Journal of Agricultural Chemistry and Environment, 2024, 13, 133-141
https://www.scirp.org/journal/jacen
ISSN Online: 2325-744X
ISSN Print: 2325-7458

The Essential Oil of *Ocimum americanum* from Senegal and Gambia as a Source of Methyleugenol for the Control of *Bactrocera dorsalis*, Fruit Fly

Yoro Tine[1*], Antonio Alain Coffi Sinzogan[2], Ousmane Ndiaye[3], Cebastiana Sambou[4], Alioune Diallo[1,5], Ismaila Mbenga[6], Kemo Badji[4], El Hadji Omar Dieng[4], Assa Balayara[4], Jeanne Diatta[7], Cheikhouna Gaye[1], Julien Paolini[5], Jean Costa[5], Alassane Wele[1], Saliou Ngom[4]

[1]Laboratoire de Chimie Organique et Thérapeutique, Faculté de Médecine, Pharmacie et Odontologie, Université Cheikh Anta Diop, Dakar, Sénégal
[2]Faculte des Sciences Agronomiques, Universite d'Abomey Calavi, Cotonou, Benin
[3]Ecole Nationale Supérieure d'Agriculture (ENSA), Université Iba Der Thiam de Thiès, Thiès, Sénégal
[4]Direction de la Protection des Végétaux, Rufisque, Sénégal
[5]Laboratoire de Chimie des Produits Naturels, Université de Corse, Corte, France
[6]National Agricultural Research Institute (NARI), Sere Kunda, Gambia
[7]Institut Sénégalais de Recherches Agricoles (ISRA), Dakar, Sénégal
Email: *yoro.tine@ucad.edu.sn

How to cite this paper: Tine, Y., Sinzogan, A.A.C., Ndiaye, O., Sambou, C., Diallo, A., Mbenga, I., Badji, K., Dieng, E.H.O., Balayara, A., Diatta, J., Gaye, C., Paolini, J., Costa, J., Wele, A. and Ngom, S. (2024) The Essential Oil of *Ocimum americanum* from Senegal and Gambia as a Source of Methyleugenol for the Control of *Bactrocera dorsalis*, Fruit Fly. *Journal of Agricultural Chemistry and Environment*, **13**, 133-141.
https://doi.org/10.4236/jacen.2024.131009

Received: December 19, 2023
Accepted: February 6, 2024
Published: February 9, 2024

Abstract

The fruit fly, *Bactrocera dorsalis* (Diptera: Tephritidae) is one of the most important pests in all mango-producing areas, particularly in West Africa. In Senegal, *O. americanum* leaves have been used for several years to control this fly. However, to our knowledge, no chemical studies have been carried out. Thus, the aim of this study is to determine the chemical composition of the essential oil of *O. americanum* leaves collected in Senegal and Gambia. The essential oil obtained by hydrodistillation of these leaves is analyzed by GC/FID and GC/MS. Yields of essential oils from *O. americanum* leaves are 3.84% and 2.13%, respectively. Analysis of these essential oils by GC/FID and GC/MS allowed the identification of 23 compounds representing almost 100% of the total compositions. These essential oils are mainly dominated by methyleugenol (72.0% and 75.8%, respectively). Other components in significant percent are trans-β-caryophyllene (13.9% and 13.0%, respectively), germacrene D (4.1% and 3.7%, respectively), β-elemene (3.3% and 0.9%, respectively). Due to the high methyleugenol content, this study explains the attractive potential of *O. americanum* towards *B. dorsalis*. In perspective, we plan to evaluate the attractive effect of the essential oil and leaf powder of *O. americanum* against *B. dorsalis*, a real pest of mango orchards in Senegal.

Keywords

Ocimum americanum, Essential Oils, Methyleugenol, *Bactrocera dorsalis*, GC/MS

1. Introduction

Fruit flies *Bactrocera dorsalis* (Diptera: Tephritidae) are major pests of various horticultural products. They present in many countries and particularly in tropical and subtropical regions [1] [2] [3] [4] [5]. This fruit fly is a major pest of mango in Senegal. Agricultural production losses due to this fly are the basis of a reduction in exports, of an increase in and of quarantine services [4] [6] [7]. In Senegal, fruit fly attacks cause yield losses of around 30% to 60% depending on the area [6].

