ICC
Iranian Chemical Communication
Original Research Article
Payame Noor University http://icc.journals.pnu.ac.ir

Separation identification and antioxidant evaluation of zingiber officinale essential oil

Ali Saberi*, Mehri Alimohammadi

Department of Chemistry, Payame Noor University, P.O. BOX 19395-4697 Tehran, Iran

Received: 13 December 2015, Accepted: 29 August 2016, Published: 29 August 2016

Abstract

Usage of herbal medicine has been under so much attention for many years. They are gradually replacing synthetic drugs in pharmaceutical fields due to their fewer side effects. Nowadays, essential oils are widely used for the treatment of diseases as well as being applied as pesticide. In this study, 32 components of Zingiber essential oil were identified representing 97.42% of the extracted oil by Gas chromatography-Mass spectrometry (GC/MS). Antioxidant activity of the extracted oil was evaluated. In this experiment, the effect of Zingiber essential oil on oxidation temperature of oleic acid was investigated using a diffential scanning calorimetric (DSC) instrument.

Keywords: Antioxidant; identification; essential oil; zingiber officinale; biological activity.

Introduction

Zingiber officinale is a plant that belongs to the Zingiberaceae family. The plant is indigenous to warm tropical climates, particularly southeastern Asia. It is extensively cultivated in India, China, Africa, Jamaica, Mexico and Hawaii [1,2]. Ginger products, such as the essential oil and oleoresin, are internationally commercialized for use in food and pharmaceutical processing. The essences due to their chemical nature are volatile at ordinary room temperature and might be called volatile oils, ethereal oils or essential oils. Various techniques have been employed to extract this valuable fraction of the plant material namely by water, steam distillation or application of microwave and liquid carbon dioxide [3]. The essential oils are composed of monoterpene hydrocarbons, sesquiterpene hydrocarbons and oxygenated monoterpene. Although the latter has the least concentration, it is the major contributor to the taste and aroma of food substances [4]. The recovery of the essential oils of Zingiber officinale depends on variety and origin of the plant as well as the cultivation, humidity at the time of harvest, the methods of extraction and to some extent on the age of the plant [5]. The essential oil and oleoresin of Zingiber officinale are used as a medicine with indications against several problems, such as a cure for swelling, sores and loss of appetite,

*Corresponding author: Ali Saberi
Tel: +98 (912) 3933625, Fax: +98 (21) 76400890
E-mail: saberi@pnu.ac.ir, saberi121@yahoo.com

stomach ache, diarrhea, tooth ache, gingivitis arthritis, asthmatic respiratory disorders and motor neurone diseases, also possessing anti-inflammatory activity [6].Therefore, the aim of this investigation is to extract the Zingiber officinale essential oil consumed in Iran, identify the chemical components and antioxidant evaluation present in this valuable fraction.

Experimental

General

The essential oil was isolated by steam distillation from 100 g fresh rhizomes of ginger. The sample was grinded, homogenized and placed in 1 liter conical flask and connected to the Clevenger apparatus. 500 mL of distilled water was added to the flask and heated to the boiling point. The steam in combination with the essential oils were distilled into a graduated cylinder for 6 h and then separated from aqueous layer. The oil was kept in the refrigerator until required for further analysis. Ginger oil was subjected to gas chromatography/mass spectrometry (GC/MS) analysis using a Hewlett–Packard gas chromatograph (Model 6890) coupled with a quadruple mass spectrometer (Model HP 5973) and a HP – 5MS capillary column. The interphase, ion source and selective mass detector temperatures were maintained at 230 °C and 150 °C, respectively. Helium was used as a carrier gas at a flow rate of 1 mL/min. For the essential oil, the oven temperature was programmed linearly at 60 °C; then increased from 60 °C to 220 °C at the rate of 5 °C/min.

Total essential oil extracted after dryness by Na_2SO_4 was calculated 0.13% (w/w). The components of zingiber officinale essential oil were identified on the basis of the comparison of their relative retention time (Figure 1) and the chemical name and structures verified (Table 1, Figure 2).

