Sudan University of Science and Technology

College of Graduate Studies

كلية الدراسات العليا

Effect of Leaves Powder Aqueous Extract of some trees against Red flour beetle *Tribolium castaneum* under Store Conditions

تأثير المستخلصات المائية لمسحوق أوراق بعض الأشجار ضد خنفساء الدقيق الحمراء
تحت ظروف المخزن *Tribolium castaneum* (Herbst)

A thesis submitted in partial fulfillment of the requirements for the M.Sc. degree in plant protection

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الآيــة

قال تعالى:

(قَالَ تَزْرَعُونَ سَبْعَ سِنِينَ دَأَبًا فَمَا حَصَدْتُمْ فَذَرُوهُ فِي سُنْبُلِهِ إِلَّا قَلِيلًا مِمَّا تَأْكُلُونَ)

صدق الله العظيم

سورة يوسف الآية (47)

Dedication

To my

Parents , sister and brothers

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Table of Contents

List of Tables

Title **Page No.**

List of Figures

Title **Page No.**

List of Plates

Title **Page No.**

List of Appendixes

Title **Page No.**

Abstract

laboratory experiments were conducted at the Department of Plant Protection, College of Agricultural Studies, Sudan University of Science and Technology. When this study aimed to assess the impact of the water extracts of Mesquite, *Prosopis sp*, Cafor ,*Eucalyptus camaldulensis* and Damas, *Concarpus lancifolious* against thethird larval instar and the adults of the red flour beetle *Tribolium castaneum*. This study used three concentrations of each plant extract 30%, 20% and 10% plus liquid soap 0.7 and untreated control.

For the adult stage the highest concentration of 20% and 30% the Mesquite extract gave mortality of 92% and 96% respectively after 24 hours of treatment. The concentration of 30% of Cafor extract gave mortality of 80% after the same time. While Damas extract gave 52.7%mortality.

For larvae the highest concentration of 20% and 30% Mesquite extract gave mortality of 84.7% and 96% after 24 hours of treatment. The concentration of 30% of Cafor extract gave mortality of 70.7% for the same time while Damas extract gave 46.0%mortality.

The concentrations which killed 50% of population (LC_{50}) of Mesquite extracts for adult stage was 5.496 p.p.m after 24 hours, 3.880 p.p.m after 48 hours and 0.014 p.p.m after 72 hours. The concentrations which killed 50% of population (LC_{50}) of Mesquite extracts for larvae instar was 8.940 p.p.m after 24 hours, 8.433 p.p.m after 48 hours and 6.903 p.p.m after 72 hours.

The concentrations which killed50% of population (LC_{50}) of Cafor extracts for adult stage was 8 p.p.m after 24 hours, 7.006 p.p.m after 48 hours and 2.476 p.p.m after 72 hours. The concentrations which killed 50% of population (LC_{50}) of Cafor extracts for larvae stage was 34.361 p.p.m after 24 hours , 10.795 p.p.m after 48 hours and 0.192 p.p.m after 72 hours.

The concentrations which killed50% of population (LC_{50}) of Damas extracts for adult stage was 10.615 p.p.m after 24 hours, 8.779 p.p.m after 48 hours and 5.126 p.p.m after 72 hours. While the concentrations which killed50% of population (LC_{50}) of Damas extracts for larvae stage was 12.342 p.p.m after 24 hours, 9.282 p.p.m after 48 hours and 4.426 p.p.m after 72 hours.

The above result showed that Mesquite gave the lowest LC_{50}0.014 p.p.m after 72 hours for the adult as well as the lowestLC_{50}6.903 p.p.m after 72 hours for larvae.

Therefore mesquite extract could be considered as promising and safe alternative for control of red flour beetle in stores using surface application methods .

ملخص البحث

أجريت تجارب معملية في قسم وقاية النبات, كلية الدراسات الزراعية, جامعة السودان للعلوم والتكنولوجيا.هدفت هذه الدراسة لتقييم الأثر القاتل للمستخلصات المائية لمسحوق أوراق أشجار ألبان *Eucalyptus camaldulensis* والمسكيت sp*Prosopis* و الدمس *Concarpus lancifolious* ضد الطور اليرقي الثالث والطور الكامل لخنفساء الدقيق الحمراء *Tribolium castaneum*.
أستخدمت في هذه الدراسة ثلاث تركيزات من كل مستخلص نباتي 30% ,20 % 10 % بالإضافة إلى الصابون السائل 0.7 والشاهد.

بالنسبة للطور البالغ أعطي أعلى تركيز 20% و30% لمستخلص المسكيت نسبة موت 92% و96% علي التوالي بعد24 ساعة من المعاملة. بينما أعطى التركيز30 % لمستخلص الكافور نسبة موت 80% بعد مرور نفس الزمن من المعاملة وأعطي مستخلص الدمس نسبه موت 52.7 %بعد نفس الزمن.

بالنسبة للطور اليرقي أعطي اعلي تركيز 20% و30% لمستخلص المسكيت نسبة موت 84.7%96 % علي التوالي بعد24 ساعة من المعاملة .بينما أعطى التركيز30% لمستخلص الكافور نسبة موت70.7% بعد مرور نفس الزمن من المعاملة بينما أعطى مستخلص الدمس نسبه موت 46.0% في نفس الزمن.

كانت التركيزات النصفية القاتلة والتي أدت إلى موت 50 % من إعداد الآفة من مستخلص المسكيت بالنسبة لحشرة الكاملة بعد 24 ساعة جزء من المليون (ج م .م) 5.496 (ج م .م) وبعد 48 ساعة3.880 (ج .م .م) و بعد 72ساعه 0.014 (ج .م .م). أما التركيزات النصفية القاتلة والتي أدت إلى موت 50 % من إعداد الآفة من مستخلص المسكيت بالنسبة ليرقات بعد 24 ساعة 8.940 (ج.م.م) وبعد 48 ساعة 8.433 (ج .م .م) وبعد 72ساعه 6.903(ج .م .م).

كانت التركيزات النصفية القاتلة والتي أدت إلى موت 50% من إعداد الآفة من مستخلص الكافور أو ألبان بالنسبة لحشرة الكاملة بعد 24 ساعة 8 (ج .م .م) وبعد 48 ساعة 7.006 (ج .م .م) وبعد 72ساعه 2.476 (ج .م .م). أما التركيزات النصفية القاتلة والتي أدت إلى موت 50 % من أعداد الآفة من مستخلصالكافور أو ألبان بالنسبة ليرقات بعد 24 ساعة34.361 (ج .م .م) وبعد 48 ساعة 10.795(ج .م .م) وبعد 72ساعه 0.192 (ج .م .م).

كانت التركيزات النصفية القاتلة والتي أدت إلى موت 50% من أعداد الآفة من مستخلص الدمس بالنسبة لحشرة الكاملة بعد 24 ساعة 10.615(ج .م .م) وبعد 48 ساعة 8.779 (ج .م .م) وبعد 72ساعه 5.126 (ج .م). أما التركيزات النصفية القاتلة والتي أدت إلى موت 50 % من إعداد

الآفة من مستخلص الدمس بالنسبة ليرقات بعد 24 ساعة 12.342 (ج .م .م) وبعد 48 ساعة 9.282 (ج .م .م) وبعد 72 ساعة 4.426 (ج .م .م).

أظهرت النتائج أعلاه إن مستخلص المسكيت أعطي اقل تركيز نصفي قاتل 0.014 (ج .م .م) بعد 72 ساعة للطور البالغ وأيضا اقل تركيز نصفي قاتل 6.903 (ج .م .م) بعد 72 ساعة لطور اليرقي الثالث. عليه يمكن إعتبار مستخلص المسكيت وسيلة واعدة وبديل آمن لمكافحه خنفساء الدقيق الحمراء في المخازن بطريقه المعاملة السطحية.

CHAPTER ONE

INTRODUCTION

Cereals in the Sudan include sorghum, millet, wheat, maize and rice. Among these grains only the surplus of sorghum and millet are exported while wheat and rice are imported, however there is a good potential for export of surplus maize in the future (Mahmoud, 2001).

Sorghum (*Sorghum bicolor*) is the staple food in many African countries including the Sudan (Shazali and Ahmed, 1998). It is the staple food in most regions of this country. It contains a reasonable amount of proteins, ash, carbohydrates, oils and fiber (Drich and Pran, 1987).In the Sudan, sorghum is widely grown in areas of sufficient rainfall or under irrigation and is the most popular food grain (Elhag,1992, Shazali *et al*., 1996).

Insect pests are the major problem in storage products throughout the world because they reduce the quantity and quality of stored products (Sinha and Watters, 1985; Madrid *et al*., 1990).

Insects are considered to be the most important pests of stored grains throughout the world. In the Sudan most of the species of stored -product pests occur throughout the more humid areas, in these areas *Sitophillusoryzae*, *Sitotroga cerealella* and *Corcyra cephalonica* are more common. In the dry northern Sudan two primary pests dominate, namely, *Trogoderma granarium* and *Rhizopertha dominica*, but *Trogoderma granarium* appears to be the most important. Most important of the secondary pests are *Tribolium*s pp. They are generally distributed throughout the Sudan but are more plentiful in areas of higher humidity (Darling, 1959). Flour beetles of the genus *Tribolium* are important pests of stored products such as flour, cereals, meal, beans, spices and even dried museum specimens (Weston and Rattlingourd, 2000).

Tribolium castaneum Herbst, (the red- flour beetle) and *T. confusum* Jacqueline duval, (the confused flour beetle) occur on a wide variety of stored processed grains and are major pests at flour mills. In the Sudan, *T.*

castaneum is more common than *T. confusum*. Both *Tribolium* spp are frequently referred to as secondary pests since they are unable to feed or attack sound grains, but cause considerable damage to grains previously attacked by internal feeders(primary pests) or are mechanically damaged (Khalil, 1970).

Botanical insecticides are either naturally occurring plant materials or products derived rather simply from such plant materials. From the late 1800s to the 1940s, botanical insecticides were used extensively on several high value fruit and vegetable crops in the U.S. Nicotine-based insecticides were important before 1900, whereas pyrethrum, rotenone, sabadilla, and yaniabecame more popular in the 1930s and 1940s. Beginning in the 1940s and 1950s, the discovery and increasing development of synthetic insecticides lead to virtual abandonment of botanical insecticides in commercial agriculture in much of the developed world. Reviews of the nature and uses of these compounds have been written by Campbell (1989), Clark *et al*., (1994), Hale and Port wood (1996), and Sparks *et al*.,1996, and DeAmicis *et al.*, (1997).

Objectives:

The objectives of this study was to in vestige the protomnce dosage rates of some botanicals water extracts a liquid soap combination against larvae and adults of *Tribolium castaneum*.

Specific objectives

1.To evaluate and applied this easily method by farmers and dealers .

CHAPTER TWO

LITERATURE REVIEW

2.1Sorghum:

2.1.1 Classification

Order: Poales

Family: Poaceae

Genus: Sorghum

Scientific name: *Sorghum bicolor*

Common names**:** Grain sorghum, Mabele, Amazimba, Amabele

2.1.2 Description

Sorghum is an upright, short-day, summer annual that is a member of the Poaceae family. The grass blades are flat, stems are rigid, and there are no creeping rhizomes. Sorghum has a loose, open panicle of short, few-flowered racemes. As seed matures, the panicle may droop. Glumes vary in color from red or reddish brown to yellowish and are at least three quarters as long as the elliptical grain. The grain is predominately red or reddish brown (Kearney and Peebles, 1969, Barkworth, 2003).

Sorghums exhibit different heights and maturity dates depending on whether they are grain sorghums (*Sorghum bicolor* ssp. *bicolor*), forage sorghums *(Sorghum bicolor)*, Sudan grass *(Sorghum bicolor* ssp. *drummondii*), or sorghum-Sudangrass hybrids *(Sorghum bicolor* x *Sorghum bicolor var. sudanense*). Growth characteristics also vary depending on the location grown, inputs, and agronomic practices. In general, forage sorghums are taller plants with later maturity dates and more vegetative growth than grain sorghums. Sudan grass and sorghum-Sudan grass hybrids fall in between grain sorghums and forage sorghums in height (Undersander, 2003).

