RED GINGER (*Zingiber officinale* var. *rubrum*): ITS CHEMICAL CONSTITUENTS, PHARMACOLOGICAL ACTIVITIES AND SAFETY

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ABSTRACT

Ginger (*Zingiber* officinale) which belongs to the Zingiberaceae family, was first cultivated in Asia (Indonesia and Malaysia). This plant is one of the most commonly used herbal supplements taken by many patients to treat various conditions. *Z.officinale* has three varieties based on its size, colors of rhizome and chemical constituents i.e. .*Z. officinale* var. *officinale* (big white ginger or giant ginger, *badak* or *gajah*), Z. *officinale* var. *amarum* (small white ginger, *emprit*), and *Z. officinale* var. *rubrum* (small red ginger, *merah* or *beureum*). These three varieties may partly be deferred from their essential oil contents and are used for different purposes. The essential oils contained in *Z. officinale* var. *rubrum* are higher than the other types of ginger, which makes stronger in its pungency smell and taste. There are many studies that confirm beneficial effects of red ginger against the symptoms of diseases, i.e. anti-inflammation, antioxidant, antiemetic, antibacterial and antidiabetics. *Z.officinale* var. *rubrum* is considered to be a safe herbal medicine with only few and insignificant adverse/side effects. Although the medicinal properties of red ginger have been known, further trials in humans are required to determine the efficacy of red ginger (or one or more of its constituents) and to establish what, if any, adverse effects are observed.
Key words: *Zingiber officinale*, ginger, herbal supplement

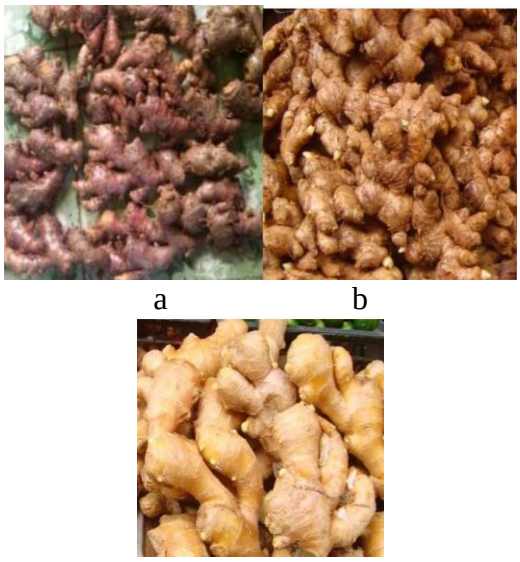
ABSTRAK

Tanaman jahe (*Zingiber officinale*) termasuk kedalam famili Zingeberaceae, pertama kali dikultivasi di Asia (Indonesia dan Malaysia). Tanaman ini umumnya digunakan sebagai suplemen herbal oleh masyarakat untuk meredakan berbagai keluhan penyakit. *Z officinale* terdiri dari 3 varietas berdasarkan ukuran rimpang, warna rimpang dan kandungan bahan kimianya yaitu *Z officinale* var. *officinale* (jahe putih besar, jahe badak, atau jahe gajah), Z. *officinale* var. *amarum* (jahe putih kecil atau jahe *emprit*), dan Z. *officinale* var. *rubrum* (jahe merah kecil, atau jahe beureum). Ketiga varietas ini sebagian berbeda dalam kandungan minyak esensialnya dan digunakan untuk keperluan yang berbeda. Minyak esensial yang terkandung dalam *Z. officinale* var. *rubrum* lebih tinggi dari jahe tipe lainnya sehingga jahe ini memiliki bau dan rasa yang lebih pedas. Berbagai studi telah membuktikan bahwa jahe merah memiliki aktifitas positif terhadap berbagai gejala penyakit seperti antiinflamasi, antioksidan, antiemetik, antibacterial, dan antidabetik. *Z.officinale* var. *rubrum* diperkirakan dapat dimanfaatkan sebagai obat herbal yang aman tanpa efek samping, atau efek samping minimal. Walaupun manfaat medis jahe merah telah diketahui secara saintifik, namun diperlukan uji klinis lebih lanjut untuk mengetahui tingkat kemanjuran serta kandungan senyawa secara lebih spesifik, serta mempelajari efek-efek samping yang mungkin terjadi.
Kata kunci: *Zingiber officinale*, jahe, suplemen herbal

INTRODUCTION

Herbal medicines are currently in great demand in developed countries for primary health care because of its usefulness, safety and lower side effects (Bhargava *et al.*, 2012). According to a report by the World Health Organization, 80 % of the population in developing countries depend on herbal medicine for their primary health care, and 85 % of herbal medicine are derived from plants (Ghasemzadeh *et al.*, 2015).

