Bioefficacy of Zingiber officinale against Prostephanus truncatus Horn (Coleoptera: Bostrichidae) infesting maize

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Bioefficacy of *Zingiber officinale* against *Prostephanus truncatus* Horn (Coleoptera: Bostrichidae) infesting maize.

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ABSTRACT

Maize is an important cereal crop grown in sub-Saharan Africa however, greater part of the grains produced is destroyed in storage by *Prostephanus truncatus* Horn (Coleoptera: Bostrichidae). In this study, the bio-activities of *Zingiber officinale* rhizome (Ginger), was investigated in the laboratory against *P. truncatus* at different proportions (25%, 20%, 15%, 10% and 5% wt/wt) with Actellic dust insecticide as a reference insecticide. The highest proportions (25% wt/wt) of *Z. officinale* powder significantly reduced the survival of *P. truncatus* to 0% after 12 days of treatment and the LD_{50} of the dust was obtained as 6.72%. The oil extract of *Z. officinale* at different concentrations (700 µL/mL, 350 µL/mL, 175 µL/mL, 87.5 µL/mL and 44 µL/mL) and Agricombi insecticide as the reference was equally evaluated for the following: contact toxicity on adult insect by dipping, grain residual treatment, repellency effect, effect on progeny and adult emergence in treated grains and damage assessment to grains. There was no survival (0%) recorded at 700 µL/mL both in contact and residual treatment of *P. truncatus*. The LD_{50} of the oil extract was obtained as 84.78 µL/mL. Grains treated with the different concentrations of *Z. officinale* oil significantly repelled insects with the highest concentration of 700 µL/mL yielding 100% repellency. The least mean adult emergence of 0.0 was recorded for both concentrations of 700 µL/mL and 350 µL/mL in treated grains. Grain damage by *P. truncatus* was significantly reduced when treated with Powder and oil extract of *Z. officinale* compared to the untreated grains.

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INTRODUCTION

Cereals crops are widely grown in the tropics and subtropics for animal and human food. Examples of cereals are maize (*Zea mays* L.), guinea corn (*Sorghum bicolour* (L.) Moench) and rice (*Oryzasativa*L.). Cereals are a major source of carbohydrate to man. Maize serves as the choicest cereal, for many homes in Africa (Eziah *et al.*, 2013). In Ghana, maize is the major staple food which is prepared and eaten in varying forms such as Banku, Kenkey, Akple and Tuozaafi commonly called TZ.However, a wide spectrum of pest attack and destroy maize both in the field and in the store causing severe economic damage (Caswell, 1981). Most importantly is the larger grain borer, *Prostephanus truncatus* Horn (Coleoptera: Bostrichidae) (Obeng-Ofori, 2008). This is a very serious pest of stored maize and dried cassava and are also called primary pest because they attack whole grains (Obeng-Ofori, 2008). They also bore into other foodstuff and materials such as wood and cause considerable damage (Hodges, 1986). Ithas become inevitable to find other alternative measures that are more ecologically friendly, cheap and easily accessible while its efficacy is not compromised, hence the use of botanicals.

Ginger root which is commonly called ginger is the rhizome of the plant *Zingiber officinale.* It lends its name to its genus, Zingiber and belongs to the family Zingiberaceae. According to Obeng-Ofori *et al*. (2007), ginger contains 1% -3% of volatile oil, which is chiefly made up of Sesquiterperne, Zingiberene, and Zingerone, which gives the pungent smell and present in the oleoresin (Obeng-Ofori*et al*., 2007). Crude ginger extractives have been reported to exhibit toxicity, antifeedant and insect growth disruption activity against *Callosobruchus maculatus*, *Spodoptera litura* (Fab.) and the cowpea aphid *Aphis craccivora* Koch (Echendu, 1991; Ofuya and Okuku, 1994). It is also active against plant pathogens, such as those causing powdery mildew of pea and cercospora leaf spot of mungbean (Singh *et al*., 1991). Ginger oil has been found to repel *Periplanetaamericana* (Linnaeus) and control the growth of *Fusarium moniliforme* Sheldon on mung seed while diarylheptenone which is a non-volatile constituent of ginger oleoresin have been found to be active against the rice fungus, *Pyricularia oryzae* Cavara (Ahmad *et al*., 1995). Actellic dust and Agricombi Insecticide(which is a combination of Fenitrothion (30%) and Fenvalerate (10%) are organophosphate insecticides which are normally used in Ghana for the control of stored product insects. This paper investigated the effects of *Z. officinale* dust and oil extracts against *P. truncatus* using Actellic dust and Agricombi insecticides as standard checks in the laboratory.