2.1.3 Economic importance

Sorghum (*Sorghum bicolor* (L.) Moench 2n= 20) is the fourth most important cereal crop following wheat, rice and maize. It is a food staple for more than 500 million people in the semi-arid tropics of Africa and Asia and more than 80% of the world area of production is confined to these two continents. In sub-Saharan Africa, over 100 million people depend on sorghum as staple food (GIZ, 2014).

Sorghum is widely produced in the Sudan by the traditional, semi-mechanized and large commercial farms. Technology is developed and supplied by the Agricultural Research Corporation and the universities, and the extension is responsible for the dissemination part. Up until recently, this process was informal and in-efficient but of late efforts are being made to formalize the linkages, and the research and extension have come to the extent of organizing common platforms to expedite the technology promotion process (Reda, 2014).

The harvest is estimated to result in a national surplus of 0.98 million MT of sorghum. The government has lifted bans on exports to neighboring countries, and exports have begun to Ethiopia and Eritrea. However, formal exports have not resumed to South Sudan, given ongoing border tensions, though informal flows continue. In most years, the Sudan has a surplus of sorghum and a balance of millet, but has a great wheat deficit. Sorghum is the staple food for most people living in the Sudan, except for the two northern states where wheat is the traditional staple. It is consumed in a number of ways, most notably as a flat bread or pancake known as "*kisra"* and as a pudding known as "*acida*". Large quantities of sorghum, particularly in the western and southern states are made into beer known as "*marisa*". The total population in Sudan is estimated at 30 million, consuming about 3.1million tones of sorghum annually (2.7 million tones for human consumption and 400,000 tonnes for animal feed). This represents a daily human consumption rate of about 250 g. of sorghum in one form or another (Mahgoub, 2014).

2.2 Main stored grain pests in Sudan

The khapra beetle, *Trogoderma granarium* Everts, is the most destructive insect in the Sudan, particularly in the semi arid hot dry northern part (Darling 1959). In the Red Sea coastal area, particularly at Port Sudan, severe infestations by many insects especially *Trogoderma granarium* and *Tribolium castaneum* Herbst were reported to occur throughout the year (Saad, 1978). *Rhizopertha dominica* is also an important grain pest particularly in central Sudan where most of the sorghum is produced and stored. *Sitophilus oryzae*., which is not found in northern Sudan, is of great importance in the southern parts of central Sudan probably due to the prevailing high humidity during the rainy season (Seif Elnasr 1992).

In the Sudan, *T. castaneum* is more common than *T. confusum* (Khalil, 1970). Other important insects include the Angoumois grain moth *Sitotroga cerealella* and the rice moth, *Corcyra cephalonica.* Neither *Sitophilus oryzae*n or *Sitotroga cerealella* were found in underground pits (matmoras) (Itto-1987; Shazali 1987).

Sitotroga cerealella is usually important in out – door or open storage, particularly sorghum stored on the heads or in loosely stacked sacks, because of its inability to penetrate deep into bulk stored grains. The population of all stored grain insects usually increases steadily during the rainy season, (June – October) with maximum numbers at the end of the season. The duration of storage also affects the relative abundance of insects as well as their succession (Shazali 1982).

2.3 Red flour beetle:

2.3.1 Classification:

Order: Coleoptera
Family: Tenebrionidae
Genus: *Tribolium*
Species: *T. castaneum*
Binomial name
Triboliumcastaneum
(Herbst, 1797)

2.3.2 Description

Although small beetles, about 1/8 of an inch long, the adults are long-lived and may live for more than three years (Walter, 1990). The red flour beetle is reddish-brown in color and its antennae end in a three-segmented club (Bousquet, 1990). Whereas the confused flour beetle is the same color but its antennae end is gradually club-like, the "club" consisting of four segments (Walter, 1990). The head of the red flour beetle is visible from above, does not have a beak and the thorax has slightly curved sides. The confused flour beetle is similar, but the sides of the thorax are more parallel (Anonymous, 1986). These two beetles are in the family Tenebrionidae and have a tarsal formula of 5-5-4 and notched eyes. The red and confused flour beetles live in the same environment and compete for resources (Willis and Roth, 1950, Ryan *et al*., 1970,). The red flour beetle may fly, especially before a storm, but the confused flour beetle does not fly. Eggs, larvae, and pupae from both species are very similar and are found in similar environments. The eggs are white, microscopic and often have bits of flour stuck to their surface. The slender larvae are creamy yellow to light brown in color. They have two dark pointed projections on the last body segment. The pupae are lighter in color, being white to yellowish. These beetles can breed throughout the year in warm areas (Ryan *et al*., 1970).

2.3.3 Distribution

Tribolium. confusum and *T. castaneum* are cosmopolitan, occurring all over the world wherever stored cereal products are to be found. As they live inside buildings and may easily be carried from place to place in small quantities of foodstuffs, these beetles are likely to be recorded from practically any part of the world. *T. castaneum* is essentially an insect of warm climates, (Good, 1936).

2.3.4 Life cycle

The female lays an average of about 450 eggs which are small and white in colour. The larvae emerge from eggs approximately 2.7 days under optimum conditions and moult 7 to 8 times in an average of 12.9 days to reach the pupal stage, which lasts for 4.5 days. Thus, under optimum conditions development from the egg to adult may take only 20 days (Anon, 1986).

2.3.5 Habits

The red and confused flour beetles may be present in large numbers in infested grain, but are unable to attack sound or undamaged grain . The adults are attracted to light, but will go towards cover when disturbed. Typically, these beetles can be found not only inside infested grain products, but in cracks and crevices where grain may have spilled. They are attracted to grain with high moisture content and can cause a grey tint to the grain they are infesting. The beetles give off a displeasing odor, and their presence encourages mold growth in grain (Walter, 1990).

2. 3.6 Damage

The red flour beetle, *T. castaneum* (Herbst) is worldwide and most destructive pest of stored products and is cosmopolitan in distribution. It is the most common pest of wheat flour. It also causes serious damage upon dried fruits, pulses and prepared cereal foods, such as cornflake, pasta, biscuit, beans, nuts, etc. It is an often the most common species in the pest complex attacking stored wheat although its pest status is considered to be secondary, requiring prior infestation by an internal feeder, it can readily infest with or other grains damaged in the harvesting operation. Both larvae and adults feed on grain dust and broken grain, but not the undamaged whole grains and spend its entire life cycle outside the grain kernels (Karunakaran *et al.*, 2004). In severe infestation, the flour turn greyish and has a pungent, disagreeable odour-making it unfit for human consumption. This insect causes substantial loss in storage because of its high reproductive potential (Prakash *et al.*,1987). They may cause an allergic response (Alanko *et al.*, 2000) but are not known to spread disease. These beetles can breed throughout the year in warm area.

2. 3 .7 Host Range

Tribolium castaneum is a cosmopolitan pest which primarily attacks milled grain products, such as flour and cereals. Both adults and larvae feed on grain dust and broken grains, but not the undamaged whole grains and spends its entire life cycle outside grain kernels (Karunakaran *et al*., 2004). *Tribolium castaneum and T. confusum* infest a wide range of commodities and products including barley, beans, biscuits, breakfast cereals, cacao, corn, cornmeal, cottonseed, dried fruits, drugs, flour, legume seeds, milk chocolate, millet, nuts, oats, peas, powdered milk, rice, rye, spices, sunflower seeds, wheat & wheat bran, herbarium and museum collections (Mason, 2003).

2.3.10 Control

2.3.10.1 Hygiene methods

Hygiene is the first step towards minimizing losses caused by the pests during storage. Clean liness of the premises is one of the most important means of minimizing losses caused by pests during storage. The removal of residues and dirt would also make pesticide treatments effective (Krishnamurthy *et* *al*.,1987). The first step in managing an infestation is to find and remove the source of the infestation (Koehler, 2003). Flour beetles can feed and survive on even the smallest bits of grain, so cleaning is a crucial part of controlling these pests. When attempting to locate the source, be sure to consider all likely food items including, dry pet food, dried flowers, nuts, birdseed, and all grain products. Be sure to look for "leaky packages." Small bits of meal or grain spilling from a package are often a signal that an infestation is present (Arbogast *et al*., 2000). Be sure to locate all infested material and discard it by placing the material into a sealed bag or container and throwing it into an outside garbage container.

2.3.10.2 Physical methods

Using low pressure for stored product insect control was employed more than eighty years ago (Back and Cotton, 1925), and has recently been revived (Finkelman *et al*., 2004). A low oxygen atmosphere achieved by application of a weak vacuum has been demonstrated to be an effective disinfestations method for durable food products. Vacuum treatment with flexible chambers is simple to apply, and is not toxic and inexpensive. Some physical controls are expensive or damaging to commodities (Mbata and Phillips, 2001). On the other hand, little has been investigated about the effects of combining one factor with some others.

2.3.10.3 Biological control

These include many natural enemies, such as predators and parasitoides mainly hymenopterous and hemipterous species attacking some insects of stored products, but the intensive use of pesticides applied to the stores caused drastic reduction in their populations. For this reason attempts have been made to use these natural enemies (Shazali, 1987). The only successful biocontrol method, which may economically be applied is the use of the bacterium, *Bacillus thuringiensis* (McGanghey, 1976).

2.3.10.4 Chemical control

Fumigation has been used against stored product insects for millennia. Sulfur was used as fumigant 3,000 years ago; phosphrous was used for pest control from the 1840s; methyl bromide has been used as fumigant since the 1930s (Ware and Whitacre, 2004). In the past, insect control in stored products relied almost entirely on fumigation by using methyl bromide and phosphine (PH3). Methyl bromide is a toxic, ozone-depleting fumigant for crops, stored products, and quarantine insecticide applications. It was echoed in the decision of the Montreal Protocol. By 2005 and 2015 methyl bromide was or will be discontinued in developed countries and worldwide, respectively (UNEP, 1997). Phosphine gas is another fumigant, but it is difficult to get good distribution of pellets in large grain bins, and a large bin needs a recirculation system. Another problem is the risk of development of insecticide resistance in the case of PH3.

2.4.Botanical insecticides

2.4.1 Mesquite tree:

Mesquite (*Prosopis* spp.) are multi-purpose ever green leguminous trees or shrubs. The genus comprises 44 species of which 40 are natives to the Americas (Pasiecznik, 2001). Mesquite grows in arrays of environments and is not restricted by soil type, pH, salinity or fertility (Pasiecznik, 2001).

2.4.1.1Classification

Order:	Fabales
Family:	Fabaceae
Subfamily:	Mimosoideae
Tribe:	Mimoseae
S.N	*Prosopis* spp

2.4.1.2 Description

Perennial deciduous thorny shrub or small tree, to 12 m tall; trunk to 1.2 m in diameter, bark thick, brown or blackish, shallowly fissured; leaves compound, commonly many more than 9 pairs, the leaflets mostly 5–10 mm long, linear-oblong, glabrous, often hairy, commonly rounded at the apex; stipular spines, if any, yellowish, often stout; flowers perfect, greenish-yellow, sweet-scented, spikelike; corolla deeply lobate. Pods several-seeded, strongly compressed when young, thick at maturity, more or less constricted between the seeds, 10–25 cm long, brown or yellowish, 10–30-seeded. Seed compressed and oval or elliptic, 2.5–7 mm long, brown (Reed, 1970).

2.4.1.3 Distribution

Originally Central and/or South American, the mesquite is now pantropically introduced and establishing, often as a weed. It is classified as a principal weed in Mexico, a common weed in the US (but does not naturally occur in the US, this report due to the long prevailing taxonomic confusion), and a weed in Australia, Dominican Republic, India, Iraq, and Venezuela. According to the NAS, the tree ranges from sea level to 1,500 m. According to the taxonomic work of Burkart (1976), neither *P. juliflora* nor *P. chilensis*, as now defined, occur in the US.

