Insecticidal activity of *Lantana camara* extract oil on controlling maize grain weevils

Adane Adugna Ayalew

**Abstract**

Postharvest losses are known to be one of the serious constraints upon food security among farmers poor resource in Africa. The use of botanical insecticide in pest management during storage against weevils is often encouraged because synthetic insecticides produce multiple side effects on human and environment. In this study, the insecticidal property of methanol, ethanol, and ethyl acetate extracts of *Lantana camara* leaf oil and powder for controlling maize weevils, *Sitophilus zeamais*, was studied. Gas chromatography–mass spectrometry and Fourier transform infrared spectroscopy (FTIR) were used to identify the chemical composition and functional group of solvent extract, respectively. Adult weevil repellency and mortality were studied by the effect of oil concentration at 0% (w/w), 2% (w/w), 3% (w/w), 5% (w/w), 7% (w/w), and 10% (w/w). Repellency effect was also conducted at 6, 12, and 24 h. The number of weevil death increased significantly as exposed time was increased. The extracted oil by the three-solvent fraction had direct repellent and toxic effect to the weevil. From all treatment applied, extracted by methanol fraction had showed highest percentage mortality (74%). The lowest mortality rate was observed in ethyl acetate extract (26%) at 2% (w/w) concentration. The effect of leaf powder and extracted oil on repellency and mortality for insects was due to the presence of bioactive and phytochemical molecules such as Phytol, Pyrroline, Paromomycin, Pyrrolizin, and 1-Eicosano. It was concluded that both *L. camara* leaf powder and extract oil can be used for the protection of stored maize from infestation *S. zeamais*.

**Keywords**

Insecticides properties, *Lantana camara*, *Sitophilus zeamais*, maize grain

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**Introduction**

Food grains constitute the major source of food in Ethiopia. It is a significant part of rural economies.¹ Currently, 85% people lead their life based on agricultural products. However, farmers are encountered serious postharvest problems from weevils mainly in storage of grain. When grain is attacked by weevils, they become less marketable and this causes economic loss to the producers and quality failure to the consumers.² As a result of these troubles, many farmers prefer to sell their crop immediately after harvesting to avoid making losses from the infestation of the weevils.³ Maize has ability to be stored for long period for latter consumption or to look for good price. However, it suffers major economic loss caused by grain infesting insect. The cumulative effects of feeding, breeding, transmission of toxic, saprophytic fungi, and associated changes in the microecological conditions in the grain bulk⁴ cause deterioration process in the grain.⁵

It has been estimated that about 15–20% of Ethiopian stored grain agricultural product is lost every year due to weevil infestation.⁶ Insect infestation results in weight loss and quality deterioration which constitute a threat to food

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security. *Sitophilus zeamais* is the most weevil pests that attack stored maize. Various control methods are available for use in storage systems in numerous and diverse with their environmental factors for the postharvest system. Storage pests have been prevented principally by synthetic chemicals insecticides such as Dichlorodiphenyltrichloroethane (DDT), Malathion, Dichlorvos, and other chemicals. But there is a global concern due to adverse effects associated with over-reliance and excessive application of these chemicals. Continued and widespread use of these synthetic insecticides has given rise to the development of lethal effects on nontarget organisms, resistance to insects, pest resurgence, chemical residues, worker safety, and increasing cost of application. The chemical contaminates stored food commodity and leaving behind harmful residue in health causes cancer especially when application dosages are not properly followed. Based on these situations, an alternative method for reducing stored-product loses by insect is attractive and preferable over conventional control method. The use of botanical extract crude oil and leaf powder is suitable for grain protection from infested insects.

Botanical plants as an alternative to synthetic insecticides are predictable because of their non-cytotoxicity, easy of biodegradable, more environmental friendly, and simulator of host metabolism. Plant extracts have shown antifeedant, ovicidal, repellent, and toxic effects in insects. Essential oils and their individual constitute have been known to play an important role in protection of stored grains and proved to hold repellent and insecticidal properties. Currently, it would increase demand and experience in the use of these eco-friendly natural products which could replace synthetic chemicals for management stored grain protection. This includes the development of nonchemical technologies which may eliminate the use of synthetic chemical insecticides and have economic and health benefits for applicators, consumers, and the environment. The present study focuses on the investigation of extract oil and leaf powder from biodegradable natural plant *Lantana camara* for controlling *S. zeamais* on stored maize grain. Extract bioactive components were characterized through gas chromatography–mass spectrometry (GC-MS) and functional groups of cellulose part of leaf were analyzed by Fourier transform infrared spectroscopy (FTIR).

