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Review Article

A Review on Family Zingiberaceae

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ABSTRACT

Traditional uses of the family Zingiberaceae have a long history and include everything from folk medicine to culinary applications. There are more than 70 different species of Curcuma, most of which are grown extensively in Western Africa, Asia, and Australia. Numerous Curcuma species have been the subject of numerous phytochemical, pharmacological, and molecular studies worldwide. The identification of novel bioactive molecules with a variety of bioactivities, including antioxidant, antiviral, antibacterial, and anti-inflammation activities, has boosted interest in its therapeutic qualities. Additionally, this priceless plant is employed as a pesticide, natural dye, and repellant. The goal of this review is to collect data on the genus Curcuma, including information on its morphological traits, phytochemicals, and the biological and pharmacological effects of these compounds, which will be used to inform future research projects.

Key Words: *Biological Activity, Morphology, Pharmacology, Phytochemicals*

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INTRODUCTION

Nature has been a source of medicinal agents for thousands of years and an impressive number of modern drugs have been isolated from natural sources that play a vital role in treatment of diseases [1]. Traditional knowledge of medicinal plants has always explored the search for new cures. Traditional medicinal plants are often cheaper, locally available and easily consumable, raw or as simple medicinal preparations. These simple medicinal preparations often bring out beneficial responses due to their active chemical constituents [2]. Medicinal plants are generally known as “Chemical Goldmines” as they contain natural chemicals, which are acceptable to human and animal systems. All these chemicals cannot be synthesised in laboratories. Many secondary metabolites of plant are commercially important and find use in a number of pharmaceutical compounds. Human beings have been dependent on plants for their health care needs since the beginning of civilisation. Of the 2,50000 higher plant species on earth, more than 80,000 are medicinal in Nature [3]. Ginger scientifically known as Zingiber officinale Roscoe, belonging to family Zingiberaceae is one of the most important plant with several medicinal, nutritional and ethnomedical values therefore, used extensively worldwide as a spice, flavouring agent and herbal remedy. Traditionally, Z. officinale is used in Ayurveda, Siddha, Chinese, Arabian, Africans, Caribbean and many other medicinal systems to cure a variety of diseases viz, nausea, vomiting, asthma, cough, palpitaion, inflammation, dyspepsia, loss of appetite, constipation, indigestion and pain [4].

The family of Zingiberaceae includes about 53 genera with more than 1200 species. Zingiberaceae is distributed across south and Southeast Asia. Some plants within this family commonly used in herbal medicines are Zingiber officinale (ginger), Zingiber zerumbet (bitter ginger) and Curcuma longa (turmeric) [5]. Currently, some members of the Zingiberaceae family have attracted enormous interest among researchers due to their popularity as spices and herbal components in traditional medicine. One of the most well-known members of the Zingiberaceae family is the common ginger, namely Zingiber officinale Roscoe or known as Jahe Emprit, Zingiber officinale Roscoe var. officinale, known as Jahe Gajah and Zingiber officinale Roscoe var. rubrum or called as Jahe Merah [6]. The rhizomes of these three gingers. The name ginger comes from the Middle English gingivere, but this spice dates back over 3000 years to the Sanskrit word srngaveram (horn root) [7]. The rhizome of ginger, the horizontal stem from which the roots grow, is a medicinal plant that has been widely used in Ayurvedic, Chinese, and Tibb-Unani herbal medicines for more than 3000 years in the Asian regions including Indonesia, Sri Lanka, Japan, Burma, China, India, and others such as the Arab nations, Congo, Germany, Greece, Tibet and the United States of America due to its beneficial characteristics such as its pungency, aroma, nutrients and pharmacological activity with negligible side effects all over the world [8]. The rhizomes contain two groups of materials, volatile compounds constituting the essential oil and non-volatile compounds, including oleoresin (a source of pungency) and other phytochemicals having biological activities which are beneficial to human health such asphenolics and flavonoids [9] With the development in science and modern technology in food products, ginger has been formulated into several products including ginger tea, ginger beer, ginger powder, ginger candies, and ginger juice [10]. The medicinal use of ginger is well known in India and its neighboring countries for more than 2000 years as one of the most versatile medicinal plants. Ginger has been using both as Ayurvedic and Chinese medicine for curing heart problems, treat stomach upset, diarrhea, and nausea [11]. It is also used as a disguise the taste of medicines; promotes the release of bile from the gall bladder [12, 13], decrease joint pain from arthritis, useful for the treatment of heart diseases and lungs diseases [9]; relief cough and cold, throat infection [14].

