Evaluation of the powder of three medicinal botanicals in the control of Maize weevil, *Sitophilus zeamais* Motschulsky.

Omotoso Olumuyiwa Temitope

Department of Zoology, Ekiti State University, P.M.B.5363, Ado Ekiti, Nigeria
topeomoth@yahoo.co.uk

Abstract: *Sitophilus zeamais* is a key pest of maize. The weevils thrive well in the tropics because of the benevolent weather which favours their biological activity. The weevils can readily decimate untreated maize grains both on the field and in the store. In a bid to check their destructive activity, the leaves of three plants; *Jatropha curcas, Citrus sinensis* and *Psidium guajava* which are known to have medicinal properties were used to admix maize grains at the dosages of 0.1g, 0.2g, 0.3g, 0.5g and 1.0g per 50g of maize. The leaves were pulverized after allowing them to dry naturally on the laboratory tables. Five pairs of newly emerged adults of *S. zeamais* were introduced into each of the rearing cups and the mortality of the insects taken daily. The experiments were monitored for 4 weeks. The results show that all the plant materials are good grain protectants. All the dosages of *J. curcas* were toxic to the weevils. The highest mortality (32.1%) of *S. zeamais* occurred in 1.0g dosage in *J. curcas* within 4 weeks. *C. sinensis* caused insect mortality of 23% within 4 weeks while *P. guajava* caused 20.5% mortality of the weevils within the same period. The mortalities of the insects are dosage dependent and the period of acquaintance with the treated maize grains also contributed to the mortality of the insects. Lower dosages of *P. guajava* and *C. sinensis* were not effective in the first week of application but starting from the second week, the mortality effects of the plants started to manifest. There was a drastic reduction in the biological activity of the insects and this was attributed to the deleterious effect of the plant powder on the normal physiology of the insects.
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Introduction

Sitophilus zeamais M. is a key pest of maize which they infest on the field and in the store. *S. zeamais* thrive well in the tropics because of the favourable weather condition of the tropical regions that promote their development. Maize is one of the major sources of carbohydrates for both man and his livestock. It is eaten whole or processed into various food and industrial products which include starch, sweeteners, beverages and fuel. It is also a major component of thousands of food and other items such as toothpaste, paper goods and textile products. This crop is bedeviled by a lot of pests which strive with the farmer and cause great yield losses both on the field and in storage. For bountiful harvest, farmers and scientist have so much relied on the use of chemical insecticides.

Indiscriminate and injudicious use of insecticides has led to a number of adverse effects in the environment (Isman, 2006). However, because of the attendant shortcomings of chemical insecticides, scientists have diverted to the use of bio-degradable and environmental friendly materials. This has led to the investigation and production of alternative pesticides which are cheap, readily available and are devoid of bio-accumulation in the system of animals. The uses of biological materials especially, plant materials are highly favoured, since the materials can easily be applied without any technical knowledge.

The effectiveness of botanical insecticides have been demonstrated in many studies (Aslan, *et al.* 2005; Cetin and Yanikoglu, 2006; Negahban *et al.,* 2007; Ayvaz, *et al.* 2009; Ayvaz, *et al.,* 2010; War, *et al.,* 2014). Many of the plants used to preserve crops have been found to be safe for human consumption. *Jatropha curcas* L. is a shrub of the Euphorbiaceae family which originated from Central America (Heller 1996). Henning (2008) reported that this plant was used in Africa to delimit fields in other to protect cereal crops against the wind and grazing animals. The use of the leaf extract of *J. curcas* wound treatment and skin infections in local communities in south-eastern Nigeria has been reported by Esimone, *et al.,* (2009). These authors (Esimone, *et al.,* 2009) further investigated the effects of the formulations of the leaf extract of the plant in a simple ointment base in pro-wounding healing activity in albino rats. *J. curcas* seeds are rich in oil and the main constituent of the leaves, bark, fruits and root is hydrogen cyanide. *Citrus sinensis* L. is an evergreen shrub or tree belonging to the family Rutaceae which are widely cultivated in sub-tropical regions. The tree grows to about 12 m high and it has oval-shaped leaves which are 5-15 cm long and 2-8 cm wide. It is a very important plant which possesses antioxidants, antibacterial, antifungal, anti-carcinogenic, anti-ulcer, anti-anxiety, antidiabetic and anti-inflammatory properties (Milind and Dev, 2012). In order to determine the nutritive value of sweet orange peels, Oluremi *et al.,* (2010) has evaluated its importance in broiler starter diet. *Psidium guajava* belongs to the family Myrtaceae. It is a small tree which is about 10 m in height. It is also another plant that is equally important to man. The plant has some medicinal properties which are useful to man. *P. guajava* leaf has been shown to be effective *in vitro*, in mice, and in human volunteers (Deguchi, *et al.,* 1998). The present study was conducted to show the importance of these three plant leaves as alternative bio-pesticides against the notorious maize weevil, *S. zeamais.*