## Materials and methods

### Plant collection

Fresh, mature, and healthy green leaves of *L. camara* were collected from shrubs of invaded forest area in Woreta, north Gondar, Ethiopia, during a month of August to December 2018. All laboratory grade reagents such as methanol, ethanol, ethyl acetate, acetone, and distill water were used in research grad laboratory. The fresh collected leaves were washed properly to remove some external dust particle and were dried in dark place at ambient temperature for 13 days before oil extraction to prevent the oxidation in sunlight. The dried leaves of the plant were finely grounded to powder using mortar and pestle. The powder was sieved through 0.5-mm size mesh to get uniform particle size. Further, the grounded powder was stored in dark and cool place which is away from sunlight and properly sealed to prevent quality loss.

### Oil extraction

There are different oil extraction techniques from the leaf of *L. camara* such as aqueous extracts, organic extracts, and hydro distillation/steam method. In this study, organic extract by Soxhlet apparatus extraction method was selected to extract the oil from the leaf. Since organic solvent extraction method has potential to extract the bioactive molecule with solvent boiling temperature, 50 g of *L. camara* leaf powder was extracted through various solvents (methanol, ethanol, and ethyl acetate) for maximum extraction time carried out for 5–6 h. The concentration was used 100 mg mL\(^{-1}\) which is 50 g powder of *L. camara* leaf was mixed into 500 mL solvents. The apparatus was then connected with the water supply to the condenser. The temperature of the heating mantle was maintained at solvent boiling temperature. The extract was transferred to Petri plates and solvent was allowed to evaporate by using rotary evaporator to separate from oil. The oil extraction was defined as crude oil extract and stored at 4°C in refrigerator and dried under anhydrous sodium sulfate. Physicochemical properties of the oil were determined using phytochemical standard methods and instrumental analysis by GC-MS and FTIR.

### Mass rearing of weevils

Rearing of the weevils in massive was necessary to make continuous supply of the test weevils during study. Maize grain was used as the growth medium for formation of adult weevils. Heavily infected grains weevils were collected from local farmer house together with the grain and screen out them from already infested grain and transferred to fresh rearing material for multiplications. A total of 200 adult weevils were reared in sack material which contains 2-kg clean grains which was disinfested and stored at room temperature. The sack was kept in dark place which had little light. Then, insects were tried to lay their eggs within 1 week. At the top, the sack was tied with piece of rob bands to prevent weevils from escaping out. The sack was comfortable for weevils for reproduction and easily gets air from the atmosphere. The weevils were allowed for free mating and ovipositional for the period of 2 weeks. Some broken grains and flour, and also weevils, were separated from the treated grains by sieving within 1 and 3 mm sieves. During sieving, the grains were retaining under the 3-mm sieve, while the weevils and the flour were retained in 1 mm sieve and easily holding. After adult weevils isolated, the fragmented grain and the flour then returned to the storage of jar to grow the remaining larva to adult weevils.
Repellency bioassay test

The repellence test of leaf powder against grains weevils was evaluated based on the method of the Ogendo et al.\textsuperscript{15} which consisting of a circular flat bottom basin container of 10 cm diameter by 2 cm height used for the experiment such as Petri dish which was divided into four portions to determine the repellence of powder leaf against adult weevils. The powder was assessed at five rates (0%, 2%, 3%, 5%, and 10% w/w). In two opposite parts of the Petri dish, 3 g of untreated and treated grain was placed with equal distance from center of the circular basin. One side of the Petri dish considered as treated grain side and other side was considered as control. On other two sides of the Petri dish, 10 S. zeamais were released and a cover with transparent muslin was placed to prevent weevils escape out to the surrounding. After all, the total numbers of weevils which settle on each part, that is, in the control side ($N_c$) and in the treated side ($N_t$) were counted at 6, 12, and 24 h interval for different dosage treatments. The percentage repellency values were measured as described by Liu et al.\textsuperscript{16}

\[
\% \text{ repellency} = \frac{N_c - N_t}{N_c} \times 100
\]

