Nig. J. Biotech. Vol. 38 (2) : 40-46 (Dec 2021)
ISSN: 0189 1731
Available online at
http://www.ajol.info/index.php/njb/index
and www.biotechsocietynigeria.org
DOI: https://dx.doi.org/10.4314/njb.v38i2.4

NIGERIAN JOURNAL OF BIOTECHNOLOGY

Pesticide Potential of *Gmelina arborea* Stem Bark and Leaf Powder against *Dinoderus porcellus* Infesting Yam Chips

W. C. John[1]*, M. Ishaya[1], T. A. Ihum[2], A. O. Oladejo[1], J. O. Oyorinde[1], C. J. Ukanyirioha[1] and O. C. Matthias[1]

[1]Federal College of Forestry, Jos, Plateau State, Nigeria.
[2]Nigeria Stored Products Research Institute, Ilorin, Kwara State, Nigeria.

Abstract
Insect pest are a major problem to food security, most especially in developing countries like Nigeria. There is an urgent need towards mitigating the effects of these group of insects, and botanical extracts had played an increasing role as an alternative insecticide. The aim of the present study is to investigate the anti-feeding effect of different dosage of *Gmelina arborea* stem bark and leaf powder against *Dinoderus porcellus* infesting yam chips. The study was conducted at the Entomology Laboratory of Federal College of Forestry, Jos. Soxhlet extraction using methanol was used to extract plant part samples. Presence of phytochemicals contained in the plant were examined following standard protocols. The antifeedant effects of different dosage of *Gmelina arborea* leaf and stem bark powder on *Dinoderus porcellus* was determined by monitoring yam chips weight loss. Data collected was subjected to analysis of variance (ANOVA) at 1 % level of significance and the means separated using Duncan test. The results revealed presence of tannin, flavoid, saponins, alkaloids, reducing sugar and phenol with absence of steroid. The results also revealed that the various dosages have remarkable antifeedant effect on the development of *D. porcellus*. The weight loss of treated yam chips was significantly different from those of untreated yam chips. Therefore, the results obtained in this work accounts for the use of *G. arborea* plant parts powders as bio-preservative for yam chips against *D. porcellus*.

Keywords: *G. arborea*; *D. porcellus*: yam chips; saponins; Jos
*Corresponding Author: Email: jwaltee@gmail.com Phone No. +2348064487369

Introduction

Yams (*Dioscorea* spp) is considered a major staple food crop in the tropics. Asia, South America, and West Africa account for most of the yam grown in the world (Kambasaka *et al.,* 2009). In 2017, the global production of yam was evaluated to be at 67.3 million tons (FAO, 2019). Yam alone account for 32% gross income obtained from crops by farmers in Nigeria (Bolarinwa and Oladeji, 2009). Yam tuber is essentially a starchy food which supply calories to the body. Yam is usually prepared in various forms for consumption, these include boiling, frying, baking, and processing into flour (Oguntade *et al.*, 2010).

Despite the economic importance of yam, yam production is faced by many biotic (viruses, fungi, nematodes, and insects) and a biotic (infertile soil, climate changes) challenges in Africa (Oguntade *et al.*, 2010). The challenge of fresh yam preservation leads to huge post-harvest losses. To overcome the challenge, most farmers and consumers transforms yams into chips which are sun dried traditionally (Hounhouigan *et al.*, 2003). Yam chips preserved using traditional storage system have been found to be heavily attacked by *Dinoderus porcellus* (Vernier *et al*, 2005).

Dinoderus porcellus causes physical damage by penetrating the chips, leading to economic loss (Babarinde *et al,* 2013). The negative effect of insects on yam chips has led to the use of synthetic chemicals continuously (Loko *et al*, 2013). Synthetic pesticides over time endangers health of farmers, animals, and food consumers. This has led to a resurgence of interest in biological pesticide which are environmentally friendly and with no side effect on consumers.

