that emerged from each vial was counted and percentage inhibition rates computed using the formula described by Tapondjou et al. [9].

Repellent assay

The repellent activities of *O. basilicum* extracts were carried out following method described by Obeng-Ofori et al. [10]. The test areas were 9 cm diameter filter-paper circles cut into half. 1 ml of each of the extract was uniformly applied to one half paper-discs while the other half disc was treated with solvent only (control). The half-paper discs were then air dried and full discs re-made by attaching the half-paper discs with adhesive paper tape. The full discs were then placed into petri dish followed by release of twenty adult *S. zeamais* at the centre of the filter discs and covered. Four replicates were made for each treatment. The number of insects present on the control half (Nc) and treated half (Nt) were recorded hourly for five hours. Percentage Repellency (PR) was then calculated using the formula described by Thien et al. [11].

Qualitative phytochemical screening

Freshly prepared organic extracts of *O. basilicum* were subjected to qualitative phytochemical screening to check for presence or absence of a number of secondary metabolites that have been have associated with fumigant toxicity and repellent activities of various plants. Particularly, terpenoids, flavonoids, phenolics, alkaloids, saponins, steroids and tannins were screened following the protocol described by Harborne [12] and Kotake [13].

Data analysis

Data obtained from this work were subjected to descriptive statistics to obtain means ± SEM. One way analysis of variance (ANOVA) was then carried out followed by Tukey's post hoc test to compare and separate the means.

Results

Fumigant toxicity of methanolic extract of *O. basilicum* against *S. zeamais*

Low mortality rates of *S. zeamais* were recorded after exposure to methanolic extracts of *O. basilicum* in the sixth hour at all extract concentration used. Nonetheless, mortality rates increased in the subsequent time periods. Highest mortality rate of 74.36% was recorded by 100% extract concentration, followed by 65.38% mortality caused by 75% extract concentration within 96 hours (Table 1). The low extract concentrations of 25 and 50% had low fumigant toxicity effects of 30.77 and 33.38% within similar time period of 96 hours. Moreover, the fumigant toxicity effects of actellic (reference pesticide) was significantly higher compared to all extract treatments throughout the experimental period ($p<0.05$; Table 1).

Fumigant activity of hexane extracts of *Ocimum basilicum* against *Sitophilus zeamais*

The hexane extract of *O. basilicum* showed varied fumigant toxicity effects against *S. zeamais* at all levels of extract concentration. In the 6th h, the acute fumigant toxicities effects of the four different extract concentrations were between 0-18.75% which was comparable to the control (Table 2). However, this was significantly lower than that of actellic treatment. In the 24th h, the actellic treatment still caused a higher acute fumigant toxicities compared to the different extract concentrations. The lowest mortality rate of 42.31% of *S. zeamais* was evoked by 25% extract concentration within the 96 hour period of exposure. The 75% and 100% extract concentrations recorded 66.67% and 78.21% mortality respectively. The fumigant toxicities effects of the extracts were significantly lower than actellic (reference pesticide) at 48, 72 and 96 hours of treatment period ($p<0.05$; Table 2).

Fumigant toxicity of hexane: methanol blend extract of *Ocimum basilicum* against *Sitophilus zeamais*

When fumigant toxicity effects of hexane: methanolic extract of *O. basilicum* was examined against *S. zeamais*, extract concentration of 25-75% evoked 0-11.25% mortality rates within 6 hours of exposure period, which were not significantly different from effects of the control ($P>0.05$; Table 3). The 100% extract concentration recorded the highest percentage mortality at the 72nd h and this was comparable to actellic (reference pesticide) ($p>0.05$; Table 3). The effects of the lowest extract concentration (25%) caused the least mortality (32%) within 96 h of the study. When the extract concentration was increased to 50%, more than double mortality was recorded. The fumigant toxicity effects of the

Concentration	Mean % corrected mortality ± S.E with exposure period (hours)				
	6 h	24 h	48 h	72 h	96 h
Control	0.00 ± 0.00^{c}	0.00 ± 0.00^{c}	0.00 ± 0.00^{e}	0.00 ± 0.00^{d}	0.00 ± 0.00^{d}
25% extract	3.75 ± 2.39^{c}	20.51 ± 3.31^{b}	23.08 ± 3.63^{cd}	26.92 ± 4.38^{c}	30.77 ± 3.31^{c}
50% extract	5 ± 2.04^{b}	8.97 ± 2.45^{c}	20.51 ± 2.56^{d}	30.77 ± 4.44^{c}	33.33 ± 2.69^{c}
75% extract	8.75 ± 2.39^{c}	21.79 ± 3.23^{b}	34.62 ± 3.85^{c}	65.38 ± 4.38^{b}	65.38 ± 4.38^{b}
100% extract	12.5 ± 3.23^{b}	26.92 ± 1.28^{b}	48.72 ± 2.96^{b}	67.95 ± 4.38^{b}	74.36 ± 2.09^{b}
Actellic	91.25 ± 5.15^{a}	100 ± 0.00^{a}	100 ± 0.00^{a}	100 ± 0.00^{a}	100 ± 0.00^{a}

Values followed by the same superscript within the same column are not significantly different by one-way ANOVA (P ≤ 0.05) followed by Tukey's test.

