# ASSESSMENT OF THE TOXICOLOGICAL PROPERTIES OF LATTICE OF SELECTED PLANTS AGAINST THE MAIZE WEEVIL (*Sitophilos zeamais* (Motschulsky) (Coleoptera: Curculionidae) ON MAIZE IN STORAGE

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## ABSTRACT
Studies were conducted to evaluate the toxicological properties of rubber (*Hevea brasiliensis* L) and pawpaw (*Carica papaya* L.) lattices against the maize weevil (*Sitophilus zeamais* Motschulsky) (Coleoptera: Curculionidae) on stored maize at two concentrations (4 and 6 mls). The experiment consisted of five treatments (two concentrations 4 and 6mls each of *H. brasilienesis* and *C. papaya* and untreated control) and four replications in a Completely Randomized Design (CRD). Results revealed significant differences (P<0.05) on the effect of test plant lattices on the mortality of the insect. The most toxic plant latex was the higher concentration (6%) of *H. brasiliensis*, while the least efficacious was *C. papaya* at 4%. Both *H. brasiensis* and *C. papaya* lattices significantly (P<0.05) suppressed the F1 progeny of *S. zeamias* when compared with the control. The highest percentage progeny (32.46%) emerged in jars treated with 4% latex of *C. papaya* and the least emergence of 14.54% was observed at 6% level of *H. brasiliensis* latex. Among the trial plant lattices, the highest percentage weight loss of grains was observed on seeds treated with 4% latex of *C. papaya*, which were however statistically heavier than the untreated control grains. Lattices of the two plants significantly (P<0.05) provided protection to the grains against damage by the weevil. Percentage grain damage (49.89%) was highest in untreated control jars. The least grain damage (11.97%) was recorded by *H. brasiliensis* at 6% dosage level. Results of phytochemical study of the test lattices revealed the presence of the phytochemical constituents at varying degrees. It was therefore, apparent that these phytochemicals are likely responsible for the toxicological properties exhibited by these plant lattices. The presence study confirms the toxicological activities of plant latex, their effect on *S. zeamais* and potential future use in biopesticide formulation for safe control on insect pests of stored products in an environmental friendly manner.

**Keywords**: Toxicological Properties, plant lattices, maize weevils (***S. zeamais***), stored maize.

## INTRODUCTION
Maize (*Zea mais* L.) is an annual crop belonging to the family poacese. In many countries, it has almost replaced earlier grown cereals such as sorghum, millet etc. (Onwueme and Sinha, 1991). Maize is the world's most widely grown cereal and essentially a food source of millions of the world's poor (Ferris and Graver, 2000). According to Food and Agricultural Organization FAO (2013), 589 million tonnes of maize was produced worldwide in 2000 on 138 million hectares of land. Maize is an important crop of West Africa including Nigeria (Onwueme and Sinha, 1991). Bonsall (1999) reported that maize is also a versatile crop that grows across large agro-ecological zones. Maize is one of the main cereal crops of West Africa and one of the most important cereal crops in Nigeria. Nigeria produces 30 million tonnes of maize per year (FAO, 2013). It comes after wheat and rice in terms of world importance (Ferris and Graver, 2000). Maize has been of great importance in providing food for men, feed for livestock and raw materials for agro-brazed industries. Maize is a staple food in many regions of the world particularly in developing countries (FAO and ILO, 1997). Maize is the number one feed grain in the world, it is used extensively as the main source of carbohydrate in animal feeds and feed formulation (Wikipedia, 2006).

Postharvest crop management is critical in crop production. This is due to the fact that substantial losses occur during storage of produce in developing countries, a major part of which is due to insect attack. A serious pest of maize in the field and storage is the maize weevil *Sitophilus zeamais* Motsch. The beetle cause characteristic damage to maize by making holes on the grain that is about 1mm in size in which the adult female deposit eggs. Maize weevil damage results directly in lost food ready for consumption or lost cash from farmers pocket ready to buy other valuable resources for the family. Damage of grains by *S. zeamais* has resulted to about 5%-10% losses after 6 months storage period (Nilsa and perez, 1995). Cabi (2010) stated that maize weevils population builds up the longer the maize is kept in store resulting to weight loss of 30%-40%.

