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Harnessing the Therapeutic Properties of Ginger (*Zingiber officinale* Roscoe) for the Management of Plant Diseases

Elias Nortaa Kunedeb Sowley and Frederick Kankam

Abstract

Ginger (*Zingiber officinale* Roscoe) is one of the most widely used spices in the world. The therapeutic benefits of ginger are mainly due to the presence of volatile oils, phenols, alkaloid, and high oleoresin content. Ginger extracts have been extensively studied for a broad range of biological activities including antibacterial, antifungal, antiviral, anticonvulsant, analgesic, antiulcer, gastric antisecretory, and antitumor. This is all the more necessary because ginger is of plant origin, specifically more biodegradable, readily available, cheaper, and environmentally friendlier than synthetic chemicals. Since, some farmers in developing countries use ginger extracts as traditional medicine in the treatment of human diseases, it will be easy for them to adopt these extracts as biopesticides for the management of plant diseases. This book chapter seeks to outline the bioactive compounds and therapeutic benefits of ginger in plant disease management, and the mechanisms of action are also discussed.

Keywords: antibacterial, antifungal, biodegradable, synthetic chemicals, ginger

1. Introduction

Ginger (*Zingiber officinale* Roscoe) is a spicy aromatic plant from the family Zingiberaceae. There are about 150 species in the genus *Zingiber*, but *Zingiber officinale* is the widely cultivated and spicy species [1]. Ginger is largely grown in the tropics [2]. In China, ginger has been useful in various indigenous medicines over the centuries [3]. Ginger is regarded as a general medicinal material in the Chinese ayurvedic culture for the treatment of digestion-related discomforts [4]. According to the Transparency Market Research [5] report, ginger is among the high-valued and economic herbal commodities of about the 6.5% per year projected increase in market value which could go up as high as US\$ 4.18 billion with about 7.5% estimated rapid growth in consumption by 2022.

Ginger has several uses or functions in our daily lives. It is importantly used in households, pharmaceutical, brewery, food, and other related industries to manufacture products such as ginger oil, ginger wine, gingerbread, ginger cake, ginger spice, ginger syrup, ginger drink, and ginger coffee [6]. Ginger oil is produced in economic and commercial quantities in countries like Australia, China,

Indonesia, and India. Recently, the oil obtained from ginger has been found to protect and maintain the kidney against toxicity [7]. Ginger is a medicinal plant and antimicrobial agent. It contains gingerols as its primary bioactive compound with high flavonoid, phytochemical, and pharmacological effects [3]. Various studies in vivo, in vitro, and clinical analysis have over the years been carried out and, thus, affirmed ginger's therapeutic properties which cannot be downplayed. For instance, some of the volatile oils contained in red ginger, namely, trimethyl-heptadienol, ar-curcumene, camphene, carbaldehyde, sesquiphellandrene, and nerol, were found to inhibit the growth of bacteria including *Bacillus cereus*, *Escherichia coli*, *Salmonella typhimurium*, and *Pseudomonas aeruginosa* [8].