2.4.1.4 Ecology

Probably ranging from Tropical Thorn to Dry through Subtropical Thorn to Dry Forest Life Zones (with little frost), mesquite is reported to tolerate annual precipitation of 1.5 to 16.7 dm (mean of 29 cases = 9.9), annual temperature of 20.3 to 28.5°C (mean of 21 cases = 25.5), and pH around neutral (Ecosystematic Data Base) (NAS, 1980a).

2.4.1.5 Mesquite in Sudan

Prosopis sp, was introduced into Sudan in 1917 from South Africa and Egypt and planted in Khartoum (Broun and Massey, 1929). The success attained in establishment and the ability to tolerate drought, fix sand dunes and capacity to furnish shade, fuel, timber, fodder and edible pods provided the impetus for repeated introductions of the tree into various agro ecologies with emphasis on dry areas (Babiker, 2006). In the period 1978-1981 the tree was planted as shelterbelts on premises of Portsudan, Tokar and Kassala towns (Elsidig *et al*., 1998). Moreover, introductions were made into the then White Nile province, western and central Sudan. The tree was planted in shelterbelts around farms, irrigated schemes and along the Nile. Repeated introductions of mesquite from unknown sources (Pasiecznik, 2001), its deliberate distribution within the country, prevailing drought, livestock and feral animal's movement coupled with decreased land-use, land tenure, under utilization of the plant, mismanagement and over exploitation of natural vegetation have led to spread of mesquite into various locations where it has become a national pest (Elhouri, 1986). The plant constitutes a threat to agriculture, biodiversity and may lead to deterioration of natural vegetation and pastures and thus jeopardize the livelihood of a large proportion of the populace, particularly, where livestock keeping and subsistent farming are the main avenues for income generation. The bulk of mesquite infestation (>90%) is in eastern Sudan, where livestock keeping and subsistence cultivation constitute the main source of income. Invading mesquite tends to form dense, impenetrable thickets. In pastures it reduces grass cover and stocking density, interferes with mustering of stalk and threatens the livelihood of traditional pastoralists. Invasion into agricultural land, along irrigation channels and water courses is also a major problem. (Elsidig *et al*., 1998).

In Sudan as in most of the countries, where mesquite has been introduced, it is underutilized. Its use, beside sand dune fixation is limited to fuel wood and charcoal production (Babiker, 2006). Animal rearing constitutes the main livelihood of land and resource less farmers in many of the mesquite endemic areas. Unpalatability of *P. juliflora* leaves to livestock limits their use as animal feed. Results from trials on feeding mesquite pods to sheep were also disappointing and over 90% of livestock owners in eastern Sudan regard mesquite as a liability (Elsidig *et al*., 1998).

2.4.1.6 Toxicity

Reports on cattle toxicity vary. Kingsbury (1964) goes into some detail on mesquite poisoning in cattle, including cases where autopsies showed pods and seeds in the rumen 9 months after the cattle could have ingested them. Mesquite poisoning may induce a permanent impairment of the ability to digest cellulose. Felker and Bandurski (1979) also provide interesting detail. If *Prosopis* pods are the sole food source for cattle, ca 1% become sick, and some die with a compacted pod ball in the rumen. Death is attributed to high sugar content repressing the rumen-bacterial cellulose activity. Mesquite feeding to pigs was promising during the first four weeks, deteriorating thereafter, perhaps due to phytohemagglutinins and trypsin inhibition. Feeding trials with sheep show a 15% higher protein digestibility coefficient for mesquite pods than for alfalfa hay. Trypsin inhibition has been demonstrated the TI content 1.4 TIU/mg (Del Valle *et al*., 1983). Contains isorhamnetin 11 3-glucoside, apigenin 6, 8-diglycoside, and traces of quercitin 3',3diOMe, leutolin 3'-OMe, and apigenindiglycoside (Simpson, 1977).

2.4.2 Damas: (*Conocarpus lancifolius*)

2.4.2.1 Classification

Order: Myrtales

Family: Combretaceae

Genus: *Conocarpus*

Species: *lancifolius*

S.N*: Conocarpus lancifolius.*

2.4.2.2 Description

Large trees up to 20m high dark brown,deeplytissured ,branches ,narrow lanceolate 7-14x1-1,5cm glabrous shiny petioles 5-7mm long .inflorescence terminal paniculate heads .Flowers small ,cream coloured strongly seented and attractive to insects ,sepals green cup ,shaped 5 lobed petals absent, stamens to slender protruding from the cup . Fruit small scale –like 2 winged ,one seeded on cone like –heads overlapping and separating at maturity brown curved and very light ,flowers Feb-March, fruits March ,April (El-Amin,1990). Damas is an evergreen tree that grows up to 20m in height and 60-250 cm or more in diameter. However, it is believed that the larger tree have now been almost entirely felled .where as it is usually a multi-branched tree in its natural habitat, trees plant in the Sudan formed single, straight stem (NAS, 1983). flowers are yellow-green, in round heads on branched stalks, slightly fragrant and it is fruit exist in dry, round, greenish heads, cone-like containing tiny, scale-like hard seeds (Bein *et al*., 1996).

2.4.2.3 Geographical distribution

Natural stand of damas are found beside intermittent water courses of northern Somalia and in the south west part of the Arabian Peninsula. Some of these streams are salty and some sulphurous. The tree is also cultivated in Somalia, Djibouti, Sudan, Kenya, North and South Yamen, and Pakistan. A small plantion has been established in the Sudan in khashm Elgirbaarboretum and about 10000 trees have been planted successfully in lime stone hear Mombasa, Kenya (NAS, 1983). Native of Somaliland and Saudi Arabia ,introduced to the Sudan in 1950 as a shelterbelt species in Khartoum ,Kassala ,Blue Nile and Kordofan (El-Amin,1990).

2.4.2.4 Bioactive properties and phytochemical screening

Abdulrahaman and Gumgumjee (2013) reported that *Conocarpus* ethanolic extracts have a strong antibacterial activity against both gram positive and gram negative bacteria.

2.4.2.5 Phytochemical screening

Phytochemical screening of *Conocarpus* plant revealed that sterols, triterpenes, flavone aglycones, emodols (anthracenosidesaglycones), coumarins, coumarin lactone derivatives, tannins (gallic), reducing compounds, anthrocenosides, sterols glycosides, cardenolides, saponins and sapogenins are present in the plant (Jagessar *et al*., 2010).

2.4.2.6 Medicinal and therapeutic uses

Conocarpus was used in its native countries as folk remedy for anemia, catarrh, conjunctivitis, diabetes, diarrhea and fever (Abdulrahaman and Gumgumjee, 2013). Abdel-Hameed *et al*., (2013) reported that methanolic extracts of *Conocarpu*s have a high antioxidant and hepato protective properties when tested against mice.

2.4.2.7 Other uses

Conocarpus tree is a pioneer species in reforestation projects in its native habitat. *Conocarpus* is one of the fastest growing trees there, producing large quantities of firewood, also Damas wood used for housing construction. *Conocarpus* is suitable for stabilizing riverbanks and improving poor, nutrient-deficient soil and also used as ornamental shade trees and windbreaks around irrigated farms (W C M C, 1998).

2.4.3 Cafor

2.4.3.1Classification

Order: Myrtales

Family: Myrtaceae

S.N*: Eucalyptus camaldulensis*

2.4.3.2 Description

Australia, *E. camaldulensis* commonly grows up to 20 m tall and rarely exceeds 50 m, while stem diameter at breast height can reach 1-2 m or more. In open woodlands it usually has a short, thick bole which supports a large, spreading crown. In plantations, it can have a clear bole of up to 20 m with an erect, lightly-branched crown. The bark is smooth white, grey, yellow-green, grey-green, or pinkish grey, shedding in strips or irregular flakes. Rough bark may sometimes occupy the first 1-2 m of the trunk on *E. camaldulensis var. camaldulensis*. This species is described in many texts including Boland *et al*., (1984), Brooker and Kleinig ,1983, Brooker and Kleinig , 1990 and Brooker and Kleinig , 1994), Doran and Turnbull (1997). Juvenile leaves are petiolate, ovate to broadly lanceolate, up to 26 cm long and 8 cm broad, green, grey-green, or blue-green, slightly discolorous. Adult leaves are lanceolate to narrowly lanceolate, acuminate, lamina 8-30 cm long, 0.7-2 cm wide, green or grey-green, concolorous; petioles terete or channelled, 1.2-1.5 cm long. Inflorescence axillary, 7-11 (sometimes up to 13)-flowered; flowers white, peduncles slender, terete or quadrangular, 6-15 mm long; pedicels slender, 5-12 mm long. Buds pedicellate; hypanthium hemispherical, 2-3 mm long, 3-6 mm wide, operculum globular-rostrate (typical) ovoid-conical (var. obtusa) or, in subsp. simulata, horn-shaped like E. tereticornis, 4-6 mm long (up to 13 mm long in subsp. simulata), 3-6 mm wide. Fruits are hemispherical or ovoid, 5-8 mm long and wide; disc broad, ascending; 3-5 exserted valves. *E. camaldulensis* is a perennial, single-stemmed, largeboled, medium-sized to tall tree to 30 m high (Bren and Gibbs, 1986), although some authors (Boland, 1984; Brooker *et al*., 2002) record trees to 45 m. According to Jacobs (1955) river red gum could reach ages of 500 to 1000 years. Brooker *et al*. (2002) for further descriptive information.

2.4.3.4 Uses

River red gum forests are historically and culturally important due to the number of significant Aboriginal sites they contain. Common relics include canoe and shield trees. Such trees show scars where the bark was removed. The wood has been used for heavy construction, railway sleepers, flooring, framing, fencing, plywood and veneer manufacture, wood turning, firewood and charcoal production (Boland, 1984). Useful for shade, shelter and in windbreaks; deep-rooted, which allows grass growth right up to the base; bark is resistant to stock damage. For southeastern Australia, *E. camaldulensis* along with *Eucalyptus melliodora* (Yellow Box) and *Acacia melanoxylon* (Blackwood) are considered superior shade trees. It is also attractive as an ornamental for acreage plantings.

2.4.3.5 Medical use

Volatile oils which are introduced into medical use contain 55- 70% lineol, plus lesser amounts of volatile aldehydes (Varro, *et al*., 1981). Essential oils of *Eucalyptus* sp. were used as an antibacterial, antimicrobial and acaricidal agent (Bagherwl, 1999; Harkenthal, *et al*., 1999; and Lisin, *et al*.,1999).
The antioxidant activities of the volatile oil and the ethanol extract as well as that of the tree bark were evaluated by the thiocyanate method. The ethanol extract of *Eucalyptus* fruit exhibited considerable activity compared with butylatedhydroxyanisole and tertiary butylated hydroquinone. The high inhibitory effect of the fruit ethanol extract on linoleic acid after 12 days might be related to the higher ellagic acid content. (Al-Ghorab, *et al*., 2002).

2.4.3.6 Insecticidal activity

The toxicity of leaves oil obtained from *E. camaldulensis*by steam distillation was tested against the fourth larvalinstar of *Anopheles stephensi*. The LD_{50} for the larvae was 113 ppm(Kumar and Dutta, 1987). *E. camaldulensis* reduced the number of galls of the nematode *Melodogyne arenaria* and eggs masses by 70 – 85 and 81-89 %, respectively (Ibrahim, *et al*.,1998). Also *E. camaldulensis* suppressed egg hatching of *M. arenaria*to varying extents, depending on the concentration used (Shahda, *et al*.,1998). *Eucalyptus camaldulensis* powder mixed with rice at a rate of 1% byweight was effective in reducing the number of adults of *S. cerealella*e merging per 100g rice to 77 compared with 369 in the untreated rice; and prevented cross-infestation by *R. dominica* (Dakshinamurthy, 1988). In Sudan Mohagir, (2000) studied the effect of application of *E. camaldulensis* on tree locust and it reduced the frequency of molting, gave high mortality, deformation and antifeedent effect. *E. camaldulensis,* also was installed in 8 areas of termite activity in different ecological zones during 1985 – 1986; observations recorded after a few months indicated that *E. camaldulensis* was very effective against termites (Hanif, *et al*., 1988).

