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Efficacy Of Wood Vinegar Toxicity On Southern Cowpea Beetle *Callosobruchus maculatus* (Fab.)(Bruchidae: Coleoptera)

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A B S T R A C T

The study proved that both eucalyptus, mulberry and willow inegar help reduce the toxicity of southern cowpea beetle at various stages (eggs, larvae, pupae and adults) when used at 2, 4, 6 and 8 percent concentrations. When comparing vinegar types, eucalyptus had a better average egg-mortality rate than the other vinegar types studied, at 73.33%, 53.33%, and 61.67%, respectively. Statistical analysis results showed a significant difference between the average egg-mortality rates of eucalyptus vinegar and the other vinegar types.The eggs were mortality more successfully as the vinegar was made more concentrated, reaching 40.00%, 51.11%, 71.11% and 88.89% respectively. The study discovered that the percentages of insect larvae mortality by vinegar were 49.16, 46.67 and 45.83%, depending on the type of wood vinegar. The results indicated that as the Vinegar concentration increased, the average mortality among the larvae grew and became 26.67. 36.67, 52.22, 73.33% for the three species in the study. The average rate of pupal deaths due to eucalyptus, mulberry and willow vinegar was 52.49, 52.77, 52.72%, respectively. As the levels of the toxic substance increased, the amount of pupal death also went up. It was demonstrated that eucalyptus vinegar mortality the highest average number of adult insects, with 55.83%, compared to the 47.50 and 42.50% results for mulberry and willow vinegar. The EUA proved that adult insect death was significantly lower when using eucalyptus vinegar compared to the other types. Adult insects experienced a higher death rate as vinegar concentration increased, reaching 26.67, 40, 55.56 and 72.22%. % Respectively.

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Introduction :

The southern cowpea beetle, C. maculatus, is one of the most prevalent and damaging storage pests of legume grains, such as beans, chickpeas, lentils, and cowpeas. The beetle infests stored grains, where the larvae feed on the seeds, reducing their nutritional value and creating the physical appearance of holed, unpleasant grains to eat [13]. It is because of this problem that the need to develop effective means of managing these pests has emerged. The methods used vary from chemical to biological, as well as the use of good agricultural practices. As effective as chemical pesticides are in mortality insects, their use comes with a host of environmental and health concerns. The pesticide residues in grains can pose a significant risk to human health upon consumption, besides their adverse impacts on the environment and non-target organisms. The shift towards safer and more environmentally friendly strategies has therefore become the need of the hour. One such promising strategy is the use of naturally derived substances procured from renewable sources [15]. Wood vinegar, a by-product from the wood thermal distillation process, is yet another of the new, eco-friendly alternatives that has been found to be effective in storage pest control. It contains high amounts of organic compounds such as organic acids, phenols, and ketones, which exhibit insecticidal properties. Research has shown that these compounds can impact the nervous system of insects and decrease their activity, thereby helping to minimize damage due to infestation [4]. The use of wood vinegar in this context is an environmentally friendly solution aimed at striking a balance between pest control and minimization of the side effects to the environment and human health. It is also an ideal choice in sustainable agriculture due to its availability and affordability compared to synthetic chemicals. A portion of the latest studies has been aimed at the role of wood vinegar in the control of storage pests, the southern cowpea beetle being one of them. Initial results have indicated that wood vinegar has been effective in suppressing the activity and damage of this pest [9]. Therefore, the study aims to determine the effectiveness of eucalyptus, mulberry and willow vinegar on the toxicity of southern cowpea beetle phases (eggs, larvae, pupae and adults).

Materials and Methods :

We obtained the southern cowpea beetle C. maculatus from a colony previously reared in the Plant Protection Laboratory of the Faculty of Agriculture and Forestry. Several pairs of the insect were then transferred to the food host used in the study, the red cowpea. After sterilizing the seeds at 55°C for four hours, they were placed in 2 kg glass containers with three replicates for each host. The containers were covered with a piece of muslin cloth using a rubber band and placed in an incubator at a temperature of 30 ± 2°C and a relative humidity of 70 ± 5%. The culture was then renewed after each generation by taking young insects to create new farms for experimental purposes [2] . 1-2 Prepare wood vinegar.