2. Nutritional components of ginger

Ginger is extensively used in various traditional and manufactured foods as a result of its richness in essential nutrients. The rhizome, which is the principal economic part of the ginger plant, possesses good amount of carbohydrate, minerals, and vitamins, among others. Ginger rhizome is a rich source of minerals including iron, calcium, and phosphorous. It also contains vitamins such as thiamine, riboflavin, niacin, and vitamin C. Ginger rhizomes also possess a potent proteolytic enzyme called zingibain [9]. Torch ginger (*Etilingera elatior* Jack.) inflorescence contains high amounts of dietary fiber, unsaturated fatty acids (palmitoleic acid, linoleic acid, and oleic acid), and essential amino acids (leucine and lysine) [10]. The inflorescence of torch ginger is enriched with essential minerals such as K (1589 mg/100 g), Ca (775 mg/100 g), Mg (327 mg/100 g), P (286 mg/100 g), and S (167 mg/100 g) with lower levels of heavy metal contaminants (Cd, As, Pb, Hg, Ni) [11, 12]. Raw ginger is also reported to contain useful minerals like Mg, Ca, Mn, Fe, Cu, and Zn [13]. Studies on ginger rhizomes obtained from Malaysia and Nigeria showed higher moisture (90.9% vs. 76.9%), crude fiber (3.8 g/100 g), and lower carbohydrate content (6.3 g/100 g sample) than the USDA database [14]. In other studies, inductively coupled plasma-mass spectrometry-based multi-elemental profiling was used to evaluate the quantitative complement of elements and nutritional quality of ginger rhizome, and the result revealed an abundance of 18 elements quantified [13]. The acid-digested rhizomes were found to have K > Mg > Fe > Ca > Na > Mn > Zn > Ba > Cu > Cr > Ni > Pb > Co > Se > As > Be > Cd metals in that order of abundance. Generally, it is supposed that paradol, formed on hydrogenation of shogaol, in ginger plant contains significant antioxidant content which produces protective health benefits in various diseases [15].

3. Bioactive components of ginger

Ginger is a rich source of some important bioactive molecules and compounds such as phenolic groups, alkaloids, and steroids which have medicinal effect [14]. The main aromatic agent of the rhizome is the zingiberol [3]. It has embedded in it some bioactive compounds such as shogaols, zingerone, paradols, and gingerols, which are structurally shown (**Figure 1**). These components do not easily vaporize and are responsible for the "burning" effect, felt in the mouth [16]. In addition to the main bio-compounds, ginger also contains other sub-compounds like 4-gingerol, 6-gingerol, 8-gingerol, 10-gingerols, 6-shogaols, 14-shogaols (**Figure 1**), and many other identified components which are reactive against inflammation [17] (**Table 1**).

The most identified and investigated components of ginger which act against oxidation reactions in biological systems are shogaols and gingerols, possessing a lot

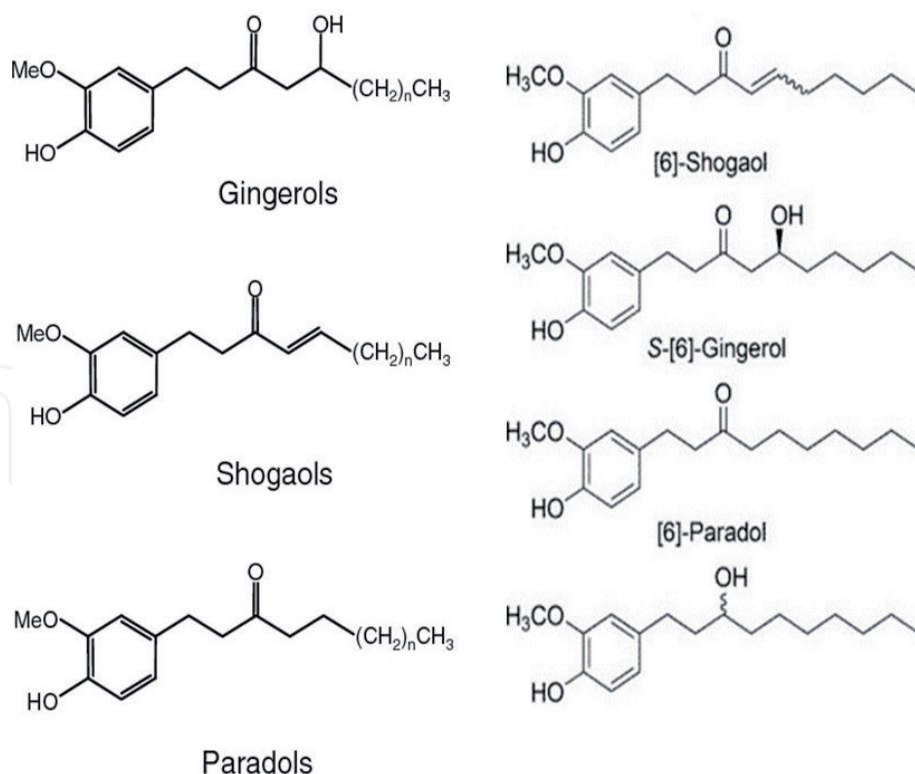


Figure 1.
 Chemical structure of major bioactive compounds of ginger.

