

ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
<http://ansijournals.com/ja>

JOURNAL OF AGRONOMY



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Gas Chromatographic Analysis of Volatile Components of Guinean and Chinese Ginger Oils (*Zingiber officinale*) Extracted by Steam Distillation

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Abstract: The volatile compounds responsible for flavor of Guinean (west-Africa) and Chinese gingers have been extracted using steam distillation. The Gas Chromatography Mass Spectrometry (GC-MS) was used to determine essential oil volatile components from Guinean and Chinese ginger. The results showed that more than 90 components were separated of Guinean and Chinese ginger, respectively were tentatively identified. The components accounted for about 93.57 and 89.55% of the total relative content for Guinean and Chinese ginger, respectively. Zinziberene (19.89 and 31.1%) was the most abundant compound identified for Guinean and Chinese ginger. The major effects of the steam distillation process are increase in terpene hydrocarbons and monoterpenes alcohols.

Key words: Extraction, steam distillation, GC-MS, ginger, volatile components, Zinziberene

INTRODUCTION

In China, Guinea and many other countries, ginger is commonly used either as a food product or as an herbal medicine. The essential oil, which is one of the products from ginger, has been internationally commercialized as a flavoring agent and/or additive for the food and pharmaceutical industry (Kelly *et al.*, 2002; Alexandre *et al.*, 1998). The chemical components in the essential oil might affect the characteristic flavoring quality of ginger. On the other hand, there are substantial differences among chemical components of ginger essential oils from different sources. Even oils from the same region can differ significantly because several varieties are cultivated. Thus, there is a growing interest in research on methods for qualitative and quantitative analysis of components from ginger oils. The chemical investigations carried out in the past showed that monoterpene hydrocarbons, oxygenated monoterpene, sesquiterpenes hydrocarbons and nonterpenoid compounds were the constituents in ginger oils (Shao *et al.*, 2003).

Ginger oil may be produced from fresh or dried rhizomes. Oil from dried rhizomes will have less of the low boiling point volatile compounds since they tend to evaporate during the drying process (Weiss, 1997). However, these compounds contribute only partially to the "flavor impact" since fresh ginger is characterized by

its aroma, as well as by its pungency. The major components in ginger essential oil are zingiberene, ar-curcumene, farnesene, bisabolene, sesquiphellandrene (Lawrence, 2000). It is interesting to note that the amount of monoterpene alcohols and sesquiterpenes alcohols in steam distilled oil was higher than those extracted by liquid carbon dioxide. These differences were due to the thermal degradative effect of steam distillation upon the non-volatile glycosides of monoterpene alcohol and/or sesquiterpenes alcohols.

In the present study, the volatile components of essential oils from Guinean and Chinese ginger extracted by steam distillation were determined and compared by GC/MS.

MATERIALS AND METHODS

Materials: Guinean and Chinese fresh ginger (*Zingiber officinale* Roscoe) was obtained from the local market (Conakry, Guinea) and supermarket (Wuxi, China) respectively in July 2006. The ginger was transported to the laboratory of Food Science and Technology, Southern Yangtze University (Wuxi, China) and stored under frozen conditions till when they were needed for analysis.

Extraction of essential oils: Essential oils were extracted from both the Guinean and Chinese gingers. About 100 g of the frozen (-18°C) fresh ginger was thawed for 15 min

before grinding. The sample was chopped into small pieces 2 mm cubes before grinding, blended with 300 mL of distilled water using a domestic blender (model MX-X61-W; National China) then the blended material was macerated in 10 min. The essential oil or volatile components were extracted by steam distillation using a vertical steam distillation unit (AOAC, 1984) (Clevenger Hydrodistillation unit, Shanghai, China) as it is a simple and effective method to obtain essential oils from plants (Lawrence, 1984). A flask containing the homogenate was heated for three hours (90°C) and the condensed vapor was separated using an auto-oil/water separator. To enable the extracted oil to be free from dissolved and suspended water it was treated with anhydrous sodium sulphate. The yields of essential oil obtained from Guinean and Chinese fresh gingers was 0.44% (g.g⁻¹) and 0.22% (g.g⁻¹), respectively.