Gmelina arborea a deciduous tree belonging to the family Verbenaceae possesses high medicinal properties (Banu *et al*., 2013). Several studies have revealed *Gmelina arborea* is an important source of insecticidal botanical. Study by Estelle *et al*. (2018) showed that extracts of three botanicals exhibited insecticidal properties against *Dinoderus porcellus* destroying yam chips and this, necessitated the present study. Hence, the present study was conducted to investigate the anti-feeding effect of different dosage of *Gmelina arborea* stem bark and leaf powder against *Dinoderus porcellus* infesting yam chips.

Materials and Method

Samples Collection

Twenty (20) fresh and healthy tubers of yam (*Dioscorea rotundata*) were procured from Farin Gada market and packaged in a sterile nylon bag. One thousand gram (1000g) of infested yam chips were purchased from Fillin Ball Market in Jos north local government Area of Plateau state. The infested yam chips were collected in a sterile polythene bag. *Gmelina arborea*, both the stem bark and leaf were collected with clean polythene bag from Federal College of Forestry, Jos and submitted to the herbarium for identification.

Preparation of *Gmelina arborea* Stem Bark and Leaf Plant Powder

The collected stem bark and leaf were washed under running water and dried under room temperature (37ºC) for 30days. The stem bark and leaf were pulverized into powder using mortar and pestle after drying. The powders were sieved to obtain fine particles (Loko *et al*., 2017). The fine powder obtained from both stem bark and leaf of *Gmelina arborea* were package in polyethylene bags and kept in dry place.

Extracts Preparation

Soxhlet extraction with methanol was done using 50 g of the dried and pulverized *Gmelina arborea* leaf and stem bark samples. Distillation was carried out and plant extracts collected through rotary evaporation and kept at 4°C in a refrigerator.

Phytochemical Screening of Gmelina arborea Leaf and Stem Bark Extract

The *Gmelina arborea* leaf and stem Bark extracts were examined for the presence of phytochemicals using standardized procedures described by Harborne (1984).

Processing of Yam Chips

The collected yam tubers were made clean by washing with water and peeled using sterile knife. The tubers were cut into slices of 2cm X 4cm. Pre-cooking of the sliced yam obtained was done by heating in water at 50ºC for 2hours. Strained and dried slices were exposed to hot air oven at 60ºC for 3days. The chips were exposed to room temperature for 1h after being sterilized at 105ºC for 2h. The dried chips were stored in the laboratory at room temperature using polythene bags.

Rearing and Identification of Dinoderus porcellus

To obtain *D. porcellus*, infested yam chips were purchased from Filin Ball market and fed on fresh yam chips following procedure by Onzo *et al*. (2015). This was carried out in plastic containers opened at one end. For aeration, hole was made at the end of the box and covered with Muslim cloth to prevent insects from escaping. Dry yam chips (500g) were infested in the plastic boxes with four hundred and fifty (450) adults of *D. porcellus*. The plastic containers were kept on a stable surface at room temperature according to Oni and Omoniyi (2012). Following two weeks of exposure, emerging adult beetles were collected, and the insect was identified using dichotomous keys {Whitworth (2010); Akbarzadeh *et al*. (2015)}at the Entomology laboratory of Federal College of Forestry Jos for identification.

Feeding Deterrence Test

Antifeedant effect test was done using the method described by Isah *et al*. (2012). Here, fifty grams(50g) of uninfected yam chips were mixed with different dosages (5, 10, 15 and 20 g) of stem bark, leaf, and stem bark + leaf powder in an experimental box measuring 10cm in height and 12cm diameter. Untreated yam chips were used as negative control. In each box, 20 adults of *D. porcellus* were introduced and covered with muslin cloths and each treatment replicated three (3) times. The containers were placed in a complete randomize block for 30, 60, and 90 days. The effect of *D. porcellus* attacked was examined based on weight loss. The weight loss was estimate according to this formula:

$$\text{Percentage weight loss} = \frac{\text{initial weight} - \text{final weight}}{\text{initial weight}} \times 100$$

Data analysis

Data collected was subjected to analysis of variance (ANOVA) at 1 % level of significance and the means separated using Duncan test. Results were presented in tables.

