integrity Research Journals

Global Journal of Fisheries Science
Volume 8(5), pages 132-137, October 2026
Article Number: 84FAF5733
ISSN: 2782-750X
https://doi.org/10.31248/GJFS2026.117
https://integrityresjournals.org/journal/GJFS

Full Length Research

Effect of *Piper guineense* seed powder on the proximate composition and mortality of *Dermestes maculatus* infesting smoked *Heterobranchus bidorsalis*

Jude Chiemela Jude*, Adaka Godwin Simeon, Ezeafulukwe Chukwuka Fabian, Chimdi-Ejiogu Ngozi and Eluu Emperor Egwu

Department of Fisheries and Aquaculture Technology, Federal University of Technology, Owerri, Nigeria.

Corresponding author. Email: chiemela.jude@futo.edu.ng

Copyright © 2026 Jude et al. This article remains permanently open access under the terms of the Creative Commons Attribution License 4.0, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Received Date: 03 September 2026 | Accepted Date: 10 October 2026 | Published Date: 30 October 2026

ABSTRACT: Smoked fish is highly susceptible to infestation by the hide beetle, *Dermestes maculatus*, which causes quantitative and qualitative losses during storage. This study evaluated the effect of *Piper guineense* seed powder on the mortality of *Dermestes maculatus* and on the proximate composition of smoked *Heterobranchus bidorsalis*. Smoked fish (250 g per jar) was treated with 0 (control), 10, 20, 30 or 40 g of *Piper guineense* seed powder, and ten beetles were introduced into each jar. The experiment was a completely randomised design with three replicates (15 experimental units). Moisture, nitrogen, crude protein, ether extract, ash and dry matter contents were determined, together with beetle mortality. Beetle mortality increased with the application rate, from none in the control to 9.67 of 10 beetles (96.7%) at 40 g. Moisture content decreased significantly ($p < 0.05$) from 36.10% in the control to 20.80% at 40 g, while dry matter increased significantly from 63.90% to 79.20%. Nitrogen and crude protein were significantly higher at 20 g and above than in the control (crude protein 57.40% in the control and 63.41% at 40 g), and fat content was significantly higher in all treated fish (8.63% in the control; highest, 13.82%, at 20 g). Ash content did not differ significantly among treatments. *Piper guineense* seed powder therefore shows potential as a botanical protectant against *Dermestes maculatus* in smoked fish. However, further studies are required to establish its food-safety implications, optimum application rate and effects under commercial storage conditions.

Keywords: African black pepper, botanical insecticide, hide beetle, post-harvest loss, smoked catfish, stored fish pests.

INTRODUCTION

Piper guineense Schumach. & Thonn. (African black pepper) is widely consumed in some parts of West Africa, especially Nigeria and Ghana, on account of its nutritional and medicinal properties. It is a plant species belonging to the family Piperaceae. The major pests of smoked fish, including catfish (*Clarias gariepinus* Burchell) in earlier studies, include *Dermestes maculatus* De Geer (hide beetle) and *Necrobia rufipes* (De Geer) (copra beetle) (Osuji, 1974; Awoyemi, 1989), which could be controlled by synthesised chemicals (Boeke *et al*., 2001). However, in recent years, there have been increasing and concerted efforts directed at developing natural pest management control agents that are relatively cheap, safe, biodegradable and environmentally friendly as alternatives to synthesised insecticides (Boeke *et al*., 2001; Akinwumi *et al*., 2007; Ileke, 2021; Akinwumi *et al*., 2022; Mobolade-Adesina *et al*., 2024).

Fish is a key contributor to food and nutrition security globally (FAO, 2022; FAO, 2024). Smoked fish is a highly relished food in many traditional dishes in Nigeria as a food condiment. Smoked fish is one of the most widely distributed and also cheap animal food products found in Nigeria (Eyo, 2006). According to FAO (1981), 45% of total fish catch in Nigeria is utilized as smoked fish. Fish post-

harvest losses in Nigeria have been estimated at 30-49% (FAO, 1981). In this regard, a variety of processing and preservation methods, such as salting, drying and the use of synthetic chemicals, have been developed to prolong the shelf life of fish.