The essential oil was stored at 4°C before GC/MS analysis.

Gas chromatography-mass spectrometry analysis: The extracted essential oils were dissolved in ether, dehydrated with anhydrous sodium sulfate and vacuum-concentrated to recover the volatile oil.

Analyses of the original ginger oil and concentrated extracts were carried out using a Perkin-Elmer GC (VF-5, USA) system with Flame Ionization Detector (FID), with helium as a carrier gas at a linear flow velocity of 25 cm s⁻¹. A fused silica capillary column with a stationary phase equivalent to Carbowax 20 M, with dimensions 50 m×0.32 mm and 1.0 µm film thickness was used. The temperature of the column was programmed initially at 50°C for 1 min and then increased at a rate of 5° min⁻¹ to a final temperature 150°C. Injector and detector temperature were maintained at 200 and 250°C, respectively. For all injection, 0.2 µL of the concentrated flavour extract was used in a split less injection mode.

Capillary gas chromatography-mass spectrometry was carried out on a Hewlett-Packard (HP) 5985 B systems (VF-5, USA) equipped with a Hewlett-Packard 5840 a gas chromatograph. A fused silica capillary column (Carbowax 20) (VF-5, USA) was used. Analytical conditions were as follows: temperature program, 50-200°C, 5°C min⁻¹, isothermal at 200°C; injector temperature, 250°C; helium carrier velocity, 30 cm s⁻¹; ion source temperature, 200°C; ionization voltage, 70eV; electron multiplier voltage, 2600V.

Identification of volatile compounds in extracts obtained by steam distillation method was accomplished by gas chromatography-mass spectrometry (GC-MS) with computerized integrated data processing and the use of retention indices.

RESULTS AND DISCUSSION

Volatile oil or essential oil yield: Essential oils are products or mixtures of products which are formed in cytoplasm and are normally present in the form of tiny droplets between cells. They are volatile and aromatic.

The analysis of ginger oil content in the two samples showed that the highest yield of 0.44% was from the Guinean ginger while Chinese ginger contained only 0.22% (Fig. 1). The volatile oil content of African ginger has been found to be from 1-4% on dry weight basis but only about 0.4% has been found in fresh African ginger (Connell, 1970).

Identification and quantification of volatile components extracted from Guinean and Chinese gingers: A typical gas chromatogram of both fresh gingers is shown in Fig. 2 and 3 and lists of the compounds identified appear in Table 1.

The compounds identified accounted for more than 90% peaks that were reliably detected. Only those that were positively identified are reported in Table 1 and the remainder is accounted for by unidentified compounds, most of which are small peaks having areas of less than 0.1% of the total area.

Figure 2 and 3 shows the capillary gas chromatogram of fresh Guinean and Chinese gingers volatile components and about 93.57 and 89.55% volatile components were identified, respectively as summarized in Table 1. Monoterpenes, alcohol compounds, sesquiterpenes, aldehydes and ester monoterpenes were major categories of volatile components identified in this fraction. Yonei and Ohinata (1995) reported ginger volatile oil content of about 50% using supercritical carbon dioxide.

