EFFECT OF PLANT EXTRACTS AND ORGANIC SUBSTANCES ON MORTALITY OF *Cornitermes cumulans* (KOLLAR, 1832) (ISOPTERA: TERMITIDAE)

MURIEL SANTOS RIZENTAL

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Dissertação apresentada à Universidade Federal de Lavras como parte das exigências do Programa de Pós-Graduação em Agronomia/Entomologia, área de concentração em Entomologia Agrícola, para a obtenção do título de "Mestre".

Orientador

Dr. Ronald Zanetti Bonetti Filho

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APROVADA em 27 de abril de 2009

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(Orientador)

LAVRAS
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A Deus pela vida, fé e coragem para a realização deste trabalho,

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À minha amada mãe,

Geraldina dos Santos

Pelo amor e apoio contínuo.

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SUMMARY

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GENERAL ABSTRACT

RIZENTAL, Muriel Santos. **Effect of plant extracts and organic substances on mortality of *Cornitermes cumulans* (Kollar, 1832) (Isoptera: Termitidae)**. 2009. 37p. Dissertation (Master Program in Entomology) – Federal University of Lavras, Lavras, MG.[1]

In Brazil, termites belonging to the genus *Cornitermes* and *Syntermes* are responsible for the high mortality of plants in the early stages of development of many crops. So, in laboratory bioassays, plants and organic substances that can control workers of *Cornitermes cumulans* (Kollar, 1832) were tested. Forty milligrams of extract were collected from each plant and mixed in a diet with sugar cane bagasse, mortality being evaluated after 48 hours. Among the thirty-two plant extracts tested, *Gymnanthes concolor* (Euphorbiaceae) (Leaves); *Croton floribundus* (Euphorbiaceae) (Tree bark); *Croton urucurana* (Euphorbiaceae) (Leaves), and *Terminalia brasiliensis* (Combretaceae) (Leaves) had significantly higher mortality than the negative control. Other laboratory bioassay was conducted to determine the effectiveness of Chalcone, Acylhydrazone, Phenols and derivatives against workers of *Cornitermes cumulans*. Two milligrams of each organic substance in a diet with sugar cane bagasse were mixed, mortality being evaluated after 48 hours. No organic substance tested showed efficiency in termite control.

[1] Adviser - Ronald Zanetti Bonetti Filho – UFLA

RESUMO GERAL

RIZENTAL, Muriel Santos. **Efeito de extratos de plantas e substâncias orgânicas na mortalidade de *Cornitermes cumulans* (Kollar, 1832) (Isoptera: Termitidae)**. 2009. 37p. Dissertação (Mestrado em Entomologia) - Universidade Federal de Lavras, Lavras, MG.[2]

No Brasil, cupins dos gêneros *Cornitermes* e *Syntermes* são responsáveis por elevada mortalidade de plantas nos primeiros estágios de desenvolvimento de diversas culturas. Por isso, foram testadas, em bioensaios de laboratório, plantas e substâncias orgânicas que possam controlar operários de *Cornitermes cumulans* (Kollar, 1832). Quarenta miligramas de extrato foram coletados de cada planta e misturados em uma dieta com bagaço de cana-de-açúcar, avaliando a mortalidade após 48 horas. Entre os trinta e dois extratos vegetais testados, *Gymnanthes concolor* (Euphorbiaceae) (Folhas); *Croton floribundus* (Euphorbiaceae) (Cascas); *Croton urucurana* (Euphorbiaceae) (Folhas); e *Terminalia brasiliensis* (Combretaceae) (Folhas) apresentaram mortalidade significativamente maior do que a testemunha negativa. Outro bioensaio em laboratório foi realizado para determinar a eficiência de Chalconas, Acil hidrazonas, Fenóis e derivados contra operários de *Cornitermes cumulans*. Foram misturados 2mg de cada substância orgânica em uma dieta com bagaço de cana-de-açúcar, avaliando a mortalidade após 48 horas. Nenhuma substância orgânica testada apresentou eficiência no controle dos cupins.

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[2] Orientador - Ronald Zanetti Bonetti Filho – UFLA

ARTICLE 1

RIZENTAL, Muriel Santos. **Effect of plant extracts on mortality of *Cornitermes cumulans* (Kollar, 1832) (Isoptera: Termitidae)**. 2009. 37p. Dissertation (Master Program in Entomology) – Federal University of Lavras, Lavras, MG.

(Prepared for publication in Journal of Chemical Ecology and directed to submission)

ABSTRACT - Termites of the genus *Cornitermes* and *Syntermes* cause damage in several crops in Brazil, such as sugarcane, pasture and eucalyptus and they are a barrier in the early development of these crops. The objective of this work was to identify plants that could control *Cornitermes cumulans*. Singly, 40 mg of thirty-two extracts in a diet with sugar cane bagasse were mixed, mortality being evaluated after 48 hours on Petri dishes. Among the plant extracts tested, *Croton floribundus* (Euphorbiaceae) (Tree bark) (25/Jan/2008); *Croton urucurana* (Euphorbiaceae) (Leaves) (12/Dec/2007); *Gymnanthes concolor* (Euphorbiaceae) (Leaves) (15/Dec/2007) and *Terminalia brasiliensis* (Combretaceae) (Leaves) (20/Dec/2008) showed efficiency in termite control.

Keywords: termites, natural products, control.

EFFEITO DE EXTRATOS DE PLANTAS NA MORTALIDADE DE *Cornitermes cumulans* (KOLLAR, 1832) (ISOPTERA: TERMITIDAE)

RESUMO - Os cupins do gênero *Cornitermes* e *Syntermes* causam danos em várias culturas no Brasil, como cana-de-açúcar, pastagens e eucaliptos, e são uma barreira ao desenvolvimento inicial destas culturas. O objetivo deste trabalho foi identificar plantas que possam controlar *Cornitermes cumulans*. Separadamente, foram misturados 40 mg de trinta e dois extratos em uma dieta com bagaço de cana-de-açúcar, avaliando a mortalidade após 48 horas, em placas de Petri. Entre os extratos vegetais testados *Croton floribundus* (Euphorbiaceae) (Cascas) (25/Jan/2008); *Croton urucurana* (Euphorbiaceae) (Folhas) (12/Dec/2007); *Gymnanthes concolor* (Euphorbiaceae) (Folhas) (15/Dec/2007); e *Terminalia brasiliensis* (Combretaceae) (Folhas) (20/Dec/2008) foram eficientes no controle dos cupins.

Palavras-chave: cupins, produtos naturais, controle.

1 INTRODUCTION

Cornitermes cumulans (Kollar, 1832) is a neo-tropical termite species occurring in several habitats, including forest, savannah and man-modified habitats, such as pastures or even gardens (Marins & Souza, 2008). This species has caused several damages in a number of crops and it has been controlled with synthetic insecticides, but it is necessary to find another way to control this insect like developing insecticides based on natural products.

