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Research Article

INSECTICIDAL ACTIVITIES OF PLANT POWDERS AGAINST *RHYZOPERTHA DOMINICA* AND *SITOPHILUS ORYZAE* IN STORED RICE

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ABSTRACT

The entomotoxic effect of the dry powders of leaves of *Annona muricata*, *Carica papaya*, *Citrus sinensis* and *Psidium guajava* on the survival of *Rhyzophertha dominica* Fabricius (Bostrichidae: Coleoptera) and *Sitophilus oryzae* L. (Coleoptera: Curculionidae) was assessed in the laboratory. All the plant leaf powders exhibited various levels of toxicity, with *Annona muricata* exhibiting the highest potency of 90% for both insect pests and *Carica papaya* showing the lowest mortality of 60% for both insects at the end of the experiment. This study revealed that plant powders of can be used to efficiently to control *S. oryzae* and *R. dominica* in stored rice and its incorporation into traditional storage pest management is strongly recommended in developing countries.

Keywords: Insecticidal, *Rhyzophertha dominica*, *Sitophilus oryzae*, *Oryza sativa*, Entomocidal.

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food for more than half of the world's population, providing more than 20% of calories consumed worldwide (Sharif *et al*., 2014). Global production of milled rice in 2021 was 505.4 million tonnes making rice the world's third-most produced agricultural crop behind sugarcane and corn (maize), which both have a wide variety of non-consumption uses (Childs, 2021). Rice is a source of protein and contains various vitamins, such as thiamin and niacin, and minerals, such as zinc and phosphorus (IRRI, 2018). Some specialty types of rice, such as those that are purple or red in colour, contain more of the pigment anthocyanin, a known antioxidant (IRRI, 2018). In spite of its importance to food security in the world and in Ghana in particular as well as the numerous nutritional benefits derived from it, its storage is seriously jeopardized by several stored-product insects' pests. These stored-product insects can cause post harvest losses, estimated up to 70% in developing countries (Kavita, 2004). Notably among these pests that are the lesser grain borer, *Rhyzophertha dominica* Fabricius (Bostrichidae: Coleoptera) and the rice weevil, *Sitophilus oryzae* L.(Coleoptera: Curculionidae). These insect pests harm the cereal in both quantitative and qualitative ways (Fornal *et al*., 2007). *R.dominica* is a grain pest that causes havoc, both as a larval and an adult (Raju, 1984). The adults are strong fliers who move from one warehouse to another, generating new infestations. When the infestation is severe, the adults produce a large amount of frass, contaminating more than just what they eat (Atwal, 1994). The flour created in this manner feeds the baby grubs until they are ready to bore into the grain. It not only reduces the amount, but also the quality of grain and its products (Atwal 1994). *S. oryzae* (L.) (Coleoptera: Curculionidae), is a major and destructive pest of rice and other crops (Hatami *et al.*, 2011). It causes considerable losses in both quantity and quality of stored food grains all over the world (Arannilewa *et al.*, 2002). It is a grain-boring insect that feeds on stored rice. Adult weevil's digcircular holes in the grain and consume largely the endosperm, reducing carbohydrate content, whilst larvae preferentially feed on the grain germ, consuming a significant quantity of protein and vitamins (Akbar *et al*., 2021).

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Efforts to control these dreadful insect pests of rice have been overwhelmingly relied upon the use of synthetic insecticides. These synthetic products, however, are not without their hazards to human health and the environment (Babarinde *et al*., 2008). Apart from the health and environmental hazards posed by synthetic insecticides, mis-use and over-use by applicators have led to serious problems, including development of insect resistant strains to insecticides, toxic residues on stored grains, health hazards to grain handlers, food poisoning, environmental pollution (Zettler and Coperus, 1990). These problems have stimulated research into plants with insecticidal properties grown locally that are readily available, effective, affordable, less poisonous and less detrimental to the environment (Tierto, 1994).Most plants are rich sources of compounds that have insecticidal properties (Obeng Ofori *et al*., 1997). *Moringa oleifera* (Buxton *et al*., 2014), *Zanthoxylum xanthoxyloides* (Koomson *et. al*., 2016), *Alchornea cordifolia* (Koomson *et al*., 2022) and many others have been successfully used to control insect pests. *Annona muricata* Lin, is a species of the genus *Annona* of the custard apple tree family, Annonaceae, which has edible fruit (Gopalan *et al*., 2007). The fruit is usually called soursop due to its slightly acidic taste when ripe. *Annona muricata* is native to the Caribbean and Central America but is now widely cultivated- and in some areas, becoming invasive-in tropical and subtropical climates throughout the world, such as India (Gopalan *et al*., 2007). It has been found to control some pests of Fleabeetles (*Podagrica spp.*) on okra (Ogbuehi and Onuh, 2019).

