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# Efficacy Of Ruta Chalepensis, Lantana Camara And Ocimum Basilicum Extracts In Controlling Sitophilus Oryzae, Acanthoscelides Obtectus And Tribolium Castaneum Infestations In Stored Grain: A Review

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*Abstract:* An infestation of stored grains is a very important issue because different stages of the life cycle of insects damage the economy and lower the quality of food grains and food products. The use of chemical pesticides against insect pests of stored food has adverse effects on both health and the environment. These issues forced researchers to create substitute techniques with less negative impacts. Since the plant-based biopesticides are safe for humans and other living things, environmentally friendly, biodegradable, and have a narrow target spectrum. Essential oils and plant-based extracts have been very useful in controlling insects that display a range of insecticidal mechanism. Due to their distinct qualities, they can also serve as viable substitutes to protect grains from pest infestations (repellent, deterrent, and insecticidal). Among the stored grain pests *Sitophilus oryzae* (Rice weevil), *Acanthoscelides obtectus* (Bean weevil) and *Tribolium castaneum* (Red flour beetle) are considered as destructive pests in India. So, this review focused on the insect repulsive and insecticidal power of *Ruta chalepensis* (Fringed rue), *Lantana camara* (Lantana) and *Ocimum basilicum* (Basil) essential oil (EO) the ultimate is to develop a biological and ecological control strategy against pests.

## I. Introduction

There are currently about 7.6 billion people on Earth and by 2030 and 2050, that number is expected to increase to about 8.6 billion and 9.8 billion, respectively[1]. Every year, almost 2 million tons of insecticides are used worldwide[2]. Food grains and pulses play a vital role in the food chain because they are the most widely consumed and commonly stored food products worldwide particularly in tropical and sub-tropical areas, solutions to the issues of food insecurity[1]. Where traditional structures like earthen pots, silos, gunny bags, steel drums and baskets are used in the villages to store 70% of the harvested grains. Food grains and pulses can lose quality after harvest due to a number of reasons and the greatest concern is the harm caused by insects[1]. Products that are stored may become contaminated by primary pests or develop secondary contamination from previously damaged grains; secondary contamination may also result from improper handling, drying and threshing of grains or from other pests (primary pests)[3]. Some chemical pesticides have been banned by the World Health Organization (WHO) and more are being phased out. In this context number of research are focusing on plants in an effort to isolate or identify secondary metabolites that have the potential to possess insecticidal, repulsive or anti-palatable properties against insects[4]. Essential oils and their constituent parts have been shown to have repellent and insecticidal qualities and to play a significant role in protecting grains that have been kept[5].

Studies have been conducted on the essential oils of *Ruta chalepensis, Lantana camara* and *Ocimum basilicum* as a potential substitute for controlling pests of stored grains. Essential oils can be extracted using a variety of methods, including the traditional approach of distilling water vapor, percolation, extraction of solid fluid and supercritical fluid extraction. One of the oldest techniques is hydro-distillation (HD) presents steam distillation (SD) in which the vapor develops from the herb's suspension in the balloon[6]. Insect pests mostly cause damage to products that are kept in storage by direct feeding and contamination from insect parts. In storage there are significant losses, The Food and Agricultural Organization (FAO) calculated that the yearly losses in insect-related storage grain amounts up to 13 million tons. While a variety of insect species are accountable for the decline in grain yield, beetles and moths are the most common ones are *Acanthoscelides obtectus, Sitophilus oryzae* and *Tribolium castaneum* is a frequent and dangerous pest that targets wheat, corn and flour and other items in areas with tropical temperatures[7]. The red flour beetle or *Tribolium castaneum* is a serious pest in goods that are kept in storage and frequently results in large losses of food and grains. *T. castaneum* directly eats storage materials and as a result of its infestation, the storage environment's temperature and humidity rise which would ultimately cause mold development—including the proliferation of toxic species—to accelerate. At the moment, synthetic insecticides play a major role in keeping insect pests out of long-lasting stored goods[7]. The mandibles of the *Tribolium species* are not powerful enough to chew through the tough outer layer of grain, hence they cannot feed on complete grains that are intact[8]. Because they will constantly reproduce and infest almost every food item on board, they rank among the worst pests on ships carrying edible produce of any type[8]. Some of the prevalent and harmful pests of cereals that are kept in storage belong to the genus *Sitophilus Schoenherr and Sitophilus oryzae(*rice weevil), is most prevalent in warm, tropical, and subtropical regions[9]. The rice weevil, may feed on both brown and white rice because its larvae develop inside rice kernels while its adults eat on rice. The kernels of rice are rubbed, lose their pericarp coating and turn white while being polished[10]. Because of the mechanical action of the polishing process and the resulting low nutritional quality of white rice. The rice weevils are negatively impacted by it. The rice weevil's female creates a hole in the kernel with her teeth, places the egg inside, and then plugs the hole to keep the egg safe[10].

