INSECTICIDAL ACTIVITY OF CINNAMOMUM CASSIA EXTRACTIONS AGAINST THE COMMON EGYPTIAN MUMMIES' INSECT PEST (DERMESTES MACULATUS)

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Abstract

Dermestes maculatus is considered the responsible of the most serious pests which caused damage to Egyptian mummies. Hexane, petroleum ether, chloroform, acetone and ethanol extracts from Cinnamomum cassia were tested for their insecticidal activities against Dermestes maculatus larvae isolated from Egyptian mummies. Responses varied according to type of solvent, concentrations and exposure time. The results showed that the chloroform extract from Cinnamomum cassia was the most effective one at the lethal concentration (LC) $_{25,50,75,90,95\&99}$ levels against Dermestes maculatus larvae. The data also showed that the Chloroform extract at any concentration realized complete mortality after a period that did not exceed 5, 8, 10, 13, 16 days with petroleum ether, hexane, acetone and ethanol respectively.

Keywords: Mummy; Cinnamomum cassia; Dermestesmaculatus; Biological activity; Extracts

Introduction

Mummies are organic materials that need special environmental conditions due to their high sensitivity to damage, especially biological deterioration by insects. Environmental conditions in most Egyptian museums and their magazines are not appropriate for the preservation of mummies, due to the fluctuation between the relative humidity and temperature, strong light and air pollution. These factors are considered the catalysts of biological deterioration, especially for the one caused by insects.

Many mummies show signs of insect infestation, either within the wrappings or on the body. A wrapped mummy may have areas on the surface which appear to have been attacked by insects such as moth larvae, or there may be small distinctive holes indicating penetration to some depth below the surface. If a mummy is being unwrapped, similar holes may be found in the deeper layers of bandages. It is also possible to find the remains of insects between the many wrapping layers [1]. David (2000) [2] said that beetles, may have infested bodies at the time of death, during embalming, in the tomb, during transportation, or even in the museum.

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The flies require a moist food source when they are in their larvae stage, and therefore they probably infested the bodies prior to, or during, the embalming process. Insect remains can be viewed under dissection microscope or by means of scanning electron microscope (SEM). Several studies of insect remains found during autopsies of mummies have been conducted. Nair (1986) [3] states that the Dermestidae beetles could be very destructive to museum collections in tropical countries. Several species of Dermestidae beetle are belonging to genera such as *Anthrenus*, *Attagenus*, *Dermestes* and *Trogoderma*, and have been reported by Nair (1986) [3] as being present in museums.

The widespread use of pesticides has significant drawbacks including increasing cost, handling hazards, concern about pesticide residues on food, and threat to human health and environment. Public awareness of these risks has increased interest in finding safer alternative protectants to replace synthetic chemical pesticides. One such alternative is the use of natural plant protectives with pesticidal activity that tend to have low mammalian toxicity, less environmental effects and wide public acceptance [4].

The use of medicinal plants as a source for relief and illness is ancient and well documented in the written documents of the early civilization, but it is without question an art as old as mankind [5]. Medicinal plants usually produce many natural products, such as phenols, flavonoids, quinons, tannins, alkaloids, saponins, sterols, and volatile essential oils. These secondary metabolites have various functions, including antimicrobial, insecticide and appetite suppressant properties. Additionally, natural products are generally easily biodegradable. Therefore, they do not tend to persist in the environment [6]. Although, hundreds of plant species have been tested for antimicrobial and insecticide properties, the vast majority of them have not been thoroughly evaluated including cinnamon (*Cinnamomum cassia*) [5].

Cinnamon has been a favorite spice around the world not only because of its health benefits but also because it flavors and preserves food [7]. The name cinnamon refers to the tropical evergreen tree as well as the bark that is extracted from the plant. Cinnamon is known as *cannelle* in French; *ceylonzeimt/kaneel* in German; *canella* in Italian; *canela* in Spanish, *yookgway* in Chinese, *dal-chini* in Hindi and *kurunda* in Sinhalese. Cinnamon is classified in the botanical division Magnoliophyta, class Magnoliopsida, order Magnoliales and family Lauraceae. The tree grows to a height of 7 to 10 m in its wild state and has deeply veined ovate leaves that are dark green on top and lighter green underneath, both bark and leaves are aromatic, it has small yellowish-white flowers with a disagreeable odor and bears dark purple berries [8].

The genus *Cinnamomum* consists of 250 species of trees and shrubs distributed in South-East Asia, China and Australia. In India, it is represented by 26 species, of which 12 each are reported from North-East and South India. The true cinnamon, *Cinnamomumverum* syn. *C. zeylanicum*, is a native of Sir Lanka and South India. *Cassia cinnamon* is derived from different source, such as Chinese cassia (*C. cassia* syn. *C. aromatica* from China and Vietnam, Indonesian cassia (*C. burmannii*) from Sumatra and the Java region and Indian cassia (*C. tamala*) from the North-Eastern region of India and Myanmar (Burma) [9]. *Cinnamomum cassia* contains coumarin, cinnamyl alcohol, cinnamaldehyde, cinnamic acid, methoxycinnamaldehyde and cinnamyl acetate as its bioactive constituents. Cinnamon is high in antioxidant activity. The essential oil of cinnamon also has antimicrobial properties [10, 11].