Many control strategies have been adopted for the control of this notorious stored product pest of cereal crop including the use of synthetic pesticides with varying degrees of success. Synthetic insecticides are generally preferred due to easy availability and potency, but their indiscriminate use has resulted into development of pesticide resistance, longer residual persistence in the environment, poison the food chain generate undesirable effects against humans, toxicity to fish and beneficial organisms. Thus alternatives to synthetic chemicals have been explored in the form of pesticides of natural or plant origin, which have low impact on the environment, exhibit low toxicity to humans and have low costs. Onolemhemhem and Oigiangbe (1991) revealed that various plant materials and plant extracts have been used effectively to control storage pests of cereals, legumes and to a limited extent field pests.

Plant latex is a natural plants polymer secreted by highly specialized cells known as laticifers (Hagel *et al*; 2008). Studies have revealed the insecticidal potential of latex-bearing plants. Plant latex show deleterious effects like toxicity, antifeedant, growth and reproduction inhibition on a number of insect species (Carlin and Grossi-de-sa, 2002). According to Ogunleye and Omotoso (2011), *Jatropha curcas* offered 100% mortality of adult *S. zeamais* at the rates of 0.3mls and 0.4mls after 24 hours of application. The insecticidal activity of *Calotropis procera* have been tested and reported by Vikash (2003). The plant latex of *C. procera* at the rates of 1.5mls and 2.0mls evoked 100% mortality of adult *Callosobruchus maculatus* after 4 days. Braga *et al*, (1997) reported that *Hevea brasiliensis* latex protected the seeds of cowpea (*Vigna unguiculata* L.) against *C. maculatus*. Latex from few plant families possess phytochemicals which showed insecticidal activity (Shaalan *et al*; 2005). Thus the import of this study was to determine the efficacy of two latex bearing plants *H. brasiliensis* and C. papaya and their phytochemicals against the maize weevils *S. zeamais*.

## MATERIALS AND METHODS

The experiment was conducted in the Pest Management Technology Laboratory of Federal College of Agriculture, Ishiagu, Ebonyi State, Nigeria. Ishiagu is located between latitude N5$^0$ 55' and N6$^0$ 00' and longitudes E7$^0$ 30' and E7$^0$ 35' (Ezepue, 1984) in the south-East agro-ecological zone. The relief is low-lying and undulating.

**Insect culture**: A culture of *S. zesmais* Motsch was maintained on a susceptible maize variety TZSR-Y. The insect was reared in a growth chamber (5L) in the laboratory at 28+2$^{0c}$, 70+5% relative humidity with a light/dark photoperiod of 12:12 hours. The test crop maize grain was fumigated with phostoxin for 48 hours to obtain on insect free grain.

**Collection of Plant Latex**: Latex was obtained from the stems of both plants in separate aseptic glass vessels. Lattices were collected by tapping method in which sharp incisions were made on tree trunks to open the latex vessels in the bark to collect unconjugated latex in sterile plastic vessels following the method adopted by Buranov and Elmuradov (2010). The lattices were therefore stored under refrigeration at -20$^{0c}$ until used.

**Experiment**

Fifty grammes maize grain was weighed into each of the kilner jars using an electric balance. With a syringe, lattices derived from Para rubber *H. brasiliensis* and *C. papaya* plants were collected at two volumes of 4 and 6mls each and dropped into 500mls measuring cylinder. Therefore, the products (lattices) were homogenized in water through a serial dilution of each of these volumes by pouring 100mls of distilled water into each cylinder of the latex corresponding to 4 and 6% concentrations of the lattices. The 50g uninfected maize grains in kilner jars were steeped in solutions of 4 and 6mls latex treatment concentrations in 100mls beaker for 30 seconds and latex air-dried for 4 hours. Maize grains immersed in sterile water served as control. Therefore, each jars was inoculated with 22 days old adults of *S. zeamais* and later covered with muslin white cloth with perforated lid to ensure ventilation. Treated and untreated jars were arranged in a completely randomized design (CRD) with four replications on laboratory table undisturbed.