Results and Discussion

The results on Table 1 indicated the phytochemical composition of *G. arborea* Leaf and Stem Bark. The results revealed presence and varying estimate of Tannin, Flavoid, Saponins, Alkaloids, Reducing sugar and Phenol with absence of Steroid between the *G. arborea* Leaf and Stem Bark. The phytochemical analysis provided an insight on the type of primary and secondary metabolite present in the plant material studied. These metabolites possess wide array of prophylactic activities. Previous study on the phytochemical and antioxidant properties of *Gmelina arborea* from four different geographical regions by Iswarya *et al*. (2017), confirmed the presence of alkaloids, saponins and tannins. Kaswale *et al*. (2012) also revealed metabolites like flavonoid and alkaloids.

Table 1: Phytochemical Composition of *G. arborea* Leaf and Stem Bark

Phytochemical	Leaf Composition	Stem Composition
Tannins	++	+
Flavonoids	+	++
Saponins	++	+
Terpenes	-	-
Glycosides	-	-
Volatile Oil	-	-
Alkaloids	+++	+
Reducing sugar	+	++
Phenols	++	+
Steroid	-	-
Carotenoids	-	-

The results of percent weight loss of treated yam chips after exposure to *D. porcellus* for 30 days showed excellent anti-feeding effects of *G. arborea* Leaf, Stem Bark, and Leaf + Bark powder at all the dosages compared to the control (untreated) (Table 2). Significant difference was observed between weight loss of yam chips treated with different dosage of *G. arborea* Leaf, Stem Bark and Leaf + Bark powder at $p \leq 0.01$. The results on Table 2 also revealed increased dosage of *G. arborea* Leaf, Stem Bark and Leaf +Bark powder led to reduced percentage weight loss of treated yam chips after 30 days expose to *D. porcellus.* The highest percentage weight loss of 16.80 ± 1.31 was observed in untreated (0 g) yam chips.

The lowest percentage weight loss of treated yam chips exposed to *D. porcellus* for 30 days was observed when 20 g of *G. arborea* Leaf +Bark powder was used (Table 2). Similar trends were also observed after exposure for 60 and 90 days, however, increase in time of the exposure of the treated yam chips to *D. porcellus* led to increased weight loss of yam chips. The results on Table 4 showed 5.83 ± 0.90 % weight loss using 20 g Leaf +Bark powder yam chips after 90 days exposure to *D. porcellus* but this is lower compared to 33.27 ± 3.5 % weight loss of untreated yam chips indicating the preservative potential of *G. arborea* powder.

Table 2: Percentage Weight Loss of Treated Yam Chips after 30 days Exposure to *D. porcellus*

Treatment	**Mean ± SD**		
	Leaf (%)	**Bark (%)**	**Leaf +Bark (%)**
5 g	8.67 ± 1.15^{b}	9.80 ± 1.71^{b}	6.93 ± 1.01^{b}
10 g	5.03 ± 1.56^{c}	7.73 ± 0.83^{c}	4.33 ± 1.14^{c}
15 g	3.27 ± 1.10^{cd}	3.47 ± 0.61^{d}	1.13 ± 0.50^{d}
20 g	2.00 ± 1.83^{d}	2.33 ± 0.58^{d}	1.00 ± 0.87^{d}
0 g	16.80 ± 1.31^{a}	15.33 ± 1.15^{a}	13.13 ± 1.55^{a}
ANOVA	52.696	72.565	65.940
P-value	< 0.01**	< 0.01**	< 0.01**

Mean values with different superscripts in the same column are significantly different.