The use of natural products, such as fungicides, herbicides, molluscicides, nematocides and insecticides in these respects traces back in antiquity and a large number of such materials still remain to be chemically investigated and evaluated. Although, the majority of the pesticides used in modern agriculture are synthetic (Evans, 2004).

Plants provide potential alternatives to currently used insect-control agents because they constitute a rich source of bioactive chemicals. Much effort has been focused on plant-derived materials for potentially useful products as commercial insect-control agents (Kim et al., 2003).

In these bioactive chemicals, many of them are known as phytochemicals that can also serve as leading compounds from which others, exhibiting, for example, a greater toxicity towards the pest, a wide spectrum of activity, a lowered mammalian toxicity (Evans, 2004).

Several classes of phytochemicals, including the flavonoids, affect the molting, reproduction, feeding, and behavior of insects (Reyes-Chilpa et al., 1995; Musayimana et al., 2001; Simmonds, 2001).

Flavonoids are numerous and widespread among natural plant constituents and serve many functions, including plant defense, pigmentation, and a great deal of diverse host-plant interactions. Most plants contain an array of flavonoids, and evidence has been presented suggesting that insects are able to discriminate among plants with varying flavonoid profiles (Feeny et al., 1988; Simmonds, 2001).

Certain flavonoids either stimulate insect feeding (Bernays et al., 1991) or act as feeding deterrents (Morimoto et al., 2000). They can act as endocrine disruptors in mammalian systems, having high binding affinities for estrogen receptors, and have been shown to bind the ecdysone receptor of insects (Oberdorster et al., 2001). Several studies have examined the effects of natural bioactive products on feeding, behavior, mortality, and fecundity of termites (Chang et al., 2001; Tellez et al., 2001; Zhu et al., 2001).

Many plants contain bioactive chemicals that can repel or kill termites (Ahmed et al., 2006); noted among these are *Citrus* spp. (Raina et al., 2007), *Taiwania cryptomerioides* (Chang et al., 2001), *Calotropis procera* (Singh et al., 2002b), *Ocimum basilicum*, *Cymbopogon winterianus*, *Cinammomum camphora*, *Rosmarinus officinalis* (Sbeghen et al., 2002), and *Coleus amboinicus* (Singh et al., 2002a).

Fecundity, mortality, and food consumption of the Formosan subterranean termite, *Coptotermes formosanus* Shiraki, were evaluated in response to five plant flavonoids (genistein, biochanin A, apigenin, quercetin, and glyceollin). Apigenin fed at 50 µg/primary reproductive pair proved to be the most toxic flavonoid. Biochanin A was most effective in reducing fecundity (Boué & Raina, 2003).

In order to verify the activity of the insecticidal plants, the mortality of workers of *C. cumulans* caused by leaf and tree bark extracts under laboratory conditions was evaluated.

2 METHODOLOGY

Parts of eleven plants species (Table 1) were collected in savannah areas (Cerrado) in the State of Minas Gerais, Brazil, to be packed in paper bags. Part of the material was taken to the Laboratory of Natural Products, Department of Chemistry (DQI) at the Federal University of Lavras (UFLA), where the corresponding plant extracts were prepared. Another part was taken to the UFLA Herbarium, Department of Biology (DBI) of the UFLA, where the specimens were identified and deposited in the UFLA's Herbarium.

During the plant collection, a form should be filled to record information such as: the collecting place, popular name, scientific name, family, habitat, date of collection, time, conditions of weather, part harvested, the development phase of the plant, soil type, occurrence of pests or diseases. Whenever possible, samples from at least two individuals in different environments were collected for each plant species.

Identifications of specimens were done from exsiccated comparisons with the UFLA's Herbarium, consultations with specialists and classical works. The determinations of the specimens collected were based on vegetative, reproductive and morphological characters and, if necessary, anatomical characters were also employed. The specimens were classified according to the system of APG II (Angiosperm Phylogeny Group, 2002).

Initially, leaves and tree barks with diseases or pests were discarded to avoid contamination of the extracts. Next, the leaves were dried in a ventilated stove at 40ºC for 48 hours to reduce the water content to the smallest possible value. This drying stage was very important to prevent the proliferation of microorganisms and to avoid enzymatic transformation during storage, which occurred before the preparation of extracts. Dried leaves and tree barks were ground to increase their contact surface and, consequently, make the extraction with methanol easier.

The dried and ground barks and leaves were separately subjected to two grindings with methanol for 48 hours at room temperature to extract the maximum amount of substances from plant tissues. The resulting dried residues, which are henceforth named plant extracts, were stored in a freezer at -15 ºC until they were used.

On the UFLA campus, state of Minas Gerais, in southeastern Brazil, termite hills were broken into pieces using a hoe. Each piece was beaten into a sieve placed over a 2-liter plastic bucket. The termites were taken into the laboratory and separated with a stainless spoon. 30 termites per Petri dish of 9cm of diameter were separated, and the bottom covered with filter paper soaked with tap water (distilled water because it does not contain solids, so that it enters the termite’s body by osmosis, and may cause its death, a fact already observed) and the plastic lid was perforated (13 holes of 1.5mm in diameter), which was placed on the top of a piece of cotton soaked with tap water in order to keep humidity inside the plate next to saturation.

For each treatment, which consisted of each plant extract (Table 1), 10ml of artificial diet that were composed of: 10% sugar cane bagasse, 4% glucose, 0.2% sucrose, 0.1% hydrolyzed casein, 0.05% cholesterol and 1.5% agar were used (Buffalino et al., 2008). This diet was autoclaved at 20ºC for 20 minutes in which 40mg of plant extracts dissolved in 1ml of Dimethyl Sulfoxide (DMSO) were added when the diet was in its liquid state, kept the temperature at 55ºC, thus preserving heat-sensitive molecules.

After the diets became solid, the insects were fed 0.5cm³ artificial diet containing the plant extract, and the dishes moved to a climatic chamber under the conditions of temperature 1ºC ± 2ºC, 90 ± 10% relative humidity and 24-hour darkness.

TABLE 1 Scientific name, family and collected part of the plants tested.