CHAPTER THREE

MATERISLS AND METHODS

A study was conducted at the laboratory of Entomology, College of Agricultural Studies, Sudan University of Science and Technology (SUST), Shambat, during December to April .2015-2016.

3.1 Inset culture

Parent adults of test insects were obtained from stock cultures maintained at grain storage from laboratory conditions at College of Agricultural Studies Sudan University of Science and Technology, Shambat. The red flour beetle, *T. castaneum*, Insects were reared at the rate of 10 adults in jars containing 250 g of Sorghum flour. The jars were covered with muslin cloth tied with rubber bands and kept in laboratory conditions.

3.2 Collection of plant materials

The leaves of the plants, Cafor (*Eucalyptus camaldulensis*), Mesquite (*Prosopis sp*) and Damas: (*Conocarpus lancifolius*) were collected from the experimental field, college of agriculture studies, Shambat-. The plants were identified and confirmed at herbarium, Botany department, faculty of agriculture, Khartoum University, Sudan. The plants were washed and dried in shade for 5-7 days under room conditions, and then powdered by using electrical blender. The resulting powder of each plant was kept safe in plastic bags until used.

The following master stock solutions were prepared:

About 30 g of powder For each plants (Cafor, Mesquite and Damas) were added to 100 ml of tab water. Soaked in tap water, thoroughly agitated, left for 24 hours and finally filtered by a piece of cotton cloth. For lethal concentration (LC) determinations, three test concentrations were prepared by further diluting the stock solutions. The serial dilutions started from the highest to the lowest concentration at dilutions ranging from 30 to 10 ml.

3.3 Method of preparing the dilutions

Stock solution 30 % concentration

To made the concentration 20 % from 30 % we used the dilution equation

$$C_1*V_1 = C_2*V_2$$

Such as

$C_{1=}$ concentration one

C_2 = concentration require

$V_{1\,=}$ volume one

$V_{2\,=}$ volume require

3.4 The liquid spray and spraying area

To spray one meter square in store it require 100 Ml from the spraying solution .1 m^2 =100*100 cm =10.000 cm^2

We divided this result by 100 ml equal 10.000 cm^2 to get the spraying solution for every cm^2 which equal 0.01 ml .

The experiment unit area 16*16 =256 cm^2

To know the spraying solution for the above area it equal 0.01 *256=2.56 ml for each experimental unit

The requirement quantity =3 *2.56 =7.63.For the 3 replications.

0.71 soap ………… 100 ml.

3.5 Insecticide application

The experiments were conducted in the laboratory at room temperature. The experimental surfaces consisted of cement blocks (16X16X2.5 cm). The cement blocks were made of a mixture of sand and cement with a total surface area of 256 cm^2. Adults and larvae of *T. castaneum*, were counted in batches of 50 insects each s in small glass vials. The test insects were assigned at random to the cement blocks and were confined to the surfaces by glass rings. The blocks were individually sprayed with 2.56 ml (100 ml/m^2) of each concentration and tap water for the control, using perfume sprayer. Each concentration (and control) were replicated three times. Mortality was observed 24 ,48 and 72 hr following treatment.

3.6 Data Analysis

Experimental design. These experiments were designed in a Complete Randomized Design (C R D). Statistical analysis Are you made transformed for the data. The obtained data was statistically analyzed according to analysis of variance (ANOVA) Duncan's Multiple Range Test was used for means separation. Probit analysis. Environmental Protection Agency (EPA) Probit analysis program used for calculating LC/ EC values version 1.5 software was adopted to compute C_{50} values for each plant extract used in these experiments.

(a)

(b)

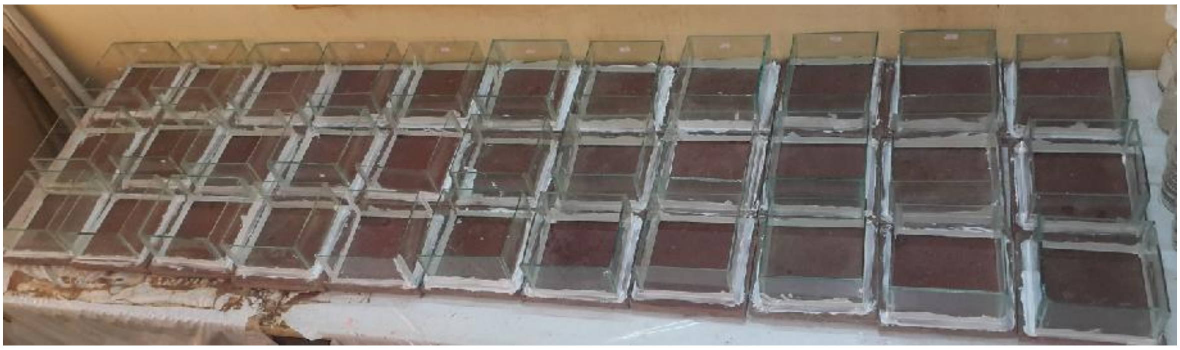
Plate 1: Mesquite plant (a) and aqueous extract (b).

(a) (b)

Plate 2: Damas *C. lancijolius* plant(b) and aqueous extract (a).

(a) (b)

Plate 3: Cafor *E. camaldulensis* plant (a) and aqueous extract (b).



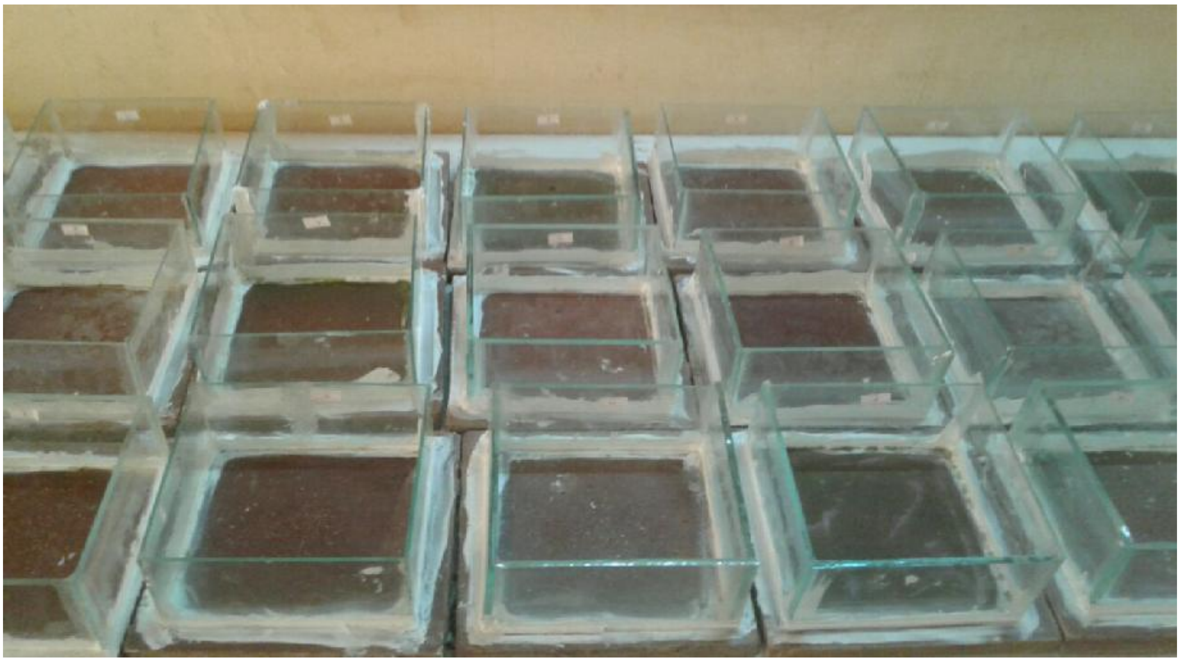


Plate 4: Experiment Design

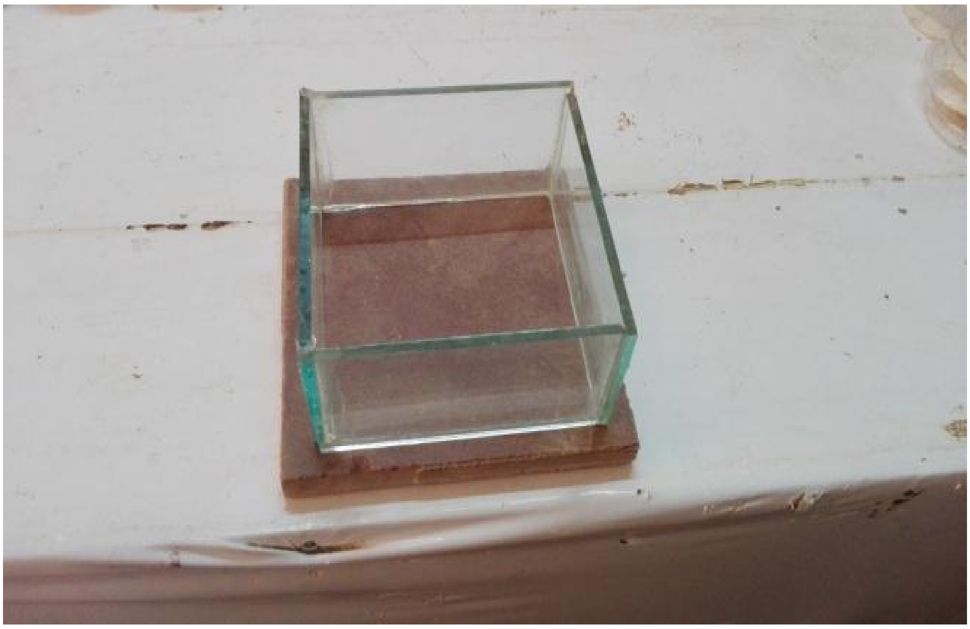


Plate 5:Insect treatment

CHAPTER FOUR

RESULTS

4.1 Effects of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the adults stage of Tribolium castaneum under store conditions after 24 hour.

All tested treatments were significantly different from both the liquid soap alone and untreated control (Table 1, Fig 1, Appendixes 1.4.7).

The best result was obtained by 30 % Mesquite which gave 96 % mortality followed by Mesquite 20 % which gave 92 % mortality .Then followed by Cafor 30 % which gave 80 % mortality while a mortality of 75.4 % was obtained by Damas 30 %.

The least mortality of 52.7 % given by Damas 10 %.

Table 1: Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditionsafter 24 hour.

Treatment	**Rates (g/100 mm of water+0.7 ml liquid soap)**	**Mortality (%)**
Cafor leaves powder	10	58.0 (49.6) c
Cafor leaves powder	20	61.4 (51.6) c
Cafor leaves powder	30	80.0 (63.5) b
Mesquite leaves powder	10	63.4 (52.8) de
Mesquite leaves powder	20	92.0 (73.9) a
Mesquite leaves powder	30	96.0 (78.6) a
Damas leaves powder	10	52.7 (46.6) c
Damas leaves powder	20	54.7 (47.7) c
Damas leaves powder	30	75.4 (60.4) b
Liquid soap	0.7 ml/100	6.7 (14.4) d
Control	-	2.0 (6.6) e
C.V(%)	-	7.0
SE±	-	2.0

- Means at the same column with the same letter (s) are not significantly different at $P \leq 0.05$.
- Values between brackets were transformed using Arcsine.