** = significant difference exists at p ≤ 0.01

Table 3: Percentage Weight Loss of Yam Chips after 60 days Exposure to *D. porcellus*

Treatment	Mean ± SD		
	Leaf (%)	**Bark (%)**	**Leaf +Bark (%)**
5 g	13.47 ± 0.70^{b}	14.20 ± 0.89^{b}	12.27 ± 1.72^{b}
10 g	12.80 ± 0.60^{b}	10.90 ± 2.93^{c}	11.83 ± 1.07^{b}
15 g	6.80 ± 2.00^{a}	4.07 ± 1.70^{d}	9.97 ± 2.25^{b}
20 g	5.03 ± 2.40^{c}	5.10 ± 1.10^{d}	5.23 ± 1.19^{c}
0 g	25.33 ± 1.45^{a}	17.80 ± 1.61^{a}	20.90 ± 2.27^{a}
ANOVA	74.878	32.095	30.820
P-value	< 0.01**	< 0.01**	< 0.01**

Mean values with different superscripts in the same column are significantly different.
** = significant difference exists at p ≤ 0.01

Table 4: Percentage Weight Loss of Yam Chips after 90 days Exposure to *D. porcellus*

Treatment	Mean ± SD		
	Leaf (%)	**Bark (%)**	**Leaf +Bark (%)**
5 g	18.03 ± 0.47^{b}	13.27 ± 1.53^{b}	15.87 ± 6.30^{b}
10 g	19.23 ± 4.54^{b}	7.80 ± 0.76^{c}	10.73 ± 2.14^{bc}
15 g	8.67 ± 0.93^{c}	6.37 ± 1.45^{c}	7.63 ± 0.67^{c}
20 g	8.77 ± 1.82^{c}	5.03 ± 1.36^{c}	5.83 ± 0.90^{c}
0 g	35.30 ± 1.95^{a}	31.23 ± 4.37^{a}	33.27 ± 3.55^{a}
ANOVA	61.605	67.537	31.663
P-value	< 0.01**	< 0.01**	< 0.01**

Mean values with different superscripts in the same column are significantly different.
** = significant difference exists at p ≤ 0.01

Table 5 showed the comparative percent antifeedant effect of various dosages of the different parts of *G. arborea* powders after 30 days exposure to *D. porcellus*. The results revealed there was no significant difference on the Percent Weight Loss of Yam at 5 g and 20 g powder using the 3 different plant parts. The plant parts provided protection against *D. porcellus* with 20 g dosage giving the lowest weight loss of treated yam chips, but no significant difference was observed among the different plant parts used after 30 days exposure to *D. porcellus* (Table 5). Similar trend continued after 60- and 90-days exposure (Table 6, 7). All the various dosages of the different plant parts used showed no significant difference on the weight loss of treated yam chips when compared except 15 g dosage (Table 6).

The results on Table 7 indicated the lowest weight loss of treated yam chips was achieved when 20 g of Stem Bark and Leaf +Stem Bark *G. arborea* powders was used compared with 20 g leaf *G. arborea* powder. The result showed significant difference between 20 g leaf of *G. arborea* powder and 20 g stem Bark and Leaf+ Stem bark of *G. arborea* powders at 0.05 p value (Table 7). In general, the results from the comparatives studied revealed that all the plant parts at different dosages were effective against *D. porcellus* leading to reduction in weight loss of treated yam chips.

Table 5: Comparative Percentage Effect of *G. arborea* Powders against Yam Chips Weight Loss after 30 days Exposure to *D. porcellus*

Treatment	Mean ± SD	ANOVA	p-value

	Leaf (%)	Bark (%)	Leaf +Bark (%)		
5 g	8.67 ± 1.15	9.80 ± 1.71	6.93 ± 1.01	3.562	0.096
10 g	5.03 ± 1.56[b]	7.73 ± 0.83[a]	4.33 ± 1.14[b]	6.549	0.031*
15 g	3.27 ± 1.10[a]	3.47 ± 0.61[a]	1.13 ± 0.50[b]	8.181	0.019*
20 g	2.00 ± 1.83	2.33 ± 0.58	1.00 ± 0.87	0.973	0.431
0 g	16.80 ± 1.31[a]	15.33 ± 1.15[ab]	13.13 ± 1.55[b]	5.607	0.042*

