

Microwave extraction of Ginger

Yadav Rahul¹, Tripathi Sandeep², Prajapati Sumit³, Rathore A.K.⁴

^{1, 2, 3, 4} Department of Chemical Engineering, H.B.T.I Kanpur, India

Abstract

The purpose of this study is to extract essential oil from ginger (*Zingiber Officinale Roscoe*) using water as a solvent by modifying conventional microwave (equipped by condenser at the top). Essential oils from aromatic herbs like ginger are extensively used in food industry and medicines. The preliminary lab study shows essential oil extracted by microwave by adding 200 ml of water in crushed samples is comparatively higher than oil obtained from small pieces and crushed samples. The oil obtained from crushed samples (which are soaked in water for 16 hours) is quite same as extracted by adding 200 ml water. The results showed that the solvent and size of ginger affects the extraction process. From GC-MS analysis essential oil of ginger was found to contain four major compounds such as *zingiberene*, *β -sesquiphellandrene*, *β -phelladrene* and *cineol*.

Keywords: *Ginger* (*Zingiber Officinale Roscoe*), *Microwave extraction*, *Essential oil*, Gas chromatography–mass spectrometry (GC–MS).

1. Introduction

Essential oil is usually used to describe any concentrated, hydrophobic (immiscible with water), typically lipophilic (fat soluble) liquid of plants that contains highly volatile aroma compounds and carries a distinctive scent, flavor or essence of the plant. Interest in essential oil has received attention in recent decades because of the popularity of aromatherapy to rejuvenate body. The essential oils are thought to be vital for the life of the plant as they contain compounds that help them to fight parasites and infections. For humans, essential oil is used in perfumes, cosmetics, bath products, flavored food and drink and medicinal purposes [1].

The name Ginger is said to be derived from Sanskrit word *srngaveram* meaning “horn root” with reference to its appearance. *Zingiber Officinale Roscoe* or its common name ginger is a perennial herb which is said to originate from India, China and Java, Africa and the West Indies [2, 3, 4, and 5]. Ginger mainly consists of three parts: (i) rhizomes (ii) flowers (iii) fruits. The main chemical constituent

is zingiberene. Ginger has peppery flavor and is slightly sweet with pungent and spicy aroma. Six forms like fresh ginger, dried ginger, pickled ginger, preserved ginger, crystallized ginger and ground ginger are used in different cuisines. Gingers are distinguished by the presence of labellum, formed by the fusion of two sterile stamens, and by the presence of essential oils in their tissues. The obtained extracts from the roots often contain polyphenol compounds (6-gingerol, 8-gingerol, 10-gingerol and its derivatives) [6, 7, 8], which have a high antioxidant activity [9] and anti-inflammatory effect [10].

Now days, microwave assisted extraction have received much attention from the scientists as it gives better yield and selectivity in less time as compared with other extraction methods. No residual solvents, contaminants or artifacts are present in essential oil when essential oils are extracted using microwave thus not only environment friendly but also safe for human consumption. This technology is first demonstrated in 1992, by Pare [11]. Recently, usages of microwave as a heating source afford fast in situ heating of volatiles [12, 13, 14, and 15]. Microwave assisted techniques have been described as time saving, energy saving and highly efficient [16].

In most literature, the essential oil content in the dry rhizomes is reported to be about 0.85-2% [17]. The essential oil yield from ginger differs according to origin as from China (0.98%), Thailand (1.58%), Nigeria (2.4%) and Egypt (0.96-0.85%) [18, 19].

2. Method

The most important production method for essential oils is steam distillation. It is carried out in different ways depending on the botanical characteristic, nature and condition of material. One of the most promising variations is microwave extraction of essential oil from ginger roots. Five different ways were tried and compared to extract essential oil from ginger.

In the first experiment, 100 gm of crushed ginger was micro waved for 1 hour without addition of any solvent or water at atmospheric pressure. The internal heating of the in situ water within the ginger oil glands and sacs causes the rupture of the glands and oleiferous receptacles. The removed essential oil gets evaporated along with in situ water of the plant material. A cooling system outside the microwave oven condenses the distillate continuously.

