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Alternative Feed Resource for Growing African Palm Weevil (*Rhynchophorus phoenicis*) Larvae in Commercial Production

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Abstract

A six (6)-week long experiment was undertaken to develop an alternative feed resource for the production of African palm weevil (*Rhynchophorus phoenicis*) larvae and to evaluate the performance of the larvae raised on the different diets. After two weeks, four-hundred (400) young larvae (hatchlings) which weighed between 0.6 – 1.6 g were selected and randomly grouped into 40 sets, each group comprising ten (10) larvae of similar weights and then randomly allocated to four (4) dietary treatments, using a completely randomized design (CRD) with ten (10) replications of 10 larvae. The four treatments designated as T1, T2, T3 and T4 had varying inclusion levels of oil palm yolk at 100%, 50%, 50% and 25% respectively with various combinations of agro-waste materials including fruit waste of banana and pineapple and millet waste. Three (3) kilograms of each diet was formulated and fed every two weeks of the four weeks feeding trial period; with feed being provided *ad libitum*. Results of the feeding trial revealed that parameters such as total feed intake and mean total feed intake per larva, feed conversion efficiency, pH of larvae and feed cost per kilogram showed significant ($p<0.05$) differences among treatments. Results of the proximate analysis of diets used revealed significant ($p<0.05$) differences among the various treatment diets. In conclusion, the study demonstrated that diets did not have any adverse effects on growth performance of larvae, whiles a relatively improved performance was observed at the least inclusion level of oil palm yolk, OPY (25 %). The agro-waste materials exploited actually proved to be potential alternative feed resources for raising the larvae and the diets used served as nutritionally suitable growth media for production of palm weevil larvae.

Keywords: agro-waste materials; feeding; hatchlings; inoculation; substrate.

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1. Introduction

With the world's population estimated to exceed nine (9) billion by the year 2050, researchers are continuously pressed towards developing researches to establish findings that will mitigate the issues of food insecurity [7]. Along with the increasing population, is the growing demands of consumers for food, essentially animal protein sources that often pose challenges owing to the high cost of animal production [6, 12]. In the bid to finding solutions for food security and Poverty Alleviation Strategies (PAS), focus has shifted to adopting non-traditional farming methods for exploring other protein feed resources other than the conventional protein sources. An obvious way to salvaging this impending doom as declared in related researches is "Entomophagy" which literally refers to consumption of insects and their products [9, 20]. Besides their ecological importance, insects play a significant role in the nutrition of both the rural and urban folks [19]. In this vein, the prospects of entomophagy in the campaign for food security and Poverty Alleviation Strategies must be immensely exploited. Notably among insects species that have proven important roles in the nutrition of humans include; Grasshoppers, Bees, Rhinoceros beetles, Crickets, Termites, Palm weevils etc. [5]. The palm weevil larvae is one of such edible insects which has gained recognition as playing very important role as a delicacy in most parts of West Africa and Asia [15]. Besides the concerns of feed cost and constraints of obtaining feed, other challenges of production partly arise from weather and climate difference as well as environmentally unfriendly activities [2, 13]. These limitations create a sense of urgency for researchers to investigate and adopt some non-traditional farming methods and evaluate these unconventional means to producing food, specifically protein food and feed [7]. In Ghana, the adult African palm weevils and their larvae are often harvested from the wild especially the trunks of decaying oil palm species. Conversely, with the upsurge of indiscriminate activities and industrialization on farmlands, it has become prudent to explore ways of cultivating them intensively for consumption.

1.1 Objectives

The objectives of the study sought to explore alternative feed resource for the production of African palm weevil (*Rhynchophorus phoenicis*) larvae and to evaluate the performance of the larvae raised on the different diets.

2. Materials and Methods

2.1 Location and duration of study

This study was undertaken at the "*Akokono*" Farming Research Centre, Aspire Food Group at Kwame Nkrumah University of Science and Technology, Kumasi- Ghana, West Africa. The experiment lasted for six (6) weeks between the months of May and July, 2017.

