The Effect of Alkaloid and Phenolic Extracts of Some Plants on the Biological of the Periplaneta Americana

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KEYWORDS
Periplaneta americana, Xanthium strumarium, Achillea L., terpenoids and alkaloid extracts.

ABSTRACT
The study was conducted to determine the extent of the effect of some plant extracts on the death of some of the biological stages of the Periplaneta americana, it tested two types of terpenoids extracts and the alkaloid extract of Xanthium strumarium and Achillea L. the extract of terpenoids and alkaloid compounds of the Achillea L in killing eggs, and it was also noted that the extract of terpenoids in both the X.strumarium and Achillea L was superior to the rest of the extracts of the same two plants.
The two extract recorded an effect on the adults of the P.americana, as it was noted that the terpenoids and alkaloids of the extract were clearly superior to the X.strumarium, it was also noted that the superiority of the alkaloid extract in the X.Strumarium. We also note that there is a direct relationship between the concentrations of the extract and the percentage of death. The extracts work to kill insect eggs in several ways that have a physiological effect, including that they contain a percentage of oils that cover the surface of the eggs with a thin layer that prevents the exchange of gases between the egg embryo and its external environment, it hardens, thus preventing the egg shell from hatching, or the penetration of the extract into the egg, which affects the protoplasm, leading to the killing of embryos, or the inhibitory effect of the terpenoids compounds present in the extract of the two plants, which affects the growth of the embryos of these eggs.

1. Introduction

Periplaneta americana are among the common household insects that live in various human environments and in contact with human food and tools, as they can be seen in any place used or inhabited by humans (Zhang et al., 2010). They are also mechanical carriers of many dangerous pathogens (Zeng et al., 2019). including Klebsiella, Pseudomonas, Escherichia coli, Staphylococcus, Enterobacter, Streptococcus, Serratia, Bacillus, and proteus, which cause health problems for humans (Herz et al, 2016). They also transmit many nematodes such as malaria) Chagas disease, leishmaniasis, African trypanosomiasis, and lymphatic filariasis, which wastes the lives of millions of people. (Benelli et al., 2020). Researchers were interested from an early stage in combating P. americana, and perhaps chemical control was not the most effective method for eliminating P. americana has disappeared in various regions of the world, but the damage resulting from it was not insignificant, the use of these pesticides led to pollution of water, air, and soil, on the other hand, P.americana gained the ability to adapt to toxic substances and develop immunity to them (Gondhalekar et al., 2021).

Many insect growth regulators were also used to combat P. americana, but they did not achieve the desired goal of eliminating them, so it was necessary to search for other alternatives, including the use of plant extracts as insecticides due to their spread and widespread presence in nature and their low environmental impact (Ahmed et al., 2021). Plant extracts contain metabolic compounds that are toxically effective against insects (Iram et al., 2015; Al-Mayali & Al-Hassani, 2016). Among the plant pesticides commonly used in cockroach control are nigrescens Parquetina, Zanthoxyloides Zanthoxylum, and cariophyllus Eugenia (Soonwera et al., 2022).

X. strumarium is one of the plants that have shown broad effects on different stages of the life of insects, as it causes a lengthening of the larval stage, a decrease in the weight of the pupa, and an increase in the mortality rate when it is included in their diet (Elizabete et al., 2017). as shown It has a harmful effect on insect development, as it delays the growth stages of larvae and pupae and prevents the formation of adults, which makes it a promising candidate for integrated insect control programs (Sonam et al., 2015). The Achillea L. is considered one of the plants that have proven its efficiency in combating many insects, as it causes an increase in the mortality rate and prolongs the moulting stages of larvae and pupae of many insects, Baccharis dracunculifera (Silvana et al., 2023). Baccharis dracunculifera extract also showed significant larvicidal activity against frugiperda Spodoptera, with a dose of 0.2% causing increased mortality and longer larval stages. However, the ethanol extract of Baccharis dracunculifolia did not affect the viability of insect eggs .

Haloxylon is also a desert halophytic plant, and its effect in combating insects has been proven, there are no studies available that specifically indicate the potential effects of plants on combating insects, as the plant contains many active ingredient, including peroxidase, abscisic acid, auxins, gibberellin, and proline and amino acids that may have an effective insect control effect (Fang & Guanghui, 2022). Aim of the study to due to the scarcity of research on the use of plant extracts, the effectiveness of extracts of secondary and organic compounds of plants (Achillea L. and X.strumarium) in the biological of P.americana was tested for the first time in Iraq to be an alternative to pesticides.