Materials and Methods

Mortality bioassay

Fresh leaves of *Jatropha curcas, Citrus sinensis* and *Psidium guajava* were obtained from Ado-Ekiti, in Ekiti State of Nigeria. The leaves were spread on the laboratory tables and allowed to naturally dry under the laboratory condition (25^0 ±5^0 C and 75% ±5% RH). The leaves were separately pulverized with a blender and sieved before being poured into air-tight bottles, labeled and kept in the laboratory. Both the infested and un-infested maize grains used for the experiment were obtained from Oja Oba in Ado-Ekiti. Plastic cups of dimension 5cm x 3 cm x 2 cm were used to rear the insects.

The infested maize kept in a ventilated small plastic bucket (through nylon mesh) was used as stock culture. The un-infested maize grains were further disinfested by oven-drying in an oven at 60^0 C for 1 h. The maize grains were allowed to cool down for 1 h before used. Fifty grams of the oven-dried, un-infested maize grains was measured into the plastic rearing cups. Each plant powder was admixed thoroughly by shaken with the maize grains for 10 min each, at five levels of concentrations of 0.1 g, 0.2 g, 0.3 g, 0.5 g and 1.0g. Then ten newly emerged adults (5 males and 5 females) of *S. zeamais* (taken from the stock culture kept in the laboratory) were introduced into the treated maize grains in each of the rearing cups and later covered with nylon mesh. The mesh was to allow ventilation into the rearing cups as well as to prevent the weevils from flying out. The control had only untreated maize grains and ten newly emerged adult weevils (5 males and 5 females). The numbers of dead insects who did not respond to pin probes, were counted and replaced daily in each of the rearing cups. This was done by pouring the content of each rearing cup on a white sheet of paper and the insects sorted out of the mixture. The total number of mortalities for each week was calculated by adding the daily mortalities together for the week and recorded. The experiments were monitored for 4 weeks. At the end of the fourth week, the content of each cup was poured on white paper and all the insects were removed and the dead ones noted. The content of each rearing cup was returned back and covered with nylon mesh. The rearing cups were left on the laboratory tables for 40 days to determine adult emergence. On the 40^{th} day the content of each rearing cup was poured on white paper to determine adult emergence.

Statistical analysis

The data obtained were subjected to analysis of variance (ANOVA) and where significant differences existed, means were separated by Tukey test.

Results

The results of the effects of the plant powders on the mortality of *S. zeamais* within a week are shown in Table 1. The powder of *J. curcas* caused high mortality of the weevils at all dosages (0.1g – 1.0g) within a week. The mortality recorded in *J. curcas* was 1.5% at 0.1g dosage within a week. At 0.1g and 0.2g plant dosage, there was no mortality in *P. guajava* while 0.25% and 0.5% mortalities were recorded in *C. sinensis* at 0.1g and 0.2g plant dosage respectively. At 1.0g plant dosage, 7.25% mortality was recorded in *J. curcas* while 2.6% and 2.1% mortalities were recorded in *C. sinensis* and *P. guajava* respectively within a week. Other dosages showed mild effects on the weevils within the week. No mortality was recorded in the control experiment rather mating were observed.

Table 1. % insect mortality within a week

Pant powders	Dosages (g) 0.1	0.2	0.3	0.5	1.0
Jatropha curcas	1.5±0.100	3.25±0.21	4.25±0.12	5.00±0.20	7.25±1.10
Citrus sinensis	0.25±0.11	0.5±0.11	0.6±0.200	1.26±0.11	2.60±0.22
Psidium guajava	0.00±0.00	0.00±0.0	0.50±0.20	1.01±0.21	2.10±0.12
Control	0.00±0.00	0.00±0.0	0.00±0.0	0.00±0.00	0.00±0.0

Each value is a mean ± standard deviation of quadruplicates

Table 2. shows the results of plant powders on weevil, *S. zeamais* mortality within 2 weeks. There were noticeable improvements in the weevils mortality within 2weeks. There was a progressive increase in the mortality rate of the weevils from 0.1g-1.0g plant dosage in *J. curcas*. The mortality ranged from 6%-22.5% in 0.1g-1.0g plant dosages of *J. curcas. Citrus sinensis* showed improvement in causing insect mortality of 4.25%, 7.75% and 14% at 0.1g, 0.3g and 1.0g plant dosages respectively. The least mortality in *P. guajava* within 2 weeks was obtained at 0.1g plant dosage (1.5%) while 11.5% mortality was recorded at 1.0g plant dosage. No mortality was recorded in the control but mating activities were observed.

