Comparative yield of maggots and nutrient composition of maggot meal produced from three different substrates

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Abstract

As part of the effort in developing alternative protein ingredient to reduce the costs of feed associated with livestock production, maggotries were constructed to compare the yield and chemical composition of maggot meal produced from three substrates – poultry dropping, pig, and cattle dung. 150 kg each of poultry droppings, pig, and cattle dung were assigned into three treatments and further divided into 3 replicates of 50 kg each. Three liters of fresh cattle blood (attractant) was added per replicate without stirring. The housefly (*Musca domestica*) shed its eggs on the blood in the course of feeding which later developed into maggot. The collection of data started 5 days after the emergence of maggots on the substrates. 4.91 kg of maggot was obtained from poultry dropping, 3.53 kg from pig dung, and 0.95 kg from cattle dung. The chemical composition showed that maggot meal produced from poultry dropping substrate is higher in crude protein and crude fat (42.53% and 7.38%) than that of pig dung (40.78% and 6.08%) and cattle dung (41.69% and 6.29%) respectively. The amino acids composition of maggot meal produced from poultry dropping (lysine 0.89%, methionine 0.67%, and tryptophan 0.74%) were also comparably higher than that from pig dung (lysine 0.57%, methionine 0.38% and tryptophan 0.51%) and cattle dung (lysine 0.76%, methionine 0.51 kg and tryptophan 0.68%). However, the microbial load and mineral composition were observed to be higher in maggot meal produced from pig dung than those obtained from poultry dropping and cattle dung. Poultry dropping is of higher yield in maggot meal production, crude protein, crude fat, amino acid composition, and lower microbial load than pig and cattle dung. Although the maggot meals obtained from the three substrates can be used as an alternative protein source, poultry dropping has a higher yield and nutrient profile.

Keywords: maggot meal, attractant, poultry droppings, cow dung, pig dung.

Rendimento comparativo de larvas e composição nutricional da farinha de larvas produzida a partir de três substratos diferentes

Resumo

Como parte do esforço no desenvolvimento de ingredientes proteicos alternativos para reduzir os custos de alimentação associados à produção pecuária, larvas foram construídas para comparar o rendimento e a composição química da farinha de larvas produzida a partir de três substratos – fezes de aves, esterco de porco e gado. 150 kg cada de excrementos de aves, esterco de suínos e bovinos foram distribuídos em três tratamentos e posteriormente divididos em 3 repetições de 50 kg cada. Três litros de sangue fresco de gado (atraente) foram adicionados por repetição sem agitação. A mosca doméstica (*Musca domestica*) derramou seus ovos no sangue durante a alimentação, que mais tarde se transformou em larva. A coleta de dados iniciou-se 5 dias após a emergência das larvas nos substratos. Foram obtidos 4,91 kg de larvas de excrementos de aves, 3,53 kg de esterco de suínos e 0,95 kg de esterco de gado. A composição química mostrou que a farinha de larva produzida a partir de substrato de fezes de aves é mais rica em proteína bruta e gordura bruta (42,53% e 7,38%) do que a de esterco suíno (40,78% e 6,08%) e esterco bovino (41,69% e 6,29%), respectivamente. A composição de aminoácidos da farinha de larvas produzida a partir de fezes de aves (lisina 0,89%, metionina 0,67% e triptofano 0,74%) também foi comparativamente maior do que a do esterco de porco (lisina 0,57%, metionina 0,38% e triptofano 0,51%) e esterco de gado (lisina 0,76%, metionina 0,51 kg e triptofano 0,68%). No entanto, observou-se que a carga microbiana e a composição mineral são maiores na farinha de larvas produzida a partir de esterco de porco do que naquelas obtidas a partir de excrementos de aves e esterco de gado. A excreção de aves apresenta maior rendimento na produção de farinha de larvas, proteína bruta, gordura bruta, composição de aminoácidos e menor carga microbiana do que esterco de suínos e bovinos. Embora as farinhas de larvas obtidas dos três substratos possam ser utilizadas como fonte alternativa de proteína, as fezes de aves apresentam maior rendimento e perfil nutricional.

Palavras-chave: farinha de larvas, atrativo, excrementos de aves, esterco de vaca, esterco de porco.