Table 1: Fumigant toxicity effect of methanolic extract of *Ocimum basilicum* on adult *Sitophilus zeamais*.

Concentration (% extract)	Mean % corrected mortality ± S.E with exposure period (hours)				
	6 h	24 h	48 h	72 h	96 h
Control	0.00 ± 0.00^{c}	0.00 ± 0.00^{e}	0.00 ± 0.00^{e}	0.00 ± 0.00^{e}	0.00 ± 0.00^{e}
25	0.00 ± 0.00^{c}	10.90 ± 4.84^{de}	28.21 ± 2.09^{d}	35.90 ± 4.44^{d}	42.31 ± 3.23^{d}
50	1.25 ± 0.25^{c}	25.64 ± 1.48^{cd}	44.87 ± 2.45^{c}	56.41 ± 1.48^{c}	62.82 ± 2.45^{c}
75	2.50 ± 1.44^{c}	26.92 ± 6.74^{c}	52.56 ± 1.28^{c}	61.54 ± 1.48^{bc}	66.67 ± 3.31^{c}
100	18.75 ± 4.27^{b}	48.72 ± 2.09^{b}	62.82 ± 2.45^{b}	70.51 ± 2.45^{b}	78.21 ± 1.28^{b}
Actellic	91.25 ± 5.15^{a}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}

Values followed by the same superscript within the same column are not significantly different one-way ANOVA (P ≤ 0.05) followed by Tukey's test.

Table 2: Fumigant toxicity effect of hexane extract of *Ocimum basilicum* on adult *Sitophilus zeamais*.

extract at 75% and 100% concentration were not significantly different from actellic (reference pesticide) 96 hours exposure period (p>0.05; Table 3). In general, the extract activity was dose dependent. Again, the hexane; methanolic blend extract of *O. basiicum* showed greater fumigant toxicity than individual solvent extracts. The difference in toxicities was even more marked with higher concentrations of the extracts (Figures 1 and 2).

Repellence activity of methanolic extracts of *Ocimum basilicum* against *Sitophilus zeamais*

The methanolic extract of *O. basilicum* at all tested concentrations recorded repellence activities of 72.5% and above by the end of the fifth hour against *S. zeamais*. All the treatment tested showed activity above 57% during the first hour. The 25% extract concentration recorded upto 72.5% activity by the end of the fifth hour of exposure. A slightly higher repellence effect of 82.5% was realized when treatment concentration was increased to 50% extract. Both 75% and 100% extract concentration achieved greater repellence activities of 80% and 87.5% respectively. The mean Percentage Repellence (PR) for all extracts was above 68%. Among all the extract concentrations tested, the repellence activities were not significant difference in the first, third, fourth and fifth hours of exposure (p>0.05; Table 4). The repellent activities of actellic control was significantly higher than that of extracts in the first hour. However, in the following hours the repellent activities of actellic was comparable to that of the higher concentration of extracts (Table 4).

Repellent activity of hexane extracts of *Ocimum basilicum* against *Sitophilus zeamais*

The hexane extract of *O. basilicum* demonstrated repellence activity on *S. zeamias* at different concentrations (Table 5). In the first hour of experimental period, all the extract concentrations tested caused repellent activities greater than 67%. The high repellent effect of 90% was caused by 100% concentration during the fifth hour which was not significant different from that caused by control pesticide. The 25% and 75% extract concentrations caused repellence activities of between 67- 80% during the entire experimental period, while 50% concentration caused repellence activities of between 65% and 77.5%. The repellence activities of all extract concentrations tested were not significantly different in the fourth hour of exposure (p>0.05; Table 5). Mean percentage repellence effects for the 5 hours experimental period were between 73 to 90.50%. The repellent activities of actellic were compared to that of the extract at higher doses (Table 5).

Repellent activity of hexane: methanolic blend extracts of *Ocimum basilicum* on *Sitophilus zeamais*

The blend extract concentrations of *O. basilicum* strongly repelled *S. zeamais* as indicated by results in Table 6. At the lowest extract concentration (25%), a repellence activity of 80% was achieved within the first hour, and then it decreased to 60% in the third hour but slightly increased to 75% and 72.5% by fourth and fifth hour respectively. When extract concentration was increased to 50%, the repellence effect increased to 95% in the end of fifth hour. Similarly, 75% extract

Concentration (% extract)	Mean % corrected mortality ± S.E with exposure period (hours)				
	6 h	24 h	48 h	72 h	96 h
Control	0.00 ± 0.00^c	0.00 ± 0.00^d	0.00 ± 0.00^e	0.00 ± 0.00^d	0.00 ± 0.00^d
25	0.00 ± 0.00^c	8.97 ± 3.23^{cd}	20.51 ± 2.56^d	28.21 ± 3.63^c	32.05 ± 4.85^c
50	2.50 ± 1.44^c	24.36 ± 4.38^c	47.44 ± 5.29^c	58.97 ± 6.62^b	73.08 ± 5.69^b
75	11.25 ± 4.27^c	52.56 ± 2.45^b	74.36 ± 7.25^b	88.46 ± 7.36^a	89.74 ± 6.28^a
100	30.00 ± 6.12^b	82.10 ± 11.40^a	97.44 ± 2.56^a	100.00 ± 0.00^a	100.00 ± 0.00^a
Actellic	91.25 ± 5.15^a	100.00 ± 0.00^a	100.00 ± 0.00^a	100.00 ± 0.00^a	100.00 ± 0.00^a

Values followed by the same superscript within the same column are not significantly different one-way ANOVA (P ≤ 0.05) followed by Tukey's test.