The bark of the tree is used for flavoring food and beverages and also in pharmaceutical preparations and perfumery. The bark of C. *cassia* is coarser and thicker with more intense aroma than true cinnamon. The volatile oil from leaf and bark and the oleoresin from bark are used in soaps, perfumes, spice essences and beverages. While the major constituent of cinnamon bark oil is cinnamaldehyde and leaf oil *is* eugenol, both bark and leaf oils of *C. cassia* have cinnamaldehyde as the major chemical constituent. While the percentage of cinnamaldehyde in the cinnamon bark oil is 60-65, that of cassia bark and leaf oil is 70-80 [12].

During ancient times, cassia and cinnamon were both referred to, although to what extent their botanical terminology aligns with that of modern times is unknown. *C. cassia* was mentioned in Chinese herbal texts as early as 4,000 years ago [13]. Ancient records pointing to the use of cinnamon and spices date from the Old Kingdom, around 2,600 BC [13]. There is considerable doubt as to whether cinnamon and cassia were used in ancient Egypt, but Baumann (1960) [14] mentioned that in the Karnak Reliefs of the Nineteenth Dynasty, it is written: "I gather together all the countries of Punt, all their tribute, of gum of myrrh, cinnamon ..." In the Harris Papyrus from the Twentieth Dynasty as well, cinnamon is mentioned four times and cassia only once, in the lists of tributes. Because of its natural preservative properties and potent scent, cassia and cinnamon were a part of ancient embalming practices, most notably in Egypt. The art of embalming was often a partly medical and partly spiritual practice, and cinnamon played an important role in both spheres. Its chemical properties make it a practical ingredient in embalming, but its distinctive scent, high price, and vibrant color served symbolic purposes as well [15]. Pettigrew (1834) [16] mentioned that on the surface of a Twentieth Dynasty mummy was "... a thick layer of spicery ... (which) ... still retains the faint smell of cinnamon or cassia".

Recently, cinnamonum plant extracts were developed and proposed for antimicrobials and anti-fungal. Chaudhry and Tariq (2006) [7] reported the antimicrobial effect of *Cinnamomum cassia,* as well as their potential application in the treatment and prevention of diseases caused by bacterial flora. Therefore, their study represents an inexpensive or cost effective source of natural mixtures of antibacterial compounds that exhibit potentials for use in food systems to prevent the food borne bacteria and extend the shelf life of the processed food. In addition, it may be effective in reducing the number or preventing the growth of pathogenic bacterial flora e.g., *Staphylococcus aureus, Klebsiellapneumoniae, Salmonella* species, *Escherichia coli* and *Pseudomonas aeruginosa* etc.

Lee et al., 2007 [17] reported that the methanol extracts of *C. cassia* had minimum inhibitory concentration (MIC) values of 13.3mg/mL^{-1}, when tested against *Fusarium. moniliforme* and *Phyllosticta caricae*. The acetone extracts of *C. cassia* had MIC values of 8.3mg/mL^{-1} and 10mg/mL^{-1} respectively, when tested against *B. cinerea* and *G. cingulata*. The hot water extracts of *C. cassia* inhibited significantly the growth of *Aspergillus niger*, *Botrytis. cinerea*, *F. moniliforme*, and *P. caricae* with MIC values at 10.0, 11.7, 5.0, and 6.7mg/mL^{-1} respectively. Nguyen et al., 2009 [6] found that Cinnamon methanol extracts and their substrate fractions could be useful as fungicide against Rhizoctonia *solani.* AL-Saghir, 2009 [5] proved that the cinnamon Cinnamon *(Cinnamomum cassia)* extract at (250, 500 and 750mg/mL^{-1}) concentrations showed antibacterial activity against *Bacillus subtilis, Enterobacterae ruginosa, Escherichia coli, Staphylococcus aureus* and *Staphylococcus epidermidis.*

However, little study has been done on the effects of plant extracts including cinnamon against insects [18]. The present study was conduced to screen the effect of cinnamon extracts against the common mummies' pest (leather beetle).

Materials and methods

Biological material

The Dermestidae are generally oval small in size, the largest species 0.8mm in length. These chunky beetles have pale grey/brown markings which are formed of minute scales. They roll over on their backs with their legs folded and lie still feigning death. Females lay up to 150 eggs from which small hairy larvae hatch within about 3 weeks. The larval stage lasts from 5 to 15 weeks depending on temperature and food type. Larvae are hairy 'woolly bears' which have urticating properties. The pupal stage lasts 2 weeks - 2 months. The beetles enter the pupal shell towards the end of year during winter and emerge the following spring. The hide beetle, *Dermestes maculatus*, is a small, carrion-eating insect. Natural aggregations vary in size depending on the food source, but on a small carcass they typically range from one to thirteen adults. Males possess a pheromone gland on the base of their abdomen that elicits an aggregation response in both sexes. In the laboratory, the species mates and females commence oviposition within 24h following their first mating. Females are capable of ovipositing throughout their 4–6 month life span and will, given the opportunity, re-mate. Males prefer to mate with virgin females, however they will also mate with non-virgins. Females will re-mate with the same male, although less readily than with novel males. To date there has been no assessment of the skew in male or female reproductive success when individuals are maintained in aggregations [19].

