Effect of varying levels of quantities of water on the quantity and quality of maggot production from two substrates

Anene Afamdi[1], Ukpabi [1] H. Ugochukwu and Igwilo U. Janefrancis
Animal Nutrition Laboratory, Department of Animal Science and Fisheries, Faculty of Agriculture, Abia State University, Umuahia Campus, Umuahia, Abia State, Nigeria.
Corresponding author: afamanene31@gmail.com

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Abstract

A maggot production study was conducted. In this experiment maggots were grown on 10 kg of two substrates (cattle blood and poultry droppings) treated with same levels of sawdust but at 0.5, 1.0 and 2.0 liters of inclusion of water. Each treatment was replicated three times. Harvesting of maggots was done by the use of sedimentation techniques (S.T). Maggots harvested from each replicate were weighed to the nearest 0.1 g when wet to obtain the wet weight (W_1) and then weighed again after drying to a constant weight at 35 °C in an oven to obtain the dry weight (W_2). All the weighing was done using a Mettler's digital balance. Dried maggot samples were subjected to proximate analysis. Data obtained in each measured parameter were subjected to analysis of variance. These results showed that there were no differences ($p > 0.05$) in the wet weight of maggots produced from the two substrates containing varying levels of water inclusion while there were differences ($p < 0.05$) in the dry weight of maggots produced from the two substrates containing varying levels of water inclusion. Cattle blood produced maggots of higher ($p < 0.05$) crude protein content of 37.20% and 39.9% in substrates containing 0.5 and 1.0 liter of water, respectively. The corresponding crude protein values for poultry dropping substrates were 35.3 and 22.54%. There are differences ($p < 0.05$) in the percentage of ether extract in maggots produced from cattle blood. These values were 20.47%, 14.55% and 15.27% at 2.0, 1.0 and 0.5 l of added water respectively. Crude fiber content of maggots differed significantly ($p < 0.05$) especially with respect to those produced from poultry manure. The result also shows that maggots produced from poultry droppings recorded 30.45% and 22.32% at 1.0 and 2.0 l of water. Peak crude fiber levels in maggots produced from cattle blood was recorded at 2.0 l of water.

Key words: maggot, cattle blood, poultry droppings, substrates, saw dust

Introduction

In fish and livestock production, feed is the most expensive factor, and protein components of livestock diet, constitute the highest cost. Maggot meal has been reported to be possible alternative to the expensive protein source. (Sheppard, 2002; Teguin, 2002; Ogunji, 2006).

In Nigeria, the quantity of the feed used in fish production, especially for catfish (*Clarias gariepinus* and *Heterbranchus bidorsalis*) is imported, and this has led to a high cost of production of fish. The rising cost of feed ingredients especially fish meal, has delayed the growth and development of agriculture in Africa. With the ever-increasing demand for fish meal globally, it is expected that its cost will continue to increase in the world market. In order to stem this trend, scientists have been carrying out studies to identify cheaper alternatives with comparable nutri-

tional quality. Maggot meal has been reported to possess good nutritional quality cheaper and less tedious to produce than most other source of animal protein.

House-fly larvae meal (maggot), like earthworms and other insect larvae such as termites has been found to contain good quality protein that can be utilized for the production of poultry and fish feed. (Sheppard, 2002, Awoniyi et al., 2003; Fasakin et al., 2003). The use of maggot protein for poultry and fish production has been widely reported by Atteh and Adedoyin (1993) and Sheppard et al. (2002).

There are variations in the values of maggot meal reported by, Teguia et al. (2002). These differences were attributed to factors such as, age at harvesting, method of processing, species of fly and type of substrates (Teotia and Miller, 1974; Fasakin et al., 2003; Teguia and Beynen, 2005). Some variations have been reported in the crude protein content of maggot meal (Fasakin et al., 2003) and this has been attributed the variations to drying methods while Atteh and Ologbenla (1993) attributed the variations in the chemical composition of the maggot meal difference to time of harvesting. Maggot meal is an animal protein source produced from waste; it has been reported to be highly nutritive with crude protein ranging between 43.9 and 62.4%, crude fibre 5.8 and 8.2% (Awoniyi et al., 2003; Fasakin et al., 2003; Ajani et al., 2004). Maggot meal is also rich in phosphorus, trace elements and B complex, vitamins (Teotia and Miller, 1973).

Maggot has good nutritional value, cheaper and less tedious to produce than other animal protein sources. Maggot can be produced from congealed cattle blood, dead animals and rotten meals. The production of maggot thus serves many purposes including providing nutrient-rich resources for animal feed and as a method of waste transformation and reduction. Maggots produced from wastes promote environmental friendliness of animal farmhouse operations.