Systematic position and morphology

The family zingiberaceae is represented by about 46 genera, distributed through the tropics and subtropics. The type genus of this family is Zingiber. The plant is an aromatic herb and its taxonomic position is as follows:

Table 1. Scientific classification

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

The ginger plant has a perennial, tuberous root or rhizome; the stems are erect, oblique, round, annual, and invested by the smooth sheaths of the leaves, 2 or 3 feet in height, yellow green flowers and thick tuberous rhizome. Laterally compressed rhizomes are 7-15 cm long and 1-1.5 cm broad. About 1-3 cm long branches arise and terminate in depress scars or in undeveloped buds. The flesh of the ginger rhizome can be yellow, white or red in color, depending upon the variety. It is covered with a brownish skin that may either be thick or thin, depending upon whether the plant was harvested when it was mature or young [15].

METHODOLOGY

Throughout this review, the strategy of literature selection consisted of searching and studying the literature using several databases SciFinder, Web of Knowledge, Scopus, PubMed, and Google Scholars which appear in several publishers including American Chemical Society, Science Direct, Springer, Francis and Taylor, Wiley, and BioMed Central. The keywords used are Ginger or (Zingiber officinale Roscoe) or (Zingiber officinale Roscoe var. officinale) or (Zingiber officinale Roscoe var. rubrum) + phytochemicals or chemical composition + biological activities or pharmacological activities + authenticity or authentication analysis. After that, the obtained literature was subjected to screening by removing the redundant articles appearing in several databases. The selected articles were critically evaluated by applying inclusion and exclusion criteria and critical assessment and then used for making a review in logical structure according to the journal's guidelines. The inclusion criteria of selected papers were: (1) studies regarding phytochemical compositions, biological activities and authenticity analysis of ginger; (2) year of publication of 2000-2020, while the exclusion criteria used are all papers written in non-English. Phytochemical composition and stability It is reported that the rhizome of ginger contains carbohydrates (60–70%), protein 9%, crude fibre of approximately 3-8%, ash 8%, fatty oil 3–6% and volatile oil 2–3%. The carbohydrates consist of polysaccharides, soluble sugar, and cellulose [16] Table 1 shows some of the phytochemical compounds of the ginger rhizome. The protein contains a variety of amino acids namely aspartic acid, serine, glutamate, alanine, glycine, threonine, methionine, cysteine, valine, tyrosine, leucine, isoleucine, histidine, lysine, phenylalanine proline, tryptophan, and arginine [17]. Some compounds namely zingerone, shogaols, gingerols, and volatile (essential) oils account for up to 3% (mainly alfa-zingiberene, βsesquiphellandrene, β-phellandrene, camphene, cineol, geraniol, citral) contributed to the characteristic flavor of ginger (Srinivasan, 2017). The chemical structures are depicted in Figure 2.