In the second experiment, 100 gm of small pieces (1 cm) of ginger were heated for 1 hr without addition of any solvent or water and the oil is condensed by over head condenser.

In third experiment, 100 gm of crushed sample was heated with addition 200 ml of water to crushed ginger and then micro waved for 1 hour.

In the fourth experiment the 100 gm of crushed samples of ginger was soaked in water for 16 hours and was then heated by microwave for 1 hr without addition of any solvent or water and in the last experiment (6 th) 100 gm of small pieces (1 cm) of ginger were soaked in water for 16 hours and then heated by microwave for 1 hr without addition of any solvent.

2.1 GC-MS analysis of essential oil

A standard gas chromatograph-mass spectroscope was used for the analysis of ginger oil obtained from *Zingiber Officinale* Roscoe. The analysis was carried out at a Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow. For GC-MS analysis, a HP-5MS capillary column (30 m x 0.25 mm i.d. x 0.25 µm film) was used. The column oven temperature was programmed to rise from initial temperature of 40°C (3 min) to 160°C at 6°C min⁻¹, then to 300°C (10 min) at 10°C min⁻¹. The injection temperature and ion source temperature were 250 and 280°C, respectively. Helium was used as the carrier gas with a flow rate of 1 ml min⁻¹. The ionizing energy was 70 eV.

2.2 Experimental Setup

Solvent-free microwave extraction method was reported to be an efficient extraction method in terms of selectivity, yield and speed. SFME is combination of microwave heating and dry distillation, performed

at atmospheric pressure without adding any solvent or water. Solvent free microwave extraction has been performed in a multi-mode microwave oven with frequency of 2450 MHz and delivers a maximum power of 800 W. The dimensions of the oven cavity are 206 mm (H) x 300 mm (W) x 302 mm (D).

A cooling system outside the microwave oven condenses the distillate continuously as shown in the figure .1.

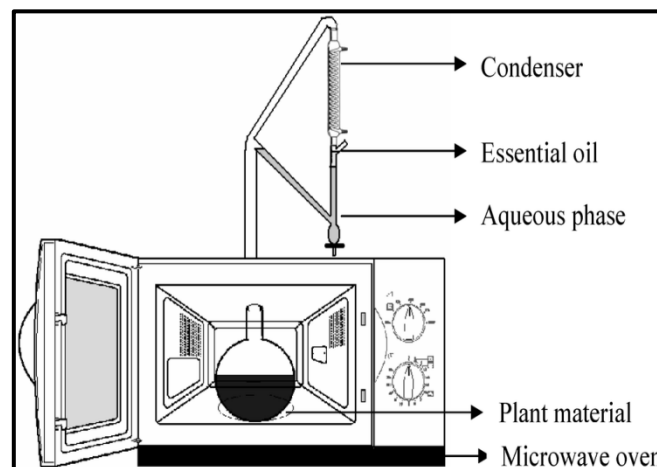


Fig.1: Experimental setup

3. Results and Discussion

Table 1: Variation of % oil obtained with respect to time of crushed samples of same weight

Sample No.	Time (min)	Oil obtained (ml)
	0	0
S ₁	30	0.19
S ₂	40	0.22
S ₃	50	0.27
S ₄	60	0.30
S ₅	70	0.30

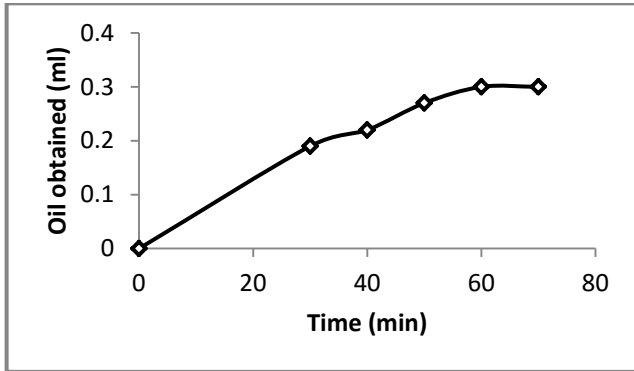


Fig.2: Variation of oil obtained with time

Table 2: Variation of oil obtained with respect to time of small pieces (1 cm) of the samples of same weight

