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Chemical composition and insecticidal activity of *Cymbopogon citratus* essential oil from Cuba and Brazil against housefly

Composição química e atividade inseticida do óleo essencial de *Cymbopogon citratus* de Brasil e Cuba contra mosca doméstica

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Abstract

Essential oil of *Cymbopogon citratus* collected from Brazil and Cuba was tested to a chemical characterization and then was tested on the post-embryonic development of *Musca domestica*. The chemical composition analysis by GC-MS of the oils from Brazil/Cuba allowed the identification of 13 and 12 major constituents respectively; nine of them common to both. In the both oils, the main components were the isomers geranial and neral, which together form the compound citral. This corresponds to a total of 97.92%/Brazil and 97.69%/Cuba of the compounds identified. The monoterpene myrcene, observed only in the sample of Cuba, presented a large relative abundance (6.52%). The essential oil of *C. citratus* (Brazil/Cuba) was dissolved in DMSO and tested at concentrations of 5, 10, 25, 50, 75 and 100% and citral was prepared by mixing 16.8 mg with 960 µL DMSO. Both essential oils and monoterpene citral were applied topically to newly-hatched larvae (1µL/larva). The results showed a lethal concentration (LC50) of 4.25 and 3.24% for the Brazilian and Cuban essential oils, respectively. Mortalities of larval and newly-hatched larvae to adult periods were dose-dependent for the two both oils as for monoterpene citral, reaching 90%. Both essential oils and citral caused morphological changes in adult specimens.

Keywords: Vector control, essential oil, house-fly, lemongrass, *Cymbopogon citratus*.

Resumo

O óleo essencial de *Cymbopogon citratus*, coletado no Brasil e em Cuba, foi caracterizado quimicamente e testado no desenvolvimento pós-embrionário de *Musca domestica*. A análise da composição química dos óleos essenciais (Brasil/Cuba), por Cromatografia Gasosa acoplada ao espectrômetro de massa (GC-EM), permitiu a identificação de 13 e 12 componentes principais, respectivamente; nove deles comuns aos dois. Em ambos os óleos, os principais componentes foram os isômeros geranial e neral, que, juntos, formam o composto citral. Esse corresponde a um total de 97,92%/Brasil e 97,69%/Cuba dos compostos identificados. O monoterpeno mirceno, observado na amostra cubana, apresentou grande abundância relativa (6,52%). O óleo de *C. citratus* (Brasil/Cuba) foi dissolvido em DMSO, obtendo–se as concentrações de 5, 10, 25, 75 e 100%; e o citral (16,8 mg) foi misturando com 960mL de DMSO. Tanto o óleo essencial como o monoterpeno citral foram aplicados topicamente nas neolarvas (1µL/larva). Os resultados mostraram uma concentração letal (CL50)

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de 4,25% e 3,24% para o óleo essencial brasileiro e cubano, respectivamente. As mortalidades do período larval e o de neo-larva a adulto foram dose-dependentes, tanto para os óleos como para o monoterpeno citral, podendo chegar a 90%. Ambos os óleos essenciais e citral causaram alterações morfológicas nos espécimes adultos.

Palavras-chave: Controle de vetores, óleo essencial, mosca doméstica, lemongrass, *Cymbopogon citratus*.

Introduction

The use of chemical insecticides in pest control induces insect resistance, and impact the environment through water and soil contamination, becoming toxic to vertebrates (PRADO, 2003). Thereby, multiple worldwide efforts to use botanical products to control insect vectors and pests appeared in the latest years. Biopesticides offer an alternative to insect control in which the damage to the environment is minimized, reaching only target organisms, with a minimal residual activity against predators, parasites and pollinator insects (LIU et al., 2000), making its use appropriate in integrated pest management programs (ISMAN, 2006; KOUL et al., 2008).

