

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900

Open access books available

186,000

International authors and editors

200M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com



Utilisation and Functional Components Evaluation of Ginger

Suwijiyo Pramono

Abstract

Ginger is a Zingiberaceae plant having different purposes in the community and industry. The important parameters of quality of ginger are the functional components so the aims of this chapter are to review the utilisation of ginger in the community and industry and to evaluate the functional components of ginger and its products. Ginger (*Zingiber officinale* Roscoe) has at least three types, i.e. big ginger, small ginger and red ginger. Fresh, dried and preserved ginger and also its extract, oleoresin and volatile oil were considered as basic products of the utilisation of ginger. Different formulas have been developed for drinks, culinary purposes, flavouring desert and herbal medicines. In folk medicines, ginger is used as remedy for warming body, gastritis and fracture condition. Based on scientific researches, ginger has been developed as anti-emetic, anti-inflammatory, analgesic and anti-influenza. Evaluation of chemical constituents of ginger and its products can be done qualitatively for authentication and quantitatively for standardization. This chapter consists of the utilisation of ginger based on empirical and scientific data, and the functional components evaluation consisting of authentication and standardization.

Keywords: ginger, utilisation, functional components, authentication, standardization

1. Introduction

Ginger (*Zingiber officinale* Roscoe) is a Zingiberaceae plant having different purposes in the community and industry. People use its rhizome as spice, drink, or as a component of herbal medicines. People use fresh or dried rhizomes and preserved ginger. The scientific name of plant material is Rhizoma Zingiberis. Actually there are several genus *Zingiber* in Zingiberaceae family such as *Zingiber zerumbet*, *Z. amaricans*, *Z. aromaticum* and *Z. purpureum* and the name of plant material must completely refer to the name of species such as Rhizoma Zingiberis Zerumbeti and Rhizoma Zingiberis Purpurei, but especially for ginger, the name refers only to genus even though some Pharmacopoeias use the complete name: Rhizoma Zingiberis Officinalis [1]. There are three varieties of ginger, i.e. *Zingiber officinale* var. *officinale*, namely big white ginger or big ginger; *Zingiber officinale* var. *amarum*, namely small white ginger or small ginger; and *Zingiber officinale* var. *rubrum*, namely red ginger. In Indonesia, big white ginger is called jahe gajah (jahe: ginger, gajah: elephant), small white ginger is called jahe emprit (jahe: ginger, emprit: small bird) (**Figure 1**).

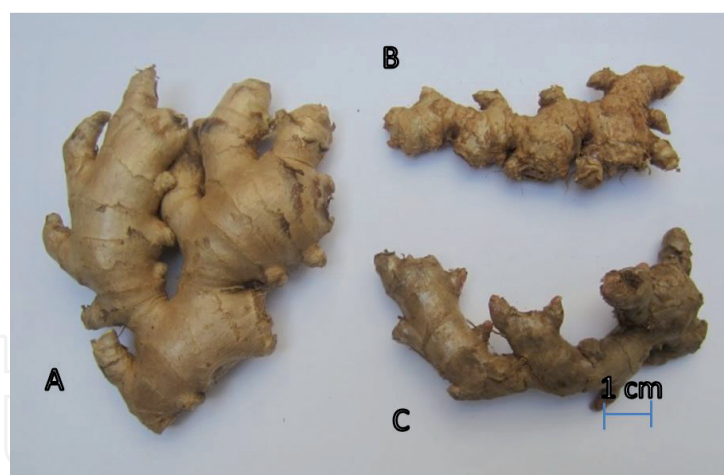


Figure 1.
Fresh ginger: (A) big ginger, (B) small ginger and (C) red ginger.

2. Products of ginger

2.1 Fresh ginger

In South-East Asia, fresh ginger is used in cooking as flavouring or as a vegetable and also to make ginger ale or other drinks. Fresh ginger is prepared from immature or mature rhizomes. Big ginger contains less fibre and is less odorous and less pungent than small and red ginger. Traditionally, people take three fingers of fresh ginger to grate and bandage a sprained leg. The decoction of fresh ginger is taken orally to cure nausea and vomitus [2]. Some traditional drinks often use fresh ginger than the dried one in order to keep the aroma. In the market, there are a lot of ginger products especially in instant dosage form with hot taste but lack of aroma. A remedy for headache caused by influenza is to use 10 g of grilled fresh ginger and 20 g of coconut sugar, boiled with 200 mL water and drink in warm condition. Javanese people have special drink, namely 'serbat', used for warming body, which consists of 5 g fresh ginger, 2 g lemongrass, 2 g clove, 1 g nutmeg, 1 g cinnamon, 2 g kaffir lime leaves, 5 g cubeba fruits and 100 g palm sugar, boiled with 100 mL water for 10 min and then drink 2 times a day, 1 glass each [3].