However, studies have shown that a high proportion of dried fish in Nigeria is usually infested by insect pests, such as *D. maculatus* and *N. rufipes* (Odeyemi *et al*., 2000; Osuji, 1974). Osuji (1974) further reported that about 71.5% of dried fish infestation in most of the producing areas was caused by *D. maculatus*. It is important to note that many of the natural protectants are regarded as safe because they are also commonly used traditionally as spices and herbal medicines. Further studies have shown that some of such plants contain noxious compounds which may render them unsafe for human consumption. For example, the toxicity of *Piper guineense* to the nymph and adult of the grasshopper, *Zonocerus variegatus* (L.) and rat, respectively, has been reported (Ivbijaro and Agbaje, 1986; Raji *et al*., 2003). Okon (2002) also reported the sub-lethality of the same plant on *Oreochromis niloticus*. The powder of *Piper guineense* has been reported to protect smoked fish from these pests (*Dermestes maculatus*) and may therefore serve as a measure to control infestation of smoked fish (Philip-Attah, 2019; Akinwumi *et al*., 2022). Protection of smoked fish from insect infestation is important because infestation causes quantitative and qualitative losses, reduces market value and may compromise the nutritional quality of the product during storage.

This study was therefore carried out to provide information on the effect of *Piper guineense* seed powder on the protection of smoked *Heterobranchus bidorsalis* Geoffroy Saint-Hilaire against *Dermestes maculatus* and on the proximate composition of the fish. The specific objectives are:

1. To determine the effect of different levels of *Piper guineense* seed powder on the mortality of *Dermestes maculatus* infesting smoked *Heterobranchus bidorsalis*.
2. To evaluate the effect of *Piper guineense* seed powder on the proximate composition of smoked *Heterobranchus bidorsalis*.
3. To determine the relationship among the proximate composition parameters of treated smoked fish.

MATERIALS AND METHODS

Study area

The study was carried out at Federal University of Technology, Owerri, Teaching and Research Farm, Imo State, Nigeria. The location lies approximately at 5°25′N latitude and 7°00′E longitude. The area has an annual rainfall of approximately 192–194 cm and a mean annual temperature of approximately 32.1°C.



Plate 1. Seed of *Piper guineense* ground into powder.



Plate 2. *Dermestes maculatus*

Collection and preparation of fish samples

Twelve specimens of *Heterobranchus bidorsalis* with an average weight of 1.1 kg were purchased from Novana Farms, Warri, Delta State, Nigeria. All the fish were obtained from this single source and were identified to species level by a fisheries expert. The fish were taken to the Laboratory of the Department of Fisheries and Aquaculture Technology, Federal University of Technology, Owerri, and were smoked by the researcher before the experiment. The smoked fish was then disinfested by heat in a Gallenkamp oven at 60 °C for 60 min to eliminate any pre-existing infestation, and was air-dried to prevent mould growth (Adedire and Lajide, 2000), before being transferred to the Federal University of Technology, Owerri, Teaching Farm.

Source of *Piper guineense* seeds and *Dermestes maculatus*

Piper guineense seeds were purchased in Afor Ogbe market in Ahiazu Mbaise LGA, Imo State, and were air-dried in the laboratory because the active ingredients may be volatile, and ground into fine powder (Plate 1). This grinding was carried out in the Fisheries Wet and Dry Laboratory of the Department of Fisheries and Aquaculture Technology, Federal University of Technology, Owerri. *Dermestes maculatus* (Plate 2) were obtained from heavily infested smoked fish bought from a

fish seller in Afor Ogbe market in Ahiazu Mbaise LGA, Imo State.

