AJFAND ONLINE Scholarly, Peer Reviewed ISSN 1684 5374
African Journal of Food, Agriculture, Nutrition and Development
Volume 11 No. 7
December 2011
Published by African Scholarly Science Communications Trust

EFFECT OF *Dermestes maculatus* ON THE NUTRITIONAL QUALITIES OF TWO EDIBLE INSECTS (*Oryctes boas* AND *Rhynchophorus phoenicis*)

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ABSTRACT

This study aimed to assess the effect on nutritional composition of two 'Edible Insects' (Larva of *Oryctes boas* and *Rhynchophorus phoenicis*) after infestation by *Dermestes maculatus.* The study was done over a period of six weeks by subjecting these edible insects to different conditions of storage (using pepper and salt). The assessment was based on weight and proximate analysis differences before and after infestation under these media of storage. The larva of *Oryctes boas* in the container with salt as preservative had the least weight loss (from 30.00 ± .0000 → 39.70 ± .3000 → 36.30 ± 1.000), followed by the container with pepper as preservative (from 30.00 ± .0000 → 31.05 ± 5.000 → 25.25 ± .1500) while the highest weight loss occurred in the container without preservative constituents (from 30.00 ± .0000 → 30.30 ± 1.000 → 21.15 ± 5.000). Likewise, the larva of *Rhynchoporus phoenicis* in the container with salt as preservative constituent had the least weight difference of (16.00 ± .0000 → 20.80 ± .0000 → 13.65 ± .1500); followed by the container with pepper as preservative (from 16.00 ± .0000 → 16.40 ± 1.000 → 6.700 ± .2000), while the highest weight loss occurred in the container without preservative (from 16.00 ± .0000 → 7.850 ± 5.000 → 6.300 ± .0000). The mortality rate of *Dermestes maculatus* was also determined, showing that the larva of *Oryctes boas* and *Rhynchophorus phoenicis* containing salt as preservative had the highest mortality rate of 60% and 80%, respectively, followed by that containing pepper as preservative having 20% and 30% respectively, and that containing no preservative constituent had no mortality rate. It was concluded that, *Dermestes maculatus*' infestations on the larva of edible insects showed a difference in the proximate analysis of these edible insects before and after infestation. Therefore, it was suggested that edible insects should be well dried and locally preserved with salt and pepper.

Key words: *Dermestes maculatus, Rhynchoporus phoenicis, Oryctes boas*, proximate, mortality

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INTRODUCTION

Over the past decades, recognition by people of the effects of *Dermestes maculatus* on the role of nutritional value of stored product in food security has grown considerably. Several investigations have shown that in addition to insects' fundamental contributions to pollen dissemination, insects contribute significantly to livelihoods in both rural and urban areas [1]. Insects are popular food in many cultures all over the world as an occasional delicacy or a replacement food in times of shortages as in droughts, floods or war. The potential of insects need to be more seriously considered in Food Security and Poverty Alleviation Strategies in sub-Saharan Africa [2]. Insects have played an important role in the history of human nutrition in Africa, Asia and Latin American. Some of the most important groups of the hundreds of insect species that have been used as human food include: Grasshoppers, Rhinoceros beetles, Caterpillars, Termites, Bees, Wasps, and Broods (larvae and pupae) as well as winged ants, cicadas and a variety of aquatic insects, which insects have a high population in the tropics [3].

The problems with utilizing insects' proteins are the lack of social acceptance, nutritional knowledge, information and disbelief about delicacies of these insects that are naturally abundant in our farms and forests. There is need for insect eaters to educate the public about the value of edible insects. Despite these problems that pose challenges to insect Cultivators and Gatherers, it is also noticed and confirmed that *Dermestes maculatus* (Hide beetle), regarded as pests of stored food products, feed on dead insects. Hide beetle has recently been a pest in poultry houses where huge populations of matured larvae have damaged wooden structural materials as reported by Josland [4] in the UK and USA.

Dermestes maculatus is widely recognized as a cosmopolitan pest of stored commodities especially those containing animal proteins. The Hide beetle feeds on hides, skins, feathers and horns; and is a known pest of dried fish [5]. These are groups of small beetles whose larvae are especially injurious to dried meat, wool, fur and other animal materials [6]. *Dermestes'*s occurrence in a range of stored products in various countries had been reviewed in relation to its general biology and infestation of dried fish in Nigeria, by investigating the effects of regulated salt treatment of fish on the developmental biology of the beetle when reared in diets under two sets of conditions of temperature and humidity [7, 8].