Plants and their natural enemies (insects, bacteria or viruses) have undergone a co-evolution process in which a new plant resistance character that reduces enemy attack is developed. The essential oils are a type of metabolite with this function, characterized by complex mixtures of monoterpenoids and sesquiterpenoids as major metabolites. The number and quantities of compounds in the essential oil produced by a single plant can change with the environment characteristic, place of collection, plant age and other conditions, but in general, the major compounds remain as a significative chemical marker. Due to the volatile, odorous and lipophylic characteristics of the essential oils, they can be toxic to insects, induce behavioral modifications, provoke direct disruption of specific physiological routes related to neuroendocrine system and in their reproduction (PRATES & SANTOS, 2002; GARCIA & AZAMBUJA, 2004). In addition, essential oils have been shown to be relatively non-toxic to fish, birds and mammals and easily biodegrade in the environment (KUMAR et al., 2012), turning them into good biopesticides.

Diptera Muscoid presents a great medical-sanitary importance and is closely related to animals and human environment, acting as an important vector of pathogens, such as bacteria, protozoa cysts and oocysts, helminthes, fungi and viruses (VAZIRIANZADEH et. al., 2008; BARIN et al., 2010), besides being responsible for the production of myiasis in humans and animals (ZUMPT, 1985). The immature stages of some species of these flies develop in animal and plant decaying organic matter such as feces, garbage, corpses and carrion (GRABOVAC & PETRIĆ, 2003).

Some studies revealed satisfactory results from the use of several essential oils for insect management such as the cosmopolitan pest house fly, *Musca domestica* L. (PAVELA, 2008); malarian vector mosquito, *Anopheles gambiae* Giles (McALLISTER & ADAMS, 2010); parasitic mites of the honeybees bee *Varroa destructor* (ANDERSON & TRUEMAN, 2000); Acari: Varroidae (GHASEMI et al., 2011); and the maize weevil adults, *Sitophilus zeamais* Motschulky (FAZOLIN et al., 2007).

The essential oil of *Cymbopogon citratus* (DC) Stapf (Poaceae), most known as "lemongrass", is commonly used by folk medicine in many countries. Native from India and Southeast Asia, it is distributed in numerous tropical countries, including Brazil (DUARTE & ZANETI, 2004; SOUSA et al., 2010). There are several popular uses for this plant, including treatment for stomach pains, diarrhea (TANGPU & YADAV, 2006), also having several pharmacological activities such as anti-amoebic and as antifungal (SHAH et al., 2011). Also it has been reported as potentially useful against insects (CAVALCANTI et al., 2004; KUMAR et al., 2013). Recently, some studies revealed that *C. citratus* essential oil and their main components (citral and 1.8 cineole), are important repellent and insecticide against housefly, but these studies are focused mainly in the instant effectiveness after application and not in long time effect. (KUMAR et al., 2011b, 2013; SINTHUSIRI & SOONWERA, 2013). As of today, no study considered the effect of the essential oil in all the stages of the fly's life cycle; that's why it became important to reveal the effect of those essential oils in the post-embryonic development of *M. domestica*.

This report describes the evaluation of the chemical composition and insecticidal activity of *C. citratus* essential oil collected in Brazil and Cuba and its major compound (Citral) on the post-embryonic development of *M. domestica*.

Materials and Methods

Plant collection and identification

The Brazilian lemongrass fresh leaves were collected at Laboratory of Cultivation and Biomass Production of Farmaguinhos/Fiocruz- Jacarepaguá campus, Rio de Janeiro, Brazil (22º87'49"S, 43º24'53"W). A voucher specimen was deposited at Rio de Janeiro Botanical Garden Herbarium (RB) under the number RB3273021. The Cuban specimen was collect in the district of Miraflores, municipality of Moa, Holguín, Cuba (20°38'21"N-75°01'44"W). The identification of the species and the quality parameters of vegetable drugs were secured by the Company of Agriculture municipality of Moa, the exclusive plant provider in this region of Cuba. A voucher specimen was deposited at BSC Herbarium under the number 16443.

Extraction and component characterization by Gas Chromatographic mass spectrometry (GC-MS) analysis

Fresh leaves of *C. citratus* were extracted by hydrodistillation using a "Clevenger type apparatus", as recommended by the Anvisa (2010). The chemical composition analysis of *C. citratus* oils (Brazil and Cuba) was done by High Resolution Gas Chromatography (HRGC) coupled to a mass spectrometer (MS). The gas chromatograph equipment model HP7590 (Agilent

Technologies, USA), equipped with DB-5MS capillary column produced by the same company with dimensions 30 m × 0.32 m and 0.25 mm thick film, was used. The program temperature conditions consisted in a temperature program from 40 °C until 290 ºC, with an increment of 4 ºC/min. The injection volume of the sample was 1µL with a split ratio of 100:1, using helium as the carrier gas at a flow rate of 0.5 ml per minute. Both injector and detector temperature were maintained at 290 °C. The percentage composition was calculated using peak normalization method assuming equal detector response. The samples were then analyzed by a quadrupole mass spectrometer model HP5972 A with an electron impact ionization at 70 eV. The compounds separated were characterized from their mass spectral data using the National Institute of Standards and Technology mass spectrometry library (ADAMS, 2007) and according with their Kovact retention indexes.