Table 3: Fumigant toxicity effect of mortality of hexane; methanolic blend extract of *Ocimum basilicum* on adult *Sitophilus zeamais*.

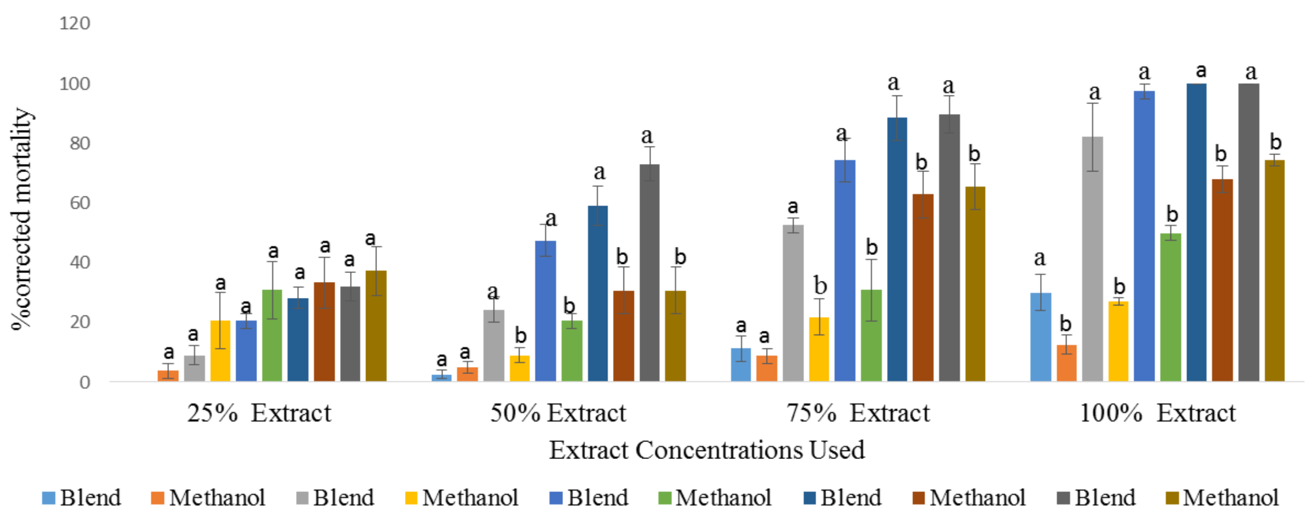

Figure 1: Comparison of fumigant toxicities of methanolic and hexane: methanolic blend extracts of *Ocimum basilicum* against *Sitophilus zeamais*.