Development of *Dermestes maculatus* is not possible at 40^0C or above, because, temperature above 40^0C can kill or repel all these beetles. Such temperature can disinfect fish or delay invasion by *Dermestes maculatus* as long as it is achieved throughout the batch. If some of the fish remains at normal temperatures, the beetle will migrate. Well-dried fish reduces the rate of *Dermestes* population growth.
Salting of fish gives protection against *Dermestes maculates,* partly because larval development is prolonged and larval mortality increases with increase in salt content. In experiments at 30^0C, larval development took 37 days on fish with 3.5% salt content compared with $21^1/_2$ days on unsalted fish and mortality reached 100% when the salt content was increased to 9.2% by brining for $1^1/_2$h [7]. This susceptibility to

salt may explain the less frequent occurrence of *Dermestes maculatus* in cured marine fish, as salt is more commonly used in marine fish processing. *Dermestes ater* is also adversely affected by salting, by contrast, *Dermestes frischii* is relatively tolerant of salt, at 30^0C and 75% RH, the total developmental period increased only to 42 - 53 days instead of the 34 days on unsalted fish meal. Developments of these pests were prevented when the salt contents were 14% and 25%, respectively [9].

Insects, fish and meat play the same role in the human body. As food, caterpillars are regulars in the village but meat is rare [10], being that these insects are readily available as food and less expensive to procure compared to meat. Many people in Tropical Africa collect edible insects as food. The habit is especially well developed among the Cultivators of the forest regions. It is uncertain whether these insects are eaten because of their nutritional qualities or due to their cultural heritage or folktales. The aversion to insects as human food among Europeans is nothing more than custom and prejudice [11]. Grubs(beetles) of the palm weevil, *Rhynchophorus phoenicis Fabri* (*Coleoptera curculionidae*) and *Analeptes trifasciata* (*Coleoptera: Scarabaeidae*) are fried and eaten in several parts of Western Nigeria, in Delta, Edo and Bayelsa States where active marketing of these insects takes place. The people in the river-rine areas of Ondo State: (Bolowou, Opuba, Ajapa, Apata and all other people in towns of Arogbo Kingdom) do eat these insects when fried, roasted and even in the raw form.

Edible insects like caterpillars and grubs are important sources of protein and should be considered an alternative in efforts to increase food security in central African countries. Caterpillars are already an important food intake for many in central Africa; about 85% of participants in a survey in the Central African Republic consume caterpillars, 70% in the Democratic Republic of Congo and 91% in Botswana [8].

Edible insects like *Rhynchophorus phoenicis* (*Coleoptera curculionidae*) and *Analeptes trifasciata* (*Coleoptera scarabaeidae*), snout beetle and Rhinoceros beetle, respectively are species that damage palms. The former is a major secondary pest of Raphia (*Raphia hookeri* Mamwendland) and young oil palm (*Elaesis gunineensis Jacq*) which are abundant in the palm belt of the Niger Delta wetland which has suitable environmental conditions for its growth. *Rhynchophorus phoenicis* normally invades these palms after they have been damaged by *Rhinoceros beetle (larvae)* or by humans during tapping for wine and other insects. The larval stages of these insects, which are big with fleshy bodies, are highly nutritious and cherished as traditional delicacies by the indigenes of all the ethnic tribes in the Niger Delta (Ijaw, Urhobo, Ikwerre), Igbo and Yoruba in Nigeria, as well as other countries like Angola, Columbia, India, Cameroon and France [12].

The nutritional potentials of both *Rhynchophorus Phoenicis* and *Analeptes trifasicata* has not been tapped accordingly in the tropical world. People still use the crude traditional methods of farming and harvesting this valuable insect due to lack of modern implements for its harvest. For instance, the Bari and Indians use only the Jessenia palms as “grub farms” by cutting them down as logs for *Rhynchophorus*

infestation [13]. The Columbians also cut down palm trees deliberately to provide fodder for these insects, while in Nigeria people cut down oil and Raphia palm trees to be infested by *Oryctes boas* or *Rhynchophorus phoenicis.* The palm weevils are highly valued as human food by people of Manipur state of North Eastern India, who see insects as the cheapest sources of animal protein [14].

