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A sustainable production of Maggots (squatts) as live food for Nile tilapia (*Oreochromis niloticus*)

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ABSTRACT
The study was aimed at ensuring a sustainable production of live maggots for tilapia feeding. The study was carried out in the Department of Biotechnology- University for Development Studies, Nyankpala campus, and part at Water Research Institute, Tamale-Ghana. Three different substrates (Pito waste-PIW, Poultry waste-POW, and Animal digester or rumen liquor-AD) were used as culturing media for the maggots. Also the relishing effect of live maggots by tilapia at different growth phases was realized. Significant difference in the length, girth, quantity and weight were observed. There was significant difference in all the parameters between the substrates types with maggots cultured in animal digester showing significantly higher yield than those cultured in pito and poultry wastes. Tilapia at all phases of growth relished live maggots but the adult tilapia (100 g) showed the highest total percentage rate of uptake of live maggot at 43.06% per 6 hours. This study has shown that maggots can be quantitatively bred from waste materials like poultry, pito and abattoir wastes by careful selection of a suitable substrate, fly attractants and day of harvesting maggots among other factors. Yield of maggots was highly influenced by the type of substrate and the day of harvesting of the maggots.

Keywords: Maggots; substrates; tilapia; feed; aquaculture

1. Introduction
Fishes as part of living organisms are also selective in what they eat. Different species of fish not only have different nutritional requirements, but they also seem to have different palate requirements [5].
On a global basis, more than 85.5 percent of fed fish and crustacean aquaculture production was produced on the Asian continent in 2008 (26.9 million tons), followed by the Americas (1.93 million tons, or 6.1 percent), Europe (1.64 million tons, or 5.2 percent), Africa (0.94 million tons, or 3.0 percent), and Oceania (50 317 tons, or 0.2 percent) [15]. Therefore, Ghana as part of Africa needs to pay much attention to aquaculture with respect to fish feeding in order to meet the demand for valuable proteins from fish, and some economic benefits from exported fish.
The growth of aquaculture has increased as more people around the globe turn to fish as a source of lean protein. The percentage of the fish meal used for aquaculture feed increased from 10% in 1988 to around 45% in 2002 [6]. Aquaculture is likely to grow over the next 20 years and some experts are concerned that rising demand for fish meal and fish oil could place heavier fishing pressure on already threatened stocks of fish used for feed [4]. In developing nations, the cost of commercial livestock farming and fish feed have become very expensive (Ayinla, 1988) [2] accounting for over 60% of the recurrent overhead costs of livestock farming and about 70% of a fish farming venture [14]. Replacements for fishmeal and fish oil are therefore needed to support sustainable aquaculture [5].

1.1 Alternative feed for fish
A relatively new advancement in aquaculture is the use of insects as a source of animal protein in fish nutrition [7]. In Ghana, several researches have been carried out on the production and use of squats as fish feed [8] but with little experiment on the comparison of substrates and this has created a potential ground for research.

1.2 Objectives
The objectives of the study was to determine a suitable substrate for culturing squats and the rate of uptake of live maggots by tilapia

2. Materials and Methods
2.1 Substrate preparation
Poultry waste which was made up of dry poultry droppings, liter, broken eggs, and feathers were further processed by pounding and mixing with 0.5 litres of water, 2 ml of dawadawa (*Parkia biglobosa*) paste was then added. Animal digester (rumen liquor) of a cattle and pito waste (brewer spent) were directly mixed with 2 ml of dawadawa paste. 200 g of each substrate was wrapped in old newspapers and placed in different bioreactors which were filled with rice bran up to 1 cm.

The bioreactors were labeled as AD.D1.R1 to AD.D4.R3, PIW.D1.R1 to PIW.D4.R3, and POW.D1.R1 to POW.D4.R3, where;
AD is animal digester, PW is pito waste and POW is poultry waste
R1-R3 represents replication 1, replication 2, and replication 3 respectively
D1-D4 represents day 1, day 2, day 3, and day 4 of harvesting after inoculation
The bioreactors were opened to about ¼ of the lids and left under a shade of a tree for 6hrs for the houseflies to oviposit. The bioreactors were then completely covered with perforated lids and transferred into a net enclosed house.

