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Suppression of the Cowpea Bruchid (*Callosobruchus maculatus* (F.) Infesting Stored Cowpea (*Vigna unguiculata* (L.) Walp.) Seeds with Some Edible Plant Product Powders

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Abstract: Five Edible Plant Product Powders (EPPP), West African black pepper (*Piper guineense* Schum and Thonn), clove (*Syzgium aromaticum* (L.) Merril and Percy), Ethiopian pepper (*Xylopia aethiopica* (Dunn.) A. Rich), Alligator pepper (*Aframomum melegueta* Schum) and African locust bean (*Parkia biglobosa* (Jacq.) R. Br. Ex G. Donf.) were studies for their effectiveness in suppressing oviposition, egg hatch and progeny emergence against *Callosobruchus maculatus* (F.). Pulverized EPPP at the rate of 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 g/20 g cowpea seeds were applied as pre-treated and treatment after infestation. All the plant product powders significantly ($p \leq 0.05$) reduced oviposition by *C. maculatus* when tested as pre-treated application, compared with oviposition in control treatments. Consequently, F1 progeny emergence was significantly ($p \leq 0.05$) suppressed compared with emergence in control. In the treatment after infestation, egg mortalities were highest in treatments with WABP, Clove and Ethiopian pepper. There were however significant differences ($p \leq 0.05$) between the EPPP and the control treatment at all dosage rates tested. The effectiveness of the EPPP in both studies was thus ranked as follows: WABP>Clove>Ethiopian pepper>Alligator pepper>African locust bean.

Key words: Edible plant product powders, *Callosobruchus maculatus*, *S. aromaticum*, *P. guineense*, *A. melegueta*, *X. aethiopica*, *P. biglobosa*, oviposition, egg-mortality

INTRODUCTION

Cowpea, *Vigna unguiculata* (L.) Walp., is a very important grain legume in West Africa (Stanton *et al*., 1966). It is widely cultivated and eaten in Nigeria (Ohiagu, 1986), the most important producing areas in Nigeria being located in the savanna regions (Agboola, 1979). It is however cultivated in a large range of ecologies in all the continents of the world (Rachie and Robets, 1974). Nigeria accounts for 70% of the world's production. It is an extremely valuable crop both as a source of revenue and as an important source of cheap dietary protein for the third world where meat is expensive (Stanton *et al*., 1966; Alghali, 1991). The high protein and lysine contents of the seeds make them a natural supplement to staple diets of cereals, roots, tubers and fruits (Bressani, 1985).

The cowpea seed bruchid, *Callosobruchus maculatus* (F.) (Coleoptera:Bruchidae) is a cosmopolitan field-to-store pest ranked as the principal post-harvest pest of cowpea in the tropics (Jackai and Daoust, 1986; Singh *et al*., 1990). It causes substantial quantitative and qualitative losses manifested by seed perforation and reduction in weight, market value and germinability of seeds (IITA, 1989; Adeduntan and Ofuya, 1998). At least 4% of the total annual production of about 30,000 tonnes valued at over 30 million US dollars is lost annually in Nigeria alone to this bruchid (Caswell, 1980; Singh *et al*., 1983). Under traditional storage conditions, 100% infestation of cowpea occurring within 6 months or more often within 3 to 5 months of storage is common (Booker, 1967; Caswell and Akibu, 1980; Seck, 1993).

The use of synthetic insecticides has been the major means through which cowpea seeds are protected during storage. The use of synthetic pesticides over the years has revealed the nuisance they constitute to the ecosystem such as their undesirable side effects on non-target organisms including man and the fact that they are environmentally disruptive (Schwab *et al*., 1995).

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Due to the problems associated with the use of synthetic insecticides, some insecticides of plant origin with a long history of traditional use have been identified (Flint and Bosch, 1981). Some of these plants have been reported not to have the problems associated with the use of synthetic insecticides (Arnason *et al*., 1989). To this end, there has been a re-new interest in tropical countries towards the search for safer and cheaper ways of controlling the major storage insect pests of pulses and cereal grains (Singh *et al*., 1978; Malik and Naqvi, 1984). One area receiving greater attention is the use of certain edible plant materials as grain protectants (Iwuala *et al*., 1981; Ivbijaro and Agbaje, 1986).

The candidate plant products used for this study have been used previously in the management of some stored product Coleopteran (Grainge and Ahmed, 1988; Lale, 1992). There are also reports of their use as condiments and for culinary purposes in homes (Cobley and Steele, 1976; Rehm and Espig, 1991).

This present study evaluated the insecticidal efficacy of five edible plant product powders (EPPP) obtained from African locust bean (ALB) *Parkia biglobosa* (Jacq.) R.Br. exG. Donf; clove, *Syzgium aromaticum* (L.) Merril and Percy; West African black pepper (WABP) *Piper guineense* Schum and Thonn, alligator pepper, *Aframomum melegueta* Schum and Ethiopian pepper, *Xylopia aethiopica* (Dun.) A. Rich. on the biology of *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae).