Experimental design and procedure

The experiment consisted of five treatment levels of *Piper guineense* seed powder (0, 10, 20, 30 and 40 g per 250 g smoked fish), each replicated three times, giving 15 experimental units. The treatments were arranged in a completely randomised design. Each experimental unit consisted of 250 g of smoked fish in a plastic jar, into which ten adult *Dermestes maculatus* were introduced. In the control (T0), no powder was applied. In T1, T2, T3 and T4, 10, 20, 30 and 40 g of *Piper guineense* seed powder, respectively, were applied to 250 g of the smoked fish (g/250 g fish). The jars were kept for 90 days under ambient laboratory conditions.

Data collection

Beetle mortality was recorded at the end of the 90-day experimental period as the number of dead insects per jar and expressed as: Mortality (%) = (number of dead insects/number of insects introduced) × 100.

Proximate analysis

Moisture content (MC), nitrogen (N), ether extract (EE, fat) and ash contents of the fish were determined using standard procedures (AOAC, 2005). Crude protein (CP) was calculated as N × 6.25 and dry matter (DM) as 100 − MC.

Statistical analysis

The design was completely randomised. Data were subjected to one-way analysis of variance (ANOVA) using IBM SPSS Statistics version 20. Where significant differences existed, treatment means were compared at the $p < 0.05$ significance level using Tukey's HSD test. Results are presented as means of three independent replicates. Relationships among the proximate parameters were examined using Pearson's correlation coefficient ($n = 15$) at $p < 0.05$. Correlations between variables that are mathematically derived from each other (N and CP; MC and DM) were not interpreted.

RESULTS

The bio-activities of the residual toxicity of *Piper guineense* seed powder on *H. bidorsalis* infested by *Dermestes maculatus* are presented in Tables 1 to 3. The impact of *P. guineense* on moisture content (MC), nitrogen (N), crude protein (CP), ether extract (EE), ash, dry matter (DM) and their coefficients of variation (CV) of *D. maculatus*-infested *Heterobranchus bidorsalis* is presented in Table 1. Treatment levels were: control (T0), 10 g (T1), 20 g (T2), 30 g (T3) and 40 g (T4) per 250 g smoked fish.

Moisture content differed and decreased significantly with increasing application rates of *P. guineense*. Values were 36.10% (T0), 28.50% (T1), 22.30% (T2), 21.60% (T3) and 20.80% (T4), with the lowest value at the highest rate (40 g); T2, T3 and T4 did not differ significantly from one another. Differences in moisture contents of the various treatments were, however, very high, with a CV of 28.80%. Nitrogen content increased significantly with treatment rates relative to the control. The values were 9.18% (T0), 9.70% (T1), 10.07% (T2), 10.10% (T3) and 10.13% (T4), with T2, T3 and T4 significantly higher than T0 and T1, and variations amongst them being low (CV = 1.80%). Crude protein content increased significantly ($p < 0.05$) with treatment application relative to the control, just as nitrogen. The values were 57.40% (T0), 59.10% (T1), 62.94% (T2), 62.23% (T3) and 63.41% (T4); T2, T3 and T4 were significantly higher than T0 and T1 but did not differ significantly from one another. Variation in concentration amongst the five treatments (0, 10, 20, 30 and 40 g *P. guineense*) was low, having a CV of 4.00%.

Fat content was significantly ($p < 0.05$) higher with *Piper guineense* additions compared to the control (8.63%, T0). The largest concentrations, 13.82% and 13.05%, were at 20 g (T2) and 30 g (T3), and were higher than 11.20% and 11.30% at 40 g (T4) and 10 g (T1), respectively. Variations amongst the various treatments were high, with a coefficient of variation (CV) of 60.90%. Ash content did not differ significantly with the addition of *Piper guineense* relative to the control. Addition of 20 g and 30 g of *P. guineense* gave the highest ash content (13.70% and 12.50%), followed by 10 g and 40 g (10.30% and 10.00%), then the control (8.00%). Variation in ash content amongst the control, 10 g, 20 g, 30 g and 40 g *P. guineense* was moderate, with coefficient of variation (CV) being about 21.90%. Dry matter content increased significantly ($p < 0.05$) with increased levels of *Piper guineense* application compared to the control. Values were 63.90% (T0), 71.50% (T1), 77.70% (T2), 78.40% (T3) and 79.20% (T4), i.e., from 63.90% in the control to 79.20% at 40 g. The coefficient of variation amongst the various treatments was low at 1.80%.