Carica papaya L. is a herbaceous succulent plant popularly known as pawpaw, and belongs to the Caricaceae family (Sharmeen *et al*., 2012). It is native to the tropics of the Americas but now is widely cultivated in other tropical regions of the world for its edible melon-like fruit, which is available throughout the year (Manfo *et al., 2014*). It has been found to be effective in controlling insects especially mosquitoes (Ahmad, 2019). *Citrus sinensis* L. Is a fruit of various citrus species in the family Rutaceae. It is also called sweet orange, to distinguish it from the related *Citrus aurantium*, referred to as bitter orange (Nicolosi *et al., 2000)*. The sweet orange reproduces asexually (apomixis through nucellar embryony) varieties of sweet orange arise through mutations (Nicolosi, 2000). It has been used to control some insect pests (Morawej and Abbar, 2008). *Psidium guajava* L., the common guava, yellow guava, lemon guava, or apple guava is an evergreen shrub or small tree native to the Caribbean, Central America and South America *Apis mellifera* (Guaterrez *et al*., 2008). It is easily pollinated by insects; when cultivated, it is pollinated mainly by the common honey bee, *Apis mellifera* (Guaterrez *et. al*. 2008). It has been found to be effective in controlling mosquitoes (Rwang *et al*., 2016). This present study is aimed at comparing the insecticidal efficacies of the powdered form of *A. muricata*, *C. papaya*, *C. sinensis* and *P. guajava* to control these dreadful insect pests of stored rice.

MATERIALS AND METHODS

Culturing the Insects

R.dominica Fabricius (Bostrichidae: Coleoptera). The initial stock was obtained from infested rice purchased from the Winneba market, Winneba. The adult beetles were introduced into uninfected rice in jars covered with muslin cloths and allowed for oviposition in the laboratory. After two weeks of oviposition, the adults were sieved out. The adults that emerged were transferred into another jar such that the F1 adults (which were used as the culturing stock for the experiments) were of uniform size and age. The set up was kept in the laboratory under a temperature of 32.2^{O}C and 70% relative humidity.

Sitophilus oryzae L.(Coleoptera: Curculionidae). The initial stock was obtained from infested rice purchased from the Winneba market. The adult weevils were introduced into uninfected rice in jars covered with muslin cloths and allowed for oviposition in the laboratory. After two weeks of oviposition, the adults were sieved out. The adults that emerged were transferred into another jar such that the F1 adults (which were used as the culturing stock for the experiments) were of uniform size and age. The set up was kept in the laboratory under a temperature of 32.2^{O}C and 70% relative humidity.

Collection of the plant samples

The plant species that were used were obtained from the following places: *A. muricata*: Agona Asafo, *C. papaya*: Winneba.*C. sinensis*: Agona Asafo and *P. guajava*: Tema. The leaves of these plants were collected and used for the research.

Preparation of plant leaf powders

The leaves were removed from the branches, rinsed in clean water to remove sand and other impurities, air dried at room temperature in the laboratory for 15 days, after which they were cut into smaller pieces with a pair of scissors, pulverised into very fine powder using an electric blender. The powders were further sieved to pass through 1mm^{2}perforations. The powders were packed in plastic containers with tight lids to ensure that the active ingredients are not lost and stored in the laboratory prior to use.