2.2 Source of experimental materials

The oil palm yolk (OPY) used in this study was obtained from oil palm plantations at Donyina, a town located in the Bosomtwe district of Ashanti region of Ghana, West Africa. Millet waste (MW) was obtained from local porridge producers at Bomso whiles Fruit waste (FW) materials were sourced from the local market at Adum, both suburbs in the Kumasi Metropolis, Ashanti Region.

2.3 Experimental diets

The composition of the formulated diets for the different groups of larvae is shown in Table 1. Experimental diets were designated as;

- T1= 100 % OPY= 3 kg of OPY
- T2= 50 % OPY + 50 % FW= 1.50 kg OPY + 1.50 kg FW (banana + pineapple)
- T3= 50 % OPY + 50 % MW= 1.50 kg OPY + 1.50 kg MW
- T4= 25 % OPY + 75 % (MW+ FW)= 0.75 kg OPY + 1.125 kg FW (banana + pineapple) + 1.125 kg MW

Table 1: Ingredients and composition of experimental diets

Ingredients	Treatments			
	T1 (100 % OPY)	T2 (50 % OPY)	T3 (50 % OPY)	T4 (25 % OPY)
Oil palm yolk (OPY), kg	3.000	1.500	1.500	0.750
Millet waste (MW), kg	-	-	1.500	1.125
Fruit waste (FW)*, kg	-	1.500	-	1.125
TOTAL (kg)	3.000	3.000	3.000	3.000

**- composition of fruit waste: Banana and Pineapple combined in the ratio 1: 1 respectively.*

2.4 Experimental insects, procedure and design

2.4.1 Feeding trial of African palm weevil larvae

Four hundred (400) selected young larvae were randomly grouped into 40 sets, each group comprising ten (10) larvae. Initial weights of larvae were taken and the means for the various groups of larvae were noted, after which, groups of larvae were randomly allocated to 4 different dietary treatments. The four (4) dietary treatments were replicated ten (10) times with ten (10) larvae per replicate, using a Completely randomized design (CRD). Agro-waste materials such as oil palm yolk, fruit waste of banana and pineapple and millet waste were combined according to the formulae for diet composition as indicated in Table 1. Three (3) kilograms of each diet was formulated every two weeks of the feeding trial period; with feed being provided *ad libitum*. At 4-weeks of feeding experimental diets, mature larvae were harvested per treatments.

2.5 Parameters measured

Among the parameters of interest in the present study were total feed intake, live weight gain, feed conversion efficiency, feed cost, number of larvae lost/mortality, length and width of larvae and pH of feed/ diet and ground larvae samples. The proximate analysis of samples of feed was done using the standard procedures as defined by the Association of Official Analytical Chemists [3] and was undertaken at the Soil Science laboratory of the Department of Crop and Soil Sciences, Faculty of Agriculture, KNUST. Metabolizable energy values of the feed samples were calculated from the results of the proximate composition using the Pauzenga's equation [19];

$$M.E\ (Kcal/\ kg) = (37 \times \%\ CP) + (81.8 \times \%\ E.E) + (35 \times \%\ N.F.E) \qquad (1)$$

2.6 Statistical analysis

The entire sets of data collected were organized in Microsoft Excel Spreadsheet and further subjected to the analysis of variance (ANOVA) using GenStat Release 11.1 [10] at $p< 0.05$. Differences between treatment means were separated using Tukey's test at 95 % confidence intervals.