Table 2 shows the inter-correlation among ash, CP, DM, fat (EE), MC and N. Ash content was significantly ($p < 0.05$) correlated with crude protein ($r = 0.58$) and N ($r = 0.59$), but not significantly with DM ($r = 0.25$), fat ($r = 0.47$) and MC ($r = -0.25$). Fat was significantly ($p < 0.05$) correlated with CP ($r = 0.76$) and N ($r = 0.76$). Dry matter was not significantly correlated with CP ($r = -0.10$), fat ($r = 0.29$) or N ($r = -0.11$), and MC was not significantly correlated with CP ($r = 0.10$), fat ($r = -0.29$) or N ($r = 0.11$). The correlations of N with CP ($r = 1.00$) and of MC with DM

Table 1. Mean effects of *P. guineense* seed powder on the proximate composition (%) of *Heterobranchus bidorsalis* infested with *Dermestes maculatus.*

Parameter	T0 (0 g)	T1 (10 g)	T2 (20 g)	T3 (30 g)	T4 (40 g)	CV (%)	Sig.
MC	36.10[a]	28.50[b]	22.30[c]	21.60[c]	20.80[c]	28.80	*
N	9.18[c]	9.70[c]	10.07[b]	10.10[b]	10.13[b]	1.80	*
CP	57.40[b]	59.10[b]	62.94[a]	62.23[a]	63.41[a]	4.00	*
EE	8.63[c]	11.30[b]	13.82[a]	13.05[a]	11.20[b]	60.90	*
Ash	8.00	10.30	13.70	12.50	10.00	21.90	ns
DM	63.90[c]	71.50[b]	77.70[a]	78.40[a]	79.20[a]	1.80	*

T0 = control (0 g); T1–T4 = 10, 20, 30 and 40 g of *P. guineense* seed powder per 250 g smoked fish. MC = moisture content; N = nitrogen; CP = crude protein (N × 6.25); EE = ether extract (fat); DM = dry matter (100 − MC); CV = coefficient of variation. Values are means of three replicates. Means within a row with different superscript letters differ significantly at $p < 0.05$ according to Tukey's HSD test. * = significant at $p < 0.05$; ns = not significant.

Table 2. Correlation matrix of the proximate components of *P. guineense*-treated *Heterobranchus bidorsalis* infested by *Dermestes maculatus* (n = 15).

	Ash	CP	DM	EE	MC	N
Ash	–					
CP	0.58*	–				
DM	0.25	−0.10	–			
EE	0.47	0.76*	0.29	–		
MC	−0.25	0.10	†	−0.29	–	
N	0.59*	†	−0.11	0.76*	0.11	–

Ash = ash content; CP = crude protein; DM = dry matter; EE = ether extract (fat); MC = moisture content; N = nitrogen. * = significant at $p < 0.05$. † = not interpreted, because N and CP (CP = N × 6.25) and MC and DM (DM = 100 − MC) are calculated from each other.

Table 3. Effect of different levels of *P. guineense* seed powder on the mortality of *Dermestes maculatus.*

Treatment	Mean number of dead insects (out of 10)	Mortality (%)
T0 (control, 0 g)	0	0.0
T1 (10 g)	2.00	20.0
T2 (20 g)	4.00	40.0
T3 (30 g)	6.00	60.0
T4 (40 g)	9.67	96.7

Treatments are g of *P. guineense* seed powder per 250 g smoked fish; ten insects were introduced per jar. Values are means of three replicates. Mortality (%) = (number of dead insects/number of insects introduced) × 100.

(r = −1.00) result from the way these variables were calculated and are therefore not interpreted.

