# Fumigant toxicity of four botanical plant oils on survival, egg laying and progeny development of the dried yam beetle, *Dinoderus porcellus* (Lesne) (Coleoptera: Bostrichidae)

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## Abstract

*This research reported fumigant toxicity of three (3) citrus peels oil and Eugenia aromatica oil tested for longevity of adults, the number of eggs laid and adult emergence of Dinoderus porcellus. The fumigant oils were extracted from peels of Citrus aurantifolia, Citrus sinensis, Citrus paradis and seeds of Eugenia aromatica. The most efficient is Eugenia aromatica and Citrus aurantifolia that resulted in 100% mortality 24 hours post treatment, zero oviposition and zero emergence of adults. Citrus peel oils can be used as a good alternative to pesticides against Dinoderus porcellus in dried yams and other stored products commodities.*

*Keywords:* Dinoderus porcellus, dried yam, citrus oils, Eugenia aromatica

## Introduction

Post harvest loss of staple food crops in Nigeria, due to insect infestation had caused a decline in the countries economic situation. Yam, dioscorea specie is an important staple food crop in Nigeria, and a cheap source of carbohydrate for human consumption (Adedire and Oni, 1998; Kocklar, 1986). In Nigeria, yam tubers are been consumed in a muber of forms among the different ethnic groups. Freshly harvested tubers of *dioscorea rotundata* (white yam) are processed by slicing, parboiling and sun dried before storage (Adesuyi, S.A. 1965).

Quite a number of insect pest infesting dried yam have been reported, among which *Dinoderus porcellus* Lesne, *Rhizopertha dominica* fab, and *Tribolium castaneum* herbst (Adesuyi, 1965; Osuji 1980) are regarded as most abundant.

Several control measures have been undertaken to reduce storage losses encountered in stored food products. The use of synthetic insecticides has been reported to be very effective and expensive with detrimental effects on animals and man health. (Arannilewa, 1998).Current measures of controlling pest infestation in grains and other food commodities rely heavily upon toxic fumigants and contact botanicals.Fumigant activity of essential oils extracted from some aromatic plant parts, including leaves, roots, stem, bark and fruits, have been evaluated on some major stored product insects, to be of good protectants efficacy (Aranilewa et al, 2002; Adedire and Lajide, 1999; Odeyemi, 1993; Ivbijaro, 1983; Ofuya, 1986 and Lale, 1995) which may be safer, readily affordable and available ( Olotuah et al, 2006). Huge number of botanical oils have also been screened for preventing post harvest losses due to insects (Golob and Webley, 1980; Odeyemi, 1993; Osisiogu & Agbakwuru, 1978; Ofuya and Fuyape, 1999) with high degree of success reported on storage pests of grains. In spite of several concerted research efforts on the use of oils in the control of stored product pests in grains, virtually no effort has been made on the use of botanical oils either as contact or fumigant toxicity against *Dinoderus porcellus* in stored dried yam. This paper reports laboratory bioassays of fumigant toxicity of four botanical oils in the control of *Dinoderus porcellus* in dried yams.

## Materials and methods insect cultures

Parent stock of *Dinoderus porcellus* (Lesne) was obtained from established laboratory culture reared on disinfested dried yams in oven, at 105°C for 1hour at ambient temperature of 28-+2°C and relative humidity of 75+5% in the Crop. Science and Pest Research laboratory, School of Agriculture, Federal University of Technology, Akure, Nigeria. Dried yam chips used as food medium was prepared from fresh tubers of

*Dioscorea rotundata* and *Dinoderus porcellus* of 1-4 days old was raised in 3 litre kilner jar from the above culture and used for subsequent bioassays.

**Table 1: Plant oils evaluated for insecticidal activities against *Dinoderus porcellus***

| Scientific name | Family | Parts used | Common name |
|---|---|---|---|
| *Citrus aurantifolia* | Rutaceae | Fruit peel | Lime |
| *Citrus sinensis* | Rutaceae | Fruit peel | Sweet orange |
| *Citrus paradis* | Rutaceae | Fruit peel | Grape |
| *Eugenia aromatica* | Martaceae | Fruits | Clove |

## Preparation and extraction of plant material

Citrus species and Eugenia were purchased from Oja-oba market in Akure, Nigeria, citrus fruit bark was peeled, sun dried and pulverized, kept in separate plastic containers. Eugenia was also air-dried and pulverized into powder. The soxhalation was carried out with n-hexane for 3-4hours, re-distilled to recover the solvent and the resulting extract was air-dried in order to remove traces of the solvent.