2.2 Dried ginger

Ginger occurs in horizontal, laterally flattened, irregularly branching pieces, 3–16 cm long, 3–4 cm wide, up to 2 cm thick, sometimes split longitudinally; pale yellowish buff or light brown externally, longitudinally striated, somewhat fibrous, branches known as 'fingers' arise obliquely from the rhizomes, are flattish, obovate and short, about 1–3 cm long; fracture, short and starchy with projecting fibres. Internally, the colour is yellowish brown, showing a separating the narrow cortex from the white stele. It contains and numerous scattered fibrovascular bundles, scattered on the whole surface. Ginger has the following characteristics: odour, aromatic; taste, pungent and aromatic; and colour, internally pale yellow to brown [4]. Dried ginger is used in the form of powder and is applied worldwide for domestic culinary purposes, and also extensively in the flavouring desserts. In folk medicine, dried-powdered ginger is used as component of remedies for certain indications. Powder of 1 g ginger, 1 g cardamom and 1 g cinnamon are mixed, divided into three sachets and taken orally after mixed with 200 mL boiled water, 3 times a day, one sachet each. This remedy is used for curing throat inflammatory [3]. A mixture of 1 g powdered ginger and 2 g rhubarb is divided into three sachets and then taken orally 3 times a day after treated with boiled water to reduce gastritis [3].

2.3 Preserved ginger

There are two methods in preparing preserved ginger. The first one is started by freezing the fresh ginger overnight and then peeling and cutting it into small pieces. Place water and ginger in a 3-quart pan. Remove the ginger and put the liquid back in the pot, add sugar and then boil until the liquid becomes syrup [5]. The second method begins by grating fresh ginger to obtain porridge. Press the porridge with addition small quantity of water and then filter with a funnel and tissue. The sap is evaporated until viscous and then white sugar or maltodextrin is added until crystallization. In Indonesia, this product is popularly named instant ginger product. There are a lot of these dosage form sold in the market with promotive indication [6].

2.4 Extract, oleoresin and essential oils of ginger

The fresh and dried rhizomes of ginger yield an essential oil ('ginger oil') and oleoresin ('ginger extract'). Ginger oil has the aroma and flavour of the spice but lack of pungency. It is used for flavouring beverages and in cosmetics, perfumes and pharmaceuticals. Ginger oleoresin has the aroma and flavour and pungency of the spice. It is more often used in pharmaceuticals. In the United States, the regulatory status 'generally recognized as safe' has been accorded to ginger (GRAS 2520), ginger oil (GRAS 2522) and extract/oleoresin (GRAS 2521/2523) [4].

Ginger has been used medicinally in Asia since ancient times, e.g. in China and India. In Indonesia, there is a term of indication that is not recognized in medical dictionary, i.e. 'masuk angin'. The term "masuk angin" is defined as a weakness condition of body with several symptoms such as flatulent, cool in sweat but high temperature of body, sleepy and pain in the muscles and the bones. The weakness condition of body may be caused by fatigue, decrease of immune system or influenza. The products contain ginger extract as the main component, and it is considered as carminative, stimulant of gastrointestinal tract, rubefacient and counterirritant. An example of famous product consists of *Rhizoma Zingiberis*, *Herba Echinacea*, *Radix Valerian*, *Radix Panax ginseng*, *Fructus Foeniculi*, *Fructus Isorae*, *Semen Myristicae*, *Fructus Amomi*, *Folium Caryophylli* and *Herba Menthae Arvensis* [6]. People consider that 'masuk angin' is similar to influenza. Furthermore, red ginger is considered having more potential as aphrodisiac in comparison to small and big white ginger.

2.5 Pharmacological effects based on utilisation

Pharmacologically, ginger has anti-inflammatory activity with the increase of arachidonic acid oxidation by inhibition of cyclooxygenase and 5-lipoxygenase, resulting in the synthesis of prostaglandin E and leukotriene B₄. An in vitro experiment showed that the aqueous extract of ginger inhibited cyclooxygenase and lipoxygenase and decreased prostaglandin and leukotriene. The in vivo experiment showed that oral treatment of rats with ginger extract reduced paw oedema. Furthermore, an artefact constituent of ginger, namely shogaol, reduced paw oedema of rats induced by carrageenan. Two labdane compounds isolated from ginger showed their ability as inhibitor of 5-lipoxygenase in in vitro experiment. Injection of sterile preparation of ginger extract to 113 patients suffering from rheumatic condition and back bone pain in China reduced the level of pain, nodules and inflammatory, and ameliorated the bone function [7]. Ginger extract showed peripheral antiemetic activity in dog but it did not act on central nervous system. This anti-emetic effect is caused by synergism between zingerone and shogaol. A clinical study showed that the oral treatment of 90 g powdered ginger was more effective in comparison to dimenhydrinate in reducing

motion sickness symptom [8]. The oral treatment of 500 mg/kg BW water extract of ginger for 4 weeks decreased significantly blood cholesterol levels in rats but did not decrease triglyceride levels. Intraperitoneal treatment of this extract decreased blood cholesterol in rats [8].

A crossover design of a double-blind, randomized placebo-controlled study on 13 patients with history of motion sickness and circularvection showed that pretreatment of 1000 and 2000 mg water extract of ginger reduced significantly headache, nausea and plasma vasopressin [8]. Ginger also increased tonus and peristaltic of stomach [9]. A double-blind randomized trial without placebo compared with scopolamine, dimenhydrinate and other conventional drugs on 1489 voluntary subjects 2 h after pretreatment with 500 mg ginger before journey with car did not have problem of motion sickness, statistically similar to all tested conventional drugs [10]. A one double-blind placebo-controlled trial on women after gynaecologic surgery randomly treated with 1 g powdered ginger or 10 mg metoclopramide showed that patients with ginger treatment had less problem of vomiting [11]. From six double-blind randomized clinical trials (RCT) with a total of 675 voluntary patients and a prospective observational cohort study ($n = 187$), 4 of 6 RCT showed high significant difference between ginger treatments and placebo; 2 RCT showed that ginger treatments were more effective than those of Vit B₆ in managing nausea and vomiting. There was no report on the undesirable effect in pregnancy [12].