Contact toxicity of plant leaf powders to insects

Twenty pairs of *R. dominica* were introduced into clean sterilized 250ml plastic containers containing 100g of uninfected sterilized rice seeds One hundred grams (100g) (w/w) of each of the plant leaf powders was weighed and added to each the experimental jars except in the control treatment there was no plant material added. Each of the jars was gently shaken well to ensure uniform coating. The jars were covered with muslin cloth and secured with rubber bands as a ventilated lid. The experiment was laid out in Randomized Compete Block Design (RCBD) with three replications in the laboratory. Live and dead insects were recorded daily for 1 week. Adults were considered dead when probed with sharp objects and there were no responses (Obeng Ofori *et. al*., 1997). Percentage adult mortality was corrected using the Abbott (1998) formula, thus:

$$P_T = \frac{P_o - P_c}{100 - P_o} \times \frac{100}{1}$$

Where P_T = Corrected mortality (%)
P_o = Observed mortality (%)
P_c = Control mortality (%)
The same procedure was repeated for *S. oryzae*
Data were then analyzed using Analysis of Vairance at 0.05 probability level using GenSat Statistical Package 22.13 (22^{nd} edition).

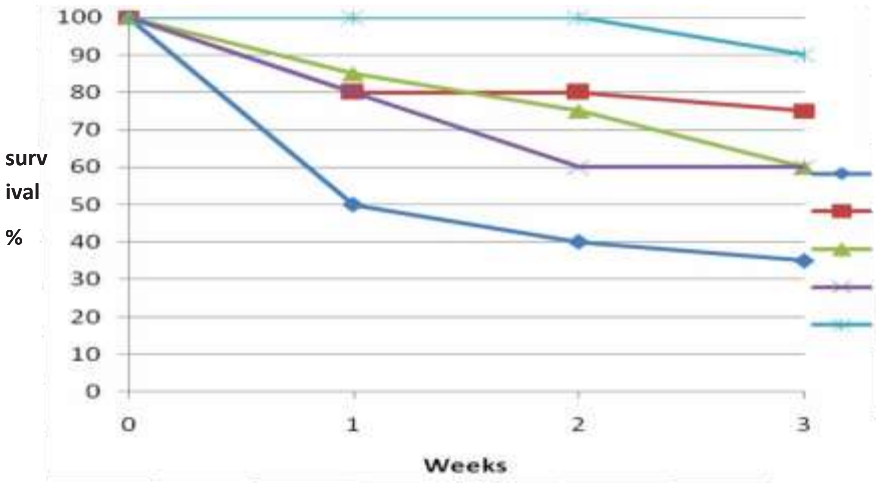

Figure1. Effect of treatment of powdered leaves of *A. muricata*, *C. papaya*, *C. sinensis* and *P guajava* on the mortality of *S. oryzae.*

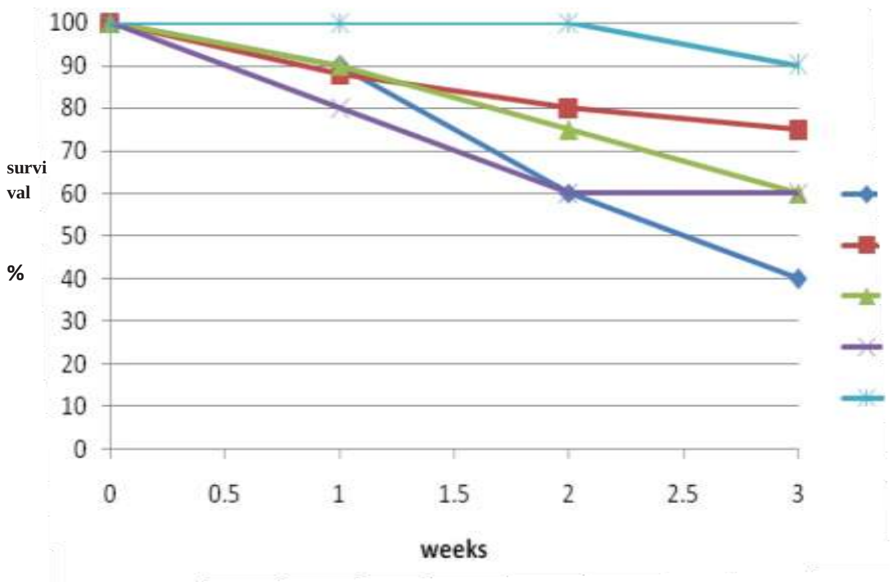

Figure 2. Effect of treatment of leaves of *A. muricata*, *C. papaya*, *C. sinensis* and *P guajava* on the mortality of *R. dominica.*