Toxicity bioassay/adult mortality test

Fifty grams of grains were taken into glass jar and were mixed with different fraction of extracted oil (w/w). The mixture then carefully shook very well for 5 min to make uniform contact and distribution of the oil on the surface grain. After well mixed, 10 weevils were introduced to the treated grain. Extract oil may have highly volatile compounds characterized by strong odor and lipophilic properties. Experiment was performed in glass jars secured with aluminum foil cover to permit vapor to penetrate and obviate the volatile components. The glass jar was covered by muslin clothe and sealed with molten wax to prevent insects from escaping. The weevils mortality was monitored within contentiously days starting from first day until the number of weevil mortality reach high level. The number of died weevils then counted in each glass jar. The percentage of adult mortality was calculated by counting the number of dead weevils and number of introducing weevils. Based on Jian’s\textsuperscript{17} method, the weevils mortality can be calculated by the following equation:

Weevils mortality = \[\frac{\text{Number dead weevils} \times 100}{\text{Total number of weevils}}\] (2)

Fourier transform infrared spectroscopy (FTIR) analysis

The FTIR analysis of solvent extract oil was carried out using Shimadzu FTIR-8400s Fourier transform infrared spectrophotometer, Japan. The FTIR spectrum was used to identify the functional group of the cellulose components based on the peak value in the region of infrared radiation. The extracted crude oil was encapsulated in 100 mg of Potassium bromide (KBr) pellet carried out by scanning the samples through wave number range of 400–4000 cm\textsuperscript{-1}.\textsuperscript{18}

GC-MS analysis

GC-MS analysis was performed on an Agilent/5975C-GC/MSD instrument (Agilent Technology, Santa Clara, California, USA) coupled with an HP-5MS fused silica capillary column (30 m \(\times\) 0.25 mm \(\times\) 0.25 \(\mu\)m). The GC oven temperature was initially increased from 60°C to 120°C at a rate of 10°C min\textsuperscript{-1}, then elevated at a rate of 3°C min\textsuperscript{-1} up to 175°C, then increased at a rate of 5°C min\textsuperscript{-1} up to 205°C, then went up at a rate of 0.8°C min\textsuperscript{-1} up to 210°C, and then raised to 280°C at a rate of 5°C min\textsuperscript{-1}, held for 5 min, giving a total runtime of 55.583 min; 1 \(\mu\)L volume of solvent extract oil was injected into the GC. Helium was used as carrier gas at a constant flow rate of 1.0 mL min\textsuperscript{-1}. Mass spectrometer was operated in full scan with electron energy of 70 eV and interface temperature was 280°C. MS source temperature was set at 230°C and MS quadruple temperature was 150°C. The scan range was from m/z 30 to 550. Identification of component was carried out by computer matching mass fragment pattern with the National Institute of Standard and Technology mass spectra database library by comparison with their retention time and mass spectra.\textsuperscript{19}

Results

Phytochemical analysis of extract oil

The different secondary metabolites compounds of extract oil are presented in Table 1. The preliminary phytochemical screening showed that the leaf extract contains Steroids, Flavonoid, Tannins, Glycerol, and Saponins in all the three solvent, while Alkaloids is present only in methanol and ethanol extracts compounds. The presence of these phytochemical components may be responsible for the experimental insecticidal property of the plant leaf extract.