Prepare wood vinegar: Suitable wood species eucalyptus, mulberry and willow were selected, containing a high percentage of cellulose, as cellulose is the primary material that decomposes to form wood vinegar. The wood is cut into small pieces to increase its surface area. The cut wood is then placed in a fermentation reactor at high temperatures, where catalysts such as yeasts or bacteria are added to help convert the cellulose into organic acids. The preparation of wood vinegar can be summarized in the following points [5]:

The wood is burned in the absence of oxygen (destructive cracking) using a sealed furnace or iron core.

The smoke is collected and condensed using a cooling system.

The product of the distillation system is three products:

a.Wood vinegar . Prepared wood vinegar samples.

b.Wood tar.

c.Methane gas.

Insect farm preparation : The southern cowpea beetle *Callosobruchus Maculatus* (Fab) was obtained from a colony previously reared in the Plant Protection Laboratory of the Faculty of Agriculture and Forestry. Several pairs of the insect were then transferred to the food host used in the study, which is cowpea. The stages were exposed to vinegar concentrations at a rate of (3) replicates, each replicate containing (10) individuals of the insect stages. The treatments were placed in small plastic boxes with a volume of (1) kg, covered with a woven cloth and placed under laboratory conditions at a temperature of (28±2) oC and a relative humidity of 60%. The farm was renewed after each generation by taking young insects to make new farms for conducting experiments on them.

Study of the effect of eucalyptus, willow and thyme vinegar on the acute toxicity of the southern cowpea beetle C. maculatus: Egg exposure: The seeds of the host used in the study, which is cowpea, containing eggs, were taken and all eggs were destroyed except one. The seeds containing eggs were placed in small plastic boxes and exposed to vinegar concentrations (8%, 6%, 4%,

2%) at a rate of three replicates, each of which contained (10) seeds for each replicate. They were treated by spraying. As for the control treatment, it was sprayed with distilled water only. The plastic boxes were covered with a woven cloth and placed in an incubator at a temperature of 27±2°C and a relative humidity of 55±5% until the eggs emerged. The percentages of egg mortality were calculated compared to the control treatment. The percentages of mortality were corrected using Abbott mentioned in [1].

Corrected Lethality Percentage=100*Comparison in Lethality Percentage-Treatment in Lethality Percentage/Comparison in Lethality Percentage – 100.

Lines of toxicity were plotted, and the value of LC_{50} and its slope were calculated along with the confidence limits using the method of [6]. The LC_{50} values were then used to calculate relative toxicity according to the following equation:

Relative Toxicity =(Lethality of Vinegar at Higher LC50)/(Lethality of Other Vinegar LC_{50} *100

Relative Efficiency =(Lethality of Vinegar at Lower LC_{50}/Lethality of Other Vinegar LC_{50} *100 . [7]

Larval exposure: Seeds of the host used in the study, cowpea, were taken. After laying the eggs, they were left for (15) days to ensure the presence of larvae inside the grain. They were exposed to vinegar concentrations (8%, 6%, 4%, 2%) at a rate of (3) replicates, each containing (10) seeds. They were treated by spraying. As for the control treatment, it was sprayed with distilled water. The samples were transferred to an incubator at a temperature of 27±2°C and a relative humidity of 55±5% until the adults emerged. The mortality rates were compared to the control treatment. The mortality rates were corrected using the Abbott equation. The slope values, Lc50 values, relative toxicity, and relative efficacy were also calculated.

Pupae exposure: Seeds of the host used, the southern cowpea beetle, containing eggs, were taken and left for (21) days until the pupae emerged. They were exposed to vinegar concentrations (8%, 6%, 4%, 2%) at a rate of (3) Replicates, each containing (10) individuals, were treated by spraying. The control treatment was sprayed with distilled water and transferred to the incubator as above. The mortality rates, slope values, Lc50, relative toxicity, and relative efficacy were calculated.

Exposing the adults: (10) adults individuals were taken with a quantity of (10) cowpeas, placed in small plastic containers under laboratory conditions, and exposed to vinegar concentrations of (8%, 6%, 4%, 2%) in (3) replicates, each containing (10) seeds, which were treated by spraying. The control treatment was sprayed with distilled water only, and the samples were transferred to the incubator as above. The mortality rates were calculated after 24 hours and corrected using the Abbott equation. The slope values, Lc50, relative toxicity, and relative efficacy were calculated.

Set values for LC_{25} and LC_{50} : The values of LC_{25} and LC_{40} were determined from the results of the first axis (probit analysis). Probit software[6] was used to estimate the LC_{25} and LC_{40}, which at a concentration of 2.5 and 3.5 % .