Adult mortality of the weevils was assessed at 1, 3 and 7 days after insecticidal treatment data obtained was arcsine transformed. After adult mortality assessment, the maize grains were carefully returned to the jars and allowed to stay for 35 days for progeny development. A count of the emerging adults was taken and square root transformed. At the end of the storage, weight loss of grains was determined by re-weighing the grains left in each experimental jar. The differences in weight between the weight at the commencement of the study and at the end of the experiment constitute loss in weight due to the insect pest activity. Percentage weight loss was calculated by the method of FAO (1985) as:

% weight loss= (UaN-CU+D) X 100UaN X 1

Where U= weight of undamaged fraction in the sample

N= total number of grains in the sample

Ua= average weight of undamaged grains

D= weight of damaged fraction in the sample.

Grain damage was observed through a random selection of 100 grains from each treatment and a count of the number of grains with adult emerged holes.

**Data Analysis**: Data obtained were subjected to analysis of variance (ANOVA) and significant means were separated using the Least Significant Difference test at 5% level of probability.

Therefore, the phytochemical composition of the plant materials (*H. brasiliensis* and *C. papaya*) studies was analyzed following the method of Oberlease (1973).

## RESULTS AND DISCUSSION

Results in Table showed that they were no significant differences among the treatments on insect mortality 1 day post-infestation. However, at days 3 and 7 after insect infestation, potencies of the plant derived products differed statistically such that by day 7, the highest percentage mortality (74.11%) of the weevil occurred in jars treated with the higher dose (6%) of *H. brasiliensis* latex, which was followed by the lower concentration (94%) of *H. brasiliensis* 69.30% and the higher rate 6% of *C. papaya* with toxicity of 59.12%. The least potent of the trial plant lattices was 4% C. papaya with 45.75% mortality, which was however statistically more toxic than the untreated control, which did not record any mortality.

The lattices of both *H. brasiliensis* and *C. papaya* significantly suppressed the F1 progeny of *S. zeamais* when compared with the control (Table 2).

Among treatments, the most effective in protecting grains against post embryonic development was 6% concentration of *H. brasiliensis* with 14.54% progeny emergence, while the least efficacious was C. papaya at 4% (32.46%). Progeny emergence was inversely concentration dependent as the higher the concentration of insecticidal treatments the lower the progeny development.

The lowest percentage weight loss of the grains was recorded by *H. brasiliensis* latex at 6% (Table 3), which was significantly (P<0.05) different from the 4% concentration of *H. brasiliensis* and the higher rate of *C. papaya* at 6%. The highest percentage weight loss of grains was found o seeds treated with 4% latex of *C. papaya*, which were however, statistically heavier than the untreated control grains.

Table 4 revealed the effect of the test lattices on grain damage, in which the plant lattices of both *H. brasiliensis* and *C. papaya* significantly (P<0.05) provided protection to the grains against *S. zeamais* damage. Percentage grain damage (49.89%) was highest in untreated control jars. The least grain damage (11.97%) was recorded by *H. brasiliensis* at 6% dosage level, which statistically differed with the rest treatments.

The result of phytochemical study shown in Table 5 revealed the typical composition of the plant materials assayed including alkaloids, flavonoids, saponins, tannins, oxalates and phenols but in different