Mean values with different superscripts in the same row are significantly different.
** = significant difference exists at p ≤ 0.01

Table 6: Comparative Percentage Effect of *G. arborea* Powders against Yam Chips Weight Loss after 60 days Exposure to *D. porcellus*

Treatment	Mean ± SD			ANOVA	p-value
	Leaf (%)	Bark (%)	Leaf +Bark (%)		
5 g	13.47 ± 0.70	14.20 ± 0.89	12.27 ± 1.72	2.019	0.214
10 g	12.80 ± 0.60	10.90 ± 2.93	11.83 ± 1.07	0.805	0.490
15 g	6.80 ± 2.00[ab]	4.07 ± 1.70[b]	9.97 ± 2.25[a]	6.562	0.031*
20 g	5.03 ± 2.40	5.10 ± 1.10	5.23 ± 1.19	0.011	0.989
0 g	25.33 ± 1.45[a]	17.80 ± 1.61[b]	20.90 ± 2.27[b]	13.134	0.006**

Mean values with different superscripts in the same row are significantly different.
* = significant difference exists at p ≤ 0.05
** = significant difference exists at p ≤ 0.01

Table 7: Comparative Percentage Effect of *G. arborea* Powders against Yam Chips Weight Loss after 90 days Exposure to *D. porcellus*

Treatment	Mean ± SD			ANOVA	p-value
	Leaf (%)	Bark (%)	Leaf +Bark (%)		
5 g	18.03 ± 0.47	13.27 ± 1.53	15.87 ± 6.30	1.214	0.361
10 g	19.23 ± 4.54[a]	7.80 ± 0.76[b]	10.73 ± 2.14[b]	12..341	0.007**
15 g	8.67 ± 0.93	6.37 ± 1.45	7.63 ± 0.67	3.513	0.098
20 g	8.77 ± 1.82[a]	5.03 ± 1.36[b]	5.83 ± 0.90[b]	5.825	0.039*
0 g	35.30 ± 1.95	31.23 ± 4.37	33.27 ± 3.55	1.049	0.407

Mean values with different superscripts in the same row are significantly different.
* = significant difference exists at p ≤ 0.05
** = significant difference exists at p ≤ 0.01

The findings of this present work showed that the combination of yam chips with leaf, stem bark and leaf + stem bark powder of *G. arborea* at 15g has antifeeding effect on *D. porcellus.* The weight losses induced by *D. porcellus* on treated yam chips at different dosage of Leaf, Stem bark and Leaf + Stem bark powder of *G. arborea* were low compared to the control (untreated). The low weight loss observed in this could be attributed to the insecticidal activities of the phytochemical constituents of the Leaf, Stem bark and Leaf + Stem Bark powder of *G. arborea* used (Chothani and Patel, 2018). This present study is similar with earlier work of Angaye *et al.* (2017) who demonstrated efficacy of Leaf extracts of *Gmelina arborea* against Mosquito Larvae. Estelle *et al.* (2018) showed effects of combined powders of *Bridelia ferruginea* Benth, *Blighia sapida* Juss and *Khaya senegalensis* Cronquist against *Dinoderus porcellus* infesting yam chips.

The bioactive activities of *G. arborea* has been documented in many literatures. The different parts of *G.arborea* power showed the presence of tannins, saponins phenols, alkaloids, flavonoids and steroids. The antimicrobial activities of saponins provide safety for plants against insect attack. They are also known as plant defense systems (Lacaille-Dubois and Wagner, 2000). Alkaloids is also involved protecting and survival of plant species because they provide feeding deterrents against insects and herbivores (Attanayake *et al*., 2015).