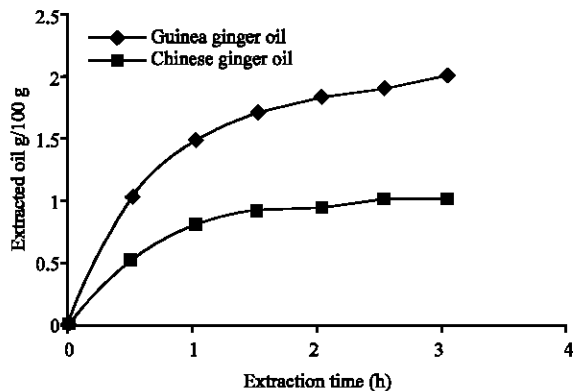


Fig.1: Guinean and Chinese ginger oil extractions times using hydrodistillation

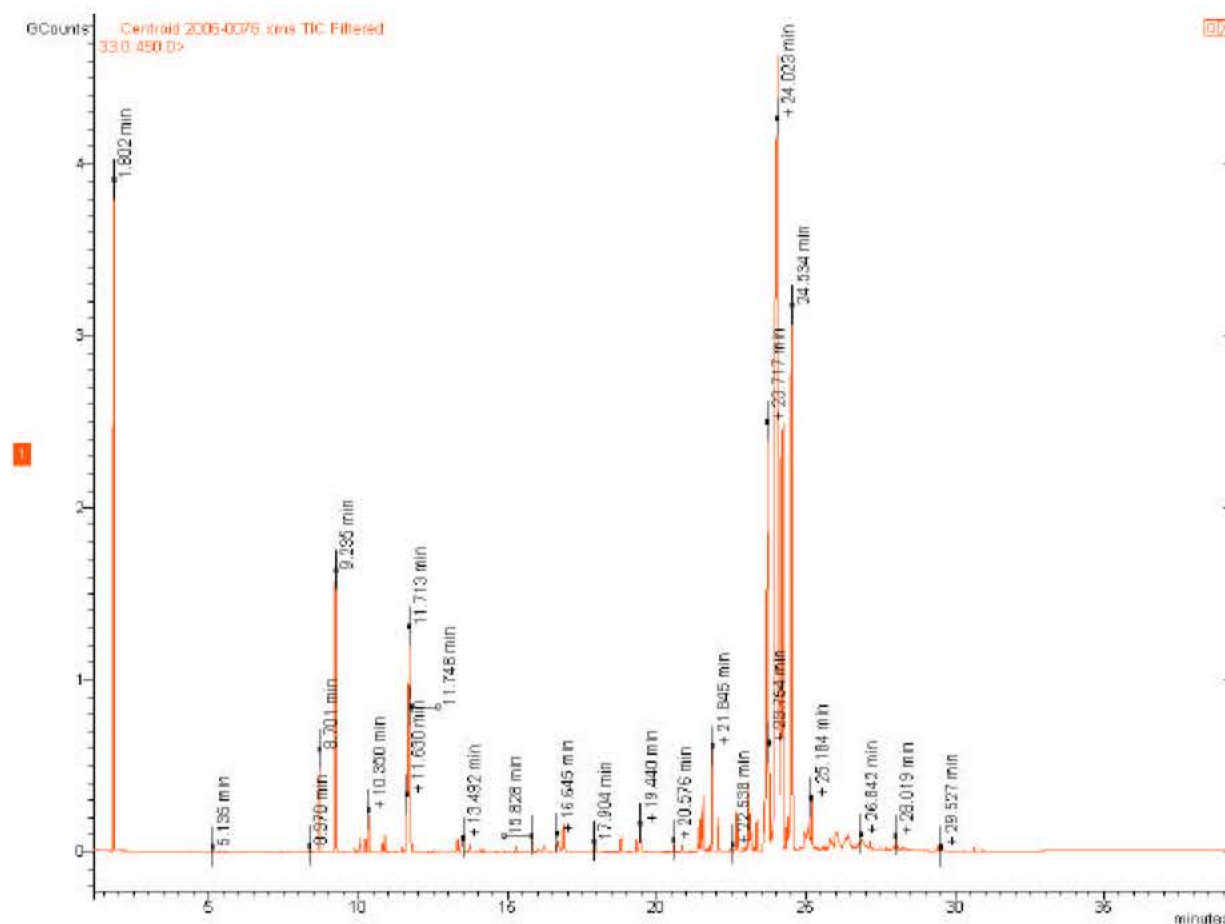


Fig. 2: Capillary gas chromatogram of Guinean fresh ginger volatile extracted by steam distillation

In this study, the principal constituent was Zinzipherene, a kind of sesquiterpenes hydrocarbon, as shown by Fig. 2 and 3 however its content was higher in Chinese than Guinean ginger, that is, 31.1 and 19.89%, respectively. Results by John and Amanda (2000) found Zinzipherene was about 13.44% using supercritical carbon dioxide in Australian ginger.