Ginger constituent	Mechanism of actions	References
Zingerone	Act against inflammation of cells Moderation of prostaglandins synthesis	[19]
10-Gingerol	Inhibition of cell expression, declining the rate of cell multiplication, halt and weakening of the S phase cell cycle	[20]
Paradol	Controlling blood sugar levels Enhances cells recovery and resistance against cancer Promoting the formation and action of antibodies	[21]
8-Gingerol	Inhibition of cancer cell growth Antiplatelet actions Inhibition of blood vessels generations	[22]
Flavonoid	Antioxidant actions against reactive oxygen, which can endanger plant and cells. Protecting cells against risks of damage by oxidation related imbalances	[23, 24]
Oleoresin	Antimicrobial actions against the growth of plants and animal disease microorganism like <i>Staphylococcus aureus</i> , <i>Candida albicans</i> , <i>Escherichia coli</i>	[25–27]
6-Gingerol	Causing cell cycle actions in the G0/G1-phase to cease Reducing cyclin E1, cyclin A, and cyclin D1 levels. Increasing caspase manifestation Stopping the sensing channel of mammalian target of rapamycin (mTOR)	[28]
Phenolic acid	Inhibiting reactive nitrogen and oxygen generation in plants and animal cells, as a result of its ability to stop certain enzymes from action Removing reactive oxygen and nitrogen from cells	[24, 29]
6-Shogaol	Suppress prostaglandin E2 and nitric oxide generation	[30]
Essential oil	Inhibitory actions against microbes Antioxidative reactions	[25, 27]

Table 1.
 Some ginger constituents and possible means of bio-actions.

of therapeutic properties like anti-hepatotoxicity and antiprostaglandin production among others [18]. Ginger contains some chemical derivatives and other constituents aside the primary bioactive compounds, which are also highly reactive and with useful therapeutic mechanisms (**Table 1**).

4. Methods of extraction of components of ginger

Before the introduction of modern methods, conventional methods such as infusion, decoction, and percolation, which are a direct simple solvent extraction, were used [31]. Although new techniques have been developed, these conventional methods are still used in Phytochemistry Laboratories. Traditional extraction techniques, though still in use, pose several challenges during extraction. These methods consume a lot of energy and time as well as require large amount of solvents and are also difficult to automate. In recent times, modern extraction techniques such as microwave-assisted, ultrasound-assisted extraction, negative pressure cavitation extraction, and accelerated solvent extraction have been developed to curb the challenges associated with the traditional extraction methods. These techniques are easy to automate and require shorter extraction time and smaller amount of solvents [31].

5. Pharmacological properties

Ginger is used in herbal treatment for colds and other viral infections, poor appetite, digestive problems, arthritis, and headache [32]. Ginger and its constituents have antiemetic, antithrombotic, anti-inflammatory, and antioxidant effects [33]. The major pharmacological activity of ginger appears to be due to gingerol and shogaol [34]. Studies have shown that ginger exhibits several pharmacological activities, such as antioxidant, cytotoxic agent, gastrointestinal, cardiovascular disorders and anti-vomiting, anti-inflammatory, antimicrobial action, and pesticidal effects [34].

5.1 Antioxidant effects of ginger

Many cell culture studies have revealed the antioxidant actions of ginger [35–38]. Some progressive biological studies also show the protective actions of gingerol and ginger extract on many tissues against shocks on the account of several actions that cause oxidation [35]. Ginger is a strong antioxidant substance and may either mitigate or prevent generation of free radicals. Ginger, which is the underground stem or rhizome of the plant *Zingiber officinale Roscoe*, contains polyphenol compounds (6-gingerol and its derivatives), which have a high antioxidant activity [39].

