Journal of Spices and Aromatic Crops
Vol. 15 (1) : 19–24 (2006)
Indian Society for Spices

Effect of short and long-term storage on essential oil content and composition of cinnamon (*Cinnamomum verum* Bercht. & Presl.) leaves

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Received 04 January 2005; Revised 13 October 2005; Accepted 09 December 2005

Abstract

The effect of duration of storage of cinnamon (*Cinnamomum verum*) leaves on the content and chemical composition of essential oil was studied. The results revealed that neither the essential oil content (1.9%–2.2%), nor the chemical composition of essential oil (eugenol 87.1%–90.7%; eugenyl acetate 2.9%–5.5%; linalool 0.8%–1.2%; benzyl benzoate 0.3%–0.6%) was affected during the storage of leaves for up to 15 months.

Keywords: cinnamon, *Cinnamomum verum*, leaf essential oil, storage.

Introduction

In many aromatic crops where shoots or leaves are the essential oil storage plant parts, drying the leaves/biomass prior to distillation for more than few hours altered the content and chemical composition of the essential oils as seen in *Ocimum basilicum* L. (Srivastava 1980); *O. gratissimum* L. (Balyan *et al*. 1982); *Cymbopogon pendulus* (Nees ex Steud) Wats. (Singh *et al*. 1982); *C. winterianus* Jowitt. (Sangwan *et al*. 1984); *Mentha citrata* Ehrh., *M. piperita* L., *M. spicata* L. (Singh *et al*. 1990) and *Pelargonium* sp. (Rao *et al*. 1992). However, in cinnamon (*Cinnamomum verum* Bercht. & Presl.) the air-dried leaves are stored for different periods and traded for commercial use.

Cinnamon leaf oil isolated from air-dried and stored leaves has various applications in food and flavouring industry. The flavour quality of the leaves is dependant on the content and chemical composition of the essential oil present in them. As the dried leaves stored for different periods are traded, the present study was undertaken to determine the influence of storage period on the content and the chemical profile of the essential oil of cinnamon.

Materials and methods

Experimental details

Two experiments were conducted in the present investigation. In the first experiment, cinnamon leaves were stored for 0 to 29 days and in the second experiment, the leaves were stored for 0 to 15 months. Essential oils isolated from these leaves were analyzed for their chemical profiles by gas chromatography (GC) and GC-mass spectrometry (MS).

Collection and storage of leaves

For both the experiments, fully grown mature cinnamon leaves were harvested during

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October from 14-year-old trees grown in the Research Farm of the Central Institute of Medicinal and Aromatic Plants Resource Centre, Hyderabad. The experimental location experiences a semi-arid tropical climate. In the first experiment, the freshly harvested leaves were divided into 90 samples of 500 g (fresh weight) each and air-dried in shade under ambient conditions. Starting from the day of harvesting, for 30 days, triplicate leaf samples were drawn for isolation of essential oil from them. Thus, on the first day, freshly harvested leaf samples and on the last day, 29-day-old air-dried leaf samples were used.

In the second experiment, the freshly harvested leaves were divided into 48 samples of 500 g (fresh weight) each and air-dried in shade under ambient conditions. Out of these, 3 freshly harvested samples were used on the day of harvesting for essential oil isolation. From the rest of the 45 samples, air-dried triplicate samples were drawn once in a month, for 15 months, for essential oil isolation. Thus, the last sample was 15 months old.

Essential oil isolation

Leaf samples were hydro-distilled for 6 h in a modified Clevenger glass apparatus for essential oil isolation. The oil samples were dried over anhydrous sodium sulphate to make them moisture free, weighed and stored at 0^0C in airtight containers, prior to analysis by GC and GC-MS. Essential oil concentration in the leaves was calculated on fresh weight basis.