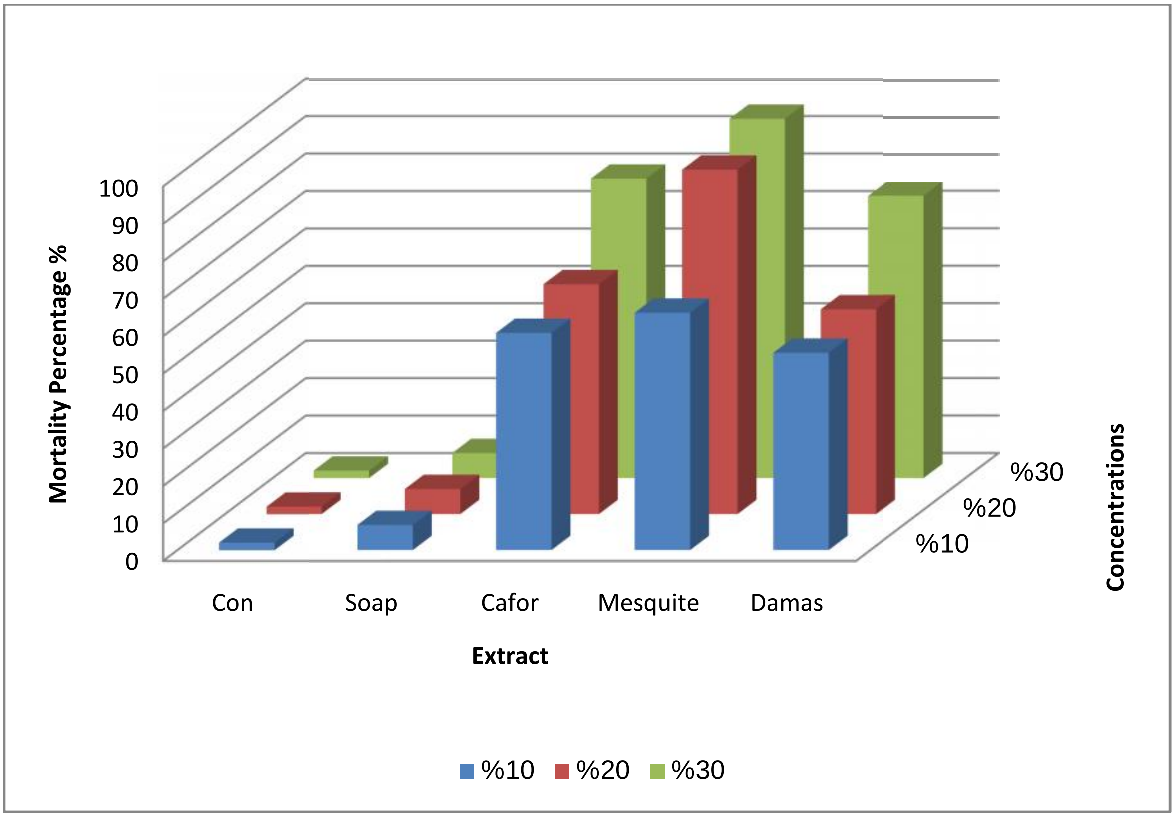


Fig.1: Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditions after 24 hour.

4.2 Effects of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store condition after 48 hour.

All treatments test obtained were significantly different from both the liquid soap alone and untreated control (Table 2, Fig 2 and Appendixes 2.5.8)

The best result was obtained by 30 % Mesquite which was 99.4% mortality followed by Cafor 30 % which gave 80.0% mortality then Damas 30 % which gave 75.7% mortality. (Table 2, Fig 2, Appendix 2.5.8).

The 20% concentration of Mesquite gave 94.4 % mortality followed by the 20% concentration of Cafor which gave 71.4% mortality followed by Damas 20 % which gave 69.4% mortality (Table 2, Fig 2, Appendixes 2.5.8).

The 10% concentration of Damas gave 52.7% mortality. The 10% concentration of Mesquite gave 72.7 % mortality. The least mortality was given by Cafor which gave 68.0 % mortality (Table 2,Fig 2, Appendixes 2.5.8).

Table 2: Effect of leaves powder aqueous extract of Mesquite , Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditions after 48 hour.

Treatment	**Rates (g/100 mm of water+0.7 ml liquid soap)**	**Mortality**
Cafor leaves powder	10	68.0 (55.5) cd
Cafor leaves powder	20	71.4 (57.7) cd
Cafor leaves powder	30	80.0 (63.5) c
Mesquite leaves powder	10	72.7 (58.6) de
Mesquite leaves powder	20	94 .4 (75.2) b
Mesquite leaves powder	30	99.4 (87.3) a
Damas leaves powder	10	52.7 (46.5) e
Damas leaves powder	20	69.4 (56.3) cd
Damas leaves powder	30	75.7 (59.8) cd
Liquid soap	0.7 ml/100	8.7 (16.9) f
Control	-	3.4 (10.1) f
C.V(%)	-	8.3
SE±	-	2.5

- Means at the same column with the same letter (s) are not significantly different at $P \leq 0.05$.
- Values between brackets were transformed using Arcsine .

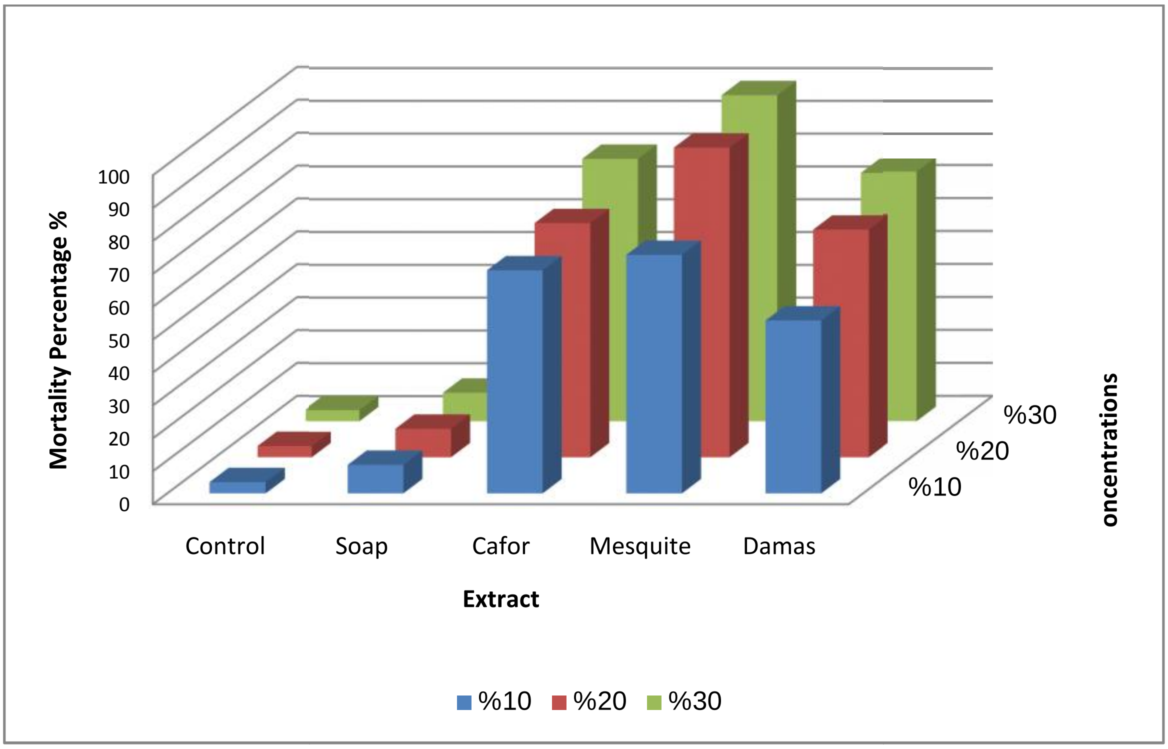


Fig.2: Effect of leaves powder aqueous extract of Mesquite , Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditions after 48 hour.

4.3 Effects of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store condition after 72 hour.

All treatments test obtained were significantly different from both the liquid soap alone and untreated control (Table 3,Fig 3 , Appendixes 3.6.9).

The best result was obtained by 30% Mesquite which gave 99.4% mortality followed by Mesquite 20% which gave 94% mortality. Then followed by Cafor 30 % which gave 87.4 % mortality followed by the 20% concentration of Cafor gave 84.0 % mortality while a mortality of 83.4 % was obtained by Damas30%.

The least mortality of 66.7% given by Damas 10% .

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Table 3: Effect of leaves powder aqueous extract of Mesquite , Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditions after 72 hour.

Treatment	Rates (g/100 mm of water+0.7 ml liquid soap)	Mortality (%)
Cafor leaves powder	10	85.4 (67.5) bc
Cafor leaves powder	20	84.0 (67.4)bc
Cafor leaves powder	30	87.4 (69.3)bc
Mesquite leaves powder	10	79.4 (63.1) b
Mesquite leaves powder	20	94. 0 (75.6)b
Mesquite leaves powder	30	99.4 (87.3)a
Damas leaves powder	10	66.7 (54.8)e
Damas leaves powder	20	80.7 (64.2)cd
Damas leaves powder	30	83.4 (66.0)cd
Liquid soap	0.7 ml/100	21.4(26.9) f
Control	-	3.4 (10.1)g
C.V(%)	-	8.6
SE±	-	2.6

- Means at the same column with the same letter (s) are not significantly different at $P \leq 0.05$.
- Values between brackets were transformed using Arcsine.

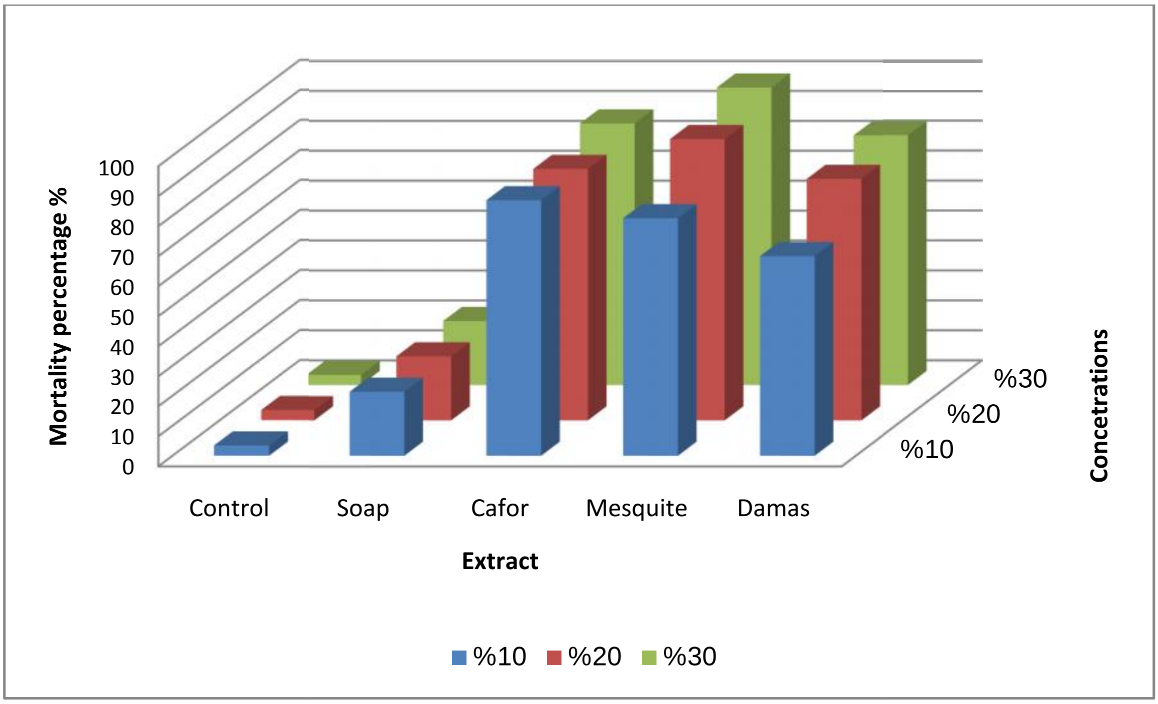

Fig.3: Effect of leaves powder aqueous extract of Mesquite , Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditions after 72hour.

4.4 Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instars of *Tribolium castaneum* under store conditions after 24 hour.

All treatments test obtained were significantly different from both the liquid soap alone and untreated control (Table 4,Fig 4 , Appendixes 10.13.16).

The best result was obtained by 30% Mesquite which gave 96.0% mortality followed by Mesquite 20 % which gave 84.7% mortality .Then followed by Cafor 30% which gave 70.7% mortality while a mortality of 62.7% was obtained by Damas 30%.

The least mortality of 46.0 % given by Damas 10%.