3. Results and Discussion

3.1 Performance of larvae

Larvae raised on T3 (50% OPY+50% MW) and T4 [25% OPY+75% (MW+FW)] consumed similar ($p> 0.05$) quantities of feed, however, these quantities of feed were significantly ($p<0.05$) lower than the quantities consumed by their counterparts fed T2 (50% OPY+ 50% FW) and T1 (100% OPY). Larvae fed T1 diets also consumed significantly ($p<0.05$) more feed than T2. The mean total feed intake per larva followed a similar trend as the total feed intake of larvae. The range of mean values for feed consumption (3.03 – 4.32 kg) recorded in this study disagrees with the mean value of 6.96 kg reported by [4] upon feeding raffia palm to *R. phoenicis* larvae. Again, the mean value (4.32 kg) recorded for total feed intake for larvae solely fed T1 (control) was lower than the 4.80 kg reported by [4] for larvae fed similar feed, oil palm substrate. The highest feed intake value (4.32 kg) registered by larvae raised on T1 may be due to their preference, suitability and adaptability of the palm substrates to which they are important pests of [21]. With regards to conversion efficiency of feed into tissues, larvae raised on T2, T3 and T4 showed similar ($p> 0.05$) feed conversion efficiencies (FCE), meanwhile, similar ($p> 0.05$) FCE was also shown among larvae raised on T1, T2 and T3. However, larvae fed T4 diets showed significantly ($p< 0.05$) better FCE than their counterparts fed T1 diets. As suggested by [16], the kind of diets fed to insects confer significant effect on insect's body mass and other related functions.

Although, the mean pH values of larvae produced fell within the alkaline range (7.35 – 7.64) on the pH scale (Table 2), larvae raised on T3 and T4 seemed to show significant ($p<0.05$) difference compared to those raised on T1 and T2. However, larvae harvested from T1 and T2 showed similar ($p> 0.05$) pH levels whiles T3 and T4 showed significantly ($p< 0.05$) lower (7.35) and higher (7.64) alkaline levels respectively.

Table 2: Performance of larvae raised on the various experimental diets

PARAMETERS (%)	**TREATMENTS**				**P-VALUE**
	T1(100% OPY)	**T2**(50%OPY+50 %FW)	**T3**(50%OPY+50 %MW)	**T4**[25%OPY+75 %(MW+FW)]	
Mean initial weight per larva (g)	1.320	1.34	1.32	1.24	0.500
Mean final weight per larva (g)	5.58	5.24	5.01	5.36	0.175
Mean weight gain per larva (g)	4.260	3.90	3.66	4.12	0.082
Total feed intake (kg)	4.320^{c}	3.56^{b}	3.095^{a}	3.03^{a}	<0.001
Mean total feed intake per larva (g)	432.0^{c}	356.5^{b}	309.5^{a}	303.0^{a}	<0.001
Feed conversion ratio	103.4^{b}	93.7^{ab}	85.9^{ab}	74.1^{a}	0.003
Feed conversion efficiency (%)	0.99^{a}	1.10^{ab}	1.20^{ab}	1.36^{b}	0.002
Mean number of larvae lost	2.20	2.10	2.90	1.60	0.432
Mortality (%)	22.0	21.0	29.0	16.0	0.432
Mean pH of feed	4.088	3.951	4.028	3.889	0.218
Mean length per larva (cm)	5.187	5.085	5.205	5.393	0.640
Mean width per larva (cm)	1.677	1.710	1.765	1.667	0.797
Mean pH of larva	7.43^{b}	7.46^{b}	7.35^{a}	7.64^{c}	<0.001
Feed cost per kilogram (GH ¢)	0.750^{ab}	0.810^{b}	0.650^{a}	0.720^{ab}	0.007

$^{a, b, c-}$ Mean values in the same row with different superscripts are significantly ($p< 0.05$) different, P- Probability value, OPY- Oil palm yolk, FW- Fruit waste, MW- Millet waste.

Cost analysis of formulating each treatment diet in this study (Table 2) revealed that producing a kilogram of T3 (GH ¢0.650) diet was significantly ($p< 0.05$) cheaper than T2 (GH ¢0.810) but similar ($p> 0.05$) to T1 (GH ¢0.750) and T4 (GH ¢0.720). Meanwhile, cost for producing a kilogram of T1, T2 and T4 diets were not significantly ($p> 0.05$) different.