Fourier transform infrared spectroscopy (FTIR) analysis

The FTIR spectra of methanol, ethanol, and ethyl acetate extracted of L. camara leaf were presented in Figure 1. The functional groups present in oil are amines, phenols, alcohol, carboxylic acid, alkenes aliphatic compounds, carboxyl compounds, esters, and phenols which are responsible for insecticidal activities. The band at 3464 and 3462 cm\textsuperscript{-1} is related to vibration of starching hydroxide (O–H) group for methanol and ethanol extract, respectively. The band found at 1628 cm\textsuperscript{-1} could be due to stretching vibration of C=C groups and assign of aromatic group of deformation due to vibration of C–O lipids and flavonoid. The band at 1350 and 1349 cm\textsuperscript{-1} could be related to CH3, CH2
flavonoid, and aromatic group. A band at 1250 and 1247 cm$^{-1}$ is related to stretching vibration of carboxyl group (O–H and C–O stretch), that is, stretching of C–O of flavonoid and lipids. Characterization of ethyl acetate extract bands at 3470 cm$^{-1}$ is related to OH stretching (OH) compound. A band at 1127 and 1128 cm$^{-1}$ is related to C–O stretching ester group. The band at 780 cm$^{-1}$ would be due to C–C stretching vibration. The band occurs at 1435 and 1430 cm$^{-1}$ due to lipids and alcohol groups (stretching of C–O and bending of C–OH). The band at 2994 cm$^{-1}$ could be related to C–H stretching vibration of methyl and methoxy groups and to stretching vibration of –CH3 or –CH2 groups in carboxylic acid. The band at 1630 cm$^{-1}$ could be related to C=O stretching vibration of aromatic rings and to the vibration of N–H amines, C=O of carboxylic group, and also the band could be related to flavonoid and amino acids (C=O), (C=C), (N–H). The band at 1130 cm$^{-1}$ was considered to occur due to lipids and alcohol group (stretching of C–O and bending of C–OH). At 1347 cm$^{-1}$, band could be related to vibration of aromatic C–H. The band at 745 cm$^{-1}$ would be related to C–C stretching vibration.

### Table 1. Phytoconstituent of Lantana camara leaf extracted oil.

| S/N | Photochemical | Positive indicator       | Methanol | Ethanol | Ethyl acetate |
|-----|---------------|--------------------------|----------|---------|---------------|
| 1   | Steroids      | Blue colorization        | ++++     | ++      | +             |
| 2   | Terpenoids    | Reddish brown            | –        | –       | –             |
| 3   | Alkaloids     | Orange precipitation     | +        | +++     | –             |
| 4   | Flavonoid     | Yellow precipitate       | ++++     | +       | ++            |
| 5   | Tannins       | Greenish black           | ++       | +       | ++            |
| 6   | Glycosides    | Brown interface          | +        | ++      | +             |
| 7   | Saponins      | Froths/foams present     | ++++     | ++      | +             |

### Figure 1. FTIR spectra of (a) methanol, (b) ethanol, (c) ethyl acetate, and (d) all combined solvent extract of Lantana camara leaf.
FTIR spectra of all extract oil appear fairly similar. However, careful examination of FTIR spectra of all oils reveals some significant differences either in number of peaks. From the FTIR, graph can be observed and the methanol extract has the lowest transmittance value and high absorbance than ethanol and ethyl acetate extract. This due to methanol has a higher potential to extract active biological components from the leaf. As the result, the extract oil contains many bioactive molecules which exhibit for biological activity.

### Chemical composition identification

The gas chromatography shows the relative concentration various compounds getting fraction at their specific retention time. The photochemical analysis of leaf crude oil was performed on GC–MS which resulted in the identification of a total of 43 major components with different retention time. The identified compounds and their relative contents are listed in Tables 2 to 4 and Figure 2(a) to (c). The percentage peak area was taken as percentage composition of the constituents. The major compounds are included pyrrolizin, 1-eicosano, 1-docosene, 1,3-dioxolan-2-one, imidazole, 1,2-nonadecanediol, azabicyclo octane, 3,7-diazabicyclo 4-undecene, Z-2-acetoxy-12-tetradecenitril, 4-[(4-methoxyphenyl) methyl]-1,2-oxazole, and 6-ethoxy-7-methoxy-1-(3-nitro-phenyl) and have been expressed tritrophic interaction as reported by earlier findings as well as insecticides and antimicrobial properties.

