



# **Repellency Effects of Three Indigenous Plant Extracts Against the Red Rust Flour Beetle *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae) in Northeastern Nigeria**

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## **Author's contribution**

*This work was done solely by author MAM and all those that contributed to the success of this research were fully acknowledged in the acknowledgment section.*

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## **ABSTRACT**

**Background:** The current study was conducted in the Laboratory of Department of Crop Protection, Modibbo Adama University of Technology, Yola to evaluate the repellent effects of different concentrations of extracts of *Azadirachta indica* (Neem), *Moringa oleifera* (Drum stick) and *Hyptis suaveolens* (Pig weed) against *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) at various time intervals and their interactions. Three concentrations viz; 5, 10 and 15% were applied to evaluate the Repellence of *T. castaneum* at five different exposure periods of 24, 48, 72, 96 and 120 hours. Repellence action of extracts of *A. indica*, *H. suaveolens* and *M. oleifera* evaluated against the *T. castaneum* had maximum repellency (81.63%) at highest concentration of 15%, followed by *H. suaveolens* (79.37%) and *M. oleifera* (50.46%). Regarding interaction between concentration and time, repellence increases with respect to increase in concentration, but reduces with passage of time. This shows that toxicity effects of these plant extracts is directly affected by concentration and time. Therefore, this study confirmed that these plant extracts are effective in the

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management of *T. castaneum* and most effectively at higher concentration within short period of time.

**Keywords:** *Tribolium castaneum*; biotoxicity; repellency; plant extracts.

## 1. INTRODUCTION

Cereals are members of the family (Poaceae) grown for their characteristics fruit and the caryopsis, which have been the most important sources of world's food for the last 100,000 years [1]. Stored cereals are vulnerable to diversity of insects attack both in storage as raw grains or when processed into fine flour [2] and a possible infestation can deteriorate the quality as well as the quantity [3] resulting in significant losses in volume, weight, lower market value and reasonable germination reduction [4,5,6,7,8]. Insect pests of post-harvest cereal products can cause up to 9-20% losses in storage and among these stored grain insect pests *Tribolium castaneum* is the major secondary pest of stored food products and processed foods throughout the world [9]. Synthetic chemicals is the conventional scheme in insect pests management and it causes many worse effects on environment which in turn [10] have a definite impact on health of living organisms including humans [11,12]. Fumigation is the important way for control of stored grain insect pests. At present, most frequently used fumigants are methyl bromide and phosphine. But their use is restricted due to their toxic effects on environment.

Therefore, alternative methods for control of this pest should be developed which must be effective, socially acceptable, ecologically reliable and economically feasible [13,14,15,7,16]. Plant extracts are best substitute methods for control of stored products insect pests by the use of plant parts and their products as repellents and deterrents such as essential oils and powders of parts of plants [17,18]. Natural plant extracts have proved to be effective against various stored grains insects especially *Tribolium castaneum* [6]. Extracts of these plants contain volatile compounds that affect insect behavior and physiology [19,20,17]. In this study, experiments were focused on the evaluation of natural plant extracts of *Hyptis suaveolens*, *Moringa oleifera* and *Azadirachta indica* as biocidal and repellent against *T. castaneum*.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The experiment was conducted in the Laboratory of the Department of Crop Protection of Modibbo Adama University of Technology, Yola. Yola is located in the Northern Guinea Savannah Agro-Ecological Zone of Nigeria at latitude 9° 14' N, longitude 12° 28' E and altitude 190.5m and has the minimum and maximum rainfall, temperatures and relative humidity of 0.80 and 4.92ml; 27°C and 42°C and 35% and 75%, respectively [21].

### 2.2 Sources of Experimental Materials

#### 2.2.1 Sources of plant materials

Leaves of *Azadirachta indica* (Neem), *Moringa oleifera* (Drum stick) and *Hyptis suaveolens* (Pig weed) were collected from around the University Staff Quarters, Modibbo Adama University of Technology, Yola, Adamawa state, Nigeria. The leaves of each plant were collected in the early morning hours before the Sun set out. This was done by hand picking on the mother plant and put inside a polythene bag then taking to the laboratory for shade drying.

#### 2.2.2 Source of insect and insect culture

The test insect (*Tribolium castaneum*) used to establish a laboratory colony was collected from naturally infested wheat flour obtained from Girei market Adamawa state, Nigeria. It was brought to the laboratory and cultured on disinfected wheat flour to obtain similar aged weevils for the experiments at ambient room temperature. This was done by placing 50 pairs of unsexed *T. castaneum* adults into 1 litre capacity bottle containing 500g wheat flour. The bottles were covered with muslin cloth and secured with rubber band to prevent escape of insects and to allow aeration. After seven (7) days, when oviposition had been noticed, the parent stock of *T. castaneum* was removed. The flour with the oviposited eggs was then left under laboratory conditions until emergence of F<sub>1</sub> progeny [22].

The F<sub>1</sub> progeny 1 – 3 days old from the cultures was then used for the experiment.