Beverage products obtained through lactic anaerobic biochemical processing of plants from the ginger family contain antioxidant properties [40]. Ginger is one of the prominent herbs noted for its “shock-absorber” actions, which helps to promote insulation for the human system including pregnancy [41, 42]. The antioxidant property of ginger was also confirmed in a study where the extract effectively inhibited rancidity of fats and prevented linoleic acid from oxidizing [43]. The application of ginger also interfered with the generation of nitric oxide [44].

5.2 Cytotoxic properties

The potency of ginger against various forms of cancer like cervical, breast, and prostate have been largely studied [45, 46], and ginger has been found to be effective

against the rapid degeneration of cancers, the death of affected cells [22, 47]. Ginger terpenoids were found to promote the stimulation of p53 and thus making the cancer cells relating to endometrium inactive [48]. Rapid multiplication of PC-3 prostate cancer cell was cooperatively prevented by the double mixture of 6-shogaol, 8-gingerol, 6-gingerol, and 10-gingerol [49]. Cell culture studies have demonstrated that ginger served as an inhibitory substance toward cancer of the skin and abnormal growth in the bladder and lung [50, 51].

Recent studies have shown that the administration of ginger powder at two grams per day for a period of 4 weeks suppresses the development of cyclooxygenase-1, an inflammatory-related enzyme which is closely associated with cancer of the large intestine [52]. In similar studies, it was reported that 6-gingerol, a bioactive component responsible for the stingy sensation of ginger, was highly effective against the formation and generation of new blood vessels either within an organism or in an artificial medium outside an organism, and this action could best prevent an abnormal growth and spread of cancers from one cell to the other [53]. Research has revealed that 6-shogaol exhibited inhibitory action against cancer of the breast by stopping the colonization of cells and decreasing of metalloproteinase-9 manifestation [54].

5.3 Gastrointestinal properties of ginger

Ginger has been helpful in the alleviation of numerous gastrointestinal discomforts such as ulcers of the duodenum and other digestive canal. The stomachic mucous membrane is being secured against a number of potential ulcer factors due to its antagonistic reactions toward oxidation [55, 56]. Essence from ginger reportedly blocked *Helicobacter pylori* in a study conducted in an artificial environment [57]. A study has shown that signs of vomiting and nausea were effectively relieved when the powdered form of ginger was administered by mouth, 4 times per day at 250 mg, to 27 gravida women with pregnancy-related morning discomfort for more than a 4-day period [58]. Ginger helps to get rid of constipation when used in the fresh form [59]. The phenolic content in aqueous extract of ginger is reported to have potential ulcer-preventing ability; the aqueous extract of ginger will also reduce free radical damage during ulceration. Hence, ginger is used as an ulcer-preventive agent [60].

5.4 Cardio and antivomitory actions of ginger

Several studies have identified the medicinal properties of shogaol and gingerol bioactive groups of ginger components. Ginger helps to stimulate the muscles of the heart to facilitate blood flow, lower the concentration of blood, and boost metabolic reactions in the cells, which greatly secure the organ systems against offensive muscular contractions [61]. Powdered ginger root in the dose used was found to be effective in reducing nausea and vomiting induced by low-dose cyclophosphamide in combination with drugs causing mild emesis [62].

The 6-gingerol, 6-shogaol, and other ginger-based compounds with two carbonyl groups are catalytically active against the bio-generation of leukotriene, prostaglandin, and thromboxane [63]. Chemo-constituents of ginger like alkaloids, flavonoids, saponins, peptides, and non-primary amino acids showed characteristic actions of dilation and blood pressure reduction [64].

Ginger is a good bio-inhibitory agent against neurotransmitter receptors, which promote flexibility and movement in the lumen of the intestines. Ginger also induces a supportive counteraction in the alimentary canal toward the 5-hydroxytryptamine receptors [55, 56]. Powdered ginger administered at 1 g or more per day

suppressed intense and excessive vomiting during pregnancy for about 92% of the studies carried out [65].