Scientific name	Family	Collected part
Croton floribundus Sprengel	Euphorbiaceae	Leaves and Bark
Croton urucurana Baillon	Euphorbiaceae	Leaves and Bark
Chrysophyllum gonocarpum (Mart. e Eichler) Engl.	Sapotaceae	Bark
Geonoma schottiana Mart.	Arecaceae	Leaves
Gymnanthes concolor (Sprengel) Müll. Arg.	Euphorbiaceae	Leaves
*Heteropterys byrsonimifoli*a A. Juss	Malpighiaceae	Leaves
Merremia tomentosa (Choisy) H. Hallier	Convolvulaceae	Leaves
Sabicea brasiliensis Wernham	Rubiaceae	Leaves
Solanum argenteum Dunal	Solanaceae	Bark
Terminalia brasiliensis Camb.	Combretaceae	Leaves
Vismia brasiliensis Choisy	Clusiaceae	Leaves

The bioassays were completely randomized with three replicates per treatment, each replication comprised of a Petri dish containing 30 termites, including positive and negative control. As positive and negative controls: 10ml of artificial diet + 1ml of DMSO and 10ml of artificial diet + 1ml of fipronil (800 WG; 0.003%) were used, respectively.

The percentage of mortality of insects treated was evaluated 48 hours after the treatments were given. The data were transformed in $\sqrt{(x+1)}$ and submitted to analysis of variance and the means compared by the Scott-Knott test ($p \leq 0.05$).

3 RESULTS AND DISCUSSION

Plant extracts of *Terminalia brasiliensis* (Leaves); *Croton urucurana* (Leaves); *Gymnanthes concolor* (Leaves) and *Croton floribundus* (Tree bark) showed high mortality of termites (Table 2) and they provide a source of natural chemicals that could be used in controlling these insects.

Out of the plants tested, the genus *Terminalia* showed the highest mortality after 48 hours with 72.78% and 68.89% respectively for specimens 3 and 4 (Table 2). The genus *Terminalia* is rich in secondary metabolites, responsible for the insecticidal effect, such as pentacyclic triterpenoids and their derivatives glycosides, flavonoids, tannins and other aromatic compounds (Araújo & Chaves, 2005). They are also used as expectorant and against coughs and diarrheas (Agra et al., 2008). Many compounds such as phytochemicals of diverse chemical structures, like terpenoids, flavonoids, limonoids, chinones and fatty acids had repellent, antifeedant or toxic effects on termites in feeding assays (Zhu et al., 2001; Boué & Raina, 2003; Maistrello et al., 2003).

TABLE 2 Mortality (mean ± standard error) of *Cornitermes cumulans* treated with plant extracts via ingestion after 48 hours.

Treatment	Collection date	Mortality (%)*
Diet + DMSO		31.67 ± 3.0 a
Croton floribundus (specimen 1 - bark)	25/Jan/2008	63.33 ± 3.9 b
Croton urucurana (specimen 1 – leaves)	12/Dec/2007	67.22 ± 2.9 b
Croton urucurana (specimen 2 – leaves)	12/Dec/2007	38.33 ± 4.1 a
Croton urucurana (specimen 3 – leaves)	12/Dec/2007	52.78 ± 4.4 a
Croton urucurana (specimen 4 – leaves)	12/Dec/2007	32.78 ± 4.0 a
Croton urucurana (specimen 5 – leaves)	12/Dec/2007	45.56 ± 4.3 a
Gymnanthes concolor (specimen 1 –leaves)	15/Dec/2007	64.44 ± 4.5 b
Terminalia brasiliensis (specimen 1 – leaves)	20/Dec/2008	28.89 ± 3.2 a
Terminalia brasiliensis (specimen 2 – leaves)	20/Dec/2008	39.44 ± 2.2 a
Terminalia brasiliensis (specimen 3 - leaves)	20/Dec/2008	72.78 ± 2.4 b
Terminalia brasiliensis (specimen 4 – leaves)	20/Dec/2008	68.89 ± 4.7 b
Control (fipronil 0.003%)		82.78 ± 1.9 b

* Averages followed by same letter do not differ significantly from each other by Scott and Knott test ($p \leq 0.05$).

Several specimens showed different behaviors (Table 2), while in the same species, what can be inferred due to the variance in bioactive compounds, which may vary depending on the plant species and variety of the plant species, so there will always be difference in the effectiveness of plant extracts on insects' mortality (Cloyd, 2004). This author also states that there is a rapid degradation in the bioactive compound of the plant extract so that many applications are required to achieve satisfactory control in insect pests.

The third, fourth and fifth highest mortalities were caused by plants from the family Euphorbiaceae, *C. urucurana*, *G. concolor* and *C. floribundus* which showed 67.22%, 64.44% and 63.33% of mortality in termites, respectively (Table 2). The chemistry of the genus *Croton* has been exploited and phytochemical studies have led to the isolation of alkaloids (Bittner et al., 1997), flavonoids, triterpenoids and a variety of structural diterpenoids (Palmeira Júnior, 2005; Santos et al., 2005).

Studies on seed extracts of *Croton tiglium* proved efficient in termite control when it was applied in soil (Ahmed et al., 2007). An insect antifeedant component was also isolated from *Croton jatrophoides* (Nihei et al., 2005).

TABLE 3 Mortality (mean ± standard error) of *Cornitermes cumulans* treated with plant extracts via ingestion after 48 hours.

Treatment	Collection date	Mortality (%)*
Diet + DMSO		1.11 ± 0.6 a
Croton floribundus (specimen 2 –leaves)	22/Ago/2008	6.66 ± 2.2 a
Croton floribundus (specimen 3 –leaves)	22/Ago/2008	4.44 ± 0.0 a
Croton floribundus (specimen 4 - bark)	19/Ago/2008	2.22 ± 0.6 a
Croton floribundus (specimen 5 - bark)	19/Ago/2008	2.22 ± 0.6 a
Croton floribundus (specimen 6 - bark)	19/Ago/2008	6.66 ± 1.1 a
Croton floribundus (specimen 7 - bark)	19/Ago/2008	5.55 ± 0.6 a
Croton urucurana (specimen 6 - leaves)	18/Ago/2008	2.22 ± 1.2 a

"Table 3 continues…"

Croton urucurana (specimen 7 - bark)	19/Ago/2008	1.11 ± 0.6 a
Croton urucurana (specimen 8 - bark)	19/Ago/2008	6.66 ± 2.2 a
Gymnanthes concolor (specimen 2 - leaves)	18/Ago/2008	2.22 ± 0.0 a
Gymnanthes concolor (specimen 3 - leaves)	18/Ago/2008	5.55 ± 0.6 a
Terminalia brasiliensis (specimen 5 - leaves)	08/Set/2008	1.11 ± 00.6 a
Terminalia brasiliensis (specimen 6 - leaves)	08/Set/2008	1.11 ± 0.6 a
Control (fipronil 0.003%)		83.33 ± 1.9 b

* Averages followed by same letter do not differ significantly from each other by Scott and Knott test ($p \leq 0.05$).

It was observed that there are differences in the mortality of termites in the genus *Croton*. Bark of *C. floribundus* was effective in termite control (Table 2) but the same action was not found in the leaves (Table 3). In contrast, *C. urucurana* showed efficiency only in the leaves (Table 2). The difference in these observations may be due to the types of chemicals contained in each part of the plants (Ahmed et al., 2007).