Cassia (Cinnamomum cassia) barks were purchased from the market (*Abd El RahmanHarraz, Agricultural seeds, spices and medicinal plants Co.* Cairo) and were grounded to fine powder before extraction. It contains coumarin, cinnamyl alcohol, cinnamaldehyde, cinnamic acid, methoxycinnamaldehyde, and cinnamyl acetate as its bioactive constituents.

Extract preparation

250g of *Cinnamomum cassia* bark finely powdered was successively extracted with organic solvents of increasing polarities by soaking with 500mL Hexane and left 24 hrs and shaken from time to time to ensure contact between the solvent and components which leads to equilibrium and then filtered. The filtrate was evaporated and then weighed (3g taken and dissolved with 7.5mL Hexane as stock sol. to make six concentrations for the test). The residual amount of the sample was transferred to petroleum ether and the same steps were carried out in the previous solvent (the filtrate 2.6g taken and dissolved with 15mL petroleum ether). Chloroform was the third solvent used and the filtrate (2.8g) was taken and dissolved with 10mL of chloroform. Acetone was used and the filtrate (5.5g) was taken and dissolved with 15mL Acetone. Alcohol was the last solvent used and the filtrate (21g) was taken and blended with 15mL of ethanol [20].

Test on D. maculatus larvae

Several unsexed adults of *D. maculatus* were selected at random from the stock cultures to a glass jars containing the appropriate culture medium (smoked fish) to initiate new colonies

and to form numbers of larvae used for the experiment. Glass jar is provided with a screw-top lid containing a breathing hole covered with coarse filter paper. The insects are then reared under controlled atmospheric conditions in incubators (25°C and 65%RH). During this time all dead adults are removed from the test cultures and additional medium is added when necessary. Larvae of *D. maculatus* of third instars were chosen to give sensitive and accurate results.

1g sample of the fish was weighed into each of disinfected Petri dishes and mixed with different concentrations of *Cinnamomum cassia* extracts. Ten larvae of *D. maculatus* of the third instar were introduced into each of the Petri dishes containing different concentrations and the fish. The Petri dishes without any of treatment and solvents with fish sample served as the control. Concentration of mortality, $LC_{25,50,75,90,95,99}$, correlation coefficient (r), resistance ratio (RR), index, slope values and fiducially limits were estimated by using a software package ″LD-P line″″, copyright of Dr. Ihab M. Bakr, Plant Protection Research Institute.

Results and discussions

Biological activity of cassia (Cinnamomum cassia)

Using solvent fractionation, different extracts in polarities were obtained from finely ground cassia bark based on differentiation between the potency of solvent extracts:

1. Hexane extract

Biological activity of cassia hexane extract to *Dermestes maculatus* larvae was studied. Six selected hexane extract concentrations were used [0.02mL (2mg/g), 0.04mL (4mg/g), 0.08mL (8mg/g), 16mL (16mg/g), 0.032mL (32mg/g) and 0.064mL (64mg/g)]. Mortality response of hexane extract showed that the highest percentage (100%) of death was recorded with the sixth concentration (64mg/g) within one hour of the test, while the first concentration (2mg/g) was less effective, it gave 100% mortality after 11 days. There was no recorded death rate in the control sample.
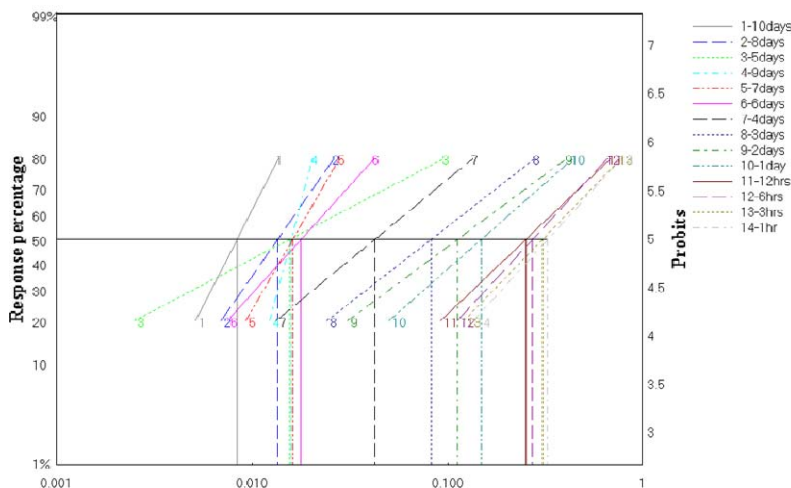

Fig. 1. Ldp lines of Hexane extract concentrations on leather beetle larvae: *D.maculatus.*

The LC $_{25,50,75,90,95\ \&\ 99}$ slope values, correlation coefficient (r), resistance ratio (RR) and index toxicity were calculated (Fig. 1). Hexane extract for all investigated times was active. $LC_{25,50\ \&\ 75}$ decreased as the number of days increased, Whereas it was found that there was a fluctuation between high and low in $LC_{90,95\&99}$ in the first eight days and a return to regularity in the ninth and tenth days.

