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MINI REVIEW

# *Zingiber mioga*: a perspective of its botany, uses, chemical constituents and health benefits

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**Abstract**

In this review, the botany, uses, bioactive metabolites and health benefits of *Zingiber mioga* or myoga (Zingiberaceae), a popular edible ginger in Japan, Korea and China, are highlighted. Myoga is endemic to Japan, occurring naturally in Honshu, Shikoku and Kyushu. Available during summer, *Z. mioga* flower buds (ZMB) are consumed fresh or pickled. Major production areas in Japan are Gumma and Kanto, where *Z. mioga* is widely planted in home gardens. The plant is deeply enshrined in Japanese culture and tradition with annual festivals held to celebrate its mythology and folklore. Major pungent principles are labdane-type diterpene aldehydes identified as galanal A, galanal B, miogadial, miogatrial and mioganal. Health benefits of ZMB include anti-inflammation, anti-obesity, hypolipidemic, anti-diabetic, antioxidant, acetylcholinesterase inhibition, memory improvement and skin nourishment. Bioactive compounds from ZMB display antimicrobial, antioxidant, anti-inflammatory, anti-cancer, human platelet aggregation, 5-lipoxygenase inhibitory, and indoleamine 2,3-dioxygenase 1 inhibitory activities. Bioactive compounds from the rhizomes have antibacterial and cytotoxic properties. Studies on allergic dermatitis due to regular contact with *Z. mioga* have been conducted. Some areas for future research on *Z. mioga* are suggested. Sources of information referred were from Google Scholar, PubMed, PubMed Central, Science Direct, J-Stage and PubChem.

## 1. Introduction

Gingers of the family Zingiberaceae are perennial herbs producing aromatic, tuberous and subterranean rhizomes, and have pseudo-stems formed by leaf sheaths (Larsen *et al*., 1999; Wu and Larsen, 2000). Ginger rhizomes are renowned for their use as spice, condiment and medicine. Rhizomes, leaves and flower buds of ginger plants are eaten raw, pickled or cooked as vegetables (Chan *et al*., 2008). Species that are widely cultivated are *Alpinia galanga*, *Curcuma longa*, *Etlingera elatior* and *Zingiber officinale*.

Species of the genus *Zingiber* are perennial, medium-sized herbs with stout rhizomes (Sabu and Skinner, 2003). Most species produce inflorescences as separate shoots emerging from subterranean rhizomes. The showy and long-lasting inflorescences bear colourful bracts that are widely used as cut flowers. Recent reviews by Sharifi-Rad *et al*. (2017) and Deng *et al*. (2022) showed that *Zingiber* plants are rich in bioactive phytochemicals, and possess diverse ethnomedicinal and pharmacological properties. Both reviews have highlighted *Zingiber mioga.*

In this short article, the botany, uses, chemical constituents and health benefits of *Z. mioga* was chosen as the species for review as there are none in the literature. The flower buds are a popular cuisine among people in Japan, Korea and China. In addition, the flower buds have been reported to possess medicinal properties. In this review on *Z. mioga*, topics covered included botany, uses, chemical constituents and health benefits. Plant parts such as flower buds, rhizomes and leaves are specified. The section on dermal toxicity among greenhouse cultivators of flower buds would be of concern to horticulturists.

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## 2. Botany and uses

*Zingiber mioga* (Thunb.) Roscoe plants belong to the ginger family (Zingiberaceae). The species is endemic to Japan where it is called myoga (Gracie *et al*., 2000; 2004). Occurring naturally in Honshu, Shikoku and Kyushu (Stirling, 2004), plants are 1.0−1.8 m tall producing lanceolate-elliptic leaves with extended caudate tips (Clark and Warner, 2000; Wu and Larsen, 2000). Radiating from the stems are yellowish rhizomes that grow horizontally near the soil surface. From the rhizomes of *Z. mioga*, flower buds (ZMB) develop as underground shoots protruding from the ground level (Figure 1). After a period of dormancy during winter, vegetative shoots grow from the original rhizome in spring followed by a flush of ZMB in mid-summer to early autumn (Gracie *et al*., 2000; Stirling *et al*., 2002).


Figure 1. *Zingiber mioga* plant and flower buds as inset.

ZMB are actually young inflorescences. They are picked when they are plump, fleshy, crimson red, emitting a distinctive ginger aroma (Abe, 2019). If harvesting is delayed, ZMB are not marketable when they turn green, producing white or pale-yellow flowers from August to October (Cole and Nürnberger, 2014). Fruits of myoga are red, bearing black seeds with white aril. Like other *Zingiber* species, *Z. mioga* is monoecious, producing male and female flowers from the same plant. Reproduction of myoga is by vegetative propagation *via* rhizomes or rootstocks.

