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Effect of the speed of the drying air on the quality of essential oil from *Aristolochia cymbifera* Mart. and Zucc.

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Dehydrating plant material ensures the conservation of active compounds in medicinal plants. Thus, the object of the present study was to evaluate the effect of three drying air speeds on the content and the chemical composition of essential oil from *Aristolochia cymbifera* Mart. and Zucc. The tests were conducted in a fixed-layer dryer with drying chambers measuring 0.60 x 0.60 x 0.60 m on a plate with 25% perforation. The treatments consisted of three drying air speeds (0.5, 1.0, and 2.0 m·s^{1}), with four replicates and a mean temperature of 34.7±15°C. The experimental design was in randomized blocks. The essential oil was extracted by hydrodistillation. It was concluded that the drying air did not influence the essential oil content; however, there was a slight influence on the minor constituents of the essential oil extracted.

Key words: Medicinal plants, chemical composition, content of essential oil, extraction.

INTRODUCTION

Brazil is a leader in the natural product market, which includes essential oils. According to Bizzo et al. (2009), there is growing interest in natural products, and there are appeals for environmental preservation policies, which can be used as marketing tools and provide a great opportunity for the development of sustainable processes of biodiversity exploitation.

The Cerrado is one of the biomes that contains genetic resources of great medical diversity; a bibliographic survey performed only for the State of Mato Grosso found a total of 509 species described as medicinal, surpassing the estimates made by other works, and projected more than 600 species around the biome (Neto and Morais, 2003).

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This species is an herbaceous perennial vine native to Brazil that is characteristically vigorous and better adapted to hot environments (Lorenzi and Matos, 2002). According to these authors, *A. cymbifera* Mart. and Zucc. contains mono/diterpenes and sesquiterpenoids in the leaves, stems and roots.

In folk medicine, *A. cymbifera* Mart. And Zucc. is used for various problems and is considered to be a diuretic, antiseptic and antispasmodic (Lorenzi and Matos, 2002). The work of Urzúa and Sotes (2008) compared several species of the *Aristolochia* genus in terms of the presence or absence of compounds in the essential oil, such as linalool monoterpenoid, sesquiterpene compounds derived from farnesane, bisabolane, elemane, germacrane, bicyclogermacrane, humulane, aristolane, caryophyllanes, eudesmane, cadinane, guainane, aromadendrane, cubebane, himachalane, santalane, copaane and bourbonane. All of these compounds are found, in varying amounts, in the species of the genus *Aristolochia*. *A. cymbifera* is thought to contain few components, but one reason for this finding may be the lack of studies on this species. The components found include germacrene A, α-farnesene and α-trans-bergamotene (Urzúa and Sotes, 2008).

The collection method is an important factor in the quality of medicinal plant essential oils because features such as plant organ, stage of development, time of year, and time of day can influence the production of substances with therapeutic activity (Blank et al., 2007; Gobbo-neto and Lopes, 2007).

In addition to the above aspects, the quality of the essential oils will depend on their processing. Soares et al. (2007), have been able to obtain extractive yields of *Ocimum basilicum* L. essential oils when the drying process was accomplished with an air temperature of 40°C. However, the highest linalool yield was obtained when the drying process was accomplished with an air temperature between 50 and 60°C. However, the drying of the material will not always be suitable for the samples. According to Rocha et al. (2011a), there was a downward trend in the level of essential oil obtained from *Mikania glometa* Sprengel with increasing temperature compared with the fresh plant.

The dehydration of plant material ensures that the compounds do not deteriorate because enzyme activity is inhibited or reduced, allowing the preservation of active compounds. Additionally, dehydrated plant materials are easily stored for a long time (Chudnicka and Matysik, 2005). There are many studies on the effects of drying on the quality of bioactive compounds. These studies are necessary because each species behaves differently (Soares et al., 2007; Rocha et al., 2011b).

Therefore, the objective of the present study was to assess the effect of three drying air speeds on the content and the chemical composition of essential oil from *A. cymbifera* Mart. and Zucc.. The species *Aristolochia cymbifera* Mart. and Zucc., popularly known as “jarrinha”, “milhomem”, or “cassau”, is a species of the genus *Aristolochia* (Aristolochiaceae).