MATERIALS AND METHODS

Insect culture

The initial stock of *P. truncatus* was obtained from maize purchased at the Madina market, Accra, Ghana. Untreated maize grains were sterilized in the oven at 60^{o}C for 3 hours and allowed to cool for an hour. The adult *P. truncatus* were then introduced into the uninfested (sterilized) maize and allowed to oviposite, after which the adults were sieved out. The emerged adults were transferred into another jar of sterilized grains. This was to make sure that the F1 adults used as the culturing stock for the experiment were of uniform size and age. The cultures were kept under a temperature of 32 ± 2^{0}C, 70% relative humidity and 12L: 12D photo regime.

Preparation of plant powder and oil extract

The ginger roots were cut in smaller pieces and air dried under shade. The dried ginger was then pulverized with an electric blender to obtain fine powders. The extraction of oils from the pulverized plant samples were carried out in the MPhil laboratory of the Chemistry Department, University of Ghana, Legon, Accra. Plant powder of 150 g was soaked in a 1L of 100% petroleum ether and allowed to stand for a week. This was then filtered off and concentrated using the rotary evaporator. Serial dilutions of the plant oil were prepared in acetone to obtain 70%, 35%, 17.5%, 8.75%, and 4.4% thus, yielding 700 µL/mL, 350 µL/mL, 175 µL/mL, 87.5 µL/mL and 44.0 µL/mL of oil per 1 mL aliquot, respectively.

Toxicity effect of *Z. officinale* powder

Whole maize (2 kg) was weighed separately and sterilized in an oven at 60^{0}C for 3 hours. Maize grain (100 g each) was put into separate plastic jars and *Z. officinale* powders admixed in the following proportions 5%, 10%, 15%, 20%, and 25% (Wt (g) of dust/100 g of grains). Actellic dust was used as the reference at the recommended rate of 1000 kg of grains to 500 g of the dust while the control had no plant powders admixed to it. After one hour, 20 adult insects were introduced into the treatments. Each treatment was replicated three times. The setup was kept under laboratory conditions as mentioned above. Mortality was recorded daily for 12 days starting from 24 hours after treatment. This was done by sieving out the insect from the set ups using a multiple sieve. An insect was considered dead if it does not respond to probing using a blunt probe.

Toxicity effect of oil extract of *Z. officinale*

Adult *P. truncatus* (20 each) of same age were placed in petri dishes lined with filter paper.The insects were then dipped in turns into the different concentrations of the extracts prepared (700 µL/mL, 350 µL/mL, 175 µL/mL, 87.5 µL/mL and 44.0 µL/mL) for one seconds each and transferred back into the petri dish. Agricombi insecticide (which is a combination of Fenitrothion (30%) and Fenvalerate (10%)) was used as the reference at the recommended concentration of 20 mL/L of water while acetone alone was used as the control. Each treatment was replicated three times and the setup was kept under laboratory conditions as mentioned above. Mortalities were recorded after 24 hours for four days.

Residual effect of oil extracts of *Z. officinale*

Sterilized maize grains (100 g) were put into plastic jars and treated with 2 mL of the different concentrations of the oil extracts (700 µL/mL, 350 µL/mL, 175 µL/mL, 87.5 µL/mL and 44.0 µL/mL). Agricombi insecticide was also used as the reference while acetone was used as the control. The grains were air dried for 3 hours and a cohort of 20 *P. truncatus* introduced into the treated maize. Each treatment was replicated three times and the set up kept under laboratory conditions as mentioned above. Mortality was recorded daily after 24 hours for 4 days. Insect were considered dead if they did not respond to probing using a blunt probe.