For antioxidant evaluation of Zingiber officinale essential oil, the differential scanning calorimetry (DSC) method was used. According to the protocol [7] first oleic acid was placed in an aluminium pan and subjected to oxidation under O_2 inside the DSC oven. The temperature was increased at a constant rate of 10 °C/min to 220 °C as reference (Figure 3). Then, the extracted essential oil (250, 500, 750 and 1000 ppm) was added to the oleic acid and the temperature was increased again at a constant rate of 10 °C/min to 220 °C (Figures 4-7).

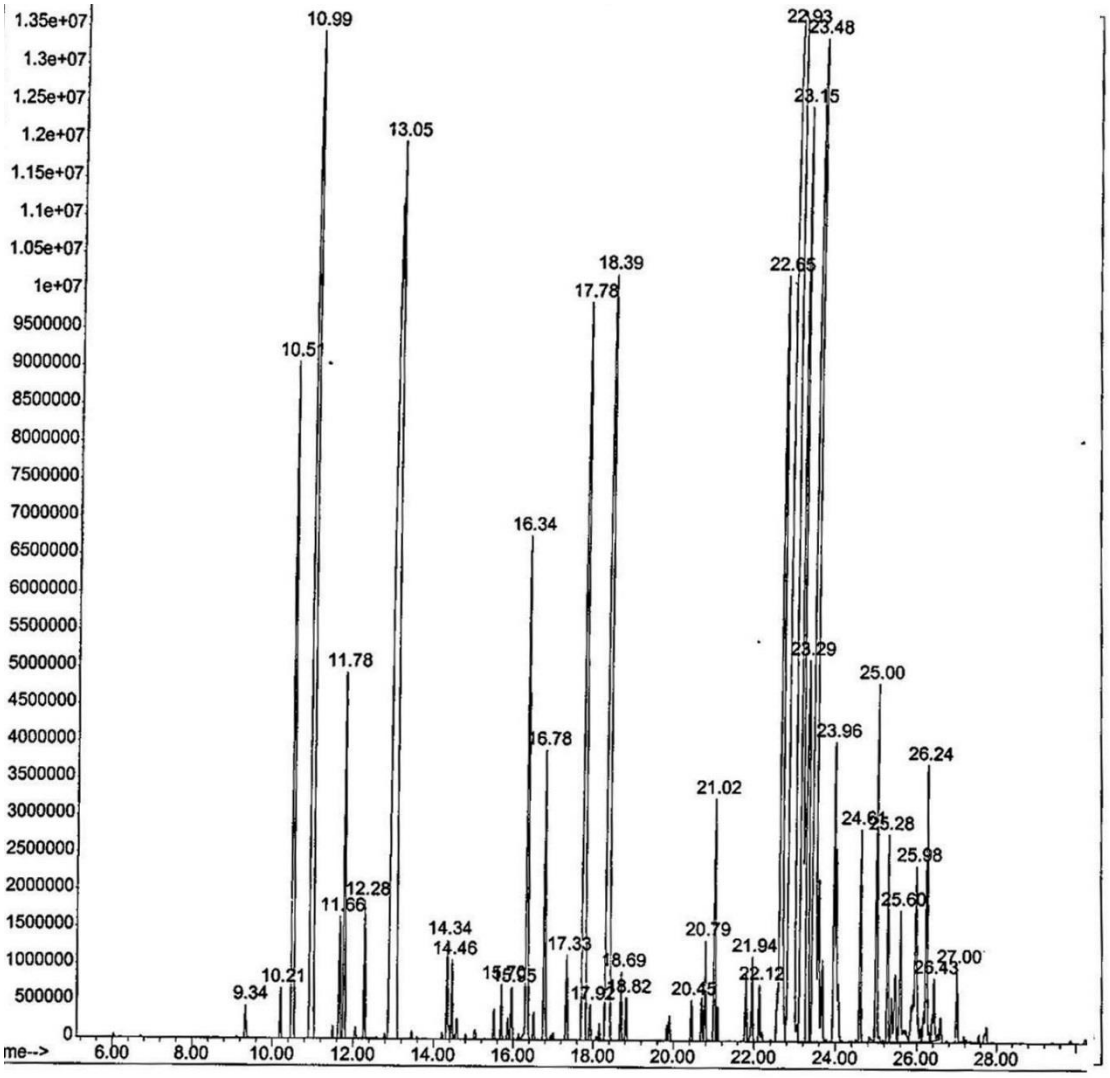
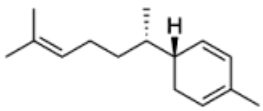