MATERIALS AND METHODS

Harvest and selection of plant material

Plants of *A. cymbifera* Mart. and Zucc. were collected in the Rio Verde region, at coordinates S 17°55’56.8” WO 50°56’33.2”, between 7:00 and 8:00 in the morning, in October, 2011. The exsiccated material is registered with the Herbarium Jataiense under number 5,642. The plants were harvested by cutting the shoots 5 cm above the ground, packing them in a row inside plastic bags, and sending them to the Natural Products section of the Plant Tissue Culture Laboratory in the Federal Institute of Education, Science, and Technology of Goiania, Campo Verde campus. After harvesting, the plants were subjected to defoliation and selection, and plants that were diseased or had been attacked by insects were discarded.

Determination of moisture content

The moisture content was determined before and after drying, as described by Asae (2000) for forage species and similar plants (plants or leaves). To determine the moisture content, the leaves were placed in a convection oven at 103± 2°C for 24 h, with four replicates (Asae, 2000)

Drying

The initial moisture content of the leaves was approximately 75.5 (% wet basis, w.b.). During the drying process, the samples were weighed periodically until they reached water levels of 11.1 (% w.b.). The drying was conducted in a fixed-layer dryer manufactured from #16 metal sheets. The drying chamber measured 0.60 x 0.60 x 0.60 m, for a total volume of 0.216 m^3, and contained a plate with 25% perforation placed at a height of 0.33 m. The fan was of the centrifugal type, driven by a three-phase motor with a power of 1.5 HP and rotation at 1,720 rpm, consisting of a rotor, palettes, a volute and support. The connection between the drying chamber and the fan was held by an expanding element that shifted from the 0.20 x 0.20 m cross-section at the fan output to 0.57 m x 0.03 m at the entrance of the drying chamber over a distance of 0.64 m (Figure 1). Each dryer was composed of six swinging temperature sensors and four electrical resistors of 1,500 ohms, for a total of 6,000 ohms. The sensors were positioned before and after the resistance and inside each tray. Four removable trays with perforated bottoms that measured 0.28 x 0.28 x 0.15 m were placed in the drying chamber (Figure 2). The system also featured an automatic controller that managed the system and stored the data generated. *A. cymbifera* Mart. and Zucc. leaves were woven into a voile fabric and spread on the tray. The system was set to 34.7±1.5°C with controlled air speeds of 0.5, 1.0, and 2.0 $m \cdot s^{-1}$.

Obtaining essential oil

Essential oil was extracted using a clevenger appliance adapted into a 3 L flask. The sample was placed in the flask along with 2 L of distilled water. Approximately 60 g of dried leaves were used, which were ground in a Willye TE – 648 micro mill (TECNAL). The extraction time was 150 min, counted from the time of boiling. The essential oil was extracted from the aqueous phase using