Caterpillar has been used as a protein supplement in poultry and cattle feeds. It contains 38 +% proteins, 16+% fats, 13+% carbohydrates and some chitin [15]. The lipids are made up of C16 and C18 saturated fatty acids and C18:1 and C18:2 saturated fatty acid. It has been estimated that 100 grams of it may provide 76% of an average human daily protein requirements and 100% of the daily requirements of vital vitamins and minerals which makes it compare favourably with meat and fish in terms of protein, fat, vitamins and calorific content [15].

To this effect, it has become pertinent to investigate the infestation effect of *Dermestes maculatus* on the nutritional composition of two selected edible insects *Oryctes boas* and *Rhynchophorus phoenics* larvae, commonly known as Rhinocerous beetle larvae and Snout beetle larvae, respectively, having been observed to be a major source of protein like fish and other animal meat.

MATERIALS AND METHODS

Collection of samples

Two different samples of insects were collected. These were: the larvae of *Rhynchophorus phoenicis* and *Oryctes boas*) and *the sample of Dermestes maculatus* (Hide beetle). The samples were collected from different locations in Ondo and Lagos States in the South Western part of Nigeria. The larvae of *Oryctes boas* were collected at Bolowou, Ese-Odo Local Government Area in Ondo State; the larva of *Rhynchophorus phoenicis* were collected at Itokin in Lagos State and samples of *Dermestes maculatus* were collected from Igbokoda(fish market), area of Ondo State.

Sorting and identification

The selected larvae of edible insects and *Dermestes maculatus* were collected and sorted for proper identification in the Laboratory of Entomology Department, Olabisi Onabanjo University, Ago-Iwoye of Ogun State.

Processing and preservation

The two samples collected were processed and preserved as follows:-
The larvae of *Oryctes boas* were washed with clean water, posterior end cut open to remove faecal waste and boiled for ten (10) minutes. The water was sieved again and the sample boiled for another fifteen (15) minutes and then sun-dried for twenty-one (21) days from 10 am to 4 pm daily. While the larvae of *Rhynchophorus phoenicis* were only washed with clean water without removing the intestines and parboiled for ten (10) minutes. The water was sieved and the sample boiled on a stove for another fifteen (15) minutes and then sun-dried for twenty-one (21) days from 10a.m to 4p.m daily.

The *Dermestes maculatus* (hide beetles) were picked with a soft (moist) camel hair brush and kept in a plastic jar (Container) along with little fish meal and covered with fine netting and placed in a waterbath for preservation by disallowing invasion of thief ants on the fish meal.

The processed and preserved edible insects were prepared in 30grams of three replicates for each sample; the insects were grounded separately for proximate and mineral analysis at the Nigerian Institute of Science Laboratory Technology (NISLT), Samonda in Ibadan (Oyo State). The samples were analyzed chemically according to the official methods of analysis recommended by the Association of Official and Analytical Chemists [16]. .

The larvae of *Rhinoceros beetle* were labeled with X_1X_2, Y_1Y_2 and Z_1Z_2, while the *Rhynchophorus phoenics* was labeled with A_1A_2, B_1B_2 and C_1C_2 to show the three (3) experiments in three replicates, respectively.

Method of infestation

In each of the set up replicates, twenty (20) *Dermestes maculatus* and thirty (30) grams of *Oryctes boas* were introduced into each container, respectively. Ten (10) grams of salt was also introduced into the replicates of X_1X_2 and that of Y_1Y_2 replicates was also ten grams of dried pepper, and that of replicates Z_1Z_2 container contained *Dermestes maculatus* and *Oryctes boas*, likewise for *Rhynchophorus phoeniicis,* labelled A_1A_2, B_1B_2 and C_1C_2.

Determining rate of infestation

Before the experiment commenced, the edible insects were weighed, then subjected to *Dermestes maculatus* for infestation. After the first two weeks, the insects were weighed again to access or determine the manifestation of depreciation or loss in weight. The weighing was done at two (2) weeks' intervals.

At the end of the experiment in six (6) weeks, the sample were weighed at four different times and these infested edible insects by *Dermestes maculatus* were grounded in each pair of container in replicates and subjected to proximate analysis and mineral composition analysis.