## Fumigant effect on beetle mortality

500ml transparent plastic container was used as fumigant chamber. 0.1v/w, 0.2 v/w and 0.5v/w of each oil extract were measured onto the floor of each container using 1ml syringe. 50 grammes of sterilized dried yam chips were weighed into muslin cloth each. Newly emerged teneral adults of *Dinoderus porcellus* were sexed according to Halstead(1963) and introduce into the muslin cloth, tied with a thread and then hung from the plastic container using a tight fitting cork (Ashamo, 2006). Each container was then covered with the lid to prevent escape of insects. *Dinoderus porcellus* and active ingredients in the oil extracts. Each treatment was replicated three times. 1ml n-hexane was used for the control. Beetle mortality was assessed at 24, 48, 72 and 96hours post treatment.

## Fumigant effect on oviposition and adult emergence

In another experiment, oviposition and adult emergence inhibitory activity of *Citrus aurantifolia, Citrus sinensis, Citrus paradis, Eugenia aromatica* was tested against *Dinoderus porcellus* in oil treated and solvent treated fumigant chambers with 0.1, 0.2 and 0.5v/w of each oil extract. Insects were left undisturbed to oviposite for 7 days. Insects, dead and alive were removed and numbers of eggs laid were counted under binocular electron microscope. The set up was left undisturbed for 7 weeks in order to determine progeny production. Total numbers of emerged insects in both oil treated and solvent treated fumigant chambers were recorded.

## Data analysis

Data were subjected to analysis of variance and where significant differences existed, treatment means were compared at 0.05 significant level using the New Duncan's Multiple Range Test (Zar 1984).

## Results

Fumigant toxicity bioassay of plant oils on mortality of dried yam beetle at different hours of treatment are presented in Table 2. 100% adult mortality was recorded at 24hours post treatment with toxic vapours from *Citrus aurantifolia* and *Eugenia aromatica* which was significantly different from other citrus oils. This was followed by *Citrus paradis* (86.67 and 100%) and *Citus sinensis* (83.33 and 86.67%) mortality at 96 hours post treatment. This was significantly different from the control where no adult mortality was recorded. Plant oils are commonly used in insect control because the oils are relatively efficacious against all stages of insects.( Adedire, 2002; Don-Pedro, 1989, 1990). Oviposition inhibition was observed in dried yam fumigated with eugenia and *Citrus aurantifolia* where no egg was laid(0.00) and significantly different from *Citrus paradis* followed by *C. sinensis* with the highest oviposition (24.00) significantly lower than the control (167.67)

Adult emergence after 7 weeks of storage is presented in Table 4. Virtually, no adult emergence was recorded on dried yam fumigated with *C. aurantifolia, C.paradis* and *Eugenia*. *C. sinensis* showed a significant difference (0.67) compared to 155.00 in solvent control. In addition, no physical damage was observed on the dried yam chips.

**Table: 2: Effect of plant oils on adult beetles of *Dinoderus porcellus***

| Plant oil | Conc.v/w | Mean Mortality (±S.D)(%) At 24-96Hrs Post- Treatment | | | |
|---|---|---|---|---|---|
| | | 24 Hours | 48 Hours | 72 Hours | 96 Hours |
| *Citrus* | 0.10 | 88.33±0.58b | 100.00±0.00d | 100.00±0.00e | 100.00±0.00d |
| *aurantifolia* | 0.20 | 100.00±0.00c | 100.00±0.00d | 100.00±0.00e | 100.00±0.00d |
| | 0.50 | 100.00±0.00c | 100.00±0.00d | 100.00±0.00e | 100.00±0.00d |
| *Citrus* | 0.10 | 0.00±0.00a | 1.67±0.33b | 31.67±0.67b | 31.67±0.86b |
| *sinensis* | 0.20 | 0.00±0.00a | 6.67±0.33b | 40.00±0.58bc | 83.33±0.67d |
| | 0.50 | 0.00±0.00a | 10.00±0.58b | 35.00±1.00b | 86.67±0.60d |
| *Citrus* | 0.10 | 0.00±0.00a | 8.33±0.33b | 20.00±0.58a | 43.33±1.20c |
| *paradis* | 0.20 | 3.33±0.33a | 23.33±0.33c | 51.67±0.67c | 86.67±1.20d |
| | 0.50 | 10.00±0.58a | 31.67±31.6c | 63.33±1.33d | 100.00±0.00d |
| *Eugenia* | 0.10 | 100.00±0.00c | 100.00±0.00d | 100.00±0.00e | 100.00±0.00d |
| *aromatica* | 0.20 | 100.00±0.00c | 100.00±0.00d | 100.00±0.00e | 100.00±0.00d |
| | 0.50 | 100.00±0.00c | 100.00±0.00d | 100.00±0.00e | 100.00±0.00d |
| Control | 0.00 | 0.00±0.00a | 0.00±0.00a | 0.00±0.00a | 0.00±0.00a |

Each value is the mean of three replicates. Means followed by the same letter are not significantly different ($P<0.05$) from each other, using New Duncan's Multiple Range Test.