The β -sesquiphellandrene was higher in Chinese ginger than Guinean ginger that is 13.82 and 8.95%, respectively. The results was higher than that reported by Fan *et al.* (2004) who found the volatile compound to be low using steam distillation as extraction method in Hong Kong ginger (China). The low boiling point monoterpenes α -pinene, Zinzipherenol (3.22%), Linalool (3.31%), Terpineol (0.26%), Borneol (2.01%), Eucalyptol (3.41%), 1, 8-Cineole (1.43%), Cubenol (0.7%), Cadinal (0.37%), β -Eudesmol (1.46%) and Nerolidol (0.46%) were more abundant and present in various proportions and they imparted aromas characteristic to the products. Comparatively, less monoterpene were detected by Connell and Sutherland (1969) in Australian ginger. The detection of

two dehydration products of Zinzipherenol (Zinzipherene and β -sesquiphellandrene) during GC analysis was indirect evidence confirming the presence of Zinzipherenol in this fraction as reported by researchers Terhune *et al.* (1975). Further more β -bisabolene from Guinean oil (5.37%) was less than that from Chinese oil (7.77%) while Camphene was higher in Guinean oil than Chinese oil that is 8.1 and 4.27%, respectively. Citral was detected in Guinean oil (3.44%) and was higher than the result (1.31%) determined by steam distillation described by Zhen *et al.* (1998) which impart a lemony aroma to the final product, in Chinese ginger.

In Chinese ginger and volatile components, trace amounts of thermal degradative products of nonvolatile gingerols compounds were detected which is contrary to the result found using steam distillation by Zhen *et al.* (1998). In Guinean ginger, Aldehydes [Hexanal (peak 2), Octanal (peak 8), decanal (peak 18)] and ketene [2-undecanone (peak 22)] were detected. The same findings of hexanal, Octanal, decanal and 2-undecanone in steam distilled volatiles of ginger have been reported