2.2 Harvesting of maggots
Harvesting was done by taking advantage of the peristaltic movement and photo sensitive nature of maggots with the aid of a plastic spoon. The first harvesting was done 24 hrs after inoculation with subsequent harvesting at 24 hrs interval.

2.3 Live maggots uptake test
The experiment was conducted using 15 tilapias grouped into three, of which five (5) were fingerlings, five (5) were juveniles, and 5 were adults with an average weights of 30 g, 50 g, and 100 g respectively. Fifty (50) active live maggots were fed to each of the three (3) groups of tilapia. The number of maggot(s) taken up by the tilapias every hour was recorded consecutively for six hours.

2.4 Data collection and analysis
Ten (10) maggots from each substrate were randomly selected and made immobile or dead by keeping them in ethanol for 30 - 60 minutes. This was to facilitate the measurement of growth parameters. The growth parameters were measured as shown below;

$$AL = \frac{TL}{10} \quad \text{and} \quad AG = \frac{TG}{10}$$

Where: AL____ average length of ten (10) maggots
AG ____ average girth of ten (10) maggots
TL _____ total length of ten (10) maggots
TG_____ total girth of ten (10) maggots

Also 50 maggots from each substrate were selected at random per day and weighed using an electrical balance.

$$W_{50m} = TW\text{-}WP$$

Where: $W_{50mag.}$ _____ Weight per 50 maggots
WP_____ weight of petri dish
TW_____ weight of petri dish + weight per 50 maggots

Maggots from each substrate were physically counted per day and recorded.

3. Results
3.1 Evaluation of the effect of day of harvesting on the maggot production

Table 1: Effect of day of harvest on maggot production

Day	Girth (mm)	Length (mm)	Quantity(log10_ 1)	A.w .50$_{mag.}$ (g)
1	0.189^{a}	0.880^{a}	0.83^{a}	0.173^{a}
2	0.556^{a}	2.440^{a}	1.55^{b}	0.507^{b}
3	1.033^{b}	4.480^{b}	1.98^{b}	0.638^{b}
4	1.456^{c}	7.540^{c}	1.96^{b}	0.972^{c}

Means with different superscripts (a-c) in the same column are significantly different ($p<0.05$). Where A.W.50$_{mag}$ was average weight of 50 maggots recorded in grams per day.

3.2 Evaluation of the effect of substrates on the maggot production.

Table 1: Effect of substrates on maggot production

Substrate	Girth (mm)	Length (mm)	Quantity(log10_ 1)	A.W.50$_{mag.}$ (g)
AD	1.517^{a}	7.020^{a}	3^{a}	1.011^{a}
PIW	0.517^{b}	2.570^{b}	0.79^{b}	0.364^{b}
POW	0.392^{b}	1.920^{b}	0.94^{b}	0.342^{b}

Means with different superscripts (a-c) in the same column are significantly different ($p<0.05$).

3.3 Analysis of the combined effect of day of harvest and the substrate type on maggot Yield.

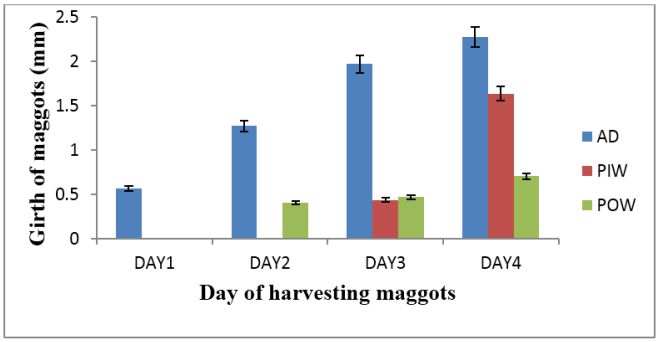

Fig 1: Mean girth distribution of maggots in relation to the effect of day of harvesting and the type of substrate used.

The combined effect (day of harvesting and substrate type) on the girth of maggot showed significant ($p<0.05$) increase in the girth of maggots harvested from the three substrates (AD, PIW, and POW) as the days go by. Maggots cultured on AD were significantly ($p<0.05$) higher in girth compared to the rest with day (Figure 1).