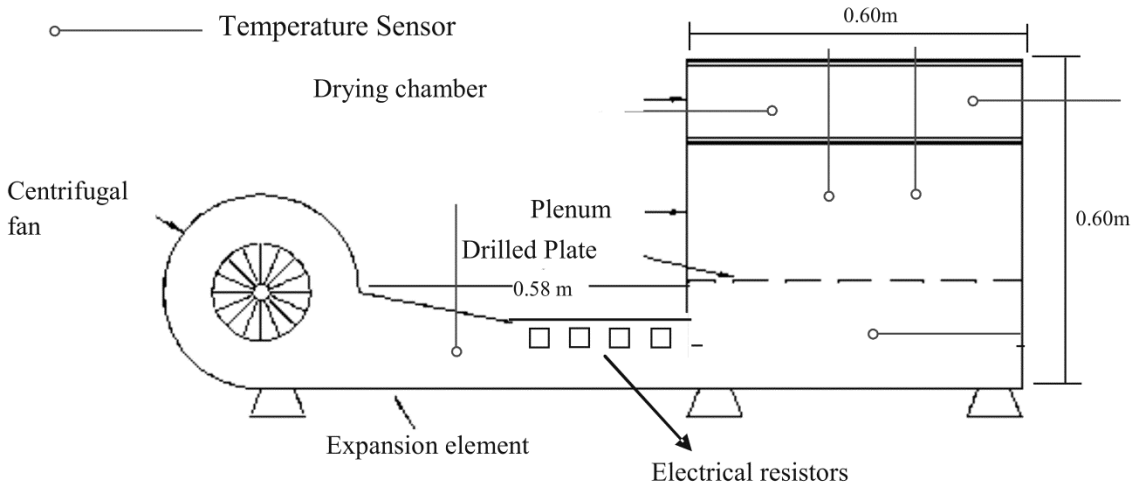

Figure 1. Side view of the experimental dryer.

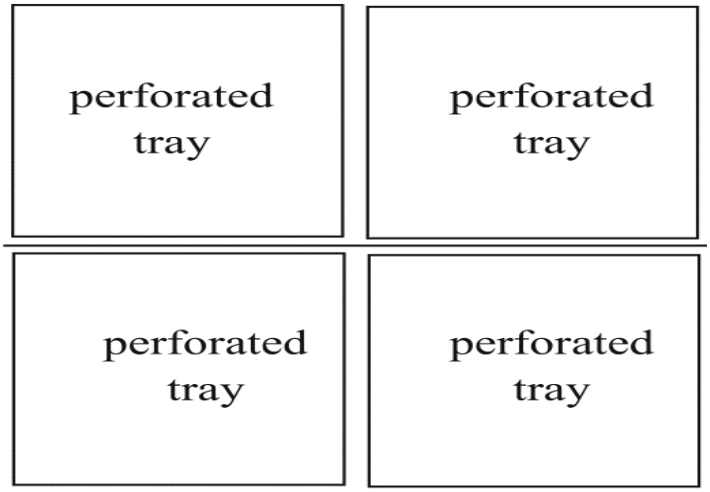

Figure 2. Top view of the experimental dryer – detail of the perforated trays.

dichloromethane (3 x 6 ml/20 min each). The obtained organic fractions were combined and mixed with anhydrous sodium sulfate, and the sulfate was withdrawn by filtration after 30 min. The mass of the obtained oil was determined by weighing on an analytical balance accurate to 0.0001 mg. The obtained oil samples were transferred to amber glass bottles capped with aluminum foil, and small holes were made in the lids to allow solvent evaporation. The bottles were stored in a refrigerator at 4 to 8°C until analysis.

Chemical analyses by gas chromatography/mass spectrometry

The chemical analyses were performed at the Department of Chemistry of the Federal University of Lavras, Lavras-MG, on a gas chromatography apparatus coupled to a Shimadzu QP5050A quadrupole mass spectrometer (GC-MS) (Kyoto, Japan) under the following operating conditions: fused silica capillary column, DB-5 model (30 m long X 0.25 mm internal diameter X 0.25 µm film thickness) (Shimadzu, Japan), with a flow of 1 ml·min^{-1} of helium as the carrier gas; heated to programmed temperatures (60°C with a gradient of 3°C·min^{-1} up to 240°C, then a gradient of 10°C·min^{-1} up to 270°C, keeping an isotherm of 7 min, with a total run time of 70 min). The ionization energy of the detector was 70 eV, and the sample injection volume of 1.0 ml was diluted in dichloromethane (ultra residue grade, Baker, EUA) and an injection ratio of 1:20. The detector and injector temperatures were maintained at 220 and 240°C, respectively. The analysis was conducted in scan mode at a speed of 2.0 scans·s^{-1}, with a mass range of 45 to 500 *m/z*.

