Chemical Aspects of Ginger (*Zingiber officinale*)

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Ginger (*Zingiber officinale*) has emerged as one of the 20 top selling herbal supplements in USA over the last two decades [1]. It has more than 2000-year long history, thus, ginger holds a prominent place among the most famous folk medicine in many Asian countries exhibiting various medicinal properties: anti-oxidative, anti-cancerous, anti-inflammatory, anti-obesity, and ant-imicrobial effects [1-4]. Ginger exhibits these properties mainly due to the presence of phytochemicals (*e.g.*, terpenes, polyphenols, flavonoids) in it [4,5]. Ginger enriches the flavor of the cuisines and serves as a natural food preservative [4, 6].

History

The name of ginger is derived from 3000-year-old Sanskrit word "śṛṅgavera" signifying a "horn like body" [2]. It is one of the spices traded to Europe from Asia (*i.e.*, ginger has been exported from India to the Roman Empire over 2000 years). In 13th and 14th centuries, the value of a pound of ginger was equivalent to the price of a sheep. The scientific name of ginger plant, *Zingiber officinale* was proposed by an English botanist, William Roscoe in 1807 [7]. In Greek, "*Zingiberis*" alludes to the shape of deer's antlers, and "*officinale*" denotes medical properties of ginger [7].

Distribution and Morphology

Ginger is native to Asia, even though it is cultivated in other tropical and subtropical countries such as Jamaica, Ethiopia, Nigeria, Haiti, *etc.* India, China, Nepal, Indonesia and Thailand are the leading countries which cultivate ginger [2,6].

Ginger, a tuberous perennial plant (Figures 1 and 2) features the elongated leaves are clasping the stem by their sheaths. It has stout tuberous rhizomes with erect leafy stems which are between 0.6 to 1.2 m in height. Flowers of this plant are greenish in color with dark purple or purplish black lip which is similar to the orchid flower (Figure 3). The sympodial rhizome of ginger is the main edible part. Generally, its length, width and thickness are measuring 5-15 cm, 3-6 cm and 0.5-1.5 cm, respectively. Successful ginger cultivation requires rich organic soil or well drained valley clay at altitude up to 1200 m above sea level, along with an annual rainfall of about 1020 mm [8].

Figure 1: Parts of the ginger plant

Figure 2: Ginger rhizomes with leafy stems

Figure 3: Flower of ginger plant

There are several varieties of ginger, they are *Z. officinale* var. *officinale* (big white ginger or giant ginger), *Z. officinale* var. *amarum* (small white ginger), and *Z. officinale* var. *rubrum* (red ginger) (Figure 4) [8].

Figure 4: Rhizomes of red ginger

Taxonomy of ginger

Kingdom	**:** Plantae
Division	**:** Magnoliophyta
Class	**:** Liliopsida
Order	**:** Zingiberales
Family	**:** Zingiberaceae
Genus	**:** *Zingiber*
Species	**:** *Zingiber officinale*

Phytochemicals in Ginger

Phytochemicals in plants enhancing exquisite properties in them. Some of these phytochemicals are polyphenols, alkaloids, flavonols, terpenes, *etc.* [6,9-11].

The primary constituents in ginger rhizomes are carbohydrates (50–70%), lipids (3–8%), terpenes, and phenolic compounds. Amino acids, raw fiber, proteins, phytosterols, vitamins (*e.g.*, nicotinic acid and vitamin A), and minerals are also present in the ginger rhizome [3,12,13].

Major polyphenols (Figure 5) present in ginger rhizome are gingerols (23-25%), shogaols (18-25%) and paradols. Upon heating, gingerols, (*i.e.*, 6-, 8- and 10-gingerol, *etc.*) present in the fresh rhizomes are transformed into corresponding shogaols, ensuring prolonged storage [3]. The pungent taste and characteristic odor of garlic is attributed to gingerols and shogaols [1].

During cooking, these shogaols undergo hydrogenation to give paradols (*e.g.,* 6-, 8-, 10-, 11- and 13- paradols) (Figure 6) [1,6].

Zingerone (or vanillylacetone) **10**, quercetin **11**, Gingerenone-A **12**, 6-dehydro-gingerdione **13** represent some additional bioactive compounds found in ginger (Figure 7) [6, 12].