Prepare the test culture:

It was transported to the laboratory and emptied into glass tubs with a plastic cover. Biscuits and milk powder were added to these tubs to feed the nymphs. These tubs were then covered with tulle, and the method (Abd Ali, 2000) was followed. For the purpose of obtaining Oothea, the adults were fed the food mentioned above, and the egg sacs were transferred using forceps to a 650 ml plastic container containing water. After the eggs hatched, the nymphs were fed and the appearance of the adults was monitored. Slides were prepared for adult females for the purpose of diagnosis according to taxonomic keys (Abd Al- Qader, 2000).

Collecting plant samples:

Sufficient samples of the leaves of the X.strumarium, the leaves of the Haloxylon, and the leaves of the Achillea L. were collected from Um-Shawarif Road, west of the Ghams District, and the island of Al-Haydariyah and Al-Shabja, southwest sea of Al-Najaf , during the month of September and October. After the collection, they were collected. The leaves of the above-mentioned plants were taken, cleaned of dust, washed, and dried naturally in the shade at room temperature. The leaves were ground after they were completely dry using an electric grinder and stored in Plastic containers until used.

Preparation of extracts of crude secondary compounds from the leaves of X.strumarium and Achillea L

Preparation of crude alkaloid extract

An extract of the crude alkaloid compounds of the leaves of the plants Ethylene for 24 hours at a temperature of (40-45°C). The extracted material was concentrated in a rotary evaporator in order to get rid of the ethyl alcohol, and an amount of sodium hydroxide at a concentration of 10% was added to the acidic solution so that the pH became 9. After that, the solution was placed in a separating funnel and 10 ml of chloroform was added to it and shaken several times, then the mixture was left to separate into two layers took the lower layer containing the alkaloids, as the last step was repeated several times each time. We take the lower layer and neglect the upper layer until a solution of 40 ml is obtained. The collected solution was concentrated in the rotary evaporator in order to get rid of the chloroform. The samples were dried in an electric oven at 45° Celsius. This process was repeated several times to obtain a sufficient quantity of the alkaloid compounds, then they were placed in glass tubes and tightly closed in the refrigerator until use. As for the control treatment, it was by adding 20 ml of ethyl alcohol and completing the volume of 100 ml of distilled water, for the purpose of assessing the biological effectiveness of the extract of the alkaloid compounds. The concentrations and control factors were prepared according to what was mentioned in the previous paragraphs (1-2-4-3) (2-2-4-3).

2. Methodology

Sample collection:

Immature and adult cockroaches of the *P.americana* were collected from a water drainage area in Al-Hamza District in Al-Diwaniyah Governorate. Samples were also collected from some homes, restaurants, and stores located in markets in the city of Al-Diwaniyah. Samples were collected during the month of October 2023 until April 2024. The collection was done using plastic containers placed inside the sewer, as well as by picking up the insect with the hand after wearing paws.

Preparation of crude terpene extract

Prepared in the same way as the alkaloid compounds except using chloroform instead of ethyl alcohol.

Effect of crude alkaloid and terpene compounds of the leaves of *X.strumarium* and *Achillea* L. separately in destroying eggs of the *P. americana*

20 eggs that were 24 hours old were taken using a soft brush and placed in a 300 ml plastic container placed on a filter paper at a rate of 3 replicates for each concentration. The eggs were treated with the previously prepared concentrations of plant extracts and for each plant separately using a manual brush to a rate of 3 ml for each replicate. As for the control treatment it was using distilled water with the solvent used in the extraction. After that, I covered each of these dishes with a perforated petri dish lid. The dishes were incubated at a temperature of 30°C and a relative humidity of 65. The percentages of destruction were calculated and the percentages were corrected according to the Abbott equation (Abbott, 1925).

The effect of crude alkaloid and terpenoids compounds of the leaves of *X. strumarium* and *Achillea* L., separately, on the death of adults of the *P. americana*.