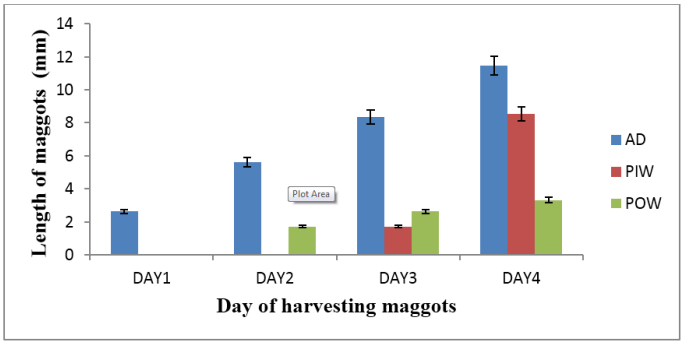

Fig 2: Mean length distribution of maggots in relation to the effect of day of harvesting and the type of substrate used.

The combined effect (day of harvesting and substrate type) on the length of maggot showed significant ($p<0.05$) increase in the length of maggots harvested from the three substrates (AD, PIW, and POW) as the days go by. Maggots cultured on AD were significantly ($p<0.05$) higher in girth compared to the rest with day (figure 2).

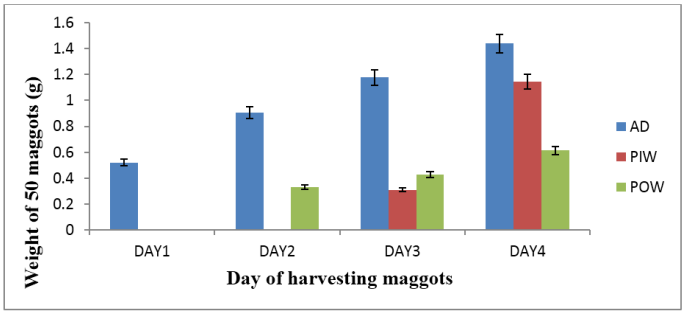

Fig 3: Mean weight distribution of 50 maggots in relation to the effect of day of harvesting and the type of substrate used.

The combined effect (day of harvesting and substrate type) on the weight of maggot showed significant ($p<0.05$) increase in the weight of maggots harvested from the three substrates (AD, PIW, and POW) as the days go by. Maggots cultured on AD were significantly ($p<0.05$) higher in terms of weight compared to the rest with day (figure 3).

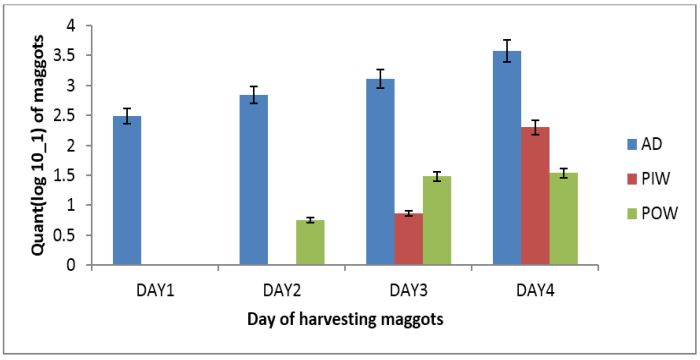

Fig 4: Mean quantity distribution of maggots in relation to the effect of day of harvesting and the type of substrate used.

The combined effect (day of harvesting and substrate type) on the quantity of maggots showed an increase in the quantity of maggots harvested from the three substrates (AD, PIW, and POW

Table 3: Maggot uptake analysis

Rate of uptake PER 50 MAG in hours(HR)	Percentage fingerlings (F) uptake	Percentage Juvenile (J) uptake	Percentage adults uptake	Total percentage of uptake
1	26.39	18.06	30.56	75
2	0	12.5	6.94	19.44
3	0	0	0	0
4	0	0	0	0
5	0	0	2.78	2.78
6	0	0	2.78	2.78
Total	26.39	30.56	43.06	100

Table 3 showed higher percentage rate of uptake in the first hour for adults (30.56%), fingerlings (26.39%), and juveniles (18.06%). Adult tilapias recorded the highest uptake followed by fingerlings and juveniles respectively in the first hour of observation.

The total percentage uptake of 50 maggots fed to fingerling, juvenile, and adult tilapias was 26.39%, 30.56% and 43.06% respectively (Table 3).