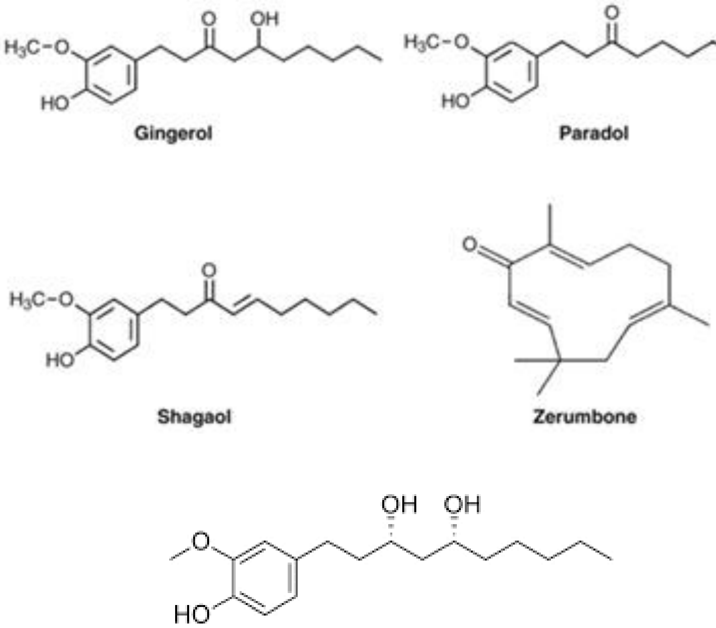

Figure 2: Gingerol compounds in Zingiber officinale consist of gingerol (23-25%), shagaol (18-20%), paradol (1-3%) and zerumbone (1-3%)

Biological activities include gingerols, shogaols, and paradols. Gingerol is the component responsible for the spicy taste of ginger. It consists of several compounds such as gingerol, shogaol, zingerones, paradols, gingerdiols, and gingerdiones which all of them having a functional group of 3-methoxy-4-hidroxyphenyl. The difference of each compound is based on the different fatty chains connected by the functional group [17]. Gingerols such as 6-gingerol, 8-gingerol, and 10-gingerolin are the major polyphenols found in fresh ginger. During storage or heat treatment, the levels of gingerol can be decreased and can be transformed into corresponding shogaols. Furthermore, shogaols can be transformed into paradols after hydrogenation. Besides, the other phenolics present in ginger are zingerone, gingerenone-A, 6-dehydrogingerdione and quercetin [18] In the fresh ginger rhizome, the gingerols were identified as the major active components [19] The sensory perception of ginger arises from two distinct groups of chemical namely volatile oils and non-volatile pungent compounds. The volatile oil components in ginger consists mainly of sesquiterpene hydrocarbons, predominantly zingeberene (35%), curcumene (18%) and farnesene (10%) [20].

Biological activities

Antioxidant

The in vitro antioxidant assays of different extracts of ginger have been studied using different methods which can be categorized into radical scavenging assay, reducing power, chelating agent, and lipid peroxidation inhibition using linoleic-thyocyanate or beta carotene bleaching. The natural antioxidants extracted from rhizome were frequently correlated with the presence of phenolics, flavonoid and carotenoid contents. The antioxidant activities along with total phenolics contents of ethanolic extract of ginger have been evaluated by Stoilova [21]. The ginger extract had a phenolics content of 870.1 mg/g dry extract, while antioxidant activities as determined by DPPH radical scavenging assay, linoleic acid/water emulsion system and chelating activities revealed strong activities. Including the capability to inhibit hydroxy radical, the ethanolic extract (IC50 of 1.90 μg/mL) showed higher activity than the positive control of quercetin (IC50 of 2.78 μg/mL). Some extracts (methanol, ethyl acetate, and hexane) were evaluated for in vitro antioxidant assays using radical scavenging of DPPH, ABTS, and nitric oxide. The methanolic extract of ginger (MEG) revealed the highest radical scavenging activities toward DPPH, ABTS and nitric oxide assays with inhibition percentages of 86.26%, 91.04% and 86.72%, respectively. Using GC-MS, some bioactive compounds are responsible for radical scavenging in MEG, such as 6-gingerol, zingiberene, dihydrocapsaicin, zingerone, curcumene, beta bisabolene and 8-gingerol [22].