About 20 adults were isolated from the permanent farm of the insect for each replicate, in addition to the control factor using distilled water with the solvent used in the extraction. They were placed in a container with a capacity of 300 ml for three replicates, and (0.5) grams of biscuits were added to each container for the purpose of feeding and monitoring the adults. The mortality rates were recorded in each concentration after (24-48-72) hours, and the percentage of destruction was corrected according to the Abbott equation (1925).

Statistical analysis

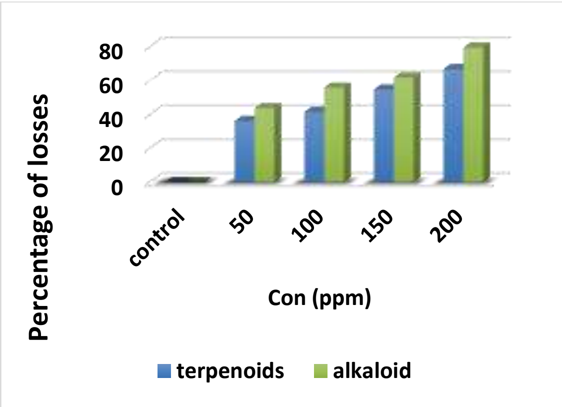
The results of the effectiveness of the extracts and secondary compounds at different concentrations and at different times against the different stages of the *P.americana* were statistically analyzed using the statistical program SPSS, version 32, where the percentages of destruction were corrected according to (Abbott, 1925), and a comparison was made between the percentages of destruction of the listed materials. The study used a two-way ANOVA test with the value of the least significant difference (LSD) calculated at a significance level of 5%. The value of LC50 was also calculated for all materials prepared in the study using a Probit analysis with the calculation of the chi-square value, the calculated probability value, and the regression equation for each compound. It was used in the study (Rahman, 2015).

3. Results and discussion

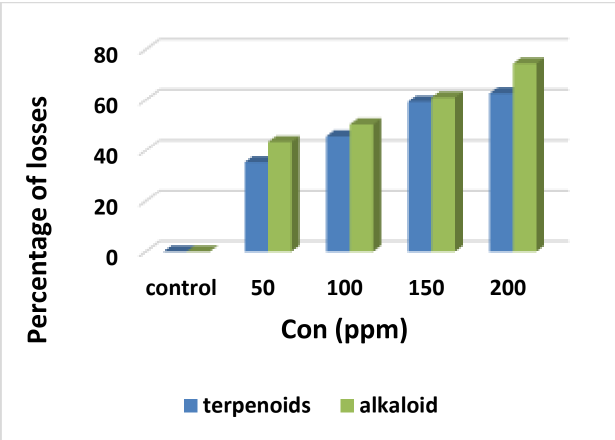
The effect of crude secondary compound extracts from the leaves of *X.strumarium* and *Achillea* L. on the non-accumulative destruction of immature and adult stages of the *P. american*.

Effect on eggs.

Shows (Fig .1) the effect of the concentrations of raw secondary compounds (alkaloids and terpenoids) of the leaves of the plants under study on the percentage of *P. americana* eggs killed, if the extract of terpenoids and alkaloids from the *X.strumarium* plant recorded a clear superiority over the extract of the terpenoids and alkaloids from the *Achillea* L. It was also noted that the extract of terpenoids compounds in both the *X.strumarium* and *Achillea* L plants was superior to the rest of the extracts of the same two plants, and it was observed that the *X.strumarium* plant was superior to the *Achillea* L. for all extracts and at all concentrations. We also notice the direct relationship between the concentrations of the extracts and the percentage of non-cumulative destruction, as the percentage of destruction increases with the increase in the concentration of the extract, so the concentration of 200 ppm gave the highest percentage of destruction for all the plants tested if the percentage of destruction reached (74, 79.33%) for the extracts of alkaloid and terpenoids compounds, respectively. The mortality rate of *Achillea* L. was 71.66 and 74.33% due to alkaloid and terpenoids extracts, respectively. (Table. 1) shows the values of LC_{50} for the mentioned secondary compounds if the value of LC_{50} reached the death of eggs. If the value of LC_{50} for eggs reached (89.21, 93.37%) for the alkaloid extract of *X.strumarium* and *Achillea* L., respectively, the LC_{50} value for the eggs was higher than the terpenoids extract of *Achillea* L. and *X.strumarium*, and the LC_{50} value was (78.22, 71.74)% for the terpenoids extract of *X.strumarium* and *Achillea* L., respectively.



