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Comparative efficacy of seven plant products on the cowpea burchid, *Callosobruchus maculatus* F. development and damage

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ABSTRACT

An experiment was conducted to investigate the insecticidal activities of seven plant materials (1-5g/100g cowpea seeds) namely: citrus peel powder (CPP), *Acacia* leaf powder (ALP), *Occimum* leaf powder (OLP), mahogany bark powder (MBP), hot pepper powder (HPP), ginger powder (GP) and mahogany wood ash (MWA) and a synthetic insecticide, pirimiphos-methyl dust (PMD) (0.1-0.5g/100g cowpea seeds) as standard. The experiment was laid out in a completely randomized design, replicated three times. Results showed that MWA was superior at all rates of application in reducing cowpea seed weight loss and seed damage. The effectiveness of the treatments in succession was MWA> PMD> GP> HPP>MBP>OLP>ALP>CPP. The most effective rate of application was 5g/100g cowpea seeds, rather than by 2-3g/ 100g cowpea seeds. There was no significant difference among treatments and the untreated control in the germinability of cowpea seeds, although the lowest germination was recorded in cowpea seeds treated with 1g HPP. Similarly, when the seeds treated with plant materials were cooked, they did not leave any flavour strong enough to influence acceptability by the consumers.

Key words: Plant products, cowpea burchid, development, reproduction.

INTRODUCTION

Cowpea [*Vigna unguiculata* L. (Walp.)] is one of the most important food legumes in the tropics and sub–tropics (Rajapakse and Van Emden, 1997). In West and Central Africa, cowpea constitutes the cheapest source of dietary protein for low-income sector of the population thus helping to alleviate protein malnutrition in human (Rachie, 1995). It is also an important cash crop that makes up part of the export commodities for the countries cultivating it. Nigeria produces about 60 per cent of the world's total production (Ansari and Singh, 1984). Other countries with significant area and grain production in West Africa include Niger, Benin, Togo, Ghana, Mali, Burkina Faso and Senegal (Singh *et al*., 1997).

In most parts of West Africa, insect pests have been reported to be the single most important constraint to cowpea production (Jackai and Daoust, 1986; Singh *et al*., 1990; Karungi *et al*., 1999) and this account for the low annual harvest. After harvest, the crop is normally stored by farmers in the pod, and much of it is stored in mud granaries while the rest is stored in sacks. A granary may hold from 100 to 500 kg of grain (Caswell, 1981). Eggs of some insect species are usually laid on the ripening pods and larvae or adults may be found at harvest. Such insect pest species include the agromyzid, *Melanagromyza vignalis* Spencer, the apionid, *Piezotrachelus varius* Wagn. and the bruchids, *Bruchidius atrolineatus* Pic., *Callosobruchus rhodesianus* Pic., *C. maculatus* (Fabricious), *C. chinensis*, *C. analis* (Fabricious), *C. phaseoli* (Chevrolat) and *Acanthocelides obtectus* (Say) (Haines, 1991). The agromyzid and apionid do not survive in the store and of the bruchids *B. atrolineatus* and *C. maculatus* have been reported as the main bruchid species attacking stored cowpea in the sahelian zone of West Africa (Huignard *et al*., 1985). Caswell (1981) reported that *C. maculatus* alone accounts for over 90% of the damage done to cowpea seeds by insects. Observations in cowpea stores in West African Sahel show that *B. atrolineatus* can be dominant species during the early months of storage resulting in significant losses to cowpea seeds (Germain *et al*., 1987).

High temperatures and relative humidity are reported to be responsible for rapid increase in the number of insect population (Ohiagu, l987). Singh (1977) reported 100% loss of cowpea within 3–5 months of storage. Caswell (1968) reported that damage of the seeds in the Nigerian markets varied from 14 to 37% and losses amount to 24,000 tonnes yearly (4% of national production). It has been estimated that a 5% loss of cowpea due to bruchid infestation cost Nigeria US $30 million per year (Caswell, 1973). This kind of situation also prevails in other tropical countries and these high losses might have contributed immensely to cowpea's subsidiary position in the farming systems of several countries in the tropics. Few other important food crops suffer such losses from insects.