Based on empirical and scientific data until 1999, the World Health Organization divided ginger utilisation into three categories [13]:

Uses described in folk medicine, not supported by experimental or clinical data: to treat cataracts, toothache, insomnia, baldness, and haemorrhoids and to increase longevity.

Uses described in pharmacopoeias and in traditional systems of medicine: to treat dyspepsia, flatulence, colic, vomiting, diarrhoea, spas and other stomach complaints. Powdered ginger is further employed in the treatment of colds and flu, to stimulate the appetite, as a narcotic antagonist and as an anti-inflammatory agent in the treatment of migraine headache, rheumatic and muscular. In addition, Chinese *Materia Medica* mentioned the use of ginger in the treatment of abdominal pain due to cold from deficiency and stagnant blood; to warm the middle and expel cold: for warming the spleen and stomach both in condition of excess due to externally contracted cold, as well as cold from deficiency due to insufficiency of the yang qi; to warm the lungs and transform phlegm: for lung cold with expectoration of thin, watery, or white sputum; to warm the channels and stop bleeding: for cold from deficiency that may present with haemorrhage of various types, especially uterine bleeding. It is used in treating haemorrhage only if the bleeding is chronic and pale in colour, and is accompanied by cold limbs, ashen white face, and a soggy, thin pulse [14].

Uses supported by clinical data: the prophylaxis of nausea and vomiting associated with motion sickness, postoperative nausea, pernicious vomiting in pregnancy, and seasickness. However, the use of ginger for early pregnant woman must be careful because there were several experiments that showed teratogenic effect on rats.

In addition, based on scientific data published after 1999, utilisation of ginger has been developed as an analgesic and anti-inflammatory agent. Ginger extract has a beneficial influence on morphine analgesia and can be an efficacious adjunct for pain management [15]. Ginger oil (0.25–1.0 g/kg) inhibited significantly carrageenan-induced paw oedema, active as adjuvant arthritis, anti-inflammatory mediators-induced vascular permeability in rats [16]. An ethanolic extract of ginger (50 and 100 mg/kg BW) produced significant inhibition of carrageenan-induced rat paw oedema and a reduction in the number of writhing induced by acetic acid in mice [17]. Other potential benefits of ginger are antimicrobial, lowering blood pressure, lowering cholesterol, antiplatelet aggregation, chemopreventive agent, antioxidant

and hypoglycemic properties [18]. However, the antiplatelet aggregation effect gives the possibility in enhancing blood dilution effect of acetosal, vitamin K, heparin and other blood dilution substances. Ginger essential oils were reported having appetite stimulant property in rats, so it will be contradictive with its lowering cholesterol effect. The relatively high dose of ginger can stimulate lacrimation due to its hot taste.

3. Evaluation

The use of traditional medicines in a country is part of the practice and culture for centuries. However, in general, herbal materials have not been supported by adequate standardization. In this respect, it is deemed necessary to establish standards of herbal material as reference to reach optimum health control. In general, pharmacopoeia is a good choice to be a reference for the evaluation of an herbal material such as ginger. If an herbal material complies to the standard, it will give reproducibility of product to be marketed. Evaluation of herbal material consists of qualitative and quantitative assessment. The qualitative assessment is applied for identification and authentication, while the quantitative assessment is applied for standardization. Authentication of ginger can be done by evaluation of description, microscopic data and chromatography. The last one can be thin-layer chromatography, high-performance liquid chromatography or other qualitative methods. Standardization of ginger consists of loss on drying, total ash, acid-insoluble ash, water-soluble extract, ethanol-soluble extract and chemical content. The last one can be determined by spectrophotometry or chromatography analysis.

4. Description

The sliced thin rhizome has a short-branch edge and reverse egg shape, is usually 3–4 cm in length and has 1–6.5 mm thickness, and is yellowish white coloured. Outer part is yellowish brown. Cross-sectional cut shows narrow cortex, with the depth of less than a third from the radius and endoderm. Xylem vessel is spread and greyish; oil globules are yellowish smaller spots. It has strong characteristic odour and spicy taste [1] (**Figure 2**).



Figure 2.
Dried ginger rhizome.