Gas chromatography

GC analyses were performed on a Varian Star 3400 CX gas chromatograph equipped with flame ionization detector (FID), a Panasonic KX-P1150 printer-plotter and an electronic integrator. Separation of compounds was done on 2 columns with distinct polarity: Supelcowax-10 and SPB-1 (both 30 m x 0.25 mm ID, 0.25 mm film thickness), both purchased from Supelco. Hydrogen was employed as carrier gas at a flow rate of 1 ml min^{-1} and 10 psi inlet pressure. The column temperature was initially held at 80^0C for 2 min, then increased to 150^0C at 5^0C min^{-1} and further increased to 220^0C at 7^0C min^{-1} with a final hold time of 5 min. The injector and detector were maintained at 200^0C and 240^0C, respectively. The samples (0.1 ml) were injected neat with 1:50 split ratio.

Gas chromatography-mass spectrometry

GC-MS analyses of essential oil samples were carried out on Hewlett-Packard (HP)-5850 gas chromatograph coupled with HP-5850 mass-selective detector (MSD) system, using HP-1 (25 m x 0.20 mm ID, 0.25 mm film thickness) column. Helium was used as carrier gas at 1 ml min^{-1} flow rate. The temperature programme was the same as in the GC analyses. Mass spectra were recorded over 40–400 amu range at 1 scan s^{-1}, with ionization energy of 70 eV and an ion source temperature of 250^0C.

Compound identification and quantification

Essential oil constituents were identified by the retention times of the GC peaks, by comparison of retention indices available in literature (Jennings & Shibamoto 1980; Davies 1990), and by comparing the mass spectra of the peaks with published literature (Masada 1976; Jennings & Shibamoto 1980; Adams 1995). Kovats (1965) retention indices were calculated from the gas chromatograms by logarithmic interpolation between bracketing *n*-alkanes. The homologous series of *n*-alkanes C_8 to C_{23} of Poly Science Inc., Niles, USA were used as the standards. The relative amounts of individual constituents were computed from peak areas without FID response factor correction.

Statistical analysis

The data of both the experiments were statistically analyzed following the methods described by Panse & Sukhatme (1978).

Results and discussion

Short-term storage effects

Physical parameters

Air-drying the leaves in shade under ambient conditions retained the colour of the

leaves. The leaves lost 50% moisture by the end of the third day and 55% moisture by the end of 1 week. There was no further loss of moisture. The leaves on rubbing the surface with hand emitted the characteristic cinnamon spicy odour and had hot taste. Therefore, the leaves could be safely stored up to 1 month.

Essential oil content

The essential oil content (% on weight by fresh weight basis) of the leaves ranged from 1.9% to 2.2% with an average content of 2.0% (Table 1). The variation during the storage period did not show any definite trend and was not statistically significant.

Essential oil profile

Twenty constituents accounting for more than 95% of the essential oils were identified. The compounds α–pinene, camphene, β-pinene, sabinene, α-terpinene, limonene, *trans*-β-ocimene, terpinen-4-ol, α-terpineol and piperitone that were present in less than 0.2% concentration, were not tabulated. Eugenol and eugenyl acetate were the major compounds accounting for more than 90% of the oil (Table 1). The eugenol content varied from 87.1% to 90.7%, the eugenyl acetate from 2.9% to 5.5% and linalool from 0.8% to 1.2%, but the differences were not statistically significant. The overall chemical composition of the essential oils of cinnamon leaves did not show any statistically significant variations during the storage period.

Long-term storage effects

Physical parameters

Long-term storage of the leaves led to some loss of colour. The leaves lost 57.5% moisture from 2nd to 11th month and 58.5% moisture from 12th to 15th month. On rubbing the surface with hand, the leaves emitted the characteristic cinnamon spicy odour and had hot taste.

Essential oil content

The essential oil content (% g/g) of the stored leaves varied from 1.2% to 1.6% with an average content of 1.4% (Table 2). The variation during the storage period was not statistically significant as in the first experiment.

Essential oil profile

Twenty constituents constituting more than 95% of cinnamon leaf oils were identified (Table 2). Eugenol percentage fluctuated from 86.1% to 90.9%, eugenyl acetate from 2.0% to 3.9% and linalool from 0.9% to 1.7%, but the differences were not statistically significant. The overall chemical composition of essential oils of cinnamon leaves did not show any statistically significant variation during the storage period as in the first experiment.