**Table 3:Fumigant effect on Oviposition of *D.porcellus***

| Plant oil | Conc(%.v/w) | Mean number of eggs laid(±)SD |
|---|---|---|
| *C.aurantifolia* | 0.10 | 0.33±0.33a |
| | 0.20 | 0.00±0.00a |
| | 0.50 | 0.00±0.00a |
| *C.sinensis* | 0.10 | 32.67±3.48d |
| | 0.20 | 27.33±1.76cd |
| | 0.50 | 24.00±2.65c |
| *C.paradis* | 0.10 | 13.67±1.20b |
| | 0.20 | 12.00±1.53b |
| | 0.50 | 11.00±1.00b |
| *E.aromatica* | 0.10 | 0.00±0.00a |
| | 0.20 | 0.00±0.00a |
| | 0.50 | 0.00±0.00a |
| Solvent control | 0.00 | 167.67±8.41e |

Each value is the mean of three replicates. Means followed by the same letter are not significantly different (P>0.5) from each other.using New Duncan's multiple Range Test.

**Table4: Fumigant effect on *Dinoderus porcellus* adult emergence**

| Plant oil | Conc (%v/w) | Mean number of emerged adults S.D |
|---|---|---|
| *C.aurantifolia* | 0.10 | 0.00±0.00a |
| | 0.20 | 0.00±0.00a |
| | 0.50 | 0.00±0.00a |
| *C.sinensis* | 0.10 | 0.67±0.33b |
| | 0.20 | 0.00±0.00a |
| | 0.50 | 0.00±0.00a |
| *C.paradis* | 0.10 | 0.00±0.00a |
| | 0.20 | 0.00±0.00a |
| | 0.50 | 0.00±0.00a |
| *E.aromatica* | 0.10 | 0.00±0.00a |
| | 0.20 | 0.00±0.00a |
| | 0.50 | 0.00±0.00a |
| Solvent Control | 0.00 | 155.00±6.71c |

Each value is the mean of three replicates . Means followed by the same letter are not significantly different (P>0.05) from each other , using New Duncan's Multiple Range Test.

## Discussion

These results confirmed that volatile plant oils can be used as fumigants to protect dried yams and other stored products commodities Don-Pedro , 1996a & b ; Keita et al , 2001 ; Shaaya et al , 1991 and Ofuya et al , 2005. reported the effectiveness of plant oils and extract in grain protection against pest depreciation in storage .The fumigant action of toxic vapors of six citrus peel oils against *C.maculatus .S .zeamais* and *D.maculatus* have been reported by Don Pedro . 1996 a & b as having similar bioactivities . *E.aromatica* and citrus peels showed high protectability. may be potent and of strong choky odour disrupting respiratory activity of beetles in this study. and this resulted in rapid mortality. oviposition and f1 inhibition.

This work reports zero F1 emergence with *E.aromatica. C.aurantifolia* and *C.paradis.* this may be attributed to the presence of limonene ,eugenol and cincole toxic chemicals (Olotuah .et al 2006) found in eugenia and acetaldehyde .borneol. caprilic acid , carvone .furfural. geraniol and histamine (Don-Pedro , 1996a & b) as chemical components present in citrus peels .The vapours of chemical components in oils probably has a remarkable effect on the survival of eggs . Though eggs were laid on some fumigated food sample, but the degree of hatchability was zero.

From this study, efficiency of citrus peel oils and eugenia is well established on dried yams and have been reported by other researchers on grains .It reveals that fumigant oils of *Citrus aurantifolia* and *Eugenia aromatica* display high fumigant potential while.C.sinensis and C.paradis showed little fumigant toxicity.little oviposition inhibition.and zero progeny development . Fumigant oil of these plants may be sufficiently insecticidal and of good alternative to commercial pesticides for farmers and for household or small scale storage in other to protect stored products commodities against insect infestation. An investigation is going on presently to compare the effectiveness of the powders of this plant extract to the potentiability of the oils. Since the plant materials are edible. readily available.affordable and used for medicinal purposes. may also be used by low scale farmers in powder form if the protectability result is promising.

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