Table 2. % insect mortality within 2 weeks

Pant powders	Dosages (g) 0.1	0.2	0.3	0.5	1.0
Jatropha curcas	6.00±0.21	8.25±0.20	12.00±.42	14.50±.21	22.50±0.40
Citrus sinensis	4.25±0.10	6.25±0.11	7.75±0.12	10.00±0.12	14.10±0.22
Psidium guajava	1.50±0.33	3.50±0.02	4.00±0.13	7.00±0.21	11.50±0.38
Control	0.00±0.0	0.00±0.00	0.00±0.0	0.00±0.0	0.00±0.0

Each value is a mean ± standard deviation of quadruplicates

The results of the effects of plant powders on the weevils mortality within 3 weeks is shown in Table 3. At 0.1g, 0.5g and 1.0g plant dosages, *J. curcas* caused 9%, 20% and 29.95% insect mortalities respectively within 3 weeks. *Citrus sinensis* caused 8.25%, 16.75% and 19.75% insect mortalities respectively within the period while *P. guajava* caused 5.25%, 10.5% and 17.5% insect mortalities respectively within the same period. In the control experiment, no mortality was recorded but mating occurred.

Table 3. % insect mortality within 3 weeks

Pant powders	Dosages (g) 0.1	0.2	0.3	0.5	1.0
Jatropha curcas	9.00±0.10	9.50±1.70	13.25±2.50	20.00±2.70	29.95±2.82
Citrus sinensis	8.25±0.80	11.75±1.67	15.25±2.00	16.75±2.11	19.75±2.21
Psidium guajava	5.25±1.90	7.50±0.87	9.00±1.77	10.50±1.53	17.50±2.00
Control	0.00±0.0	0.00±0.0	0.00±0.0	0.00±0.0	0.00±0.0

Each value is a mean ± standard deviation of quadruplicates

The results of insect mortality within 4 weeks of plant powder application are presented in Table 4. At 0.2g, 0.5g and 1.0g plant powder dosages, *J.curcas* caused 13%, 21.50% and 32.10% insect mortalities respectively. *C. sinensis* caused 8.95%, 19.7% and 23% insect mortalities respectively while *P.guajava* caused 7.50%, 11.75% and 20.50% insect mortalities respectively within 4 weeks. No mortality was recorded in the control but mating took place.

Table 4. % insect mortality within 4 weeks

Pant powders	Dosages (g) 0.1	0.2	0.3	0.5	1.0
Jatropha curcas	10.00±0.14	13.00±1.70	16.75±2.10	21.50±2.00	32.10±2.15
Citrus sinensis	7.20±0.67	8.95±1.56	14.25±1.10	19.70±1.20	23.00±2.51
Psidium guajava	6.50±0.20	7.50±0.60	10.00±1.22	11.75±1.82	20.50±1.63
Control	0.00±0.0	0.00±0.0	0.00±0.00	0.00±0.0	0.00±0.0