House-fly colony

Specimens were collected on the campus of Fundação Oswaldo Cruz, Rio de Janeiro, and were reared and maintained in the Laboratório de Transmissores de Leishmanioses - Setor de Entomologia Médica e Forense of the same Institution following the methodology used in previous works according to Queiroz & Milward-de-Azevedo (1991). Flies were kept in cages at room temperature with water and sugar *ad libitum*. Decaying bovine ground beef was given for the maturation of the ovarioles and to stimulate oviposition. The second generation was reared following the same methodology and newly hatched larvae were used in the experiments.

Bioassay

Serial dilutions were performed from essential oils of *C. citratus* from Brazil and Cuba dissolved in dimethylsulfoxide (DMSO) (SIGMA - USA) to obtain six different test concentrations: 5% (25 µL/oil + 475 µL/DMSO); 10% (50 µL/oil + 450 µL/DMSO); 25% (125 µL/oil+ 375 µL/DMSO); 50% (250 µL/oil + 250 µL/DMSO); 75% (375 µL/oil + 125 µL/DMSO) and 100% (pure oil). Citral (purchased from Tedia® - Brasil) was prepared by mixing 16.8 mg with 960 µL DMSO.

Both essential oils (Brazil´s and Cuba´s) and citral were applied topically (1µL/larva) to newly hatched larva bodies of *M. domestica* using micropipettes. In all experimental groups each concentration was performed in quadruplicate using fifty newly-hatched larvae for each replicate. In addition, two control groups were performed (with/without DMSO). After treatment, the newly-hatched larvae were transferred and placed onto recipients with 50g of putrefied bovine meat (1g/larva), to guarantee enough food for maximum development. These recipients were placed into larger ones (500 mL) containing a substrate for pupation and then covered with a nylon cloth held down with rubber bands. Mature larvae (L3), that spontaneously abandoned the diet, were individually weighed in analytical balance and transferred to glass tubes containing vermiculite to one-fourth of their volume and sealed with cotton. The experiments were maintained in acclimatized chambers set at 27±1°C, 70±10% RH, 12:12 light/dark cycle. Daily observations were made until the emergence of the adults, with subsequent sex ratio calculation (nFemale/nFemale+nMale) (RODRIGUES, 2004) and morphologic deformities analysis. Viability and duration of each period (larval, pupal and newly-hatched larvae to adult) were analyzed. Another variable considered was the weight of mature larvae. Results were analyzed by One-way Analysis of Variance (ANOVA) (P <0,0001), and mean values were compared by the Tukey–Kramer test at significance level of 0.05 (ZAR, 1999). Values of LC_{50} and LC_{90} were computed with Microsoft Office Excel Program.

Results and Discussion

Chemical characterization of essential oil

Compounds identified in *C. citratus* essential oils from Brazil and Cuba are presented in Table 1**.** GC/MS analysis allowed the identification of 13 and 12 main chemical components for Brazilian and Cuban oils, respectively. In both of them, the major components were the isomers geranial with 53.2 and 51.14% and neral with 36.37 and 35.21% for Brazilian and Cuban samples, respectively. Besides that, other 8 compounds appear in common. The monoterpene myrcene (6.52%), observed in Cuban sample, was the only differentiating compound that it is present in high relative abundance.

Chemical studies of *C. citratus* in different habitats around the world identified citral as the major volatile constituent (SOLÓRZANO-SANTOS & MIRANDA-NOVALES, 2012).

Table 1. Chemical composition (%) of essential oils from fresh leaves of *Cymbopogon citratus* (DC) Stapf natives from Brazil and Cuba.