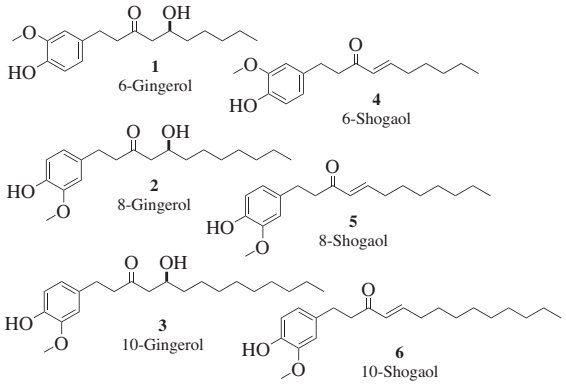

Figure 5: Structures of some gingerols and their corresponding shogaols

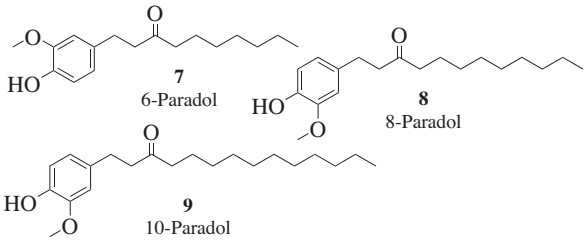

Figure 6: Structures of some paradols

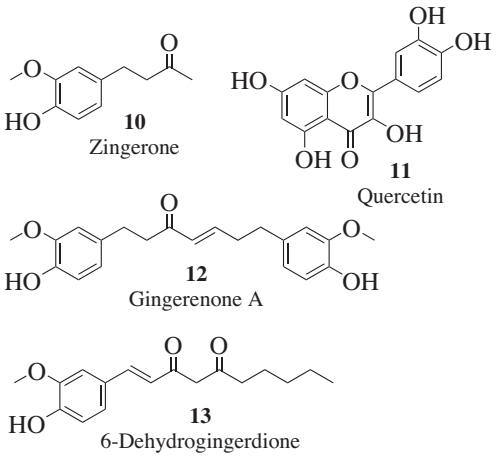

Figure 7: Structures of compounds **10-13**

Terpenes such as beta-bisabolene **14**, alpha-curcumene **15**, zingiberene **16**, alpha-farnesene **17**, and beta-sesquiphellandrene 18 are the main constituents in the essential oil of ginger (Figure 8) [6, 11-14].

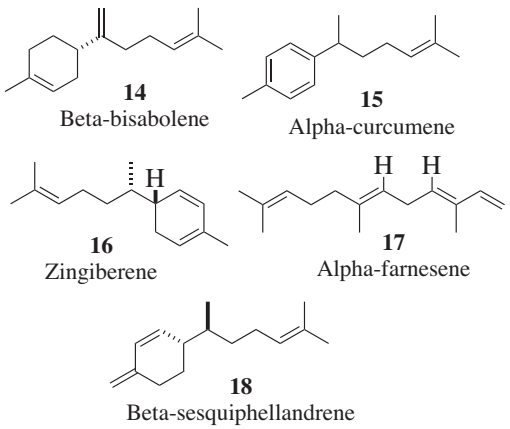

Figure 8: Structures of some terpenes

Uses and Health Benefits of Ginger

Generally, housewives use ginger rhizomes to enhance the flavor of sauces, curry dishes, confections, pickles, *etc*. [6]. Beverages like ginger tea, ginger beer and instant ginger drinks have gained popularity due to their unique flavor and medicinal value [1]. In Indonesia, instant ginger drink is used as an energy drink since it contains vitamin A and niacin. "Wedang empon" is a rhizome-based functional refreshment drink in Indonesia, enhancing blood circulation and reducing cholesterol in the body. Ginger is also utilized as a fragrance in soap and cosmetics [3, 5].

Antioxidant activity of ginger rhizomes increases as follows: dried ginger > stir ginger > carbonized ginger > fresh ginger. Dried ginger containing more shogaols exhibits increased antioxidant activity [15].

Ginger plays a vital role in food preservation, since it exhibits antibacterial, antifungal and antiviral properties [2,4,5,14]. For example, *Staphylococcus aureus* bacterium is inhibited by Gingerenone-A and 6-shogaols present in the rhizome [15]. Essential oil of ginger exhibit lipophilic properties [6,17]. The oil can break the integrity of plasma membranes of fungi by increasing the permeability [15]. Terpenes and citral in ginger suppress aflatoxin synthesis in fungi. Fresh ginger hinders plaque formation which is induced by human respiratory syncytial virus (HRSV) in respiratory tract cells. Scientific studies suggest that ginger extract has a capability to decrease the Hepatitis C Virus [6,15].

Ginger has demonstrated various health benefits including anticancer, antidiabetic, neuroprotective, hepato-protective anti-inflammatory, anti-obesity, and cardio-protective properties [2,4,14,16-18]. In traditional and Ayurvedic medicine, ginger is used to treat sore throats, constipation, nausea, fever, arthritis, helminthiasis, muscular aches, infectious diseases, toothaches, asthma, Alzheimer's, Parkinson's diseases, *etc*. [2-4,16,18]. Ginger is given to pregnant mothers to alienate the symptoms of morning sickness and to reduce blood loss in heavy menstrual bleeding [2].