Figure 1. The GC-MS profile of chemical analysis of zingiber officinale essential oil

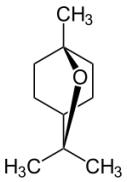
Table 1. Chemical composition and concentrations of compounds present in the examined zingiber officinale

No.	Compound	RT	Standard Kovats index	Kovats index	%
1	*Tericyclene*	10.21	927	934	0.2
2	*α-Pinene*	10.51	934	945	3.5
3	*Camphene*	10.99	954	964	8.4
4	*β-Pinene*	11.66	979	990	0.5
5	*Myrcene*	11.78	991	994	1.5
6	*α-Phellandrene*	12.28	1003	1010	0.5
7	*1,8-Cineole*	13.06	1047	1031	12.6
8	*Terpinolene*	14.34	1100	1084	0.4
9	*Linalool*	14.46	1097	1105	0.2
10	*Citronellal*	15.70	1153	1160	0.2
11	*Chrysanthenol (cis)*	15.95	1164	1171	0.2
12	*Borneol*	16.34	1169	1188	2.5
13	*α-Terpineol*	16.78	1189	1208	2.5
14	*Citronellol*	17.33	1226	1234	0.3
15	*Neral*	17.78	1238	1255	5.3
16	*Geraniol*	17.92	1253	1262	0.1
17	*Geranial*	18.39	1267	1284	6.8
18	*Undecanone*	18.69	1294	1299	0.2
19	*Geranyl acetate*	20.45	1381	1387	0.1
20	*β-cubebene*	20.79	1388	1404	0.5
21	*β-elemene*	21.02	1391	1416	1.00
22	*z- β – Farnesene*	21.94	1443	1465	0.6
23	*E- β – Farnesene*	22.12	1457	1474	0.2
24	*Ar-Curcumene*	22.65	1481	1502	5.8
25	*α-Zingiberene*	22.94	1494	1519	17.2
26	*β-Bisabolene*	23.16	1506	1532	6.9
27	*γ-cadinene*	23.24	1514	1539	2.8
28	*β-Sesquiphellandrene*	23.16	1523	1550	10.0
29	*(z)-Nerolidol*	23.96	1533	1577	2.2
30	*epi-di-1,15 cubenol*	25.01	1619	1638	1.5
31	*β-eudesmol*	25.98	1651	1695	1.40
32	*α - epi -Bisabolol*	26.24	1685	1711	1.32
Total percentage				97.42	