Each value is a mean ± standard deviation of quadruplicates

Discussion

Jatropha curcas, Citrus sinensis and *Psidium guajava* have shown significant mortality effects on *Sitophilus zeamais.* These leaves powder are toxic to the weevils. The toxicity of the leaves powders are dosage dependent. Also the duration of exposure of the weevils to the treated maize grains, significantly increased the mortality rate. Reduced biological activities were observed in the treated maize and the weevils abstained from feeding. This could have been as a result of the antifeedant property of the plant leaves, which prevented them from feeding. The mortality of the weevils are higher in higher plant powder dosages and this actually led to the dead of the weevils. Within the 1st, 2nd, 3rd and 4th weeks, *J. curcas* consistently caused 7.25%, 22.5%, 29.95% and 32.1% weevils' mortalities (Tables 1-4). Singh (2008) reported that *J. curcas* caused antifeedant activity in termite, *Macrotermes beesoni.* Omotoso (2004) has earlier reported that the leaves and seeds of *Azadirachta indica* and *Ricinus communis* as well as the leaves of *Eucalyptus camaldulensis*, *Lonchocarpous seriseus* and *Erythrophleum guineense* are good toxicants and antifeedants against *S. zeamais.* It has been reported that the toxicity of *J. curcas* oil have been due to the presence of phorbol esters (Makker, *et al.,* 1997). The insecticidal activity of *J. curcas* has been reported by Habou *et al.* (2011). They reported further that the oil extracts of the plant has biocidal effects on cowpea pests such as *Aphis craccivora* K.*,* *Megalurothrips sjostedti* T and *Anoplocnemis curvipes* F. Bashir and Shafie. (2013) reported that the seed oil extracts of *J. curcas* caused significant mortality in the desert locust, *Scistocerca gregaria* Forskal, within 7 days of application. Bashir and Shafie (2014) reported that both oil extracts of neem and *J. curcas* resulted in 99.71% gg un-hatchability in the desert locust, *S. gregaria. J. curcas* is a good insecticide against *S. zeamais.* This plant has many medicinal properties. The extracts obtained from the leaves are used as nematicide (Sharma and Trivedi, 2002, Kumar and Sharma, 2008). It has been used as molluscide, rodenticide and fungicide (Rug, *et al.,* 1997, Goel *et al.,* 2007, Rahman, *et al.,* 2011). The leaf extracts of *J. curcas* also has antimicrobial, larvacidal and insecticidal properties (Igbinosa, *et al.,* 2009, Kalimuthu, *et al.,* 2010, Kalimuthu, *et al.,* 2011). Rahman *et al.* (2011) reported that the extracts from the seeds and leaves of *J. curcas* inhibit the growth of mycelium of *Colletotrichum gloeosporioides,* which causes anthracnose disease in bananas. Gutierrez Jr. *et al.,* (2014) reported that phytochemical screening revealed the presence of alkaloids, flavonoids and steroids in the leaf and bark extracts of *J. curcas* while the leaf and bark/stem extracts of *Citus grandis* and *Tinospora rumphi* are rich in alkaloids, saponins, tannins, flavonoids and steroids. These compounds possess insecticidal and larvacidal properties that cause mortality of insects and other pests (Nweze, *et al.,* 2004, Akinyemi *et al.,* 2005, Gutierrez Jr. *et al.,* 2014). Alkaloids, saponins and tannins are known to possess medicinal and pesticidal properties. Saponins are harmful to insects (Chaieb, 2010).

At the highest dosage of 1g plant powder treatment, *P. guajava* caused 23% insect mortality. Mostafa *et al.* (2012) reported that *P. guajava* caused 50% mortality of *T. castaneum* within 72 h. *P. guajava* leaf powder exhibited both strong repellent and anti-feedant effects on larger grain borer, *Prostephanus truncatus* (Mukanga, *et al.* 2010). They reported further that petroleum ether exracts of neem and *P. guajava* are highly toxic to *P. truncatus.* Zaka *et al.* (2010) reported that *P. guajava* leaf possessed a repellent effect against the adult citrus psyllids, *Diaphrorina citri* Kuwayama. They reported further that fewer psyllids were found on citrus leaves in the presence of *P. guajava* foliage. In all the treated maize grains, the activities of weevils were greatly reduced. This is an indication that the plant powders have actually controlled the weevils. Iram *et al.* (2013) reported that *P. guajava* leaves and fruit peels showed promising effects of seed protection and insecticidal properties against *Tribolium castaneum* Herbst. Omotoso (2005) has earlier reported that the ethanoic extracts of eight plants are good maize grains protectants through the inhibition of the activities of *S. zeamais.*

The emergence of new adults in the control experiment show that the weevils were not disturbed in their environment. However, in the treated maize, no newly emerged adults were seen. The plant powders may have prevented mating and oviposition of eggs by the females. This could have also been as a result of the blockage of the hatchability of the eggs. Juliet *et al.* (2012) reported that leaf the extracts of *J. curcas* caused significant blocking of the ova of ticks, *Rhipicephalus (Boophilus) annulatus* from hatching. Some plant extracts have been reported to cause significant reduction or total inhibition of oviposition and fecundity of insect pests (Gehlot and Singhvi, 2006, Singh, 2011, Jide-Ojo, *et al.,* 2013). It is not only the plant powders of these plants that are effective as insecticides; some authors have worked on the importance of oil extracts of the leaves, seeds and fruits of the plants. Siskos *et al.* (2007) reported that the fruit extracts of *Citrus aurantium* show toxicity against olive fruit flies, *Bactrocera oleae* Gmelin, indicating that the toxic chemicals accumulate mainly in the fruit of the plant. Accumulation of chemicals with insecticidal activity have been reported in the fruits and oil extracts of fruit peels and seeds of many citrus and other plant species (Talukder and Howse, 1994, 1995). Yekeen *et al.* (2014) reported that the oils extracted from the peels and seeds of *C. sinensis* have insecticidal and antimicrobial activity. Mansour *et al.* (2004) reported that all the tested citrus peel oils induced 100% mortality in *Culex pipiens* larvae at 1000ppm (0.1%) concentration level. The authors further reported that five of the tested oil extracts of citrus peels showed efficacy against the mosquito, *C. pipiens* adults and that the highest potency was observed in lemon oil while sweet orange oil recorded the lowest potency. Ethanolic and aqueous extracts of four medicinal plants have been reported to be highly toxic to the bean weevil, *Callosobrucus maculatus* (Omotoso, 2008).