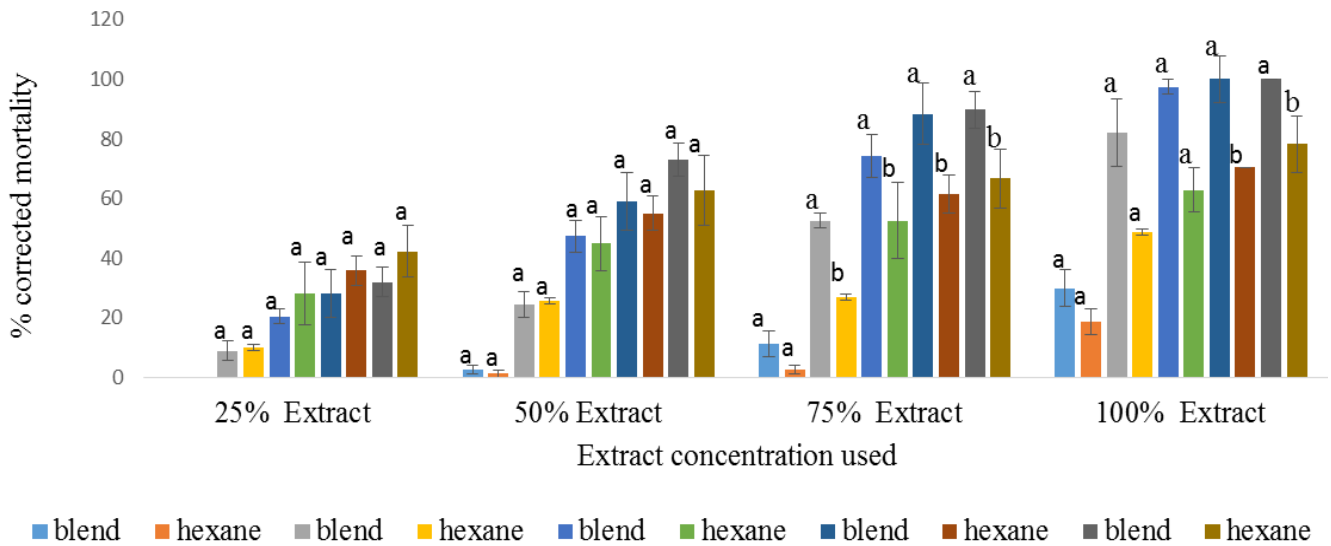

Figure 2: Comparison of fumigant toxicities of hexane and hexane: methanolic blend extracts of *Ocimum basilicum* against *Sitophilus zeamais.*

Concentration (%extract)	PR (mean% ± S.E)^m with time					PR (mean%)^n
	1 h	2 h	3 h	4 h	5 h	
25	62.50 ± 4.79^{cb}	65.00 ± 2.89^b	65.00 ± 2.89^b	70.00 ± 4.08^b	72.50 ± 4.79^b	69.00
50	67.50 ± 4.79^b	57.50 ± 2.50^b	62.50 ± 4.79^b	72.50 ± 4.08^b	82.50 ± 2.89^a	68.5
75	57.50 ± 2.50^c	72.50 ± 2.50^a	75.00 ± 2.89^a	80.00 ± 4.08^{ab}	77.50 ± 4.79^{ab}	70.5
100	65.00 ± 6.45^{cb}	75.00 ± 8.66^a	75.00 ± 6.45^a	82.50 ± 4.79^a	87.50 ± 4.79^a	77
Actellic (control)	87.50 ± 4.79^a	87.50 ± 4.79^a	85.00 ± 6.45^a	97.50 ± 2.50^a	95.00 ± 5.00^a	90.50

Values followed by the same superscript within the same column are not significantly different (P ≤ 0.05) determined by one way ANOVA following Tukey's test. Superscript m values were based on four extract concentrations, four replicates. Superscript n values were means obtained over the 5 hour duration

Table 4: Repellent activity of methanolic extract of *Ocimum basilicum* on *Sitophilus zeamais.*

Concentration (%extract)	PR (mean% ± S.E)^m with time					PR (mean%)^n
	1 h	2 h	3 h	4 h	5 h	
25	80.00 ± 0.00^{ab}	70.00 ± 4.08^b	67.50 ± 2.50^c	77.50 ± 4.79^b	75.00 ± 2.89^b	74.00
50	70.00 ± 4.08^b	72.50 ± 4.79^{ab}	80.00 ± 4.08^{ab}	72.50 ± 2.50^b	77.50 ± 4.79^b	73.00
75	80.00 ± 4.08^{ab}	77.50 ± 4.79^{ab}	70.00 ± 4.08^b	67.50 ± 4.79^b	75.00 ± 2.89^b	74.00
100	85.00 ± 2.89^a	87.50 ± 2.50^a	82.50 ± 6.29^{ab}	75.00 ± 2.89^b	90.00 ± 0.0^a	84.00
Actellic (control)	87.50 ± 4.79^a	87.50 ± 4.79^a	85.00 ± 6.45^a	97.50 ± 2.50^a	95.00 ± 5.00^a	90.50

Values followed by the same superscript within the same column are not significantly different (P ≤ 0.05) determined by one way ANOVA followed by Tukey's test. Superscript m values were based on four concentrations, four replicates. Superscript n values were means obtained over the 5 h duration.

Table 5: Repellence activity of hexane extract of *Ocimum basilicum* on *Sitophilus zeamais.*

concentration also had a strong repellence effect of 95.5% in the fourth hour. At the highest extract concentration (100%) repellence effect of 97.5% was recorded in the fourth and fifth hour. The repellent effects of 50, 75 and 100% extract concentration were not significantly different in the first and fourth hour of extract exposure (p>0.05). The mean percentage repellence of the extracts for five hour during was between 71.5 and 86.50 %. The repellent activities of actellic were significantly higher than extract in the first hour, but compared in the following hours (Table 6).

Qualitative phytochemical screening

Methanolic extract of *O. basilicum* contained phenolics, alkaloids, terpenoids, flavonoids, saponins and steroids. Hexane extract of *O. basilicum* contained phenolics, alkaloids, terpenoids, flavonoids, saponins and steroids.

Discussion

When methanolic extracts of *O. basilicum* were tested against *S. zeamais*, the results obtained revealed that the extract had distinct effect on the mortality of the tested pest on treated maize. The methanolic extract was able to cause up 74% mortality at highest applied concentration and 37% mortality at lowest applied concentration. This corroborates with the work done by Mwangangi and Mutisya [14], who found out that *O. basilicum* leaf powder caused up to 90% mortality of maize weevils within two weeks when applied at 2 g powder per 100 g of maize grains. Other works by Boeke et al. [15] showed much greater effect of *O. basilicum* essential oils on closely related coleopteran, *C. maculatus* with a record of 49% mortality within 24 h of exposure.