TABLE 4 Mortality (means ± standard error) of *Cornitermes cumulans* treated with extracts of plants via ingestion after 48 hours.

Treatment	Collection date	Mortality (%)*
Diet + DMSO		5.56 ± 1.7 a
Chrysophyllum gonocarpum (bark)	23/Nov/2006	4.44 ± 1.7 a
Geonoma shotiana (leaves)	18/Abr/2007	8.89 ± 1.3 a
Gymnanthes concolor (specimen 4 - leaves)	16/Set/2006	3.33 ± 1.9 a
Heteropterys byrsonimifolia (leaves)	10/Nov/2005	2.22 ± 0.6 a
Merremia tomentosa (leaves)	02/Nov/2005	4.44 ± 0.6 a
Sabicea brasiliensis (leaves)	25/Nov/2005	7.78 ± 1.3 a
Solanum argenteum (bark)	23/Nov/2006	4.44 ± 1.7 a
Vismia brasiliensis (leaves)	21/Jun/2006	4.44 ± 2.6 a

"Table 4 continues…"

Control (fipronil 0.003%)	98.89 ± 0.6 b

* Averages followed by same letter do not differ significantly from each other by Scott and Knott test ($p \leq 0.05$).

Four specimens of *G. concolor* were tested and only one showed efficiency in controlling termites (Tables 2, 3 and 4). That also happened to all the other species that showed efficiency in the first experiment (Table 2), which can be explained by the action of several biotic and abiotic factors such as light, temperature, relative humidity, rainfall, geographical position of the species as latitude and altitude, date and time of collection, soil quality, cultural treatments and plant phenology (Shalaby et al., 1988; Russo et al., 1998; Andrade & Casali, 1999; Carvalho & Casali, 1999). These factors influence the production of secondary metabolites that are related to defense mechanisms of plants (Catehouse, 2002).

Date of collection, age of the plant, different specimens and other factors mentioned influenced the production of toxic compounds against insects. *G. concolor* (specimen 1 - leaves) collected in 15/Dec/2007 (Table 2) presented activity in termite control, in contrast with the same species collected in 18/Ago/2008 (Table 3) and in 16/Set/2006 (Table 4).

Pant age can influence the activity as seen in a study on essential oils extracted from the leaves of *Cryptomeria japonica* at different ages (58, 42, and 26 years old) against *Aedes aegypti* and *Aedes albopictus*. Results obtained using essential oils from the leaves of 58-year-old *Cryptomeria japonica* proved most effective against *Aedes aegypti* and *Aedes albopictus* larvae, indicating that tree age has significant influence on the larvicidal activity (Cheng et al., 2009).

Treatments with fipronil presented, on average, 88.33% efficiency in the mortality of termites, which confirms the control done by this chemical in other studies (Saran & Rust, 2007). An investigated testing efficiency of the insecticide fipronil in the control of the subterranean termites obtained 90% to 100% of control, regardless of the dosage, formulation and manner of application during 145 days' evaluation period (Wilcken & Raetano, 1995).

4 CONCLUSION

Croton floribundus (Tree bark) (25/Jan/2008); *Croton urucurana* (Leaves) (12/Dec/2007); *Gymnanthes concolor* (Leaves) (15/Dec/2007) and *Terminalia brasiliensis* (Leaves) (20/Dec/2008) are effective against *Cornitermes cumulans* in laboratory bioassays. These results indicate that these plant extracts should be tested in fields to check its efficacy.

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ARTICLE 2

RIZENTAL, Muriel Santos. **Effect of organic substances on mortality of *Cornitermes cumulans* (Kollar, 1832) (Isoptera: Termitidae)**. 2009. 37p. Dissertation (Master Program in Entomology) – Federal University of Lavras, Lavras, MG.

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ABSTRACT – Some conventional insecticides used in termite control had their use limited in a great deal of crops in Brazil. Then, some alternatives are necessary in order to replace these products in the control of these pests. This study was conducted to determine the efficacy of Chalcones, Acylhydrazones, Phenols and derivatives against *Cornitermes cumulans* under laboratory conditions. Two milligrams of each organic substance in a diet with sugar cane bagasse were mixed, the mortality of termites after 48 hours being evaluated. It was found that none of the substances controlled the termites.

Keywords: termites, organic compounds, control.

EFFEITO DE SUBSTÂNCIAS ORGÂNICAS NA MORTALIDADE DE *Cornitermes cumulans* (KOLLAR, 1832) (ISOPTERA: TERMITIDAE)

RESUMO - Alguns inseticidas convencionais utilizados no controle de cupins tiveram seu uso restringido em diversas culturas no Brasil. Então, algumas alternativas são necessárias para substituir tais produtos no controle dessas pragas. Este estudo foi realizado para determinar a eficiência de Chalconas, Acil hidrazonas, Fenóis e derivados contra *Cornitermes cumulans* em condições de laboratório. Foram misturados 2 mg de cada substância em uma dieta com bagaço de cana-de-açúcar, analisando a mortalidade dos cupins após 48 horas. Foi observado que nenhuma das substâncias controlou os cupins.

Palavras-chave: cupins, compostos orgânicos, controle.

1 INTRODUCTION

Plants are important sources of substances with bactericidal, virucidal, fungicidal, anti-parasitical and insecticidal properties, which can be used for agricultural, medicinal and cosmetic applications (Bakalli, 2008).

Among the great variety of chemical structures from plant origin are chalcones (Wang et al., 2005). They are essential intermediate compounds in the biosynthesis of flavonoids. Many studies have shown that they are very interesting compounds because they exhibit biological activities (Dimmock et al., 1999; Ni et al., 2004) such as antifungal (Lopez et al., 2001; Boeck et al., 2005) antiviral (Phrutivorapongkul et al., 2003), antibacterial (Lin et al., 2002), anti-malarial (Lin et al., 2001), anti- leishmania (Nielsen et al., 1998; Boeck et al., 2006), anti-inflammatory (Ko et al., 2003; Won et al., 2005), anti-tumor (Edwards et al., 1990; Nam et al., 2003; Won et al., 2005) properties, among others. Besides to their being widely distributed among plants, they can be easily synthesized by chemical methods. As a result, different substitutions in the A and B-rings may be obtained, affording compounds with different biological activities (Chiaradia et al., 2008).

Another interesting class of organic compounds is the one composed by hydrazones, which can exhibit many biological properties as fungicidal, bactericidal, herbicidal and insecticidal activities (Segupta & Chandra, 1979). When the nitrogen of the hydrazone moiety is linked to an acyl group, the resulting structure may be characterized as an acylhydrazone.