The rhizome of *Zingiber officinale* has been used as a component in Indonesian *jamu*. This particular plant is classified into three varieties based on its size, colors of rhizome, and chemical constituents, i.e. *Z. officinale* var. *officinale* Roscoe (big white ginger or giant ginger, *badak* or *gajah*), Z. *officinale* var. *amarum* (small white ginger, *emprit*), and *Z. officinale* var. *rubrum* (small red ginger, *merah* or *beureum*) (Figure 1). The essential oils of the big white ginger is the lowest compared to the other varieties. The big white ginger is commonly used for food and beverages, while the others are mostly used for medicinal purposes (Setyawan *et al.*, 2014).



a b c

Figure 1: Rhizome of *Z. officinale* var. *rubrum* (a), Z. *officinale* var. *amarum* (b), Z. *officinale* var. *officinale* Roscoe (c)

Table 1. Taxonomy of *Z. Officinale* var. Rubrum

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

Botanical Description

Z. officinale var. *rubrum* is an annual plant that can grow up to 50-100 cm tall. The leaves are lancet-shaped with a length of 5-25 cm and width of 1.5-2 cm, the tip of the pointed leaves and clasping the stem

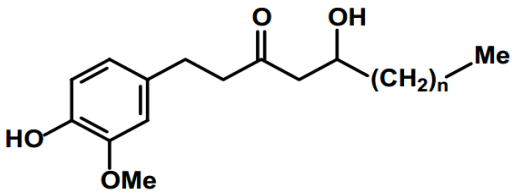
by long sheaths. Stems grow perpendicular and rounded flat, not branched. Flowers are compounded and ovoid with stem length 10-25 cm oval shaped with a stalk length of 10-25 cm and crown of flowers purple measuring 2-2.5 cm. Small flower petals are tubular and jagged three. The fleshy rhizomes are thick and reddish-brown and red rhizome skin. The single root is getting bigger along with its age, to form the rhizomes and shoots that will grow into new plants. The roots grow from the bottom of the rhizome, while the buds will grow from the top of the rhizomes (Ross, 1999 and Supriadi *et al.*, 2011).

Phytochemistry

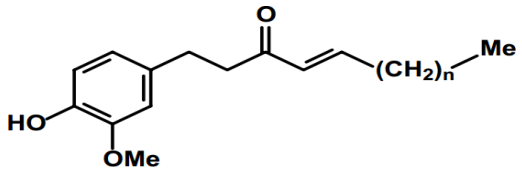
The chemical constituents of this plant varies considerably, depending on the location of cultivation and whether the product is fresh, dried, or processed (Singletary, 2010). Chemical analysis of *Z. officinale* var. *rubrum* showed over 400 different compounds. The major constituents in ginger rhizomes are carbohydrates (50–70%), lipids (3–8%), terpenes (zingiberene, β-bisabolene, α-farnesene, β-sesquiphellandrene, and α-curcumene), and phenolic compounds (gingerol, paradols, and shogaol) The characteristic odor and flavor of ginger are due to a mixture of volatile oils like shogaols and gingerols. Gingerols and shogaol were found in higher amounts in the other two types of ginger with average levels of gingerol (23-25%) and shogaol (18-25%) (Prasad S. dan Tyagi, K. A. (2015).

Gingerol were identified among other [4]-, [6]-, [8]-, and [10]-gingerol, while shogaol were identified [4]-, [6]-, [8]-, [10]- and [12]-shogaol (Figure 2) (Ali *et al.*, 2008).

The pungency of fresh ginger is due primarily to the gingerol, of which [6]-gingerol is most abundant. While on the other hand, dry ginger exhibits a pungency due to the shogaol [6]–shogaol. Shogaols are formed from the corresponding gingerol during thermal processing Wohlmuth (2005). Degradation rates of gingerol to shogaol were also found to be pH dependent, with greatest stability at pH 4, whereas at 100^{o} C and pH 1, the reversible degradation was relatively rapid (Bhattarai *et al.*, 2001).



[4]-, [6]-, [8]-, and [10]-gingerol



[4]-, [6]-, [8]-, [10]- and [12]-shogaol

Figure 2. Chemical structures of gingerol and shogaol

Pharmacological Activities

The rhizome of *Z. officinale*, var. *rubrum* was reported for various medicinal properties including anti-inflammatory activity, anti-oxidant activity, anti-nausea/antiemetic activity, anti-bacterial activity, cytotoxic activity and antidiabetic activity.

Anti-Inflammatory Activity

The effect of *Z. officinale*, var. *rubrum* extract (10–100 mg/kg) on acute inflammation was experimented on acetic acid induced abdominal inflammation model in mice[4]. In addition, intraperitoneal injection of [6]-gingerol (50mg/kg) relieved pain by 50%. As revealed in this experiment, this plant extract in low oral dose of 0.2–2mg/kg demonstrated effective

analgesic and anti-inflammatory effects suggesting the synergisms of various physiological compounds presents in the extract (Shimoda *et al*., 2010).