The effectiveness of this extract in causing mortality could be due to the presence of active compounds such as terpenoids, alkaloids, steroids,

Concentration (%extract)	PR (mean% ± S.E)^{m} with time					PR (mean%)^{n}
	1 h	2 h	3 h	4 h	5 h	
25	80.00 ± 4.08^{ab}	70.00 ± 0.00^{b}	60.00 ± 4.08^{b}	75.00 ± 5.0^{b}	72.50 ± 4.79^{b}	71.50
50	70.00 ± 4.08^{bc}	85.00 ± 2.89^{a}	87.50 ± 4.79^{a}	92.50 ± 2.50^{a}	95.00 ± 2.89^{a}	86.00
75	75.00 ± 2.89^{ab}	82.5 ± 2.50^{a}	87.50 ± 4.79^{a}	95.00 ± 5.00^{a}	87.50 ± 2.50^{a}	84.00
100	67.50 ± 4.08^{c}	82.50 ± 2.89^{a}	87.50 ± 2.50^{a}	97.50 ± 2.50^{a}	97.50 ± 2.50^{a}	86.50
Actellic (control)	87.50 ± 4.79^{a}	87.50 ± 4.79^{a}	85.00 ± 6.45^{a}	97.50 ± 2.50^{a}	95.00 ± 5.00^{a}	90.50

Values followed by the same superscript within the same column are not significantly different (P>0.05) determined by one way ANOVA followed by Tukey's test. Superscript m values were based on four concentrations, four replicates. Superscript n values were means obtained over the 5 h duration.

Table 6: Repellent activity of hexane; methanolic extract *Ocimum basilicum* on *Sitophilus zeamais.*

glycosides and flavonoids that tested positive in the phytochemical analysis. Triterpenoids of various plant extract have be proven to have toxic effect against coleopterans [16,17]. Moreover, aromatic compounds such as glycosides, saponins, flavonoids and phenols have toxic effects on coleopterans too [18]. It is also possible that some of the extract came into contact with the insects' spiracles contributing to further mortality by suffocation. Since coating the grains with the extracts minimized contact between grains and weevils, some weevils might have died as a results of starvation [7]. Glycosides, terpenoids, tannins and certain monomeric flavonoids found among lamiaceae are excellent feeding deterrents against pest insect [18,19]. Therefore, could have enhanced more mortality again due to starvation.

Hexane extracts of *O. basilicum* had potent toxic activity against *S. zeamais*. The highest application rates caused 48% and 78% mortality at within 24 and 96 hours respectively, while the lowest application rates showed 10% and 42% mortality of the maize weevils within the same assessment period. The information available on the use of hexane extract of *O. basilicum* against insect pest is scanty. However, these results are in agreement with the findings of related studies done by Popović et al. [20] that reported 21.8% mortality of *S. oryzae* within 24 hours of exposure to *O. basilicum* essential oils at lower doses. Other studies done by Kerdchoechuen et al. [21] showed higher mortality rates of *S. zeamais* when subjected to *O. basilicum* essential oil treatment.

A range of phytochemical compounds such as glycosides, alkaloids, flavonoids and saponins were found to be present in this extract which could be responsible for its toxic activity against the tested pest. Saponins for example, have been shown to impair ecdysteroid synthesis [22]. Terpenoids especially monoterpenes have also been previously reported to possess insecticidal activity against coleopterans [23-25]. A combination of several mechanisms both physical and biological could have attributed to the efficacy the plant extract.

The hexane: methanolic blend extract of *O. basilicum* applied was found effective in controlling maize weevils. Higher efficacy rates of up to 100% mortality within 72 hour were recorded at the highest applied concentration. The extract also showed acute toxicity against the pest at higher dosage application. The findings of this present study were in agreement with earlier studies by Bekele and Hassanali, [26] that also recorded 100% mortality against *S. zeamais* and *Rhyzopertha dominica* when subjected to blend of various component of *Ocimum kilim* and *scharica* and *Ocimum kenyense*. Related studies by Ranger et al. [27] also revealed acute toxicities of blends of various plant components to coleopteran larvae. Toxicity of the blend extract could be attributed to presence of active constituents such as alkaloids, terpenoids, cadiac glycosides, saponins, steroids, tannins and phenols that are reported to be toxic to post harvest pest in several ways [18,28,29]. For example, alkaloids and tannins have been reported to impart toxicity by iron chelation and enzyme inhibition [30].

A complex mixture of these active compounds also contributes to synergism to greater extent which could have promoted much activity against the tested pest [29]. The greater toxicity of the blend extract *O. basilicum* could be in line with fact that higher concentration levels of the active constituents were obtained with blend maceration. Other factors such as suffocation and starvation might also have equally led to more mortality of *S. zeamais* within the treated grains [7].