Statistical Analysis: Data obtained on a shared communication system were analyzed using a completely randomized design (C.R.D.) using Duncan's multiple range test (Duncan's multiple range test) to test differences between means at the 5% probability level [3].

Results and Discussion :

The results of Table (1) showed, under concentrations of (2%, 4%, 6%, 8%), the effect of eucalyptus, mulberry and willow vinegars on the toxicity of the eggs of the southern cowpea beetle *C. maculatus*. The results of the effect of the type of wood vinegar and the concentration on the toxicity of the eggs of the southern cowpea beetle showed that the type of wood vinegar eucalyptus, mulberry and willow varied, and the percentages of mortality eggs exposed to eucalyptus wood vinegar were superior to the rest of the vinegar concentrations, as the general average of the percentages of mortality insect eggs reached 73.33%, 53.33%, and 61.67%, respectively. The results of the statistical analysis showed a significant difference in the average percentages of mortality insect eggs between eucalyptus wood vinegar and the rest of the types, such as mulberry and willow. These results are consistent with what was reported by, who reported that phenolic and alkaloid plant extracts from the seeds and leaves of the sesaban plant varied in their average mortality rate against red flour beetle *Tribolium castaneum* , reaching 66.25% and 68.33%, respectively .The death of southern cowpea beetle eggs due to exposure to wood vinegar is attributed to the presence of secondary phenolic and alkaloid compounds, which prevent gas exchange between the egg embryo and the egg. The penetration of these compounds into the egg may also explain the embryo's death and its failure to develop into larvae.

From the same table, we note that the average mortality rate of insect eggs is directly proportional to the increase in vinegar concentrations for the three types used (2,4,6 and 8%). The overall average mortality rate was 40.00%, 51.11%, 71.11%, and 88.89%, respectively. These results are consistent with what . reported, which stated that the mortality rates of the rusty red flour beetle increased with increasing concentrations of galangal and kassop seed oils (8, 6, 4, 2%), reaching 55.00%, 72.50%, 77.50%, and 80.00%, respectively. These results are consistent with what Imran et al. reported with the oil extract of black seed. It provided the highest average mortality rates for the southern cowpea beetle. These results can be explained by the fact that vegetable oils surround and encase the insect's eggs,

preventing gas exchange by closing the spiracles. Furthermore, some vegetable oils affect the behavior and functions of the nervous system, leading to a nervous shock that leads to insect death by affecting the nerve cell membrane [13].

Table (2) shows the slope values and LC_{15} and the slope values and LC_{15} and LC_{50} for the eucalyptus, mulberry, and willow vinegar types in the toxicity of the larvae of the southern cowpea beetle for the eucalyptus, mulberry, and willow vinegar types in the toxicity of the eggs of the southern cowpea beetle. The eggs are more sensitive to eucalyptus vinegar and the LC_{50} values reached 2.25%. This was confirmed by the relative toxicity values that reached 100%. The relative toxicity efficiency that gave 175.65% for eucalyptus vinegar, while raspberry vinegar was less toxic and the LC_{50} value reached 3.95% and the relative toxicity value was 56.96%. The relative efficiency was less than the rest of the vinegar types and was 100%.

The results in Table (3) clearly demonstrate the effect of eucalyptus, Willow, and Thistle vinegars at concentrations of (2%, 4%, 6%, and 8%) on southern cowpea beetle (*Callosobruchus maculatus*) larvae. The mortality rate increased with increasing concentration for each type of vinegar used. The effect began to appear at a concentration of 2% but gradually increased as the concentration increased to 8%. It also revealed a clear variation in the efficiency of vinegar among the three types, with eucalyptus vinegar generally outperforming the other types.

When analyzing the results by vinegar type, we find that eucalyptus vinegar showed the highest efficiency in mortality larvae compared to the other types. At a concentration of 2%, the mortality rate was 30%, and at a concentration of 8%, it reached 73.33%. This indicates that eucalyptus vinegar was the most effective overall across all concentrations. In contrast, oak vinegar came in second place, with a 2% mortality rate of 26.66%, gradually increasing to 70% at 8%. Willow vinegar, on the other hand, was less effective compared to the other types, ranging from 23.33% at 2% to 76.66% at 8%.When examining the effect by concentration, it is clear that the mortality rate increases with increasing concentration. At 2%, the mortality rate was 26.67% overall, then increased to 36.67% at 4%, 52.22% at 6%, and 73.33% at 8%. These results confirm that higher concentrations significantly increase the effectiveness of vinegar. In conclusion, it can be concluded that the type of vinegar and the concentration are the main factors determining the effectiveness of vinegar against southern cowpea beetle larvae. Eucalyptus vinegar showed the highest efficacy at all concentrations, while saffron inegar was the least effective, but still showed efficacy at higher concentrations. This is consistent with what [14]. reported on the use of essential oils and plant extracts, such as eucalyptus oil, in controlling stored product pests, including the cowpea beetle *Callosobruchus maculatus*. The paper compares the efficacy of various plant treatments and analyzes their impact on different developmental stages of the pest. The study is consistent with the findings of eucalyptus vinegar.