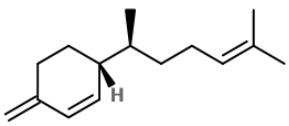
α-Zingiberene



1,8-Cineole



β-Sesquiphellandrene



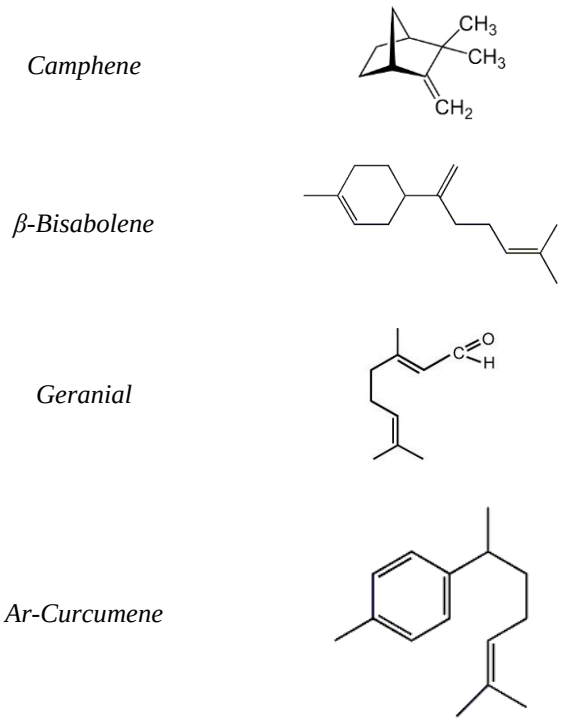


Figure 2. The structure of some chemical compound in zingiber officinale essential oil

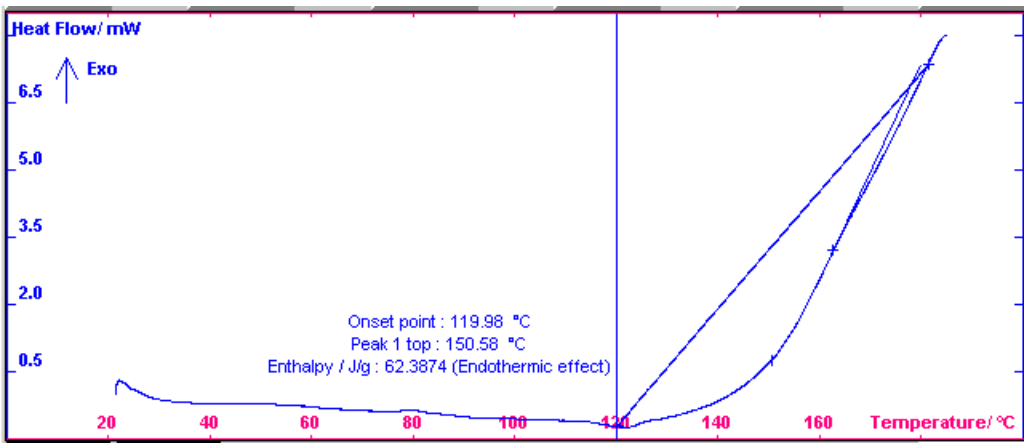


Figure 3. Oleic acid oxidation stability thermogram

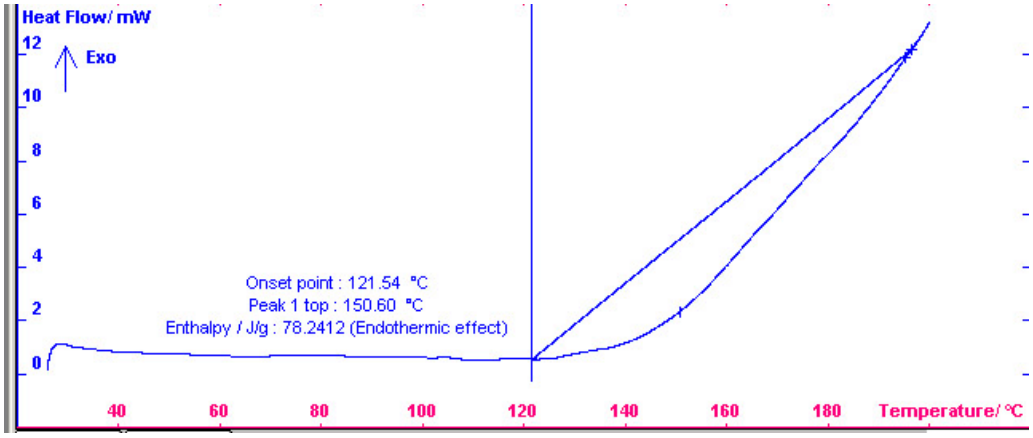


Figure 4. Oleic acid and 250 ppm zingiber officinale essential oil oxidation stability thermogram