Several strategies are used to combat fruit flies, such as collecting infested fruits (sanitation) [8] [9] [10], spraying insecticide or protein baits [11] [12], trapping with attractants [13] [14], the release of natural enemies [15] [16] and the sterile insect technique [17]. However, pesticides endanger the health and well-being of farmers and consumers. They also cause serious damage to the environment [2] [3]. It is therefore essential to find alternative and environmentally friendly management techniques to combat these fruit flies. The current trend is moving towards the use of natural plant-based products for more sustainable control. Many studies have shown that essential oils can be used to control fruit flies. It has been reported that essential oils of *Syzygium aromaticum* [2], *Melaleuca bracteata* [3], *Ocimum* sp. rich in methyleugenol (64.2% - 73.5%) [3] [18] and *Myristica fragrans* containing 8.33% methyleugenol [19] have the ability to attract male fruit flies. However, in Indonesia, the repellent activity of *Pogostemon cablin* essential oil against *B. dorsalis* has been reported [20]. Thongdon *et al.* (2009) showed that *Limnophila geoffrayi* oil rich in d-Pulegone (27.1%) and perillaldehyde (19.1%) has significant insecticidal properties against *B. dorsalis* flies [21].

In Senegal and Gambia, the leaves of *Ocimum americanum*, also known as *Oimum canum*, have been used for several years to control *B. dorsalis*. However, to our knowledge, no chemical studies have been performed to support this practice. Thus, the aim of this study was to determine the chemical composition of oils from the leaves of *O. americanum* collected in these two neighboring countries.

2. Material and Methods

2.1. Plant Material

Leaf samples of *O. americanum* were collected from Senegal and Gambia. The plant material was identified by botanists from the Institut Fondamental d'Afrique Noire (IFAN) at Cheikh Anta Diop University in Dakar.

2.2. Extraction of Essential Oils

The plant samples were air dried for a period of two weeks at ambient temperature. The samples were hydrodistilled (5 h) using a Clevenger-type apparatus according to the method recommended in the European Pharmacopoeia [22]. Essential oil yields (w/w, calculated on the basis of dry weight) are given in **Table 1**.

Table 1. Chemical composition of the essential oils from *O. americanum* leaves.

No.[a]	Compounds	lRI[b]	RIa[c]	RIp[d]	Senegal	Gambia
1	*α*-Pinene	931	931	1015	0.5	0.3
2	Camphene	950	948	1059	0.6	0.3
3	Sabinene	973	964	1120	0.1	0.1
4	*β*-Pinene	978	972	1108	0.4	0.2
5	Limonene	1025	1022	1200	0.2	0.1
6	Linalol	1086	1081	1544	0.3	-
7	Borneol	1150	1148	1698	0.7	1.1
8	Chavibetol	1346	1352		1.2	1.1
9	*α*-Cubebene	1346	1350	1452	0.1	tr
10	Methyleugenol	1369	1367	2009	**72.0**	**75.8**
11	*β*-Elemene	1389	1386	1589	**3.3**	0.9
12	*β*-Cubebene	1390	1390	1500	0.5	0.5
13	Trans-*β*-Caryophyllene	1421	1417	1583	**13.9**	**13.0**
14	*δ*-Elemene	1429	1429	1638	0.1	tr
15	*β*-Barbatene	1445	1440	1663	0.2	-
16	*α*-Humulene	1455	1450	1660	0.8	0.7
17	Germacrene D	1479	1476	1704	**4.1**	**3.7**
18	*β*-Selinene	1486	1483	1712	0.1	-
19	δ-Cadinene	1520	1514	1746	0.3	0.2
20	(Z)-*γ*-Bisabolene	1505	1509	1744	0.2	-
21	*β*-Elemol	1541	1535	2072	0.1	1.6
22	Caryophyllene oxide	1570	1573	1959	0.3	0.4
23	*γ*-Eudesmol	1618	1619	2197	-	tr
	Hydrocarbon monoterpenes				1.8	1.0
	Oxygenated monoterpenes				1.0	1.1
	Hydrocarbon sesquiterpenes				23.6	19
	Oxygenated sesquiterpenes				0.4	2.0
	Phenylpropanoids				73.2	76.9
	Total identified (%)				100	100
	Yields (w/w vs dry material)				3.84	2.13

[a]Order of elution is given on apolar column (Rtx-1). [b]Retention indices of literature on the apolar column (lRIa). [c]Retention indices on the apolar Rtx-1 column (RIa). [d]Retention indices on the polar Rtx-Wax column (RIp). tr = trace (<0.05%).