RESULTS AND DISCUSSION

All plant parts tested positive for bioactivity against adult *R. dominica* and *S. oryzae*. When the entomocidal effect of the leaf powder treatments against the insects were compared, *A. muricata* produced the highest percentage mortality rates of 90% against both *S. oryzae* and *R. dominica*. On the other hand, for the leaf powdered treatments of *C. papaya*yielded the lowest percentage mortality values of 60% against both insects as can be found in figures 1 and 2.There was significant (P < 0.05) difference between the leaf powders of the different plants against both stored product insect pests.

According to Ogungbite (2015), for an insecticide to be accepted, it will depend on its ability to prevent or reduce infestation by insects and also to have less or no adverse effect on the human and environmental health. Since botanical insecticides however remain the most accessible source of insect control for both poor and mechanize farmers, their method of application still remain a major challenge which need to be tackled (Ogungbite *et al.*, 2014b). In the current study, mortalities were recorded when the rice was treated with the plant material. The result obtained from this research showed that the leaf powders of *A. muricata*, *C. papaya*, *C. sinensis* and *P.guajava* had a significant effect on the mortalities of the *R. dominica and S. oryzae* when compared to the controls. This suggests the promising potential of the plant material for controlling these insect pests of stored rice.

A. muricata contains chemicals such as acetogenins (annomuricins and annonacin), alkaloids (coreximine and reticuline) and flavonoids (quercetin), which are predicted to be responsible for the biological activity (Vijayameena *et al*., 2013). A study by Ogbuehi and Onuh, 2019 indicated that *A. muricata* leaf extract is very effective in controlling *Podagrica spp* on okra. Similarly, *P.guajava* contains high content of organic and inorganic compounds such as antioxidants, polyphenols, antiviral compounds, anti-inflammatory compounds (Naseer *et al.,* 2018). Some of these compounds in the plant have been found to be effective in controlling immature stages of mosquitoes (Rwang *et al.,* 2016) *C. sinensis* is a rich source of secondary metabolites which contribute to the pharmacological activities attributed to this plant. Several types of chemical compounds have been identified in fruits, peel, leaves, juice and roots of *C. sinensis*, which include the following groups: flavonoids 1–54**.** steroids 55**,**56, hydroxyamides, alkanes and fatty acids 57–60**,** coumarins 61–67 peptides 68–70**,** carbohydrates 71–74**,** carbamates and alkylamines 75-78**,** carotenoids 79-82**,** and volatile compounds 83–148 (Favela Hernandez *et al*., 2016). These compounds have shown greater insecticidal properties against several insect pests by acting as antifeedant, repellent, growth disrupters and reproduction inhibitors (Laudani *et al*., 2022). Furthermore, *C. papaya* has also been found to contain carpaine, methyl gallate, loliolide, rutin, clitorin, kaempferol-3-*O*-neohesperidoside, isoquercetin, nicotiflorin and isorhamnetin-3-*O*-β-D-glucopyranoside (Hamed *et al*., 2022). The presence of these compounds in the plant makes it effective in controlling several insect pests (Rahayu *et al*., 2020). Under the same wt/wt powder treatment of the plants there were different levels of mortality between the two insects. There was higher rate of survival of *S. oryzae* than *R. dominica* in the powdered treatment even though both insect pests are primary pests and feed inside the kennel. This according to Bhavya *et al*. (2019) may be related to the insects genetic. The present study has therefore shown that plant leaf powders have entomocidal properties against *R. dominica* and *S. oryzae*.

CONCLUSION

This could go a long way in the quest of providing alternatives to the use of chemical insecticides for protecting rice in storage and for increasing its shelf life. Moreover, these plants are readily available in Ghana and so can beincorporatedinto integrated pest management strategies in developing countries because they are locally available, potentially less expensive to the traditional farmer and relatively less harmful to human health and the environment. Since the plant powders could lead to qualitative losses through discoloration of the grains, further studies on the leaf extracts of the various plants could be tested against stored product pests to determine its efficacy.

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