It was found that the correlation coefficient (r), which defines the relationship between the concentrations and ratios of death, was positive and average in five of the tests (0.76, 0.77, 0.79, 0.65, 0.65 after 1hr, 3hrs, 12hrs, 9 days and 10 days respectively) and positive and strong in others. The fluctuation in slope values between up and down was recorded as slope values (2.213, 2.0884, 2.1773, 3.5074 and 7.6186) after (1hr, 3hrs, 6hrs, 7days and 9days) respectively.

The toxicity index values increased with an increase in days of exposure, so the superior efficiency of cedar wood oil was shown by the tenth day (100%). It was found that the resistance ratio (RR) of *Dermestesmaculatus* larvae to hexane extract decreased with increased duration of exposure reaching 1 by the tenth day.

In figure 2 the relationship between time and death rates (lethal time (LT)) with different concentrations was studied. It was noted that death rates increase with increasing exposure time in each concentration such as in the first concentration (LT_{25}59.46hr and LT_{99}735.37hr), in the second concentration (LT_{25}17.02hr and LT_{99}1842.05hr), in concentration three (LT_{25}11.86hr and LT_{99}1013.58hr), in concentration four (LT_{25}7.65hr and LT_{99}1004.38hr), and in concentration five (LT_{25}3.86hr and LT_{99}373.13hr). The decrease of death time with increasing concentration was shown in figure 2, for instance LT_{25} for the first concentration was 59.46hr and LT_{25} for the fifth concentration was 3.86hr. Despite the decrease of slope values with increased concentration, this was not achieved with the third and fifth concentrations. The correlation coefficient was positive and strong with all concentrations.
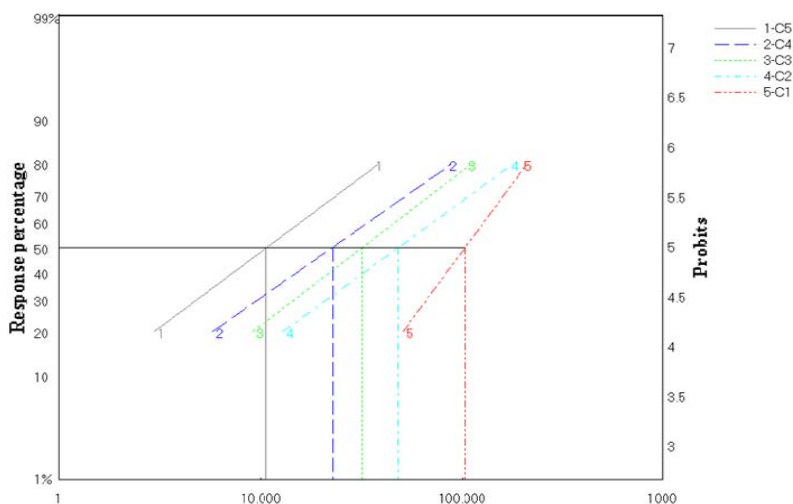

Fig. 2. LT_{50} of Hexane extract concentrations on leather beetle larvae: *D. maculatus.*

2. Petroleum ether extract

Biological activity of cassia petroleum ether extract to *Dermestes maculatus* larvae was studied. Six selected hexane extract concentrations were used (0.02mL (0.017mg/g), 0.04mL (0.034mg/g), 0.08mL (0.068mg/g), 0.16mL (0.136mg/g), 0.32mL (0.272mg/g) and 0.64mL (0.544mg/g)). Mortality response to petroleum ether extract showed that the highest percentage (100%) of death was recorded with the sixth concentration (0.544mg/g) one hour after the test, followed by the fifth concentration (0.272mg/g), the fourth concentration (0.272mg/g), the third concentration (0.068mg/g), the second concentration (0.068mg/g) and the first concentration (0.017mg/g), which gave 100% mortality after 12hrs, 5 days, 6 days, 8 days and 9 days respectively. No death rates were recorded in control.

The $LC_{25,50,75,90,95,99}$, slope values, correlation coefficient (r), resistance ratio RR and index toxicity were calculated. As shown in figure 3, petroleum ether extract for all investigated times was active. LC_{25} was decreased over time in first five days but increased in the sixth, seventh and eighth days. LC_{50} decreased over time for the first six days but increased in the seventh and eighth days. LC_{75} decreased regularly. Fluctuations in $LC_{90,95\&99}$ between the ups and downs along the test period were observed. The correlation coefficient (r) values were positive and strong during the entire test period, except on the eighth day when it was positive and average.

The resistance ratio (RR) of *Dermestesmaculatus* larvae to petroleum ether extract decreased with increasing duration of exposure, reaching 1 by the tenth day. Also the resistance ratio for the fourth and fifth days had the same value (1.25).