Anti-inflammation

Using approaches of systematic review and metaanalysis, Morvaridzadeh et al. have evaluated the effect of ginger supplementation on anti-inflammation activities by investigating the concentrations of Creactive protein (CRP), high sensitivity C-reactive protein (hs-CRP), tumour necrosis factor-alpha (TNF-α), soluble intercellular adhesion molecule (sICAM), and interleukin-6 (IL-6) in randomized controlled trials (RCTs). The increased levels of IL-6, TNF-α and CRP are related to the increased risk of inflammation. These increased markers are coming from the increased expression of immune system factors, such as nuclear factor- kappa-B (NF-κB) and peroxisome proliferatoractivated receptor-gamma (PPAR-γ) [23]. As a consequence, the suppression of the inflammatory response is an important point in the management of some chronic diseases such as cardiovascular diseases. The results revealed that there was a significant reduction in circulating CRP, hs-CRP and TNF-α levels due to ginger supplementation. However, from the meta-analysis, the supplementation of ginger did not show any significant impact on IL-6 and sICAM levels [24]. Ginger is also used as an adjuvant of chemotherapy to ameliorate nausea and vomiting induced by chemotherapy through studies of a systematic review and meta-analysis. Ginger supplementation might have the benefit to ameliorate chemotherapy-induced vomiting and fatigue, however, because of the clinical heterogeneity; this systematic review reported that there is no association between ginger supplementation and chemotherapy-induced nausea and vomiting-related outcomes [25].

Gastrointestinal relief

Modern scientific research has revealed that ginger possesses numerous therapeutic properties including antioxidant effects, an ability to inhibit the formation of inflammatory compounds, and direct antiinflammatory effects. Ginger is very effective in preventing the symptoms of motion sickness, especially seasickness. Ginger reduces all symptoms associated with motion sickness including dizziness, nausea, vomiting, and cold sweating [26]. Some active components of ginger are reported to stimulate digestion, absorption, relieve constipation and flatulence by increasing muscular activity in the digestive tract [27, 28].

Antimicrobial activity of ginger

Ginger has been traditionally exploited for having broad range of antimicrobial activity against both gram positive and gram negative bacteria and fungi. In vitro studies have shown that active constituents of ginger inhibit multiplication of colon bacteria, these bacteria ferment undigested carbohydrates causing flatulence, this can be counteracted with ginger [29]. It inhibits the growth of Escherichia coli, Proteus sp, Staphylococci, Streptococci and Salmonella [30]. Ginger has strong antibacterial activity and to some extent antifungal properties [31]. Ginger inhibits Aspergillus sp, a fungus known for the production of aflatoxin, a carcinogen [32]. Fresh ginger juice showed inhibitory action against Aspergillus niger, Sacharomyces cerevisiae, Mycoderma sp. and Lactobacillus acidophilus. Thus, ginger which is a normal ingredient of our routine food preparations can provide protection against our natural enemies like bacterial and fungal pathogens.

Anti-obesity activity

Ginger is reported to have anti-obesity and related metabolic disorders. The anti-obesity effect of ginger associated with energy metabolism in mice has been evaluated. Mice were divided into two groups, namely the control (given with normal diet) and the treated group with a high-fat diet (HFD) with and without ginger at a dose of 500 mg/kg (wt/wt). The results revealed that the administration of ginger could alleviate HFD-induced body weight and fat accumulation. Ginger also reduces the levels of triglyceride, cholesterol and serum glucose. Therefore, it can be deduced that ginger plays a role in preventing obesity and related metabolic disorders [33]. Previously, it is reported that the anti-obesity of ginger, especially bioactive compounds of 6-shogaol and 6-gingerol, was due to the activation of Peroxisome proliferator-activated receptor δ (PPARδ), a major transcriptional regulator of energy metabolism in skeletal muscle and adipose pathway. Ginger, also improved the capacity of exercise endurance by increasing the fat catabolism in skeletal muscle. In micemodels, the supplementation of ginger also exhibited anti-obesity effects through modulation of the gut microbiota capable of increasing the levels of beneficial bacteria (probiotics) such as Bifidobacterium [34].