Constituents	Percentage composition		Kovat´s R.I.	ID
	Brazil	Cuba		
6-methylhept-5-en-2-one	0.19	0.23	936	MS, RI
Camphene	0.29	-	953	MS, RI
Myrcene	-	6.52	988	MS, RI
Limonene	0.99	-	1030	MS, RI
Linalool	0.42	0.69	1079	MS, RI
Citronellal	-	0.16	1132	MS, RI
n – decanal	0.19	-	1214	MS, RI
Z – citral (Neral)	36.37	35.21	1231	MS, RI
Geraniol	2.66	2.23	1247	MS, RI
E – citral (geranial)	53.2	51.14	1258	MS, RI
2 – undecanone	0.22	0.35	1287	MS, RI
geranyl acetate	1.5	0.20	1359	MS, RI
(E) – caryophyllene	1.03	-	1414	MS, RI
2- tridecanone	-	0.10	1486	MS, RI
γ – cadinene	0.27	0.27	1513	MS, RI
caryophyllene oxide	0.59	0.59	1583	MS, RI
Total identified	97.92	97.69		

ID = Identification methods; MS = comparison of the mass spectrum with those of the computer mass libraries, and Adams (2007); Kovat`s RI. = Kovat´s Retention Index with those reported in the literature.

Twelve Brazilian samples submitted to GC/MS indicated the presence of 22 substances, being neral and geranial the major components with variations from 40.7 to 75.4% (BARBOSA et al., 2006). Pino & Rosado (2000) identified and quantified neral (38.2%) and geranial (49.5%) as the major components of *C. citratus* oil collected in Havana (Cuba) but low amount of myrcene (1.7%) when compared with our studies. Moreover, compounds such as 6-methyl-5-hepten-2-one, linalool and 2-undecanone were found in the essential oils of the lemongrass collected in Brazil and Cuba (COSTA et al. 2005, 2013). Quantity and chemical composition range of essential oil plants of the same species in different regions may be caused by microclimatic factors, phytogeographic, genotype plants and geographical and agronomical conditions, especially soil. Nevertheless, as general rule the major components remain being the same ones, only varying their concentration levels (KUMAR et al., 2011a).

Bioassays

Post-embryonic development of *M. dometica* appeared to be drastically influenced by treatment with essential oils from Brazil and Cuba, with no difference between them. Larval period at concentrations of 5, 10, 25 and 100% showed a delay in development while 50 and 75% shortened the period duration. For larval, pupal and newly-hatched larvae to adult periods all the concentrations delayed the period time. (Table 2). The insecticidal activity of *Mentha piperita* Linnaeus and *Lavandula angustifolia* Mill essential oils were evaluated against house fly and induced a significant prolongation in larval and pupal periods (BOSLY, 2013). In contrast, the duration of the larval, pupal and newly-hatched larvae to adult periods of *M. domestica* with citral treatment were faster in the presence of this substance (3.18; 4.91; 7.91 days respectively), showing a significant difference (P <0,0001) when compared to the control groups (larval period: 5.29 and 6.50 days, pupal period: 5.27 and 5.37days, newly-hatched larvae to adults: 10.54 and 11.85days, with/without DMSO, respectively) (Table 2). This contradiction turns into a challenge to be clarified.

Biological properties of essential oils can be the result of a synergy of all the major molecules or just the molecules present at higher concentrations. Generally, the main components reflect their biophysical and biological characteristics and the extent of its effects depends on the concentrations when tested alone or included in essential oils (BAKKALI et al., 2008). However, literature suggests that the minor compounds may contribute to an antagonistic effect on the activity of the essential oil (BOTELHO et al., 2007). According to Nascimento et al. (2007) it is also possible that the emulsifying agent affects the activity of metabolites, acting antagonistically or synergistically to active compounds. DMSO has low toxicity and facilitates the penetration of toxic substances to the body, causing serious risks to health. (STURION et al. 1999). According to Brayton (1986) and Richardson (1973), among the properties and physiological/pharmacological effects of DMSO include a rapid and strong penetration of the other substances through biological membranes, it easily penetrates the skin, in five minutes can be detected in the blood and after 20 minutes can be found in all organs of the body. Based on that the choice of DMSO as solvent decreases the chances of the effects observed in post-embryonic development of *M. domestica* are derived from external factors.