Interesting studies using acylhydrazone in insects have showed activity, one with *Spodoptera litura* treated with benzophenone acylhydrazone derivatives showed excellent insecticidal activity combined with low mammalian toxicity. Eighty percent of the larvae were controlled with 500 ppm and at 100 mg/kg orally, it was nonlethal in rats, this result denotes the efficiency against insects and its safety to mammals (Tomioka et al., 1995).

Phenolic substances also seemed a very promising class of organic compounds in the present study, since structures like pentachlorophenol are widely used to control termites and protect wood from fungal-rot and wood-boring insects, and are often detected in the aquatic environment. Although phenol and some of its derivatives are considered environmental pollutants, their toxicity may be considerably reduced by the connection of some groups to the aromatic ring (Dey & Harborne, 1997; Zha et al., 2006).

Phenolic substances tend to be water-soluble, since they most frequently occur combined with sugars as glycosides and they are usually located in the cell vacuole. Among the natural phenolic compounds, of which several thousands of structures are known, flavonoids form the largest group (Harborne, 1998).

The use of these compounds is an alternative in the control of insects in agriculture and the termites are important pests in it. Termitidae is the largest family among termites. Known as superior termites, they are extremely abundant in tropical forests where they play an important role in organic water decomposition (Jones et al., 2006). In Brazil, one of the termites of the above-mentioned family found very often in eucalyptus forest is *Cornitermes cumulans* (Kollar, 1832). In addition, such a termite can also attack sugarcane plantation and pastures in Brazil (Almeida et al., 2003), accounting for losses in the production of food and biofuels.

Taking into account the great damage that *C. cumulans* can cause in many crops, this work was conducted to screen active chalcones, acylhydrazones or alkylphenols against this termite in order to contribute to the development of new products to control termites.

2 METHODOLOGY

Chalcones and acylhydrazones were provided by the Natural Products Laboratory of the Federal University of Lavras (UFLA), where they were prepared in accordance with the work by Nunes (2008). Phenol and its derivatives were isolated from natural sources and converted in the above mentioned laboratory to alkylphenols and other derivatives by the use of common procedures for hydrogenation, alkylation and acylation of organic substances (House, 1972).

Termite hills were broken into pieces using a hoe. Each piece was beaten into a sieve placed over a 2 liter plastic bucket. The termites were taken into the laboratory and separated with a stainless spoon. 30 individuals per Petri dish (9cm in diameter) were separated and bottom covered with filter paper soaked with tap water (because it does not contain solids, so that it enters the termite's body by osmosis and may cause its death, a fact already observed) and the plastic lid was perforated (13 holes of 1.5mm in diameter). It was placed on the top of a piece of cotton soaked with tap water in order to keep the humidity inside the card next to saturation.

For each treatment, 10ml of artificial diet were used, which consisted of: 10% sugar cane bagasse, 4% glucose, 0.2% sucrose, 0.1% hydrolyzed casein, 0.05% cholesterol and 1.5% agar (Buffalino et al., 2008). This diet was autoclaved at 120ºC for 20 minutes. In the artificial diet, 2mg of organic substances dissolved in 1ml of Dimethyl Sulfoxide (DMSO) we added, when the diet was in its liquid state, the temperature of 55ºC was maintained, thus preserving heat-sensitive molecules.

After the diets became solid, the insects were fed 0.5cm^{3} of artificial diet containing the organic substances, and the dishes moved into a climatic chamber under the temperature conditions of 21ºC ± 2ºC, 90 ± 10% relative humidity and 24 hours' darkness.

In the bioassays, 86 chalcones (Table 1), 18 acylhydrazones (Table 2) and 13 phenols and its derivatives were tested (Table 3 and Figure 1). The bioassays were completely randomized with six replicates per treatment; each replication comprised a Petri dish containing 30 termites, with different treatments, including positive and negative controls. As negative and positive controls: 1ml of DMSO and 1ml of fipronil (800WG; 0.003%), dissolved into 10ml of artificial diet were used, respectively.

The percentage of mortality of the insects treated 48 hours after the diets were given, was evaluated. The data were transformed in √(x+1) and submitted to analysis of variance and the means compared by the Scott-Knott test ($p \leq 0.05$).

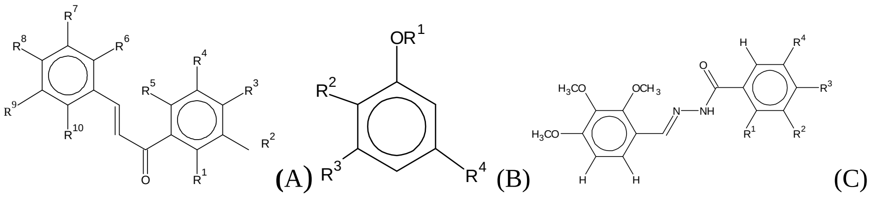

FIGURE 1 Basic structures of Chalcones (A), Phenol (B) and Acylhydrazones (C) tested against *Cornitermes cumulans* under laboratory conditions.

TABLE 1 Structures of Chalcones tested against *Cornitermes cumulans* under laboratory conditions, considering the basic structure and its components in each position (R).

Structure	R^1	R^2	R^3	R^4	R^5	R^6	R^7	R^8	R^9	R^{10}
1	H	H	OCH_3	H	H	H	H	H	$CH(CH)_2CH$	
2	H	NO_2	H	H	H	H	H	H	$CH(CH)_2CH$	

"Table 1 continues…"