Table 3 shows the effect of *Piper guineense* seed powder on the mortality of *Dermestes maculatus*. The mean number of dead beetles (out of ten per jar) was 0 in the control (T0) and 2.00, 4.00, 6.00 and 9.67 in T1, T2, T3 and T4, corresponding to mortality of 0, 20.0, 40.0, 60.0 and 96.7%, respectively. The ANOVA showed that application of *Piper guineense* seed powder had a significant effect on beetle mortality ($p < 0.05$). The highest mortality was observed in T4 (40 g of *P. guineense* per 250 g fish), while the control (T0) had the lowest mortality (none).

DISCUSSION

Beetle mortality increased progressively with the application rate of *Piper guineense* seed powder, from no mortality in the control to a mean of 2.00, 4.00, 6.00 and 9.67 dead beetles per jar (20, 40, 60 and 96.7%) at 10, 20, 30 and 40 g per 250 g fish, respectively (Table 3), indicating an increasing insecticidal response with increasing application rate. The lower rates did not kill most of the beetles, which suggests that the higher rates are needed for effective control. This is consistent with earlier reports that *P. guineense* and other plant materials reduce survival of *D. maculatus* and damage to dried and

smoked fish (Adedire and Lajide, 2000; Akinwumi *et al*., 2007; Jatau *et al*., 2015; Philip-Attah, 2019; Ileke, 2021; Ileke *et al*., 2021; Koomson *et al*., 2022; Mobolade-Adesina *et al*., 2024; Amulejoye and Maulu, 2024). In particular, fine powder of *P. guineense* has been reported to prevent *D. maculatus* infestation of dried catfish (Akinwumi *et al*., 2022). Many plant extracts have insecticidal properties that can be used against stored product insect pests (Adedire and Ajayi, 2003), and aromatic seed oils are toxic to a number of insects at various stages of application (Huang and Lamend, 2000). The insecticidal feature of *P. guineense* has been attributed to the aromatic components or essential oils present in its fruits and seeds (Orwa *et al*., 2009). Previous studies have reported bioactive compounds such as α-pinene, limonene and linalool in plant materials with insecticidal activity (Golob *et al*., 1999); however, the present study did not chemically characterise the *P. guineense* powder, so the constituents responsible for the observed mortality were not identified.

Application of *P. guineense* seed powder was associated with lower moisture and higher dry matter contents of the fish. Moisture decreased from 36.10% in the control to 20.80% at 40 g, and dry matter increased from 63.90% to 79.20% (Table 1). Most of this change had occurred by 20 g, as the higher rates did not differ significantly from it. These changes may reflect reduced insect activity in treated jars and/or the contribution of the powder itself to the solids of the sample; neither explanation was tested in this study. The observed insecticidal effect may also be associated with changes in moisture content, since severity of infestation could be related to the condition of the dried fish, but this mechanism was not directly investigated.

Nitrogen and crude protein were higher at 20 g and above (crude protein 62.23–63.41%) than in the control (57.40%), and fat content was higher in all treated fish (11.20–13.82%) than in the control (8.63%). Infestation by *D. maculatus* is known to cause substantial losses in dried fish (Osuji, 1974), and the higher protein and fat contents in treated fish may therefore be associated with reduced infestation. However, the powder itself contains nutrients that could contribute to the values measured, and powder-only samples were not analysed, so the two effects cannot be separated. The response of fat and ash was not linear, being highest at 20–30 g, and ash did not differ significantly among treatments.

The correlations among the proximate components (Table 2) showed that ash was positively correlated with crude protein and nitrogen, and fat with crude protein and nitrogen, indicating inter-dependence among some, but not all, of the components of treated fish. The perfect correlations between N and CP and between MC and DM arise from the way the variables were calculated and carry no independent information.

Although *P. guineense* is widely used as a spice, toxicity of the plant to some animals has been reported (Ivbijaro and Agbaje, 1986; Okon, 2002; Raji *et al*., 2003). The present study did not assess residues, sensory quality or safety of the treated fish, and the results do not show that the treated fish is safe for consumption or that its overall food value was preserved. Further studies are required to establish the food-safety implications, optimum application rate and effectiveness of *P. guineense* seed powder under commercial storage conditions.