Statistical analysis

The experimental design was in randomized blocks, with three drying air speeds. Each treatment had three replicates, for a total of

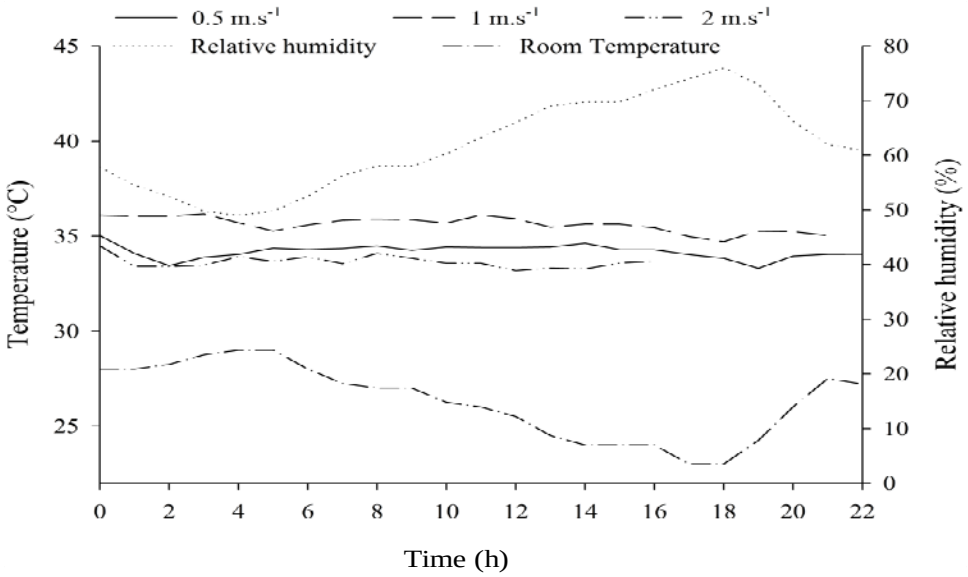

Figure 3. The temperatures inside the trays containing *Aristolochia cymbifera* Mart. and Zucc. leaves at the three air speeds, as well as the room temperature and the relative humidity.

12 experimental units. The experimental results were subjected to analysis of variance (Prob F<0.05), and the means were compared using Tukey's test at a 5% level of significance using the SISVAR analysis program (Ferreira, 2011).

RESULTS AND DISCUSSION

The *A. cymbifera* Mart. And Zucc. leaves were dried to a moisture content of 11.1±0.3 (% w.b.). Figure 3 shows the temperatures on the inner side of the trays containing the leaves for the three drying speeds, as well as the room temperature and the relative humidity.

The temperature inside the trays ranged from 36.2 to 33.2°C. The mean temperatures were 34.2, 35.6, and 33.6°C, respectively, for the 0.5, 1.0, and 20 $m \cdot s^{-1}$ air speeds. The mean room temperature and the relative humidity were 26.3°C and 61.8%, respectively. Barbosa et al. (2006), studied the influence of drying air temperature (room, 40, 50, 60, 70, and 80°C) on the content and chemical composition of *Lippia alba* (Mill) N. E. Brown essential oil, and found that there was no significant difference in the content of essential oil extracted from the product after drying at different temperatures.

Figure 4 shows the drying curves for different drying air speeds. It is evident that water was removed from A. *cymbifera* Mart. and Zucc. leaves faster at higher air speeds. Drying times of 22, 21, and 16 h were required to decrease the moisture content from 75.5 to 11.1 (% w.b.) for air speeds of 0.5, 1.0, and 2.0 $m \cdot s^{-1}$, respectively. Martins (2000), evaluated drying lemongrass at temperatures of 40, 50, and 60°C with speeds of 0.5 and 1.0 $m \cdot s^{-1}$ and found that the drying air speed decreased the drying time for all of the temperatures evaluated but did not influence the essential oil content or the major components.

Oliveira et al. (2013), evaluated the drying *A. cymbifera* Mart. and Zucc. in different temperatures with the same air velocity, they found that the increase in temperature reduces the drying time. Drying air speeds of 0.5, 1.0, and 2.0 $m \cdot s^{-1}$ did not influence *A. cymbifera* Mart. and Zucc. essential oil content (Figure 5). This result differed from that of Soares et al. (2007) who found that air speeds of 0.9 and 1.9 $m \cdot s^{-1}$ and temperatures of 40, 50, 60, and 70°C influenced *O. basilicum* essential oil content, indicating that the oil of this species undergoes volatilization.