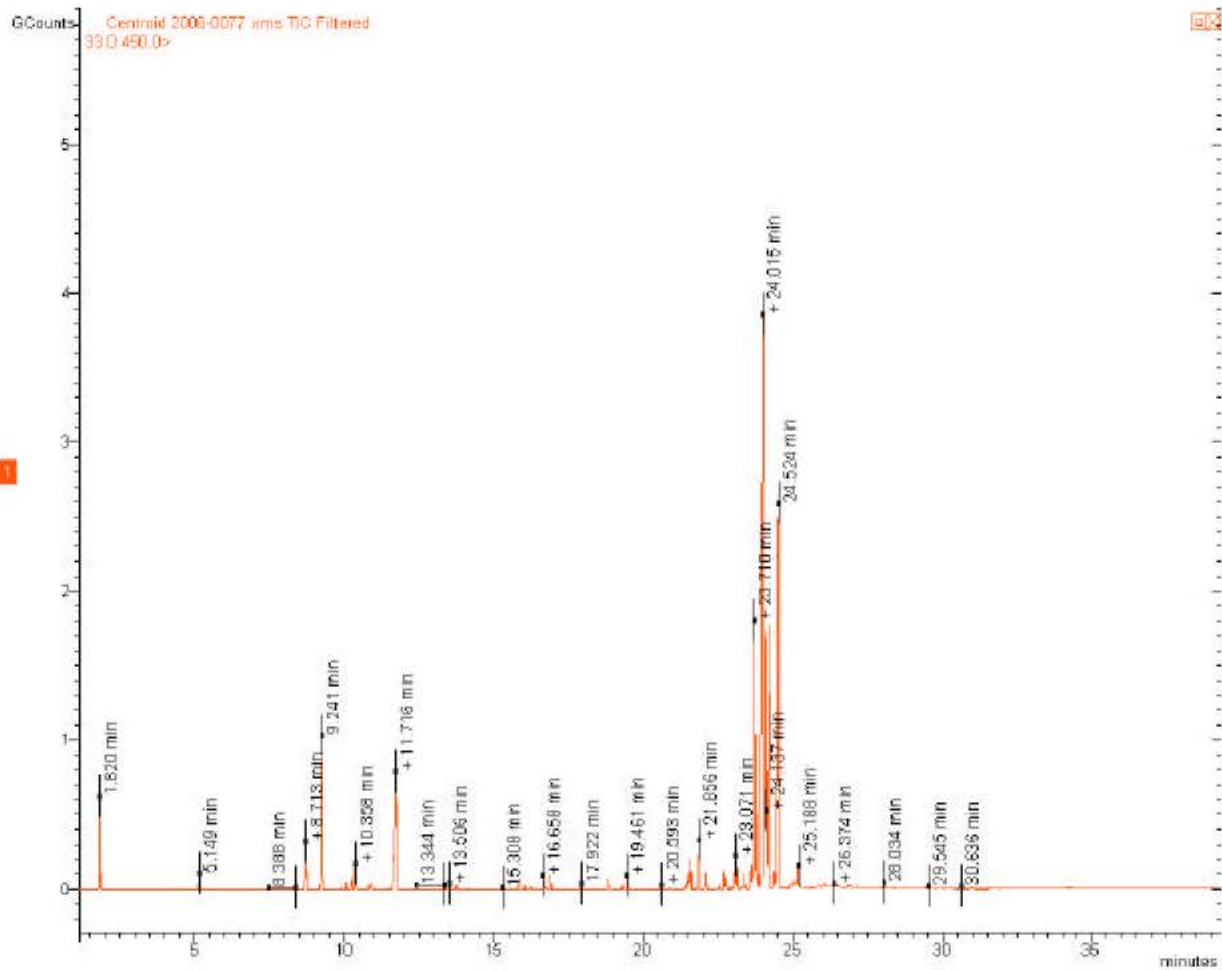


Fig. 3: Capillary gas chromatogram of Chinese fresh ginger volatile both extracted by steam distillation

Table 1: Volatile components of Fig. 2 and 3 of steam distillation extracted ginger oil

Peak	Chinese ginger		Guinea ginger		Amount (%)	
	Compounds	Retention time (min)	Compounds	Retention time (min)	China	Guinea
1	Ethane	1.820	Ethane	1.852	1.14	2.16
2	Hexanal (CAS)	5.149	α -pinene	10.632	0.30	2.70
3	Tricyclene	8.388	Camphene	11.111	0.07	8.10
4	α -pinene	8.704	β -pinene	11.778	1.30	0.45
5	Camphene	9.241	β -Myrcene	12.056	4.27	1.37
6	β -pinene	10.063	α -Phellandrene	12.471	0.15	0.23
7	β -Myrcene	10.358	p-menth-2-en-1	13.125	0.56	2.93
8	Octanal	10.822	Eucalyptol	13.178	0.13	3.41
9	α -Phellandrene	10.921	1, 8-Cineole	13.192	0.20	1.43
10	Limonene	11.642	α -Terpinolene	14.28	1.03	0.38
11	β -Phellandrene	11.716	Linalool	14.587	3.85	1.28
12	1, 8-Cineole	11.756	Citronella	15.649	1.86	0.54
13	α -Terpinolene	13.344	Limonene oxide	15.821	0.14	0.30
14	Linalool	13.747	Borneol	16.226	0.13	2.01
15	Camphor	15.308	Terpineol	16.304	0.07	0.26
16	Borneol	16.030	Zinziberenol	16.608	0.14	1.59
17	Terpineol	16.234	LINALOOL	17.424	0.53	1.28
18	Decanal (CAS)	16.897	Z-Citral	17.925	0.36	0.56
19	Z-Citral Z	17.922	Citral	17.965	0.18	3.44
20	Citral	18.816	Linalool	17.997	0.34	3.31
21	Endobomyl acetate	19.309	2-undecanone (cas)	18.276	0.14	0.36