The presence of pungent volatile substances like phenol in the plant parts could play a major role in deterring *D. porcellus* from feeding (Onzo *et al*., 2015). Furthermore, tannins contained in the plant parts powder as repulsive agents and act on insects' olfactory receptors (Moore and Lenglet, 2004). The synergistic effect of tannins and, saponin led to decreased weight losses caused by *D. porcellus*. These factors played a role in retarding *D. porcellus* feeding habit and hence lowered *D. porcellus* yam chips consumption rate.

Though the weight losses of the treated yam chip were attributed to the introduced *D porcellus,* previous studies by other researchers implicated other factors that cause yam chips weight loss. According to Chukwulobe and Echezona (2014), environmental conditions such as temperature and humidity could lead to weight losses. The texture of yam used for yam chips and pre-cooking which causes curing of the yam chips could also lead to weight loss (Estelle *et al*., 2018). However, the low weight loss of yam chips treated with *Gmelina arborea* powder compared to the untreated yam chips which have high weight loss, prove the effectiveness of the plant powders.

Conclusion

The results obtained from the present study revealed that *Gmelina arborea* parts powders contains significant amounts of phytochemicals. Our findings also showed that use of leaf, stem bark and leaf and stem bark powder of *Gmelina arborea* at different dosages studied have a strong bioactivity in control and prevention of *D. porcellus* infestation of yam chips. The highest activities were observed when 15 and 20 g powder of the botanical was used. However, further studies are required to identify the active constituent in the plant's materials responsible for bio-insecticidal activities.

References

Akbarzadeth, K.; Wallman, J.F.; Sulakova, H. and Szpila, K. (2015). Species identification of Middle Eastern blowflies (Dipptera; Calliphoridae) of forensic importance. Parasitol Res 114(4).1463-1472.

Angaye, T.C.N., Oyinke, G.N., Angaye, W.W.T., Igbeinkutu, V.D. (2017). The Comparative Phytochemical and Bio-larvicidal Efficacy of Leaf Extracts of *Gmelina arborea* against Mosquito Larvae. International Journal of Innovative Healthcare Research 5(1):1-6*.*

Attanayake, A.P., Wijewardana, J.K.P., Pathirana, C., Boralugoda, M.L.K. (2015). Antioxidant activity of *Gmelina arborea* Roxb. (Verbenaceae) bark extract: In vivo and in vitro study. Journal of Medical Nutrition and Nutraceuticals, 4:32-38.

Babarinde S.A., Babarinde, G.O., Odewole A.F., Alagbe O.O. (2013). Effect of the prevalent insect species of yam chips on consumers acceptability of yam past. *Journal of Agricultural Extension and rural Development* 46 (3): 97 -101.

Banu M, Gururaja GM, Deepak M, Roopashree T, Sashidara S.(2013). Anphyto-chemistry and pharmacological propereties of *Gmelina arborea.*

Bolarinwa, K.K., Oladeji, J.O. (2009). "Adoption and Relevance of Yam Minisett Technology Practices to Farmers Indigenous Practices in Rain Forest and Derived Savannah Zones of Nigeria" J. App. Sci. Res., 5(12): 2461- 2465.

Chothani, D.L. and Patel, N.M. (2018). Phytochemical screening and quantification of phytoconstituents in *Gmelina arborea* fruits extract. Journal of Medical Plants Studies. 6(4): 31-35.

Chukwulobe, M.N., Echezona, B.C. (2014). Relative susceptibility of dried root/tuber and Musa chips to red flour beetle *Tribolium casteneum* (Herbst) (Coleoptera: Tenebrionidae) Infestation. International Journal of Plant and Soil Science 3:1398-1414.

Estelle, L.Y.L., Gnaho, A.C., Toffa J., Orobiyi A., Dansi, A. and Tamò M. (2018). Management of *Dinoderus porcellus* L. (Coleoptera: Bostrichidae) infesting yam chips using varietal resistance and botanical powders of three medicinal plants. African Journal of Agricultural Research, Vol. 13(40), pp. 2118-2133.