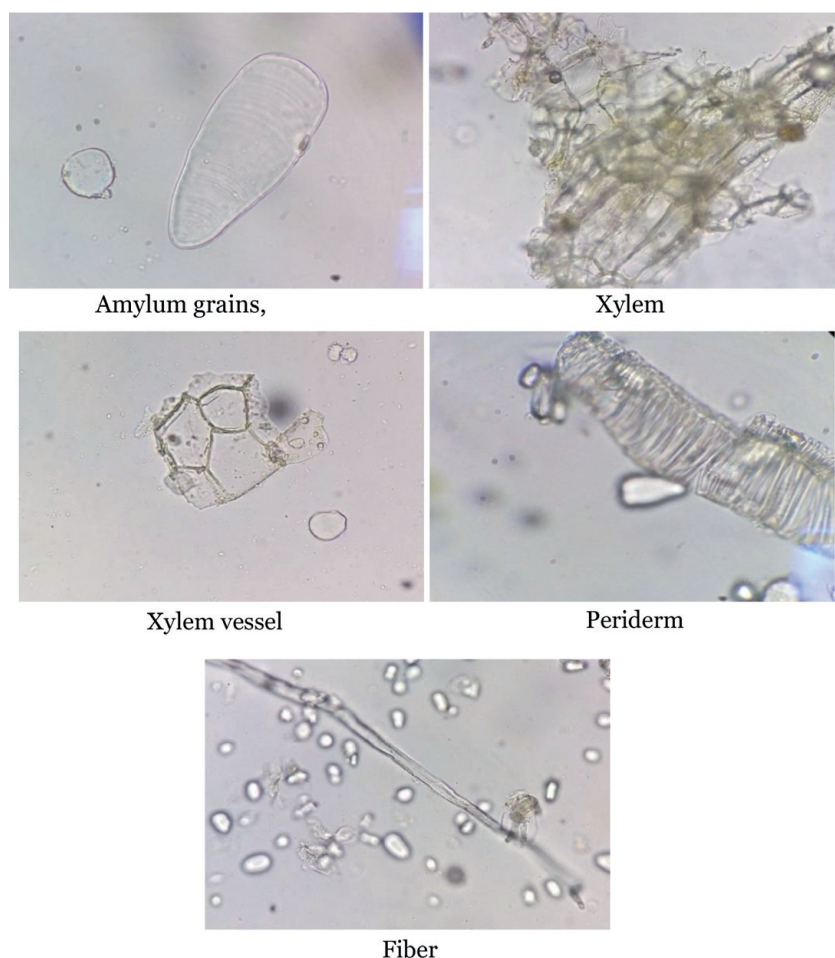


Figure 3.
Fragments of ginger powder.

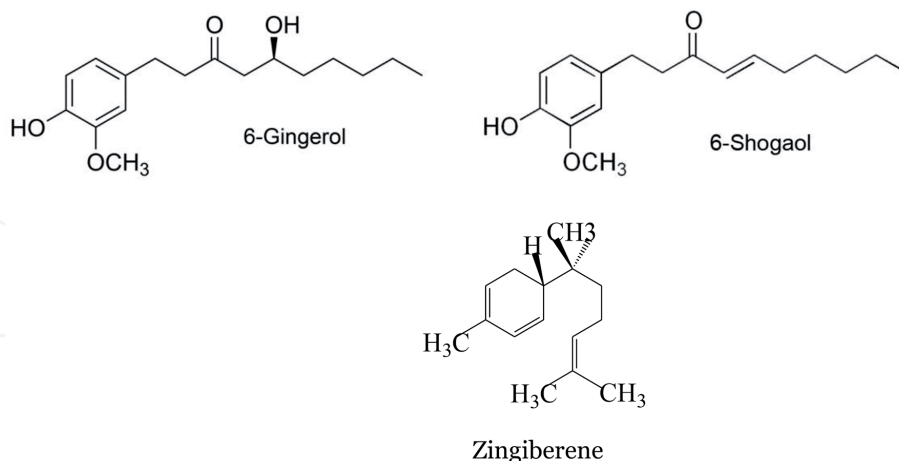
5. Microscopic

Identification fragments are amylum, xylem, xylem vessel, periderm and fibers [1] (**Figure 3**).

6. Chemical compounds as base of evaluation

Ginger contains two groups of important chemical constituents: 1 g volatile oil and pungent principle. The volatile oil or essential oil gives the odour of the plant material, while the second one is not volatile and gives the pungent taste of the rhizome. The composition of volatile oil varies as a function of geographical origin, but the main constituent sesquiterpene hydrocarbons (responsible for the aroma) seems to remain constant. These compounds include (–) zingiberene, (+) ar-curcumene, (–) β -sesquiphellandrene and β -bisabolene. Monoterpene aldehyde and alcohol are also present. On the other hand, the chemical components of pungent principle are gingerols (having a side chain with 7–10, 12, 14 or 16 carbon atoms, respectively) and their corresponding dehydration products which are known as shogaols [19]. Among the components of the pungent principle of ginger, 6-gingerol (IUPAC name: (S)-5-hydroxy-1-(4-hydroxy-3-methoxyphenyl)-3-decanone) and 6-shogaol are the most available in the market. Thin-layer chromatography (TLC) and high-performance liquid chromatography (HPLC) are suitable for analysis of pungent principles, while gas chromatography-mass spectroscopy is suitable to identify the components of volatile oil. Even though if the sample to be

analysed is in the form of ethanolic extract, the obtained data will contain components of volatile oil and those of pungent principle.



7. Thin-layer chromatography

If one of the standard references (zingiberene, 6-gingerol or 6-shogaol) is available, use it for TLC analysis. If it is not available, use eugenol as standard reference.

Carry out thin-layer chromatography (TLC) using the following parameters:

Mobile phase: toluene—ethyl acetate (93:7 v/v); stationary phase: silica gel 60 F₂₅₄; test solution: 10% ginger powder in ethanol; standard solution: 1.0% eugenol in ethanol; spotted volume: apply separately 3 μ L test solution and 1 μ L standard solution in the plate; detection: anisaldehyde-sulphuric acid, dry at temperature 100°C for 5–10 min (**Figure 4**).

This procedure of TLC analysis uses eugenol as standard reference because it is not easy to obtain shogaol as a marker substance. The correct evaluation is TLC with zingiberene, gingerol or shogaol as a standard reference and R_f will be used instead of R_x. Furthermore, the use of reagent for visualization such as anisaldehyde-sulphuric acid is lack of reproducibility. If the constituents of plant material have fluorescence under UV light such as those from ginger, it will be better to perform TLC without reagent for visualization. The following figures represent TLC profile of the three varieties of ginger with same system of TLC such as mentioned above.