1. Introduction

Livestock generates an important source of protein for human consumption (Boland et al., 2013; Pojić et al., 2018; Wu et al., 2024; Singh et al., 2022). In Nigeria, the total estimated population of poultry is 82.4million, small ruminants 56.6 million and pigs is 3.5 million (FAO, 2021). Conversely, manure generated by livestock presents a primary management challenge in areas with high-density livestock populations. In the US, over a billion tons of livestock manure is produced annually and a cow produces 29.5 kg of feces daily which is equivalent to 12 tons per year. (FAO, 2014). In areas with high animal density and limited options for export, total manure generation can be in excess that can be safely applied to agricultural land as fertilizer (Gollehon; Caswell 2000) contributing to eutrophication of water bodies, contamination of groundwater and threats of disease (Mallin; Cahoon 2003).

The high cost of protein feed resources (mainly fishmeal and soybean meal) has pushed animal nutritionists and livestock farmers into utilization of cheaper alternatives. Maggots and other non-conventional animals like winged termites, earthworms, and garden snails have been explored to check their nutrient contents, relative abundance, use and conversion into processed meals, incorporated into formulated diets and subsequent development of techniques for on-farm mass production (Vodounnou et al., 2015).

The increasing world population has led to a reduction in land availability for soybean cultivation while marine over-exploitation has continued to reduce the abundance of small forage fish from which fishmeal and fish oil are derived (Daniel et al., 2019) thus making the ingredients expensive with ultimate increase in the cost of production. Apart from being expensive, adulterations and poor storage are leading to lower quality. It is therefore unreasonable to continue relying on fishmeal and soybean as protein source in feed production. Several efforts have been made to find inexpensive and relatively abundant nutrient-rich substitutes to partially or wholly replace fishmeal as the most frequently used animal protein source in the diet of livestock and poultry (Makinde, 2015).

Many authors have reported interesting results about the suitability of different types of insect meal as ingredients for livestock (Veldekamp et al., 2012; Henze; Tran 2013; Van-Huis 2013; Makkar et al., 2014). Maggot meal has also been reported as a possible alternative to expensive animal protein sources (Sheppard, 2002; Teguia et al., 2002; Ogunji et al., 2008; Ajiboye et al., 2022). Advantageously, the short life cycle of maggots and their production in large quantities from materials regarded as waste makes them a possible alternative to explore.

Maggot is the larva of housefly (*Musca domestica*) which grows extensively on animal dung including cow, goat, sheep, and poultry dropping under favorable conditions. Nigeria being a tropical country provides a suitable environment and climate for maggot development. According to Aniebo et al. (2009), maggot is a potential alternative protein source for fish and livestock as reflected in its proximate composition. Also, the ease of maggot production, processing, storage, and acceptability by fish qualifies it as a suitable supplementary feed for fish.

Atteh & Ologbenla (1993) stated that maggot has good nutritional value and are cheaper and less tedious to produce than other animal protein sources. The maggot production system serves the dual purpose of providing a nutrient rich resource as well as a means of waste transformation, and reduction and the attendant negative impact on the environment (Teguia et al., 2002). The reported crude protein values range from 43 to 62% (Awoniyi et al., 2003; Fasakin et al., 2003). Adesulu & Mustapha (2000) reported that the levels of some essential amino acids including cystine, histidine, phenylalanine, tryptophan, and tyrosine in maggot meal is higher than in fish meal and soybean meal. In addition, Zheng et al. (2010) reported that essential amino acids accounted for around 48.5% of the total amino acids. Ogunji et al. (2008) reported that the biological value of maggot meal was comparable to that of whole fish meal and that the larvae contained no anti-nutritional or toxic factors sometimes found in alternative protein sources of plant origin. The present study was therefore designed to compare the maggot meal from three substrates- poultry dropping, pig, and cattle dung.

2. Materials and Methods

2.1 Description of the experimental site

The study was carried out at the maggotry unit of the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Oyo state, Nigeria. Ogbomoso lies on the longitude $4^{0}15^{1}$ east of the Greenwich meridian and latitude $8^{01}5^{1}$ northeast of the equator in the derived Savannah Zone of Nigeria. It is about 145 km northeastward from Ibadan, the capital of Oyo State, Nigeria. The altitude is between 300-600 meters above sea level. The mean annual temperature is about 27 ºC while the rainfall is 1247 mm. The vegetation of the area is derived from savanna with a relative humidity of 75 and 95% (Ewetola et al., 2015).

2.2 Collection and preparation of attractant and substrate

Fresh cattle blood (the attractant used) was collected from the central abattoir, Ogbomoso, Oyo State, Nigeria. A bucket was used to collect the blood as it gushed out after cutting the jugular vein of the slaughtered cattle, covered, and transported to the maggotry for immediate use.