In this study, hexane, methanolic and blend extracts of *O. basilicum* showed considerable potential as repellent against maize weevils. At low concentration of 25% extracts, above 68% mean repellency was true for all the tested combination of sweet basil. Similar observation has been reported on number of plant extract tested against a range of insect pest. Asawalam et al. [31] described moderate repellent activity of *O. grattissium* to *S. zeamais*. Essential oils of *Eucalyptus globulus* and *O. basilicum* have showed strong repellency against *S. oryzae* and *T. casteneum* at remarkably low concentration [32]. This supports the findings of this study.

Padin et al. [33] work on aqueous and methanolic extracts of *Jacaranda mimisifolia, matricaria chamomilla* and *T. minuta* also recorded high repellency index of these extracts against *T. casteneum* (Coleopteran). Many other related studies have also documented much on repellent potential of various plants against post-harvest pest [34-39].

A number of secondary metabolites are linked to repellent activities of plants in which they occur. Hydrocarbons especially monoterpenes and oxygenated compounds like phenols and esters determine distinctive odor of plants [37]. Monoterpenes such as eugenol, limonene, camphor and thymol commonly found in basil have strong repellent activity against insects [40]. Therefore the activity of *O. basilicum* extracts could have been due presence of these monoterpenes. Odalo et al. [41] also found out alcohol components of basil (labiate) as effective repellents against *A. gambiae* (Diptera). Other studies have also indicated terpenoids as Arthropod-repellent compounds [37]. As much as repellent properties of these extracts could be attributed to specific compounds, a synergistic effect as a result of combination and interaction between various active phytochemicals could also have contributed to a greater activity of the extracts against the tested pest [42,43].

Adult emergence of *S. zeamais* was also affected by different *O. basilicum* extracts at all the tested extract of concentrations. High inhibition rate ranging between 86 and 100% were recorded in every study treatment. These results are in agreement with previous studies that showed various labiate plants as valuable source of potential grain protectant against development of all life stages of a number of post-harvest grain pests. Keita et al. [44] observed zero emergence of *C. maculatus* F1 progeny in cowpea treated with *O. basilicum* extracts. A closely related study conducted by Vanmathi et al. [45] also reported that aqueous extracts of *O. tenuiflorum* greatly reduced F1 adult emergence of coleopterons. However, studies carried out by Vanmathi et al. [45] recorded much lower inhibition rates of *O. tenuiflorum* extracts against *C. maculatus*. A number of botanicals have also been shown to inhibit adult emergence of *S. zeamias* in treated grains [46].

The reduction in adult emergence could be as a result of high adult mortality of *S. zeamias* in treated grain. In addition, active phytochemicals such as alkaloids have been found to disrupt growth and reduce larval survival by hindering loss of exoskeleton during larval development [47]. Other active principles such as isoflavonoids, flavonoids and terpenoids have also been reported to inhibit reproduction and fertility among coleopterons [29,48].

Other studies have also shown phenolic compounds of basil to have ovicidal, larvicidal and nymphicidal properties [49]. Change in behavior and physiology of the insects following extract treatment due to chemical nature of the extract might have also led to low egg laying capacity of *S. zeamais* within the grain and subsequently few hatch adults [29]. These factors collectively may have led to high inhibition of rates F1 adult emergence within the treated grains.

Conclusion

This study recommends the use of hexane; methanolic blend extracts of *Ocimum basilicum* in control of *Sitophilus zeamais*. However further research should be undertaken to determine the mechanism of action of each active compound of *O. basilicum* extract.