**Proportions:**

**Table 1: Effects of Latex on Adult Mortality of *Sitophilus zeamais* at Days 1, 3 and 7 after Treatment.**

| **Treatments** | **Con.**(mls/ 50g, grains) | No of insects inoculated | Mean No of dead insects in days 1,3 & 7 | | | Mean % mortality in days | | |
|---|---|---|---|---|---|---|---|---|
| | | | **1** | **3** | **7** | **1** | **3** | **7** |
| ***H. brasiliensis*** | **4.00** | **20** | **0.25(0.39)** | **0.5(0.78)** | **17.5(4.21)** | **1.3(6.6)** | **2.5(9.1)** | **87.5(69.30)** |
| ***H. brasiliensis*** | **6.00** | **20** | **0.5(0.79)** | **1.00(1.57)** | **18.50(4.30)** | **2.50(9.10)** | **5.00(12.9)** | **92.5(74.11)** |
| ***C. papaya*** | **4.00** | **20** | **0.00(0.00)** | **0.25(0.39)** | **10.25(3.08** | **0.00(0.00)** | **1.25(6.55)** | **51.25(45.75)** |
| ***C. papaya*** | **6.00** | **20** | **0.00(0.00)** | **0.25(0.39)** | **14.75(3.84)** | **0.00(0.00)** | **1.25(6.55)** | **73.75(59.12)** |
| **Control** | | **20** | **0.00(0.00)** | **0.00(0.00)** | **0.00(0.00)** | **0.00(0.00)<br>0.00(0.00)<br>0.00(0.00)** | | |
| **LSD (0.05)** | | | **NS** | **0.69** | **0.97** | | | |

**Figures in parenthesis are arcsine values to which LSD is applicable.**

**Table 2: Effect of Latex on Progeny Emergence**

| **Treatments** | **Conc. (mls/50g grains)** | **No of insects Inoculated** | **Mean F1 generation** | **% F1 generation** |
|---|---|---|---|---|
| ***H. brasiliensis*** | **4.00** | **20** | **2.75 (1.6526)** | **13.75 (21.81)** |
| ***H. brasiliensis*** | **6.00** | **20** | **1.25 (1.1036)** | **6.25(14.54)** |
| ***C. papaya*** | **4.00** | **20** | **5.75 (2.3961)** | **28.75(32.46)** |
| ***C. papaya*** | **6.00** | **20** | **4.25 (2.0590)** | **21.25 (27.49)** |
| **Control** | | **20** | **17.25 (4.1530)** | **86.25 (68.28)** |
| **LSD** | | | **0.2076** | |

**Table 3: Effect of Latex on Weight Loss of Grains after 3 Months of Storage**

| **Treatments** | **Conc. (mls/50g grains)** | **Initial weight Of grains** | **Final weight Of grains** | **Weight loss of grains** | **% weight loss** |
|---|---|---|---|---|---|
| ***H. brasiliensis*** | **4.00** | **200** | **163** | **37.00 (6.08)** | **18.50 (24.48)** |
| ***H. brasiliensis*** | **6.00** | **200** | **186** | **14.00 (3.74)** | **7.00 (15.34)** |
| ***C. papaya*** | **4.00** | **200** | **126** | **74.00 (8.60)** | **37.00 (37.47)** |
| ***C. papaya*** | **6.00** | **200** | **143** | **57.00 (7.55)** | **28.50 (32.27)** |
| **Control** | | **200** | **49** | **151.00 (12.29)** | **75.50 (60.33)** |
| **LSD (0.05)** | | | | **0.13** | |

**Table 4: Effect of Latex on Grain Damage**

| **Treatments** | **Conc. (mls/50g) Grains** | **No. of grains sampled** | **Means no. of grains with adult emerged holes** | **% grains damage** |
|---|---|---|---|---|
| *H. brasiliensis* | 4.00 | 100 | 14.00 (3.7417) | 14.00 (21.97) |
| *H. brasiliensis* | 6.00 | 100 | 4.25(2.0509) | 4.25 (11.97) |
| *C. papaya* | 4.00 | 100 | 20.00 (4.47) | 20.00 (26.56) |
| *C. papaya* | 6.00 | 100 | 19.00 (4.36) | 19.00 (25.84) |
| Control | | 100 | 58.50 (7.65) | 58.50 (49.89) |
| LSD (0.05) | | | 0.08 | |

**Table 5: Results of Phytochemical Analysis of *C. papaya* (Pawpaw) and *H. brasiliensis* (Rubber)**

| Plant Materials | Alkaloid | Flavonid | Saponins | Tannins | Oxalate | Phenol |
|---|---|---|---|---|---|---|
| | % | % | % | % | % | % |
| Pawpaw leaves | 3.78 | 0.66 | 2.48 | 0.48 | 1.82 | 0.045 |
| Pawpaw stem | 0.84 | 0.48 | 0.22 | 0.76 | 0.34 | 0.020 |
| Pawpaw seed | 2.52 | 2.26 | 1.40 | 1.12 | 2.24 | 0.58 |
| Rubber leaves | 2.34 | 0.84 | 1.06 | 0.54 | 1.65 | 0.066 |
| Rubber sap | 0.42 | 3.86 | 0.62 | 0.08 | 0.34 | 2.38 |
| Rubber bark | 1.14 | 2.10 | 0.75 | 1.24 | 0.24 | 1.36 |