### 2.3 Preparation of Plant Extracts

The plant materials were washed in water and then Shade dried. Grinder was used to crush the plant material to fine powder and then sieved with a fine mesh sieve. The extracts were made by mixing 50 g of ground sieved sample and 100 ml of ethanol and then shaken to for 24 hours with the help of Rotary Shaker (IRMICO OS-10), adjusted at 120 rpm. After 24 hours, filtration was then made with the help of filter paper. Preliminary extract was subjected to the Rotary evaporator to get 100% stock solution as described by [6].

### 2.4 Experimental Procedure and Bioassay on Repellency

Different concentrations (0%, 5, 10 and 15 %) were made by diluting the concentrated stock with ethanol. These dilutions were then applied on the half of Whatman no.1 filter paper with the help of micropipette while the other half was treated with ethanol only (control). In order to evaporate the solvent from treated and untreated halves, the filter papers were air dried for 60 minutes. After drying, the treated papers were stapled together and adjusted in the Petri dishes.

Repellency of the plant extracts was checked by using the area preference method [23]. Twenty adult (1-3 days old) weevils of *T. castaneum* were then released in the center of both halves. Repellency data was taken for a period of five (5) hours at one hour interval on both halves of filter paper (treated and untreated). Diet was provided on both sides (treated and untreated end of filter paper) to decrease mortality due to starvation [6]. The experiment was laid in Split Plot Design (SPD) replicated three times. Repellence is then calculated according to the method of [24] as;

$$\% PR = \frac{N_c - N_t}{N_c + N_t} \times 100$$

Where:

PR = % repellency;

N<sub>c</sub> = Number of insects of untreated paper;

N<sub>t</sub> = Number of insects on treated paper.

### 2.5 Statistical Analysis

Abbott's formula was used to calculate corrected mortality and data obtained were analyzed by

Analysis of Variance (ANOVA) using Statistic 7.0 software and treatments means were separated using Tukey-HSD test at 5% level of significant.

## 3. RESULTS

Repellence of *T. castaneum* by these plant extracts was observed and it varied with the type of plant (Table 1). *A. indica* at 15% concentration had the highest repellence (81.63%) followed by *H. souveolens* (79.37%) while the lowest (50.46%) was induced by *M. oleifera* extract at 5% concentration. Generally, highest repellence was observed at the highest concentrations while lowest mortality was observed at lowest concentration of the plant extracts.

Table 2 indicates the effects of time interval on the repellence. The results depicted that the repellence tended to decrease with passage of time and the highest was observed after 1 hour in case of *Azadirachta indica* (95.26 7%) while the lowest was observed on *M. oleifera* (36.87%) after 5 hours of exposure. However, all the plant extracts showed decrease in repellence when exposed for longer period of time. This indicates low persistence of these natural extracts in the environment.

Fig. 1 showed the comparative analyses effects of concentration and time. The plant extracts gave maximum repellence of 100% at 10% concentration after 5 hours exposure by *A. indica* while *H. souveolens* had 100% concentration at 15% after 5 hours exposure period. However, *M. oleifera* showed lower repellency at 5% concentration after 5 hours exposure (Fig. 1). This shows that repellency is directly affected by concentration and time.

## 4. DISCUSSION

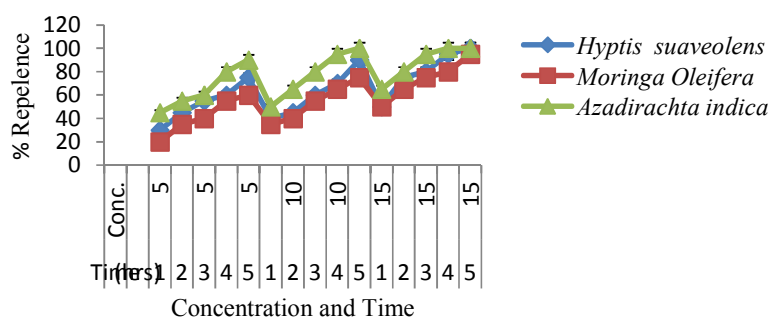
This experiment proved a definite impact of plant extracts towards inducing quick knockdown and repellence against the adults of stored grain insect pest, *Tribolium castaneum*. Plant extracts proved to be effective repellants and toxicants. In an experiment conducted by [6] he observed that maximum (83.70%) repellency action of extracts of *M. exotica*, *E. comeldulensis*, *A. indica*, *T. ammi* and *T. chebula* evaluated against the *T. castaneum* was obtained at highest concentration of 15% and at 24 hours exposure

**Table 1. Effects of different plant extracts at various concentrations (5, 10 and 15%) on repellency of *Tribolium castaneum***

| % Repellency ± SE |                      |                    |                  |
|-------------------|----------------------|--------------------|------------------|
| Conc. (%)         | <i>H. souveolens</i> | <i>M. oleifera</i> | <i>A. indica</i> |
| 5                 | 61.50 ± 2.90         | 25.21 ± 1.79       | 63.51 ± 2.79     |
| 10                | 68.72 ± 1.87         | 47.89 ± 1.71       | 71.67 ± 1.93     |
| 15                | 79.37 ± 1.69         | 50.46 ± 1.63       | 81.63 ± 1.59     |