The insecticidal activity *of C. citratus* is assigned conventionally to citral, its major component. This isomeric mix has been used as a steaming agent against *Culex pipiens quinquefasciatus* Say, 1823 (Diptera: Culicidae) (YANG et al., 2005), due to, the antifeeding activity of neral and geranial (LEAL & UCHIDA, 1998).

Structural characteristics of terpenoids can influence their insecticidal properties (PAVELA, 2008), and based on the degree of saturation and the functional group type can dispose the penetration of the insect cuticle, helping in their degradation (RICE & COATS, 1994). Although the mechanism of action of

Table 2. Duration (days) of post-embrionic development of *Musca domestica* (Diptera:Muscidae), treated with different concentrations of essential oil of *Cymbopogon citratus* from Brazil and Cuba and monoterpene citral, under laboratory conditions.

Treatments	Duration (days)					
	Larval stage (Mean ± SD)*		Pupal stage (Mean ± SD)*		Newly-hatched larvae to adult (Mean ± SD)*	
	Brazil	Cuba	Brazil	Cuba	Brazil	Cuba
Control	6.68±0.47^{a}	6.68±0.47^{a}	5.23±0.42^{a}	5.23±0.42^{a}	11.91±0.29^{a}	11.91±0.29^{a}
DMSO	5.31±0.58^{b}	5.31±0.58^{b}	5.31±0.58^{b}	5.31±0.58^{b}	10.63±1.16^{b}	10.63±1.16^{b}
5%	7.17±0.37^{c}.37.37^{c}	7.14±0.35^{c}	7.14±0.34^{b}	7.12±0.32^{b}	14.51±0.50^{c}	14.42±0.49^{c}
10%	7.20±0.40^{c}	7.15±0.36^{c}	7.11±0.31^{b}	7.10±0.30^{b}	14.49±0.50^{c}	14.39±0.49^{c}
25%	7.18±0.39^{c}	7.17±0.38^{c}	7.15±0.36^{b}	7.13±0.34^{b}	14.44±0.50^{c}	14.43±0.49^{c}
50%	5.18±0.39^{b}	5.19±0.39^{b}	7.14±0.34^{b}	7.10±0.31^{b}	12.55±0.50^{d}	12.46±0.50^{d}
75%	5.20±0.40^{b}	5.23±0.42^{b}	7.17±0.37^{b}	7.23±0.42^{b}	12.56±0.50^{d}	12.50±0.50^{d}
100%	12.15±0.36^{d}d^{d}	12.18±0.39^{d}	7.20±0.40^{b}	7.17±0.38^{b}	19.52±0.51^{e}	19.50±0.50^{e}
Control	6.50 ± 0.51^{a}		5.37 ± 0.49^{a}		11.85 ± 0.36^{a}	
DMSO	5.29 ± 0.47^{b}		5.27 ± 0.45^{ab}		10.54 ± 0.90^{b}	
Citral	3.18 ± 0.40^{c}		4.91 ± 0.30^{b}		7.91 ± 0.30^{c}	

*Values within a column followed by the same letter are not significantly differen at the 5% level according to Tukey's HSD. Oil test with four replication, N=50 and Citral test with three replication, N=10. DMSO= dimetilsulfoxide.

essential oils and its constituents is unknown, the appearance of toxic signs is fast (KNAAK & FIUZA, 2010).

Any of these observations could explain the differences in development time and mortality of *M. domestica* treated with pure citral and citral found in the essential oil diluted in DMSO.

Sex ratio did not differ significantly in any of the treated groups when compared to control groups (Table 3). Larval weight from Brazil and Cuba showed significant difference ($p < 0.0001$) when compared to control groups.

Lightest larvae (17.53mg oil/Brazil and 17.49mg oil/Cuba) belong to concentration of 10% while the heaviest larvae (27.01mg oil/Brasil and 26.97mg oil/Cuba) belong to the concentration of 50%, when compared to control groups with DMSO (21.59mg) and without DMSO (21.50mg). Monoterpene citral significantly increased larval weight (25.65mg) when compared to control groups with DMSO (22.22mg) and without DMSO (21.18mg) (Table 3).