Larvicidal activity

Larvicidal activity of isolated compounds from the rhizome of ginger was reported against Adese aegypti and Culex quinquefasciatus. The study reported the larvicidal activity of (4) gingerol, (6)dehydrogingerdione and (6)-dihydrogingerdione against fourth instar larvae of A. aegypti (LC50 4.25, 9.80, 18.20 ppm) and C. quinquefasciatus (LC50 5.52, 7.66, 27.24 ppm), respectively. Similarly, larvicidal activity of ginger was reported against Angiostrongylus Cantonensis, a roundworm. A. cantonens is a parasitic nematode which causes angiostrongyliasis, the most common cause of eosinophilic meningitis in Southeast Asia and the Pacific Basin. In the study, [6]-gingerol were isolate from the roots of ginger and screened for larvicidal activity against the larvae of A. Cantonensis [35].

Breast cancer

The effects of chronic treatment with hot water extract of ginger rhizome on spontaneous mammary tumorigenesis have been examined in mice. In mice given free access to extract of ginger (0.125%) in drinking water, the development of mammary tumors was significantly inhibited [36].

Marketed products


tealyra
Freeze-Dried
GINGER
4 OZ
Ginger Candy
Just Jaivik
ORGANIC
GINGER
Zingiber Officinale
90
CAPLETS
DIETARY SUPPLEMENT
USDA ORGANIC
Allin
Ginger Oil
Zingiber Officinalis
WEIGHT : 15ML
Tropical Holistic
100% Pure Organic Essential Oil
GINGER
Zingiber officinale
15 mL (0.5 fl oz.)
MERLION NATURALS
GINGER
Zingiber officinale
120 Tablets
Dietary Supplement
Himalaya
SINCE 1930
Sunthi
DIGESTIVE WELLNESS
Sunthi has carminative and anti-emetic properties that relieve nausea and motion sickness.
EACH TABLET CONTAINS:
EXTRACT
Sunthi
(Zingiber officinale)* Rz. 50 mg
Ref.: * API
DOSAGE: 1-2 tablets twice a day, or as directed by your physician.
Himalaya
SINCE 1930
Green Tea
GINGER
RELIEVES INDIGESTION
clave organic
DRIED GINGER POWDER
From the Western Ghats
Chukkupodi
Zingiber Officinale
100 g
3.5 OZ

