh and Olobgbenla (1993) and Aniebo et al. (2008), but they exceed the 3.14% crude fiber level noted by Arong and Eyo (2017). The crude fiber level observed in this study is acceptable, given that levels above 12% can impair nutrient digestibility and absorption (Obeng *et al*., 2015). Crude fiber plays a crucial role in gut development and maintaining digestive health (Bumhira *et al*., 2025). The ash content of HFLM in this study aligns with findings from other researchers (Jonathan, 2012; Obeng *et al*., 2015). However, the ash content results in this research are greater than those reported by Arong and Eyo (2017). Variations in ash composition often reflect differences in the mineral

content of the materials used to rear the HFL (Aniebo *et al*., 2008; Obeng *et al*., 2015). The moisture content of HFLM reported by the authors in this investigation is similar to that noted by other researchers (Atteh and Olobgbenla, 1993; Jonathan, 2021). Nonetheless, the moisture level found is lower than that reported by Arong and Eyo (2017). The moisture level in feed should not exceed 12% because wet feed is more susceptible to mould and has a shorter shelf life (Okoli *et al*., 2013).

Amino Acid Profile of Housefly Larvae Meal

Understanding the amino acid profiles of ingredients used in broiler feeds is crucial for animal nutritionists, as deficiencies in essential amino acids such as methionine, lysine, and threonine often limit broiler diet effectiveness (Maynard *et al*., 2022). Methionine is essential for cell development, feather growth, and protein synthesis (Alabi & Adedokun, 2025). Lysine supports overall body growth and breast meat yield, while threonine helps maintain gut health and supports immune function (Farkhoy *et al*., 2012). The levels of methionine, lysine, isoleucine, phenylalanine, and histidine found in HFLM in this study surpass those reported by Pretorius (2011). The levels of methionine, isoleucine, phenylalanine, and histidine identified in this study exceed those documented by Ochoa *et al*. (2025). In contrast, this paper reports lower lysine and tryptophan levels than Ochoa *et al*. (2025). However, the HFLM amino acid ratios relative to lysine, based on the amino acids identified in this study, exceed the ideal amino acid profiles for broiler chickens described by Baker (2003), Wu (2014), and Macelline *et al*. (2026).

1.1.6 **Conclusion**

An evaluation of the proximate composition and amino acid profile of housefly larvae meal indicates that it could serve as a viable substitute for soybean meal in broiler diets. Nevertheless, additional studies are needed to assess its feeding value, optimal inclusion rates, and effects on gut microbiota composition, metabolite profiles, and morphometric and morphological parameters in broiler chickens.

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Authors Contribution

EB developed the research concept, designed the experimental setup, and conducted the study, including data collection and fieldwork. TM provided overall oversight, gave essential direction during planning and execution, and handled statistical analysis and data interpretation. NC oversaw the research and supported the entire process. Both TM and NC edited and refined the manuscript, ensuring its scientific integrity.

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Data Availability

The datasets created and examined in this study are not publicly available per institutional guidelines, but the corresponding author, Edmore Bumhira, can provide them upon reasonable request.

Declarations

Ethics approval and consent to participate

All procedures for handling animals and conducting experiments complied with the ethical guidelines set forth by the National Animal Research Ethics Committee (NAREC) (2021). The authors also obtained permission from Great Zimbabwe University (Ethical Clearance Certificate Approval No. GZU2609-07).

Consent for Publication

Not applicable.

Competing Interests

The authors state that they have no conflicting interests.

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