Necrophagous Diptera are more suitable to pupate even when the final weight is below the average estimated for other species (MENDONÇA et al., 2011). According to Lomonaco & Germanos (2001), the increasing in the development period may be due to delays in obtaining the necessary weight for pupating (ROPER et al., 1996), due to the difficulties in obtaining food. These data are similar to some of the results obtained in this experiment.

Mortality of *M. domestica* in larval, pupal and newly-hatched larvae to adult periods was affected in a dose-dependent manner for both oils. Mortality of newly-hatched larvae showed highly significant values for Brazil and Cuba, respectively: 5% (62.5 / 61.5); 10% (62.0 / 63.0); 25% (64.0 / 65.0); 50% (75.0 / 73.0); 75% (77.5 / 78.0) and 100% (87.5 / 87.0) (Figure 1, 2).

Monoterpene citral presented a slightly higher mortality at all development stages when compared to essential oil of *C. citratus*

Table 3. Larval weight (mg) and sex ratio of *Musca domestica* (Diptera:Muscidae) treated with essential oil of *Cymbopogon citratus* from Brazil and Cuba and monoterpene citral, under laboratory conditions.

Treatments	Weight (mg) (Mean ± SD)*		IV		Sex ratio	
	Brazil	Cuba	Brazil	Cuba	Brazil	Cuba
Control	21.50±1.76[a]	21.50±1.76[a]	19.00 – 24.40	19.00 – 24.40	0.50	0.50
DMSO	21.59±1.39[a]	21.59±1.39[a]	15.00 – 24.20	15.00 – 24.20	0.51	0.51
5%	19.60±1.41[b]	19.50±1.32[b]	17.20 – 21.50	17.50 – 21.00	0.50	0.50
10%	17.53±1.23[c]	17.49±1.27[c]	15.80 – 20.60	15.60 – 20.60	0.51	0.51
25%	20.37±0.95[d]	20.36±0.93[d]	19.40 – 21.80	19.40 – 21.80	0.51	0.49
50%	27.01±2.18[e]	26.97±2.38[e]	21.90 – 33.00	24.80 – 33.00	0.54	0.53
75%	21.50±2.65[f]	21.35±2.69[f]	17.40 – 25.30	17.20 – 25.20	0.53	0.53
100%	22.05±1.65[f]	22.39±2.19[f]	19.50 – 25.60	19.00 – 25.60	0.53	0.52
Control	21.18± 1.55[a]		19.00 – 24.00		0.54	
DMSO	22.22 ± 1.30[a]		20.80 ± 24.20		0.56	
Citral	25.65 ± 5.42[b]		16.50 – 31.70		0.49	

*Values within a column followed by the same letter are not significantly differen at the 5% level according to Tukey's HSD. DMSO= dimetilsulfoxide. Oil test with four replication, N=50 and citral test with three replication, N=10.

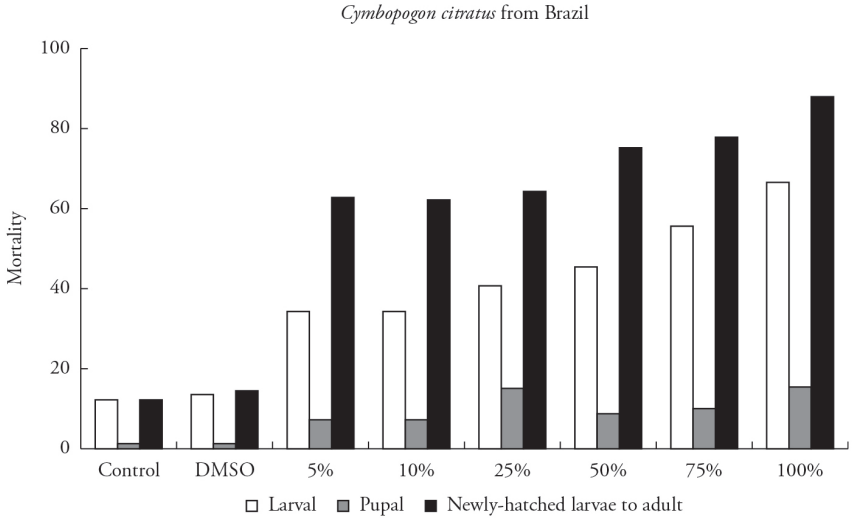

Figure 1. Mortality of larval, pupal and newly-hatched larvae to adult periods of *Musca domestica* after exposure to different concentrations of *Cymbopogon citratus* oil from Brazil, under laboratory conditions.