Cinnamon leaves are leathery, thick and shining and the essential oil is stored in oil glands that are not exposed to the external environment. The leaves did not lose more than 58% of moisture even on prolonged storage, unlike in many other aromatic crops where the leaves lost up to 80% moisture on drying (Rao *et al*. 1992). This may be one of the mechanisms evolved by the plant to protect the oil from catabolism (Croteau 1987) during the storage period. Therefore, in spite of storing the leaves for prolonged periods, the oil content did not decrease significantly. This was further evident from the oil composition data of both the experiments. The percentage of the major compound eugenol was more than 86% even after storing the leaves up to 15 months. The range of values observed for eugenol and other constituents during the storage periods of these experiments are comparable to those reported by many workers for commercial cinnamon leaf oils (Wijesekera *et al*. 1974; Variyar & Bandyopadhyay 1989: Cheng & Yu 1993; Mallavarapu *et al*. 1995; Lawrence 1997) indicating that the oil composition of cinnamon leaves was not affected by storing them either for short or for prolonged periods. The essential oil of the 15-month-old leaves was assessed as good and was readily accepted in the market.

Table 1. Influence of short-term storage on content (% w/w, fresh weight basis) and constituents (%) of essential oils of cinnamon leaves

Storage period (days)	Oil	Myrcene	1,8-Cineole	p-Cymene	Linalool	β-Caryophyllene	Safrole	(E)-Cinnamaldehyde	Eugenol	Eugenyl acetate	Benzyl benzoate
0	2.0	0.3	0.1	0.2	0.9	0.5	0.5	0.7	87.2	4.4	0.4
1	1.9	0.1	0.2	0.2	1.1	0.6	0.3	0.5	88.5	3.9	0.5
2	2.0	0.3	0.3	0.3	0.9	0.5	0.2	0.8	87.1	3.3	0.5
3	1.9	0.1	0.1	0.2	1.2	0.6	0.3	0.6	90.7	3.2	0.3
4	2.0	0.2	0.2	0.3	1.0	0.5	0.5	0.6	87.1	5.5	0.4
5	2.0	0.2	0.1	0.3	1.0	0.5	0.2	0.9	87.8	4.4	0.4
6	1.9	0.2	0.2	0.3	1.0	0.5	0.4	0.6	88.9	3.6	0.4
7	2.0	0.2	0.2	0.2	0.9	0.5	0.2	0.9	88.4	4.2	0.6
8	2.0	0.3	0.2	0.3	1.0	0.5	0.3	0.5	89.6	3.3	0.5
9	1.9	0.3	0.2	0.3	1.1	0.6	0.5	0.9	87.9	3.8	0.5
10	2.0	0.1	0.1	0.2	0.9	0.4	0.5	0.9	88.8	4.8	0.5
11	2.0	0.3	0.2	0.3	1.0	0.5	0.4	0.6	89.2	3.0	0.4
12	2.0	0.1	0.1	0.2	0.9	0.7	0.2	0.9	88.5	4.1	0.6
13	1.9	0.3	0.2	0.3	0.9	0.5	0.4	0.7	90.1	2.9	0.4
14	1.9	0.3	0.2	0.3	1.0	0.4	0.5	0.7	89.5	3.3	0.3
15	1.9	0.2	0.2	0.3	1.0	0.4	0.3	0.5	90.3	3.2	0.4
16	2.0	0.3	0.2	0.2	1.0	0.5	0.4	0.7	88.6	4.8	0.3
17	2.2	0.2	0.1	0.2	0.9	0.6	0.4	0.5	89.2	3.4	0.3
18	1.9	0.3	0.2	0.2	1.2	0.8	0.2	0.6	88.7	4.0	0.5
19	2.0	0.2	0.1	0.1	0.8	0.4	0.4	0.7	90.4	3.5	0.4
20	2.2	0.4	0.2	0.3	1.2	0.4	0.5	0.6	88.6	4.2	0.3
21	2.2	0.4	0.2	0.3	1.1	0.6	0.4	0.6	89.5	3.6	0.4
22	2.1	0.2	0.1	0.2	0.9	0.5	0.4	0.7	90.6	4.3	0.3
23	2.2	0.3	0.1	0.2	1.0	0.4	0.5	0.7	89.7	3.3	0.3
24	2.2	0.2	0.2	0.3	1.1	0.4	0.5	0.4	89.5	4.1	0.3
25	1.9	0.1	0.1	0.1	0.8	0.5	0.5	0.7	88.8	4.7	0.6
26	1.9	0.1	0.1	0.2	0.9	0.5	0.4	0.8	90.3	4.1	0.4
27	1.9	0.1	0.1	0.1	0.9	0.5	0.2	0.9	89.5	4.0	0.5
28	1.9	0.2	0.1	0.2	1.1	0.5	0.4	0.7	89.7	5.1	0.3
29	2.1	0.1	0.1	0.1	1.0	0.5	0.6	0.6	89.4	3.9	0.4