Table 4: Effect of leaves powder aqueous extract of Mesquite , Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instars of *Tribolium castaneum* under store conditions after 24 hour.

Treatment	Rates (g/100 mm of water+0.7 ml liquid soap)	Mortality (%)
Cafor leaves powder	10	54.0 (47.3) de
Cafor leaves powder	20	57.4 (49.2) de
Cafor leaves powder	30	70.7 (57.3) c
Mesquite leaves powder	10	56.7 (48.8) de
Mesquite leaves powder	20	84.7 (67.2) b
Mesquite leaves powder	30	96.0 (80.6)
Damas leaves powder	10	46.0 (42.7) e
Damas leaves powder	20	59.4 (50.3) d
Damas leaves powder	30	62.7 (52.3) cd
Liquid soap	0.7 ml/100	2.7 (9.2) f
Control	-	0.0(0.0)g
C.V(%)	-	8.3
SE±	-	1.2

- Means at the same column with the same letter (s) are not significantly different at $P \leq 0.05$.
- Values between brackets were transformed using Arcsine.

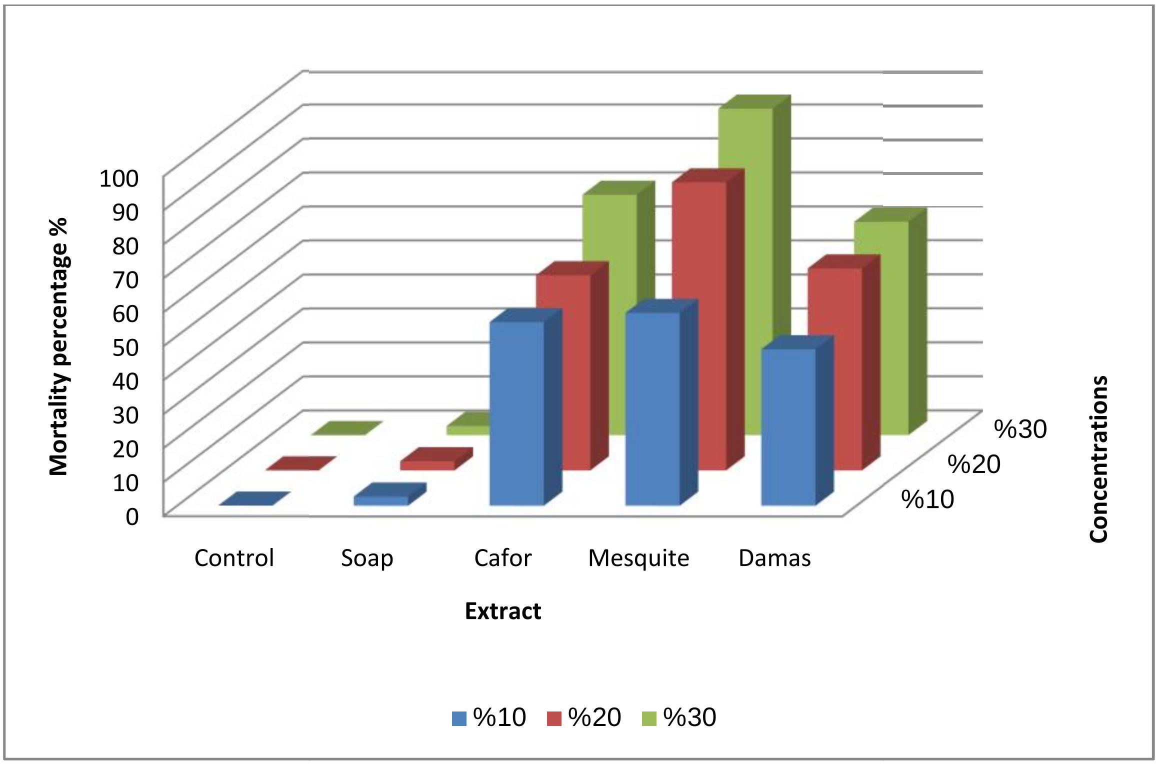

Fig.4: Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instars of *Tribolium castaneum* under store conditions after 24 hour.

4.5 Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instars of *Tribolium castaneum* under store conditions after 48 hour.

All treatments test obtained were significantly different from both the liquid soap alone and untreated control (Table 5,Fig 5, Appendixes 11.14. 17)

The best result was obtained by 30% Mesquite which gave 99.4% mortality followed by Mesquite 20% which gave 98.7% mortality .Then followed by Cafor 30% which gave 96.0% mortality followed by Cafor 20% which gave 83.4 %mortality, while a mortality of 82.7% was obtained by Damas30% (Table 5,Fig 5, Appendixes 11.14.17) .

The least mortality of 57.7% given by Damas 10%.

Table 5: Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instars of *Tribolium castaneum* under store conditions after 48 hour.

Treatment	**Rates (g/100 mm of water+0.7 ml liquid soap)**	**Mortality (%)**
Cafor leaves powder	10	67.4 (55.1) cd
Cafor leaves powder	20	83.4 (67.7) bc
Cafor leaves powder	30	96.0 (79.1) ab
Mesquite leaves powder	10	69.4 (57.9) cd
Mesquite leaves powder	20	98.7 (86.1) a
Mesquite leaves powder	30	99.4 (87.2) a
Damas leaves powder	10	56.7 (48.8) d
Damas leaves powder	20	67.4 (55.3) cd
Damas leaves powder	30	82.7 (66.2) bc
Liquid soap	0.7 ml/100	11.4 (19.5) e
Control	-	3.4 (10.4) e
C.V(%)	-	13.0
SE±	-	4.4

- Means at the same column with the same letter (s) are not significantly different at $P \leq 0.05$.
- Values between brackets were transformed using Arcsine.

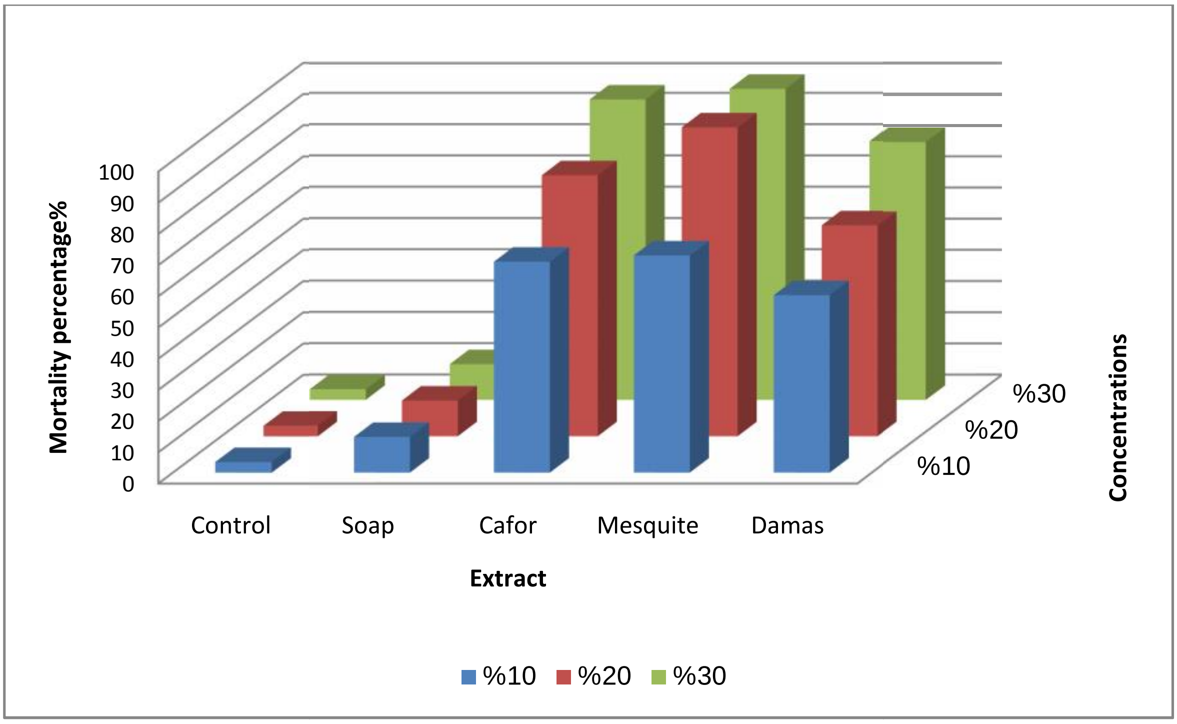

Fig.5: Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instars of *Tribolium castaneum* under store conditions after 48 hour.

4.6 Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instars of *Tribolium castaneum* under store conditions after 72 hour.

All treatments test obtained were significantly different from both the liquid soap alone and untreated control (Table 6, Fig 6, Appendixes12.15.19).

The best result was obtained by 30 % Mesquite which gave 100% mortality followed by Mesquite 20% which gave 98.7% mortality. Then followed by Cafor 30% which gave 98.4% mortality, followed by Cafor 20% which gave 96.0% mortality and Damas 30% which gave 96.0 % mortality(Table 6, Fig 6, Appendixes 12.15.19).

The least mortality of 74.7% given by Damas 10%.

Table 6: Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instars of *Tribolium castaneum* under store conditions after 72 hour.

Treatment	**Rates (g/100 mm of water+0.7 ml liquid soap)**	**Mortality (%)**
Cafor leaves powder	10	88.0 (69.8) b
Cafor leaves powder	20	96.0 (80.4) a
Caforleaves powder	30	99.4 (87.3) a
Mesquite leaves powder	10	98.0 (83.4) a
Mesquite leaves powder	20	98.7 (86.2) a
Mesquite leaves powder	30	100.0 (90.0) a
Damas leaves powder	10	74.7 (59.9) b
Damas leaves powder	20	84.7 (67.0) b
Damas leaves powder	30	96.0 (83.3) a
Liquid soap	0.7 ml/100	21.4 (27.4) c
Control	-	5.4 (13.3) d
C.V(%)	-	8.4
SE±	-	3.3

- Means at the same column with the same letter (s) are not significantly different at $P \leq 0.05$.
- Values between brackets were transformed using Arcsine.

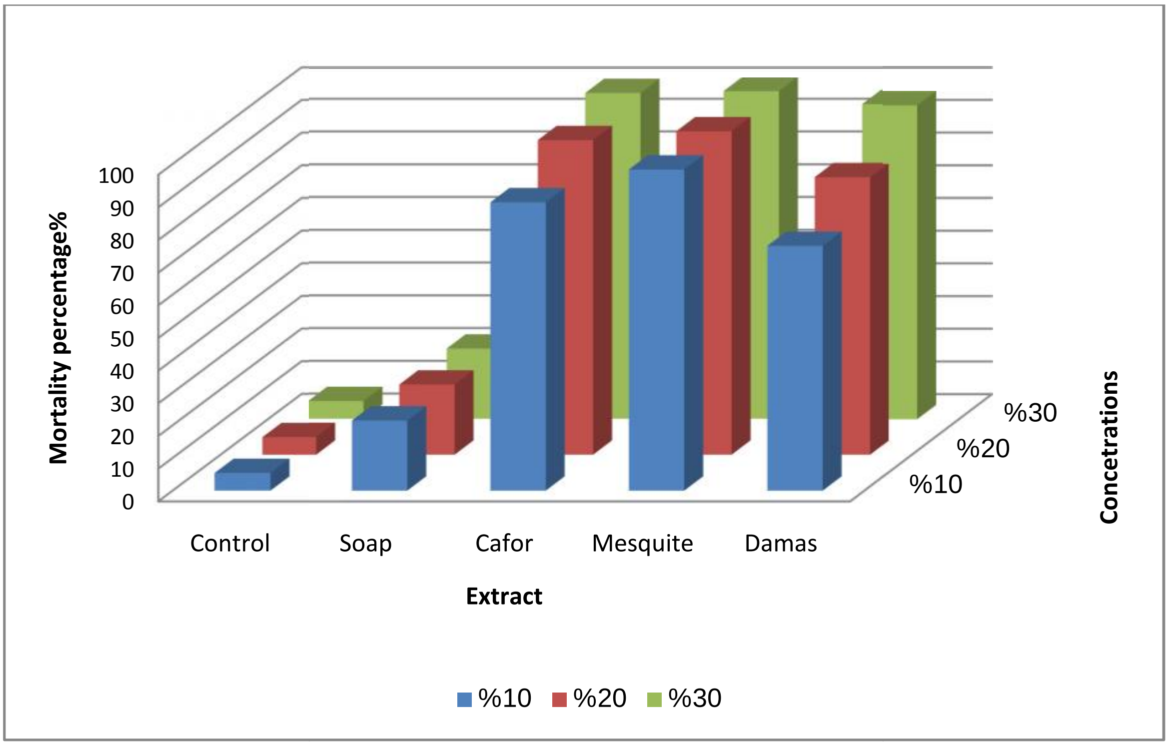

Fig.6: Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instars of *Tribolium castaneum* under store conditions after 72 hour.