Repellent effect of the plant extract

Filter paper disc was cut into small hexagonal shapes which were large enough to contain 4 maize grains. Four of these small cut filter papers were placed equidistance from each other on a petri dish. Each of the filter papers on the petri dish was glued (using superglue) to the petri dish. Four whole uninfested grains were placed and equally glued on each of the filter papers. This was to avoid the displacement of the grains from the filter paper by the insect in their cause of feeding. The culture was allowed for 30 min to air dry properly in order to effectively glue the grains to the filter paper. With the use of a syringe, two of the filter papers with the grains glued on them were carefully treated with each concentration of the oil extracts while the other two filter papers were treated with acetone as the control. Agricombi insecticide was also used as the reference insecticide. The treatments were air-dried for 48 hours to avoid the direct contact of the insect with the treatments. Adult insects 20 each was then introduced at the centre of each Petri dish after immobilizing them in the refrigerator at 4^{o}C for 5 min and covered. Each of the treatments was replicated three times. The treatments were kept in the dark at a temperature of 32 ± 2^{0}C and 70% relative humidity. Adult insects on treated and untreated portions of the filter papers were counted after 24 hours for 4 days. The percentage repellency (PR) was determined using the formula adopted by Obeng-Ofori *et al*., (1997).

Oil extracts on progeny development and adult emergence

The effect of extracts on progeny development and adult emergence was determined by modifying the method used by Eziah*et al.* (2013). Grains of 100 g each were weighed and put into separate plastic jars. Which was then infested with 50 unsexed adults of *P. truncates.*The set up was allowed to stand in the laboratory for 2 weeks to allow for oviposition. After two weeks the adults were sieved out (this was to give ample time for oviposition) and the setup was treated with the different concentrations of the plant extracts (700 µL/mL, 350 µL/mL, 175 µL/mL, 87.5 µL/mL and 44.0 µL/mL). The setup was then monitored for 25 days for larval and pupal development (Obeng-Ofori, 2008) at temperature of 32 ± 2^{0}C and 70% relative humidity. Agricombi insecticide was used as the reference while acetone was used as the control. Each treatment was replicated three times. The number of adults that emerged after the 25 day period were counted and recorded.

Damage assessment

Damage caused by the insect in the powder and residual treatments were determined using the count and weigh method. This was done by separately counting the number of damaged and undamaged grains in the setup of treated maize seeds. Damage was assessed using the method of FAO (1985).

Data collection and Analysis

The data collected were analysed using GenStat Package 9.2 (9th edition). Analysis of variance was run at 95% confidence level. All count and percentage data were transformed using square root ($y = \sqrt{x}$) and arcsine ($y = \text{Sin}^{-1}\sqrt{x/100}$) transformations, respectively. Probit analysis was equally done to determine the LD_{50}. Percentage survival was calculated and control mortality was also corrected using Abbott's formula (Abbott, 1925).

RESULTS AND DISCUSSIONS

Toxicity of *Z. officinale* powder against *P. truncatus*

The rhizome powder of *Z. officinale* resulted in no survival of *P. truncatus* at 25% and 20% of the dust, after 12 days of exposure. The lowest concentration of 5% of *Z. officinale* rhizome powder gave a survival of 52% to *P. truncatus* (Figure 1). The result showed that increase in the concentration of the dust led to a decrease in the survival of the insect. The probit analysis showed that the lethal dose 50 (LD_{50}) of the powder was **6.72 g**.

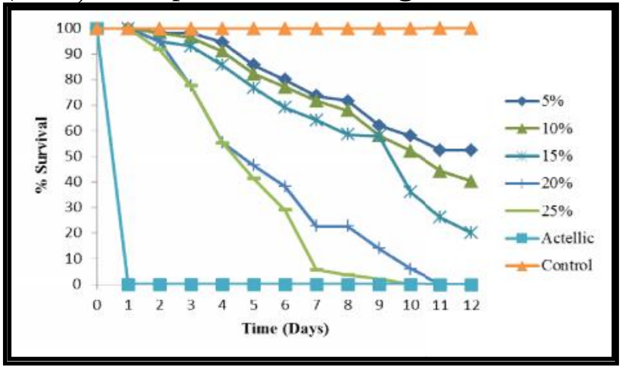

Fig 1. Percentage survival of adult *P. truncatus* treated with different concentrations of *Z. officinale* rhizome powder.