REFERENCES

1. Cragg GM, Newman DJ. (2001). Medicinal for the Milennia. Annals of the NewYork Academy of Sciences. 953:3-25.
2. Park EJ, Pezzutto JM. (2002). Botanicals in cancer chemoprevention. Cancer and Metastasis Reviews. 21(3-4):231-255.
3. Thomas J. (1997). Medicinal and aromatic plants research in India. In UNDP. 1997. Proc. Training course on Industrial Exploitation of Indigenous Medicinal and Aromatic Plants. Beijing, China. 17-27.
4. Grzanna R, Lindmark L, Frondoza C. (2005). Ginger - A herbal medicinal product with broad anti-inflammatory actions. Journal of Medicinal Food. 8(2):125-132.
5. Koga, A.Y., Beltrame, F.L. and Pereira, A.V. (2016). Several aspects of Zingiber zerumbet: A Review. RevistaBrasileira de Farmacognosia, 6(3), 385391. https://doi.org/10.1016/j.bjp.2016.01.006
6. Seow, S.L.S., Hong, S.L., Lee, G.S., Abd Malek, S.N. and Sabaratnam, V. (2017). 6-shogaol, a neuroactive compound of ginger (jahegajah) induced neuritogenic activity via NGF responsive pathways in PC-12 cells. BMC Complementary Alternative Medicine, 17(1), 230-238. https://doi.org/10.1186/ s12906-017-1837-6
7. Benzie, I.F.F. and Wachtel-Galor, S. (2011). The Amazing and Mighty Ginger In Bode, A.M. and Dong, Z. (Eds.) Herbal Medicine. Biomolecular andclinical aspects. 2nd ed. United Kingdom: CRC Press/ Taylor & Francis. https://doi.org/10.1201/b10787
8. Kiyama, R. (2020). Nutritional implications of ginger: chemistry, biological activities and signaling pathways. Journal of Nutrition and Biochemistry, 86, 108486. https://doi.org/10.1016/ j.jnutbio.2020.108486
9. Motawi, T.K., Hamed, M.A., Shabana, M.H., Hashem, R.M. and Aboul-Naser, A.F. (2011). Zingiber officinale acts as a nutraceutical agent against liver fibrosis. Nutrition and Metabolism, 8, 40–46.https:// doi.org/10.1186/1743-7075-8-40
10. Krüger, S., Bergin, A. and Morlock, G.E. (2018). Effectdirected analysis of ginger (Zingiber officinale) and its food products, and quantification of bioactive compounds via high-performance thin-layer chromatography and mass spectrometry. Food Chemistry, 243, 258–268. https://doi.org/10.1016/ j.foodchem.2017.09.095
11. Y. Shukla and M. Singh, (2007). Cancer preventive properties of zinger: a brief review, Food and Chemical Toxicology, 45(5), 683–690
12. M. Kato, M. L. Rocha, A. B, Carvallo, M.E. Chaves, M.C. Rana, and F. C. Olverra, (1993). Occupational exposure to neurotoxicants. Preliminary survey in five industries of caricari petrochemical complex. Brazil Environ. Res. 61, 133-139.
13. M. O'Hara, D, Keifer, K, Farrel and K, Kemper, (1998). A review of 12 commonly used medicinal herbs. Archives of Family Medicin, 7(6), 523-536.
14. D.V.C. Awang, (1992). Ginger. Canadian Pharmaceutical Journal, 125 (7), 309–311.
15. Subash kumar Gupta1, Anand Sharma2, (2014). Medicinal properties of Zingiber officinale Roscoe - A Review, e-ISSN: 2278-3008, p-ISSN:2319-7676. Volume 9, Issue 5 Ver. V, PP 124-129 www.iosrjournals.org
16. Kikuzaki, H. and Nakatani, N. (1996). Cyclic diarylheptanoids from rhizomes of Zingiber officinale. Phytochemistry, 43(1), 273–277. https:// doi.org/10.1016/0031-9422(96)00214-2
17. Liu, Y., Liu, J. and Zhang, Y. (2019). Research progress on chemical constituents of Zingiber officinale Roscoe. Biomed Research International, 5, 5370823. https://doi.org/10.1155/2019/5370823
18. Schadich, E., Hlaváč, J., Volná, T., Varanasi, L., Hajdúch, M. and Džubák, P. (2016). Effects of ginger phenylpropanoids and quercetin on Nrf2-ARE pathway in human bj fibroblasts and HaCaT keratinocytes. Biomed Research International, 2016, 2173275. https://doi.org/10.1155/2016/2173275
19. T. Hoffman, (2007). Antimicrobial activity of some medicinal plants from India. Hawaii Medical Journal, 66, 326-327.
20. V. Govindarajan, (1982). Ginger-chemistry technology and quality evaluation: Part-I CRC. Critical Reviews in Food Science and Nutrition, 17, 1–96.
21. Stoilova, I., Krastanov, A., Stoyanova, A., Denev, P. and Gargova, S. (2007). Antioxidant activity of a ginger extract (Zingiber officinale). Food Chemistry, 102 (3), 764–770. https://doi.org/10.1016/ j.foodchem.2006.06.023