MATERIALS AND METHODS

Preparation of plant materials: Five hundred grams of dried seeds of *Parkia biglobosa* (African locust bean), *Syzgium aromaticum* (clove), *Piper guineense* (West African black pepper), *Aframomum melegueta* (alligator pepper) and *Xylopia aethiopica* (Ethiopian pepper) were purchased from the open market in Sabon-Gari, Kano State, Nigeria. The seeds were separately ground into powder using a high power electric mill. The powders were separately placed in transparent polypropylene bags and stored in a refrigerator at 4°C until ready for use.

Preparation of cowpea seeds: Two kilograms of clean and sorted uninfested cowpea seeds identified by Nigeria Stored Products Research Institute (NSPRI), Kano as variety Dan-illa was purchased from the open market in Kano. Screened seeds were fumigated with aluminum phosphide (from phostoxin pellets) in an air-tight container for 24 h to kill any insect present. The seeds were later aired for three days to allow for dissipation of fumigant effect. Thereafter, the cowpea seeds were stored in a black polypropylene bag until ready for use.

Maintenance of *C. maculatus* culture: One kilogramme of already fumigated cowpea (var. Dan-illa) seeds was divided into two parts and were placed in each of two kilner jars and infested with adult bruchid from an insect culture raised in the laboratory over five generations. Bruchid that emerged from this culture were used for the bioassay test. From this new culture, 1-2 day old of 1st or 2nd progeny of adult *C. maculatus* raised for the bioassay were used for the study. The colony of cowpea bruchid was maintained under laboratory conditions of 25-32°C and 56-71% h. The bioassay experiment was carried out under these conditions.

Bioactivity testing: Each of the powders of *P. biglobosa*, *S. aromaticum*, *P. guineense*, *A. melegueta* and *X. aethiopica* was applied at six different levels (0.5, 1.0, 1.5, 2.0, 2.5 and 3.0) and admixed with 20 g of cowpea (var. Dan-illa) seeds in a 100 mL glass jar.

Each treatment was shaken vigorously for proper mixing and allowed to stand for an hour before introducing 5 pairs of 1-2 day old adult *C. maculatus* into each jar. Control batches were set along for each dosage rates without any admixture of powders. Adult female *C. maculatus* were allowed to oviposit for 7 days before being removed and discarded. The number of eggs laid in each replicate of the treatments was counted and recorded. F1 progeny that emerged in each treatment was removed and recorded for 14 consecutive days after date of first emergence.

Each of these dosage rates and treatments were separately carried out as pre-treatment and treatment after infestation. Treatments were carried out as described above in both bioassays.

Experimental design and statistical analysis: Each experiments and treatments was carried out in a randomized complete block design with each treatments replicated four times. The adults that emerged in each replicate for the F1 progeny were expressed as a percentage of the number of eggs laid and was also used to determine egg mortality. Percentage data were arc sine transformed and the entire data collected were subjected to two-way ANOVA and means were separated using the Least Significant Difference (LSD) ($p \leq 0.05$) statistic.

RESULTS AND DISCUSSION

Both pre-treated and treatment after infestation with the Edible Plant Product Powders (EPPP) provided effective control of *C. maculatus* infesting stored cowpea seeds through reduced oviposition and/or reduced adult emergence. Table 1 compares the oviposition of *C. maculatus* in pre-treated infestation.

Table 1: Mean Oviposition of adult *C. maculatus* on cowpea (var. Dan-illa) seeds pre-treated with five edible plant product powders

	Edible plant products powders					
Dosage (g/20 g seeds)	ALB	Clove	WABP	Alligator pepper	Ethiopian pepper	Mean
0.5	44.00	7.50	1.75	64.00	34.50	30.35
1.0	36.75	1.75	0	58.25	15.25	22.40
1.5	34.75	0.5	0	56.25	7.50	19.80
2.0	33.25	0	0	54.00	1.25	17.70
2.5	27.25	0	0	25.75	0	10.60
3.0	23.50	0	0	18.00	0	8.30
Control	93.00	89.50	95.50	91.00	103.25	94.45
Mean	41.79	14.11	13.90	52.46	23.11	

ALB = African locust bean; WABP = West African black pepper; SED = 1.66; LSD ($p \leq 0.05$) = 3.17 (Plant Products); SED = 1.96; LSD ($p \leq 0.05$) = 3.74 (Dosage), SED = 4.38; LSD ($p \leq 0.05$) = 8.36 (Interaction)