The major contents of *A. cymbifera* Mart. And Zucc. essential oil, spathulenol, caryophyllene oxide, β-elemene, α-himachalene, bicyclogermacrane, and (E)-nerolidol were not affected by the drying conditions (Table 1). These results may indicate that the components are not influenced by the speed of the drying air, corroborating the results of Rocha et al. (2011b) who found that neral and geranial, the major constituents of oil from *Cymbopogon citratus* (D.C.) Stapf myrceno, did not suffer any volatilization during the drying process, compared with the fresh plant.

Oliveira et al. (2013), who found that the major contents of *A. cymbifera* Mart. and Zucc. essential oil were bicyclogermacrene, spathulenol, (E)-nerolidol, δ-cadinene, α-himachalene and viridiflorol, which represent approximately 67.93, 65.52 and 69.93% of the oil obtained from plants dried in the temperatures 44 8, 36.4

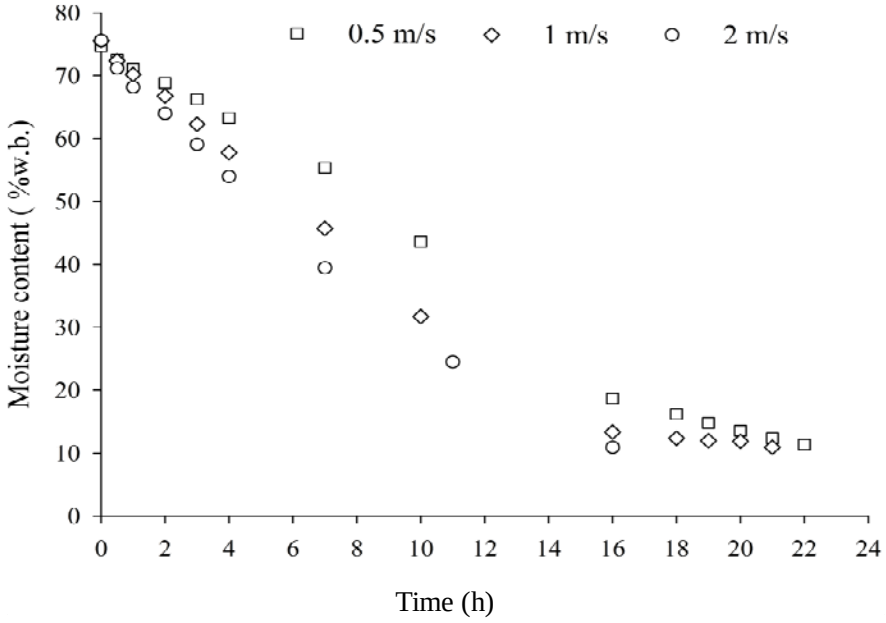

Figure 4. The drying curves for *Aristolochia cymbifera* Mart. and Zucc. at different drying air speeds.