In figure 4, the relationship between time and death rates (LT) using different concentrations was studied. It was noted that death rates increase with increasing exposure time in each concentration, in the first concentration (LT_{25}44.35hr and LT_{99}480.23hr), in the second concentration (LT_{25}24.92hr and LT_{99}510.44hr), in concentration three (LT_{25}16.58hr and LT_{99}553.94hr), in concentration four (LT_{25}5.27hr and LT_{99}893.09hr), and in concentration five (LT_{25}0.231hr and LT_{99}21.93hr). The decrease in death time in relation to increasing concentration was also shown in figure 4, LT_{25} for the first concentration was 44.35hr and LT_{25} for the fifth concentration was 0.23hr.
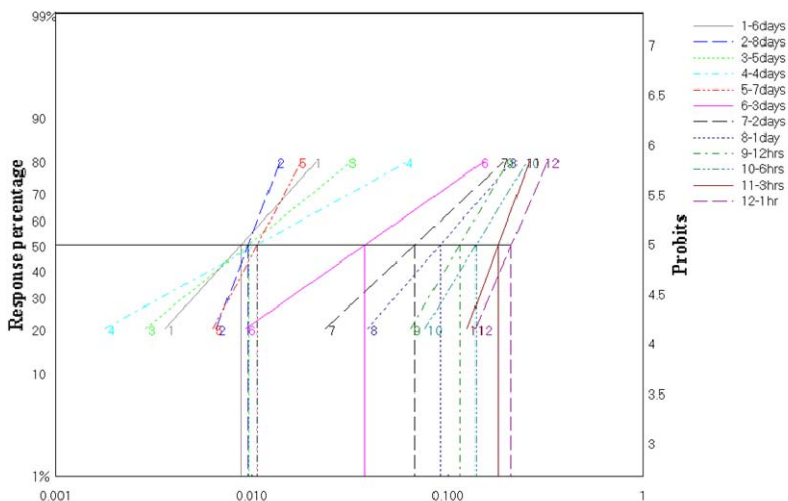

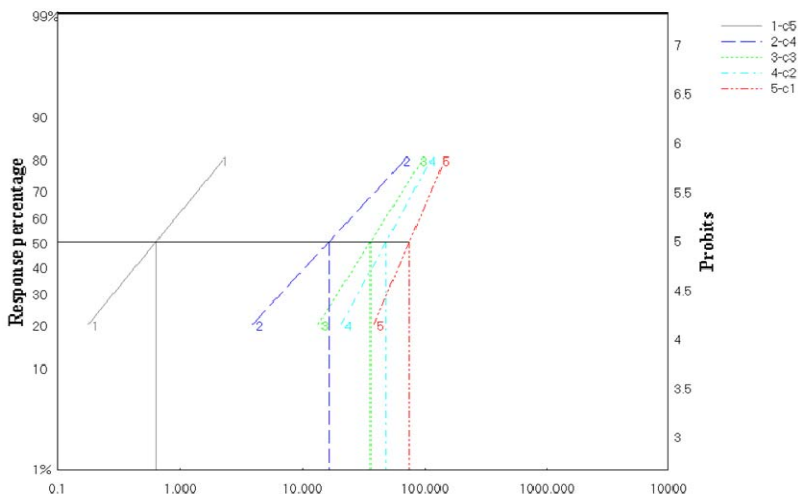**Fig. 3.** Ldp lines of petroleum ether extract concentrations on leather beetle larvae: *D.maculatus.*

Fig. 4. LT$_{50}$ of petroleum ether extract concentrations on leather beetle larvae**:** *D.maculatus.*

3. Chloroform extract

Biological activity of cassia chloroform extract to *Dermestes maculatus* larvae was studied. Six selected hexane extract concentrations were used (0.02mL (0.0187mg/g), 0.04mL (0.0374mg/g), 0.08mL (0.0784mg/g), 0.16mL (0.1496mg/g), 0.32mL (0.2992mg/g) and 0.64mL (0.5984mg/g)). Mortality response to chloroform extract shows that the highest percentage (100%) of death was recorded with the sixth concentration (0.5984mg/g) and the fifth concentration (0.2992mg/g)after one hour of the test, followed by the fourth concentration (0.1496mg/g), the third concentration (0.0748mg/g), the second concentration (0.0748mg/g) and the first concentration (0.0187mg/g) which gave 100% mortality after 12hrs, 1 day, 5 days, 7 days respectively. No death rate was recorded in the control sample.
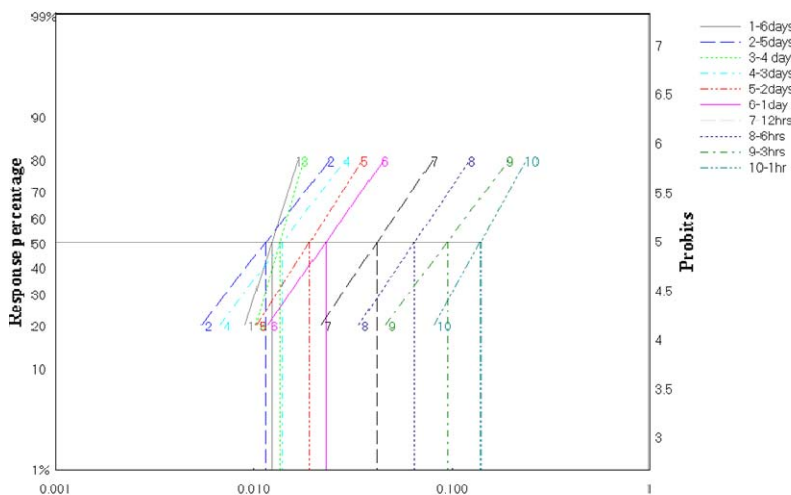