ZMB are available during summer and are consumed fresh or pickled. It has been estimated that the quantity of ZMB consumed per year exceeds 6,000 tonnes per year (Abe *et al*., 2002; Miyoshi *et al*., 2003). Major production areas are Gunma and Kanto in Japan where *Z. mioga* is widely planted in home gardens (Stirling, 2004). Fresh ZMB is finely sliced and added as a garnish to traditional soy food products such as natto, miso and tofu, and other food items including pickled vegetables, salads, sushi, sashimi and tempura (Cole and Nürnberger, 2014). Blanched etiolated shoots of *Z. mioga* plants are another speciality in Japan. They are pencil-like with pale green and pink stripes. ZMB and shoots are fresh and gingerly in flavour. The plant *Z. mioga* is deeply enshrined in Japanese culture and tradition with annual festivals held to celebrate its mythology and folklore. A train station in Bunkyo Ward, Tokyo, is named Myogadani Station because myoga was widely grown in the area during the Edo period.

Known as yangha in Korea and ranghe in China, *Z. mioga* is also cultivated in New Zealand and southern Australia (including Tasmania) during summer, supplying myoga buds to the off-season Japanese market during winter (Cole and Nürnberger, 2014). Several varieties of myoga exist, some with variegated foliage e.g., 'Dancing Crane' and 'Silver Arrow'. In Japan, four cultivars have been recognised, known as jindawase 1, jindawase 2, jindawase 3 and akimyoga (Abe *et al*., 2004).

ZMB are consumed as spice and pickle in countries of East Asia because of their pungent and pleasant flavour (Abe *et al*., 2004). In Japan, the buds are consumed raw as salad, or eaten with sushi or with cold noodles in summer (Tuladhar, 2021). The plant *Z. mioga* is a well-known traditional medicine used for the treatment of inflammation, rheumatism and gastrointestinal disorders (Miyoshi *et al*., 2003; Abe *et al*., 2008; Deng *et al*., 2022). Unique to certain places in Japan, leaves of *Z. mioga* are used to wrap cakes and desserts such as mochi in Gifu, manju in Kumamoto and sushi in Yamaoka (Nagaya *et al*., 2003). The use of myoga leaves as food wrapper is to prevent spoilage, and to impart pleasant ginger taste cum flavour. In traditional Korean Buddhism, ZMB and leaves of yangha are consumed as temple food (Kim *et al*., 2006).

## 3. Chemical constituents

The volatile constituents of ZMB are classified as alcohols, aldehydes, ketones, esters and pyrazines (Kurobayashi *et al*., 1991). Major components of the essential oils are α-pinene (61%), β-pinene (17%), β-terpinene (15%) and β-phellandrene (12%) (Lee *et al*., 2007). The dominance of 11-diene (29%), β-elemene (27%) and eudesma-4 (14%) have been reported (Takahashi *et al*. 2011). In addition, main pungent principles from ZMB were labdane-type diterpene aldehydes identified as galanal A, galanal B and miogadial or aframodial (Abe *et al*., 2002; 2004);

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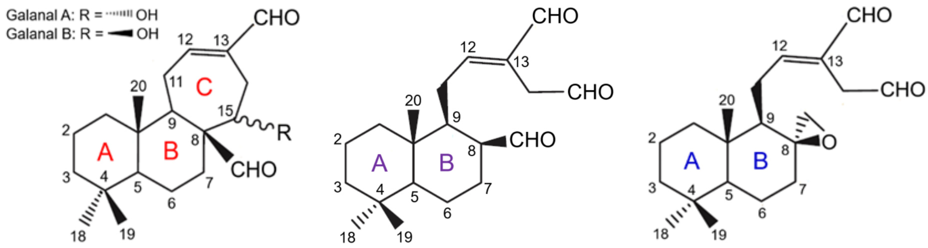


Figure 2. Galanals A and B (left), miogatrial (middle), and miogadial or aframodial (right).

miogatrial and polygodial (Abe *et al*., 2006); and mioganal (Abe *et al*., 2008). The molecular structures of galanal A, galanal B, miogatrial and miogadial or aframodial are shown in Figure 2. The red colour of ZMB bracts is due to anthocyanins that include cyanidin, delphinidin and malvidin 3-rutinoside (Kim and Han, 2018; Abe, 2019). The pungency of mioganal was been estimated to be eight times that of miogadial. Among the four cultivars of myoga in Japan, the contents of miogadial were highest in the ZMB, while galanal A and galanal B dominate the leaves and rhizomes (Abe *et al*., 2004). From *Z. mioga* rhizomes, miogadial, galanal A and galanolactone have been reported (Kim *et al*., 2003).