The important medicinal attributes of the three plants used for this study and some other plants have been highlighted by some authors. *P. guajava* is useful in many ways. It produces fruits which are palatable, admirable and highly relished by humans, other mammals and birds. The leaves of the plant have been reported to be moderate sources of natural antioxidants (Roy and Das, 2011). Sugeng (2013) reported that red *P. guajava* fruits have the same antioxidant potency as vitamin C. Leaves extracts of *P. guajava* have been reported to be suitable for the treatment of diarrhea by inducing a decrease in the propulsion movements of the intestinal contents in mice (Salgado, *et al.,* 2006). In addition, Sushma, *et al.,* (2012) reported that the extracts of the leaves of *P. guajava* at higher and medium doses, produce highly significant and sustained increases in the onset of convulsion and decreases in the rate of convulsion. These results suggest that *P. guajava* extract possesses clinically applicable anti-epileptic activity. The authors reported further that this activity may be due to the presence of flavonoids and saponins in the extract. In their own contribution, Roy and Das, (2011) reported that the aqueous extract of the leaves of *P. guajava* posseses good hepatoprotective activity when administered orally at doses of 250 mg/kg to 500 mg/kg. Moreover, the analgesic and antipyretic activity of ethanolic extracts of *P. guajava* on rats have been reported by Victor *et al.,* (2005). *J. curcas* extract has been reported to be effective in wound healing in rats (Esimone *et al.* 2009). Nisha *et al.* (2013) has reported that the extracts of *Citrus* peel showed antibacterial activity against various diarrhoeal pathogens such as *Escherichia coli* M., *Klebsiella pneumonia* S., *Pseudomonas aeruginosa* S., *Salmonella typhi, Salmonella paratyphi A*., *Salmonella paratyphi B*., *Sihigella flexneri* C and C., and *Vibrio cholera* P. The seeds of *Artocarpus heterophyllus* and *Citrus sinensis* are reported to have possessed significant antiglycation activity which proved that these seeds can be used as traditional medicine in the management of chronic diabetes mellitus (Shakthi, *et al.,* 2014). *Manilkara zapota* is another plant with traditional and medical importance in India. It contains several compounds like phenols, alkaloids, epicatechin, leucocyanidin leucodelphinidin, leucoperlargonidin, chlorogenic acid, gallic acid, sugars, carotenoids and minerals such as Zinc, Calcium, Iron, Potassium, and Copper (Shakthi, *et al.,* 2014). It also has antiulcer, antibacterial, antifungal, antipyretic and antioxidant properties and is used in the treatment of diarrhea, wounds, pulmonary ailments and fever (Singh and Shivhare, 2011).

Conclusion

In conclusion, the three plants used for this study are rich in insecticidal and medicinal properties. The medicinal properties of the plants have been thoroughly studied by some authors. They have been used to treat a lot of diseases and ailments. Thus, the fear of food poisoning by the plant powder is not entertained since they are actually medicine in disguise. However, the insecticidal properties on which this study was based has revealed, that the reduction in the biological activity of *S. zeamais* in the treated maize grains can be attributed to the toxicity of the plant powders which affected the normal physiology of the insects.