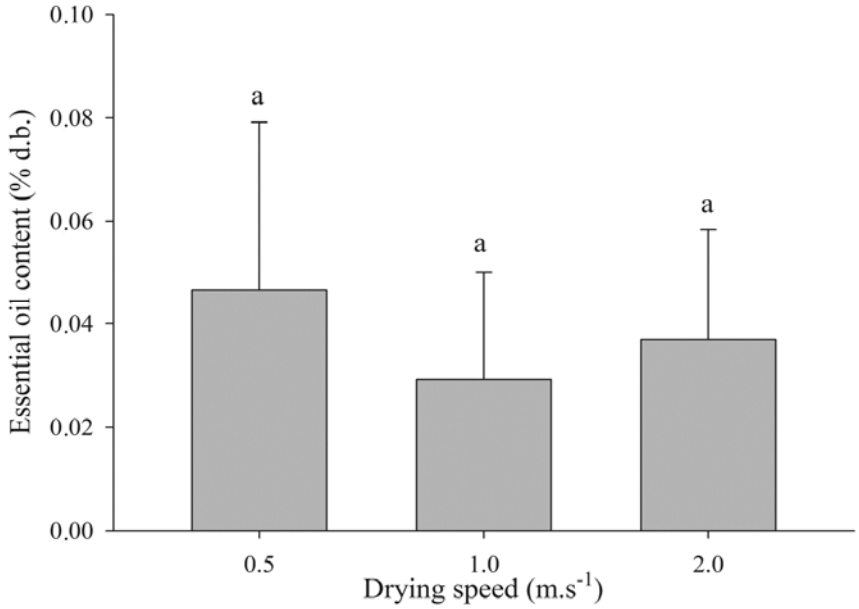

Figure 5. The content of essential oil extracted from leaves of *Aristolochia cymbifera* Mart. and Zucc. subjected to drying at different drying air speeds. Tukey's test at a 5% level of significance.

and 28.4°C, respectively. One of the reasons for volatilization not occurring may be the temperature of 34.7±1.5°C used in the present study, which may have minimized the loss. According to Soares et al. (2007), the levels of *O. basilicum* essential oil declined at higher drying temperatures, and the greatest concentrations were obtained at 40°C with air flows of 1.9 and 0.9 $m \cdot s^{-1}$.

The minor constituents germacrene B, hex-2-enal, viridiflorol and cedrol were influenced by the speed of the drying air. The contents of germacrene B and hex-2-enal

Table 1. The chemical composition of essential oil from the leaves of *Aristolochia cymbifera* Mart. and Zucc. subjected to three drying air speeds.

S/N	Oil compound	KI[2]	Drying treatment		
			0.5 m·s^{-1}	1.0 m·s^{-1}	2.0 m·s^{-1}
1	Hex-2-enal	839	0.26±0.20[1a]	0.00±0.00[b]	0.00±0.00[b]
2	<butyl> butanoic acid ester	984	0.01±0.01[a]	0.03±0.03[a]	0.02±0.04[a]
3	Limonene	1024	0.38±0.20[a]	0.30±0.23[a]	0.43±0.29[a]
4	Linalool	1097	0.03±0.04[a]	0.07±0.05[a]	0.06±0.05[a]
5	cis-Limonene oxide	1137	0.40±0.46[a]	0.50±0.37[a]	0.34±0.35[a]
6	α-Terpineol	1187	0.01±0.02[a]	0.03±0.03[a]	0.03±0.04[a]
7	Geraniol	1249	0.07±0.06[a]	0.06±0.04[a]	0.05±0.06[a]
8	Undec-10-enal	1301	0.16±0.23[a]	0.15±0.11[a]	0.08±0.06[a]
9	Cyclosativene	1368	2.43±0.96[a]	2.99±0.53[a]	2.,67±0.77[a]
10	α-Copaene	1368	1.41±0.86[a]	1.04±1.04[a]	1.20±0.71[a]
11	β-bourbonene	1387	2.70±0.73[a]	2.63±0.84[a]	2.76±1.61[a]
12	β-Elemene	1390	5.05±2.10[a]	3.61±1.71[a]	4.58±1.23[a]
13	Aromadendrene	1439	2.85±1.13[a]	3.28±2.22[a]	3.46±1.35[a]
14	α-Himachalene	1448	8.83±1.64[a]	7,04±0.78[a]	6.76±2.50[a]
15	α-Humulene	1452	1.05±0.44[a]	0.70±0.11[a]	0.84±0.27[a]
18	Alloaromadendrene	1458	1.38±0.75[a]	0.76±0.77[a]	1.48±0.13[a]
19	γ-Gurjunene	1473	0.73±0.34[a]	0.48±0.16[a]	0.99±0.91[a]
20	β-chamigrene	1476	0.08±0.10[a]	0.13±0.13[a]	0.49±0.71[a]
22	α-Curcumene	1480	0.31±0.48[a]	0.67±0.41[a]	0.79±0.89[a]
23	Germacrene D	1483	0.25±0.30[a]	0.39±0.26[a]	0.79±0.61[a]
24	β-Selinene	1485	1.78±0.60[a]	1.01±0.59[a]	1.11±0.54[a]
25	α-Muurolene	1489	0.13±0.26[a]	0.11±0.13[a]	0.26±0.30[a]
26	Valencene	1494	0.20±0.23[a]	0.06±0.08[a]	0.04±0.08[a]
27	Viridiflorene	1494	0.15±0.23[a]	0.42±0.69[a]	0.37±0.45[a]
30	Bicyclogermacrene	1500	10.38±5.22[a]	6.22±0.88[a]	5.69±1.87[a]
31	β-Bisabolene	1505	0.18±0.19[a]	0.25±0.18[a]	0.45±0.13[a]
32	α-Bulnesene	1509	0.05±0.06[a]	0.06±0.07[a]	0.03±0.05[a]
33	δ-Cadinene	1522	2.43±0.87[a]	3.23±1.74[a]	2.62±0.49[a]
34	α-Elemol	1542	0.46±0.54[a]	1.00±0.25[a]	0.60±0.34[a]
35	Germacrene B	1559	2.28±0.46[a]	1.05±0.59[b]	0.46±0.62[b]
37	(E)-Nerolidol	1561	9.31±2.44[a]	9.04±0.90[a]	8.12±0.50[a]
38	Spathulenol	1575	27.82±4.02[a]	29.56±1.24[a]	26.65±2.74[a]
39	Caryophyllene oxide	1582	5.00±1.24[a]	4.24±0.87[a]	5.99±0.75[a]
47	Viridiflorol	1589	1.66±0.79b	3.76±0.93[a]	3.50±0.26[a]
48	Cedrol	1597	2.23±0.21[a]	0.76±0.41[b]	1.91±1.08[ab]
49	α-Muurolol	1643	0.45±0.46[a]	0.56±0.40[a]	0.23±0.37[a]
51	β-Eudesmol	1649	0.38±0.75[a]	0.13±0.26[a]	0.21±0.24[a]
52	(Z)-α trans-Bergamotol	1690	0.46±0.61[a]	0.00±0.00[a]	0.26±0.44[a]
53	Farnesol (cis, cis)	1715	0.02±0.04[a]	0.22±0.32[a]	0.04±0.07[a]
54	Lanceol	1759	0.19±0.10[a]	0.14±0.28[a]	0.08±0.17[a]
-	Total identified	-	93.91±1.69	86.64±4.29	86.39±2.37