The volatile oil of *Z. mioga* flowers sampled from Guizhou province in China was extracted by steam distillation and was analysed by GC-MS (Lu *et al*., 2004). A total of 54 compounds were identified, accounting for 96% of the volatile oil. The main compounds include β-phellandrene, α-humulene, β-elemene, β-pinene, α-phellandrene, α-pinene and β-caryophyllene. From stems of *Z. mioga*, the main volatile components were n-hexadecanoic acid (17.4%), caryophyllene oxide (11.2%) and 4-(1-methylethyl)-2-cyclohexen-1-one (10.9%) (Tan and Yu, 2008).

Three new diterpenols, zingiberols A–C, together with four known compounds were isolated from *Z. mioga* rhizomes (Li *et al*., 2019). Diterpenols are diterpenes with a hydroxy (–OH) group attached. Zingiberols A–C share similar molecular formula of $C_{20}H_{34}O$ and a molecular weight of 290.3 g/mol. Zingiberols A and B have the –OH group at C3 while zingiberol C has the –OH group at C1 (Li *et al*., 2019). The known compounds were sesquithujene, 8-gingerol, 6-shogaol and 6-gingerdiol, all of which have been isolated from the rhizomes of *Z. officinale*.

The nutritional constituents of ZMB sampled from Korea comprise water (95%), crude protein (0.6%), crude lipid (0.2%), carbohydrate (3.3%), ash (0.9%) and fibre content (0.7%), and the proximate composition is rich in potassium (600 mg/100 g), magnesium (56 mg/100 g) and calcium (41 mg/100 g) (Jeong *et al*., 2005). The total amino acid content is 645 mg/100 g with glutamic acid (97 mg/100 g), aspartic acid (60 mg/100 g) and valine (54 mg/100 g) as major components.

## 4. Health benefits

### 4.1 Extracts

ZMB extract displayed anti-inflammatory properties by suppressing the inflammatory responses in ovalbumin-induced asthmatic mice and lipopolysaccharide-stimulated RAW264.7 cells, suggesting that *Z. mioga* may be a potent therapeutic agent in inflammatory diseases such as allergic asthma (Shin *et al*., 2015). Molecular mechanisms were attributed to the suppression of inducible NO-synthase and matrix metalloproteinase-9 expression.

ZMB extract significantly inhibited fat accumulation in 3T3-L1 adipocytes, and reduced body weight gain and fat mass in mice (Iwashita *et al*., 2001). A recent study on the anti-obesity properties of ZMB extracts showed that they reduced weight gain, insulin resistance and hepatic gluconeogenesis in diet-induced obese mice, possibly *via* suppression of lipogenesis and reduced hepatic inflammation (Lee *et al*., 2016). Another recent study reported synergistic lipid-lowering effects of ZMB extract mixed with *Hippophae rhamnoides* (Park *et al*., 2020). Values were significantly more pronounced than those of the extracts when used alone. Suppression of lipid accumulation in the liver and adipose tissue of mice was *via* the regulation of gene expression. An early study on the effects of ZMB and root extracts on lipid concentration in hyperlipidemic rats showed that the extracts reduced total serum cholesterol and triglyceride concentration, but increased HDL-cholesterol concentration (Shin *et al*., 2002).

Results of the novel object recognition test and the Y-maze test showed that both the water extract and ethanol extract of ZMB resulted in an improvement in memory impairment in scopolamine-treated mice (Cho *et al*., 2014). ZMB extract helps regulate nerve growth factor and synaptic plasticity in the hippocampal area of rats, resulting in learning and memory improvement (Kim *et al*., 2016).

In addition, ZMB extracts strongly inhibited superoxide generation in HL-60 and AS52 cell lines (Kim *et al*., 2002), displayed radical scavenging and

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acetylcholinesterase inhibitory effects (Cho *et al*., 2014), and possessed anti-diabetic properties by reducing *in vitro* and *in vivo* post-prandial blood glucose levels (Jo *et al*., 2016). The $IC_{50}$ values of α-glucosidase and α-amylase inhibitory activities of the ZMB butanol fraction were 121 μg/mL and 233 μg/mL, respectively (Kim and Han, 2018). The antioxidant properties of extracts of *Z. mioga* rhizomes and aerial parts were comparable with those of *Z. officinale* (Han *et al*., 2015). Radical scavenging antioxidant activities and acetylcholinesterase inhibitory effects of ZMB and rhizomes have been reported (Cho *et al*., 2014).