Farmers have been reported using even banned and highly toxic chemical insecticides in their quest to protect their agricultural products against insect pests. These poisonous pesticides have been reported to affect the nervous system, producing a range of symptoms from nausea, vomiting, headache, dizziness to seizures, convulsions and sometimes death in addition to development of tolerance by treated insects (Banks *et al*., 1990). Therefore, in small–scale farming, control of storage insect pests should not become dependent on the use of fumigants or residual insecticides.

There is a tremendous wealth of traditional local knowledge on the use of plant materials in storage protection (Govindan *et al.,* 2010). Some of this knowledge has been neglected over past decades. However, there is an increasing interest and necessity to reactivate the knowledge (Stoll, 2000). Therefore, it has become necessary to search for an option that can produce satisfactory result in a way that such option is not only acceptable to the farmers, but must also be feasible from a socio–economic stand point. In the present circumstance, an approach that would rely on the use of plant products (without involving synthetic pesticides) appears to hold the greatest hope for increased cowpea production in the traditional cereal–dominated cropping system throughout the tropics and sub–tropics, including Nigeria. This research is therefore, designed to study the impact of seven plant products and a synthetic pesticide (for comparison) on damage by *C. maculatus* to cowpea seeds and to compare the effects of the level of treatments on germinability and palatability of cowpea seed.

MATERIALS AND METHODS

Preparation of seeds and bruchid culture

The cowpea variety, *Kananado* was obtained from the Bauchi State Agricultural Development Programme, Bauchi. It was fumigated for 24 hours with phostoxin before the experiment in order to kill any insect pest present. The seeds were later exposed for 48 hours to get rid of the gas and then sieved with a 2mm sieve to remove dead insects, exuviae and frass. These seeds were then packed into polythene bags and later used for the experiment.

The test bruchid, *C. maculatus* were collected from previously infested cowpea seed purchased from Muda-Lawal market in Bauchi. They were cultured in white cowpea variety, *Kananado* at room temperature and relative humidity in the laboratory. Twenty pairs of *C. maculatus* were introduced into earthenware pots each containing 1kg of the cowpea variety. The technique described by Bandera and Saxena (1995) for sexing and handling of bruchids was used in the experiment. The pots were then covered with fine mesh cloth fastened with rubber bands to prevent the contamination and escape of insects. Seven days were allowed for mating and oviposition. The parent stocks were sieved out and the cowpea seeds containing eggs were left undisturbed until the new adults emerge. The subsequent F_1 progenies of the bruchids, which emerged from the cultures, were used for the experiment.

Preparation of Test Plant Materials

The plant materials evaluated for insecticidal activity against *C. maculatus*, the parts used and other pertinent information are provided in Table 1. The fresh leaves of basil and *Acacia* were obtained from different locations at ATBU, Bauchi. They were shade-dried and ground into powder in a laboratory mill. Each material was kept in separate plastic bags until needed. Fruits of chilli, rhizomes of ginger and orange fruits were purchased from Muda-Lawal market in Bauchi. The fruits of chilli and rhizomes of ginger were dried and milled as previously described, while the orange fruits were peeled using a sharp knife. The peel was also dried and milled as described above. Wood of Mahogany was obtained and the bark was stripped off. Both bark and wood were shed-dried. The dried bark was pounded into smaller particles using laboratory pestle and mortar, before milling into fine powder. Dry wood was burnt to ashes. After cooling, the ash was placed in sealed jar to prevent the absorption of air moisture. Each plant product was labeled and kept. The pirimiphos–methyl dust (Actellic 2%) used in the experiment was purchased from the Bauchi State Agricultural Supply Company.

Table 1. Experimental plants used to evaluate the insecticidal activity

Plant materials	Common name	Family	Parts used
Citrus sinensis Osbeck	Sweet orange	Rutaceae	Fruit Peel
Occimum basilicum L.	Sweet Basil	Labiataceae	Leaves
Acacia nilotica (Linn.) Willd. ExDel.	Babul	Fabaceae	Leaves
Capsicum frutescens L.	Chilli pepper	Solanaceae	Fruits
Zingiber officinale Rosc.	Ginger	Zingiberaceae	Rhizome
Khaya senegalensis (Desv.) A. Juss.	Mahogany	Meliaceae	Bark
Khaya senegalensis (Desv.) A. Juss.	Mahogany	Meliaceae	Wood ash