Actellic dust treatment resulted in no survival to *P. truncatus* after 24 hrs while the control resulted in 100% survival. There was a significant ($P < 0.001$) difference in the survival of both insects treated with the different concentrations of *Z. officinale* rhizome powder. The highest concentration (25%) significantly ($P < 0.001$) reduced the survival of the insect compared to the least concentration (5%) and control.

Contact toxicity of oil extract of *Z. officinale* on adult *P. truncatus*

Generally, percentage survival of the insects reduced as the concentration of *Z. officinale* rhizome oil treatment increased. *Zingiber officinale* rhizome oil at 700 µL/mL and 350 µL/mL had no survival (0%) recorded after 4 days to *P. truncatus*. The lowest concentration of 44 µL/mL of *Z. officinale* rhizome oil resulted to 76.7% survival of *P. truncatus* (Figures 2). Agricombi insecticide recorded no survival (0%) to *P. truncatus* while 100% survival was recorded in the control after 4 days. *Zingiber officinale* rhizome oil at 700 µL/mL and 350 µL/mL induced a more rapid kill resulting in no survival (0%) after 24 hours and 48 hours respectively, compared to Agricombi insecticide in which no survival (0%) resulted only after 96 hours. *Zingiber officinale* rhizome oil showed a significant ($P < 0.001$) lower survival of the insects compared to the control.

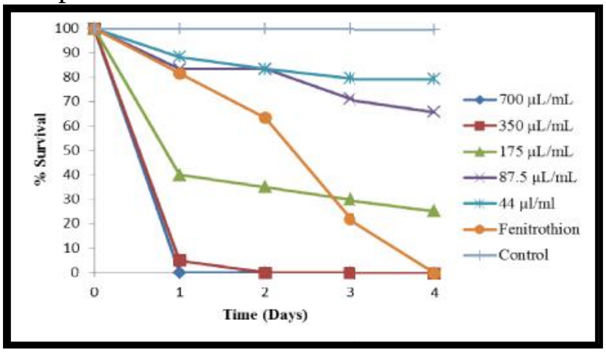

Fig 2. Percentage survival of adult *P. truncatus* treated with different concentrations of *Z. officinale* rhizome oil

Residual effect of *Z. officinale*oil extract on treated grain to adult *P. truncatus*

The highest concentration of 700 µL/mL of *Z. officinale* rhizome oil resulted in no survival (0%) of *P. truncatus* after the fourth day while the lowest concentration of 44 µL/mLresulted in a survival of 95% to *P. truncatus* after the 12th day (Figures 3).Agricombi insecticide treatment resulted in 0% survival in *P. truncatus* while 100% survival was recorded in the control after 12 days. There was a significantly (P<0.001) lower survival of insects in grains treated with *Z. officinale* rhizome oil compared to the control.

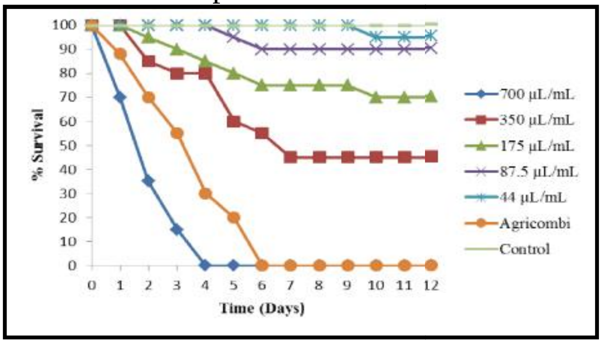

Fig 3. Percentage survival of adult *P. truncatus* in maize grains treated with different concentrations of *Z. officinale* rhizome oil.