Table 2: Mean percentage adult *C. maculatus* emergence in cowpea (var. Dan-illa) seeds pre-treated with five edible plant product powders

	Edible plant products powders					
Dosage(g/20 g seed)	ALB	Clove	WABP	Alligator pepper	Ethiopian pepper	Mean
0.5	77.30	17.30	0.0	91.30	29.80	38.60
	(61.54)*	(24.61)	(0.0)	(72.86)	(33.06)	(38.42)
1.0	72.80	0.0	0.0	67.30	18.70	21.80
	(58.55)	(0.0)	(0.0)	(55.12)	(25.65)	(27.86)
1.5	53.50	0.0	0.0	28.50	0.0	8.50
	(47.09)	(0.0)	(0.0)	(32.30)	(0.0)	(15.88)
2.0	41.70	0.0	0.0	34.70	0.0	6.90
	(40.22)	(0.0)	(0.0)	(36.07)	(0.0)	(15.26)
2.5	51.00	0.0	0.0	40.60	0.0	8.60
	(45.56)	(0.0)	(0.0)	(39.59)	(0.0)	(17.03)
3.0	42.90	0.0	0.0	36.50	0.0	8.30
	(40.93)	(0.0)	(0.0)	(37.19)	(0.0)	(15.62)
Control	85.20	81.20	88.10	87.60	77.20	84.00
	(67.34)	(64.31)	(69.86)	(69.37)	(61.45)	(66.46)
Mean	61.40	39.40	3.00	56.80	8.70	
	(51.60)	(38.90)	(9.98)	(48.93)	(17.17)	

ALB = African Locust Bean, WABP = West African Black Pepper, SED = 1.54; LSD ($p \leq 0.05$) = 2.94 (Plant products), SED = 1.82; LSD ($p \leq 0.05$) = 3.47 (Dosage), SED = 4.06; LSD ($p \leq 0.05$) = 7.75 (Interaction), *Figures in parentheses are arc sine values to which SED and LSD are applicable

Some of the edible plant products, particularly *P. guineense*, *S. aromaticum* and *X. aethiopica* were effective in suppressing or completely inhibiting oviposition, while *A. meleguata and P. biglobosa* were only effective at high dosage rates. There was however significant ($p \leq 0.05$) differences between all the treatment levels and control. The ability of the EPPP to suppressed progeny emergence is shown in Table 2. *A. melegueta* and *P. biglobosa* recorded the highest mean number of adult emergence of 91.30 and 77.30% at 0.5 g dosage rate, respectively, compared to 88.10% in control. Table 2 also showed that treatments with *P. guineense, S. aromaticum* and *X. aethiopica* completely inhibited adult emergence at dosages of 0.5-3.0, 1.0-3.0 and 1.5-3.0 g/20 g, respectively. There were however, significant differences ($p \leq 0.05$) in adult emergence in cowpea seeds treated with *P. biglobosa* and *A. melegueta* at treatment levels of 1.0-3.0 g/20 g when compared with adult emergence in control.

Table 3 shows the mean number of eggs laid in cowpea seeds treated after infestation had taken place. There were no significant differences ($p \geq 0.05$) among all the EPPP and control treatments and between the dosage rates. The effects of the EPPP on egg mortality are reported in Table 4. This showed that *P. guineense* recorded 100% egg mortality at dosage rates of 1.0-3.0 g/20 g cowpea seeds. There was significant difference ($p \leq 0.05$) between egg mortalies in *P. guineense* (96.30%), *S. aromaticum* (90.90%) and *X. aethiopica* (90.40%), respectively. Mean differences between *S. aromaticum* and *X. aethiopica* were not significant ($p \geq 0.05$). *A. melegueta* (70.90%) and *P. biglobosa* (33.20%) were however significantly different ($p \leq 0.05$) from each other. All the EPPP at the different dosage rates recorded highly significant ($p \leq 0.05$) differences when compared with the control treatments.

The differences exhibited in suppressing and/or inhibiting oviposition, adult emergence and in causing egg mortalities by the EPPP could be due to the different active ingredients (ai) constituents contained in the EPPP. Earlier reports have shown that products from these plant materials either as oil extracts or their powders have been used in the control of stored products pests (Lale, 1992; Ajayi and Lale, 2001; Ajayi and Lale, 2000/2001; Odeyemi *et al*., 2000; Okunade *et al*., 2002a,b). The effectiveness of

Table 3: Mean Oviposition of adult *C. maculatus* on cowpea (var. Dan-illa) seeds treated after infestation with five edible plant products powders