Mobile phase: toluene—ethyl acetate (93:7 v/v); stationary phase: silica gel 60 F₂₅₄; test solution: 10% ginger powder in ethanol; standard solution: 1.0% 6-shogaol in ethanol; spotted volume: apply separately 3 μ L test solution and 1 μ L standard solution in the plate; detection: UV₃₆₆ (**Figure 5**).

The quantitative evaluation can be done by TLC-densitometry if shogaols or gingerols are available in laboratory. If not, UV/vis spectrophotometry can be used to determine total phenol using Folin-Ciocalteu method. In this method, eugenol can be used as a standard reference. It must be noted that TLC method is the most recommended method for phytochemical screening and not only for the colour and precipitation observation in the tube. As we know that the colours of extract to be tested are generally green or light chocolate. It gives confusion to the colour produced by reaction occurs. In the colour reaction test of flavonoid for example, the produced colour in the tube is yellow. If it is not intensively appears it will be difficult to justify when the extract solution in the tube is green or light chocolate. There were some publications reporting the existence of alkaloid in ginger according to colour reaction in tube. After verification by TLC method, the result was negative, so the colour reaction in tube was not true and we called it as a false

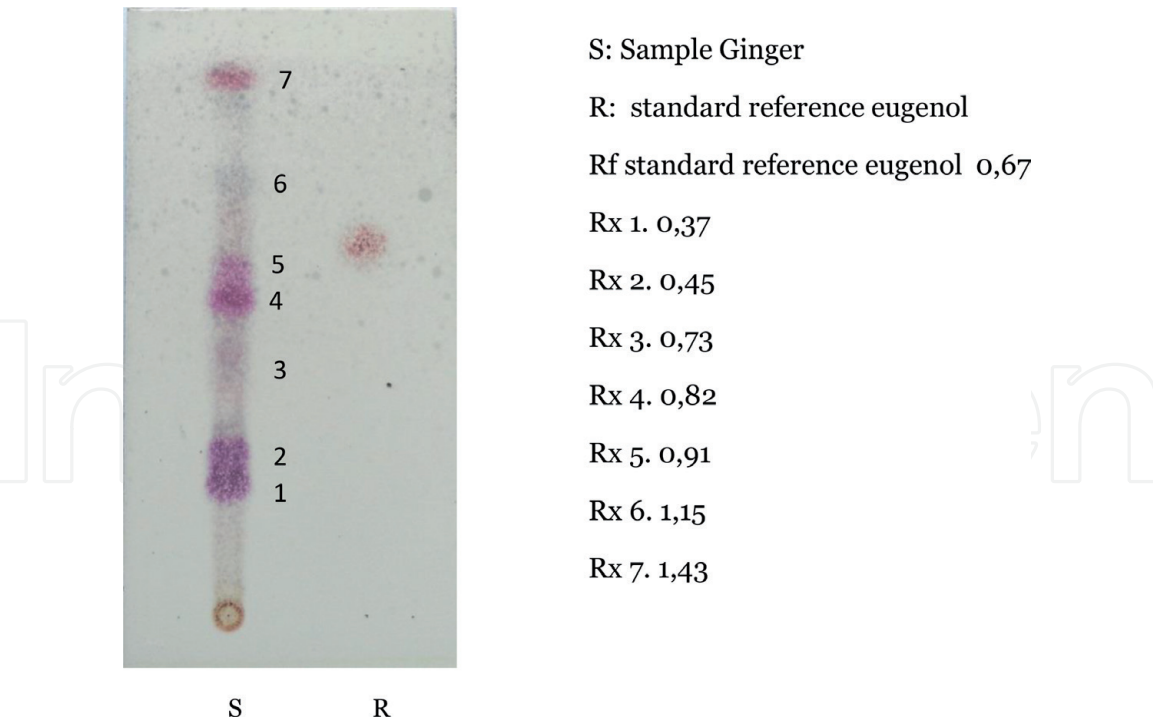


Figure 4.
TLC profile of ginger.