Poultry droppings from laying birds in a battery cage system were collected directly from the poultry unit of the Teaching and Research farm of Ladoke Akintola University of Technology, Ogbomoso, Oyo state, Nigeria. One hundred and fifty (150 kg) of poultry dropping was collected and divided into 3 substrate tanks and 3 L of water was mixed with the 50 kg of poultry dropping in each tank. The substrates were watered to enable the maggots to migrate to the surface.

Cattle dung was collected from the central abbatior, Ogbomoso, Oyo state. One hundred and fifty (150 kg) of cattle dung was collected and divided into 3 parts (50 kg each). 10 L of water was mixed with the 50 kg of cattle dung poured into each substrate tank measuring 1 m x 0.6 m x 0.1 m.

One hundred and fifty (150 kg) pig dung was collected from a commercial farm at Kinnira, Ogbomoso, Oyo State, and divided into 3 parts. Each 50 kg of the pig dung was poured into 3 substrate tanks and 5 L of water was mixed with each.

After preparing the substrates in replicates, 3 L of fresh cattle blood was poured on the poultry dropping, cattle, and pig dung in each of the substrate tanks. The houseflies in the course of feeding on the blood laid tiny white eggs which later developed into maggots. The emergence of the maggots was observed on the 5^{th} and 7^{th} day. This was done to prevent the maggots from escaping. The maggots were drained, oven-dried at 65 ºC for 18 h, and weighed.

2.3 Composition of the maggot

The dried maggot was ground into powdered form and sub-sampled for chemical analysis. The representative samples of the test ingredients were analyzed for proximate composition, mineral composition, and amino acid composition using the standard methods of AOAC (2012). The total microbial count was determined by the pour plate method using Gallenkamp Incubator.

3. Results and Discussion

The total quantities of maggots produced from poultry dropping, pig, and cattle dung on days 5 and 7 of harvesting were 4.91 kg, 3.53 kg, and 0.95 kg respectively as shown in (Table 1).

Table 1. Quantities of maggot produced from the three substrates.

Parameters per tank	Poultry Dropping				Pig Dung				Cattle Dung			
	1	2	3	Total	1	2	3	Total	1	2	3	Total
QDI (Kg)	50	50	50	150	50	50	50	150	50	50	50	150
QMH-Post Incubation 5 days (kg)	2.79	1.10	1.02	4.91	0.22	0.74	1.58	2.54	0.11	0.08	-	0.19
QMH-Post Incubation 7 days (kg)	-	-	-	-	0.41	0.28	0.31	0.99	0.15	0.24	0.37	0.76
Total (Kg)				**4.91**				**3.53**				**0.95**

Note: N.B: QDI: quantity of dung/dropping incubated, QMH: quantity of maggot harvested 1, 2, 3: substrate tank number. Source: Authors, 2024.

From this experiment, the yield of maggots was largely influenced by the type of substrate and the day of harvesting the maggots. Maggot yield was largely affected by the quantity of fly attractant, this agrees with the submission of Nzamujo (2001). Poultry dropping was found to be the best substrate for the production of housefly maggots in terms of yield, this is because poultry manure is less rich in fiber and therefore provides a better diet for maggots. In addition, being mixed with fresh cattle blood, the substrate produced a fouler odour which attracts many flies that come to feed and lay there. This agrees with the report of Daniel et al. (2019); Ajani et al. (2004) and Adesulu & Mustapha (2000) which show that the type of substrate is an important factor influencing the production of maggots.

The proximate composition and microbial load of maggot meal produced from the three substrates is presented in (Table 2) while the mineral and amino acid composition is presented in (Table 3). Results obtained indicate that proximate composition of maggot meal was influenced by the substrate medium. The dry matter content of maggot meal from poultry dropping (7.76%) is lower than the values obtained from pig dung (8.35%) and cattle dung (8.09%). Also, the values of crude fibre, ash, and nitrogen-free extract from poultry dropping (6.11, 7.55, and 28.67%) are lower than the values obtained from pig dung (6.23, 7.90 and 30.68%) and cattle dung (6.46, 7.74 and 29.73%) respectively.

The crude protein and crude fat of maggot meal from poultry dropping (42.53 and 7.38%) show higher values than that of pig dung (40.78 and 6.08%) and cattle dung (41.69 and 6.29%) respectively. According to Akpodiete & Inoni (2000), maggot meal contains the ten essential amino acids that are comparable to fishmeal, thus, it has high nutritive value. The percentage of crude protein obtained in this study ranges between 40.78 - 42.53% which is in line with the report of 43.27% by Bokau et al. (2020). Though, higher than the 39.55% reported by Ogunji et al. (2006) but lower than 55% reported by Ahmad, (2022). The crude fiber (6.11 – 6.46%) obtained in this study is lower than the 8.55% obtained by Ugwumba *et al.* (2003) and 14.11% reported by Bokau et al. (2020) but higher than the 3.37% reported by Ahmad, (2022). Also, the ash content (7.55 – 7.90%) is close in range to 8.40% reported by Sogbesan et al. (2005) and 8.33% obtained by Ahmad, (2022). These variations might be due to differences in the compositions and location where the manures are collected.