Bioassay

Each plant powder of citrus peel, *Occimum* spp, mahogany bark, hot pepper, ginger, *Acacia* and mahogany wood ash was separately applied to cowpea seeds in glass bottles (2 litres) at 1, 2, 3, 4 and 5 g/100g of cowpea. Pirimiphos-methyl (actellic dust 2%) was used as standard insecticide and was applied at 0.1, 0.2, 0.3, 0.4 and 0.5g/100 g cowpea seed. There was untreated check which did not contain any plant material. Three replications were maintained for each dose. The jars containing cowpea and powders were gently shaken for about 30 seconds to ensure thorough admixture of cowpea seeds and treatment powders or ash. The powders and ash were allowed to settle down for about 15 seconds before five pairs of adult *C. maculatus* (one-day-old) were added to each jar. The jars were covered with fine mesh cloths fastened with rubber bands, labelled and left at room temperature and relative humidity. Treated jars and untreated controls were laid out in a completely randomized design for 12 weeks. At the end of the period, the following observations were recorded.

Weight of the emerged bruchids

Each jar was sieved with 2mm sieve in order to separate the cowpea seeds and the insects along with the plant materials, frass and exuviae. These were further sieved in order to obtain only the bruchids in each jar, which were then weighed.

Seed damage rate (% seeds with holes)

The effects of plant materials and pirimiphos- methyl were assessed from the proportion of seeds with bruchid emergence holes. One hundred seeds were randomly selected from each treatment and the number of seeds damaged by the bruchids in each random sample counted. Seeds with typical "emergence holes" were counted as damaged. The Percentage grain damage (PGD) was therefore, calculated using the formula: $PGD = G_1/G_2 \times 100$

Where, G_1 is number of cowpea seeds with holes and G_2 is total number of cowpea seeds

Percentage seed weight loss

Ten uninfested and ten infested seeds were randomly picked from each treatment jar, weighed and recorded. The differences in weight between the uninfested and the infested seeds gave the loss in weight as a result of bruchid infestation. Percentage infestation was then calculated using the formula: Percentage seed weight loss $= X_1 - X_2 / X_1 \times 100$

Where X_1 is weight of uninfested seeds and X_2 is weight of infested seeds.

Seed germination (% viability) test

The viability of treated and untreated seeds was tested four months after treatment with plant materials and infestation by bruchids. Ten seeds were selected randomly from each treatment, moistened in glass covered Petri dishes, labeled and left on a laboratory bench exposed to sunlight for seven days. There were three replicates per treatment. Emerged seedlings were counted at seven days after planting and percentage germination was calculated using the relation:

$$\text{Percentage germination} = \frac{\text{Number of seeds that germinated}}{\text{Total number of seeds planted}} \times 100$$

Palatability evaluation test

Cowpea seeds preserved for four months with mahogany bark powder (MBP), mahogany wood ash (MWA), *Acacia* leaf powder (ALP), ginger powder (GP), citrus peel powder (CPP), *Occimum* leaf powder (OLP), hot pepper powder (HPP) and pirimiphos–methyl dust (PMD) as well as those of untreated checks were rinsed with several changes of water and cooked in water for one hour without flavouring material (including common salt). The cooked seeds were served in tablespoons to a panel of 10 respondents for palatability evaluation. Each respondent rinsed his mouth three or more times between samples. The respondents rated acceptability of the cooked seeds based on taste characteristics, on a scale from 1 to 4, where 1 = highly unacceptable, 2 = unacceptable, 3 = marginally acceptable and 4 = acceptable (Ogunwolu and Odunlami, 1996). Data was analyzed as a completely randomized experiment.

Data Analysis

Exit hole counts and the developmental durations having low counts and zero values were transformed to $\sqrt{?x\ ?\ 0.5?}$ before analysis of variance (ANOVA), while treatment efficacy criteria expressed as percentages were arcsine – transformed prior to the ANOVA. Significantly different treatment means at P = 0.05 were separated by Student–Newman-Keuls Test using the SAS software (SAS, 2000).

RESULTS

Percentage of cowpea seeds with holes

The result shows that CPP and at 1g and 4g plant materials, respectively showed 100% cowpea seeds with holes. The most effective plants were GP, OLP, and MWA 1g , 2g and 3g, 4g and 5g plant materials, respectively. There were no significant differences (P< 0.05) among GP, ALP and MWA and between MBP and HPP (Table 2).