Fig. 5. Ldp lines of chloroform extract concentrations on leather beetle larvae: *D.maculatus.*

The $LC_{25,50,75,90,95,99}$, slope values, correlation coefficient (r), resistance ratio RR and index toxicity were calculated. As shown in Figure 5, chloroform extract for all investigated times was active. $LC_{25,50,75,90,95,99}$ values decreased with an increase of time for all times except on the fifth day. The correlation coefficient (r) values were positive and strong during all test periods, except on the fourth and sixth days when it was positive and average.

The resistance ratio (RR) of *Dermestes maculatus* larvae to chloroform extract decreased with increasing duration of exposure, reaching 1 on the seventh day. Also, the resistance ratio for third and fourth days had the same value (1.167).

In figure 6, the relationship between time and death rates (LT) with different concentrations was studied. It was noted that death rates increase with increasing exposure time for each concentration, such as in the first concentration (LT_{25} 12.73hr and LT_{99} 865.50hr), in the second concentration (LT_{25} 5.35hr and LT_{99} 560.82hr), in concentration three (LT_{25} 2.87hr and LT_{99} 54.02hr) and in concentration four (LT_{25} 0.89hr and LT_{99} 16.98hr).
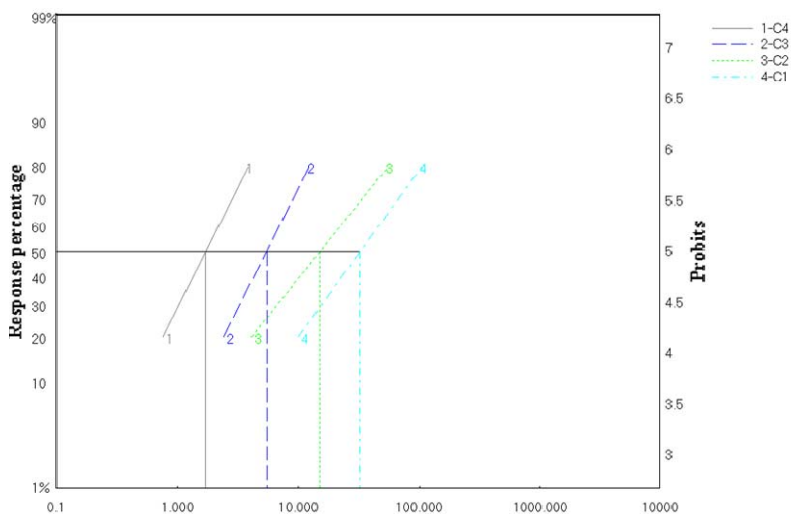

Fig. 6. LT_{50} of chloroform extract concentrations on leather beetle larvae: *D.maculatus*.

The decrease in death time with an increase in the concentration was also shown in Figure 6 such as LT_{25} for the first concentration was 12.73hr and LT_{25} and for the fourth concentration was 0.89hr. The correlation coefficient (r) values were positive and strong.

4. Acetone extract

Biological activity of cassia acetone extract to *Dermestes maculatus* larvae was studied. Six selected hexane extract concentrations were used (0.02mL (0.03727mg/g), 0.04mL (0.07454mg/g), 0.08mL (0.14908mg/g), 0.16mL (0.29816mg/g), 0.32mL (0.59632mg/g) and 0.64mL (1.19264mg/g)). Mortality response to acetone extract showed that the highest percentage (100%) of death was recorded with the sixth (1.1925mg/g) and the fifth concentration (0.596mg/g)one hour after the test, followed by the fourth concentration (0.298136mg/g), the third concentration (0.298136mg/g), the second concentration (0.074534 mg/g) and the first concentration (0.037267mg/g), which caused 100% mortality after 10 days, 11 days, 13 days, 15 days respectively. A death rate of 3% was recorded in the control sample and all results were corrected according to this percentage.

The LC$_{25,50,75,90,95\ \&\ 99}$ slope values, correlation coefficient (r), resistance ratio (RR) and index toxicity were calculated. As shown in figure 7, acetone extract for all investigated times was active. LC$_{25,50,75}$ values decreased as the number of days increased. There were fluctuations in LC$_{90,95\ \&\ 99}$ results between the ups and downs after 6hrs, 12hrs, 1day, 2days, 3days, 4days and 5days and return to decrease regularity.

LC$_{25,50,75,90,95\ \&\ 99}$ had the same value on the first and second days, this may be returned to the symmetrical mortality for each one during these days. It found that the correlation coefficient (r) values were positive and strong throughout all test periods, except on the thirteenth day when it was positive and weak, and on fourteenth day when it was positive and average.