Sample No.	Time (min)	% Moisture Content
	0	0
S ₆	30	0.18
S ₇	40	0.20
S ₈	50	0.24
S ₉	60	0.26
S ₁₀	70	0.26

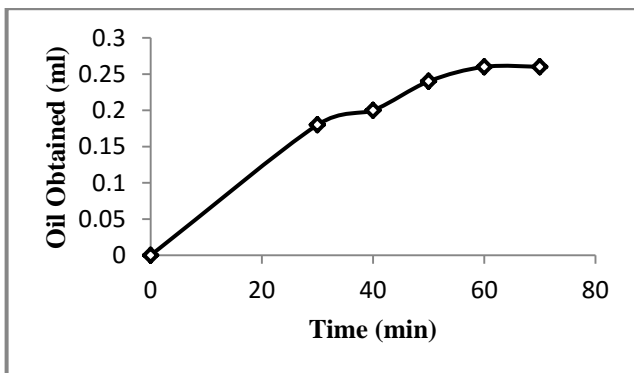


Fig.3: Oil obtained from small pieces (1 cm)

Table 3: Variation of oil obtained with respect to time of crushed samples of same weight with addition of 200 ml of water

Sample No.	Time (min)	Oil obtained (ml)
	0	0
S ₁₁	30	0.22
S ₁₂	40	0.26
S ₁₃	50	0.30
S ₁₄	60	0.33
S ₁₅	70	0.33

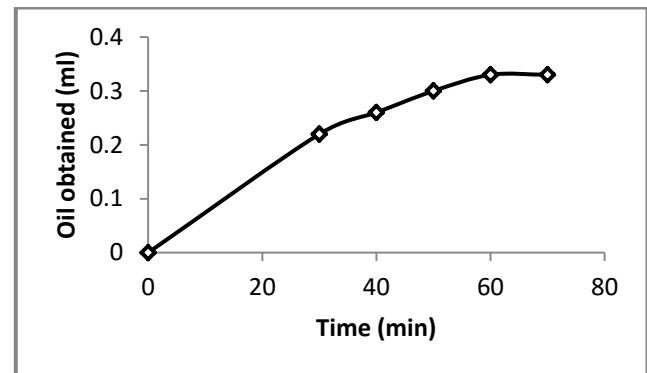


Fig.4: Oil obtained from crushed samples with addition of water

Table 4: Variation of oil obtained with time of crushed samples soaked in water for 16 hrs.

Sample No.	Time (min)	Oil Obtained (ml)
	0	0
S ₁₆	30	0.21
S ₁₇	40	0.27
S ₁₈	50	0.31
S ₁₉	60	0.33
S ₂₀	70	0.33

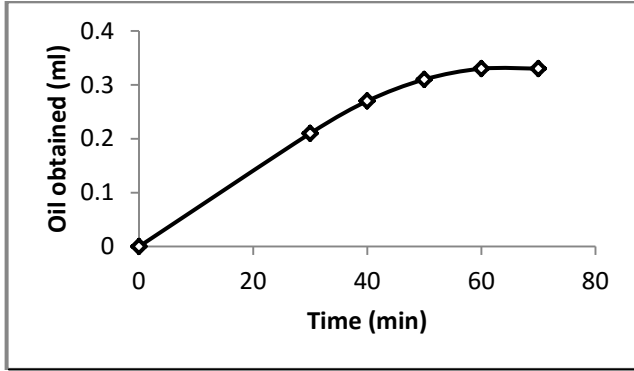


Fig.5: Oil obtained from crushed samples soaked in water

Table 5: Variation of oil obtained with respect to time from small pieces (1 cm) of same weight soaked in water for 16 hrs.