Percentage cowpea weight loss

Table 3 shows the effect of rate of application of plant materials and PMD on mean percentage cowpea weight loss after

Table 2. Effect of rate of application of plant materials and pirimiphos-methyl on mean[a] percentage cowpea seeds with holes

Weight of plant material (g)/100g cowpea seeds[c]					
Treatment[b]	1	2	3	4	5
CPP	100.0a	73.5b	48.2d	37.9de	26.3d
ALP	33.6ef	31.5e	71.2b	69.2b	69.5b
OLP	79.9c	29.4e	34.4e	40.1de	72.6b
MBP	66.0d	53.9c	52.8c	46.3d	23.9d
HPP	70.0d	36.5d	34.4e	35.4e	35.4c
GP	29.4f	30.1e	35.8e	60.7c	34.7c
MWA	33.3ef	15.7f	10.0f	4.7f	2.7e
PMD	39.0e	36.5d	32.2e	30.8e	29.1d
CNTL	87.7b	99.8a	90.1a	100.0a	95.7a
S.E. +	0.02	0.01	0.01	0.03	0.02

[a] Means in column followed by the same letter (s) are not significantly different (P<0.05) using Student Newman- Keul's Test (SNK).
[b] CPP= citrus peel powder, ALP= Acacia leaf powder, OLP= Occimum spp. leaf powder, MBP= mahogany bark powder, HPP= hot pepper powder, GP= ginger powder, MWA= mahogany wood ash, PMD= pirimiphos-methyl dust, CNTL= control.
[c] PMD was applied at the rate of 0.1, 0.2, 0.3, 0.4 and 0.5g/20g cowpea seeds.

Table 3. Effect of rate of application of plant materials and pirimiphos-methyl on mean[a] percentage cowpea seed weight loss

Weight of plant materials (g) 100g cowpea seeds[c]					
Treatment[b]	1	2	3	4	5
CPP	11.4f	3.3e	16.9b	17.8d	6.2e
ALP	13.5e	11.9c	17.6b	28.1b	30.0c
OLP	27.7c	6.8d	10.9d	21.1c	31.7b
MBP	20.8d	12.6c	13.0c	11.7e	4.8e
HPP	30.5b	14.9b	16.8b	10.3e	4.6e
GP	8.6g	1.5e	3.5f	22.1c	15.3d
MWA	8.2g	3.1e	4.3f	3.2g	2.4f
PMD	7.6g	4.3e	7.6e	7.5f	4.9e
CNTL	40.3a	40.2a	38.9a	41.0a	37.4a
S.E. ±	0.01	0.00	0.00	0.01	0.00

[a] Means in column followed by the same letter (s) are not significantly different (P<0.05) using Student Newman- Keul's Test (SNK).
[b] CPP= citrus peel powder, ALP= Acacia leaf powder, OLP= *Occimum* spp. leaf powder, MBP= mahogany bark powder, HPP= hot pepper powder, GP= ginger powder, MWA= mahogany wood ash, PMD= pirimiphos-methyl dust, CNTL= control.
[c] PMD was applied at the rate of 0.1, 0.2, 0.3, 0.4 and 0.5g/100g cowpea seeds.

protecting the cowpea seeds for 12 weeks against *C. maculatus.* At 1g, 2g, 3g, 4g and 5g plant materials/100g cowpea seeds, MWA at 1g and 5g plant materials/100g cowpea seeds and GP at 2g, 3g, 4g and 5g plant materials/100g cowpea seeds caused significantly low seed loss than other plants.

Germinability of cowpea seed

The effect of rate of application of plant materials and PMD on mean percentage germinability of cowpea seeds after protection with plant materials against *C. maculatus* for 12 weeks is shown on Table 4. The highest percentage germinability was recorded with PMD and MBP treatment at 1g/100g cowpea seed; MBP at 2g/100g cowpea seed; CPP, MBP and GP at 3g/100g cowpea seed; MBP at 4g/100g cowpea seed and PMD and MBP at 5g/100g cowpea seed.