22. Murugesan, S., Venkateswaran, M.R. and Jayabal, S. S.P. (2020). Evaluation of the antioxidant and antiarthritic potential of Zingiber officinale Rosc. by in vitro and in silico analysis. South African Journal of Botany, 130, 45–53. https://doi.org/10.1016/ j.sajb.2019.12.019
23. Aboonabi, A., Meyer, R.R., Singh, I. and Aboonabi, A. (2020). Anthocyanins reduce inflammation and improve glucose and lipid metabolism associated with inhibiting nuclear factor-kappaB activation and increasing PPAR-γ gene expression in metabolic syndrome subjects. Free Radical Biology and Medicine, 150, 30–39. https://doi.org/10.1016/ j.freeradbiomed.2020.02.004
24. Morvaridzadeh, M., Fazelian, S., Agah, S., Khazdouz, M., Rahimlou, M. and Agh, F.E.P.S.H. (2020). Effect of ginger (Zingiber officinale) on inflammatory markers: A systematic review and meta-analysis of randomized controlled trials. Cytokine, 135, 155224. https://doi.org/10.1016/ j.cyto.2020.155224
25. Crichton, M., Marshall, S., Marx, W., McCarthy, A.L. and Isenring, E. (2019). Efficacy of ginger (Zingiber officinale) in ameliorating chemotherapy-induced nausea and vomiting and chemotherapy-related outcomes: A systematic review update and metaanalysis. Journal of The Academy of Nutrition and Dietetics, 119(12), 2055–2068. https:// doi.org/10.1016/j.jand.2019.06.009
26. J. Yamahara and Q. Huang, (1990). Gastrointestinal motility enhancing effect of ginger and its active constituents. Chemical and Pharmaceutical bulletin, 38(2), 430- 431.
27. J. Stewart, M.J. Wood, C.D. (1991). Wood and M.E. Mims, Effects of ginger on motion sickness susceptibility and gastric function. Pharmacology, 42(2), 111-120.
28. D.B. Mowrey and D.E. Clayson, (1982). Motion sickness, ginger and psychophysics. Lancet,i, 655-657.
29. S. Gupta and S. Ravishankar, (2005). A comparison of the antimicrobial activity of garlic, ginger, carrot, and turmeric pastes against Escherichia coli O157:H7 in laboratory buffer and ground beef. Food borne Pathogens and Disease, 2 (4), 330-40.
30. B. White, (2007). Antimicrobial activity of ginger against different microorganisms: Physician, 75, 1689-1691.
31. P.V. Nielsen and R. Rios, (2000). Inhibition of fungal growth on bread by volatile compounds from spices and herbs and mustard essential oil. *International Journal of Food Microbiology*, 60(2-3), 219-229.
32. S.P. Nanir and B.B. Kadu, (1987). Effect of medicinal plant extracts on some fungi. Acta Botanica Indica, 15(2), 170-175.
33. Wang, J., Li, D., Wang, P., Hu, X. and Chen, F. (2019). Ginger prevents obesity through regulation of energy metabolism and activation of browning in high-fat diet-induced obese mice. The Journal of Nutritional Biochemistry, 70, 105–115. https://doi.org/10.1016/ j.jnutbio.2019.05.001
34. Wang, J., Wang, P., Li, D., Hu, X. and Chen, F. (2020). Beneficial effects of ginger on prevention of obesity through modulation of gut microbiota in mice. European Journal of Nutrition, 59(2), 699–718. https://doi.org/10.1007/s00394-019-01938-1
35. G. Kumar, L. Kathie and K. V. B. Rao, (2011). A review on pharmacological and phytochemical properties of Zingiber officinale Roscoe (Zingiberaceae), Journal of Pharmacy Research, 4(9), 2963-2966.
36. H. Nagasawa, K. Watanabe, H. Inatomi, (2002). Effects of bitter melon (Momordica charantia l.) or ginger rhizome (Zingiber offifinalerosc) on spontaneous mammary tumorigenesis in SHN mice. American Journal of Chinese Medicine, 30(2-3), 195–205.