Conclusion

Piper guineense seed powder demonstrated potential for reducing *Dermestes maculatus* infestation of smoked *Heterobranchus bidorsalis* (beetle mortality of 96.7% at 40 g per 250 g fish) and was associated with changes in the proximate composition of the fish. Further studies should evaluate its safety, optimum application rate and effectiveness under practical storage conditions.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

Adedire, C. O., & Ajayi, O. E. (2003). Potential of sandbox, *Hura crepitans* L. seed oil for protection of cowpea seeds from *Callosobruchus maculatus* Fabricius (Coleoptera: Bruchidae) infestation. *Journal of Plant Diseases and Protection*, *110*(6), 602-610. https://www.jstor.org/stable/43215555.

Adedire, C. O., & Lajide, L. (2000). Effect of pulverized plant materials on fish damage and growth performance of the fish beetle, Dermestes maculatus (De Geer). In: Dike, M. C., Ajayi, O., Okunade, S. O., Okoronkwo, N. O., Abba, A. A. (eds.). *Entomology in nation building: the Nigerian experience. The Proceedings of ESN 30th Annual Conference held at Kano, Nigeria, 4th-7th October 1999*. Pp. 215-218.

Akinwumi, F. O., Fasakin, E. A., & Adedire, C. O. (2007). Toxic and repellence activities of four plant extracts to *Dermestes maculatus* Degeer on smoked African mud catfish, *Clarias gariepinus* Burchell. *Journal of Entomology*, *4*(2), 149-154.

Akinwumi, F. O., Olatunji, K. E., & Ademoroti, A. A. (2022). Effectiveness of particle size of selected plant materials as protectants of stored *Clarias gariepinus* against *Dermestes maculatus* infestation. *International Journal of Biological and Pharmaceutical Sciences Archive, 4*(2), 65-72. https://doi.org/10.53771/ijbpsa.2022.4.2.0089

Amulejoye, F. D., & Maulu, S. (2024). Repellent effects of some plant oils on *Dermestes maculatus* larvae in smoke-dried West African lungfish (*Protopterus annectens*). *Cogent Food & Agriculture, 10*(1), Article 2325199. https://doi.org/10.1080/23311932.2024.2325199

AOAC. (2005). *Official methods of analysis* (18th ed.). AOAC International.

Awoyemi, M. D. (1989). Insect infestation of dried fish in the Kainji Lake area. *National Institute for Freshwater Fisheries Research, New Bussa, Annual Report*, 5–12.

Boeke, S. J., van Loon, J. J. A., van Huis, A., Kossou, D. K., & Dicke, M. (2001). *The use of plant materials to protect stored leguminous seeds against seed beetles: A review*. Backhuys Publishers.

Eyo, A. A. (2006). *The effect of traditional handling, processing and storage method on the quality of dried fish in small scale fisheries in Nigeria*.

FAO. (1981). *The prevention of losses in cured fish* (FAO Fisheries Technical Paper No. 219). Food and Agriculture Organisation of the United Nations.

FAO. (2022). *The state of world fisheries and aquaculture 2022: Towards Blue Transformation*. Food and Agriculture Organization of the United Nations. https://doi.org/10.4060/cc0461en

FAO. (2024). *The state of world fisheries and aquaculture 2024: Blue Transformation in action*. Food and Agriculture Organization of the United Nations. https://doi.org/10.4060/cd0683en

Golob, P., Moss, C., Dales, M., Fidgen, A., Evans, J., & Gudrups, I. (1999). *The use of spices and medicinals as bioactive protectants for grains* (FAO Agricultural Services Bulletin 137). Food and Agriculture Organization of the United Nations. Retrieved from https://www.fao.org/4/x2230e/x2230e00.htm.