Sample No.	Time (min)	Oil obtained (ml)
	0	0
S ₂₁	30	0.19
S ₂₂	40	0.21
S ₂₃	50	0.24
S ₂₄	60	0.26
S ₂₅	70	0.26

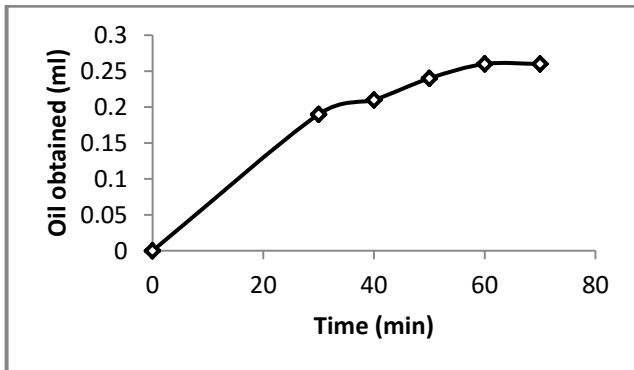


Fig.6: Variation of oil obtained from small pieces soaked in water

Table 6: Variation of oil obtained with crushed samples of different weight at constant time

Sample No.	Sample weight (gm)	Oil Obtained (ml)
S ₂₆	100	0.30
S ₂₇	150	0.41

S ₂₈	200	0.53
S ₂₉	250	0.67
S ₃₀	300	0.79

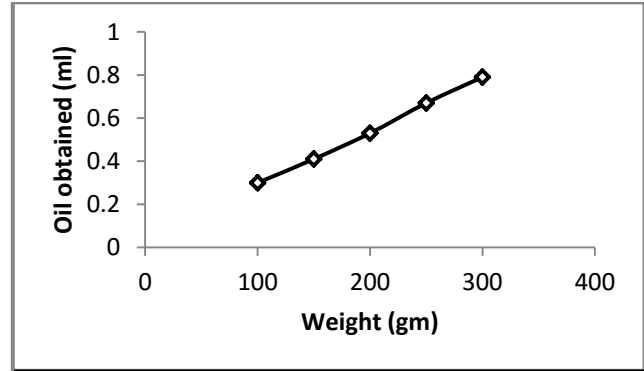


Fig.7: Oil obtained from crushed samples of different weight

Table 7: Variation of oil obtained from different crushed samples of same weight

Sample No.	Oil Obtained (ml)
S ₃₁	0.29
S ₃₂	0.31
S ₃₃	0.30
S ₃₄	0.30
S ₃₅	0.31

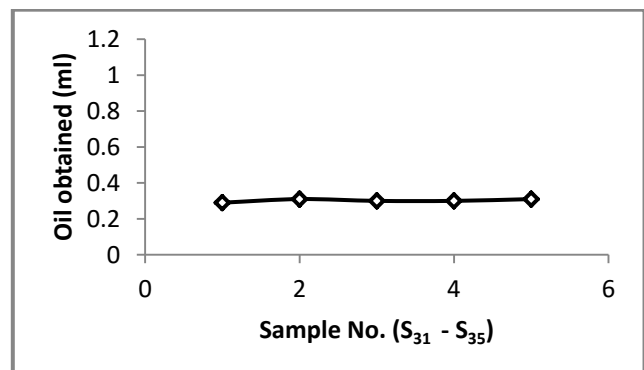


Fig.8: Oil content for crushed samples of same weight

Above the figures and tables show the variation of oil obtained (ml) with respect to time (min) for 5 methods of extraction of ginger essential oil. The maximum oil was obtained for sample which was crushed (then 200ml of water was added) and for the sample soaked in water for 16 hours and then crushed. The amount of oil extracted in both cases is almost

identical as they have higher water content in comparison to other samples. The result suggests that water molecule plays an important role in microwave extraction of essential oil (heat is generated in the interior of matter instantaneously due to dipole rotation and ionic conductance leading to rapid extraction)[20]. Water molecules here vibrate to produce heat under the influence of microwave due to their polarity thus enhancing the extraction of ginger oil. Fig. 7 shows that there is proportional increase in the oil obtained with weight of crushed samples. There was not much variation in the oil extracted when different samples of same weight were taken as shown in the fig. 8.