Achillea L



X.strumarium

Table (**1**) Effect of concentrations of secondary crude compounds of (*X.strumarium* and *Achillea* L.) leaves on the LC_{50} value of *P. americana* eggs

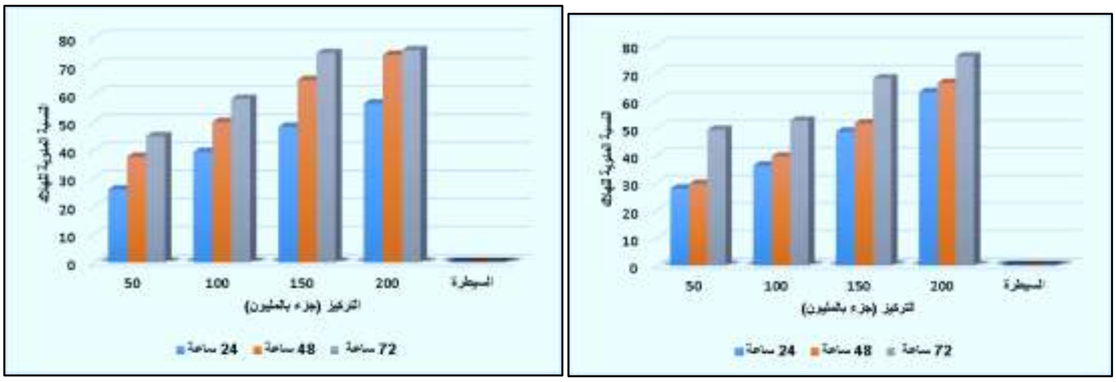
LC_{50}	*Achillea L.*		*X.strumarium*	
	terpenes	**alkaloids**	**terpenes**	**alkaloids**
LC_{50} value	**78.22**	**93.37**	**71.74**	**89.21**
Limits 95%	**0-137.03**	**32.2166.4**	**2.29-113.9**	**3.71-165.6**
X2	**0.567**	**0.998**	**0.749**	**1.95**
P value	**0.753**	**0.607**	**0.688**	**0.376**
Regression equation	$y = -2.42 + 1.28*X$	$y = -2.27 + 1.15*X$	$y = -2.71 + 1.46*X$	$y = -2.08 + 1.07*X$

Effect on adults

It is clear from (Fig. 2, 3) the effect of the concentrations of the crude secondary compounds (alkaloids and terpenes), respectively, of the leaves of the plants under study on the percentage of deaths of adults of the *P. americana*, as the superiority of the terpenoids and alkaloid extracts of *X.strumarium* and

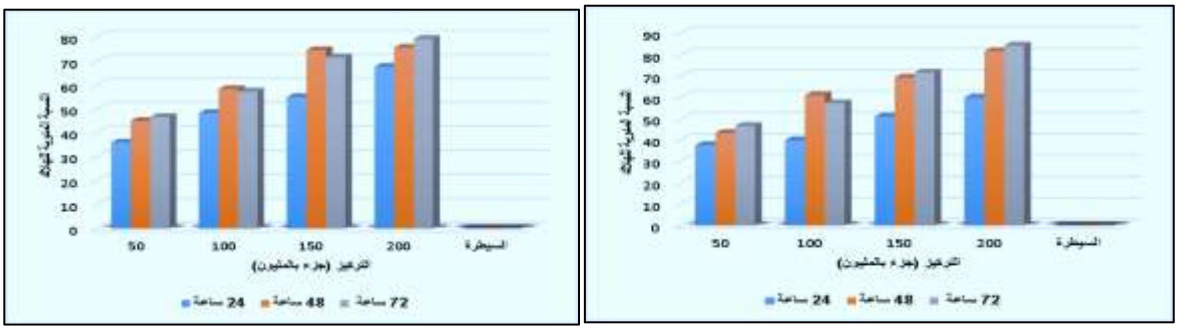
Achillea L. is also clearly observed. The alkaloid extract of *X. strumarium* was superior to the rest of the extracts of the same plant. It was observed that the *Achillea* L. was superior to the *X.strumarium* for all extracts and at the same concentrations. We also note that there is a direct relationship between the concentrations of the extract and the percentage of non-cumulative mortality, as the percentage of mortality increases with the increase in the concentration of the extract, as the concentration of 200 ppm gave the highest percentage of mortality for all the plants tested if the percentage of adult deaths within 72 hours reached (76, 75.66%) for the alkaloid extract of *X. strumarium* and *Achillea* L., respectively.