References

1. Akinyemi, K. O., Mendie, V. E., Smith, S. T., Oyefolu, A. O. and Coker, A. O. (2005). Screening of Some Medicinal Plants Used in Southwest Nigerian Traditional Medicine for Anti-*Salmonella typhi* activity. *Journal of Herbal Pharmacoth.* 5(1): 45-60.
2. Aslan, I., Calmasur, O., Sahin, F., and Caglar, O. (2005). Insecticidal effects of essential plant oils against *Ephestia kuehnielia* (Zell.), *Lasioderma serricome* (F.) and *Sitophilus granarius* (L.). *Journal of Plant Diseases and Protection.* 112: 257-267.
3. Ayvaz, A., Karaborklu, S., and Sagdic, O.(2009). Fumigant toxicity of five essential oils against the eggs of *Ephestia kuehniella* Zeller and *Plodia interpunctella* (Hübner) (Lepidoptera: Pyralidae). *Asian Journal of Chemistry*. 21: 596-604.
4. Ayvaz, A., Sagdic, O., Karaborklu, S., and Ozturk, I. (2010). Insecticidal activity of the essential oils from different plants against three stored-product insects. *Journal of Insect Science* 10(21): 1-13.
5. Bashir, E. M. and Shafie, H. A. F. (2013). Insecticidal and Antifeedant Efficacy of *Jatropha* oil extract against the Desert Locust, *Schistocerca gregaria* (Forskal) (Orthoptera: Acrididae). *Agriculture and Biology Journal of North America.* 4(3): 260-267.
6. Bashir, E. M. and Shafie, H. A. F. (2014). Toxicity, Antifeedant and Growth Regulating Potential of Three Plant Extracts against the Desert Locust *Schistocerca gregaria* Forskal (Orthoptera: Acrididae). *American Journal of Experimental Agriculture.* 4(8): 959-970.
7. Cetin, H., and Yanikoglu, A. (2006). A study of the larvicidal activity of *Origanum* (Labiatae) species from Southwest Turkey. *Journal of Vector Ecology* 31: 118-122.
8. Chaieb, I. (2010). Saponins as insecticides: A Review. *Tunisian Journal of Plant Protection.* 5: 39-50.
9. Deguchi, Y., Osada, K., Uchida, K., Kimura, H., Yoshikawa, M., Kudo, T., Yasui, H., and Watanuki, M. (1998). Effects of extract of guava leaves on the development of diabetes in the mouse and on the postprandial blood glucose of human subjects. *Nippon Nogeikagaku Kaishi*. 72(8): 923-931.
10. Esimone, C. O., Nworu, C. S., and Jackson, C.L. (2009). Cutaneous wound healing activity of a herbal

ointment containing the leaf extract of *Jatropha curcas L.* (Euphorbiaceae). *International Journal of Applied Research in Natural Products*. 1(4): 1-4.