3.2 Proximate composition of experimental diets

It is worth an important fact to establish that all the parameters or proximate components revealed significant ($p<0.05$) differences among the various treatment diets understudied. The range of mean values (5.4 – 23.9 %) recorded for crude fibre composition showed significant ($p<0.05$) differences with a steadily declining trend from T1 (23.9 %) to T4 (5.4 %) as oil palm yolk inclusion levels decreased in diets. This range of values were not reflective of the set of values reported by [17] for exudates of raffia substrates for larvae (30.46 %) and pupae (45.45 %). Again, the value of 23.9 % recorded for T1 was lower than crude fibre values of 31.1 % and 29.4 % reported for oil and raffia palm substrates respectively by [4].

Table 3: Proximate composition of experimental diets (on dry matter basis)

	TREATMENTS				
PARAMETERS	**T1**(100% OPY)	**T2**(50%OPY+ 50%FW)	**T3**(50%OPY+ 50%MW)	**T4**[25%OPY+75 %(MW+FW)]	**P-VALUE**
Ash	9.72^a	4.78^b	1.16^d	2.39^c	<0.001
Crude fibre	23.97^a	19.02^b	7.59^c	5.42^d	<0.001
Crude protein	5.26^d	6.13^c	11.86^a	10.95^b	<0.001
Ether extract	5.07^a	2.94^b	5.96^a	5.97^a	<0.001
Moisture	53.50^d	65.47^a	54.48^c	55.80^b	<0.001
Nitrogen free extract*	2.49^b	1.66^b	18.96^a	19.47^a	<0.001
M.E (Kcal/kg)*	696.3^b	525.5^c	1589.6^a	1575.2^a	<0.001

*a, b, c, d- Mean values in the same row with different superscripts are significantly ($p< 0.05$) different, P- Probability value, OPY- Oil palm yolk, FW- Fruit waste, MW- Millet waste, M.E- Metabolisable Energy. *- Calculated based on proximate values obtained.*

Crude protein percentage revealed a significantly ($p<0.05$) increasing trend from T1 (5.26 %) to T3 (11.86 %) but declined slightly in T4 (10.95 %) than T3, although, this value was significantly ($p<0.05$) greater than T1 and T2 (6.13 %). The authors in [4] reported a rather lower crude protein percentage for oil (3.2 %) and raffia (3.5 %) palm substrates than 5.3 % recorded for oil palm yolk (T1) in this study. The higher crude protein levels recorded in T3 and T4 may be due to the level of crude protein percentage of millet waste (29.4 %) incorporated, as reported by [11]. Study by [14] also reported that millet residue meal has high crude protein ranging between 10.51 and 21.86 %. Metabolisable energy levels revealed similar ($p>0.05$) energy values for T3 (1589.6 Kcal/ kg) and T4 (1575.2 Kcal/ kg), however, both were significantly ($p<0.05$) greater than T1 (696.3 Kcal/ kg) and T2 (525.5 Kcal/ kg) as T2 recorded the least energy level. The energy values recorded in this study disagree with the set of values of 668.8 versus 644.9 Kcal/ kg reported by [4] for oil and raffia palm substrates respectively. The higher metabolisable energy levels observed for T3 and T4 may be attributed to the inclusion of millet waste, which has been reported to possess metabolisable energy value of 3240.5 Kcal/ kg by [1]. Authors in [8] reported a set of metabolisable energy values of 2575 and 2364 (Kcal/ kg) for millet offals obtained from "*Kunu*" and "*Fura*" respectively. **4. Conclusions and Recommendations**

In summary, the results of this study demonstrated that;

1. The various dietary treatments administered did not have any adverse effects on the growth performance of larvae.
2. At the least inclusion level of oil palm yolk, OPY (25%), a relatively improved performance was observed.
3. The Agro-waste materials or by-products exploited actually proved to be potential alternative feed resources for raising the larvae.
4. The different treatment diets served as nutritionally suitable growth media for the production of palm weevil larvae.

It is therefore recommended that with regards to this practice of insect farming, further researches should be carried out to explore the potential of Agro-waste materials or by-products for optimum use as feed resources for production of insect proteins for both human consumption and animal industry.

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