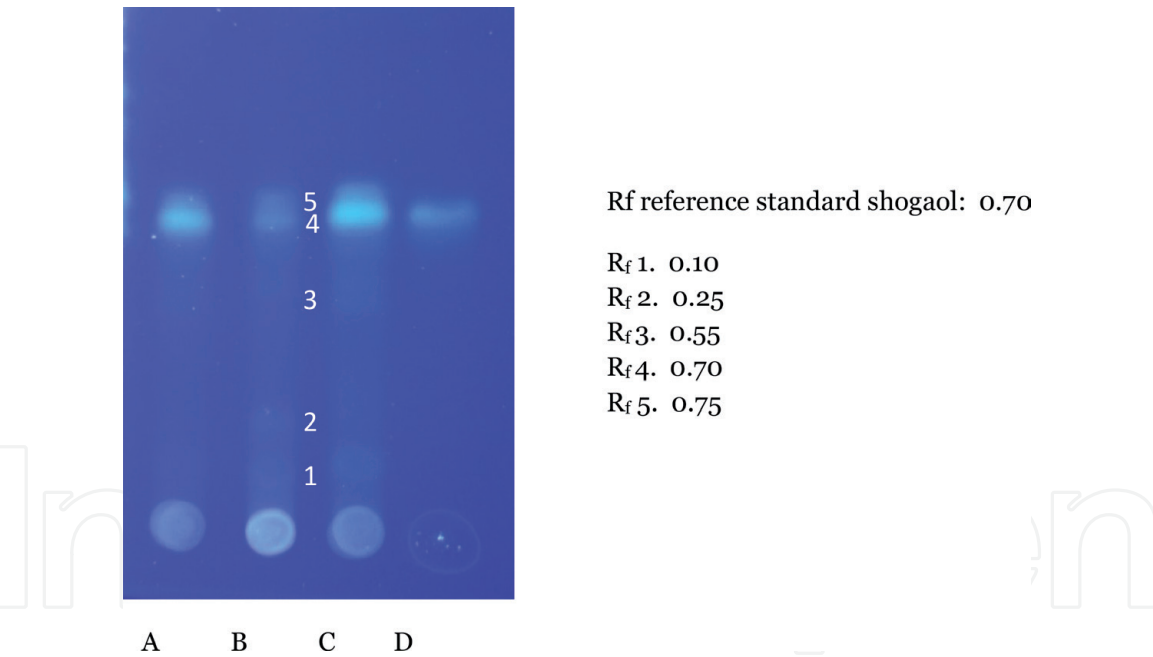


Figure 5.
TLC profile of 3 ginger varieties: (A) small ginger, (B) big ginger, (C) red ginger and (D) 6-shogaol.

positive reaction. According to chemotaxonomic approach, the existence of alkaloid in Zingiberaceae family is very rare. The similar case is sometimes found in the colour reaction of steroid. The appearance of red-pink colour in green solution is not easy to be detected; hence, it will be better and clear if we use TLC methods.

8. High-performance liquid chromatography

There are several publications concerning the HPLC analysis of ginger. Kawakishi et al. used Develosil ODS-5 column (8 × 250 mm),

methanol-water-acetic acid (80:20:1, v/v/v) mobile phase at flow rate of 3 mL/min; detection at 254 nm [20]. Schwertner and Rios analysed 6-gingerol, 8-gingerol, 10-gingerol and 6-shogaol in ginger-containing dietary supplements, spices, teas and beverages on C-8 reverse phase column at 282 nm [21]. A simple HPLC method for analysis 6-gingerol in multiple shoot cultures of ginger was performed by Cafino using an ODS column and the best mobile phase was found to be methanol-water (90:10, v/v) with retention time observed at 3.8 min [22].

9. Gas chromatography-mass spectrophotometry

Ginger contains two main constituents, volatile oil and pungent substances. The first one gives the specific aroma of ginger, while the second one expresses the pungent taste of ginger. The volatile oil can be isolated by distillation method and then Gas chromatography-mass spectrophotometry can be used for determination of the components.

In order to evaluate the different components in ginger volatile oil, the peaks of chromatogram can be determined, and their chemical structure by comparing the recorded fragmentation with library. Furthermore, quantitative composition of volatile oils can be seen from the values of area versus high of peak (A/H).

Table 1 represents the chemical composition of volatile oils of three varieties of ginger. There is no significant difference between small and big ginger. Some constituents of small ginger such as nerol, E-citral, endobornyl acetate and neryl acetate are not present in both the other variety of ginger. On the contrary, a component of big ginger, namely, geranyl acetate is not present in small ginger, while interestingly volatile oil of red ginger contains substances totally different with those of small and big ginger. These data are in line with the odour of those three ginger. The aroma of small ginger is stronger than big ginger, while the aroma of red ginger is totally different.

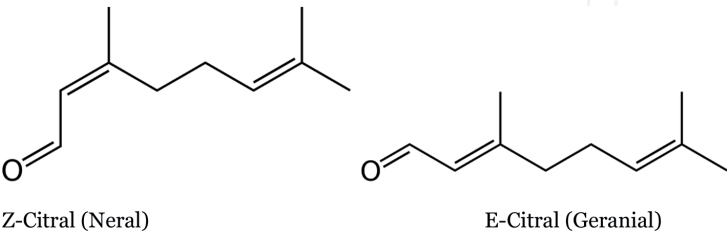
It can be seen in **Figure 6** that all peaks of red ginger essential oil are recorded after 8.9, and there is no overlap with big and small ginger that also can be seen in **Table 1**.

Retention times	Dried small ginger (area/high)		Dried big ginger (area/high)		Dried red ginger (area/high)
8.979	Z-citral	6.04	Z-citral	6.49	
9.261	Nerol	2.64			
9.342	E-citral	1.41			
9.527	Endobornyl acetate	1.26			
10.296			Geranyl acetate	1.73	
10.298	Neryl acetate	2.26			
11.165	Ar-curcumene	1.56	Ar-curcumene	1.24	
11.280	Zingiberene	1.27	Zingiberene	1.48	
11.325			Farnesene	1.14	
11.385	cis-Farnesol	1.18	cis-Farnesol	1.24	
11.493	Beta-sesquiphellandrene	1.22	Beta-sesquiphellandrene	1.29	
11.649			Elemol	1.41	
12.072	Zingiberenol	1.47			
12.355			Hedycaryol	2.01	

Retention times	Dried small ginger (area/high)	Dried big ginger (area/high)	Dried red ginger (area/high)
12.396			Unknown 4.82
12.509			Isospatulenol 1.35
12.589			1H-Benzo-cycloheten-7-ol, 2,3,4,4a,5,6,7,8-octahydro-1,1,4a,7-tetramethyl 1.42
12.650			4-Bromo-1-naphthalen-amine 1.41
12.786			Beta-maaliene 1.29
12.954			3-Oxatricyclo [20.8.0.0E7,16] triaconta-1(22), 7(16),9,13,23,29' 2.22
13.207			Beta-guaiene 1.29
13.318			6-Isopropenyl-4,8A-dimethyl-3,5,6,7,8,8A-hexahydro-1H 1.41
13.473			Zierone 1.15
14.774			9-Octadecenoic acid, methylester

Table 1.
Component profile of volatile oil of small, big and red ginger.