As the polishing process rubs the rice kernels, it could damage this protection and consequently could increase the vulnerability of larvae to natural enemies[10]. All varieties of beans have been impacted by the bean weevil (*Acanthoscelides obtectus*), with *Phaseolus multiflorus* being the most severely affected. Soybeans and chickpeas were occasionally targeted as well. When larvae ate the inside of grains, they caused harm. Depending on how big they are, 1-26 larvae may grow into grains. Grains lost their usefulness for eating and planting[11]. In the Mediterranean and Middle East region, *Ruta chalepensis* is widely dispersed. Many nations employ traditional herbal medicine to treat a wide range of illnesses and one such remedy is the aerial section of this plant. It is taken orally as an antipyretic, anti-analgesic and antispasmodic, anthelmintic, abortifacient, inflammatory, relieves rheumatic pain and helps with mental health issues. It also helps with menstrual issues. It is applied topically for snakebite, insect repellent and hair tonic purposes. *R. chalepensis* usually referred to as Fijin or Sathab, is used as a flavoring agent in food and beverages and in traditional herbal medicine in Jordan[12]. The most common species in this genus, *Lantana camara*, also referred to as wild or red sage, grows luxuriantly at heights of up to 2000 m in tropical, subtropical and temperate climates. Camara species was most likely taken from the West Indian slang term for the widespread species. This woody creeper has flowers that are red, pink, white, yellow, and violet in color. There are instances when the branches and stems are covered in spines or prickles. The plant has been used to cure a wide range of illnesses in various regions of the world. *Lantana camara* was used in traditional medicine to treat tumors and malignancies[13]. Fever, sickness, and stomachaches were treated with a tea prepared from the leaves and blossoms. Throughout Central and South America, the leaves were applied topically to treat wounds, chicken pox, and measles infection. Plant-derived medications were used to treat high blood pressure, rheumatism, colds, and fevers[13]. *Ocimum basilicum* known as sweet basil, is a native plant of the Indo-Malayan region and a member of the Lamiaceae family. The "king of herbs" as it is known is said to include a large number of phytochemicals with important nutritional, antioxidant and health effects. *Ocimum basilicum* has been grown since ancient times in India because of its profound spiritual and religious connotations. It is also thought to bring good energy into homes. Sweet basil is utilized as an ingredient in dental and oral health care products, scents and was used by Saints in Vedic times to suppress their appetites. Basil essential oils are made up of a wide variety of chemical components that vary according to the plant's origin, flower and leaf color, scent, and chemotype. Additionally, the morphological and aromatic qualities of plants are significantly impacted by agronomic practices and environmental factors[14].

## II. RESEARCH METHODOLOGY

### 2.1 Identification and selection of plants:

The common name for *Ruta chalepensis* is fringed rue. It is a flowering plant in the *Rutaceae* family that is native to the Mediterranean. It is also known as Egyptian rue. There are two different plants which belongs to same family but differs in morphological and phytochemical aspects. One is *Ruta chalepensis* other one is *Ruta graveolens*. *Ruta chalepensis* is more likely to be found in hot and dry climates, while *Ruta graveolens* is more likely to be found in cooler and wetter climates. *Ruta chalepensis* has a stronger, more pungent odour than *Ruta graveolens*. There is another main difference between these two plants to identify very easily i.e., petals are fringed or ciliated in case of *Ruta chalepensis* not in *Ruta graveolens*. The insecticidal activity of Ruta plants is primarily attributed to the presence of secondary metabolites, especially alkaloids. A volatile compound called 2- undecanone is the compound primarily responsible for repellency of pests[4].

Lantana is a fast-growing and invasive plant in many tropical and subtropical regions. This easy availability makes it a readily accessible and cost-effective option for insect control, particularly in resource-limited communities. Lantana plants contain a variety of secondary metabolites, including alkaloids and terpenoids, which are known for their bioactive properties. *Lantana camara* plants has an allelopathic effects (lantana plants produces the certain chemicals responsible for inhibiting the growth of other plants and insects). *Lantana camara*, an erect shrub, which grows widely in the tropics, exhibits insecticidal activity against several insects. The methanol extract from leaves of L. camara has fumigant and contact toxicity against *S. oryzae* and *T. castaneum*[5].