4. Discussion

4.1 Maggot yield

According to Aniebo and Owen [1] maggots are primarily harvested for its food value which is dependent upon their chemical composition which is affected by both age of larvae and method of harvesting. There is therefore, the need to identify the actual mature age concomitant with time of harvesting that will give maximum food value (proximate composition).

From the experiment conducted, yield of maggots was largely influenced by the type of substrate and the day of harvesting of the maggots. The combined effect of these two factors revealed no significant difference in the quantities of maggots produced.

4.2 The effect of day of harvest on maggot production

The results showed that mean girths, lengths, quantity and the mean weights were significant different among the days of harvesting ($p<0.05$) (Table 1). Even though the length of maggots obtained on the fourth day of harvest was in the range of 7.5 mm to 11 mm, the mean length recorded for day four (4) after analyses was 7.54 mm (Table 1).

According to Sanchez-Arroyo [12] the full-grown maggots with a greasy, cream-colored appearance are about 8 to 12 mm long and this differed slightly from the outcome of the research. Maggots were less active on the fourth day after the day of inoculation and this is due to their pupating preparation on the fifth day after day of inoculation as it can complete its life cycle in as little as seven to ten days [12]. It can be therefore suggested that harvesting would be more appropriate on day three after inoculation.

4.3 The effect of substrates on maggot production

Table 2 shows a summary of analysis of maggots yield cultured on three (3) different substrates. It was revealed that there was significant difference between the substrates at $p<0.05$.

The outcome revealed that substrates were significant different in terms of the mean length, girth, weight and quantity. Maggots cultured on animal digester showed significantly higher yield than those cultured on pito and poultry wastes and this could be as a result of the presence of higher protein constituent generated by the rumen microbial protein synthesis [9].

There was no significant difference in yield of maggots produced in both pito and poultry waste when culturing under the same conditions with reference to size, quantity and weight (Table 2).

4.4 The effect of day of harvest and the substrate type on maggot production.

The combined effect of day of harvesting and type of substrate showed a significant different distribution of mean girths, lengths and weights as shown in figure 2, 3, and 4 respectively.

There was no significant difference in the total quantities and it is suggested that the same and equal quantities of fly attractant (Dawadawa paste) used for each substrate, and culturing at the same weather condition are the probable cause of this effect since these directly influence the quantity of fly inoculums (figure 5). The stronger the attractant the higher the rate of inoculation and when all things being equal, the quantity of inoculums are directly proportional to the quantity of maggots produced and this corresponds to [11], where poultry droppings was mixed with fly attractant to obtain sufficient maggots for further nutritive analysis. It is believed that the type, quantity of fly attractant and weather condition are the major factors that account for the intensity of inoculation and hatchability of eggs as far as the total quantity of maggots to produce was concern. This finding agrees with the submission of [10] that maggot yield is largely affected by the quantity of fly attractants as well as weather conditions.

4.5 The effect of live maggot uptake by tilapia

Findings indicated that, fingerlings, juveniles and adults tilapia had live maggot uptake at 26.39%, 18.06% and 30.56% respectively in the first hour observation. The percentage uptake of live maggots decreased tremendously from the third to sixth hours across the various growth stages (Table 3).

It was suggested that tilapia in general prefer live maggots than the dead or immobile maggots and from observation during the preference test, the maggots in each of the units appeared to be dead or inactive on the water surface at the third and sixth hours but the adult tilapia were able to record uptake rate at 2.78% at the fifth and 2.78% at the sixth hours (Table 3) and this was probably attributed to the ability of tilapia to change feeding habit as they grow which was also reported by [3].

The adult tilapia (100 g) showed the highest total percentage of live maggot uptake rate at 43.06% (Table 3) and this may be attributed to the fact that adult fish have a higher feed up take than fingerlings and juveniles which was reported by [3] and [13].

However there was no maggot uptake recorded for all the fish groups during the third and fourth hours and this can be attributed to satisfaction of the fish.

5. Conclusion

This study has shown that maggots can be quantitatively bred from waste materials like poultry, pito and abattoir wastes.

Yield of maggots was highly influenced by the type of substrate and the day of harvesting of the maggots.

Maggots cultured in animal digester showed better response than for pito and poultry wastes.

Tilapias at all growth stages relish live maggots as their food and sustainable production of maggots for aquaculture should be encouraged.

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