11. Gehlot, L. and Singhvi, P.M. (2006). Effect of plant extracts against *Callosobruchus maculatus* and seed germination of moth bean (*Vigna aconitifolia*)., *J. Applied Zoo. Res.* 18(1): 165-168.
12. Goel, G., Makkar, H. P.S., Francis, G. and Becker, K. (2007). Phorbol esters: Structure, biological activity, and toxicity in animals. *Int. J. Toxicol*. 26(4): 279-288.
13. Gutierrez Jr, P. M., Antepuesto, A. N., Eugenio, B. A. L. and Santos, M. F. L. (2014). Larvicidal Activity of Selected Plant Extracts against the Dengue vector *Aedes aegypti* Mosquito. *International Research Journal of Biological Sciences*. 3(4): 23-32.
14. Habou, Z. A., Haougui, H., Mergeai, G., Haubruge, E., Toudou, A. and Verheggen, F. J. (2011). Insecticidal effect of *Jatropha curcas* oil on the Aphid, *Aphis fabae (Hemiptera: Aphididae)* and on the main Insect pests associated with cowpeas *(Vigna unguiculata)* in Niger. *Tropicultura*. 29(4): 225-229.
15. Heller J., 1996, Physic nut. *Jatropha curcas* L., *in*: Institute of Plant Genetics and Crop Plant Research, Gatersleben, International Plant Genetic Resources Institute, Rome, 66 pp.
16. Henning, R. K. (2008). *Jatropha curcas* L. in Africa: assessment of the impact of the dissemination of the *Jatropha* System on the ecology of the rural area and the social and economic situation of the rural population (target group) in selected countries in Africa golbal facillition for undertilizer speceies, 49 pp. *http://www.underutilized-pecies.org/Documents/jatropha_curcas_africa.pdf, 09/10/209).*
17. Igbinosa, O. O., Igbinosa, E. O. and Aiyegoro, O. A. (2009). Antimicrobial activity and phytochemical screening of stem bark extracts from *Jatropha curcas* (Linn). *Afr J Pharm Pharacol.* 3(2): 58-62.
18. Isman, M. B. (2006). The role of botanical insecticides, deterrents and repellents in modern agriculture and an increasingly regulated world. *Annual Review of Entomology.* 51: 45–66.
19. Iram, N., Arshad, M. and Akhter, N. (2013). Evaluation of Botanical and Synthetic Insecticide for the Control of *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). *BioAssay:* 8(3): 1-10.
20. Jide-Ojo, C. C., Gungula, D. T. and Ojo1, O. O. (2013). Extracts of *Jatropha curcas* L. exhibit significant insecticidal and grain protectant effects against maize weevil, *Sitophilus zeamais* (Coleoptera: Curculionidae). *Journal of Stored Products and Postharvest Research.* 4(3): 44-50.
21. Juliet, S., Ravindran, R., Ramankutty, S. A., Gopalan, A. K. K., Nair, S. N., Kavillimakkil, A. K., Bandyopadhyay, A., Rawat, A. K. S. and Ghosh, S. (2012). *Jatropha curcas* (Linn) leaf extract -a possible alternative for population control of *Rhipicephalus (Boophilus) annulatus. Asian Pacific Journal of Tropical Disease.* 3(12): 225-229.
22. Kalimuthu, K., Vijayakumar, S. and Senthilkumar, R. (2010). Antimicrobial activity of the biodesel plant, *Jatropha curcas. Intern J Pharm Bio Sci*. 1(3): 1-5.
23. Kalimuthu, K., Kadarkaral, M., Savariar, V. and Siva, K. (2011). Larvicidal efficacy of *Jatropha curcas* and bacterial insecticide, *Bacillus thuringiensis,* against lymphatic filarial vector, *Culex quinquefasciatus* Say(Dipteria: Culicidae). *Parasitol Res*. 109(5):1251-1257.
24. Kumar, A. and Sharma, S. (2008). An evaluation of multipurpose oil seed crop for industrial uses (*Jatropha curcas* L.): a review. Ind. Crop. Prod. 28(1): 1-10.
25. Makkar, H.P.S., Becker, K., Sporer, F. and Wink, M. (1997). Studies on nutritive potential and toxic constituents of different provenances of *Jatropha curcas*. *J. Agr. Food Chem*. 45: 3152-3157.
26. Mansour, S. A., El-Sharkawy, A. Z. and Ali, A. R. (2004). Botanical biocides.12. mosquitocidal activity of citrus peel oils with respect to their limonene content. *Egyptian Journal of Natural Toxins*. 1: 111-134.
27. Milind, P., and Dev, C. (2012). Orange: Range of Benefits. *Int Res J Pharm*. 3(7): 59–63.
28. Mostafa, M., Hossain, H., Hossain, M. A., Biswas, P. K. and Haque, M. Z. (2012). Insecticidal activity of plant extracts against *Tribolium castaneum* Herbst. *Journal of Advanced Scientific Research.* 3(3): 80-84.
29. Mukanga, M., Deedat, Y. and Mwangala, F. S. (2010). Toxic effects of five plant extracts against the larger grain borer, *Prostephanus truncatus*. *African Journal of Agricultural Research.* 5(24): 3369-3378.
30. Negahban, M., Moharramipour, S., and Sefidkon, F. (2007). Insecticidal activity of essential oil from *Artemisia sieberi* Beser against three stored-product insects. *Journal of Stored Products Research* 43: 123-128.
31. Nisha, S. N., swedha,A. A. and Rahaman, J. S. N. (2013). Antibacterial activity of *citrus sinensis* peel against enteric pathogens. *International Journal of Pharmaceutical Research and Bio-Science.* 2(5): 1-13.
32. Nweze, E. I., Okafor, J. I. and Njoku, O. (2004). Antimicrobial Activities of Methanolic Extracts of *Trema guineensus* (Schunm and Thorn) *Morindalucida* (Benth) used in Nigeria, *Bio-research.* 2(1): 39-46.
33. Oluremi, O. I. A., Okafor, F. N., Adenkola, A. Y. and Orayaga, K. T. (2010). Effect of fermentation of sweet orange (C*itrus sinensis*) fruit peel on its phytonutrients and the performance of broiler starter. *International Journal of Poultry Science.* 9 (6): 546-549.
34. Omotoso, O. T. (2004). Evaluation of some plant powders as toxicants and antifeedants in the control of maize damage by the maize weevil, *Sitophilus zeamais* Motschulsky in storage. *Ultra Science.* 16(2): 221-230.
35. Omotoso, O. T. (2005). Determination of susceptibility index of ethanoic extracts of some plants to maize weevils, *Sitophilus zeamais* Motschulsky. *Journal of Science and Technology Research.* 4(1): 16-20.