References

1. Vowotor KA, Meikle WG, Ayertey JN, Markham RH (2005) Distribution and association between the Larger Grain Borer *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) and the Maize Weevil *Sitophilus zeamais:* Motschulsky Coleoptera: Curculionidae) in Maize Stores. Stored Prod Res 41: 498-512.
2. Arthur FH, Throne JE (2003) Efficacy of diatomaceous earth to control internal infestations of rice weevil and maize weevil (Coleoptera: Curculionidae). J Econ Entomol 96: 510-518.
3. Boxall RA (2002) Damage and loss caused by the larger grain borer *Prostephanus truncatus*. Integrated Pest Manag Rev 7: 105-121.
4. Koul O, Walia S, Dhaliwal GS (2008) Essential oils as green pesticides: potential and constraints. Biopestic Int 4: 63-84.
5. Viglianco AI, Novo RJ, Cragnolini CI, Nassetta M, Cavallo, A (2008) Antifeedant and repellent effects of extracts of three plants from Córdoba (Argentina) against *S. oryzae* L.) (Coleoptera: Curculionidae). Bio Assay 3: 1-6.
6. Deshmukh SD, Borle MN (1975) Studies on the insecticidal properties of indigenous plant products. Indian J Entomol 37: 11-18.
7. Kemabonta KA, Falodu BB (2013) Bioefficacy of three plant products as post-harvest grain protectants against *Sitophilus oryzae* Linnaeus (Coleoptera: Curculionidae) on stored wheat (*Triticum aestivum*). Int J Sci and Nat 4: 259-264.
8. Abbott WS (1925) A method of computing the effectiveness of insecticides. J Econ Entomol 18: 265-267.
9. Tapondjou LA, Adler C, Bouda H, Fontem DA (2002) Efficacy of powder and essential oil from *Chenopodium ambrosioides* leaves as postharvest grain protectants against six-stored product beetles. Stored Prod Res 38: 395-402.
10. Obeng-Ofori D, Reichmuth CH, Bekele AJ, Hassanali A (1998) Toxicity and protectant potential of camphor, a major component of essential oil of *Ocimum kilimandscharicum*, against four stored product beetles. Int J Pest Manag 44: 203-209.
11. Thein WM, Javier PA, Ceballo FA (2013) Insecticidal activity of crude plant extracts against *Sitophilus spp*. (Coleoptera: Curculionidae) and C*allosobruchus chinensis (L.)* (Coleoptera: Bruchidae). Philippine Agricultural Scientist 96: 154-162.
12. Harbone JB (1998) Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. Chapman & Hal Publishersl, London, UK, pp 60-66.
13. Kotake CK (2000) Practical Pharmacognosy. Vallabh Prakashan, New Delhi, India 4: 107-111.
14. Mwangangi BM, Mutisya DL (2013) Performance of basil powder as insecticide against Maize Weevil, *Sitopillus zeamais* (Coleoptera: Curculionidae). Agric Food Sci 1: 196-201.
15. Boeke SJ, Barnaud C, van Loon JJ, Kossou DK, Dicke M (2004) Efficacy of plant extracts against the cowpea beetle, *Callosobruchus maculatus*. Int J Pest Manag 50: 251-258.
16. Mbailao M, Nanadoum M, Automne B (2006) Effect of six common seed oils on survival, egg lying and development of the cowpea weevil, *Callosobruchus maculatus*. Biol Sci 6: 420-425.
17. Ileke KD, Oni MO (2011) Toxicity of some plant powders to maize weevil, *Sitophilus zeamais* (Coleoptera: Curculionidae) on stored wheat grains. Afr J Agric Resour 6: 3043-3048.
18. Ekeh FN, Onah IE, Atama CI, Ivoke N, Eyo JE (2013) Effectiveness of botanical powders against *Callosobruchus maculatus* (Coleoptera: Bruchidae) in some stored leguminous grains under laboratory conditions. Afr J Biotechnol 12: 1384-1391.
19. Shadia E, El-Aziz A, Omer EA, Sabra AS (2007) Chemical composition of *Ocimum americanum* essential oil and its biological effects against *Agrotis ipsilon* (Lepidoptera: Noctuidae). Res J Agric Biol Sci 3: 740-747.
20. Popović Z, Kostić M, Popović S, Skorić S (2006) Bioactivities of essential oils from basil and sage to *Sitophilus oryzae* L. Biotechnol Biotechnol Equip 20: 36-40.
21. Kerdchoechuen O, Laohakunjit N, Singkornard S, Matta FB (2010) Essential oils from six herbal plants for biocontrol of the maize weevil. Horticulture Sci 45: 592-598.
22. Al-Rajhy DH, Alahmed AM, Hussein HI, Kheir SM (2003) Acaricidal effects of cardiac glycosides, azadirachtin and neem oil against the camel tick, *Hyalomma dromedarii* (Acari: Ixodidae). Pest Manage Sci 59: 1250-1254.
23. Waliwitiya R, Isman MB, Vernon RS, Riseman A (2005) Insecticidal activity of selected monoterpenoids and rosemary oil to *A. obscurus* (Coleoptera: Elateridae). J Econ Entomol 98: 1560-1565.
24. Kouninki H, Hance T, Noudjou FA (2007) Toxicity of some terpenoids of essential oils of *Xylopia aethiopica* from Cameroon against *Sitophilus zeamais* Motschulsky. J Appl Entomol 131: 269-274.
25. Ngamo TSL, Ngatanko I, Ngassoum MB, Mapongmestsem PM, Hance T (2007) Persistence of insecticidal activities of crude essential oils of three aromatic plants towards four major stored product insect pests. Afr J Agric Res 2: 1730-1777.
26. Bekele AJ, Hassanali A (2001) Blend effects in the toxicity of the essential oil constituents of *Ocimum kilmandscharicum* and *Ocimum kenyense* (Labiateae) on two Post-harvest insect pests. Phytochemistry 57: 385-391.
27. Ranger CM, Reding ME, Oliver JB, Moyseenko JJ, Youssef N, et al. (2013) Acute toxicity of plant essential oils to scarab larvae (Coleoptera: Scarabaeidae) and their analysis by gas chromatography-mass spectrometry. J Econ Entomol 106: 159-167.
28. Ali WK, Mohammed HH (2014) Toxic effect of some plant extracts on the mortality of flour beetle *Tribolium confusum* (Duval) (Coleoptera: Tenebrionidae). Entomol Ornithol Herpetol 2: 1-3.
29. Adesina JM, Jose AR, Rajashaker Y, Afolabi LA (2015) Entomo Toxicity of *Xylopia aethiopica* and *Aframomum melegueta* in suppressing oviposition and adult emergence of *Callasobruchus maculatus* (Fabricus) (Coleoptera: Chrysomelidae) infesting stored cowpea seeds. Jordan J Biol Sci 8: 263-268.
30. Karamanoli K, Bouligaraki P, Constantinidou HI, Lindow SE (2011) Polyphenolic compounds on leaves limit iron availability and affect growth of epiphytic bacteria. Appl Biol 159: 99-108.
31. Asawalam EF, Emosairue SO, Hassanali A (2008) Essential oil of *Ocimum grattissimum* (Labiatae) as *Sitophilus zeamais* (Coleoptera: Curculionidae) protectant. Afr J Biotechnol 7: 3771-3776.
32. Mishra BB, Tripathi SP, Tripathi CPM (2012) Repellent effect of leaves essential oils from (*Eucalyptus globulus*) (Mirtaceae) and (*Ocimum basilicum*) (Lamiaceae) against two major stored grain insect pests of Coleopterons. Nature Sci 10: 50-54.
33. Padín SB, Fusé C, Urrutia MI, Dal Bello GM (2013) Toxicity and repellency of nine medicinal plants against *Tribolium castaneum* in stored wheat. Bull Insectol 66: 45-49.