Repellent effect on adult *P. truncatus*

At the highest concentration of 700 µL/mL, *Z. officinale* rhizome oil gave a mean repellency of 100% to *P. truncatus* after 4 days. The lowest concentration of 44 µL/mL of *Z. officinale* rhizome oil induced a repellency of 6.14% to *P. truncatus*. Agricombi insecticide recorded repellency of 92.6% to *P. truncatus*. There was a significant difference (P<0.001) in the repellency of the insects to the different concentrations of *Z. officinale* rhizome oil with the highest concentration significantly different from the least concentration used (Table 1).

Table 1. Mean percentage repellency of *Z. officinale* rhizome oil against *P. Truncatus*

Conc. (µL/mL)	**% Repellency Time (Days)**				**Mean % repellency± SE**
	1	**2**	**3**	**4**	
700	100.00	100.00	100.00	100.00	100±0.00
350	100.00	76.47	64.00	61.47	75.48±8.80
175	47.00	39.26	38.25	49.07	43.38±2.72
87.5	20.68	17.95	11.00	4.92	13.64±3.55
44	9.11	8.49	5.26	1.68	6.14±1.71
Agricombi	100	100	89.47	80.95	92.60±4.61

LSD (P<0.001) = 13.38

Progeny and adult emergence

There was no emergence of adult *P. truncatus* from grains treated with 700 µL/mL and 350 µL/mL of *Z. officinale* rhizome oil while the least concentration of 44 µL/mL recorded mean adult emergence of 10.7. Agricombi insecticide recorded no emergence while the control recorded the highest mean emergence of 22.3 adults. The numbers of adult emergence for grains treated with the different concentrations of the plant extract were significantly (P< 0.001) lower compared to the control (Table 2).

Table 2. Mean adult emergence of *P. truncatus* in grains treated with *Z. officinale* rhizome oil.

Conc. (µL/mL)	**No of adult emergence** R_1	R_2	**R3**	**Mean Adult emergence± SE**
700	0.00	0.00	0.00	0.00±0.00
350	0.00	0.00	0.00	0.00±0.00
175	3.00	4.00	2.00	3.00±0.58
87.5	6.00	5.00	8.00	6.33±0.88
44	9.00	10.00	13.00	10.67±1.20
0.0 (control)	25.00	23.00	19.00	22.33±1.76
Agricombi	0.00	0.00	0.00	0.00±0.00

LSD (P< 0.001) = 2.73

Damage assessment of grains treated with *Z. officinale* powder and oil extract

Grains treated with the different concentrations of *Z. officinale* powders and oil extracts significantly (P<0.001) reduced damage caused by *P. truncatus* compared to the untreated grains. Grains treated with the highest concentration of *Z. officinale* powder (25%) and oil extract (700 µL/mL) recorded the lowest percentage weight loss of 1.2% and 0%, respectively while the least concentration of both powder (5%) and oil extracts (44 µL/mL) recorded higher percentage weight loss of 2.9% and 1.3%, respectively compared to the highest concentrations of both powder and oil extract. Actellic dust and Agricombi insecticide recorded no percentage weight loss while the highest percentage weight loss of 3.9% and 2.5% were recorded in the control for powder and oil extracts set up, respectively.

Table 3. Mean Percentage weight loss of Maize treated with *Z. officinale* powder and oil extract after 12 days and 4 days of exposure respectively to *P. truncates.*

Concentrations		**Mean % Weight loss ± SE**	
Oil extract (µL/mL)	**Powder(%wt/wt)**	**Oil extract**	**Powder treatment**
700	**25**	0.0 ± 0.0	1.2 ± 0.1
350	**20**	0.6 ± 1.0	1.4 ± 0.1
175	**15**	0.8 ± 0.3	1.9 ± 0.0
87.5/	**10**	1.2 ± 1.0	2.5 ± 0.2
44	**5**	1.3 ± 1.0	2.9 ± 0.3
0.0 (control)	**0.0 (control)**	2.5 ± 0.2	3.9 ± 0.1
AgricombiActellic dust		0.00± 0.00	0.00±0.00
LSD (P<0.001)0.01	**0.01**		