*Ocimum basilicum*, commonly known as sweet basil. Basil essential oils contain a broad array of chemical compounds depending on variations in chemo types, flower and leaf colours, aroma and particularly the origin of the plant. Moreover, the aromatic and morphological character of plants is greatly influenced by environmental conditions and agronomic techniques[12, 13]. The chemical composition of essential oils of Ocimum species has been well studied. Basil essential oils contained monoterpenes derivatives (camphor, limonene, 1, 8-cineole, linalool, geraniol) and phenyl propanoid derivatives (eugenol, methyleugenol, chavicol, estragole, methyl-cinnamate)[9, 13, 15].

### 2.2 Rearing of insects:

#### 2.2.1 Rice weevil *(Sitophilus oryzae):*

They're tiny, reddish-brown beetles with a long snout, about 2-3 mm in length. They have four light yellow or reddish spots on their wings.

They love to munch on whole grains like rice, wheat, corn, oats, and even dried pasta. Female weevils lay eggs inside individual grains, where the larvae hatch and develop. The whole cycle can take around 30-40 days in warm weather and longer in cooler temperatures[9]. The insects are retrieved from infested grains (such as Bengal gram) within the household. Subsequently, the adult insects are transferred to fresh media consisting of rice flour, supplemented with some old media to aid in their acclimatization to the new conditions. They are then placed in a closed container and kept in dark, quiet surroundings to facilitate population growth[9].

#### 2.2.2 Red flour beetle *(Tribolium castaneum):*

Insect is about 4mm long, roughly the size of a small grain of rice. Flattened, oblong body with antennae ending in a three-segmented club. Dry, starchy products like flour, cereals, pasta, and spices. They infest these by burrowing and laying eggs inside. The insects are collected from infested grains (wheat grains) from local market, then the adult insects are transferred into new media containing wheat flour along with some old media which helps them to adjust the new conditions of media in a closed container. Then kept in dark and silent conditions to increase the number[6].

#### 2.2.3 Bean weevil *(Acanthoscelides obtectus):*

Bean weevils are slightly smaller than rice weevils, typically around 3-4 mm long. More rounded and compact than rice weevils, with a short snout and prominent legs. Brownish-grey with light speckles or mottled patterns, some species have reddish hues. Primarily focus on legumes like beans, peas, lentils, and chickpeas. The insects are collected from infested beans (Hyacinth Bean) from local market, then the adult insects are transferred into new media containing whole beans along with some old media which helps them to adjust the new conditions of media in a closed container. Then kept in dark and silent conditions to increase the number[11].

### 2.3 Extraction of phytoconstituents in selected plants:

For the extraction of phytoconstituents hydro-distillation method is used. The extracts are obtained from leaves of selected plants by hydro-distillation using a simple distillation method. Distillation was carried out by boiling of fresh plant material with water in a 1-liter flask surmounted by a 60 cm long graduated column connected to a condenser[12]. Vapour loaded with essential oils, passing through the refrigerant, condenses and falls in the graduated burette, thus allowing the volume collected to be read directly. Water and oil separate by a difference in density; indeed, the condensed vapor produces two phases: an organic phase containing the essential oil and an aqueous phase (aromatic hydrosol) which contains a non negligible quantity of oil either in solubilized form or in the form of finely dispersed droplets[13]. Organic solution of the essential oil obtained was dried with anhydrous sodium sulfate ($Na_2SO_4$), then weighed, and stored at respective temperature in a tightly closed brown/amber glass bottle to protect it from air and light[4].

### 2.4 Repellency Bioassay:

An area preference method was adopted to assess the repellent activity of plant extracts against adult insects. Experiments were carried out in glass petri dishes and filter paper was cut into two equal halves and test solution (1L) was applied to filter paper half as uniform as possible using micro pipette. The other half of filter paper treated with acetone/ distilled water as a control. The treated and control half disks were air-dried to evaporate solvent completely. Adult insects were released at the centre of each filter paper disk and then Petri dishes were covered and kept in dark. The number of insects on both treated and untreated halves was recorded after 1, 2 and 3 h of exposure. Percentage repellency (PR) was calculated according to Nerio et al. (2009) as follows:

$$PR(\%) = \frac{Nc - Nt}{Nc + Nt} * 100$$

where Nc was the number of insects on the untreated area and Nt was the number of insects on the treated area[16].