#### Table 2. Major compound identified in methanol extract of Lantana camara leaf by GC-MS.

| S. N | RT (min) | Compound name | Peak area % | MW  | MF    |
|------|----------|---------------|-------------|-----|-------|
| 1    | 8.34     | 4-Undecene, 5-methyl-, (E) | 43.29       | 132 | C12H24|
| 2    | 8.395    | 1,8-Nonadien-3-ol | 47.0        | 140 | C9H16O|
| 3    | 13.365   | Pyrrolizin-1,7-dione-6-carboxylic acid | 68.0       | 197 | C9H11N04|
| 4    | 14.5     | 1-Pentanamine, N-(phenyl methylene) | 27.0       | 175 | C12H17N|
| 5    | 15.5     | 2-Oxobicyclo [2.2.1] heptane-1-carbonitrile | 12.3       | 135 | C8H9NO |
| 6    | 17.21    | 2,5-di-tet-Butylaniline | 99.4       | 205 | C14H23N|
| 7    | 19.6     | Cyclohexanamine, N-(phenyl methylene) | 28.0       | 187 | C13H17N|
| 8    | 19.88    | Cycloandecane, (1-methylthyl) | 87.1       | 196 | C14H28 |
| 9    | 19.84    | Imidazole, 2-amino-5-[(2-carboxy) vinyl] | 37.4       | 153 | C6H7N3O2|
| 10   | 20       | 1-Docosene | 73.1        | 266 | C19H38 |
| 11   | 21.4     | 4,7,10-Hexadecatrienoic acid, methyl ester | 11.4       | 264 | C12H22O2|
| 12   | 26.7     | 1-Dodecanol, 3,7,11-trimethyl | 77.6       | 228 | C15H32O |
| 13   | 30.35    | Propenitrile,3-[1-(3-(1-pyrrolidinyl) propynyl) propynyl | 4.41       | 260 | C16H24N2O |
| 14   | 32.2     | 1-Eicosano | 42.5        | 298 | C20H42O |
| 15   | 36.03    | Phytol | 3.06        | 298 | C20H40O |
| 16   | 44.7     | Pyrroline, 5-butyl-2-[1,3-heptadienyl] | 100.0      | 219 | C15H25N |
| 17   | 48.1     | 1,2-Nonadecanediol | 17.3       | 300 | C19H40O2 |
| 18   | 48.3     | 4-Acetyloxyimin-6,6-dimethyl-3-methylsulfanyl | 2.7        | 341 | C15H19N3O2 |
| 19   | 51.1     | 6-Ethoxy-7-methoxy-1-(3-nitro-phenyl) | 2.39       | 328 | C18H20N2O4 |

**GC-MS:** gas chromatography–mass spectrometry; RT: retention time; MW: molecular weight; MF: molecular formula.

#### Table 3. Result of GC-MS analysis of Lantana camara crude extracted oil by ethyl acetate.

| S. N | RT (min) | Compound name | Peak area % | MW  | MF    |
|------|----------|---------------|-------------|-----|-------|
| 1    | 8.32     | 4-Piperidinemethanamine | 59.99       | 114 | C6H14N2|
| 2    | 9.06     | Piperidine, 1-[(1-propenyl) | 1.45       | 125 | C8H15N |
| 3    | 13.34    | Azabicyclo [5.1.0] octane | 81.57      | 111 | C7H13N |
| 4    | 14.5     | 4-[(4-Methoxyphenyl) methyl]-1,2-oxazole | 50.2       | 219 | C11H13N3O2|
| 5    | 14.574   | 4-Undecene, 3-methyl-, (Z) | 2.01       | 168 | C12H24 |
| 6    | 15.5     | Amphetamine | 17.2        | 135 | C9H13N |
| 7    | 17.11    | 2,5-di-tet-Butylaniline | 87.4       | 205 | C14H23N|
| 8    | 19.84    | E-2-Tetradecen-1-ol | 100        | 212 | C14H28O |
| 9    | 21.4     | 1,2,5-Oxadiazol-3-carboxamide | 6.91      | 284 | C6H4N8O6 |
| 10   | 26.6     | 13-Methyltetradecan | 63.02      | 226 | C15H30O |
| 11   | 32.2     | Hexadecan | 33.02      | 240 | C16H32O |
| 12   | 38.7     | Imidazole, 2-amino-5-[(2-carboxy) vinyl] | 11.4       | 153 | C6H7N3O2|
| 13   | 43.8     | 4-(3-Pyridyl)-4-oxo-butyramide | 1.21       | 250 | C12H18N2O2Si |
| 14   | 52.33    | 6,7-Dimethoxy-2-oxo-3,4-dihydro-1H-quinolin | 2.266     | 265 | C13H15N5O5 |

**GC-MS:** gas chromatography–mass spectrometry; RT: retention time; MW: molecular weight; MF: molecular formula.
Repellency activity test