34. Juan HV, Saad J, Giordano O, García C, Martín T, et al. (2008) Insect growth regulatory effects of linear diterpenoids and derivatives from *Baccharis thymifolia*. Natural Products 71: 190-194.

35. Ogendo JO, Kostyukovsky M, Ravid U, Matasyoh JC, Deng AL, et al. (2008) Bioactivity of *Ocimum gratissimum* oil and two constituents against five insect pests attacking stored food products. Stored Prod Res 44: 328-334.

36. Benzi V, Stefanazzi N, Ferrero AA (2009) Biological activity of essential oils from leaves and fruits of pepper tree (*Schinus molle* L.) to control rice weevil (*Sitophilus oryzae* L.). Chilean J Agric Res 69: 154-159.

37. Nerio LS, Olivero-Verbel J, Stashenko E (2010) Repellent activity of essential oils. Bioresour Technol 101: 372-378.

38. Auamcharoen W, Chandrapatya A, Kijjoa A, Kainoh Y (2012) Toxicity and repellency activities of the crude methanol extract of *Duabanga grandiflora* (Lythraceae) against *Sitophilus oryzae* (Coleoptera: Curculionidae). Pak J Zool 44: 227-232.

39. Niroumand MC, Farzaei MH, Razkenari EK, Amin G, Khanavi M, et al. (2016**)** An Evidence-Based Review on Medicinal Plants Used as Insecticide and Insect Repellent in Traditional Iranian Medicine. Iran Red Crescent Med J 18: 1-13.

40. Yang FL, Zhu F, Lei CL (2012) Insecticidal activities of garlic substances against adults of grain moth, *Sitotroga cerealella* (Lepidoptera: Gelechiidae). Insect Sci 19: 205-212.

41. Odalo JO, Omolo MO, Malebo H, Angira J, Njeru PM, et al. (2005) Repellency of essential oils of some plants from the Kenyan coast against *Anopheles gambiae*. Acta Trop 95: 210-218.

42. Omolo MO, Okinyo D, Ndiege IO, Lwande W, Hassanali A (2004) Repellency of essential oils of some Kenyan plants against *Anopheles gambiae*. Phytochemistry 65: 2797-2802.

43. Liu CH, Mishra AK, Tan RX, Tang C, Yang H, et al. (2006**)** Repellent and insecticidal activities of essential oils from *Artemisia princeps* and *Cinnamomum camphora* and their effect on seed germination of wheat and broad bean. Bioresour Technol 97: 1969-1973.

44. Kéïta SM, Vincent C, Schmit JP, Ramaswamy S, Bélanger A (2000) Effect of various essential oils on *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). Stored Prod Res 36: 355-364.

45. Vanmathi JS, Padmalatha C, Sing AJA, Suthakar S (2010) Efficacy of selected plant extracts on the oviposition deterrent and adult emergence activity of *Callosobruchus maculatus*. F (Bruchidae; Coeleoptera). Glob J Sci Front Res 10: 2-6.

46. Akinbuluma MD, Adepetun MT, Yeye EO (2015) Insecticidal Effects of Ethanol Extracts of *Capsicum frutescens* and *Dennettia tripetala* against *Sitophilus zeamais* Motschulsky on Stored Maize. Int Res Agric For 2: 1-7.

47. Ileke KD, Ogungbite OC (2014) Entomocidal activity of powders and extracts of four medicinal plants against *Sitophilus oryzae* (L), *Oryzaephilus mercator* (Faur) and *Ryzopertha dominica* (Fabr.). Biol Sci 7: 57-62.

48. Chebet F, Deng AL, Ogendo JO, Kamau AW, Bett PK (2013) Bioactivity of Selected Plant Powders against *Prostephanus truncatus.* Plant Prot Sci 49: 34-43.

49. Belong P, Akono E, Bakwo E, Foko G, Tamesse J (2013) Chemical composition and residue activities of *Ocimum canun* Sims and *Ocimum basilicum* L. essential oils on adult female *Anopheles funestus* ss. Anim Plant Sci 19: 2854-2863.