Table (4) shows the slope values, $L_{C_{15}}$, and $L_{C_{50}}$ for eucalyptus, thautum, and saffaf vinegars on the toxicity of the southern cowpea beetle larvae. Larvae are more sensitive to eucalyptus vinegar, with $L_{C_{50}}$ values reaching 4.60%. This was confirmed by the toxicity values, which reached 100%, while the relative toxicity efficiency was 109.35% for eucalyptus vinegar. Saffaf vinegar was less toxic, with $L_{C_{50}}$ values reaching 5.03% and the relative toxicity value reaching 91.45%. The relative efficiency was lower than the other vinegar types, which was 100%.

The information in Table (5) depicts the efficacy of eucalyptus, Willow, and mulberry vinegars at (2%, 4%, 6%, and 8%) levels against the pupae of southern cowpea beetle C. maculatus. The impact is similar to that on the beetle larvae, where there is a higher mortality as a function of higher vinegar levels, with clear differences in the impacts between different vinegar types. It may be observed from this table that the best overall was eucalyptus vinegar, then mulberry and Willow vinegars.

Seeing the effect of each kind of vinegar on the pupae, we notice that eucalyptus vinegar had the highest mean mortality rate among all concentrations. With a concentration of 2%, the mortality rate was 30.00%, while with 8% concentration, it was 75.55%. This indicates that eucalyptus vinegar is extremely potent, repelling, and the higher the concentration, the better it is. As for eucalyptus vinegar, it had similar results too, with 31.11% mortality at 2% and 75.55% at 8%. Hence, this type of vinegar also was effective, but did not beat eucalyptus in overall mean.

For Willow vinegar, it showed similar efficacy to eucalyptus vinegar, ranging from mortality rates of 31.11% at 2% to 75.55% at 8%. While Willow vinegar was less effective than eucalyptus at low concentrations, it was effective at high concentrations.

As far as the effect of concentration is concerned, there actually is a direct correlation between increased mortality rate and increased vinegar concentration. For 2%, the total mortality rate was 31.11%, while it was 75.56% for 8%. This indicates that increasing concentration significantly increases the effectiveness of vinegar against pupae. Based on these results, it can be concluded that the amount and quality of the vinegar both significantly affect how

effective it will be in mortality southern cowpea beetle pupae. The most effective of them was eucalyptus vinegar at all levels, and Willow vinegar was less effective at low levels but highly effective at high levels. This is consistent with [10]. results of natural plant derivatives and their anti-feedant and toxic activities used in pest control. This entailed a broad comparison of how plant materials, like eucalyptus, affected insect pests, like the cowpea beetle *C. maculatus*, at different concentrations.[11]. also found that essential oils from plant families are insecticidal to *C. maculatus*, consisting largely of the Lamiaceae and Asteraceae families. Terpenoid and succinate compounds are most significant in the efficiency of essential oils. Different tests were used in determining the efficiency of essential oils, such as inhalation toxicity, contact toxicity, and repellency tests. The study revealed that the essential oils target the enzyme acetylcholinesterase (AChE), target modulating gamma-aminobutyric acid (GABA) receptors, and target octopamine receptors, revealing their overall mode of action against insects.

Table (6) shows the slope values, $L_{C_{15}}$, and $L_{C_{50}}$ for eucalyptus, thautum, and saffaf vinegars on the toxicity of southern cowpea beetle pupae. Pupae were more sensitive to saffaf vinegar, with $L_{C_{50}}$ values reaching 4.02%. This was confirmed by the relative toxicity values, which reached 100%. The relative toxicity efficacy of saffaf vinegar reached 101.24%, while eucalyptus vinegar was less toxic, with LC_{50} values reaching 4.07% and a relative toxicity value of 98.77%. The relative efficacy was lower than that of the other types, reaching 100%.