The powder of *Z. officinale* rhizome exhibited various levels of toxicity against adult *P. truncatus*. In a work done by Belmain *et al*. (2001), where *Securidaca longepedunculata* root powder was assayed against *P. truncatus*, it was reported that the roots were effective against the insect, which suggest the presence of some toxic substances found in some plant parts which might equally be present in the rhizome of *Z. officinale*. Also the abrasive nature of *Z. officinale* rhizome powder used might have equally contributed to the lower percentage survival recorded against *P. truncatus* as inert dust and sand works on same principle. This is consistent with a similar study by Issa *et al.* (2011) where *C. papaya* seed powder was used against *S. zeamais* and 10% mortality was recorded within 96 hrs of treatment. As expected Actellic dust gave no survival after 24 hours. This was not so compared to the botanicals used because Actellic dust is a synthetic organophosphate insecticide. The LD_{50} of the dust showed that only as low as 6.72 g of the dust is needed to kill 50% of adult *P. truncatus* in a 100 g of maize grain in the store.

The result of *Z. officinale* rhizome oil extracts also showed that increase in concentration led to a significant decrease in survival of *P. truncatus* and this is consistent with studies by Maedeh *et al.* (2012), Eziah *et al.* (2013) and Demissie *et al.* (2008). Also the low survival level observed with increase in the concentration of the oil extract is suggestive of the fact that higher concentrations contain higher level of the active substance. In a study by Maedeh *et al.* (2012) where fumigant activity of *Z. officicale* oil was assayed against *Tribolium castaneum* adult, it was shown that at concentration of 1500 µL/L of air, 96.67% mortality was recorded after 48 hours. Also, it was suggested that sesquiterpenes hydrocarbon which is one of the constituents of *Z. officinale* oil might be responsible for the death of the insect since it has a pungent odour while Agarwal *et al.* (2001), indicated that *Z. officinale* oil was effective against the larvae of *Spilosoma obliqua* where it was established that curcumene was a major volatile heat labile constituent of the oil. This may account for the reduced survival observed when the powder and oil was used against adult *P. truncatus*. In the present study, 100% mortality (0% survival) of *P. truncatus* was obtained at 700 and 350 µL/mL after 48 hours. The slight difference in the level of percentage mortality might be due to the different methods of application of the oil extracts and the different concentrations used. The low LD_{50} of 84.78 µL/mL showed that only little quantity of the oil extract is required to kill 50% of *P. truncatus* in the store.

The different concentrations of oil extracts of *Z. officinale* rhizome when treated with the grains led to decrease in the survival of adult *P. truncatus*. This may be attributed to the toxicant, antifeedant and repellent effect of the extracts as this is consistent with the work done by Eziah *et al*. (2013) where methanol extract of *Zanthoxylu mxanthoxyloides* on maize grain significantly reduced the survival of adult *P. truncatus*. Also the low percentage survival recorded when *Z. officinale* rhizome oil were admixed with the grains shows that the active substance in the extract is high and can stick to the grains at a more lethal dose since after treatment the grains were air dried for 3 hours and only 2 mL of each concentration was used for the treatment. This suggest that a lower survival may have been recorded if introduction of adult insects were done immediately after treatment (that is without air drying) and if more than 2 mL of each concentration was used for the treatment of the grains. This is also consistent with the work done by Eziah *et al.* (2013) where methanol extract of roots of *Z. xanthoxyloides* and *S. longependuncata* were used against *P. truncatus* and *T. castaneum* in treated grains.

The oil extracts was equally shown to be repellent to *P. truncatus*at the different concentrations used. The highest concentration of 700 µL/mL of *Z. officinale* rhizome gave 100% repellency to *P. truncatus.* This is an indication of the presence of chemical substances contained in the plants that made the insect move away from the source of the stimulus.(R)-linalool and (S)-2-heptanol monoterpenoids found in *Z. officinale* oil extracts and other monoterpenoids and Citral have been found to be good repellents to *T. castneum* and *R. dominica* (Ukeh and Umoetok, 2011) and these may account for the repellency observed in the present study.Other works such as those of Zhang *et al*. (2004), Tripathi *et al*. (2000) and, Jemaa and Khouja (2011) also corroborate the fact that some plants secrete volatile substances that make insect to move away from them.