Absorbents and attractants have played various roles in maggot production. An absorbent is a substance, material or item that sucks up liquid easily and retains them internally. Absorbents typically have large number of pores. The make-up of the absorbent makes it effective at soaking up water and other liquids. A loose fibre creates a product that is emptier than anything else, yet form chambers that can retain liquid. The holes between the fibres soak up the liquid and cause the fibrous material itself to swell, which also prevent the liquid from sloshing right back out.

This work is the third in a series of experiments aimed at boosting maggot production using farm yard wastes as substrates with or without sawdust. In this attempt we intend to introduce water at various levels to determine its effect on quantity and quality of maggot production.

Literature shows that poultry droppings, paw-paw leaves, cocoyam leaves, pig dung, blood meal, rice bran etc., have been used as substrates for the production of maggot, (Aniebo et al., 2008). Substrates such as poultry droppings can be mixed with leaves like paw-paw leaves. The mixture of poultry dropping and leaves makes the substrate pasty and can be put in containers and exposed in a humid environment. The leaves are used because, they can easily decay to attract flies to lay eggs which will hatch into larvae and finally to maggots. These substrates basically function as a medium for flies to lay their eggs and for the development of these eggs into maggots.

Wheat bran and sawdust have been utilized as absorbent materials for blood waste in the production of maggot (Aniebo and Erondu, 2008, Aniebo et al., 2008). However, wheat bran is becoming costly such that sawdust and wood shavings now appear to be better alternatives for blood absorbance. It was observed that maggot yield was highest at the ratio 70 : 30 wheat bran and sawdust ratio which yield about 6.2 kg of maggot when compared to the other ratios (Aniebo et al., 2008).

Attractant is a chemical or agent that lures insects or other pests by stimulating their sense of small. Natural host odour not only attracts flies from a distance but also result in increased investigating flies to artificial objects such as urine. A practical substrate for pure phenols is likely present in most ruminant farm animals. Aged urine is more attractive to flies than fresh urine due

to the development of both phenols and ammonia as the urine ages. When urine is exposed, in the presence of bacteria for a few days, ammonia is released and phenol levels in urine increases from the activity of bacteria. But the levels of ammonia decrease considerably after about a week or two. Additives such as attractants and absorbents have been used to enhance the potentials of these substrates in attracting flies and the development and production of maggots. Attractants such as milk, honey, sugar, mango peels, palm wine etc., have been used to attract flies to substrates and further boost the maggot production and potentials of the substrates (Hwangbo et al., 2009).

This work is the third in a series of experiments aimed at maggot production using farm yard wastes as substrates (Anene et al., 2013; Anene et al., 2019). In this attempt we intend to introduce various quantities of water to determine its effect on the quantity and quality of maggot production hoping that this will further provide the springboard for commercialization of maggot meal production process and thus, provide an inexpensive animal protein source for fish and poultry production.

Materials and methods

Location of Study

This study was carried out at the Green House of Teaching and Research Farm of Faculty of Agriculture, Abia State University, Umuahia Location, Nigeria. Umudike is located at Latitude 05° 29' North and Longitude 07° 33' East. It lies at an altitude of approximately 122 m above sea level. Umudike has an annual ambient temperature of 25–30 °C and relative humidity of 57–91%. It is located within the tropical rainforest zone and the environment is characterized by an annual rainfall of 2000–2484 mm.

Substrates used

The major substrates which constitute the treatments in this experiment are as follows:

- Cattle blood;
- Poultry dropping.

Each treatment was replicated three times a total of eighteen observations.

Procedure

The experiment was conducted in an open environment, 10 kg each of undiluted cattle blood and poultry dropping was mixed with same levels of sawdust (3 kg) but varying levels of water 0.5, 1.0, and 2.0 l of water which was placed in an open space under a room and protected with mosquito net to prevent lizards, snakes, birds from entering and feeding on the maggots. The odour of the cattle blood and poultry droppings attracted flies which later laid eggs on the substrates. The eggs hatched into larvae within two days, and were allowed for 48 hours to develop further. Maggot attained its optimal size in 3–4 days (15), to become the desired maggots ready to be harvested. Maggots were harvested on the fourth day using the sedimentation technique (15).

Harvesting of Maggot

Harvesting of maggots was done by sedimentation techniques (ST). Each of the replicate was mixed with 10 litres of water and was allowed for about 10–15 minutes, the substrates sank (sedimented) while the maggot floated on the water surface. Mature maggots were harvested using a 4 mm plastic sieve. The harvested maggot was collected in a labelled cellophane bag and be taken to the laboratory for measurement of weight and proximate analysis.