### 2.5 Phytochemical analysis of sample:

The identification of the constituents present in the sample/ extracts is done by GC-MS (Gas chromatography and mass spectroscopy)[17].

### 2.6 Mortality Bioassay:

Mortality tests are carried for the selected sample from repellency bioassay. Experiments were carried out in glass Petri dishes and the paper discs were attached to the lids of Petri dishes. The dishes were then covered after the introduction of 20 nonsexed adult insects (without separation between male and female sex) [18] into each Petri dish. The dishes were placed under the same environmental conditions as those used for insect rearing. The control dishes were prepared in the same way without the addition of extracts[18]. Mortality control was done by counting dead insects every 12 hours for two days. Three replicates were performed for each insect and their average would represent the percentage of mortality. The percentage of mortality observed in control and treated insects was calculated using the formula of Abbott[19].

$$Pc = \frac{Po - Pt}{100 - Pt} * 100$$

where Pc is the mortality corrected in %, Pt is the mortality observed in the control, and Po is the mortality observed in the test.

## III. DISCUSSION

Some plant extracts and phytochemicals are known to possess insecticidal activity against various stored-product insect pests. Essential oils from aromatic plants have been widely investigated for this purpose. The use of plant oils and their components as pesticides has garnered significant attention in pest management programs[20]. In previous studies, Tapondjou et al. (2005)[21] evaluated the contact toxicity of essential oils from *Eucalyptus saligna* and *Cupressus sempervirens* leaves by impregnating filter paper discs and testing them against *Tribolium confusum*. They found that these oils caused significant mortality, with LC50 values of 0.48 and 0.74 µL/cm² for Eucalyptus and Cupressus oils, respectively. Similarly, Russo et al. (2015)[22] reported that essential oils from Eucalyptus globulus exhibited noteworthy insecticidal properties against *T. confusum* adults, with contact toxicity increasing with exposure time and concentration.

After reviewing numerous papers on this topic it can be concluded that the essential oil from the flowering aerial parts of *Ruta chalepensis* exhibits stronger contact toxicity against adult *Tribolium confusum* compared to other essential oils reported in the literature. For example, the essential oils from *Eucalyptus saligna* and *Cupressus sempervirens* demonstrated significant mortality within three days of exposure[21]. Numerous factors, especially edaphic and climatic ones, can be used to explain the variations in the chemical composition of *Ruta chalepensis* essential oil seen between different regions.

According to research by Mwangangi and Mutisya,[23] when *O. basilicum* leaf powder was administered at a rate of 2 g powder per 100 g of maize grains, it may kill up to 90% of corn weevils in just two weeks. Boeke *et al.'s*[24] other research revealed a significantly stronger impact of *O. basilicum* essential oils on the closely related *coleopteran C. maculatus,* which had a 49% mortality rate within 24 hours of exposure. Nevertheless, these outcomes concur with those of related research by Popović et al.,[25] which revealed a 21.8% mortality rate of S. oryzae within 24 hours of exposure to the essential oils at lower dosages of O. basilicum. When S. zeamais were treated with O. basilicum essential oil, increased mortality rates were seen in other investigations conducted by Kerdchoechuen et al[26].

Several investigations have demonstrated *L. camara's* considerable contact toxicity against a range of coleopteran storage pests. Caryophyllene was the predominant component in all instances when the percentage composition of chemical elements changed according to the month of harvest and across different years in studies on the phytochemical characterization of lantana essential oils from Algeria[27].

Crude extracts of *Ruta chalepensis, O. basilicum* and *L. camara's* showed more repellency activity against *Tribolium castaneum.* Our findings are similar to the findings of a past study suggesting that crude extracts of rue, basil and lantana had the highest efficacy against *Tribolium castaneum.* Numerous bioactive substances included in botanical insecticides have the potential to harm creatures that come into contact with them or consume them. Plants in particular have co-evolved with insects that consume them, leading to the development of defense mechanisms. These mechanisms include the synthesis of substances that interfere with insects' normal physiology and behavior, influencing eating, mating, mortality and oviposition. Insects can be killed or repelled by the secondary metabolites of *Ruta chalepensis, O. basilicum* and *L. camara's* , which include alkaliods, flavoniods, saponins, and di-tarphene. Because of this, only poisons found in extracts with ideal polarity and chemical composition could reach an interior site of toxic action and start the molecular reactions that lead to death. The concentration of a certain crude plant extract was found to have a dose-response relationship with the corresponding percent mortality, which is in line with previously published findings.

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