Dosage (g/20 g seeds)	Edible plant products powders ALB	Clove	WABP	Alligator pepper	Ethiopian pepper	Mean
0.5	87.75	86.25	92.00	93.50	91.00	90.10
1.0	86.25	82.25	92.50	89.25	78.00	85.65
1.5	93.00	92.75	79.00	81.50	93.75	88.00
2.0	83.50	85.25	89.75	87.50	94.75	88.15
2.5	97.50	90.00	84.00	93.25	87.75	90.50
3.0	86.25	98.25	87.00	94.00	90.75	91.25
Control	92.00	83.75	85.00	92.00	90.75	88.70
Mean	89.46	88.36	87.04	90.14	89.54	

ALB = African Locust Bean, WABP = West African Black Pepper, SED = 3.31; LSD ($p \geq 0.05$) = NS (Plant Products), SED = 3.92; LSD ($p \geq 0.05$) = NS (Dosage), SED = 8.76; LSD ($p \geq 0.05$) = NS (Interaction), NS = Non - significant

Table 4: Mean percentage egg-mortality of *C. maculatus on* cowpea (var. Dan-illa) seeds treated after infestation with five edible plant product powders

Dosage (g/20 g seed)	Edible plant products powders ALB	Clove	WABP	Alligator pepper	Ethiopian pepper	Mean
0.5	22.20	68.50	99.21	42.00	65.40	63.20
	(28.11)*	(55.86)	(84.91)	(40.41)	(55.99)	(55.66)
1.0	25.10	90.50	100.00	54.10	94.40	79.60
	(30.06)	(72.06)	(90.00)	(47.37)	(76.31)	(63.16)
1.5	33.50	100.00	100.00	60.00	98.90	88.30
	(35.36)	(90.00)	(90.00)	(50.78)	(83.97)	(70.04)
2.0	41.00	100.00	100.00	87.10	100.00	93.90
	(39.82)	(90.00)	(90.00)	(68.95)	(90.00)	(75.75)
2.5	43.70	100.00	100.00	99.42	100.00	96.60
	(41.38)	(90.00)	(90.00)	(85.64)	(90.00)	(79.39)
3.0	59.20	100.00	100.00	100.00	100.00	98.10
	(50.28)	(90.00)	(90.00)	(90.00)	(90.00)	(82.09)
Control	13.20	11.10	8.60	10.00	11.20	10.80
	(21.30)	(19.45)	(17.04)	(18.45)	(19.57)	(19.18)
Mean	33.20	90.90	96.30	70.90	90.40	
	(35.18)	(72.49)	(78.87)	(57.37)	(71.97)	

ALB = African Locust Bean, WABP = West African Black Pepper, SED = 1.53; LSD ($p \leq 0.05$) = 2.92 (Plant products), SED = 1.81; LSD ($p \leq 0.05$) = 3.45 (Dosage), SED = 4.04; LSD ($p \leq 0.05$) = 7.71 (Interaction), *Figures in parentheses are arc sine values to which SED and LSD are applicable

P. guineense is attributed to piperine, while the pungency and odour is due to volatile oil containing terpenes (Purseglove, 1974; Oliver-Bever, 1986). *S. aromaticum* has been reported to contain eugenol and caryophylline (Schavenberg and Paris, 1977). Paradol has been reported to be the major constituents in *A. melegueta* (Lale, 1992).

The use of *P. guineense* powder at the rate of 1.5 g/20 g of cowpea seeds was reported to cause 100% egg mortality of *C. maculatus* and also significantly reduced F1 progeny emergence (Ivbijaro and Agbaje, 1986). In another report powder of *A. meleguata, Eugenia aromatica* (Syn. *S. aromaticum)* and *Piper umbellatum* (Syn. *P. guineense)* were reported to cause high mortalities in adult *Sitophilus oryzae* with subsequent result of lack of F1 progeny (Lajide *et al*., 1998). Okunade *et al*. (2002a, b) had also show that *Parkia* sp. can be used to control *Tribolium castaneum* and *Rhyzopertha dominica*. However, in their report it was shown that the use of *Parkia* sp. was not as effective as the other pulverized plant products tested. The reports obtained in this report corroborates with these earlier reports. The potency of the EPPP used in this study can be rated according to their ability to suppressed oviposition, inhibit progeny emergence or caused egg mortalities in order of *P. guineense*>*S. aromaticum*>*X. aethiopica*>*A. melegueta*>*P. biglobosa.*

In this study, the use of the EPPP were able to effectively control the ability of *C. maculatus* to perpetuate on cowpea seeds during storage. This is very important in reducing damage caused by the pest in storage. This is because *C. maculatus* is a field-to-store pest and hence any cowpea seeds carrying eggs after harvest or those that can be contaminated by an already infested cowpea seeds, can be controlled with the use of some of these EPPP that have been reported to be very effective. Also considering their ease of availability, safety, low cost and low technological requirement in processing as against the synthetic insecticides, there is need for their adoption for the preservation of stored crop products. They are also used as an important component of diets of many Africans and Asians.

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