The leaf powder of *L. camara* showed significant repellency activity against maize weevils, *S. zeamais*, at all concentrations. The repellency effect of powder on weevils is showed in Figure 3(a), and it has presented the repellency percentage of weevils with treated grain. Progresses

| S. N | RT (min) | Compound name | Peak area % | MW | MF |
|------|----------|---------------|-------------|----|----|
| 1    | 8.37     | Acetic acid, trifluoro-, 3,7-dimethyloctyl ester | 48.45       | 238 | C12H21F3O2 |
| 2    | 10.34    | Pyrrolizin-1,7-dione-6-carboxylic acid, | 1.01        | 197 | C9H11NO4 |
| 3    | 11.48    | Pyrimidin-2,4-dione | 1.09        | 269 | C12H19N3O4 |
| 4    | 13.345   | 1-Undecene, 9-methyl | 69.2        | 168 | C12H24 |
| 5    | 14.574   | 4-Undecene, 3-methyl-, (Z) | 2.01        | 168 | C12H24 |
| 6    | 17.184   | 2,5-di-tert-Butylaniline | 100         | 205 | C14H23N |
| 7    | 19.865   | N,N'-Tetramethylenebis | 81.86       | 396 | C10H24N2O6S4 |
| 8    | 26.69    | Z-2-Acetoxy-12-tetradecenitril | 77          | 279 | C17H29NO2 |
| 9    | 32.2     | Octadecane, 1-(ethenyloxy) | 65.5        | 296 | C20H40O |
| 10   | 36.00    | 1,5-Dinitro-3,7-diazabicyclo [3.3.1] nonane | 5.61        | 216 | C7H12N4O4 |

GC-MS: gas chromatography–mass spectrometry; RT: retention time; MW: molecular weight; MF: molecular formula.
through time, the numbers of weevils repelled and settled on the control side of the dish. The degree of repellency was greatly influenced by the dosage of the powder applied and the exposure time. It has noticed that there was progressively increased repellency with increasing exposure time. The percentage of *S. zeamais* repellency against powder was increased from 30% to 90% as the powder dosage increased from 2% (w/w) to 10% (w/w) and exposure time increased from 6 h to 24 h. The percentage of *S. zeamais* repellency was low at initial time with application of less dose of leaf powder. However, through increasing of contact time, the number of weevil repellency was increased and the repellency rate of *S. zeamais* was fast against the powder. This is due to fumigant, toxic, and anti-feeding property of the leaf powder for *S. zeamais*.

**Mortality weevil’s test**

The effect of solvent extract oil on mortality of *S. zeamais* was conducted and presented in Figure 3(b). The average percent mortality after 5 days treatment was recorded from 26% to 74%. It has been showed that the maximum percentage of *S. zeamais* mortality was observed in methanol extract fraction. The percentage of weevils mortality through three solvent extract fractions from first to fifth days exposed is showed in Figure 4(a) to (c). It has been noted that in the first and second consecutive days, the mortality of weevils was low (<20%) at a concentration of 2% w/w. After then, the numbers of weevil mortality were progressive increased as the exposure period increased. This is due to the existed of different biological active components with the extracted and formulated oil. From the result noticed that both the concentration of oil and the exposure period were significant for the weevil mortality ($p < 0.05$). In 5 days treatment with methanol extract, the percentage of mortality was 38%, 50%, 54%, 62%, and 72% of concentration oil 2%, 3%, 5%, 7%, and 10% (w/w), respectively. At a concentration of 10% (w/w), the maximum percentage mortality of *S. zeamais* was recorded by methanol, ethanol, and ethyl acetate extract at 74%, 67%, and 58%, respectively.

**Discussion**

In the present study, the phytochemical analysis of solvent extracts is known to have wide range of biological activates including antibacterial, antifungal, antiviral, antioxidant, cytotoxic, and insecticides properties. FTIR analysis of methanolic, ethanolic, and ethyl acetate leaf extracts of *L. camara* confirmed the presence of protein, oil, fats, phenolic, flavonoids, saponins, tannins, and carbohydrate as major functional groups. The FTIR result agrees as the works of Mot et al. reported that these functional groups confirm the presence of secondary metabolites and other phytol component present in plant leaf. This investigation has similar result reported by Ragavendran et al., who screened the functional groups of carboxylic acids, amines, amides, polysaccharides, organic hydrocarbons, and halogens that are responsible for various medical properties.