The resistance ratio (RR) of *Dermestesmaculatus* larvae to acetone extract decreased with increasing duration of exposure, reaching 1 by the thirteenth and fourteenth days. Also the resistance ratio for the first and second days had the same value (353.33).
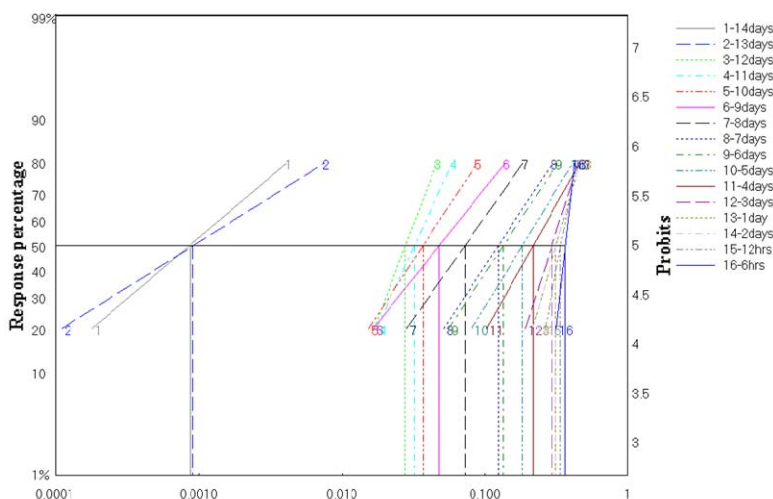

Fig. 7. Ldp lines of acetone extract concentrations on leather beetle larvae: *D.maculatus.*
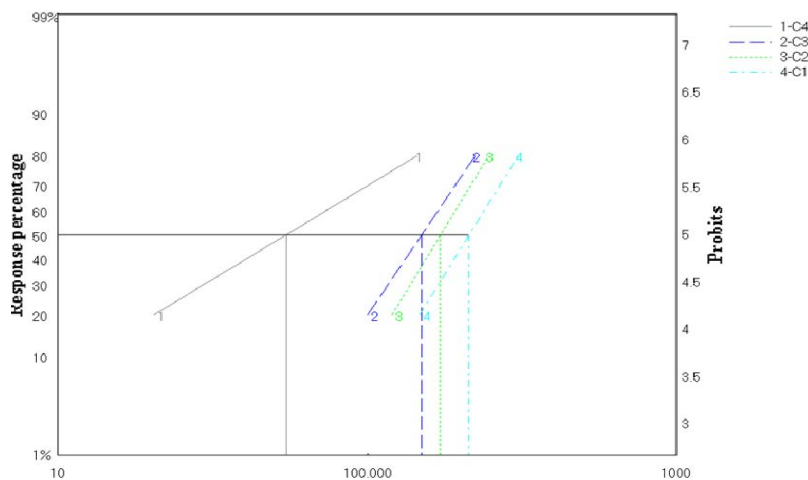

Fig. 8. LT$_{50}$ of acetone extract concentrations on leather beetle larvae: *D.maculatus.*

In figure 8, the relationship between time and death rates (LT) with different concentrations was studied. It was noted that death rates increased with increasing exposure time for each concentration such as in the first concentration (LT_{25} 159.56hr and LT_{99} 585.24hr), in the second concentration (LT_{25} 129.63hr and LT_{99} 465.97hr), in concentration three (LT_{25} 109.19hr and LT_{99} 453.42hr) and in concentration four (LT_{25} 25hr and LT_{99} 821.86hr). The shortening of the death time with an increase in the concentration was also shown in figure 8, such as LT_{25} for the first concentration was 159.56hr and LT_{25} for the fourth concentration was 25hr. The correlation coefficient (r) values were positive and strong.

5. Ethanol extract

Biological activity of cassia ethanol extract to *Dermestes maculatus* larvae was studied. Six selected hexane extract concentrations were used (0.02mL (0.14067mg/g), 0.04mL (0.28134mg/g), 0.08mL (0.56268mg/g), 0.16mL (1.12536mg/g), 0.32mL (2.25072mg/g) and 0.64mL (4.50144mg/g)). Mortality response of ethanol extract showed that the highest percentage (100%) of death was recorded with the sixth (4.50mg/g), within three hours of the test, followed by the fifth concentration (2.25mg/g), the fourth concentration (1.13mg/g), the third concentration (0.56mg/g), the second concentration (0.28mg/g) and the first concentration (0.14mg/g) which gave 100% mortality after 6 days, 10 days, 14 days, 16 days and 17 days respectively.
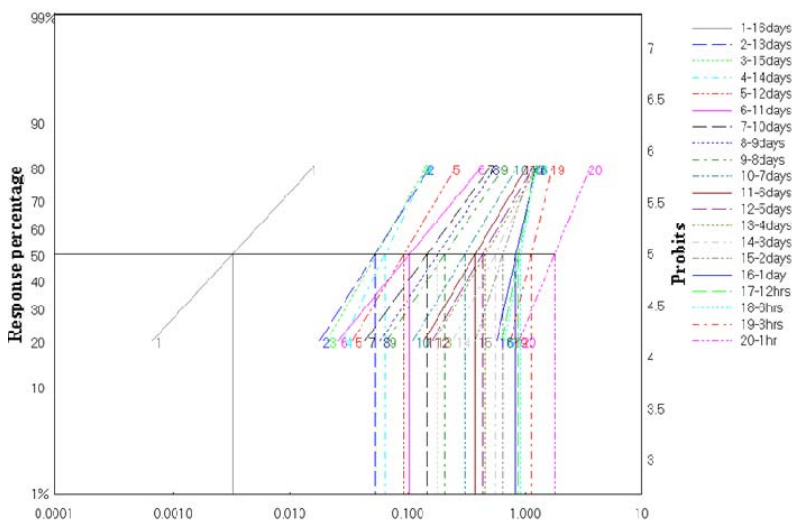

Fig. 9. Ldp lines of ethanol extract concentrations on leather beetle larvae: *D.maculatus*.