4.7 Probit Analysis

4.7.1 Probit Analysis of Mesquite extract

- Adult:

Table 7,8 and 9 showed that LC_{50} after 24 hour was 5.496,LC_{50} after 48 hour was3.880 andLC_{50} after 72 hour was 0.014.

- Larvae:

Table 10,11 and 12 revealed that LC_{50} after 24 hour was 8.940,LC_{50} after 48 hour was 8.433 and LC_{50} after 72 hour was 6.903.

Table 7: LC_{50} values of effect of leaves powder aqueous extract of Mesquite +0.7ml liquid soap on the mortality of the adult stage of *Tribolium castaneum* under store conditions after 24 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Mesquite	1.959190	3.846282	-0.000	0.082	7.325	5.496

Table 8: LC_{50} values of effect of leaves powder aqueous extract of Mesquite +0.7ml liquid soap on the mortality of the adult stage of *Tribolium castaneum* under store conditions after 48 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Mesquite	3.541133	2.379388	1.174	1.237	7.933	3.880

Table 9: LC_{50} values of effect of leaves powder aqueous extract of Mesquite+0.7ml liquid soap on the mortality of the adult stage of *Tribolium castaneum* under store conditions after 72 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Mesquite	0.743288	6.369933	0.748	-	-	0.014

Table 10: LC_{50} values of effect of leaves powder aqueous extract of Mesquite+0.7ml liquid soap on the mortality of the 3rd larval instars of *Tribolium castaneum* under store conditions after 24 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Mesquite	3.148479	2.004785	0.213	5.783	11.147	8.940

Table 11:LC$_{50}$ values of effect of leaves powder aqueous extract of Mesquite+0.7ml liquid soap on the mortality of the 3rd larval instars of *Tribolium castaneum* under store conditions after 48 hour.

Botanical extract	**Slope**	**Intercept**	**Chi-square**	**95% Confidence Limits**		**LC 50.00**
				Lower	**Upper**	
0.7 ml liquidsoap +leaves powder aqueous extract of Mesquite	3.690850	1.582269	1.066	5.503	10.443	8.433

Table 12:LC$_{50}$ values of effect of leaves powder aqueous extract of Mesquite+0.7ml liquid soap on the mortality of the 3rd larval instars of *Tribolium castaneum* under store conditions after 72 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Mesquite	3.469889	2.088582	0.379	3.400	9.114	6.903

4.7.2 Probit Analysis of Cafor extract

- Adult:

The results in table 13,14 and 15 showed that LC_{50} was 8 after 24, LC_{50} after 48 hour was 7.006andLC_{50} after 72 hour was 2.476.

- Larvae:

Table 16,17 and 18 revealed that LC_{50} after 24 hour was 34.361,LC_{50} after 48 hour was 10.615 and LC_{50} after 24 hour was 0.192 .

Table 13: LC_{50} values of effect of leaves powder aqueous extract of Cafor +0.7ml liquid soap on the mortality of the adult stage of *Tribolium castaneum* under store conditions after 24hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Cafor	1.192292	3.9161189	1.841	-	-	8

Table 14: LC_{50} values of effect of leaves powder aqueous extract of Cafor+0.7ml liquid soap on the mortality of the adult stage of *Tribolium castaneum* under store conditions after 48 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Cafor	2.429538	2.945966	3.841	-	-	7.006

Table 15:LC$_{50}$ values of effect of leaves powder aqueous extract of Cafor+0.7ml liquid soap on the mortality of the adult stage of *Tribolium castaneum* under store conditions after 72 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Cafor	1.886685	4.257214	0.003	-	-	2.476

Table 16: LC_{50} values of effect of leaves powder aqueous extract of Cafor+0.7ml liquid soap on the mortality of the 3rd larval instars of *Tribolium castaneum* under store conditions after 24 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Cafor	2.709321	3.994482	17.242	-	-	34.361

Table 17: LC_{50} values of effect of leaves powder aqueous extract of Cafor+0.7ml liquid soap on the mortality of the 3rd larval instars of *Tribolium castaneum* under store conditions after 48 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Cafor	4.677759	-2.185359	0.013	-	-	10.615

Table 18:LC_{50} values of effect of leaves powder aqueous extract of Cafor+0.7ml liquid soap on the mortality of the 3rd larval instars of *Tribolium castaneum* under store conditions after 72 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Cafor	0 .145147	5.858068	0.00	-	-	0.192

4.7.3 Probit Analysis of Damas extract

- Adult:

The results in table 19,20 and 21 showed that LC_{50} was 10.615after 24, LC_{50} after 48 hour was 8.779and LC_{50} after 72 hour was 5.125.

- Larvae:

Table 22,23 and 24 revealed that LC_{50} after 24 hour was 12.342,LC_{50} after 48 hour was 9.282 and LC_{50}after 24 hour was 4.426 .

Table 19: LC_{50} values of effect of leaves powder aqueous extract of Damas+0.7ml liquid soap on the mortality of the adult stage of *Tribolium castaneum* under store conditions after 24 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Damas	1.59708	3.810253	2.072			10.615

Table 20: LC_{50} values of effect of leaves powder aqueous extract of Damas+0.7ml liquid soap on the mortality of the adult stage of *Tribolium castaneum* under store conditions after 48 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Damas	1.538270	3.548744	3.841	-	-	8.779

Table 21: LC_{50} values of effect of leaves powder aqueous extract of Damas+0.7ml liquid soap on the mortality of the adult stage of *Tribolium castaneum* under store conditions after 72 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Damas	1.976058	3.597519	1.138			5.126

Table 22: LC_{50} values of effect of leaves powder aqueous extract of Damas+0.7ml liquid soap on the mortality of the 3rd larval instars of *Tribolium castaneum* under store conditions after 24 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC/EC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Damas	0.921333	3.994482	0.0096			12.342

Table 23: LC_{50} values of effect of leaves powder aqueous extract of Damas+0.7ml liquid soap on the mortality of the 3rd larval instars of *Tribolium castaneum* under store conditions after 48 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC/EC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Damas	1.310579	3.731804	0069			9.282

Table 24: LC_{50} values of effect of leaves powder aqueous extract of Damas+0.7ml liquid soap on the mortality of the 3rd larval instars of *Tribolium castaneum* under store conditions after 72 hour.

Botanical extract	Slope	Intercept	Chi-square	95% Confidence Limits		LC/EC 50.00
				Lower	Upper	
0.7 ml liquidsoap +leaves powder aqueous extract of Damas	1.193040	4.229274	0.153	-	-	4.426

CHAPTER FIVE

DISCUSSION

Botanicals are naturally occurring insecticides derived from plants; they include crude extracts and isolated or purified compounds from various plant species and commercial plant products (Isman, 2006). More than 2000 plant species have been identified to have some insecticidal properties (Stoll, 2000). Neem (*Azadirachtaindica*)is probably the oldest botanical insecticide, the principle active compound is azadirachtin (Kumar, 2007).

This study was aimed to evaluate theeffects of leaves powder aqueous extract of Mesquite, Cafor and Damas against both the adults and larvae of *Tribolium castaneum*. For adult: The two highest concentrations of leaves powder aqueous extract of Mesquite used in this study (30% and 20%) induced a high mortality percentage of 96%, 92% respectively followed by Cafor 30% which gave 80%mortality and were significantly different from both liquid soap and untreated control after 24 hours of exposure.

For larvae: The two highest concentrations of leaves powder aqueous extract of Mesquite used in this study (30% and 20%) induced a high mortality percentage of 96.0%, 84.7% respectively followed by Cafor 30% which gave 70.7 mortality and were significantly different from both liquid soap and untreated control after 24 hours of exposure.

The present results are in agreement with Mekonnen (2015)who found that *Prosopis Juliflora* n-hexane extract of the proposed plant showed higher percentage mortality at 10% concentration in 30 and 42 hours against termite and cockroach respectively.

The present results are in agreement with Dakshinamurthy, (1988) who found that *E. camaldulensis* powder mixed with rice at a rate of 1% by weight was effective in reducing the number of adults of *Sitotroga cerealella*e merging per 100g rice to 77 compared with 369 in the untreated rice; and prevented cross-infestation by *Rhyzopertha dominica.* In Sudan Mohagir, (2000) studied the effect of application of *Eucalyptus camaldulensis* on tree locust and it reduced the frequency of molting, gave high mortality, deformation and antifeedant effect. *E. camaldulensis,* also was installed in 8 areas of termite activity in different ecological zones during 1985– 1986; observations recorded after a few months indicated that *E. camaldulensis*was very effective against termites (Hanif, *et al*., 1988). Also the present results are in line with Elamin (2014) who found that Seed ethanolic extract of *C. lancifolius* when applied at 14 % concentration against second larval instars of *H. elaterii* gave 53.3% mortality after 72 hrs of exposure Also Elawad (2014) reported that Damas actone extracts was very effected against the larvae of Culex and Anopheles mosquitoes under laboratory conditions.

In the present results the LC_{50} of mesquite was found to be 0.014 after 72 hours for the adult while the $LC_{50}$was 6.903 after 72 hours for larvae .This is in line with Mekonnen (2015) who found that LD_{50} was 0.472 and 1.07 for termite and cockroach respectively after 23 hours using mesquite extract.

Feeny (1970) reported that tannin content in Oak leaves inhibits the growth of winter moth caterpillars and causes death. The result obtained in this study may also be attributed to the tannin content in *C. lancifolius* seeds.

The action of liquid soap involves some physical disruption of the insect cuticle and cause internal cell damage by dissolving cell membranes causing cells to leak and collapse and resulting in dehydration and death of the insect; some evidence indicates that soap affects the insect's respiratory system and block the spiraclesor disrupting cellular metabolism (Abbasi *et. al*.,1984).

CONCLUSION AND RECOMMENDATIONS

Conclusion

Based on the above mentioned results, leaves powder aqueous extract of Mesquite and Cafor can be considered as promising to be used as a control agent for *Trilolium castaneum*.

Recommendations

1. More research are required on active ingredients of Mesquite and Cafor.
2. Further studies are needed on mode of action and compatibility with other synthetic insecticides.