3	OH	H	H	H	H	H	H	H	$CH(CH)_2CH$	
4	H	H	Br	H	H	H	H	H	$CH(CH)_2CH$	
5	H	OCH_3	OCH_3	H	H	H	H	H	$CH(CH)_2CH$	
6	H	H	NO_2	H	H	H	H	H	$CH(CH)_2CH$	
7	H	H	H	H	H	H	H	H	$CH(CH)_2CH$	
8	H	OCH_3	OCH_3	OCH	H	H	H	H	$CH(CH)_2CH$	
9	OH	H	OCH_3	H	OCH_3	H	H	H	$CH(CH)_2CH$	
10	OCH_3	H	H	OCH_3	H	H	H	H	$CH(CH)_2CH$	
11	OCH_3	H	OCH_3	H	H	H	H	H	$CH(CH)_2CH$	
12	H	OH	H	H	H	H	H	H	$CH(CH)_2CH$	
13	H	H	NO_2	H	H	H	OCH_3	OCH_3	H	OCH_3
14	OCH_3	H	H	OCH_3	H	H	OCH_3	OCH_3	H	OCH_3
15	OH	Br	OCH_3	H	OCH_3	H	H	H	$CH(CH)_2CH$	
16	OH	Br	OCH_3	H	OCH_3	OCH_3	H	H	H	H
17	OH	Br	OCH_3	H	OCH_3	H	H	$CH_4(CH_2)_3O$	H	H
18	OH	Br	OCH_3	H	OCH_3	H	H	Br	H	H
19	OH	Br	OCH_3	H	OCH_3	H	H	CH_3	H	H
20	OH	Br	OCH_3	H	OCH_3	H	NO_2	H	H	H
21	OH	Br	OCH_3	H	OCH_3	H	H	OCH_3	H	H
22	OH	Br	OCH_3	H	OCH_3	H	H	OH	H	H
23	OH	Br	OCH_3	H	OCH_3	H	H	H	H	H
24	OH	Br	OCH_3	H	OCH_3	H	H	$CH(CH)_2CH$		H
25	OCH_3	H	OCH_3	OCH_3	H	H	OCH_3	OCH_3		H
26	OCH_3	H	OCH_3	OCH_3	H	H	H	OCH_2O		H
27	OCH_3	H	OCH_3	OCH_3	H	H	H	$CH(CH)_2CH$		H
28	OCH_3	H	OCH_3	OCH_3	H	H	OCH_3	H	H	H
29	OCH_3	H	OCH_3	OCH_3	H	H	H	$(CH_3)_2N$	H	H
30	OCH_3	H	OCH_3	OCH_3	H	Cl	H	H	H	H
31	OCH_3	H	OCH_3	OCH_3	H	H	H	H	$CH(CH)_2CH$	
32	OCH_3	H	OCH_3	OCH_3	H	H	H	CH_3	H	H
33	OCH_3	H	OCH_3	OCH_3	H	H	H	H	H	H
34	OCH_3	H	OCH_3	OCH_3	H	H	OCH_3	H	H	H
35	OCH_3	H	OCH_3	OCH_3	H	OCH_3	H	H	H	H
36	OCH_3	H	OCH_3	OCH_3	H	H	H	NO_2	H	H
37	OCH_3	H	OCH_3	OCH_3	H	H	H	H	H	H
38	OCH_3	H	OCH_3	OCH_3	H	H	H	H	OCH_3	H

“Table 1 continues…”

39	H	OCH_3	OCH_3	OCH_3	H	H	H	Cl	Cl	H
40	H	OCH_3	OCH_3	OCH_3	H	H	H	Cl	H	H
41	H	OCH_3	OCH_3	OCH_3	H	H	H	CH_3	H	H
42	H	OCH_3	OCH_3	OCH_3	H	Cl	H	H	H	Cl
43	H	OCH_3	OCH_3	OCH_3	H	H	H	Br	H	H
44	H	OCH_3	OCH_3	OCH_3	H	H	H	NO_2	H	H
45	H	OCH_3	OCH_3	OCH_3	H	H	H	$(CH_3)_2N$	H	H
46	H	OCH_3	OCH_3	OCH_3	H	H	H	F	H	H
47	H	OCH_3	OCH_3	OCH_3	H	H	H	$CH_4(CH_2)_3O$	H	H
48	H	OCH_3	OCH_3	OCH_3	H	H	H	H	NO_2	H
49	H	OCH_3	OCH_3	OCH_3	H	H	H	OCH_3	H	H
50	H	OCH_3	OCH_3	OCH_3	H	Cl	H	H	H	H
51	H	OCH_3	OCH_3	OCH_3	H	H	OCH_3	OCH_3	OCH_3	H
52	H	OCH_3	OCH_3	OCH_3	H	H	OCH_3	OCH_3	OCH_3	H
53	H	OCH_3	OCH_3	OCH_3	H	H	H	$CH(CH)_2CH$		H
54	H	H	Br	H	H	H	H	$CH(CH)_2CH$		H
55	H	H	H	H	H	H	H	$CH(CH)_2CH$		H
56	OH	H	H	H	H	H	H	$CH(CH)_2CH$		H
57	H	H	NO_2	H	H	H	H	$CH(CH)_2CH$		H
58	H	OCH_3	OCH_3	H	H	H	H	$CH(CH)_2CH$		H
59	OCH_3	H	H	OCH_3	H	H	H	$CH(CH)_2CH$		H
60	H	OCH_2O		H	H	H	H	Cl	H	H
61	H	OCH_2O		H	H	H	H	H	Cl	H
62	H	OCH_2O		H	H	H	H	H	H	Cl
63	H	OCH_2O		H	H	H	H	Cl	Cl	H
64	H	OCH_2O		H	H	H	H	NO_2	H	H
65	H	OCH_2O		H	H	H	H	H	NO_2	H
66	H	OCH_2O		H	H	H	H	Br	H	H
67	H	OCH_2O		H	H	H	OCH_3	OCH_3	H	OCH_3
68	H	OCH_2O		H	H	OCH_3	H	OCH_3	H	OCH_3
69	H	OCH_2O		H	H	H	OCH_3	OCH_3	OCH_3	H
70	H	OCH_2O		H	H	H	H	OCH_2O	H	H
71	H	OCH_2O		H	H	H	H	CH_3	H	H
72	H	OCH_2O		H	H	H	H	$(CH_3)_2N$	H	H
73	H	OCH_2O		H	H	H	H	$CH(CH)_2CH$		H

“Table 1 continues…”

74	H	OCH_2O		H	H	H	H	H	$CH(CH)_2CH$	
75	H	H	H	H	H	H	H	H	OCH_2O	
76	H	H	H	H	H	H	H	CH_3	H	H
77	H	H	Br	H	H	H	H	OCH_2O		H
78	H	H	NO_2	H	H	H	H	OCH_2O		H
79	OCH_3	H	H	OCH_3	H	H	H	OCH_2O		H
80	OH	H	H	H	H	H	H	OCH_2O		H
81	H	OCH_3	OH	H	H	H	H	OCH_2O		H
82	H	H	OCH_3	H	H	H	H	OCH_2O		H
83	H	OCH_3	OCH_3	H	H	H	H	OCH_2O		H
84	H	NO_2	H	H	H	H	H	OCH_2O		H
85	H	OCH_3	OCH_3	OCH_3	H	H	H	OCH_2O		H
86	OCH_3	H	OCH_3	H	H	H	H	OCH_3		H

TABLE 2 Structures of acylhydrazones tested against *Cornitermes cumulans* under laboratory conditions, considering the basic structure and its components in each position (R).

Structure	R^1	R^2	R^3	R^4
87	H	OCH_2O		H
88	Cl	H	H	H
89	OCH_3	H	H	OCH_3
90	F	H	H	H
91	H	OCH_3	OCH_3	OCH_3
92	OCH_3	H	OCH_3	OCH_3
93	H	H	F	H
94	H	H	$CH_4(CH_2)_3O$	H
95	H	H	H	H
96	H	H	Br	H
97	H	H	NO_2	H
98	H	H	OCH_3	H
99	H	Br	OH	OCH_3

“Table 2 continues…”

100	H	I	OH	OCH_3
101	H	H	OH	OCH_3
102	$CH(CH)_2CH$		H	H
103	H	$CH(CH)_2CH$		H
104	H	H	Cl	H

TABLE 3 Structures of phenol derivatives tested against *Cornitermes cumulans* under laboratory conditions, considering the basic structure and its components in each position (R).