The study on the radical scavenging antioxidant activities of ZMB and rhizomes was based on DPPH and ABTS radical scavenging of aqueous and ethanol extracts. Results showed that the antioxidant activities were significantly stronger in the rhizomes than in the ZMB (Cho *et al*., 2014). A recent study reported that the antioxidant activities of myoga leaves were stronger than rhizomes (Han *et al*., 2015). In *Etlingera elatior*, another ginger species which produces edible inflorescences, the ranking of antioxidant activities was leaves > inflorescences > rhizomes (Chan *et al*., 2011).

A recent study reported that the hot water extract of ZMB improved moisturization and depigmentation of skin, and reduced wrinkle formation in UVB-irradiated HRM-2 hairless mice (Park *et al*., 2021). The extract increased the production of hyaluronic acid by up-regulating the expression of hyaluronic acid synthase2 (HAS2), a skin moisturizing factor. Hyaluronic acid is the key molecule involved in skin moisture because of its unique capacity in retaining water (Papakonstantinou *et al*., 2012). Earlier, it was reported that ZMB extract, when tested on Raw 264.7 murine macrophages, exhibited antioxidant, anti-inflammatory and wrinkle-improving effects, suggesting its potential use as a natural cosmetic material (Um, 2020).

### *4.2 Bioactive compounds*

From ZMB, miogadial exhibited stronger antimicrobial effects against Gram-positive bacteria and yeasts than galanal A and galanal B (Abe *et al*., 2004); miogadial, miogatrial and polygodial strongly inhibited human platelet aggregation and 5-lipoxygenase (Abe *et al*., 2006); galanal A and galanal B are potent inducers of apoptosis in Jurkat leukaemia cells (Miyoshi *et al*., 2003); and miogadial and miogatrial are potent agonists of transient receptor potential ankyrin 1 (Iwasaki *et al*., 2009). Galanal isolated from the methanol extract of ZMB was an effective inhibitor of indoleamine 2,3-dioxygenase 1 (IDO1) with an $IC_{50}$ value of 7.7 μM (Yamamoto *et al*., 2014). IDO1 is an enzyme that is associated with inflammatory diseases. Miogadial strongly inhibited nitric oxide and superoxide generation, and pro-inflammatory gene expression, suggesting that miogadal possesses potent antioxidant and anti-inflammatory activities (Kim *et al*., 2005).

Zingiberols A−C, novel diterpenols isolated from *Z. mioga* rhizomes were tested for cytotoxicity against five human cancer cell lines, namely, SMMC-7721 liver, A549 lung, MCF-7 breast, and SW-480 colon cancer cells, including HL-60 leukaemia cells (Li *et al*., 2019). Results showed that only zingiberol C displayed cytotoxicity against SMMC-7721 and SW-480 cancer cells with $IC_{50}$ values of 25.3 μM and 16.7 μM, respectively. Zingiberols A and B exhibited no cytotoxic activity. Their molecular structures differ in that zingiberol C has one cyclohexane ring while zingiberols A and B contain a peculiar cyclopentane ring each. Earlier, galanolactone and galanal A isolated from *Z. mioga* rhizomes has been reported to exhibit antibacterial activity against *Bacillus subtilis*, *B. cereus* and *Staphylococcus aureus* (Jang *et al*., 2005). Galanolactone was however not active against *S. aureus*.

## 5. Dermal toxicity

Greenhouse cultivators of ZMB in Japan often experience occupational allergic dermatitis due to regular contact. Minamoto *et al*. (2007) first reported a case of contact dermatitis from *Z. mioga*. A survey conducted on 35 subjects from 20 householders cultivating myoga in their greenhouses revealed that 8 subjects (23%) responded that they had experienced hand dermatitis since they started *Z. mioga* cultivation. Among the chemical components of ZMB, limonene is the major allergen using the guinea pig maximisation test (Wei *et al*., 2006). Results of the local nymph node assay showed that limonene, limonene oxide and β-phellandrene are major causes of allergic dermatitis (Wei *et al*., 2010).

## 6. Conclusion

Apart from ZMB, there is room for further research on the chemical constituents and health benefits of extracts and bioactive compounds of other plant parts of *Z. mioga* such as leaves and rhizomes. The prospects of isolating new compounds and the assessment of their bioactivities are promising. The therapeutical properties of essential oils from ZMB present an exciting window for *in vitro* and *in vivo* research and clinical trials. Likewise, the question of whether the other plant parts also contribute towards allergic dermatitis besides ZMB needs to be determined. The abundant information on *Z. officinale* would serve as a useful database for comparison with *Z. mioga*.

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