Weight Measurements

Maggots harvested from each replicate were weighed to the nearest 0.1 g when wet to obtain the wet weight (W_1) and then weighed again after drying to a constant weight at 60 °C in an oven to obtain the dry weight (W_2) all weighing were done using a metal' digital balance. Maggots from each replicate were pooled and the average per treatment was calculated and expressed per unit weight of substrate.

Dried samples were subjected to proximate analysis to determine the crude protein, fat, ash, moisture and crude fiber contents and all was replicated three times in a completely randomized design.

Proximate Composition of Maggots

Fat content was determined by petroleum ether (Boiling point 40–60 °C) extraction in a Soxhlet apparatus. Ash content was determined by igniting the sample at 155 °C to burn off organic materials i.e. until grey colour appears.

Protein content was determined using Kjeldahl method and calculated as follows:

$$CP\% = N \times 6.25$$

$$\%N = \frac{100 \times N \times 14 \times vt \times (T - B)}{W1000va}$$

Where W = weight of sample usually 0.5 g
N = Normality of titrate (0.02 NH_2SO_4)
Vt = Volume of digest analyzed (10 mls)
T = sample titre value
B = Blank titre value
CP = Crude protein

Experimental Design and Statistical Analysis

The experiment involves growing maggots on two substrates (cattle blood and poultry droppings) treated with same levels of sawdust but different levels of water. 10 kg each of cattle blood and poultry dropping were used per treatment. The treatment levels are as follows:

T_1 = 10% of poultry droppings + 3% sawdust + 0.5 litre of water inclusion;
T_2 = 10% of poultry droppings + 3% sawdust + 1.0 litre of water inclusion;
T_3 = 10% of poultry droppings + 3% sawdust + 0.5 litre of water inclusion;
T_4 = 10% of cattle blood + 3% sawdust + 0.5 litre of water inclusion;
T_5 = 10% of cattle blood + 3% sawdust + 1 litre of water inclusion;
T_6 = 10% of cattle blood + 3% sawdust + 2 litre of water inclusion.

Statistical Analysis

All the data collected were subjected to analysis of variances (ANOVA). Where significantly treatment effects were detected by ANOVA means were separated using Duncan's New Multiple Range Test (17, 18) taking $p < 0.05$ as significance level. The models of the experiment were:

$$Y_{ijk} = \mu + S_j + (T.S)_{ij} + e_{ijk}$$

Where Y_{ijk} = Individual or single observation
μ = population (mean)
T_i = Effect of substrate
S_j = Effect of water level
$(T.S)_{ij}$ = Interaction effect of substrate and water levels
e_{ijk} = Random error.

Results and discussion

Table 1 shows the wet and dry weight of maggots produced from poultry droppings and cattle blood, at different levels of water inclusion. The results from this study show that poultry drop-

Table 1. Quantity of Maggots Produced from Cattle Blood and Poultry Droppings at same Inclusion Level of Sawdust but Varying Levels of Water

Treatment	Wet weight (g/kg)	Dry weight (g/kg)
Poultry droppings at 0.5 L of water inclusion	$0.00^{a} \pm 0.00$	$0.00^{b} \pm 0.00$
Poultry droppings at 1.0 L of water inclusion	$31.70^{b} \pm 3.94$	$3.71^{c} \pm 1.50$
Poultry droppings at 2.0 Ls of water inclusion	$182.97^{a} \pm 2.59$	$6.73^{c} \pm 1.59$
Cattle blood at 0.5 L of water inclusion	$190.43^{a} \pm 9.37$	$20.25^{a} \pm 1.68$
Cattle blood at 1.0 L of water inclusion	$73.77^{c} \pm 31.86$	$7.06^{b} \pm 3.44$
Cattle blood at 2.0 Ls of water inclusion	$64.03^{d} \pm 4.57$	$5.85^{d} \pm 3.81$
SEM	5.88	3.37

[ab:] means in the same column with different superscripts are significantly different ($p < 0.05$)

pings at 0.5 l, 1.0 l and 2.0 l of water inclusion levels yielded a mean wet weight of 0.00 g, 31.70 g and 182.97 g respectively. Similarly, the wet weight of maggots produced from cattle blood at 0.5 l, 1.0 l and 2.0 l of water inclusion levels are 190.43 g, 73.76 g, and 64.03 g respectively.

There are significant differences ($p < 0.05$) in the wet weight of maggots produced by various experimental conditions. A peak weight (190.43 ± 9.31 g) of maggots was produced in cattle blood with 0.5 l of water. Poultry droppings with 2.0 l of water were used to produce 182.92 ± 2.59 g of maggot. The same trend was observed in the dry weights of the maggots produced.