Mortality rate of Dermestes *maculatus*

The mortality rate was taken every two (2) weeks for four different times till the end of the experiment using the equation below: $X\ (\%) = (Nt/No) \times 100$

Where: No: Initial nos of *Dermestes*
Nt: Final nos of *Dermestes*

RESULTS

The results in Figures 1 & 2 showed that there was considerable decrease in the weight values of these insects as the weeks passed by under the infestation of *Dermestes maculatus*. At the first assessment (2nd week) of infestation, larvae of

Oryctes boas X_1X_2 had the highest increase in weight of 39.70+.3000, followed by Y_1Y_2 31.05+.50 and Z_1Z_2 had the least value of 30.30 + 1.00, while *Rhynchophorus phoenicis* A_1A_2 had a weight increase of 34.80 +.00, followed by that of B_1B_2 with 30.40 + 1.00 and C_1C_2 with 21.85+5.00. In the second assessment (i.e. 4th week) X_1X_2 had a weight values of 38.80 +.20, followed by Y_1Y_2 with 30.65+5.00 and Z_1Z_2 with 21.58 + .25, while A_1A_2 had 31.30 +.40, followed by B_1B_2 28.40+.10 and C_1C_2 had 21.15 +5.00. In the third assessment (. 6th week); X_1X_2 had weight decrease of 36.30 + 1.00, followed by Y_1Y_2 weight value of 25.25 +.15 and Z_1Z_2 with 21.15 + 5.00 while, A_1A_2 had a weight decrease of 23.25 +.15, followed by B_1B_2 with 20.70+.20 and C_1C_2 had the least value of 20.30+.00.

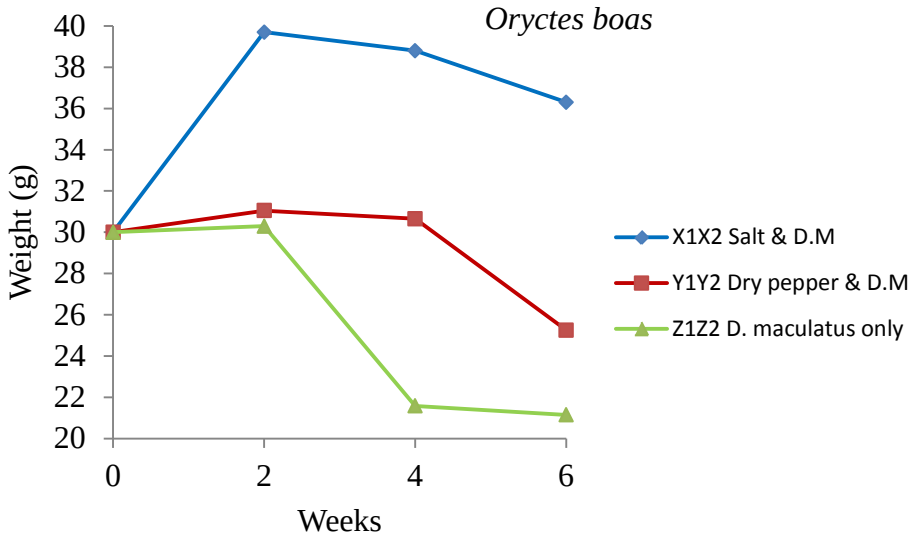

Figure 1: Weight changes of infested *Oryctes boas* (Larvae) by *Dermestes maculatus*.

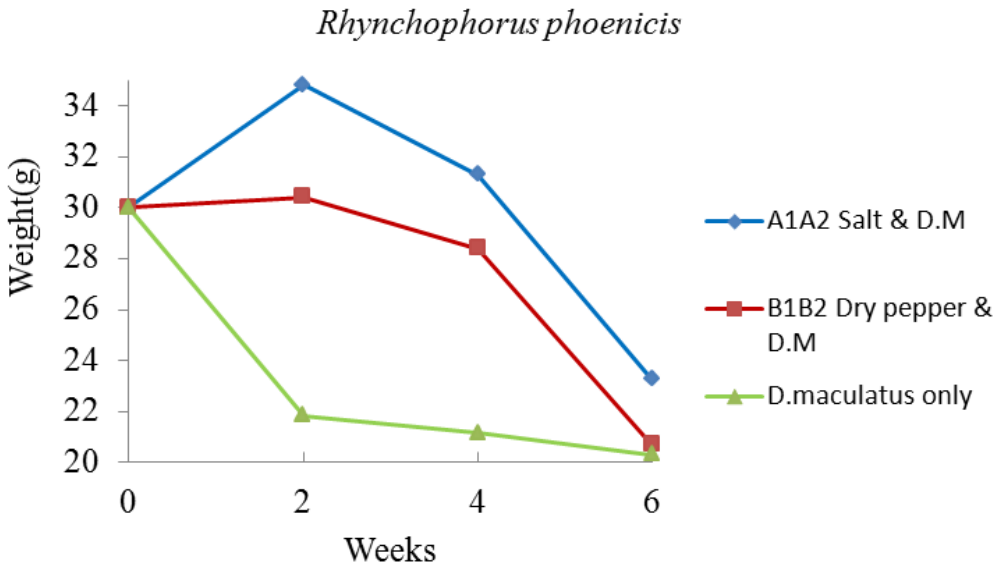

Figure 2: Weight changes of infested *Rhynchophorus phoenicis* (Larvae) by *Dermestes maculatus*.