The chemical composition of Ethiopian *L. camara* leaf oil described in this study agreed quite well with those previously reported in the literature; however, there were some difference in relative quantities of volatile compound. There is great variation in the chemical composition of *L. camara* oil reported up to now from the different parts of the world. Differences in quality and quantity of extracted oil composition can be attributed to the effluence of genetic, climate, geographical location, and seasonal variations. Among main compounds, phytol, azabicyclo octane, and 2-dodecene have been reported from essential oil of *L. camara* leaf from other studies. Some of the isolated compounds such as phytol, pyrroline, 1-dodecanol, paromomycin, 1-hexacosanol, and amphetamine are known for their application in pharmacology. The most abundant compounds found in all extract solvents constitute several flavonoid, glycosides, triterpenoids, and

![Figure 3. Effect of leaf powder (a) on weevil’s repellency percentage and (b) solvent mortality rate.](image-url)
alkaloids isolated from this plant which have been reported to exert diverse biological activities. Alkaloids from plant L. camara have high repellency efficiency for weevils due to antifeedant and inhalation fumigant property. Some of toxic biological components present in the plant are dodecanol, 1-eicosano, piperidine, and ethoxy and have insecticidal property. Similar study was reported by Isman and Miresmailli that essential oil obtained from Artemisia Judaica L. has repellent activity against the cowpea weevils. In the same way, Pavela found the strong lemon oil and Litsea cubeba oil have repellent activity against adults of Tenebrous olitor weevils. Passreiter et al. reported on adult aphids’ weevil, which caused 90% repellent at a concentration of 4.0% after 4 h of exposure. Furthermore, Taye et al. confirmed that after 14 days of observation, the application of L. camara flower and leaf powder caused 21.67% adult mortality of S. zeamais, while the mixture caused 13.33% which were highly significant compared with untreated maize grain (0%).

The fumigant toxicity of L. camara oil could be attributed to the presence of major and active biological components present. The insecticides toxicity of extract oil and their chemical constitute were induced toxic action quickly due to their fast penetration into insects. Pyrroline is an active biochemical compound which has property insecticidal and fungicidal activities by entering into insects and causes biochemical dysfunction and mortality. Dodecanol, pyrrolizin, paromomycin, acetoxy, 1-docosene, and nonadecene have an insecticides property. They cause disruption in growth and affect the reproduction of weevils. Mahboubi and Farzin have been reported as phytol having analgesic, anti-inflammatory activity, and antifungal against insects induced changes in growth and reproduction system. It has been reported that cycloundecane, 1, 3-dioxolan-2-one, imidazole, and 1-docosene have fumigant and toxicity against maize and rice weevils (Sitophilus oryzae). Inconformity those reported by Bouda et al. revealed that the oil of L. camara had the potential to control S. zeamais and a morality rate of 100% was recorded for the highest concentration of 0.5% v/w. Similar studies reported by Fang et al., after 24 h treatment with Nepeta cataria leaf oil, the mortality was 24%, 36%, 46%, 52%, 76%, and 94% of concentration 3, 8, 16, 31, 63, and 126 μL L⁻¹, respectively. Crude of extract L. camara has fumigant toxicity against rice weevils of S. oryzae. The mortality of S. oryzae was reached 74% with 10% w/w concentration and long exposure time. Due to high polarity, methanol was found to exhibit better efficiency in extracting various polar Phytol compounds from the leaf of L. camara.

**Conclusion**

According to the results of the present investigation, both leaf powder and extract oil possessed insecticidal
properties, feeding, and ovipositional deterrent effect against the most economically important maize storage pests. Sustainable use of botanical insecticides will improve the food security in that environment where investments in synthetic pest control are uneconomical. The primer screening investigation showed that the methanol extract was most toxic against maize weevils followed by ethanol and ethyl acetate extract. Methanol solvent extract of L. camara leaves contained more extractable secondary metabolite. Therefore, the resource poor farmers can use this plant in controlling maize weevils as they are not afford to buy synthetic insecticides. Further tests are recommended to investigate the penetration of such botanical compounds into stored maize grains and their impacts on the organoleptic contents of the grains. More studies on the biosafety and levels of botanical residues on the treated grains and their potential adverse side effects should be done before the extracts are used to treat grains for consumption.

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