At 0.5 l of water in poultry droppings no maggot was produced. Earlier reports indicate that generally poultry droppings are known to produce maggot even without any water (Anene et al., 2019). It is possible all the moisture was absorbed by the added sawdust.

It is important to note that the quantity of maggots produced in this study were generally higher than those reported in Anene et al. (2013). Higher weights recorded in this study may largely be attributed to the addition of water. This report however agrees that the quantity of maggots produced was primarily dependent on the nature of the substrates (Akpodiete et al. (1993); Awoniyi and Aletor, 2002; Aniebo et al., 2008).

Table 2 summarizes the proximate composition of maggots produced from poultry droppings and cattle blood with different levels of water and same quantity of sawdust.

Dry Matter:

There are differences ($p < 0.05$) in the dry matter content of maggots produced by both cattle blood and poultry droppings. Dry matter content of 89.43 ± 0.13 was recorded when 0.5 l of moisture was added to cattle blood and this was higher ($p < 0.05$) than at various levels of water addition. There was difference ($p < 0.05$) in dry matter content of maggots produced from poultry droppings. Poultry droppings with 1.0 liter of water recorded 93.12% dry matter level and this shows a decreasing ($p > 0.05$) trend as the level inclusion of water increased. This result is similar to earlier findings (Lynsk, 1993) where it was reported that high moisture manure favors the survival of the housefly larvae (maggot). The value recorded for moisture content in this study was in accord with an earlier record (Anene et al., 2013).

Ash Content:

There are significant differences ($p < 0.05$) in the ash content of maggots produced from different substrates and water levels. At 1 liter of wa-

Table 2. Proximate composition of maggot produced from cattle blood and poultry droppings with varying levels inclusion of water

Parameters	CB at 0.5 L of water	CB at 1.0 L of water	CB at 2.0 L of water	PD at 0.5 L of water	PD at 1.0 L of water	PD at 2.0 L of water	SEM
Dry matter (%)	$89.43^{b} \pm 0.13$	$88.31^{c} \pm 0.03$	$88.22^{c} \pm 1.12$	0.00 ± 0.00	$91.85^{a} \pm 0.14$	$82.43^{d} \pm 0.53$	0.84
Moisture content (%)	$10.57^{d} \pm 0.13$	$11.69^{c} \pm 0.03$	$12.50^{b} \pm 0.10$	0.00 ± 0.00	$8.15^{e} \pm 0.14$	$17.57^{a} \pm 0.52$	0.81
Ash content (%)	$4.42^{e} \pm 0.23$	$6.37^{d} \pm 0.03$	$8.43^{c} \pm 0.08$	0.00 ± 0.00	$15.42^{a} \pm 0.18$	$14.09^{b} \pm 0.12$	1.15
Crude protein (%)	$37.54^{b} \pm 0.51$	$39.91^{a} \pm 0.14$	$33.38^{d} \pm 0.58$	0.00 ± 0.00	$35.20^{c} \pm 0.21$	$22.54^{e} \pm 0.29$	1.61
Ether extract (%)	$15.27^{b} \pm 0.43$	$14.55^{c} \pm 0.26$	$20.47^{a} \pm 0.53$	0.00 ± 0.00	$4.35^{e} \pm 0.03$	$6.64^{d} \pm 0.16$	1.57
Crude fiber (%)	$15.90^{e} \pm 0.43$	$17.42^{b} \pm 0.19$	$18.54^{c} \pm 0.08$	0.00 ± 0.00	$30.45^{a} \pm 0.17$	$22.32^{b} \pm 0.33$	1.39
Nitrogen free extract (%)	$16.31^{a} \pm 0.70$	$10.26^{b} \pm 0.27$	$6.68^{c} \pm 0.31$	0.00 ± 0.00	$6.43^{c} \pm 0.28$	$16.31^{a} \pm 0.85$	1.21
Metabolizable energy (%)	$43.38^{a} \pm 3.96$	$42.08^{b} \pm 7.22$	$43.83^{a} \pm 2.87$	0.00 ± 0.00	$34.89^{c} \pm 8.88$	$32.51^{d} \pm 2.81$	1.28

[abcd]: means in the same row with different superscripts indicate significant differences ($p < 0.05$). Mean separation using Duncan multiple range test.
CB= cattle blood
PD= Poultry droppings
L= Liter.

ter, the ash content was 15.42 ± 0.18% for poultry droppings and 14.09 ± 0.12 at 2.0 l. Ash content from maggots produced from cattle blood were 4.42%, 6.32% and 8.43% at 0.5, 1.0 and 2.0 l of water respectively. The range for ash content in the maggots produced in this study was similar with the range 10.33% recorded in literature (Adesanya et al., 2011).