Food and Agriculture Organization (FAO) (2019). FAOSTAT DatabaseFood and Agriculture Organization, Roma, Italy. Available online at URL: www.fao.org.

Harborne JB. (1984). Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis, Edn 2, Chapman and Hall, London.

Hounhouigan, J.D., Kayodé, A.P.P., Bricas, N., Nago, M.C. (2003). Les caractéristiques culinaires et organoleptiques des ignames recherchées en milieu urbain au Bénin. Annales des Sciences Agronomiques du Bénin 4:143-160.

Isah, M.D., Ayertey, J.N., Ukeh, D.A., Umoetok, S.B.A. (2012). Damage and weight loss to dried chips of cassava, cocoyam, yam and plantain exposed to *Prostephanus truncatus* (horn) (Coleoptera: Bostrichidae) over three different time durations. Entomology Journal 9(3):137-145.

Iswarya, S., Sridevi, M. and Mayavel, A. (2017). Comparative Study on Phytochemical and Antioxidant Properties of *Gmelina arborea* Roxb. From four Different Geographical Regions International Journal of Pharmaceutical and Clinical Research 2017; 9(4): 275-280.

Kambaska, K.B, Sanilatasahoo, T.M. and Debashrita, P. (2009). Response of vine cuttings of rooting in different months in three Dioscorea species. Department of Botany, Ulkal University, Vanivhar, bhubansw 751004, Orissa, India.

Kaswale, R., Patel, V., Chakraboty, M., Kamat, J. V. (2012). Phytochemical and Phamarcological Profile of Gmelina arborea; An Overview. International Journal of Pharmacy, 3(2): 61 – 64.

Lacaille-Dubois M.A. and Wagner, H. (2000). Bioactive saponins from plants: An update. Studies in Natural Products Chemistry; edn 21, Elsevier Science, Amsterdam, 633-687.

Loko, Y.l., Dansis, A., Tamo, M., Bokonon-Ganta, A.H., Assogba, P., Dansi, M. and Sanni, A. (2013). Storage insects on yam chips and their traditional management in Northern Benin. Scientific world Journal, Article ID 484536.

Loko, Y. I., Gnaho, A.C, Orobiyi, A., Agre, P. and Dangi, A. (2017). Resistance of dried chips yam Dioscorea cayenensis- D. rotundata omplex) landraces to Dinoderus porceliuslesine (coleopteran Bostrictide) Cogent food and Agriculture, 3(1): 141180.

Moore, S.J. and Lenglet, A.D. (2004). An overview of plants used as insect repellents In: Willcox M, Bodeker G, Rasoanaivo P (eds): Traditional Medicinal Plants and Malaria Vol 4 Traditional Herbal Medicine for Modern Times Series CRC Press, Boca Raton.

Oguntade, A.E., Thompson, S.Y. and Ige, T. (2010). Economics of seed yam production using minisett technique in Oyo State, Nigeria. Department of Agricultural Economics and Extension, Federal University of Technology, Akure, Nigeria.

Oni, M. O. and Omoniyi, A. O. (2012) A studies on temperature influence on oviposition and Development of immature stages of the yam beetle Dinoderus Porcellus lense Coleopetera bostrichidea on dried yam species. The Journal of Agricultural science.

Onzo, A., Biaou, J.T., Loko, L.T., Tamo, M. and Dansi, A. (2015) vulnerability des cossettes issues de quelques cultivars digname a I' attaque de Dinoderus pocelluslesne (coleopteran bostrichidae) en conditions de laboratoire. International journal of biological and chemical sciences.

Vernier, P., Goerge, G., Dossou, R.A., Letourmy, P. and Chaume, J. (2005). Utilization of biological insecticides for the protection of stored yam chips. Outlook on Agriculture 34(3): 173 -179.

Whitworth, T. (2010). Keys to the genera and species of blow flies (Diptera: Calliphoridae) of the West Indies and description of a new species Lucilia Robineau-Desvoidy, Zootaxa. 2663:1-35.