**Table 2. Effects of different plant extracts at different exposure periods (1, 2, 3, 4 and 5 hours) on repellency of *Tribolium castaneum***

| % Repellency ± SE |                      |                    |                  |
|-------------------|----------------------|--------------------|------------------|
| Time (hrs.)       | <i>H. souveolens</i> | <i>M. oleifera</i> | <i>A. indica</i> |
| 1                 | 86.39 ± 1.77         | 67.13 ± 1.95       | 95.26 ± 1.21     |
| 2                 | 74.53 ± 1.95         | 65.35 ± 1.95       | 85.30 ± 1.43     |
| 3                 | 72.91 ± 1.96         | 53.17 ± 1.63       | 79.48 ± 1.68     |
| 4                 | 63.78 ± 2.13         | 49.96 ± 2.93       | 72.61 ± 1.95     |
| 5                 | 53.23 ± 1.65         | 36.87 ± 2.97       | 66.12 ± 2.01     |



**Fig. 1. Repellence effects of plant extract at different concentration (5, 10 and 15%) and exposure periods (1, 2, 3, 4 and 5 hours) on *Tribolium castaneum***

period (90.37%). This result is in agreement to the findings of this study which shows that repellency is directly affected by concentration where highest repellency is obtained at highest concentration (81.63%) and shorter exposure period (95.26%). This study proved the effectiveness of *A. indica* extract to possess repellent effects to *T. castaneum* which is similar to studies conducted by [25] who found that *Azadirachta indica* was more repellent in action as compared to *Glycyrrhiza glabra* in all the time intervals and also observed that the repellency tended to increase as the level of concentration increased. Many researchers also found out that plant extracts have repellent, antifidant and mortal effects against various stored grain insect pests [6,26,27,25,28].

This experiment proved that plant extracts is effective in terms of repellence and mortality of *T.*

*castaneum* because it was found that *A. indica* and *H. souveolens* were potent. Chaubey [29] determined the effects of essential oils of *Zingiber officinale* and *Piper cubeba* against the cowpea Bruchid, which suggested that the persistence of these extracts towards the biology of storage pest can be safely used to repel the storage beetles from the stored commodities. Iqbal et al. [30] also done work on the repellent action of Neem and it was concluded that it ranged from 63% to 75% which differ slightly from the result of this study (79.37% to 81.63%). Gradual decrease in repellency was noted over a longer period of 5 hours. At first contact, rapid effects were noted and the insect behavior showed lower repellency towards the treated half with the passage of time on all the plant extracts. This support the findings of Hasan et al. [25] who depicted that the repellence tended to decrease with the passage of time and the highest was

observed after 24h in case of *E. globules* (86.67%) while the lowest was observed in the case of *C. limon* (43.70%) after 72 hours of treatments. All the extracts showed lesser repellence after a delayed period of time showing the low persistence of these natural extracts in the environment.

They determined the highest repellent effects to be 55.47% against the *T. castaneum* at 10% while our results are 47.89%, 68.72% and 71.67% at the same concentration of *Azadirachta indica*, *Hyptis suaveolens* and *Moringa oleifera* extracts. Though, garlic extracts indicate a definite impact as a potential repellent against different insects [31]. According to the above mentioned authors, the plant extracts have toxic, fumigant, and sterilizing, anti-feeding and repellent effects against the insect pests of stored commodities. Our experiments also showed the effectiveness of the plant extracts against the rust red flour beetle and repellent effects of both plant extracts were significant. Therefore, the results suggest that *Azadirachta indica* and *Hyptis suaveolens* are effective repellents and toxicants stored grain insect pests especially rust red flour beetle, *Tribolium castaneum*.

## 5. CONCLUSION

This study clearly indicated variations in the activity of these plant extracts regarding the difference in the plant species, exposure period and concentration used. The findings of this study predict the potential of plant extracts towards the stored grain insect pest management. Based on the high repellence results of the present study, it is concluded that the application of *A. indica*, *H. suaveolens* and *M. oleifera* leaf extracts as plant derived insecticides on *T. castaneum* can control the damage caused by this beetle. *A. indica* is the most effective plant extract because it had the highest repellence effects among the three plant extracts used in this study while, *M. oleifera* had the least repellence effects. Therefore, the result suggested the persistence of these extracts towards the biology of storage pest and the repellent action can be safely used to repel the storage beetles from the stored products. However, the medicinal values, availability, biodegradable, low costs rate and potential as bio-pesticides make them necessary for the management of *T. castaneum*. Future research should target the active ingredients that are

having less toxicity for humans but have greater repellent action against the insect pests.

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## COMPETING INTERESTS

Author has declared that no competing interests exist.

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