(Figures 1, 2 and 3). This can be explained by the fact that insecticidal activity of this essential oil has been attributed to its major monoterpene citral (YANG et al., 2005).

Kumar et al. (2011b) testing several essential oils against *M. domestica*, also noted a high rate of mortality after 48h exposure. For *C. citratus* the authors found a mortality rate of 77%. An contact toxicity bioassay of *C. citratus* against *M. domestica* larvae and pupae showed lethal concentration (LC_{50}) value of 0.41 µl/cm^2 and a percentage inhibition rate (PIR) of 7% and 7.3%, respectively (KUMAR et al., 2013). Abdel Halim & Morsy (2006) also observed high mortalities in Muscidae after using essential oils of *Cupressus macrocarpa* Hartw. (Cupressaceae) and *Alpinia officinarum* Hance (Zingiberaceae) against *Synthesiomyia nudiseta* (Wulp, 1883) (Muscidae: Azeliinae).

C. citratus essential oil showed a LC_{50} of 4.25 and 3.24% and a LC_{90} of 84.25 and 83.24% for Brazil and Cuba, respectively. Different concentrations of citral presented a significant larval mortality, with LC_{90} of 0.19 and 0.09 µl/cm^3 after 24 and 48h, respectively, and the other monoterpene 1,8-Cineole LC_{90} of 0.36 and 0.15 µl/cm^3 for the same interval time (KUMAR et al., 2013). Khater et al. (2011) working with Egiptian essential oils showed a high effectiveness against *Lucilia sericata* (Meigen, 1826) (Diptera: Calliphoridae) with LC_{50} values of 0.57, 0.85, 2.74 and 6.77% for lettuce, chamomile, anise and rosemary, respectively, slowing larval growth at sublethal concentrations. Dipping assay using lemongrass demonstrated LC_{50} of 69ppm against *Aedes aegypti* (Linneaus, 1972) (Diptera:Culicidae) and *C. quinquefasciatus* larvae a LC_{50} of 144ppm. The essential oil of *C. citratus* showed to have a great larvicidal activity against *A. aegypti* and caused 100%

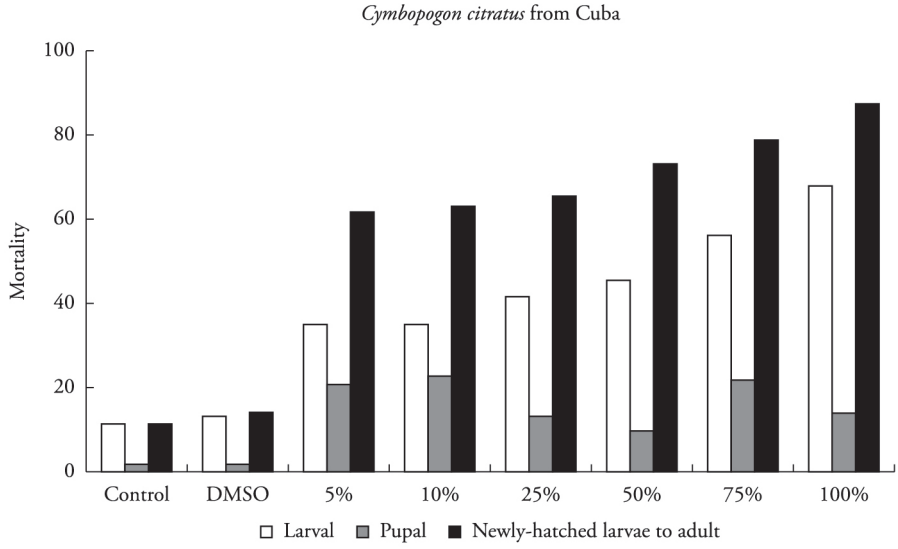

Figure 2. Mortality of larval, pupal and newly-hatched larvae to adult periods of *Musca domestica* after exposure to different concentrations of *Cymbopogon citratus* oil from Cuba, under laboratory conditions.