2.3. Chemical Compositions

Chromatographic analzses were carried out using a Perkin-Elmer Autosystem XL GC apparatus (Walthon, MA, USA) equipped with dual flame ionization detection (FID) system and fused-silica capillary columns, namely, Rtx-1 (polydimethylsiloxane) and Rtx-wax (poly-ethyleneglycol) (60 m × 0.22 mm i.d; film thickness 0.25 μm). The oven temperature was programmed from 60˚C to 230˚C at 2˚C/min and then maintained isothermally at 230˚C for 35 min. Hydrogen was employed as carrier gas (1 mL/min). The injector and detector temperatures were maintained at 280˚C, and samples were injected (0.2 μL of pure oil) in the split mode (1:50). Retention indices (RI) of compounds were determined relative to the retention times of a series of n-alkanes (C5–C30) by linear interpolation using the equation of Van den Dool and Kratz (1963) using Perkin-Elmer software (Total Chrom navigator). The relative percentages of the oil constituents were calculated from the GC peak areas, without application of correction factors.

Samples were also analysed with a Perkin-Elmer Turbo mass detector (quadrupole) coupled to a Perkin-ElmerAutosystem XL, equipped with fused-silica capillary columns Rtx-1 and Rtx-Wax. The oven temperature was programmed from 60˚C to 230˚C at 2˚C/min and then held isothermally at 230˚C (35 min): hydrogen was employed as carrier gas (1 mL/min). The following chromatographic conditions were employed: injection volume, 0.2 μL of pure oil; injector temperature, 280˚C; split, 1:80; ion source temperature, 150˚C; ionization energy, 70 eV; MS (EI) acquired over the mass range, 35 - 350 Da; scan rate, 1 s. The identification of the components was based on: 1) the comparison of their GC retention indices (RI) on non-polar and polar columns, determined from the retention times of a series of n-alkanes with linear interpolation, with those of authentic compounds or literature data; 2) the computer matching with commercial mass spectral libraries [23] [24] [25] and the comparison of spectra with those of our specific library; and 3) the comparison of RI and MS spectral data of authentic compounds or literature data. Plant samples were air dried for a period of two weeks at ambient temperature.

3. Results and Discussion

The essential oil yields from *O. americanum* leaves harvested in Senegal and Gambia were 3.84% and 2.13%, respectively. These yields are similar to those reported in Brazil (3.6%) [26] and Kenya (4.0%) [27]. On the other hand, they are very high compared to others described in the literature (8% - 9%), in Benin and Kumaun Himalayas [28] [29] [30] [31]. The analysis of the leaf essential oils by GC/FID and GC/MS allowed the identification of 23 compounds representing almost 100% of the total compositions (**Table 1**). These essential oils were mainly dominated by methyleugenol (72.0% and 75.8%, respectively). The other components in significant percent were trans-*β*-caryophyllene (13.9% and 13.0%, respectively), germacrene D (4.1% and 3.7%, respectively), *β*-elemene (3.3% and

0.9%, respectively). These results show that the two samples collected in these two neighbouring countries have virtually the same chemical composition. This confirms that the same plant is used in both countries to combat fruit flies.

However, several research works aimed at expanding knowledge about the essential oil of *O. americanum*, reveal that the chemical composition of the oil varies according to the geographical origin. To our knowledge, we report for the first time such a high content of methyleugenol in the essential oil of *O. americanum*. In this plant species, the highest content of methyleugenol (14.8%) known so far in the literature was reported by, Singh *et al.* (2013) for samples harvested in the Himalayas [32]. In other studies, methyleugenol was present at lower concentrations (trace-7.5%). However, most chemotypes of this species are dominated by compounds derived from the phenylpropanoid: thymol/p-cymène/γ-terpinene [26]; eugenol/δ-cadinene [33]; eugenol/ (E)-caryophyllene/methyleugenol [32]; eugenol/methylchavicol [32] [34]; methylchavicol/linalool [32]; methylchavicol/eugenol [32] [35]; transmethylcinamate [36]. In some studies, terpenes were described as the main constituents: terpineol, linalol, neral, geranial, terpinen-4-ol, γ-terpinene, camphor, longipinol, 1,8-cineole, β-bisabolene, limnene, γ-salinene, carvotanacetol and carvacrol [27] [28] [29] [31] [35]-[47]. This chemical variability may be due to climatic conditions, soil conditions and genetic mutations.

4. Conclusion

This study reported the chemical composition of the essential oils of *O. americanum* from Senegal and Gambia. These essential oils are mainly dominated by methyleugenol. As for other plant species rich in methyleugenol, we plan to evaluate the attractive effect of the essential oil and the powder of the leaves of *O. americanum* against *B. dorsalis*, which is a real pest of mango orchards in Senegal.

Acknowledgements

We thank the SyRIMAO/ECOWAS Project for its financial and technical support.

Conflicts of Interest

The authors declare that there is no conflict of interest related to this article.

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