Antioxidant Activity

Ginger extracts inhibited lipid peroxidation by 72% in human erythrocyte membranes, whereas in human chondrocytes, ginger's volatile oil effectively prevented the production of hydrogen peroxide usually induced by fulvic acid. Animal study using high fat diet rat model revealed that supplementation with ginger provided significant antioxidant effects, raising tissue concentrations of superoxide dismutase and catalase and reducing glutathione (Kemper, 1999). In addition, the antioxidant effect of *Z. officinale* was reported by DPPH radical scavenging activity. The total phenolic content in the alcoholic extract of the dried rhizome of *Z. officinale* was 870.1 mg/g of dry extract. The extract exhibited 90.1% of DPPH radical scavenging activity with the IC50 concentration of 0.64 µg/ml (Kumar *et al.*, 2011).

Antinausea/Antiemetic

Some of the disparities in study outcomes may be due to differences in dosages used. Typically 1 g/d of ginger powder was administered, although in some studies doses as low as 0.3 g/d and as high as 2.0 g/d were evaluated. Differences in timing of outcome measurements also could have contributed to disparities. In those studies demonstrating efficacy, there were generally no adverse effects (Chaiyakunapruk *et al*., 2006). Ginger also may act on the 5-HT3 receptor ion-channel complex in the gastrointestinal tract. In humans, ginger intake (1-2 g) may block production of gastric prostaglandins and decrease plasma vasopressin release induced by circular vection (Riyazi *et al.*, 2007).

Antibacterial

In vitro studies of ginger extracts and ginger chemical constituents have been reported and indicated a growth suppression of various common infectious bacteria including *Staphylococcus aureus* and *Listeria monocytogenes* (Norajid *et al.*, 2007). The inhibitory activity of of gingerols and phenolic metabolites towards the growth of *Helicobacter pylori* suggested a new potential use of ginger in combating *H. pylori* related gastrointestinal diseases (Siddaraju dan Dharmesh, 2007).

Cytotoxic Activity

Red ginger extract revealed anticancer activity through inhibition of NF-κB activation, furthermore this plant showed anti-inflammatory activity through inhibition of TNF-α . Single-dose toxicity test using 2000mg/kg of red ginger extract (maximum dosage without burden on animals) resulted no fatal event and no abnormal changes in the weight of mice (compared to control). Similarly, no abnormal changes detected in organs of mice upon partial inspection conducted after the test. The LD50 (oral) of red ginger extract on male/female mice is deduced to be >2,000mg/kg (Kitagata *et al.*, 2011).

Antidiabetic Activity

Hypoglycaemic activity of ginger was reported in streptozotocin-induced diabetic rats. Treatment with aqueous extract (500 mg/kg body weight, i.p.) of ginger for a period of 7 weeks significantly decreased the serum glucose, cholesterol and triacylglycerol levels in the diabetic-induced rats compared with the control group (al Amin *et al.*, 2006). Treatment with ginger juice in streptozotocin-induced type I diabetic rats resulted a significant increase in insulin levels and a decrease in fasting glucose levels. Ginger treatment also caused a decrease in serum

cholesterol, serum triglyceride and blood pressure in diabetic rats (Akhani *et al.*, 2004).

Safety and Dosage

The Food and Drug Administration has given ginger GRAS (generally recognized as safe) status for use as a food supplement. Food allergy to spices is infrequent Aside from mild stomach upset in persons unaccustomed to spicy foods, ginger has no known acute toxicity at the usual doses consumed for dietary or medicinal purposes. Very large doses of 6 grams or more of ginger may lead to gastric irritation and loss of protective gastric mucosa. At normal doses (up to 2 grams daily), ginger does not interfere with blood clotting or any individual coagulation parameter. A dose of 0.5 – 1.0 g of ginger powder ingested 2-3 times for periods ranging from 3 months to 2.5 years did not cause any adverse effects. The British Herbal Compendium documents no adverse effects of ginger. The acute oral LD 50 in rats of roasted ginger is 170 g/kg body weight. Dry ginger is more than 250 g/kg body weight. In addition other research, the acute LD50 of ginger in rats is greater than 5 grams of ginger oil per kilogram of body weight (Singletary, 2010 and Kumar, 2011).

Red ginger can be consumed as a fresh or dried root and is often prepared in teas, soft drinks (including ales), and breads. No specific dosing studies have been performed; however, most clinical research has used between 250 mg and 1 g of the powdered root in capsular form, taken one to four times daily. Recommended daily dose for (1) red ginger extract: 15-20 mg[4], (2) dried powder: 250-1000 mg four times daily by mouth. Chinese herbalists may use up to 10 times this amount (Kemfer, 1999 and White, 2007).

CONCLUSION

Z officinale var. *rubrum* is considered to be a safe herbal medicine with only few and insignificant adverse/side effects. Although the medicinal properties of red ginger have been known for thousands of years, a significant number of *in vitro, in vivo*, and epidemiological studies further provide substantial evidence that ginger and its active compounds are effective against wide variety of human diseases. Further trials in humans are required to determine the efficacy of red ginger (or one or more of its constituents) and to establish what, if any, adverse effects are observed.

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