Acceptability of cooked cowpea seeds

Table 5 shows the effect of rate of application of plant materials and PMD on mean acceptability score of cooked cowpea seeds that have been protected with plant materials and PMD for 12 weeks. The result showed that at 1g and 2g plant materials/cowpea seeds, GP and MWA respectively were significantly effective plants. All plant materials did not leave any flavour strong enough to influence non-acceptance of the cooked seeds. At 3g plant material/100g cowpea seeds treatments containing plant materials and PMD had significantly lower mean acceptability score compared to the untreated control (3.70). Furthermore, at 4g/100g cowpea seeds, all treatments containing plant materials or PMD recorded lower mean acceptability score compared with the untreated control, although the latter was not significantly different from CPP, GP, MWA and PMD. The untreated control was within the acceptable score, while CPP and GP were within the marginally acceptable score. The lowest mean acceptability score was recorded with OLP, except that it was not significantly different from ALP, MBP and HPP. Moreover, at 5g plant materials cowpea seeds, all treatments containing plant materials or PMD had lower mean acceptability compared with the untreated control. The latter was within the acceptable score but was not significantly different from CPP, MWA and PMD, although these were within the marginally acceptable score. The lowest mean acceptability score (2.60) was recorded with OLP, although that was not significantly different from the rest of the treatments except MWA and the untreated control.

Table 4. Effect of rate of application of plant materials and pirimiphos-methyl on mean[a] percentage germinability of cowpea seeds

	Weight of plant materials (g)[c]				
Treatment[b]	1	2	3	4	5
CPP	77.5ab	99.2ab	100.0	91.2abc	92.7ab
ALP	77.5ab	82.6b	82.6	77.7bc	92.7ab
OLP	73.1b	82.6b	99.2	90.6abc	91.2ab
MBP	92.7a	100.0a	100.0	94.2a	94.2a
HPP	56.4c	64.4b	73.1	67.5c	72.6b
GP	82.6ab	99.2ab	100.0	92.7ab	92.7ab
MWA	73.1b	87.7b	92.7	90.6abc	91.2ab
PMD	92.7a	99.2ab	99.2	92.7ab	94.2a
CNTL	82.6ab	99.2ab	82.6	77.7bc	77.7b
S.E. ±	0.04	0.07	0.11	0.09	0.11

[a] Means in column followed by the same letter (s) are not significantly different (P<0.05) using Student Newman- Keul's Test (SNK).
[b] CPP= citrus peel powder, ALP= Acacia leaf powder, OLP= *Occimum* spp. leaf powder, MBP= mahogany bark powder, HPP= hot pepper powder, GP= ginger powder, MWA= mahogany wood ash, PMD= pirimiphos-methyl dust, CNTL= control.
[c] PMD was applied at the rate of 0.1, 0.2, 0.3, 0.4 and 0.5g/100g cowpea seeds.

Table 5. Effect of rate of application of plant materials and pirimiphos-methyl on mean[a] acceptability[b] of cowpea seed

	Weight of plant materials (g)/100g cowpea seeds[d]				
Treatment[c]	1	2	3	4	5
CPP	3.70	3.50	3.50ab	3.20ab	3.20abc
ALP	3.70	3.80	3.20ab	3.00bc	2.90bc
OLP	3.10	3.00	2.90b	2.60c	2.60c
MBP	3.50	3.40	3.40ab	3.00bc	3.00bc
HPP	3.20	3.40	3.00ab	3.00bc	2.90bc
GP	3.70	3.50	3.40ab	3.20ab	3.10bc
MWA	3.60	3.60	3.50ab	3.40ab	3.40ab
PMD	3.60	3.50	3.50ab	3.40ab	3.30abc
CNTL	3.80	3.70	3.70a	3.70a	3.80a
S.E. +	0.167	0.186	0.162	0.138	0.171

[a] Means in column followed by the same letter (s) are not significantly different (P<0.05) using Student Newman- Keul's Test (SNK).
[b] 1= highly unacceptable, 2 = unacceptable, 3 = marginally acceptable, 4 = acceptable
[c] CPP= citrus peel powder, ALP= Acacia leaf powder, OLP= *Occimum* spp. leaf powder, MBP= mahogany bark powder, HPP= hot pepper powder, GP= ginger powder, MWA= mahogany wood ash, PMD= pirimiphos-methyl dust, CNTL= control.
[d] PMD was applied at the rate of 0.1, 0.2, 0.3, 0.4 and 0.5g/100g cowpea seeds.