Findings in Table (7) show the effectiveness of eucalyptus, saffron, and mulberry vinegars at concentrations of (2%, 4%, 6%, and 8%) on the adult Southern Cowpea Beetle *C. maculatus*. The effect was similar to that achieved on the larvae and pupae, such that the percentage of death rose with increasing concentration of vinegar. There was also variation in the type of vinegar used in affecting the adult beetles, and eucalyptus vinegar had the highest level of mortality compared to the other types. For the eucalyptus vinegar, the result showed that it was most effective at all levels. At the 2% level, the mortality rate was 33.33%, while when the level increased to 8%, the mortality rate was 80%. These results confirm that the adult Southern Cowpea Beetle is highly affected by eucalyptus vinegar and that the effect becomes greater with greater concentrations.

Mulberry vinegar, however, had an effective result but was weaker than eucalyptus. The mortality rate was 26.66% at a concentration of 2%, and at 8%, it was 70%. Even if the vinegar didn't get close to the eucalyptus's effectiveness level, it improved notably with higher concentration. Saffron vinegar was the lowest performing at both concentrations, with a mortality rate of 20% at a 2% concentration and 66.66% at an 8% concentration. In the findings, it was shown that the increase in concentration had a positive effect on Saffron vinegar's efficacy, but not to that of either eucalyptus or saffron. In terms of the general effect of concentration, a rise in concentration of vinegar resulted in a rise in mortality rate. At 2% concentration, the general mortality rate was 26.67%, rising to 40.00% at 4%, 55.56% at 6%, and 72.22% at 8%. This indicates that the higher concentration of vinegar is most effective in mortality adult beetles. The overall finding of the analysis is that the percentage and nature of the vinegar impact the efficacy of the vinegar in managing the Southern Cowpea Beetle adult. The most potent vinegar at all percentages was eucalyptus vinegar, followed by worm vinegar, while saffron vinegar was the least effective at low percentages but showed high efficacy at high percentages. This is in accordance with the work of [9] that the peppermint and eucalyptus oils are able to suppress the reproduction of the beetle considerably, by up to 70% in some cases. Cinnamon and basil spices are also effective in the elimination of the beetle because their oils degenerate the insect's ability to reproduce and feed.

Table (8) shows the slope, $L_{C_{15}}$, and $L_{C_{50}}$ values for eucalyptus, Thistle, and Willow vinegars on the toxicity of the southern cowpea beetle adults. The adults were most sensitive to eucalyptus vinegar, with LC_{50} values reaching 3.70%. This was confirmed by the relative toxicity values, which reached 100%. The relative toxicity efficiency of eucalyptus vinegar was 151.62%, while the relative toxicity of willow vinegar was less toxic, with $L_{C_{15}}$ values reaching 5.61% and the relative toxicity value reaching 65.95%. The relative efficiency was lower than the other vinegar types, which was 100%.

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Table 1. Efficiency of wood vinegar toxicity of eggs southern cowpea beetle *C. maculatus*

Vinegar Type	Conc. (%)	Range	% Mortality	Vinegar Type Overall Mean
Eucalyptus	2	(60-40)	53.33 cdb	a 73.33
	4	(80-40)	60.00 cdb	
	6	(100-60)	80.00 ab	
	8	(100-100)	100.00 a	
mulberry	2	(40-20)	33.33 d	b 53.33
	4	(60-20)	46.67 cd	
	6	(80-40)	60.00 cdb	
	8	(80-60)	73.33 cab	
Willow	2	(40-20)	33.33 d	ab 61.67
	4	(60-40)	46.67 cd	
	6	(80-60)	73.33 cab	
	8	(100-80)	93.33 a	
Overall Mean for Concentration	2		40.00 c	
	4		51.11 c	
	6		71.11 b	
	8		88.89 a	

* means with different letters in the same sectors showed a significant difference at p= 5%.

Table 2. slope values and lethal concentrations of delayed toxicity and confidence limits for vinegar of some types of wood in the eggs of the southern cowpea beetle *C. maculatus*.