The rate of death of adults within 72 hours was (84.33, 79.33%) for the terpenes extract of *X.strumarium* and *Achillea* L., respectively. Tables (2,3) show the LC_{50} values for *P.americana* adults using all the secondary compounds of the LC*50* value of the terpenes extract within 72 hours was (63.08, 62.29) for *X. strumarium* and *Achillea* L., respectively.



Achillea L *X.strumarium*

Figure (2) Effect of concentrations of alkaloid compound extracts from the leaves of (*X.strumarium* and *Achillea* L.) on the percentage of death of the adult stage of *P.americana.*



Achillea L *X.strumarium*

Figure (3) Effect of concentrations of extracts of terpenoids compounds from the leaves of plants (*X.strumarium* and *Achillea* L.) on the percentage of death of the adult stage of *P.americana*

Table (2) Effect of alkaloid extract concentrations of (*X.strumarium* and *Achillea* L.) on the percentage of LC_{50} values of the adult stage of *P.americana*

LC_{50}	**Achillea L**			**X.strumarium**		
	24	48	72	24	48	72
IC50 value	155.76	85.65	62.99	142.5	126.1	61.48
Limits 95%	91.83-24518.1	23.77-133.14	1.98-99.16	86.2-947.5	71.11-375.4	1.08-96.12
X2	0.017	0.223	0.244	0.486	0.445	0.641
P value	0.992	0.895	0.885	0.784	0.801	0.726
Regression equation	$y = -2.91$ +1.33*X	$y = -3.07$ +1.59*X	$y = -2.64$ +1.47*X	$y = -3.13$ +1.45*X	$y = -3.18$ +1.51*X	$y = -2.15$

						+1.2*X

Table (3) Effect of terpenes extracts concentrations of (*X.strumarium* and *Achillea* L.) on the percentage of LC_{50} values of the adult stage of *P.americana*

LC_{50}	**Achillea L**			**X.strumarium**		
	24	48	72	24	48	72
IC50 value	102.12	62.99	62.29	132.78	65.68	63.08
Limits 95%	0.242-378.9	1.98-99.16	2.12-97.88	86.6-754.3	10.85-98.44	10.14-94.56
X2	0.211	0.244	0.270	0.421	0.205	0.660
P value	0.900	0.885	0.874	0.810	0.903	0.719
Regression equation	$y = -2.55$ +1.27*X	$y = -2.64$ +1.47*X	$y = -2.69$ +1.5*X	$y = -1.95$ +0.92*X	$y = -3.06$ +1.68*X	$y = -3.13$ +1.74*X

Using HPLC technology (high performance liquid chromatography) to diagnose active ingredient in tested plants.

Detection of alkaloid compounds

Table (4) indicates the results and values of the active ingredient that were identified from the alkaloid compounds from the tested plants. The shapes of the bands separated by the HPLC device can be identified, which led to the appearance of separation peaks that were identical in their retention time values and the sequence of their shapes with the separation peaks and detention times of the standard samples.

It was also noted in the table that there were three alkaloid compounds in all the tested plants: (Scopolamine - Atropine - Quinine). Their retention time in the retention time in the *Achillea* L. is (3.81 - 6.08 - 4.12) minutes, while their concentrations reached (28.0 - 27.0 - 18.0 ppm). It has been shown that the compound (Scopolamine) is used in the pharmaceutical industry, and it has also been shown that the compound (Quinine) is an antimalarial and the compound (Atropine) has not been shown to be effective.