The microbial load and mineral composition were observed to be higher in maggot meal produced from pig dung substrate than those obtained from poultry dropping and cattle dung substrates. While amino acid profile was observed to be lower in maggot meal produced from pig dung than those obtained from poultry dropping and cattle dung.

Table 2. Proximate composition and microbial load of maggot meal produced from the three substrates.

Parameters	Poultry droppings	Pig dung	Cattle dung
Proximate composition (%)			
Dry Matter	7.76	8.35	8.09
Crude Protein	42.53	40.78	41.69
Crude Fat	7.38	6.08	6.29
Crude Fibre	6.11	6.23	6.46
Ash	7.55	7.90	7.74
Nitrogen Free Extract	28.67	30.68	29.73
Microbial Load			
Total Microbial Load (CFU/g^{-1})	6.14 x 10^9	7.23 x 10^9	6.48 x 10^9

Source: Authors, 2024.

The comparison of results obtained from mineral composition with literature values indicates that the percentage of Calcium obtained in this study is lower than the value of 1.54% by Nzamujo, (2001). The phosphorus contents were relatively lower to the value of 1.2% obtained by Nzamujo, (2001). Comparing the values obtained to other protein sources like fishmeal and soybean meal implies that supplementary sources of calcium and phosphorus may be required when maggot meal is used in feed formulation.

The result of this study showed that lysine, methionine and tryptophan which are essential amino acid are present in the maggot meal though at varying levels. The values for lysine and methionine were relatively lower compared to other protein sources like fishmeal. The tryptophan values of pig and cattle dung (0.51 and 0.63) were almost the same as that of fishmeal (0.69) but a higher value of (0.74) than that of fishmeal and soybean meal was obtained in poultry dropping substrate. The presence of tryptophan tends to balance the status of maggot meal as against the findings of Teguia et al. (2002) who reported that the absence of tryptophan tends to cast doubt on the balance status of maggot meal and also contradicted the report of Fasakin et al. (2003) that absence of tryptophan could be the cause of better performance of fishmeal over maggot meal in broiler diet.

Table 3. Mineral and amino acid composition of maggot meal from three substrates.

Parameters Mineral composition	Poultry Dropping	Pig Dung	Cattle Dung
Calcium (%)	0.64	0.70	0.67
Phosphorus (%)	0.35	0.41	0.39
Magnesium (%)	0.28	0.34	0.46
Potassium (%)	0.92	0.91	0.95
Sodium (%)	0.23	0.27	0.23
Manganese (mg/kg^{-1})	23.30	23.92	23.54
Zinc (mg/kg^{-1})	61.93	72.52	64.33
Iron (mg/kg^{-1})	155.60	170.03	161.68
Copper (mg/kg^{-1})	3.80	8.37	5.95
Amino acid composition (%)			
Lysine	0.89	0.57	0.76
Methionine	0.67	0.38	0.51
Tryptophan	0.74	0.51	0.63

Source: Authors, 2024.

4. Conclusions

It can be concluded from this study that the maggot meal from poultry dropping substrate is better as it has more yield, crude protein, crude fat, amino acid composition, and lower microbial load than maggot meal from pig and cattle dung. However, the mineral composition of maggot meal from pig dung is slightly higher than that obtained from poultry dropping and cattle dung.

It is recommended that maggot meal from poultry dropping should be used as an alternative protein source in livestock feed production to replace the expensive fish meal and thus lower production costs. There should therefore be consistent and commercial production of maggot meal to ensure continuity and sustainability as a viable alternative to other protein source especially fishmeal.

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6. Authors' Contributions

Ojebiyi Olusegun Ojeniyi: conceptualized the study and designed the study. *Idowu Adijat Oyeyemi*: wrote the article. *Onyia Samuel Uche*: designed the study. *Oluyemi Elizabeth Oluseyi*: experimented. *Oyetunde Sodiq Olajide*: experimented. *Leshaodo Atinuke Mary*: experimented.

7. Conflicts of Interest

No conflicts of interest.

8. Ethics Approval

Not applicable.

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