Crude Protein:

There was significant differences ($p < 0.05$) in crude protein content of maggots produced. Peak protein content was 39.91 ± 0.14 for cattle blood and 35.20 ± 0.21 for poultry manure though lower than we previously recorded (Anene et al., 2013) are similar with literature reports (Inaoka et al., 1999; Heuzè and Tran, 2013). The crude protein content of housefly maggots was shown by various researchers to vary between 40%–60% (Inaoka et al., 1999; Fasakin et al., 2003; Aniebo and Erondu, 2008; Anene et al., 2013, Heuzè and Tran; 2013). However, the presence or absence of additives such as sugar and powdered milk (Hwangbo et al., 2009) may account for the differences in protein content of maggots. The higher protein values obtained in maggot meals in this study may be attributed to the higher nutritional content of the substrate.

Ether Extract:

There are significant differences ($p < 0.05$) in the percentage of ether extract in maggots produced from cattle blood. These values were 20.47%, 14.55% and 15.27% at 2.0, 1.0 and 0.5 l of added water respectively. Similarly, addition of water to poultry droppings resulted in significant increases ($p < 0.05$) in ether extract. This variable was 0.00 ± 0.00, 4.35 ± 0.03 and 6.64 ± 0.16% in poultry droppings and followed the same trend for cattle blood.

In a related maggot breeding experiment, Inaoka et al. (1999) recorded crude fat content of 20% in maggots while some other authors have reported a highly variable lipid contents ranging between 9–25% (Heuzè and Tran, 2013). The results of this study on fat content of maggots produced from different substrates were in tandem with those of other authors. Drying methods (sun drying and oven drying) have been shown to influence the ratio of protein to fat ratio (Aniebo and Owen, 2008). Heuzè and Tran (2013) observed that fatty acid profiles of maggots are largely influenced by the substrates on which they are grown and this may account for the high variability in fat content reported by various authors (Inaoka et al., 1999, Hwangbo et al., 2009, Aniebo and Owen, 2010 and Anene et al., 2013).

Crude Fiber:

Crude fiber content of maggots differed significantly ($p < 0.05$) especially with respect to those produced from poultry droppings. The result also shows that crude fiber of maggots produced from poultry droppings were 30.45% and 22.32% at 1.0 and 2.0 l of water. Peak crude fiber levels (18.54%) in maggots produced from cattle blood was recorded at 2.0 l of water. The crude fibre in this study which ranged from 15.90%–30.45% was unusually higher than the findings by Awoniyi et al. (2003) who reported crude fibre content of 7.5% and reported that the proximate composition of maggot was not influenced by the substrate medium. It also contradicts the findings of Anene et al. (2013) who reported that the low values of crude fibre in maggot meal is an indication that it is not a good source of fibre.

Nitrogen Free Extract (NFE):

There was a difference ($p > 0.05$) in nitrogen free extract (%) of maggots produced in the different experimental settings. The nitrogen free extract in maggots produced from cattle blood decreased with increase in water level while the reverse was the case in poultry droppings. Peak NFE (16.31 ± 0.70%) in cattle blood was recorded at 0.5 l of water while that for poultry manure (16.31 ± 0.85%) was at 2.0 l of water.

Metabolizable Energy:

In this study the metabolizable energy produced from cattle blood at 0.5 and 2.0 liters of water inclusion levels was 43.38% and 43.83% showed that there are no differences ($p > 0.05$). The Metabolizable energy produced from poultry droppings at 2.0 liters of water inclusion level was 32.51% was low (Aniebo and Erondu, 2008).

The results of this study showed that there were significant differences in all proximate composition parameters investigated. The very marked observed disparities in the values obtained in this study for some parameters such as crude protein and crude fibre content, with those recoded by some other authors could be attributed to species differences of the flies that invaded the substrates or because of sawdust inclusion.

Conclusion

This report is aimed at exploiting various ways of producing maggots from farm wastes. Data here obtained show that systematic dilution of substrates up to 2.0 liters of water can enhance the quantity of maggot production.

Recommendation

It is therefore recommended that cattle blood at 0.5 l inclusion level of water produced the highest quantity of maggot, poultry droppings at 2.0 l inclusion of water also produced a very good amount of maggot, and poultry droppings can be used when a farmer cannot easily source for cattle blood. Cattle blood at 1.0 l and 0.5 l of water produced the highest crude protein of (39.91 and 37.54%). Cattle blood at 2.0 l and 0.5 l of water recorded the highest metabolizable energy in maggots.

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