Vinegar Type	Slope	LC_{15}	LC_{50}	Confidence Limits	Relative Toxicity	Relative Efficiency
Eucalyptus	2.24	0.84	2.25	4.65-1.85	100	175.56
mulberry	1.68	0.96	3.95	4.69-3.22	56.96	100
Willow	2.79	1.42	3.34	4.45-2.76	67.36	118.26

Table 3. Efficacy of wood vinegar toxicity of larvae southern cowpea beetle *C. maculatus*

Vinegar Type	Conc. (%)	Range	% Mortality	Vinegar Type Overall Mean
Eucalyptus	2	(40-20)	30.00 dc	a 49.165
	4	(50-30)	40.00 bc	
	6	(60-50)	53.33 b	
	8	(80-70)	73.33 a	
mulberry	2	(30-20)	26.66 dc	a 46.67
	4	(40-30)	36.66 dc	
	6	(60-50)	53.33 b	
	8	(80-60)	70.00 a	
Willow	2	(30-20)	23.33 d	a 45.83
	4	(40-30)	33.33 dc	
	6	(60-40)	50.00 b	
	8	(80-70)	76.66 a	
Overall Mean for Concentration	2		26.67 d	
	4		36.67 c	
	6		52.22 b	
	8		73.33 a	

* means with different letters in the same sectors showed a significant difference at p= 5%.

Table 4. slope values, lethal concentrations for delayed toxicity, and confidence limits for vinegar of some wood species on the larvae of the southern cowpea beetle, *C. maculatus*.

Vinegar Type	Slope	LC_{15}	LC_{50}	Confidence Limits	Relative Toxicity	Relative Efficiency
Eucalyptus	1.75	1.18	4.6	5.50-3.87	100	109.35
mulberry	1.82	1.34	4.97	5.96-4.23	92.55	101.21
Willow	2.27	1.67	5.03	5.95-4.55	91.45	100

Table 5. Efficacy of wood vinegar toxicity of pupae southern cowpea beetle, *C. maculatus*

Vinegar Type	Conc. (%)	Range	% Mortality	Vinegar Type Overall Mean
Eucalyptus	2	(40-20)	30.00 cd	a 52.49
	4	(50-40)	45.55 c	
	6	(60-50)	58.88 b	
	8	(80-70)	75.55 a	
mulberry	2	(40-30)	31.11 d	a 52.77
	4	(50-40)	45.55 c	
	6	(70-50)	58.88 b	
	8	(90-70)	75.55 a	
Willow	2	(40-20)	31.11 d	a 52.72
	4	(60-30)	45.55 c	
	6	(70-50)	58.88 b	
	8	(80-70)	75.55 a	
Overall Mean for Concentration	2		31.11 d	
	4		45.56 c	
	6		58.89 b	
	8		75.56 a	

* means with different letters in the same sectors showed a significant difference at p= 5%.

Table 6. Slope values, lethal concentrations for delayed toxicity, and confidence limits for vinegar of some wood species on pupae southern cowpea beetle *C. maculatus*

Vinegar Type	Slope	LC_{15}	LC_{50}	Confidence Limits	Relative Toxicity	Relative Efficiency
Eucalyptus	1.92	1.18	4.07	4.74-3.43	98.77	100
mulberry	1.88	1.13	4.02	4.71-3.37	100	101.24
Willow	1.88	1.31	4.02	4.71-3.37	100	101.24

Table 7. Efficiency of wood vinegar against of adults Southern Cowpea Beetle *C. maculatus*.

Vinegar Type	Conc. (%)	Range	% Mortality	Vinegar Type Overall Mean
Eucalyptus	2	(40-30)	33.33 F	a 55.83
	4	(50-40)	46.66 de	
	6	(70-60)	63.33 bc	
	8	(90-70)	80.00 a	
mulberry	2	(30-20)	26.66 gf	b 47.50
	4	(40-30)	36.66 ef	
	6	(60-50)	56.66 cd	
	8	(80-60)	70.00 ab	
Willow	2	(30-10)	20.00 g	b 42.50
	4	(40-30)	36.66 ef	
	6	(50-40)	46.66 ed	
	8	(70-60)	66.66 cb	
Overall Mean for Concentration	2		26.67 d	
	4		40.00 c	
	6		55.56 b	
	8		72.22 a	

* means with different letters in the same sectors showed a significant difference at p= 5%.

Table 8. Slope values, lethal concentrations for delayed toxicity, and confidence limits for vinegar of some wood species on the adults southern cowpea beetle *C. maculatus* .

Vinegar Type	Slope	LC_{15}	LC_{50}	Confidence Limits	Relative Toxicity	Relative Efficiency
Eucalyptus	2	1.12	3.7	4.29-3.10	100	151.62
mulberry	1.89	1.36	4.8	5.68-4.10	77.08	116.88
Willow	2.01	1.71	5.61	6.74-4.84	65.95	100