Table (4) Identification of active ingredient in the alkaloid extract of the tested plants using HPLC technology

Bioactivity	**Concentration of the tested substance, ppm**	**Molecular weight**	**Chemical formula**	**Area %**	**Retention time of the tested substance (RT(test).**	**Standard material holding time (standard)Rt**	**Active ingredient**	**ت**	
Pharmaceutical	24.98	303.35	$C_{17}H_{21}NO_4$	40.0	3.80	3.89	Scopolamine	1	***X.strumarium***
Antimalarial	14.55	324.4	$C_{20}H_{24}N_2O_2$	15.0	4.15	4.18	Quinine	2	
anon activity	20.25	289.4	$C_{17}H_{23}NO_3$	30.0	6.08	6.08	Atropine	3	
Pharmaceutical	17.9	303.35	$C_{17}H_{21}NO_4$	28.0	3.81	3.89	Scopolamine	1	***Achillea L***
Antimalarial	13.6	324.4	$C_{20}H_{24}N_2O_2$	27.0	4.12	4.18	Quinine	2	
anon activity	10.9	289.4	$C_{17}H_{23}NO_3$	18.0	6.08	6.08	Atropine	3	

Discussion

The results of our study indicated that the extract of the terpenes and alkaloid compounds of the *X.strumarium* showed clear superiority in killing eggs. The results of the study agreed with Sarmah & Bhola (2014), who explained that the extracts of the *X.strumarium* showed significant biological activity compared to the control against the eggs of the adult tea mosquito *Helopeltis theivora*, as the acetone extract containing terpenes recorded the highest anti-nutritional activity at a concentration of 3%. Fertility, egg hatching, and longevity of *H.theivora* decreased significantly with all other organic extracts. The phytochemical analysis of *X.strumarium* extracts revealed high activity to oxidation, which can contribute to the destruction of insect eggs (Malik *et al*., 2022). The results of our study agreed with (Al-Mekhlafi *et al*., 2017), who found that the extract of it emphasizes the promising role of organic *X.strumarium* extracts in effectively targeting and destroying insect eggs, making it a valuable resource for integrated pest control programmes.

The superiority of the extract of the terpenes and alkaloids of the plant We also note that there is a direct relationship between extract concentrations and the percentage of non-cumulative mortality, and the study agreed with Jawalkar *et al*., (2021), in his study of six medicinal plants, including *X.strumarium*, for their biological activity as an insecticide. Three different concentrations (20, 30, and 40%) were extracted. Among them against the grain weevil *Sitophilus granarius* showed good performance for all extracts, especially at high concentrations. Different levels of insect death and their growth rate decreased, which led to a significant decrease in the number of insects. The death rate in adults ranged at (96.7%) at high concentration. 40% explained that all plant extracts showed an insecticidal effect in addition to an appropriate protective effect against the grain weevil *S. granarius*, and that *X.strumarium* can be chosen as an effective control treatment after formulating the appropriate dose to prevent weevil infestation in stored grains, and that the plant contains a wide range of chemical components. Plants, such as terpenes, flavonoids, alkaloids, and phenolic compounds responsible for their physiological effects and various pharmacological activities, which cause interference with poor nutrition in adult females and thus affect the metabolism process.

Our study agreed with May'I *et al*., (2016), in his study on hexane extracts of some plant species, including *Achillea santolina*, at three concentrations (1%-5%-10%), and its insecticidal activity was recorded at a rate of (76.30-73.80-66.20). % respectively against adults of the sawfly beetle *Oryzaephilus surinamensis*. The hexane extract was more effective at all concentrations used than the alcoholic extract. The reason for the death of adults may be the difference in the active composition of the plants or their containment of active ingredient that inhibit nutrition or their effect on the protease enzyme and the membrane of the middle digestive system. In addition to lower levels of sugar and total hemoline protein, the differences in mortality rates may be due to the difference in active ingredient in plants and the accumulation of these components in the digestive system, and that the epithelial cells in the digestive system of insects contain the microsomal oxidase enzyme that works to remove the toxic effect of the natural components of plants. Also, any component that affects these enzymes causes their death. Norris *et al*., (2018) showed, during his study, the effect of plant terpenes as insecticides that affect the *P. americana* octopamine receptor (PaOA1) and tyramine receptors. The researcher reported that tyramine is able to activate octopamine receptors, and octopamine is able to activate tyramine receptors in various arthropods. The study showed that monoterpenoids are able to interact with octopamine and tyramine receptors. Among the most important terpenes were terpenoids (such as Cinnamaldehyde, thymol, and vanillin). A number of terpenoids led to an increase in the calcium messenger. The second is perhaps by modulating the receptor, compared to the octopamine control. These include terpinolene, p-cymene, linalool, thymol, pulegone, 1-terpinen-4-ol, eugenol, and cinnamyl aceta. A number of terpenoids cause a significant increase in calcium, potentially indicating positive modulating activity in this receptor, when examined under this pre-incubation method. Among these substances are citronellal, d-camphor camphoric acid, d-limonene, trans-cinnamic acid, and terpenyl acetate , camphoric acid (racemic), R-carvone, and citronellic acid, and citronellic acid was the most capable of causing positive modification in this study, and the researcher concluded in his study by evaluating the toxicity of each of these terpenoids after injecting them into *Periplaneta* *americana* nymphs. R-carvone and eugenol were the most toxic. While R-carvone was a significant positive modulator of octopamine receptors, eugenol was not a significant positive modulator. Eugenol did produce positive modulation, but this was not statistically significant. Carvacrol and thymol also produced significant mortality compared to control. While they caused a slight or no modification in the octopamine receptor, it was explained that thymol and carvacrol are able to act as positive modulators in the GABAB-gated chloride channels and that carvacrol is able to inhibit acetylcholinesterase in the *German Periplaneta.* The explanation for this high toxicity of these two components is related to the modification of the octopamine receptor.