It was observed that the different concentrations of *Z. officinale* rhizome oil extracts reduced significantly, adult *P. truncatus* emergence. Generally, the higher the concentrations of the oil used the lower the number of insects that emerged. The least adult emergence was observed at the highest concentration of 700 µl/ml of the oil extract. This is a further confirmation of the fact that the higher the concentration, the higher the presence of the toxic substance which is capable of inhibiting oviposition and progeny development in the stored grains (Eziah *et al*., 2013). This is also consistent with the work done by Ukeh *et al*. (2012) where it was observed that different plant extracts contain substances at higher concentrations that is able to reduce the emergence of adult *S. zeamais* significantly. The reduced adult emergence of *P. truncatus* in the treatment compared to the control, suggest that the active ingredient of the extract have the ability to penetrate the grains in other to inhibit the development of the immature stages inside the grains. This is also consistent with the work done by Obeng-Ofori *et al*. (1997) where it was found that the development of eggs and immature stages inside grain kernels were inhibited by 1,8 cineole from *Ocimumkenyense* essential oil.

Grain damaged caused by *P. truncatus* was significantly reduced by both the powder and oil extract. The result showed that at higher treatment of the powder and the oil extracts, damage caused by these insects was significantly reduced. This may be due to the low survival and high repellency observed in the treatment. This is consistent with the work done by Ukeh*et al*. (2012) where *Aframomum melegueta* (Alligator pepper) *and Z. officinale* (ginger) significantly reduced the damage caused by *S. zeamais* in traditional African granaries. Also, Eziah *et al*. (2013) reported that methanol extracts of *Z. xanthoxyloides* and *S. longepedunculata* roots significantly reduced the damage caused by *P. truncatus* and *T. casteneum* on maize grains.Both plant powder and oil extracts also acted as feeding deterrents as this is evident in the reduced damage caused by adult *P. truncatus* in the treated maize grains. This is also consistent with the work done by Demissie*et al*. (2008) and Tapondjou *et al*. (2002), where Noug oil, soybean oil and *Chenopodium ambrosiodes* powder and oil extract significantly reduced the damage caused by *S. zeamais* and *P. truncatus* in stored maize grains. It is therefore recommended that both powder and oil extract of *Z. officinale* rhizome at 25% (%wt/wt) and 700 µL/mL respectively can offer similar protection against *P. truncatus* just like the standard (Actellic dust and Agricombi Insecticide respectively) commonly used in Ghana.

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REFERENCES

Abbott, W. S. 1925. A method for comparing the effectiveness of an insecticide.*Journal of Economic Entomology,* **18**:265-283.

Agarwal, M., Walia, S., Dhingra, S. and Khambay, B. 2001.Insect growth inhibition, antifeedant and antifungal activity of compounds isolated/ derived from *Zingiber officinale* Roscoe (ginger) rhizomes. *Pest Management Science,* **57**:289-300

Ahmad, F.B., Mackeen, M.M., Ali, A.M., Mashirun, S.R. and Yaacob, M.M. 1995. Repellency of essential oils against the domiciliary Cockroach, *Periplaneta americana . Insect Science and its Application*, **16**:391-393.

Belmain, S.R., Neal, G.E., Ray, D.E., and Golob, P. 2001. Insecticidal and Vertebrate toxicity associated with ethnobotanicals used as post-harvest protectants in Ghana. *Food and Chemical Toxicology,* **39***:*287-291.

Caswell, G. H. 1981. Damage to stored cowpea in the Northern part of Nigeria.*Samaru Journal of Agricultural Research,* **1**:11-9.

Demissie, G., Teshome, A., Abakemal, D. and Tadesse, A. 2008. Cooking oils and Triplex in the control of *Sitophilus zeamais* in farm-stored maize. *Journal of Stored Products Research*,**44***:*173-178.

Echendu, T. 1991. Ginger, cashew and neem as surface protectants of cowpeas against infestation and damage by *Callosobruchus maculatus*. *Tropical Science,* **31**: 209-211.

Eziah, V.Y., Buxton, T. and Owusu, O.E. 2013. Bioefficacy of *Zanthoxylum xanthoxyloides* and *Securidaca longependuncata* against *Prostephanus truncatus* (Horn) and *Tribolium castaneum* (Herbst). *Journal of Biopesticides,* **6**(1), 54-62.