Toxicity of the plant lattices to the weevils was concentration dependent and increased with duration of exposure. Conversely, progeny emergence decreased with increase in the concentration of the plant lattices. It could be observed that the low progeny emergence largely is the consequence of high adult mortality few days after infestation. This result could be due to the insecticidal properties contained in members of the family Euphorbiaceae and other latex bearing plants (Adebowale and Adedire, 2006). Different latex proteins seem to participate in defensive approaches against insects (Koonno *et al*; 2004).

The result corroborates the findings of Ogunleye and Omotoso (2011) who reported 100% adult mortality of *C. maculatus* on cowpea seeds treated with drops of *J. mulfifida* latex 24 hours after application. Similarly, the plant of *C. procera* at the rates of 1.5mls and 2.0mls evoked 100% mortality of adult *C. maculatus* after 4 days (Vikash, 2003). Furthermore, it is in agreement with the work of Suleimaen *et al*; (2012) who reported zero percent adult emergence *S. zeamais* when sorghum grains were treated *J. curcas* latex. *H. brasiliensis* latex protected the seeds of cowpea (*V. unguiculata* L.) against *C. maculatus* damage (Bragay *et al*; 1997).

Phytochemical analysis of the trial plant materials showed that the more potent latex derived from *H. brasiliensis* had a high content of flavonoids phenols and tannins and lower proportions of alkaloids, saponins and oxalates, which could be responsible for the insecticidal properties. Studies performed aimed understanding the biochemical profile of latex have offered convincing evidence for a defensive role played by the saps (Ramos *et al*; 2009). According to Sabu and Vinod (2009) plant latex is a complex mixture of proteins, alkaloids, starch, sugars, oils, tannins, resins and gums. Latex bearing plant species from few families possess diverse phytochemicals having very high insecticidal activity (Shaalan *et al;* 2005). Therefore, it is likely that the phytochemicals contained in these plant lattices could be associated with their potencies.

**CONCLUSION**

The result of this study suggested that test plant lattices obtained from *H. brasiliensis* and *C. papaya* could be used to cause insect toxicity and deter adult emergence of *S. zeamais* on maize in storage. They could also reduce percentage weight losses and grain damage due to insect infestation during storage. These plant materials are readily available, cheap and could be employed as a component of integrated pest management in environmental friendly manner.

Their phytochemical constituents are likely responsible for their insecticidal properties.

**REFERENCES**

Adebowale, K.O. and Adedire, C.O. (2006) chemical composition and insecticidal properties of the underutilized *Jatropha curcas* seed oil. *African Journal of Biotchnology*, 5 (10):901-906

Bonsall, R.A. (1999). A critical review of the methodology for assessing farm level grain losses after harvest, TDRL 139Pp.

Bragay, F., Grangeiro, T.B., Freire, E.A., Lopez, H.L., Bezerra, J.N., Andrade-Neto, M.Lima,
M.A; (1997). Insecticidal activity of 2-tridecanone against the cowpea weevils (Callosobruchus maculatus (Coleoptera: Bruchidae). An Acad Bras. Cienc: 79:35-39

Buranov, A. u., and Elmuradov, B.J. (2010). Extract and characterization of latex and natural rubber from rubber bearing plants Journal of Agriculture and Food Chemistry, 58: 734-http://dx.doi.org/10.1021/if903096z

Cabi, I. (2010). Sitophilus zeamais (maize weevil) data sheet. Crop production compendium, 2010 Ed. CAB International Publishing. Wallingford, UK www.cabi.org/cpc Accessed on 28 Jan. 2010

Carlini, C.R. and Grossi-de-sa, M.F., (2002). Plant toxic proteins with insecticidal properties-A review on the potentialities as biopesticides, Toxicon, 40:1515 1539. http://dX.doi.org/10/1016/56041-0101/00240-4

Ezepue M.C., (1984). The geologic setting of lead-zinc deposits at Ishiagu South-Eastern Nigeria J. Afr. Earth Sci.2; 97-101.