CD (P=0.05)=NS

Table 2. Influence of long-term storage on content (% w/w, fresh weight basis) and constituents (%) of essential oils of cinnamon leaves

Compound	Storage period (months)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Oil content	1.6	1.5	1.4	1.4	1.4	1.5	1.4	1.5	1.3	1.2	1.5	1.4	1.3	1.2	1.2	1.4
α-Pinene	t	t	0.1	t	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.1	0.1	0.1	0.2
Camphene	t	t	0.1	t	0.2	0.3	t	0.3	0.3	0.4	0.1	0.2	0.1	0.1	0.2	0.1
β-Pinene	t	t	0.1	t	0.2	0.3	0.1	0.2	0.3	0.3	0.1	0.2	0.1	0.1	0.2	0.2
Sabinene	t	t	t	t	t	0.1	t	t	t	0.1	t	0.1	t	t	0.1	t
Myrcene	0.1	t	0.4	t	0.5	0.5	t	0.4	0.5	0.5	t	0.5	t	t	0.4	t
α-Terpinene	t	t	t	t	0.1	0.1	t	t	0.1	t	0.3	0.4	0.3	t	0.1	t
Limonene	t	t	0.1	t	0.2	0.2	t	0.1	0.2	t	0.2	0.1	0.1	0.1	0.3	t
1,8-Cineole	0.1	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.3	0.2	0.2	0.3	0.2	0.3	0.3	0.1
trans-β-Ocimene	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t
p-Cymene	0.4	0.3	0.3	t	0.3	0.4	t	0.3	0.5	t	0.4	0.5	0.3	0.5	0.4	t
Linalool	0.9	1.1	1.1	0.9	0.9	1.3	1.1	1.1	1.3	1.7	1.1	1.3	1.1	1.6	1.5	1.1
β-Caryophyllene	0.5	0.9	1.0	0.7	1.0	0.7	0.8	0.5	0.7	0.6	0.6	0.8	0.7	0.8	0.6	0.7
Terpinene-4-ol	0.3	t	0.1	t	t	t	t	t	t	t	0.1	0.1	0.1	t	0.1	t
α-Terpineol	t	0.1	t	t	0.1	t	t	0.1	t	t	t	t	0.2	0.1	0.2	0.1
Piperitone	0.2	0.1	0.1	0.1	t	0.1	0.2	0.1	0.1	t	t	0.1	t	t	0.2	0.1
Safrole	0.2	0.2	t	t	t	t	0.3	0.1	0.1	t	0.1	0.2	0.2	0.3	0.2	0.2
(E)-Cinnamaldehyde	0.7	0.8	0.7	0.7	0.8	0.8	0.9	0.6	0.7	0.9	0.9	1.0	1.0	1.0	1.0	0.7
Eugenol	90.7	88.5	86.8	90.0	86.2	86.2	86.1	90.8	88.2	86.6	90.9	87.6	89.9	90.7	88.1	90.9
Eugenyl acetate	2.0	2.6	3.8	2.9	3.9	3.9	2.8	2.7	3.3	3.4	2.3	3.1	3.5	2.2	3.2	2.3
Benzyl benzoate	0.6	0.8	0.9	0.6	0.9	0.9	0.6	0.5	0.8	0.8	0.5	0.9	0.8	0.6	0.8	0.5

CD (P=0.05)=NS; t= traces (<0.1%)

Acknowledgements

The authors express their gratitude to the Director, Central Institute of Medicinal and Aromatic Plants, Lucknow, for facilities.

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