36. Omotoso, O. T. (2008). Efficacy of extracts of some aromatic medicinal plants on cowpea bruchid, *Callosobruchus maculatus* in storage. *Bulletin of Insectology.* 16(1): 21-24.
37. Rahman, M., Ahmad, S.H., Mohamed, M.T.M. and Rahman, M.Z.A. (2011). Extraction of *Jatropha curcas* fruits for antifungal activity against anthracnose (*Colletotrichum gloeosporioides*) of papaya. *Afr. J. Biotechnol.* 10(48): 9796-9799.
38. Roy, C. K. and Das, A. K. (2011). Effect of *Psidium guajava* Linn. leaf extract on liver cells *NSHM Journal of Pharmacy and Healthcare Management* 2: 83-88.
39. Rug M., Sporer F., Wink M., Liu S.Y., Henning R. & Ruppel A. (1997). Molluscicidal properties of *J. curcas* against vector snails of the human parasites *Schistosoma mansoni* and *S. japonicum.* In: Biofuel and Industrial Products from *Jatropha curcas*. (edts by: G.M. Gübitz, M. Mittelbach and M. Trabi) Dbv-Verlag Univ. Graz. Pp 227-232.
40. Salgado, H. R. N., Roncari, A. F. F., Michelin, D. C., and Moneira, R. R. D. (2006). Evaluation of antidiarrhoeal effects of *Psidium guajava* L. (myrtaceae) aqueous leaf extract in mice. *Revista de Ciencias Farmaceuticas Basica e Aplicada.* 27(1): 89-92.
41. Shakthi, D. A., Sathish, K. T., Kumaresan, K. and Stephen, R. V. (2014). Extraction process optimization of polyphenols from Indian *Citrus sinensis* – as novel antiglycative agents in the management of diabetes mellitus. *Journal of Diabetes and Metabolic Disorders.*13 (11): 2-10.
42. Sharma, N. and Trivedi, P.C. (2002). Screening of leaf extracts of some plants for their nematicidal and fungicidal properties against *Meloidogyne incognita* and *Fusarium oxysporum*. *Asian J. Exp. Sci.* 16 (1-2): 21.
43. Singh, S. (2008). Anti-termite activity of *Jatropha curcas* L. Biochemicals. *J. Appl. Sci. Environ.* 12(3): 67–69.
44. Singh, R. (2011). Evaluation of some plant products for their oviposition deterrent properties against the *Callosobruchus maculatus* (F.) on chik pea seeds. *International Journal of Pharmaceutical Studies and Research.* 2(2): 25-28.
45. Singh, M. and Shivhare, Y. (2011). *Manilkara zapota*: An overview. *Herbal Tech Industry.* 8(6):13-16.
46. Siskos, E. P., Konstantopoulou, M. A., Mazomenos, B. E. and Jervis, M. (2007). Insecticidal Activity of *Citrus aurantium* fruit, leaf, and shoot extracts against adult olive fruit flies (Diptera: Tephritidae). *Journal of Econ. Entomol.* 100(4): 1215-1220.
47. Sugeng, M. (2013). The effects of red guava (*Psidium guajava* L) fruits on lipid peroxidation in hypercholesterolemic rats. *Basic Research Journal of Medicine and Clinical Sciences.* 2(11): 116-121.
48. Sushma, M., Eswarudu, M. M., Venkateshwaralu, G. and Radhika, P. (2012). Evaluation of anti-epileptic activity of *Psidium guajava* leaves extract in Mice *International Journal of Research in Pharmaceutical and Biomedical Sciences.* 3(2): 802-806.
49. Talukder, F. A. and Howse, P. E. (1994). Repellent, toxic and food protectant effects of pithraj, A*phanamixis polystachya* extracts against pulse beetle, *Callosobruchus chinensis* in storage. *J. Chem. Ecol.* 20: 900-908.
50. Talukder, F. A. and Howse, P. E. (1995). Evaluation of A*phanamixis polystachya* as a source of repellents in storage against *Tribolium castaneum* (Herbst). *J. Stored Prod. Res.* 31: 55-61.
51. Victor, B. O., Timothy, O. J. and Ayodele, O. S. (2005). Analgesics and antipyretic activities of ethanolic extract of *Psidium guajava* in Rats. *Recent Progress in Medicinal Plants.* 13: 473-480.
52. War, A. R., Paulraj, M. G., Hussain, B., Ahmad, T., War, M. Y. and Ignacimuthu, S. (2014). Efficacy of a combined treatment of neem oil formulation and endosulfan against *Helicoverpa armigera* (Hub.) (Lepidoptera: Noctuidae). *International Journal of Insect Science.:*6: 1–7.
53. Yekeen, M. O., Ajala, O. O. and Alarape, A. B. (2014). Antifungal activities of *Citrus sinensis* seed oil against *Lentinus sajor-caju. Advances in Applied Science Research.* 5(3): 109-113.
54. Zaka, S. M., Zeng, X. N., Holford, P. and Beattie, G. A. C. (2010). Repellent effect of guava leaf volatiles on settlement of adults of *citrus Psylla, Diaphorina citri* Kuwayama, on citrus. *Insect Science.* 17: 39–45.

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