Structure	R^1	R^2	R^3	R^4
106	H	$CH{=}CH\ C(CH_3)_2O$		$C_{15}H_{31}$*
107	Ac	H	H	$C_{14}H_{29}$*
108	Ac	H	OAc	$C_{14}H_{29}$*
109	Allyl	H	H	$C_{14}H_{29}$*
110	Allyl	H	OAllyl	$C_{14}H_{29}$*
111	Et	H	H	$C_{14}H_{29}$*
112	Et	H	OEt	$C_{14}H_{29}$*
113	H	H	H	C_8H_{17}*
114	H	H	OH	C_8H_{17}*
115	H	H	H	$C_{14}H_{29}$*
116	H	H	OH	$C_{14}H_{29}$*

* Linear alkyl groups.

3 RESULTS AND DISCUSSION

The average mortality of termites caused by the phenol derivatives tested was 15.09%, structure 114 being the most active, since it caused 25.55% of the termites’ mortality (Table 4, bioassay 25). All values observed for the phenolic substances were very far from the 94.44% efficiency presented by the insecticide used as a positive control.

TABLE 4 Mortality of *Cornitermes cumulans* treated with organic substances via ingestion after 48 hours. Lavras, MG. AH = Acylhydrazones/ P = Phenol derivatives.

Bioassay	Substance	Mortality (%)*
1	Diet + DMSO	7.22±1.13 a
	18	8.88±1.67 a
	90 AH	6.11±0.41 a
	91 AH	6.11±0.73 a
	103 AH	8.88±0.83 a
	Fipronil (0.003%)	92.77±2.94 b
2	Diet + DMSO	6.66±0.99 a
	19	6.11±0.95 a
	87 AH	0.44±0.57 a
	94 AH	7.77±0.45 a
	95 AH	6.66±0.49 a
	104 AH	20.55±6.27 a
	Fipronil (0.003%)	96.66±0.70 b
3	Diet + DMSO	15.00±1.15 a
	13	16.66 ±0.70 a
	20	13.33±1.40 a
	89 AH	36.66±3.46 b
	92 AH	16.11±1.24 a
	97 AH	40.55±1.02 b
	Fipronil (0.003%)	77.22±2.26 c
4	Diet + DMSO	15.55±1.74 a
	106 P	18.33±1.64 a
	107 P	11.11±1.30 a
	108 P	16.11±1.38 a
	109 P	12.22±1.14 a
	110 P	11.66±1.30 a
	111 P	15.55±2.37 a
	112 P	5.55±0.57 a
	113 P	10.00±0.70 a
	114 P	25.55±4.68 a
	115 P	19.44±3.32 a
	116 P	20.55±4.94 a
	Fipronil (0.003%)	94.44±0.57 b

“Table 4 continues…”		
5	Diet + DMSO	32.77 ± 0.04 a
	22	12.22 ± 0.02 a
	88 AH	15.55 ± 0.01 a
	100 AH	10.00 ± 0.01 a
	Fipronil (0.003%)	94.44 ± 0.01 b
6	Diet + DMSO	17.77±1.43 b
	93 AH	10.00±0.70 a
	96 AH	4.99±0.68 a
	98 AH	12.22±1.14 b
	101 AH	20.00±1.16 b
	102 AH	2.77±0.42 a
	Fipronil (0.003%)	89.44±0.89 c
7	Diet + DMSO	3.88±0.65 a
	4	8.33±1.35 a
	10	8.33±0.98 a
	24	2.77±0.42 a
	54	6.11±2.23 a
	99 AH	3.33±0.86 a
	Fipronil (0.003%)	100±0 b
8	Diet + DMSO	0±0 a
	5	2.77±0.42 a
	6	1.11±0.45 a
	7	3.88±0.42 a
	56	5.55±0.76 a
	57	8.33±2.21 a
	Fipronil (0.003%)	100.00±0 b
9	Diet + DMSO	8.33±1.20 a
	1	11.11±1.47 a
	15	11.66±1.25 a
	23	12.77±1.50 a
	53	8.88±1.03 a
	Fipronil (0.003%)	93.33±1.05 b
10	Diet + DMSO	8.33±0.58 a
	39	7.77±1.03 a
	40	4.99±0.76 a
	42	5.00±0.46 a
	46	11.66±1.44 a
	49	7.77±0.45 a
	Fipronil (0.003%)	100±0 b

“Table 4 continues…”		
11	Diet + DMSO	8.88±0.57 a
	8	15.00±1.43 a
	12	11.11±1.81 a
	45	11.11±1.03 a
	Fipronil (0.003%)	100.00±0 b
12	Diet + DMSO	3.88±0.74 a
	60	10.55±1.02 b
	61	2.22±0.45 a
	62	2.22±0.29 a
	63	1.11±0.29 a
	64	2.22±0.67 a
	Fipronil (0.003%)	100.00±0 c
13	Diet + DMSO	16.66±0.35 a
	41	16.11±2.03 a
	43	18.33±2.80 a
	47	16.11±1.13 a
	48	17.22±2.57 a
	51	13.33±1.31 a
	Fipronil (0.003%)	81.66±4.77 b
14	Diet + DMSO	3.88±1.08 a
	9	5.55±0.76 a
	17	6.66±1.05 a
	55	7.77±1.39 a
	58	12.77±1.08 a
	Fipronil (0.003%)	100.00±0 b
15	Diet + DMSO	12.22±0.67 a
	2	14.44±2.07 a
	3	12.77±1.70 a
	11	12.22±1.15 a
	16	12.22±1.09 a
	21	8.88±1.47 a
	Fipronil (0.003%)	73.88±1.77 b
16	Diet + DMSO	8.33±0.91 a
	52	9.44±1.13 a
	Fipronil (0.003%)	99.44±0.22 b
17	Diet + DMSO	4.99±0.68 a
	37	2.77±0.54 a
	38	2.77±1.13 a
	75	5.00±0.84 a

"Table 4 continues…"