Surprisingly, the data of gas-chromatography-mass spectrophotometry (GC-MS) showed that the percentage of zingiberene and sesquiphellandrene, which are mentioned in the WHO Monograph as responsible substances for specific flavour of ginger, is only 1.27 and 1.22%. The biggest component is z-citral or neral that represents 6.04% in small ginger and 6.49% in big ginger. As mentioned above, the volatile oil of red ginger in point view of its components showed to be totally different from small and big ginger. This is in line with the odour of the rhizome. The odour of small and big ginger is stronger than that of red ginger but the pungent taste of red ginger is stronger than small and big ginger (**Figure 7**).



Unfortunately our bibliography does not have data of the biggest substance of red ginger. The fragmentation according to mass spectrophotometry is shown in **Figure 8**.

The profile of fragmentations until m/e 190 is similar to other constituents but between 190 and 220 is rather difficult to calculate. It is not methyl, acetyl, ethyl or other alkyl. It is interesting to be programmed in the future research.

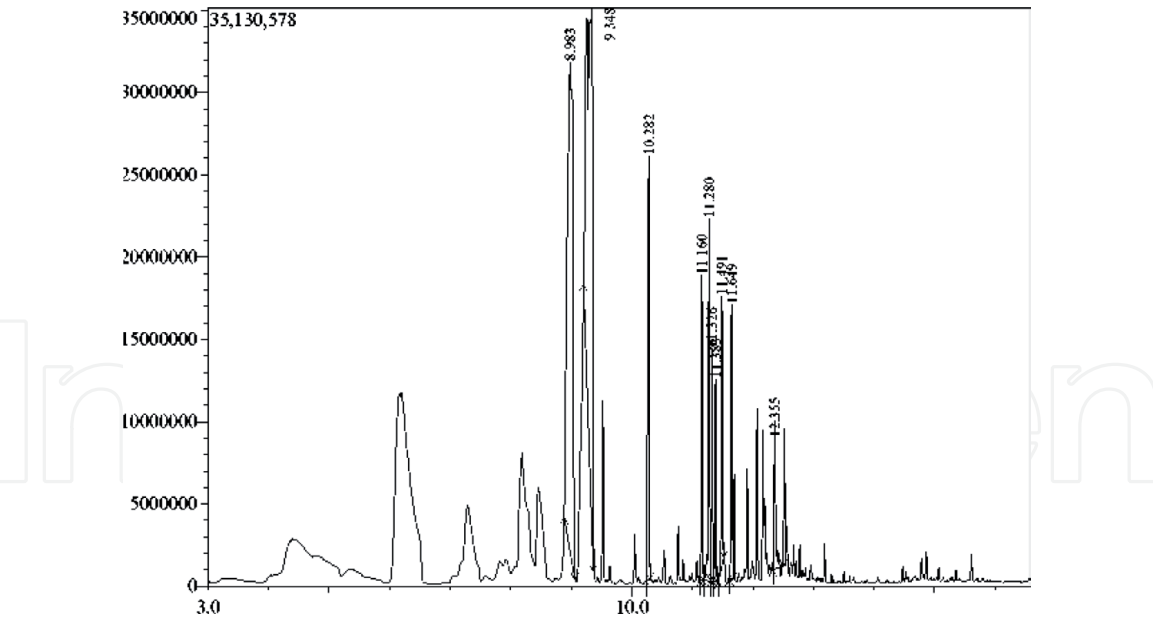
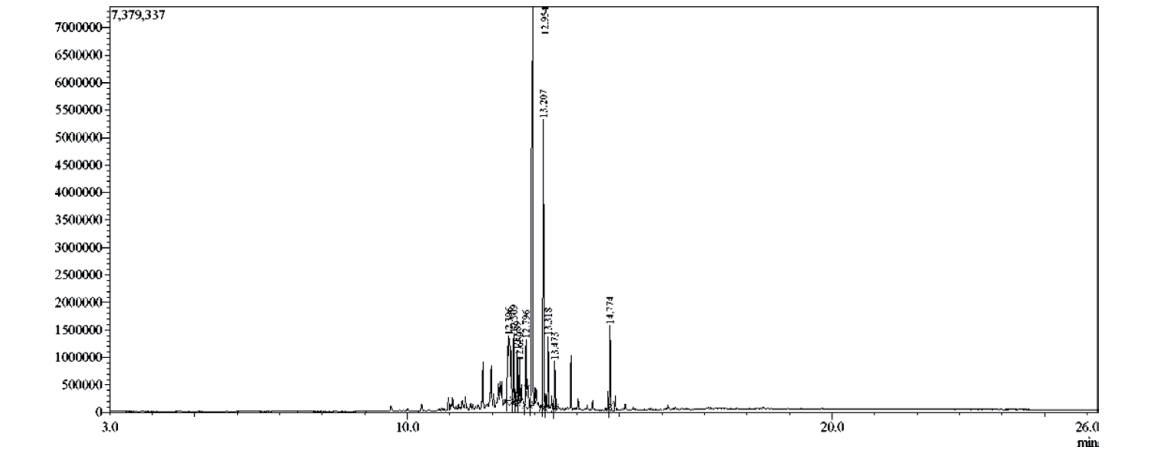


Figure 6.
Profile of gas chromatography of small ginger.