[1]The mean of four independent extractions followed by the standard deviation. [2]Kovats Index. Means followed by the same letter on the rows do not differ by Tukey's test at a 5% probability.

were lower at higher drying air speeds. In contrast, the viridiflorol content increased. The cedrol content did not differ between the 0.5 and 2.0 m·s^{-1} speeds; however, the content decreased at the 1.0 m·s^{-1} speed (Table 1). Certain components are present in small amounts at higher air speeds due to volatilization, as reported by

Soares et al. (2007), in which the duration of the exposure of *O. basilicum* leaves to drying air strongly influenced the magnitude of the effect that higher temperature and speed had on increasing levels of compounds.

The major component of *A. cymbifera* Mart. and Zucc. oil was spathulenol, which ranged from 26.65 to 29.56%. This compound has the smell of dry wood and can be used in flavoring compositions for food and sophisticated perfumes. It can also be applied in food, medicine, toothpaste, soaps, detergents, cleaning agents, cosmetics, skin care solutions, and other products (Naarden, 1985, cited by Mendes et al., 2008).

Conclusion

Increasing the speed from 0.5 $m \cdot s^{-1}$ to 2 $m \cdot s^{-1}$ reduced the drying time from 22 to 16 h. The speed of the drying air did not influence the content of essential oil extracted from *A. cymbifera* Mart. and Zucc. leaves. The minor constituents germacrene, hex-2-enal, viridiflorol and cedrol were influenced by the drying process. The major constituents, mainly spathulenol, were not influenced by the drying air speed.

Conflict of Interest

The authors have not declared any conflict of interest.

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