	79	6.66±0.61 a
	80	2.22±0.67 a
	Fipronil (0.003%)	99.44±0.23 b
18	Diet + DMSO	7.77±0.67 a
	44	13.33±1.53 a
	50	13.88±1.29 a
	65	16.66±0.70 a
	66	10.55±1.55 a
	71	6.11±0.74 a
	Fipronil (0.003%)	97.77±0.91 b
19	Diet + DMSO	3.88±0.55 a
	33	6.11±0.74 a
	34	1.11±0.29 a
	35	4.44±0.45 a
	36	5.55±0.45 a
	105 AH	3.88±1.08 a
	Fipronil (0.003%)	98.33±0.68 b
20	Diet + DMSO	5.00±0.46 a
	14	12.77±1.42 a
	25	7.77±0.67 a
	26	11.66±0.58 a
	27	12.77±0.96 a
	59	9.44±1.08 a
	Fipronil (0.003%)	87.77±0.83 b
21	Diet + DMSO	3.88±0.42 a
	28	7.77±0.76 b
	29	2.77±0.42 a
	30	7.22±0.65 b
	31	7.22±1.08 b
	32	7.77±0.45 b
	Fipronil (0.003%)	100.00±0 c
22	Diet + DMSO	1.66±0.46 a
	82	4.44±0.67 a
	83	6.11±0.42 a
	84	4.99±0.91 a
	85	9.44±0.74 a
	86	6.11±0.65 a
	Fipronil (0.003%)	89.44±1.08 b
23	Diet + DMSO	12.77±0.74 a

"Table 4 continues…"		
	67	14.44±1.67 a
	76	19.44±1.47 a
	77	18.88±2.13 a
	78	12.22±2.07 a
	81	21.11±1.09 a
	Fipronil (0.003%)	98.88±0.29 b
24	Diet + DMSO	6.11±0.74 a
	68	1.66±0.46 a
	Fipronil (0.003%)	98.33±0.46 b
25	Diet + DMSO	2.77±0.42 a
	69	8.88±0.91 b
	70	3.33±0.35 a
	72	6.66±0.99 b
	73	9.44±1.24 b
	74	2.77±0.65 a
	Fipronil (0.003%)	99.44±0.23 c

* Averages followed by same letter do not differ significantly from each other by Scott and Knott test ($p \leq 0.05$).

In a study on wood vinegar, researchers found that phenols have a potential termiticidal activity when they have some substituent and even better when they have an ortho substituent in addition to a phenolic hydroxyl group on its molecule. comparing with benzene derivatives that have no hydroxyl group. The bulkiness of the substituent at the ortho position participates in termiticidal activity; activity decreases as the size of an ortho substituent increases (Yatagai et al. 2002). There was no correlation between these factors in our experiments, in which phenol 106 with a larger size of the ortho substituent showed a higher mortality, 18.33%, than the others which have only one hydrogen in the ortho position.

Phenols can be very toxic to both humans and insects; they can induce shortening of life span of *Drosophila* sp., or show no effect on it (Massie et al., 1985). A study with *Drosophila melanogaster* showed toxic influence of 0.1%

phenol in fertility and life span in the first generation of fruit flies after the treatment (Zivanov-Curils et al., 2004).

The average mortality of the chalcones tested in this study was 8.83%, and the 81 (Table 4, bioassay 23) presented the greatest efficiency with 21.11%, well below the control with fipronil which obtained the general mean of 94.50% of termites´ mortality.

Chalcone (1,3-diphenyl-2-propen-1-one) is considered as the leading compound among all the chalcone type compounds used for the larvicidal studies, as it has the highest toxicity against the larvae of *Culex quinquefasciatus*. 4-Phenylbut-3-en-2-one, where a methyl group replaces the phenyl group of chalcone, is less active than 1,3-diphenyl-2-propen-1-one (Das et al., 2005).

A series of chalcones displayed toxicity towards the larvae of the mosquito *Culex quinquefasciatus*, use of a concentration of 100 ppm caused 100, 57, 60 and 50% mortality to the larvae, respectively to the structure: a= $R^8 = R^5 = R^4 = R^3 = H$; b= $R^8 = R^4 = R^3 = H$; R^5= OH; c= $R^8 = R^5 = R^4$ =H; R^3= OH; d= R^8 = OH; R^5 = H; $R^4 = R^3 = OCH_2O$; while 3-nitrochalcone was inactive (Das et al., 1995). One of the reasons for the high mortality in this study may be the high concentration used, 100 ppm, while we used only 2mg of each chalcone against termites.

This increase in the insecticidal activity of the compound with the increase of concentration can be seen in the 4th instar larvae of *Achoea janata* which were treated with leaf-discs containing different chalcones to measure the antifeedant activity. It was found that as the concentrations decreased the activity also decreased. It was found that chalcone (4-chloro-1-naphthyl)-3-(3-chlorohphenyl)-2-propen-1-one shows a total antifeedant activity at the concentration of 200 ppm (Thirunarayanan, 2008).

On the other hand, studies on low concentration of dibenzylidine acetone and benzylidine acetophenone (chalcone) showed insecticidal activity against the fourth instar of cotton leaf worm larvae *Spodoptra littoralis* larvae. Methomyl was used as a standard insecticide. Dibenzylidine acetone and methomyl were highly toxic to the cotton leaf worm with the same LC_{50} values (<10 ppm). The other benzylidine derivatives slightly affected the cotton leaf worm after 6 days' exposure (Abdel-Aty, 2004).

Cordifolin, a chalcone reported from natural source, has been isolated by ethanolic extract from the woody stem of *Tinospora cordifolia*. The chemical structure was established as 1-(2',3',4'-trihydroxyphenyl)-3-(4''-methoxyphenyl)-propen-1-one. The compounds exhibited good insect growth regulatory activity against larvae of *Spodoptera litura* (Shakil & Saxena, 2006).

Consideration of ingestion activity on the mortality of termites in relation to molecular structure indicates that phenols were generally more active than chalcones. There are some interesting structure-activity relationships in which phenols have their activity decreased when the size of an ortho substituent increases (Yatagai et al., 2002) and in a study on the larvae of *Culex quinquefasciatus*, chalcones have their activity decreased due to the introduction of different groups in the aromatic molecules or due to the lengthening of the conjugated portion (Das et al., 2005). The two groups act in similar ways to the addition of other groups in their structure.

Acylhydrazones showed 12.24% of average mortality, and the number 97 (Table 4, bioassay 3) showed the highest mortality with 40.55%, result that can be more studied due to low concentration used in these insects, this may be one of the reasons for the low efficiency of the control. A study using 400 ppm of O-acyl oximes and acylhydrazones proved efficient in controlling insects and mites as *Heliothis virescens*, *Nilaparvata lugens*, *Diabrotica balteata*, *Tetranychus urticae*, *Spodoptera litoralis*, *Plutella xylostella*, and *Aphis craccivora* (Maienfisch, 1998).

Some 3(2-phenyl quinazolin(3H)-4-one) acylhydrazones have been synthesized to study their bacterial and insecticidal properties. They were found to be effective on *Staphylococus aureus* and *Bacillus subtills*; and effective against adult male and female cockroaches (Segupta & Chandra, 1979).

4 CONCLUSION

The organic substances 89 and 97 caused low mortality of *Cornitermes cumulans*. These results indicate that these substances should be more studied to check its efficacy.

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