IntechOpen

IntechOpen

Author details

Suwijiyo Pramono

Department of Pharmaceutical Biology, Faculty of Pharmacy, Universitas Gadjah
Mada, Yogyakarta, Indonesia

*Address all correspondence to: suwijiyo_pramono@yahoo.com

IntechOpen

© 2019 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Ministry of Health Republic Indonesia. Indonesian Herbal Pharmacopeia. 1st ed. Jakarta, Indonesia: Directorate General Pharmaceutical Services and Medical Devices, Republic Indonesia; 2012
- [2] Mardisiswoyo S, Rajakmangunsudarso H. Cabe Puyang Warisan Nenek Moyang. Jakarta, Indonesia: Balai Pustaka; 1987
- [3] Ministry of Health Republic Indonesia. Vademekum of Medicinal Plants for Jamu Saintification. Vol. 1. Revised ed. Jakarta, Indonesia; 2012
- [4] de Guzman CC, Siemonsma JS, editors. Plant Resources of South-East Asia, No.13 Spices. PROSEA; Bogor, Indonesia; 1999
- [5] Available from: <https://www.google.com/search?client=firefox-b-d&q=preserved+ginger>
- [6] Pramono S. JAMU, in Indonesian Daily Life and Industry. Toyama, Japan: Institute of Natural Medicine, University of Toyama; 2007
- [7] Thomson N, Al-Qattan KK, Al-Sawan SM, Alnaqeeb KI, Ali M. The use of ginger (*Zingiber officinale* Rosc.) as potential anti-inflammatory and antithrombotic agent. Prostaglandins, Leukotrienes, and Essential Fatty Acids. 2002;67:475-478
- [8] Ghazanfar SA. Handbook of Arabian Medicinal Plants. Boca Raton: CRC Press; 1994
- [9] Bisset N, editor. Herbal Drug and Phytopharmaceutical: A Handbook for Practice on Scientific Basis, Medpharm Scientific. Boca Raton: Stuttgart and CRC Press; 1994
- [10] Schmid R, Sehic T, Steffen R, Tschopp A, Wilk T. Comparison of seven commonly used agents for prophylaxis of seasickness. Journal of Travel Medicine. 1994;1(4):203-206
- [11] Philips S, Ruggier R, Hutchinson SE. *Zingiber officinale* (ginger)—An antiemetic for day case surgery. Anaesthesia. 1993;48(8):715-717
- [12] Borrelli F, Aviello G, Pittler MH, Izzo AA. Effectiveness and safety of ginger in the treatment of pregnancy induced nausea and vomiting. Obstetrics and Gynecology. 2000;106(3):640
- [13] WHO. WHO Monographs on Selected Medicinal Plants. Vol. 1.1999. pp. 277-287
- [14] Bensky D, Gamble A, editors. Chinese Herbal Medicine: Materia Medica. Seattle, Washington: Eastland Press, Incorporated; 1993
- [15] Sepahvand R, Esmaeili-Mahani S, Arzi A, Rasouljan B, Abbasnejad M. Ginger (*Zingiber officinale* roscoe) elicits antinociceptive properties and potentiates morphin-induced analgesia in rat radiant heat tail-flick test. Journal of Medicinal Food. 2010;13(6):1347-1354
- [16] Jia Y, Zhao J, Zhang L, Sun B, Bao Mli F, Shen J, et al. Analgesic and antiinflammatory effects of ginger oil. Chinese Herbal Medicines. 2011;3(2):150-155
- [17] Raji Y, Udoh US, Oluwadara OO, Akinsomisoye OS, Awobajo O, Adhesoga K. Anti-inflammatory and analgesic properties of the rhizome extract of *Zingiber officinale*. African Journal of Biomedical Research. 2002;5:121-124
- [18] Gunathilake K, Rupasinghe V. Recent perspectives on the medicinal potential of ginger. Archived Journals:

Botanics, Target and Therapy.
2015;5:55-63

[19] Yoshikawa M et al. Qualitative and quantitative analysis of bioactive principles in *Zingiberis rhizoma* by means of high performance liquid chromatography and gas liquid chromatography. *Yakugaku Zasshi*. 1993;113:307-515

[20] Kawakishi S, Morimitsu Y, Osawa T. Chemistry of ginger components and inhibitory factors of arachidonic acid cascade. In: Ho C-T et al., editors. *Food Phytochemicals for Cancer Prevention II*. Washington, DC: American Chemical Society; 1994

[21] Schwertner HA, Rios DC. 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*. 2007;856(1-2):41-47

[22] Cafino EJV, Lirazan MB, Marfori EC. A simple HPLC method for analysis 6-gingerol in multiple shoot cultures of ginger. *International Journal of Pharmacognosy and Phytochemistry Research*. 2016;8(1):38-42