DISCUSSION

The severity of seed damage was significantly lower in the treatments containing plant materials or pirimiphos-methyl (PMD) than in the untreated control. Mahogany wood ash (MWA) was superior at all dosages (1-5g/100g cowpea seed, followed in succession by PMD > GP > HPP > MBP > OLP > ALP > CPP. The most effective rate of application was 5g/100g cowpea seeds, than by 2g/100g or 3g/100g cowpea seeds. This work corroborates that of Oparaeke and Daria (2005). Cowpea treated with MWA may have been protected from damage probably because the ash could have blocked or interfered with the cuticle of the insects resulting in increased mortality, reduced oviposition and infertility of the eggs. Mueke and Apuuli (1988) reported that ash mixed with cowpea seeds gave satisfactory control of *C. maculatus.*

There were significant differences among treatments and the untreated control in cowpea seed weight reduction. This showed the positive impact of the plant materials and PMD in protecting cowpea seeds against *C. maculatus* infestation. The present investigation showed that MWA was the most effective plant material by significantly reducing seed weight loss more than other plant materials. There were no significant differences among MWA, GP and PMD at lower dosages (1g and 2g/100g cowpea seed), but at higher dosages, MWA was significantly more effective than any other treatment, including PMD (Tables 3). The superiority of MWA over other plant products corroborates with the findings of Golob and Webley (1980); Golob *et al*. (1982); Cobbinah and Kwarteng (1989); which reported the effectiveness of ashes of several plants used as grain protectants against various stored products pests, including *C. maculatus*. The present work also corroborates that of Okonkwo and Ewete (1999) in*Dennettia tripetala* (pepper fruit), Ogunwolu and Idowu (1994) in root bark powders of *Zanthoxylum* spp. and neem seed. The effectiveness of CPP and HPP were comparable to that of PMD as observed by Ajayi *et al*. (1987); Oparaeke and Dike (1996); Onu and Sulyman (1997). Asawalam and Emosairue (2006) also reported that lower rate of application of *Piper guineense* and PMD were significantly less effective in reducing weight loss than higher rates and at higher rates *P. guineense* powder was statistically comparable with PMD.

There were no significant differences among the treatments and the untreated control in the germinability of cowpea seeds treated with plant materials and PMD at various rates of applications. The lowest percentage germinability was recorded with HPP treatment at 1g per 100g cowpea seeds and this was significantly different from other treatments. At higher dosages, although the percentage germinability recorded with HPP treatment was low, it was however not significantly different from other treatments except MBP and PMD. The result therefore showed that treating cowpea seeds with MBP and PMD did not affect germinability even at a high dose of 5g/100g cowpea seeds. Onu and Aliyu (1995) and Keita *et al*. (2001) reported that various pepper powders and powders from different basils provided complete protection against *C. maculatus*, but did not show significant effect on seed germination rate. The present result confirmed these studies.

There were no significant differences between treatments and the untreated control in the acceptability score of cooked seeds at low dosages. All treatments were within the acceptable score at all rates of application except OLP and HPP which were within the marginally acceptable score. CPP, ALP, MBP, GP and PMD were within the marginally acceptable score only at high rates. HPP and GP were peppery, MBP had bitter taste, while OLP had strong odour that were not detected in preserved seeds when washed and cooked. This work corroborates the findings by Ashiru (1990); Ogunwolu and Odunlami (1996), which reported that the insecticidal constituents in *Zanthoxylum* root bark powder and neem leaf, bark and seed powders are water soluble, and that was responsible for the reduced palatability when grains preserved with these materials are consumed.

Results showed that MWA was superior at all rates of application in reducing cowpea seed damage and seed weight loss. The effectiveness of the treatments in succession was MWA>PMD>GP>HPP>MBP>OLP>ALP>CPP. The effectiveness of the treatments illustrated the magnitude of insect multiplication and damage, which can occur in unprotected cowpea seeds. The most effective rate of application was 5g/100g cowpea seeds, followed by 2 - 3g/100g cowpea seeds. This showed that reduction of adult emergence, percentage cowpea weight loss and percentage of cowpea seeds with holes; and increase in adult mortality was dose dependent. No significant difference was observed between the treatments and the untreated control in the germinability of cowpea seeds, although the lowest germination was recorded in cowpea seeds containing 1g HPP. Similarly, the cooked seeds treated with plant materials did not leave any flavour strong enough to influence acceptability by consumers. This clearly showed that application of plant materials to cowpea seeds could reduce the infestation by stored cowpea pests without causing any adverse effect on seed quality including germinability and palatability.

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