Table 1: Continued

Peak	Chinese ginger		Guinea ginger		Amount (%)	
	Compounds	Retention time (min)	Compounds	Retention time (min)	China	Guinea
22	2-undecanone (cas)	19.461	(+) Cycloisositivene	19.759	0.35	0.30
23	δ-Elemene	20.593	α-Copaene	19.840	0.12	0.49
24	Citronellyl acetate	20.863	β-Elemene	20.042	0.07	0.89
25	(+) Cycloisoc acetate	21.452	Zinziberene	20.142	0.38	0.31
26	Geranyl acetate	21.520	γ-Elemene	20.678	0.41	0.25
27	α-Copaene	21.579	β-Farnesene	20.962	0.71	0.64
28	β-Elemene	21.856	Aromandendrene	21.274	1.18	0.64
29	Trans-Caryophyllene	22.078	Cubebene	21.641	0.08	0.35
30	γ-Elemene	0.40	Zinziberene	21.780	0.40	19.58
31	β-Farnesene	23.071	α-Farnesene	21.974	0.74	4.71
32	γ-Cadienene	23.608	β-bisabolene	22.076	0.74	5.37
33	GERMACRENE-D	23.764	β-sesquiphellandrene	22.358	1.55	8.95
34	Zinziberene	24.015	Elemol	22.721	31.1	2.80
35	α-Farnesene	24.095	γ-Elemene	22.903	7.46	0.27
36	γ-Cadienene	24.137	GERMACRENE-D	22.917	1.63	0.43
37	β-Bisabolene	24.214	Sesquisabinene Hydr	23.218	7.77	0.71
38	β-Bubebene	24.356	Zinziberenol	23.574	0.35	3.22
39	δ-Cadienene	24.416	Cubanol	23.955	0.15	0.78
40	β-sesquiphellandrene	24.524	Cadinol	24.091	13.82	0.37
41	Elemol	24.937	β-Eudesmol	24.352	0.87	1.46
42	Nerolidol	25.188	Globulol	24.352	0.48	0.27
43	Epiglobulol	25.911	Epiglobulol	24.372	0.09	0.56
44	Zinziberenol	26.023	Epiglobulol	24.449	0.20	1.43
45	Epiglobulol	26.060	(Z,Z)-Farnesal	24.852	0.37	0.44
46	Globulol	26.172	β-Sinensal	24.981	0.74	0.23
47	Farnesol	26.633	Nerolidol	25.220	0.47	0.46
48	β-Eudesmol	26.752	-	-	0.43	-
Total area					89.55	93.57

by several scientists (Masada, 1976; Lawrence, 1984). According to this recent report Chen *et al.* (1986) and Chen and Ho (1987), the contents of these aldehydes and ketoses in ginger products were closely related to thermal processing.

CONCLUSIONS

Steam distillation extraction combined with GC-MS has been shown to be a valuable tool for the analysis of ginger constituents and can provide a useful guide to components variation. The extraction procedure was simple and itself could also provide a valuable means of producing flavour extracts from Guinean and Chinese ginger under mild conditions which preserve the natural characteristics of the fresh product.

Guinean ginger contained higher volatile oil than Chinese ginger as the main component was Zinziberene, which was also reported as the highest component identified.

ACKNOWLEDGMENT

This research work was funded by the government of P. R. China and Guinea for the. The authors also wish to thank individuals whom have contributed to this work and successful completion of this work.

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