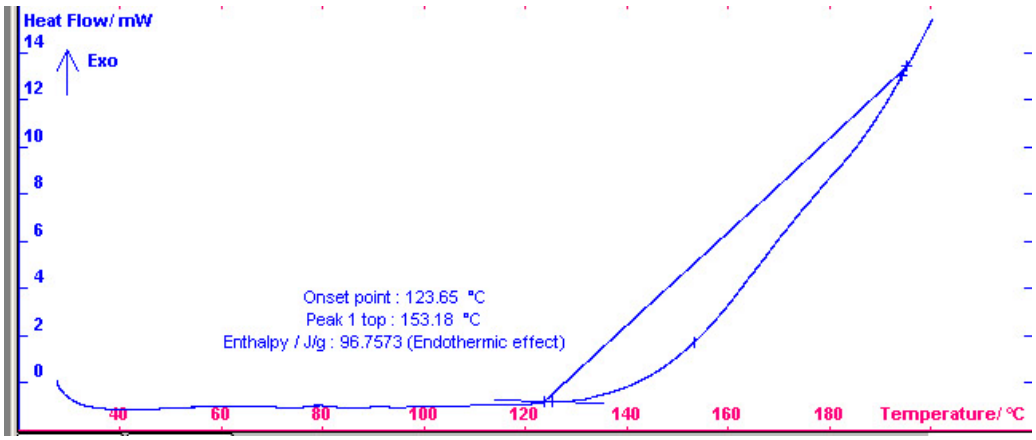


Figure 5. Oleic acid and 500 ppm zingiber officinale essential oil oxidation stability thermogram

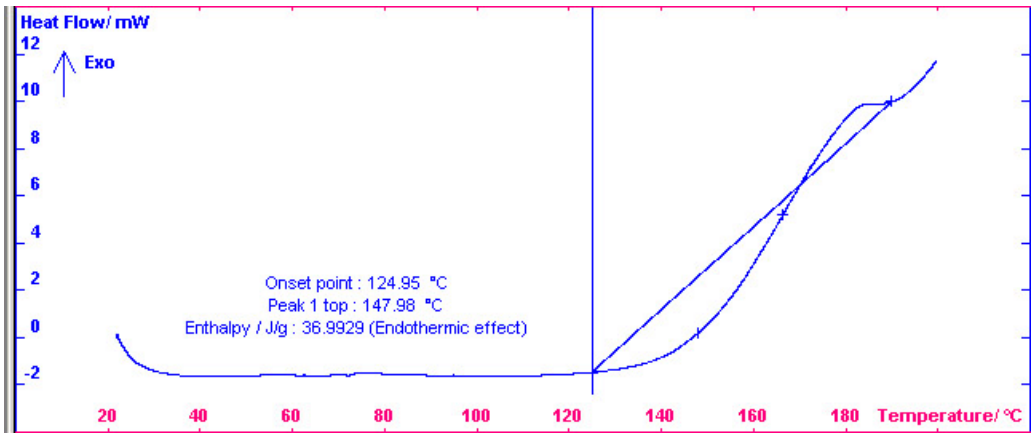


Figure 6. Oleic acid and 750 ppm zingiber officinale essential oil oxidation stability thermogram