The study agreed with Roy *et al*., (2014), who explained in his study the extraction of terpenoid compounds of insecticides present in the leaves of the *X. strumarium*, and they were isolated by thin layer chromatography (TLC) and spectroscopic studies (1 H-NMR and IR) against *Callosobruchus chinensis*. L is one of the most important pests of stored grains affecting *Vigna mungo Hepper* in Bangladesh and other tropical and subtropical countries. Bioactive ingredient derived from the plant can be used to control *C. chinensis* as a potential alternative to synthetic insecticides, the extracts have shown toxicity, repellent properties, and fertility inhibition, preventing the development of adult insects, and protecting grains, the insect mortality rate was the highest (72.6%) with the 4% extract after 4 days of treatment, and the beetles showed the highest expulsion rate (58.0%) with the 4% concentration when exposed for one hour, but insect resistance decreased over time, beetles achieved the lowest fertility and grain damage and produced the fewest number of offspring when reared on grain treated with a 4% ethyl acetate extract.

HPLC technology for diagnosing the active ingredient in the tested plants and detecting the alkaloid compounds of studied the effect of neurostimulants (acetylcholine, carbachol, and pilocarpine) and some alkaline compounds such as (atropine and scopolamine) and their effect on (muscarinic acetylcholine receptors (mAChRs) in the food tissues of the *Tenebrio molitor* beetle. The data obtained indicate that the alkaline system affects The fat body and the middle intestine directly and indirectly. There is also a multi-characteristic role for mAChRs in regulating energy metabolism in insects. The tested compounds significantly affected the level of insulin-like peptides in the hemolymph. The study showed for the first time that mAChRs participate in regulating insect metabolism of tissues. Food, and acts on them directly and indirectly. Hence, the effect of these compounds on insects is recognized because the main target of their action is the nervous system, where the cholinergic system plays a vital role. Currently available insecticides are characterized by low selectivity and work on the cholinergic systems of invertebrates and vertebrates. Acetylcholine, a neurotransmitter of the cholinergic system, acts on cells through two types of receptors: nicotinic and muscarinic, as the muscarinic cholinergic system strongly affects the metabolism in insects. Atropine binds to and inhibits muscarinic acetylcholine receptors, competitively blocking the effects of acetylcholine and other choline esters and acting as a non-specific, reversible antagonist of muscarinic receptors, showing affinity for the M1, M2, M3, M4, and M5 receptor subtypes. 2 Atropine antagonizes the effects of acetylcholine on tissues innervated by postganglionic cholinergic nerves, such as smooth muscle, heart tissue, endocrine glands, and the central nervous system. It also works in smooth muscle that is less nervous and responds to endogenous acetylcholine. The effects of atropine can be overcome by increasing the concentration of acetylcholine. choline at receptor sites (e.g. using anticholinesterase agents that prevent acetylcholine degradation) (Thomson *et al*., 2021). Alamgir & Alamgir, (2018) pointed out the phytotoxins of the extract of the eggplant plant (Atropa belladonna, Solanaceae), whose roots, leaves, and fruits contain toxic alkaloids such as atropine, hyoscyamine, and scopolamine, in addition to that all parts of the genus of the angel trumpet plant (Brugmansia) contain trepans alkaloids. Scopolamine and atropine have destructive roles against insects.

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