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APPENDIXES

Appendix 1: Adult Number mortality (actual data) (out of 50 adults) after 24 hour. Effects of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	30	28	29	29.0
Cafor leaves powder	20	30	30	32	30.7
Cafor leaves powder	30	38	41	41	40.0
Mesquite leaves powder	10	43	27	30	34.7
Mesquite leaves powder	20	45	45	48	46.0
Mesquite leaves powder	30	48	48	48	48.0
Damas leaves powder	10	24	27	28	26.4
Damas leaves powder	20	27	28	27	27.7
Damas leaves powder	30	34	38	41	37.7
Soap at 0.7 ml/100 of water	-	5	4	1	3.3
Control	-	1	2	0	1.0

Appendix 2: Adult Number mortality (actual data) (out of 50 adults) after 48 hour. Effects of leaves powder aqueous extract Mesquite, Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	34	34	33	33.7
Cafor leaves powder	20	49	40	36	41.7
Cafor leaves powder	30	46	49	49	48.0
Mesquite leaves powder	10	47	38	38	39.7
Mesquite leaves powder	20	49	48	50	49.6
Mesquite leaves powder	30	50	50	50	50.0
Damas leaves powder	10	28	27	30	28.4
Damas leaves powder	20	39	30	32	33.7
Damas leaves powder	30	41	47	36	41.4
Soap at 0.7 ml/100 of water	-	7	6	4	5.7
Control	-	1	2	2	1.7

Appendix 3: Adult Number mortality (actual data) (out of 50 adults) after 72 hour. Effects of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water+0.7 ml liquid soap)	R1	R2	R3	Means
Cafor leaves powder	10	44	44	44	44.0
Cafor leaves powder	20	50	48	46	48.0
Cafor leaves powder	30	49	50	50	49.7
Mesquite leaves powder	10	49	48	50	49.0
Mesquite leaves powder	20	50	48	50	49.4
Mesquite leaves powder	30	50	50	50	50.0
Damas leaves powder	10	39	34	39	37.4
Damas leaves powder	20	44	40	43	42.4
Damas leaves powder	30	50	50	44	48.0
Soap at 0.7 ml/100 of water	-	12	12	8	10.7
Control	-	2	3	3	2.7

Appendix 4: Adult Mean data after 24 hour. Effects of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	60	56	58	58.0
Cafor leaves powder	20	60	60	64	61.4
Cafor leaves powder	30	76	82	82	80.0
Mesquite leaves powder	10	86	76	76	79.4
Mesquite leaves powder	20	90	90	96	92.0
Mesquite leaves powder	30	96	96	96	96.0
Damas leaves powder	10	48	54	56	52.7
Damas leaves powder	20	54	56	54	54.7
Damas leaves powder	30	68	76	82	75.4
Soap at 0.7 ml/100 of water	-	10	8	2	6.7
Control	-	2	4	0	2.0

Appendix 5: Adult mean data after 48 hour. Effects of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	68	68	66	67.4
Cafor leaves powder	20	98	80	72	83.4
Cafor leaves powder	30	92	98	98	96.0
Mesquite leaves powder	10	94	54	60	69.4
Mesquite leaves powder	20	100	96	100	98.7
Mesquite leaves powder	30	98	100	100	99.4
Damas leaves powder	10	56	54	60	56.7
Damas leaves powder	20	78	60	64	67.4
Damas leaves powder	30	82	94	72	82.7
Soap at 0.7 ml/100 of water	-	14	12	8	11.4
Control	-	2	4	4	3.4

Appendix 6: Adult Mean data after 72 hour. Effects of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	88	88	88	88.0
Cafor leaves powder	20	100	96	92	96.0
Cafor leaves powder	30	98	100	100	99.4
Mesquite leaves powder	10	98	96	100	98.0
Mesquite leaves powder	20	100	96	100	98.7
Mesquite leaves powder	30	100	100	100	100
Damas leaves powder	10	78	68	78	74.7
Damas leaves powder	20	88	80	86	84.7
Damas leaves powder	30	100	100	88	96.0
Soap at 0.7 ml/100 of water	-	24	24	16	21.4
Control	-	4	6	6	5.4

Appendix 7: Adult transformed data after 24 hour. Effects of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	50.77	48.45	49.60	49.6
Cafor leaves powder	20	50.77	50.77	53.13	51.6
Cafor leaves powder	30	60.67	64.90	64.90	63.5
Mesquite leaves powder	10	68.03	60.67	60.67	63.1
Mesquite leaves powder	20	71.57	71.57	78.46	73.9
Mesquite leaves powder	30	78.46	78.46	78.46	78.5
Damas leaves powder	10	43.85	47.29	48.45	46.6
Damas leaves powder	20	47.29	48.45	47.29	47.7
Damas leaves powder	30	55.55	60.67	64.90	60.3
Soap at 0.7 ml/100 of water	-	18.43	16.43	8.13	14.3
Control	-	8.13	11.45	0.0	6.6

Appendix 8: Adult transformed data after 48 hour. Effects of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	53.55	55.55	54.33	55.1
Cafor leaves powder	20	81.87	63.43	58.05.	67.8
Cafor leaves powder	30	73.57	81.87	81.87	79.1
Mesquite leaves powder	10	75.82	47.29	50.77	57.9
Mesquite leaves powder	20	81.87	90.0	90.0	87.2
Mesquite leaves powder	30	90.0	78.46	90.0	86.1
Damas leaves powder	10	48.45	46.29	50.77	48.3
Damas leaves powder	20	62.03	50.77	53.13	55.3
Damas leaves powder	30	64.90	75.82	58.05	66.2
Soap at 0.7 ml/100 of water	-	21.97	20.27	16.43	19.5
Control	-	8.13	11.54	11.54	14.9

Appendix 9: Adult transformed data after 72 hour. Effects of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the adults stage of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	69.73	69.73	69.73	69.7
Cafor leaves powder	20	90.0	78.46	72.54	80.3
Caforleaves powder	30	81.87	90.0	90.0	87.2
Mesquite leaves powder	10	81.87	78.46	90.0	83.4
Mesquite leaves powder	20	90.0	78.46	90.0	86.1
Mesquite leaves powder	30	90.0	90.0	90.0	90.0
Damas leaves powder	10	62.03	55.55	62.03	59.8
Damas leaves powder	20	69.73	63.43	68.03	67.0
Damas leaves powder	30	90.0	90.0	69.73	83.2
Soap at 0.7 ml/100 of water	-	29.33	29.33	23.58	27.4
Control	-	11.54	14.18	14.18	13.3

Appendix 10: Larvae Number mortality (actual data) (out of 50 adults) after 24 hour. Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instar of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	26	30	25	27.0
Caforleaves powder	20	28	32	26	28.7
Cafor leaves powder	30	33	33	40	49.7
Mesquite leaves powder	10	30	30	25	28.4
Mesquite leaves powder	20	43	45	39	42.4
Mesquite leaves powder	30	48	50	46	48.0
Damas leaves powder	10	26	20	23	23.0
Damas leaves powder	20	30	29	30	29.7
Damas leaves powder	30	30	33	31	31.4
Soap at 0.7 ml/100 of water	-	1	2	1	1.4
Control	-	0	0	0	0.0

Appendix 11: Larvae Number mortality (actual data) (out of 50 adults) after 48 hour. Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instar of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	32	37	33	34
Cafor leaves powder	20	37	40	30	35.7
Cafor leaves powder	30	37	40	43	40.0
Mesquite leaves powder	10	33	35	27	31.7
Mesquite leaves powder	20	45	47	42	44.7
Mesquite leaves powder	30	49	50	50	49.7
Damas leaves powder	10	32	22	25	26.4
Damas leaves powder	20	36	34	34	34.7
Damas leaves powder	30	35	40	37	37.4
Soap at 0.7 ml/100 of water	-	3	6	4	4.4
Control	-	1	1	3	1.7

Appendix 12: Larvae Number mortality (actual data) (out of 50 adults) after 72 hour. Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instar of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	42	43	43	42.7
Cafor leaves powder	20	41	48	37	42.0
Cafor leaves powder	30	42	44	45	43.7
Mesquite leaves powder	10	37	38	34	36.4
Mesquite leaves powder	20	48	48	44	46.7
Mesquite leaves powder	30	49	50	50	49.7
Damas leaves powder	10	36	31	33	33.4
Damas leaves powder	20	38	44	39	40.4
Damas leaves powder	30	41	40	44	41.7
Soap at 0.7 ml/100 of water	-	5	10	17	10.7
Control	-	1	1	3	1.7

Appendix 13: Larvae Mean data after 24 hour. Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instar of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	52	60	50	54.0
Cafor leaves powder	20	56	64	52	57.4
Cafor leaves powder	30	66	66	80	70.7
Mesquite leaves powder	10	60	60	50	56.7
Mesquite leaves powder	20	86	90	78	84.7
Mesquite leaves powder	30	96	100	92	96.0
Damas leaves powder	10	52	40	46	46.0
Damas leaves powder	20	60	58	60	59.4
Damas leaves powder	30	60	66	62	62.7
Soap at 0.7 ml/100 of water	-	2	4	2	2.7
Control	-	0	0	0	0.0

Appendix 14: Larvae Mean data after 48 hour. Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instar of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	64	74	66	68.0
Cafor leaves powder	20	74	80	60	71.4
Cafor leaves powder	30	74	80	86	80.0
Mesquite leaves powder	10	66	70	54	63.4
Mesquite leaves powder	20	90	94	84	89.4
Mesquite leaves powder	30	98	100	100	99.4
Damas leaves powder	10	64	44	50	52.7
Damas leaves powder	20	72	68	68	69.4
Damas leaves powder	30	70	80	74	74.7
Soap at 0.7 ml/100 of water	-	6	12	8	8.7
Control	-	2	2	6	3.4

Appendix 15: Larvae Mean data after 72 hour. Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+ 0.7ml liquid soap) against the 3rd larval instar of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	84	86	86	85.4
Cafor leaves powder	20	82	96	74	84.0
Cafor leaves powder	30	84	88	90	87.4
Mesquite leaves powder	10	74	76	68	72.7
Mesquite leaves powder	20	96	96	88	93.4
Mesquite leaves powder	30	98	100	100	99.4
Damas leaves powder	10	72	62	66	66.7
Damas leaves powder	20	76	88	78	80.7
Damas leaves powder	30	82	80	88	83.3
Soap at 0.7 ml/100 of water	-	10	20	34	21.4
Control	-	2	2	6	3.4

Appendix 16: Larvae transformed data after 24 hour. Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instar of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	46.15	50.77	45.06	47.3
Cafor leaves powder	20	48.45	53.13	46.15	49.2
Cafor leaves powder	30	54.33	54.33	63.43	57.3
Mesquite leaves powder	10	50.77	50.77	45.0	48.8
Mesquite leaves powder	20	68.03	71.57	62.03	67.8
Mesquite leaves powder	30	78.46	90.0	73.57	80.6
Damas leaves powder	10	46.15.	39.23	42.71	42.6
Damas leaves powder	20	50.77	49.60	50.77	50.3
Damas leaves powder	30	50.77	54.33	51.94	52.3
Soap at 0.7 ml/100 of water	-	8.13	11.54	8.11	9.2
Control	-	0.0	0.0	0.0	0.0

Appendix 17: Larvae transformed data after 48 hour. Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instar of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	53.13	59.17	54.33	55.6
Cafor leaves powder	20	59.17	63.43	50.77	57.7
Cafor leaves powder	30	59.17	63.43	68.03	63.5
Mesquite leaves powder	10	54.33	56.79	47.29	52.8
Mesquite leaves powder	20	71.57	75.82	66.42	71.2
Mesquite leaves powder	30	81.87	90.0	90.0	87.2
Damas leaves powder	10	53.13	41.55	45.0	46.5
Damas leaves powder	20	58.05	55.55	55.55	56.3
Damas leaves powder	30	56.79	63.43	59.34	59.8
Soap at 0.7 ml/100 of water	-	14.18	20.27	16.43	16.9
Control	-	8.13	8.27	14.18	10.1

Appendix 18: Larvae transformed data after 48 hour. Effect of leaves powder aqueous extract of Mesquite, Cafor and Damas (+0.7ml liquid soap) against the 3rd larval instar of *Tribolium castaneum* under store conditions.

Treatment	Rates (g/100 mm of water +0.7 ml liquid soap)	R1	R2	R3	Mean
Cafor leaves powder	10	66.42	68.03	68.03	67.4
Cafor leaves powder	20	64.90	78.0	59.34	67.4
Cafor leaves powder	30	66.42	69.73	71.57	69.2
Mesquite leaves powder	10	59.34	60.67	55.55	58.5
Mesquite leaves powder	20	78.46	78.46	69.73	75.5
Mesquite leaves powder	30	81.87	90.0	90.0	87.2
Damas leaves powder	10	58.05	51.94	54.33	54.7
Damas leaves powder	20	60.67	69.73	62.03	64.1
Damas leaves powder	30	64.90	63.43	69.73	66.0
Soap at 0.7 ml/100 of water	-	18.43	29.57	35.67	26.8
Control	-	8.13	8.13	14.18	10.1