FAO 1985.Prevention of Post-harvest food losses.Training series No. 10(122).Food and Agriculture Organization of the united Nation, Rome, p 120.

Hodges, R.J. 1986. The biology and control of *Prostephanus truncatus* (Horn) (Coleoptera:Bostrichidae) - A destructive storage pest with an increasing range. *Journal of Stored Products Research,* **22**(1):1-14.

Issa, U.S., Afun, J.V., Mochiah, M.B., Owusu-Akyaw, M. and Braimah, H. 2011. Effect of some local botanical materials for the suppression of weevil populations.

International Journal of Plant, Animal and Environmental Sciences, **3**(1):270-275.

Jemaa, M.J. and Khouja, M.L. 2011. Composition and repellent efficacy of essential oil from *Laurus nobilis* against adults of *Lasioderma serricorne*. *Tunisian Journal of Plant Protection*, **6**:29-41.

Maedeh, M., Hamzeh, I., Hossein, D., Majid, A. and Reza, K. R. 2012.Bioactivity of Essential oil from *Zingiber officinale* (Zingiberaceae) against three stored-product insect species. *Journal of Essential Oil Bearing plants*,**15**(1): 122-133.

Obeng-Ofori, D. 2008. Major Stored Product Arthropod Pests. **In:** *Post Harvest Science and Technolgy*. Accra: Smartline Limited. **PP.** 89-146.

Obeng-Ofori, D., Afreh-Nuamah, K., Owusu, E.O., Owusu-Appiah, S., and Tawson, G.K. 2007. *Major pests of food and selected fruit and industrial crops in West Africa.* Accra-North: The City Publishers Ltd. **PP.** 127-133.

Obeng-Ofori, D., Reichmuth, C.H., Bekele, J. and Hassanali, A. 1997. Biological activity of 1,8 cineole, a major component of essential oil of *Ocimumkenyense* (Ayobangira) against stored product pestd. *Journal of Applied Entomology*, **121***:* 237-243.

Ofuya, T.I. and Okuku, I.R. 1994. Insecticidal effect of some plant extract on the cowpea aphid, *Aphis craccivora* Koch (Homoptera: Aphididae). *Anzeiger-fuer-schaedlingakunde-pfanzenschutz-um-welschutz (Germany)*,**67**:127-129.

Singh, S.R., Srivastava, B.P., Singh, K.P. and Mishra, G.D. 1991. Control of powdery mildew of pea by ginger extract. *Indian Phytopathology*, **44**:55-59 .

Tapondjou, L.A., Adler, C., Bouda, H. and Fontem, D.A. 2002. Efficacy of powder and essential oil from *Chenopodium ambrosioides* leaves as post-harvest grain protectants against six stored product beetles. *Joural of Stored Products Research*, **38**:395-402.

Tripathi, A.K., Veena Prajapati, K. K., Aggarwal, S.P. and Kumar, S. 2000. repellency and toxicity of oil from *Artemisia annua* to Certain Stored-Product Beetles. *Journal of Economic Entomology*,**93**(1):43-47.

Ukeh, D.A. and Umoetok, B.A. 2011. Repellent effects of five monoterpenoid odours against *Tribolium casteneum* and *Rhyzopertha dominica* in Calabar, Nigeria. *Crop protection*, **30**:1351-1355.

Ukeh, D.A., Umoetok, B.A., Bowman, A.S., Mordue(Luntz), J.A., Pickett, J.A. and Birkett, M.A. 2012. Alligator pepper, *Aframomum melegueta* and ginger, *Zingiber officinale*, reduce stored maize infestation by the maize weevil, *Sitophilus zeamais* in traditional African granaries. *Crop protection*, **32**:99-103.

Zhang, W., McAuslane, H.J.and Schuster, D.J. 2004. Repellency of Ginger Oil to *Bemisiaargentifolii* (Homoptera: Aleyrodidae) on Tomato. *Journal of Economic Entomology*,**97**(4):1310-1318.

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