Effect on nutritional composition

In Tables 1 & 2, the proximate analysis and mineral composition of the two edible insects' larvae before infestation were shown respectively. However, there were significant difference in the values obtained compared to those earlier reported by Banjo *et al.* [3] and Thomas [14] possibly due to time and area of collections. The aftermath of the susceptibility of these edible insects were indicated in Table 3 as regards their proximate values after the infestation. The ash, fat, and fiber contents of these edible insects were significantly affected under the presence of the two mainly used preservatives (salt and dry pepper), with a proportional increase in their protein contents as stated by Banjo *et al.* [3] and Thomas [14] that their dry matter shows significant increase in protein contents.

Mortality rate

The result in Table 4 shows the mortality rate of *Dermestes maculatus* in the experiment under an average temperature of 30^0C. The highest death rate occurred in the salt container's larva of *Rhynchophorus phoenicis* A_1A_2 been higher than that of *Oryctes boas* X_1X_2 due to the high contents of fat contained in the larva of *Rhynchophorus phoenicis.*

DISCUSSION

The precautions taken in this study were to enhance proper drying of the collected insects for good storage and assess their susceptibility to storage pests. It was noted that the protein contents of Z_1Z_2 and C_1C_2, which had no preservatives added to it, showed a decrease which could naturally had been due to the infestation of *Dermestes maculatus* on the edible insects. Although it was more evident in that there was preference of infestation on the larvae of *Oryctes boas* than that of the *Rhynchophorus phoenics*, due to higher content of protein in the latter.

The rate of decrease or depreciation in weight occurred more between the Fourth and Sixth (4th - 6th) weeks due to the fact that at Zero (initial) week to the Second week (0th - 2nd week) the concentration of the preservative constituents of salt and pepper were high and strong, thus, inhibiting the action of *Dermestes maculatus*, Thus, as the time progresses the concentration of the preservative constituents (salt and pepper) became lower and weaker, this gave room for *Dermestes maculatus* to become more active and effective in its infestation on the larvae. Therefore, between the two preservative constituents (salt and pepper), the infestation of *Dermestes maculatus* on the containers of Y_1Y_2 and B_1B_2 respectively were very significant than the containers of X_1X_2 and A_1A_2 respectively. This was due to the preservative potential of salt compared to that of dry pepper.

In Comparing the larvae of *Oryctes boas* and *Rhynchophorus phoenicis* based on the depreciation or loss of weight due to infestation of *Dermestes maculatus*, the decrease or loss in weight occurred majorly on the larvae of *Rhynchophorus phoenicis* because they were not well dried due to the high content of fat. This enhanced *Dermestes maculatus* to become more active and infests more on the larvae of *Rhynchophorus phoenicis. Dermestes maculatus* infests on soft body materials than that of tough bodies. The larvae of *Oryctes boas* were well dried thus reduces the rate of infestation of *Dermestes maculates.* This correlates with the report of Osuji [7] that well dried fish reduces the rate of *Dermestes* infestations.

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The highest death rate was recorded in the containers of the preservative constituent of salt followed by that of dry pepper. However, death rate was not recorded in the containers without preservatives constituents. This study showed that at Zero (initial) to sixth week in the container of preservative constituents of salt the mortality rate in the containers of *Oryctes boas,* X_1X_2 was 60%; *Rhynchophorus phoenicis* A_1A_2 was 85%. In the container of dry pepper preservative; mortality rate of *Oryctes boas* Y_1Y_2 was 35%; while the larvae of *Rhynchophorus phoenicis* B_1B_2 was 30%, and containers without preservative constituents; mortality rate was 10% in Z_1Z_2 and non in C_1C_2. The death rate occurred between the second weeks to the sixth week, thus, as the experiment progresses, the concentration and potentials of these preservative constituents became weaker and gradually ineffective, hence there was minimal mortality in the containers without the preservative constituents. This showed that *Dermestes maculatus* are parasites which can also infest on edible insects for survival as they occurred on fish.