A death rate of 3% was recorded in the control sample and all results were corrected according to this percentage.

The $LC_{25,50,75,90,95 \& 99}$ slope values, correlation coefficient (r), resistance ratio RR and index toxicity were calculated. As shown in figure 9, ethanol extract for all investigated times was active. $LC_{25,50,75}$ values were decreased as the number of days increased in all times. $LC_{90,95\&99}$ decreased for the first six times then increased for the third, fourth and fifth days and returned to decreasing regularity.

It was found that the correlation coefficient (r) values were positive and strong during all test periods, except on the thirteenth day when it was positive and weak, and on the sixteenth day when it was positive and average. The resistance ratio (RR) of *Dermestesmaculatus* larvae to ethanol extract decreased with increasing duration of exposure, reaching 1 in sixteen days.

In figure 10, the relationship between time and death rates (LT) with different concentrations was studied. Death rates increased with increasing exposure time in each concentration, such as in the first concentration (LT_{25} 121.12hr and LT_{99} 852.59hr), in the second concentration (LT_{25} 89.57hr and LT_{99} 989.42hr), in concentration three (LT_{25} 24.44hr and LT_{99} 2691.08hr), in concentration four (LT_{25} 0.74hr and LT_{99} 1791.39hr), in concentration five (LT_{25} 0.33hr and LT_{99} 7.62hr), and in concentration six (LT_{25} 0.36hr and LT_{99} 2.33hr). The decrease in death time with the increasing concentration was also shown in figure 10. LT_{25} for the first concentration was 121.12hr and LT_{25} for the sixth concentration was 0.36hr.
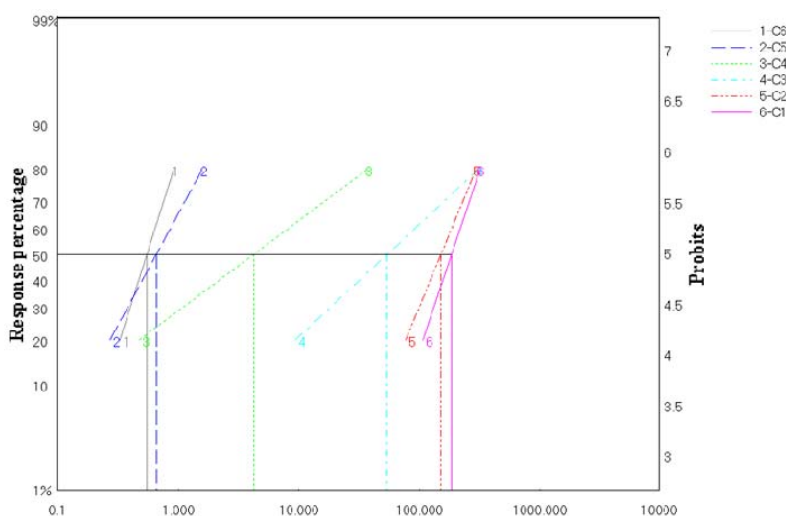

Fig. 10. LT_{50} of ethanol extract concentrations on leather beetle larvae: *D.maculatus.*

Conclusions

The activity of *Cinnamon cassia* extracts which was used against 4th instars larvae of *Dermestes maculatus* were assessed in the laboratory.

The activity of *Cinnamon cassia* extracts which was used against 4th instars larvae of *Dermestes maculatus* were assessed in the laboratory.

Cinnamon cassia was extracted by five solvents. The Data showed that the chloroform extract of cassia was the most effective against *Dermestes maculatus* larvae at the $LC_{25,50,75,90,95\&99}$ levels. Chloroform extract was followed by petroleum ether, hexane, acetone and ethanol. Chloroform extraction at any concentration realized complete mortality after a period that did not exceed 5 days, 8, 10, 13, 16 days with petroleum ether, hexane, acetone and ethanol respectively.

The Petri dishes without any of treatment and solvents with fish sample served as the control. There was no recorded death rate in the control sample of hexane, chloroform and

petroleum ether. A death rate of 3% was recorded in the control sample of acetone and ethanol. All results were corrected according to this percentage

The mortality response of *Cinnamon cassia* showed that the highest effect was yielded from sixth concentration, while the first concentration was less effective.

The Data revealed the effectiveness of *Cinnamon cassia* extracts, when used at different concentrations and after successive post-treatment periods. The obtained results obviously indicated that all the extract of *Cinnamon cassia* had a toxic effect on 4th instars larvae.

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