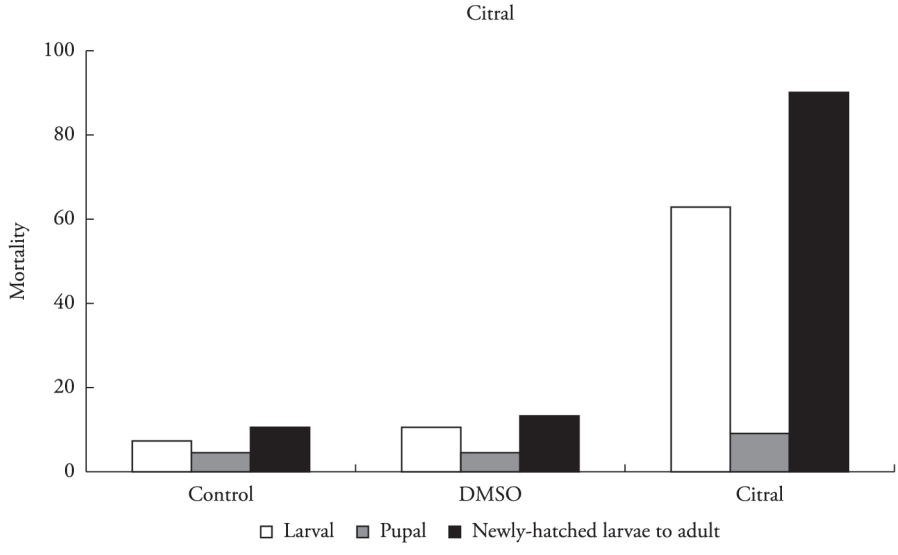

Figure 3. Mortality of larval, pupal and newly-hatched larvae to adult periods of *Musca domestica* after exposure to Citral, under laboratory conditions.

Table 4. Percentage (%) of morphological deformities from adults of *Musca domestica* treated with essential oil of *Cymbopogon citratus* from Brazil and Cuba and monoterpene citral, under laboratory conditions.

	Morphological deformities (%)	
Treatments	**Brazil**	**Cuba**
Control	0.00	0.00
DMSO	0.00	0.00
5%	38.67	37.66
10%	55.26	56.76
25%	76.39	78.57
50%	81.13	80.65
75%	86.67	88.64
100%	100.00	100.00
Control	0.00	
DMSO	0.00	
Citral	100.00	

DMSO= dimetilsulfoxide. Oil test with four replication, N=50 and citral test with three replication, N=10.

mortality at a concentration of 100 ppm (CAVALCANTI et al., 2004).

The abnormality rate in adults from *M. domestica* showed a dose-dependency, with 100% of deformity at concentrations of 100%, both for Brazil and Cuba`s essential oils and for the citral (Table 4). Elkattan et al. (2011), using different substances observed a reduction in adult emergence rate, favoring the development of male. Longevity of both sexes was affected when compared to the control. All lethal doses of *Pelargonium zonale* (Linnaeus) L'Her (Geraniaceae), *Cyperus rotundus* Linnaeus (Cyperaceae), *Acacia nilotica* Linnaeus (Fabacea), *Cupressus macrocarpa* Hartw. (Cupressaceae) and lethal doses LC_{50} and LC_{75} of *Lantana camara* Linnaeus (Verbenaceae) caused a significant reduction in the fecundity of adult females, in addition to morphological changes at all development stages. Pure extract of *Francoeuria crispa* (Forssk., Cas.) (Asteraceae) extracted with hexane, ethyl ether and ethyl acetate caused deformities in adults of *Chrysomyia albiceps* (Wiedemann, 1819) (Diptera: Calliphoridae) Abdel-Shafy et al. (2009). Khater et al. (2011) also noted that essencial oil of *Lactuca sativa* Linnaeus (Asteraceae) led to a higher percentage of deformities in *L. sericata* at all development stages. These deformations are due to the fact that some substances extracted from plants can cause changes in the endocrine system by directly attacking the hormones production (CABRAL et al., 1999).

In conclusion, results from Brazilian and Cuban essential oils and its monoterpenoid citral showed significant alterations on post-embryonic development of *M. domestica*, demonstrating its potential insecticidal activity. The oils and citral can be used in further formulations for breeding control and to avoid reinfestations.

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