Consequently Osuji [7] stated, that salting of fish gives protection against *Dermestes maculatus*, partly not because larval development is prolonged but mainly because larval mortality increases with increasing salt content. In experiment at 30^{O} C, larval development took 37 days on fish with 3.5% salt content compared with $21^{1}/_{2}$ days on unsalted fish, and mortality reached 100% when salt content was increased to 9.2% by brining for $1^{1}/_{2}$h [7]. This susceptibility to salt may explain the less frequent occurrence of *Dermestes maculatus* in cured marine fish, as salt is more commonly used in marine fish processing as stated by FAO [8].

CONCLUSION

It has been shown that *Dermestes maculatus* which infests dry fish as stated by Osuji [7] could equally infests edible insects if not properly stored, thus the use of various constituents (salt and pepper) as preservative by rural people should be encouraged as it has been indicated that these pests actually devalue the proteins' content of these edible insects if not properly stored. Therefore, the study of edible insects as host to *Dermestes maculatus* and use of salt and dry pepper as preservative constituents against the incessant infestation of *Dermestes maculatus* would help in the sustainability of the required nutrients contained in edible insects for consumption by man and the commercial value of edible insects in encouraging insects-gatherers (traders).

The extent and value of quantitative losses caused to dried fish by *Dermestes* spp. have been assessed by various investigators and estimates range from negligible up to 50% weight loss, depending on length of storage, salt content, moisture content, climatic conditions and general hygiene during processing and storage. Weight losses due to fragmentation have also been investigated but the contribution of *Dermestes* spp. to this process has not been superlatively assessed. This study is highly significant in promoting proper harvesting, storage and utilization of our naturally given sources of food to reduce malnutrition and lack of essential nutrients in our diet especially in developing countries of Africa.

ACKNOWLEDGEMENTS

The authors hereby acknowledge and express our sincere gratitude to Olabisi Onabanjo University and Tai Solarin University of Education, Ijagun, Nigeria for providing the environment to carry out this research.

Table 1: Proximate analysis of two selected edible insects

Insect Sample	%Protein	%Ash	%Moisture	%Fat	%Crude fiber
Oryctes boas	55.82	14.965	11.7	7.115	1.155
Rhynchophorus phoenicis	28.01	7.72	23.5	18.905	1.085

*Proximate Analysis % of two selected larva of edible insects

Table 2: Percentage mineral composition of two edible insects

Insect sample	%Ca	%K	PPMNa	%Mg	PPMMn	PPCu	PPMZn	PPMFe
Oryctes boas	1.32	0.195	72.095	0.45	30.4475	0.7925	4.1125	93.2045
Rhynchophorus phoenicis	1.8	0.34	95.7995	0.585	50.497	1.3745	7.141	48.9375

*Percentage Mineral Composition of Two Selected Larva of Edible Insects

Table 3: Proximate analysis of infested larva of two edible insects subjected to *Dermestes maculatus* and preservative constituents

Insect sample	Replicate (plastic jar)	Constituents	% Ash	% Protein	% Moisture	% Fat	% Fiber
Oryctes boas	X_1X_2	Salt & D.M	9.38	60.5661	30.06	7.81	1.321
	Y_1Y_2	Pepper & DM	3.36	56.1273	28.45	4.26	0.761
	Z_1Z_2	D.M only	3.92	39.3392	14.43	4.52	0.812
Rhynchophorus Phoenicis	A_1A_2	Salt & Dm	9.16	34.8127	34.79	20.07	1.221
	B_1B_2	Pepper & D.m	4.08	37.3048	14.32	30.72	0.911
	C_1C_2	D. M only	5.45	22.6617	18.5	13.47	0.887

Table 4: Mortality rate of D*ermestes maculatus* for the experiment

Insect Sample	Replicate (plastic jar)	Constituents	No of D.M Introduced	Zero week	2nd week	4th week	6th Week	death rate	Survival rate
Oryctes boas	X_1X_2	Salt	20	-	8	2	2	60	40
	Y_1Y_2	Pepper	20	-	2	3	2	35	65
	Z_1Z_2	-	20	-	-	1	1	10	90
Rhynchophorus phoenicis (larva)	A_1A_2	Salt	20	-	10	3	4	85	15
	B_1B_2	Pepper	20	-	3	2	1	30	70
	C_1C_2	-	20	-	-	-	-	0	100

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