In GC-MS analysis some compound which are identified by comparison of mass spectra fragmentation pattern and retention time. The major compounds found to be are zingiberene, β -sesquiphellandrene, β -phelladrene and cineol. Data and information obtained from GC-MS have been summarized here in table: 8

Table 8: Summary of GC and GC-MS analysis

S. No.	Retention Time (min)	Identified compound	Molecular weight
1.	10.025	Camphene	136
2.	11.175	6-methyle-5-hepten-2-one	126
3.	11.350	β -myrcene	136
4.	11.775	Octanol	128
5.	13.050	β -phelladrene	136
6.	13.325	2-heptanol	158
7.	19.275	Borneol	154
8.	25.076	2-undecanone	170
9.	27.826	Citronellyl acetate	198
10.	28.901	3-heptadecen-5-yne	234
11.	28.576	2-cyclohexen-1-one	150
12.	34.626	Naphthalene	204
13.	34.801	Germacrene D	204
14.	35.026	β -bisabolene	204
15.	35.676	β -sesquiphellandrene	204
16.	40.151	Zingiberene	204
17.	49.376	(-)-AR-Curcumene	202
18.	13.150	1,8-Cineole	154

4. Conclusion

The present investigation of microwave extraction of ginger (*Zingiber Officinale* Roscoe) shows the important role of water in augmenting the extraction and thus reducing the time of operation which can result in considerable energy savings.

References

- [1] Bartley, J.P., Jacobs, A.L., 2000. Effects of drying on flavor compounds in Australian-grown ginger (*Zingiber officinale*). Journal of the Science of Food and Agriculture 80 (2), 209–215.
- [2] Bartley, J.P., Foley, P., 1994. Supercritical fluid extraction of Australian-grown ginger (*Zingiber officinale*). Journal of the Science of Food and Agriculture 66 (3), 365–371.
- [3] Bailey-Shaw, Y.A., Williams, L., Junor, G., Green, C.E., Hibbert, S.L., Salmon, C., Smith, A.M., 2008. Changes in the contents of oleoresin and pungent bioactive principles of Jamaican ginger (*Zingiber officinale* Roscoe.) during maturation. Journal of Agricultural and Food Chemistry 56 (14), 5564–5571.
- [4] Macleod, A.J., Pieris, N.M., 1984. Volatile aroma constituents of Sri Lankan ginger. Phytochemistry 23 (2), 353–359.
- [5] Vanbeek, T.A., Posthumus, M.A., Lelyveld, G.P., Phiet, H.V., Yen, B.T., 1987. Investigation of the essential oil of Vietnamese ginger. Phytochemistry 26 (11), 3005–3010.
- [6] Pawar, N., Pai, S., Nimbalkar, M., Dixit, G., 2011. RP-HPLC analysis of phenolic antioxidant compound 6-gingerol from different ginger cultivars. Food Chemistry 126 (3), 1330–1336.
- [7] Schwertner, H.A., Rios, D.C., 2007. High-performance liquid chromatographic analysis of 6-gingerol, 8-gingerol, 10-gingerol, and 6-shogaol in ginger-containing dietary supplements, spices, teas, and beverages. Journal of Chromatography B 856 (1–2), 41–47.
- [8] Zhan, K.Y., Xu, K., Yin, H.Z., 2011. Preparative separation and purification of gingerols from ginger (*Zingiber officinale* Roscoe) by high-speed counter-current chromatography. Food Chemistry 126 (4), 1959–1963.
- [9] Stoilova, I., Krastanov, A., Stoyanova, A., Denev, P., Gargova, S., 2007. Antioxidant activity of a ginger extracts (*Zingiber officinale*). Food Chemistry 102 (3), 764–770.