Huang, Y., Lam, S. L., & Ho, S. H. (2000). Bioactivities of essential oil from *Elletaria cardamomum* (L.) Maton. to Sitophilus zeamais Motschulsky and: Tribolium castaneum (Herbst). *Journal of Stored Products Research*, *36*(2), 107-117. https://doi.org/10.1016/S0022-474X(99)00040-5

Ileke, K. D. (2021). Responses of two plant-derived bioinsecticides as protectants of smoke-dried catfish, *Clarias gariepinus* [Pisces: Clariidae] against hide beetle, *Dermestes maculatus* (De Geer) [Coleoptera: Dermestidae]. *Bulletin of the National Research Centre, 45*. https://doi.org/10.1186/s42269-020-00470-1

Ileke, K. D., Adesina, J. M., Abidemi-Iromini, A. O., & Abdulsalam, M. S. (2021). Entomocide effect of *Alstonia boonei* De Wild on reproductive performance of *Dermestes maculatus* (Coleoptera: Dermestidae) infestation on smoked catfish *Clarias gariepinus* (Pisces: Clariidae). *International Journal of Tropical Insect Science, 41*(2), 1293-1304. https://doi.org/10.1007/s42690-020-00321-6

Ivbijaro, M. F., & Agbaje, M. (1986). Insecticidal activities of *Piper guineense* Schum and Thonn, and *Capsicum* species on the cowpea bruchid *Callosobruchus maculatus* F. *Insect Science and Its Application, 7*, 521-524.

Jatau, A., Majeed, Q., Bandiya, H. M., & Ibrahim, N. D. (2015). Effects of five local spices on the mortality and development of *Dermestes maculatus* Degeer (Coleoptera: Dermestidae) larvae on dried fish. *Nigerian Journal of Entomology, 31*, 103–107. https://doi.org/10.36108/NJE/5102/13.0181

Koomson, C. K., Owusu-Fordjour, C., & Darku, A. (2022). Susceptibility of *Dermestes maculatus* Degeer (Coleoptera: Dermestidea) larvae infesting smoked African catfish (*Clarias gariepinus*) to *Alchornea cordifolia* (Schum. & Thonn.) leaf powder. *International Journal of Applied Biology*, *6*(2), 152-160. https://doi.org/10.20956/ijab.v6i2.21787

Mobolade-Adesina, T. E., Adesina, J. M., Ankush, R. M., Anaele, U. M., & Bashar, A. T. (2024). Biopesticide value of *Uapaca corbisieri* and *Sterculia oblonga* plants against *Dermestes maculatus* DeGeer (Coleoptera: Dermestidae) infestation in smoked-dried fish Clarias gariepinus Burchell. *Ruhuna Journal of Science*, *15*(2), 75-85. https://doi.org/10.4038/rjs.v15i2.150

Odeyemi, O. O., Owoade, R. A., & Akinkurolere, R. (2000). Toxicity and population suppression effects of *Parkia clappertoniana* on dried fish pests (*Dermestes maculatus* and *Necrobia rufipes*). *Global Journal of Pure and Applied Sciences, 6*, 191-195.

Okon, A. O. (2002). The effect of ethanolic extract of *Piper guineense* on the histology of some organs of *Oreochromis niloticus* (Linn) (Pisces: Cichlidae). *Global Journal of Pure and Applied Sciences, 8*(2), 193-196.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., & Anthony, S. (2009). *Agroforestree database: A tree reference and selection guide* (Version 4.0). World Agroforestry Centre.

Osuji, F. N. C. (1974). Beetle infestation of dried fish purchased from a Nigerian market, with special reference to *Dermestes maculatus* Degeer. *Nigerian Journal of Entomology, 1*(1), 69-79.

Philip-Attah, T. M. (2019). Evaluation of ethanolic extracts of *Piper guineense*, *Dennettia tripetala*, and *Capsicum frutescens* as protectant of smoked fish, *Clarias gariepinus* (Pisces: Clariidea) against *Dermestes maculatus* (Coleoptera: Dermestidae). *The Journal of Basic and Applied Zoology*, *80*, article number 7. https://doi.org/10.1186/s41936-019-0079-1

Raji, Y., Udoh, U. S., & Ojo, O. O. (2003). Gastro-ulcerogenic activities of *Piper guineense* extracts in rats. *Nigerian Journal of Physiological Sciences, 18*(2), 27-30.