Ferris, S. and Graver, S. (2000). World Food Quantity Protein Maize, PH Action News. The newsletter of postharvest forum 3:20-21.

FAO (Food and Agricultural Organization (1985). Prevention of postharvest food losses. Training series No 10, Food Agricultural Organization of the United Nations, Rome, and 122Pp.

FAO (Food and Agricultural Organization (2013). Mycotoxin prevention and control in food grains. Food and Agricultural Organization, United Nations, Rome 30-49

FAO (Food and Agricultural Organization) and I.L.O., (International Labour Organization (1997). Maize in human nutrition: Intermediate level handbook, FAO and I.L.O., Publications, Rome, Pp.19-20

Hagel, J.M.Yeung, E.C. and Farchini, P.J., (2008). G. of milk? The secret life of latifers. Trends in Plant Science, 13:631-639.

Konno, K. Hirayamura, C. Tateishi, K., Tamura, Y. and Hattori, M., (2004). Papain protects papaya trees from herbivorous insects: Role of cysteine proteases in latex. The Plant Journal 37:370-378

Morsy, T.A; Rahem, M.A. and Allam, K.A., (2001). Control Musca domestica third instar larvae by the latex of Calotropis procera (Family: Ascepiadaceae). Journal of the Egyptian Society of Parasitology, 31:107-110

Nilsa, A. and Perez, N.A., (1995). Major insect pests of maize in Africa: Biology and Control, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, and research guide 30:30-33

Oberlease, D. (1973). Phytates, In: Toxicants occurring naturally in foods. Strong, F. (Ed.)

National Academy of Sciences; Washington D.C. Pp. 363-371

Ogunleye, R.F. and Omotoso, O.T., (2011). Comparative effectiveness of the latex and extracts of six botanicals in the control of Callosobruchus maculatus. Journal of Physical and Biological Science 4 (1): 24-28

Onolemhemhem, O.P. and Oigiangbe, O.N., (1991). The biology of Callosobruchus maculates on cowpea Vigna unguiculata and pigeon pea (Cajanus cajan (L) Millsp) treated with vegetable oil of thioral samara. Journal of Agricultural Research, 8: 59-63

Onwueme, I.C. and Sinha, T.D., (1991). Federal Crop Production in tropical Africa. Technical Centre for Agriculture and Rural Co-operation (CTA) Wageningen, 480Pp.

Ramos, M.V., Pereira, D.A, Souza, D.P;Araujo, E.S; Freitas, CDT; Cavalheiro, M.G; Matos, M.P.V and Carvalho, A.F.U; (2009). Potential of laticifer fluids for inhibiting Aedes aegypti larval development: evidence for the involvement of proteolyptic activity. Memorias do instituto Oswaldo Cruz 104: 805-812

Sabu, T.K. and Vinod, K.V., (2009). Population dynamics of the rubber plantation litter beetle Lulprops tristis in relation to annual cycle of foliage phenology of its host, the Para rubber tree Hevea brasiliensis Journal of Insect Science 9:1-10

Shaalan, E.A.S, Canyon, D; Younese, M.W.F., Abdelwahab, H. and Maasoura, A.H., (2005). A review of botanical phytochemicals with mosquitocidal potential. Environmental International, 31:1149-1166

Suleiman, M., Ibrahim, N.D; Majeed, Q; (2012). Control of Sitophilus zeamais (Motsch) (Coleoptera: Curculionidae) on sorghum using some plant powders. International Journal of Agriculture and Forestry, 2 (1): 53-57.

Vikash, K.D., (2003). Procera: a stable system protease from the latex of Calotropis procera, Phytochemistry: 62 (7): 1057-1072, http//dxdoi.org/10 1016/50031-9422 (02) 00676-3

Wikipedia, (2006). World food quality protein maize Ph action. The newsletter of global postharvest forum, 4: 20-21.