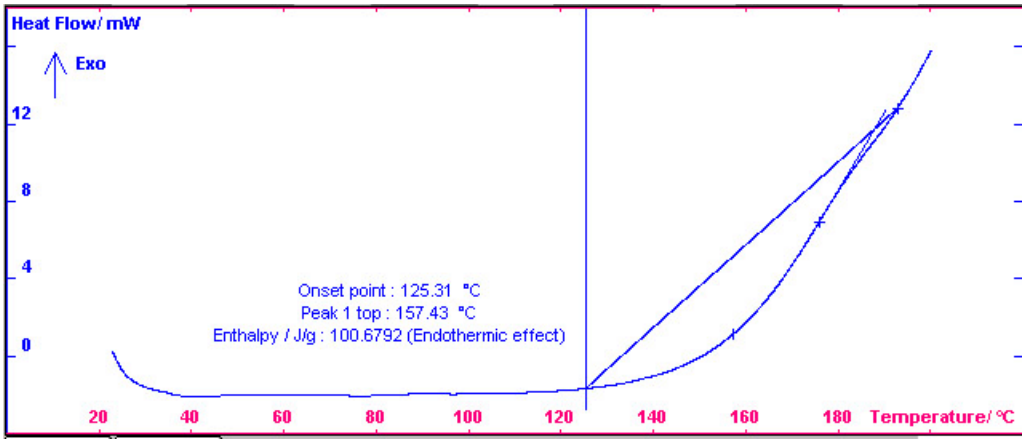


Figure 7. Oleic acid and 1000 ppm zingiber officinale essential oil oxidation stability thermogram

Table 2. Effect of zingiber officinale essential concentration on the oxidation temperature of oleic acid

No.	Zingiber officinale essential concentration (ppm)	Oxidation temperature of oleic acid (°C)
1	0	119.98
2	250	121.54
3	500	123.65
4	750	124.95
5	1000	125.31

Results and discussion

Essential oil of zingiber officinale was extracted by steam distillation. The isolated essential oil was subjected to gas chromatography/Mass spectrometry (GC/MS) analysis and the chemical composition and concentration was obtained by the chromatogram (Figure 1). Figure 2 shows the chemical structure of some compounds identified by GC-MS. As indicated in Table 1 and Figure 1, α- Zingiberene is the predominant compound belonging to the sesquiterpene hydrocarbons and constituted approximately 32 % of the total extracted essential oil. The specific aroma of ginger is predominantly related to zingiberene. Totally thirty two compounds were identified in the essential oil examined. The chemical constituents of the essential oils were extracted as mentioned in Table 1 belong to sesquiterpene hydrocarbons namely zingiberene, Ar-curcumene, β-sesquiphellandrene while the oxygenated monoterpene namely Borneol and Geraniol are present at lower concentrations and have more contributions to the flavouring characteristics of the oil. The monoterpene hydrocarbons, camphene, α-Phellandrene, sesquiterpene alcohols and β-eudesmol are also present in the extracted oil. Antioxidant evaluation of the extracted essential oil was done by Differential Scanning Calorimetry method. The results of the antioxidant activity were showed by Figures 2-7. According to the Table 2, oleic acid

stability oxidation temperature was increased by adding the extracted essential oil. By increasing concentration of the essential oil from 250 ppm to 1000 ppm, the stability oxidation temperature was increased from 121.54 °C to 125.31 °C. The results show the zingiber officinale essential oil affected the oxidation temperature of oleic acid strongly.

Conclusion

In this study, chemical analysis of ginger essential oil was done. The antioxidant evaluation of the essential oil shows that oleic acid oxidation temperature was changed from 119.98 °C to 125.31 °C by adding 250 - 1000 ppm of the extracted essential oil. The result shows strong antioxidant activity of zingiber officinale essential oil. Ginger essential oil as mentioned earlier is made of different classes of chemical compounds that might contribute to flavor and taste of the products and if used in the industry for food formulation, due to their chemical nature might contribute other characteristics namely antioxidant and preserving activities to the product.

Therefore, further investigations concerned with the chemical constituents present in the oil are required to establish the antimicrobial, stabilizing behavior, antivomitting, anticarcinogenic, antiinflammatory, antiplatelet, anti-ulcer, anticonvulsive and analgesic and cardiovascular properties of the oil as well as to identify the most potent components of the oil concerning the treatments for the above matters.

Acknowledgments

The authors are grateful to Payame Noor University for financial support.

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