- [10] Dugasani, S., Pichika, M.R., Nadarajah, V.D., Balijepalli, M.K., Tandra, S., Korlakunta, J.N., 2010. Comparative antioxidant and anti-inflammatory effects of [6]-gingerol, [8]-gingerol, [10]-gingerol and [6]-shogaol. *Journal of Ethno pharmacology* 127 (2), 515–520.
- [11] J. R. J. Pare, “Microwave assisted process for extraction and apparatus therefore,” Canadian patent, CA 2055390, 1992.
- [12] Kosar, M., Tunalier, Z., Ozek, T., Kurkcuoglu, M. & Baser, K. H. C. (2005). A Simple Method to Obtain Essential Oils from *Salvia triloba* L. and *Laurus nobilis* L. by Using Microwave-assisted Hydrodistillation, *Z. Naturforsch. C* 60, 501.
- [13] Lucchesi, M. E., Chemat, F. & Smadja, J. (2004a). An original solvent free microwave extraction of essential oils from spices, *Flavor. Frag. J.* 19, 134-138.
- [14] Lucchesi, M. E., Chemat, F. & Smadja, J. (2004b). Solvent-free microwave extraction of essential oil from aromatic herbs: comparison with conventional hydrodistillation, *J. Chromatogr. A* 1043, 323-327.
- [15] Lucchesi, M. E., Smadja, J. & Bradshaw, S. (2007). Solvent Free Microwave Extraction of *Elletaria cardamomum* L.: A multivariate study of a new technique for the extraction of essential oil, *J. Food Eng.*, 79, 1079-1086.
- [16] Wang, Z. M., Lan, D., Li, T. C., Zhou, X., Wang, L., Zhang, H. Q., Liu, L., Li, Y., Liu, Z. H., Wang, H. J., Zeng, H. & He, H. (2006). Improved solvent-free microwave extraction of essential oil from dried *Cuminum cyminum* L. and *Zanthoxylum bungeanum* Maxim, *J. Chromatogr. An* 1102, 11.
- [17] Noor, A.M., K. Mustafa and M.N. Azlina, 2004. Changes of cell structure in ginger during processing. *J. Food Eng.*, 62(4): 359-364.
- [18] Sultan, M., H.N. Bhatti and Z. Iqbal, 2005. Chemical analysis of essential oil of ginger (*Zingiber officinale*). *Pak. J. Biol. Sci.*, 8(11): 1576-1578.
- [19] El-Baroty, G.S., H.H. Abd El-Baky, R.S. Farag and M.A. Saleh, 2010. Characterization of antioxidant and antimicrobial compounds of cinnamon and ginger essential oils. *Afr. J. Biochem. Res.*, 4(6): 167-174.
- [20] Camel, V., 2001. Recent extraction techniques for solid matrices-supercritical fluid extraction, pressurized fluid extraction and microwave-assisted extraction: their potential and pitfalls. *Analyst* 126, 1182-1193.

Author Profile

Mr. Sumit Prajapati did his M.Tech. in Chemical Engineering from HBTI Kanpur in 2013 and B.Tech in Chemical Engineering from AEC Agra in 2011. Mr. Sumit is working as a Guest Faculty in Department of Chemical Engineering at HBTI Kanpur. His research focuses on Modeling & Optimization and Reactive Extraction. Tel.: 91-8574061496, Email: sumitprajapati236@gmail.

Mr Rahul Yadav did his M.Tech from HBT I Kanpur and his research interests are essential oil and catalysis.

Mr. Sandeep Tripathi is pursuing his M.Tech in Chemical Engineering from HBTI Kanpur and B.Tech in Chemical Engineering from U.I.E.T, C.S.J.M University, and Kanpur (U.P) in 2012. His research focuses on Modeling & simulation, Extractive Distillation and Reaction Engineering. Email: sandeetripathi13@gmail.com

Mr. Ashwani Kumar Rathore is pursuing PhD in Chemical Engineering from MANIT Bhopal, M.Tech. in Chemical Engineering from HBTI Kanpur and B.Tech in Chemical Engineering from GEC Raipur (presently NIT Raipur). Mr. A.K Rathore is working as an Assistant Professor in Department of Chemical Engineering at HBTI Kanpur. His research focuses on Reactive extraction, and Catalysis. Tel: +91-9721456051 Email: akrathore75@gmail.com