References

1. Ghosh, S.; Das, B.; Haldar, P. K.; Kar, A.; Chaudhary, S. K.; Singh, K. O.; Bhardwaj, P. K.; Sharma, N.; Mukherjee, P. K. 6-Gingerol contents of several ginger varieties of Northeast India and correlation of their antioxidant activity in respect to phenolics and flavonoids contents. *Phytochemical Analysis*, 2023, 1-10. doi: 10.1002/pca.3201
2. Sharma, Y. Ginger (Zingiber officinale) -An elixir of life a review. *The Pharma Innovation Journal,* **2017**, 6(10), 22-27.
3. Prasad, S.; Tyagi, A. K. Ginger and its constituents: Role in prevention and treatment of gastrointestinal cancer. *Gastroenterology Research and Practice*, 2015, 2015, Article ID 142979, 11 pages. doi: 10.1155/2015/142979
4. Zhou, Q.; Peng, Y.; Chen, F.; Dai, J. Ginger supplementation for the treatment of non-alcoholic fatty liver disease: a meta-analysis of randomized controlled trials. *Afri. Health Sci*., **2023**, 23(1), 614-21. doi: 10.4314/ahs.v23i1.65
5. Amoah, R. E.; Wireko-Manu, F. D.; Oduro, I.; Saalia, F. K.; Ellis, W. O.; Owusu, E. Application of spices in foods: consumer preferences, knowledge of health benefits, and quality of dried ginger. *Cogent Food & Agriculture*, **2022**, 8(1), 2123766. doi: 10.1080/23311932.2022.2123766
6. Ersedo, T. L.; Teka, T. A.; Forsido, S. F.; Dessalegn, E.; Adebo, J. A. A.; Tamiru, M.; Astatkie, T. Food flavor enhancement, preservation, and bio-functionality of ginger (*Zingiber officinale*): a review. *International Journal of Food Properties*, **2023**, 26(1), 928-51, doi: 10.1080/10942912.2023.2194576
7. Akhlaghi, N.; Najafpour-Darzi, G. Potential applications of ginger rhizomes as a green

biomaterial: A review. *International Journal of Engineering, Transactions B: Applications*, **2023**, 36(2), 372-383. doi: 10.5829/IJE.2023.36.02B.16

8. Supu, R. D.; Diantini, A.; Levita, J. Red ginger (*Zingiber officinale* Var. *rubrum*): Its chemical constituents, pharmacological activities and safety. *Fitofarmaka Jurnal Ilmiah Farmasi*, **2018**, 8(1), 23-29, doi: 10.33751/jf.v8i1.1168
9. Ballester, P.; Cerdá, B.; Arcusa, R.; García-Muñoz, A.M.; Marhuenda, J.; Zafrilla, P. Antioxidant activity in extracts from Zingiberaceae family: Cardamom, turmeric, and ginger. *Molecules*, **2023**, 28, 4024, doi: 10.3390/ molecules28104024
10. Gong, F.; Fung, Y.; Liang, Y. Determination of volatile components in ginger using gas chromatography–mass spectrometry with resolution improved by data processing techniques. *J. Agric. Food Chem.,* **2004**, 52, 6378−6383. doi: 10.1021/jf040102z
11. Shalaby, E. A.; Shanab, S. M. M.; Hafez, R. M.; El Ansary, A. E. Chemical constituents and biological activities of different extracts from ginger plant (*Zingiber officinale*). *Chem. Biol. Technol. Agric*., **2023**, 10(14), doi:10.1186/s40538-023-00385-9
12. Hu, W.; Yu, A.; Wang, S.; Bai, Q.; Tang, H.; Yang, B.; Wang, M.; Kuang, H. Extraction, purification, structural characteristics, biological activities, and applications of the polysaccharides from *Zingiber officinale* Roscoe. (Ginger): A review. *Molecules*, **2023**, 28, 3855, doi: 10.3390/molecules28093855
13. Thakor, H. J.; Rathi, Y. S.; Nayak, N. S. Phytochemical screening of ginger (*Zingiber officinale*), a medicinal plant. *Sch Int J Tradit Complement Med*, **2023**, 6(4), 58-62. doi: 10.36348/sijtcm.2023.v06i04.002
14. Kikani, B.; Rana, K. Development of herbal lollipop incorporated with honey and ginger (*Zingiber officinale*). *International Journal of Science and Research Archive*, **2023**, 08(02), 057–066. doi: 10.30574/ijsra.2023.8.2.0218
15. Mao, Q.; Xu, X.; Cao, S.; Gan, R.; Corke, H.; Beta, T.; Li, H. Bioactive compounds and bioactivities of ginger (*Zingiber officinale* Roscoe). *Foods,* **2019**, 8, 185, doi:10.3390/foods8060185

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