5.5 Anti-inflammatory action of ginger

The expression of an inflammation-producing related gene was inhibited in LPS-activated BV2 neuron-supportive cells of the immune system, thereby suppressing neuron-related inflammations [66]. Oral administrations of ginger oil and eugenol against acute arthritis in rats significantly inhibited the expression of joints and paw swollen [67]. The infusion of ginger oil can inhibit prolonged swelling of joints [68].

Ginger structural components like shogaol and gingerol effectively stopped leukotrienes and prostaglandins bio-generations by preventing either 5-lipoxygenase or prostaglandin synthase from expressing [69, 70]. In a published report, ginger was found to have given an outstanding performance against arthritis actions in humans, when consumed in a fresh state [71]. The study also found out that the generation of many arthritics or inflammation reactions related genes was actively suppressed by using *Alpinia galanga* and essence of ginger [19].

5.6 Antimicrobial action of ginger

Ginger extract has showed antimicrobial activity against a broad spectrum of pathogenic microorganisms. Ginger extract at the rate of 10% has been reported to possess some economic level of anti-pathogenic properties against disease-causing organisms [72]. The floral part and root of ginger contain an extractable oil that averagely act positively against *Bacillus licheniformis*, *Staphylococcus aureus* (gram-positive bacteria), *Klebsiella pneumonia*, and *Pseudomonas stutzeri* (gram-negative bacteria) [73].

An in vitro analysis demonstrated the suppressive ability of ginger essence and other components against the growth and development of contagious bacteria like *Listeria monocytogenes* [74]. Studies have shown that ginger impedes the reproduction and growth of the colon bacteria, some strains of *Salmonella*, carcinogen (23, 24), and *Aspergillus*. Again, the undiluted juice obtained from ginger rhizome has proven to be effective, under room temperature at the rate of 12 and 4% against the development of *Mycoderma* spp. and *Aspergillus niger*, respectively [75].

A study conducted by Chakotiya et al. [76] also revealed how the development of a breed of *Pseudomonas aeruginosa* was suppressed by ginger and its bioactive compounds through the prevention of the synthesis of biofilms. Paste prepared from ginger also exhibited a positive counteraction against the growth of O157:H7 strain of *Escherichia coli* (*E. coli*) when studied in laboratory culture, using beef and laboratory broth [77, 78]. In our previous studies, it was found that the growth of *Aspergillus niger* on yam tubers was suppressed by 65.5% when treated with an ethanol ginger extract [79]. Similarly, *Z. officinale* inhibited the growth of *Rhizopus stolonifer*, *Aspergillus niger*, *Aspergillus flavus*, *Fusarium oxysporum*, and *Botryodiplodia theobromae* significantly [80].

Several reports have demonstrated the effectiveness of ginger against viruses, some parasites, and a group of fungi [81–83]. The highly valued oil extracted from ginger has showed high potency against *Aspergillus flavus* development and the multiplication of certain genes linked to aflatoxin [84, 85]. An ethanol-containing extract obtained from ginger was found to have high efficacy against the multiplication of candida bacteria [86]. Ginger was used to cure tuber rot disease, a fungal disease of an economic importance in yam, by suppressing the growth of *Fusarium oxysporum*, *Penicillium oxalicum*, and *Trichoderma viride*, which are the primary causative agents [87].

6. Pesticidal properties of ginger

It has been reported that ginger extract at 3% exhibited pesticidal potential thereby reducing cabbage looper (*Trichoplusia binotalis*) [88]. Several studies have shown that the methanol extract obtained from ginger can be used in controlling trypanosomiasis, commonly known as “sleeping sickness” due to its counteractions against parasites [89–91]. A good result was achieved when an extract of ginger was evaluated for pestilence against leaf hoppers and defoliators of cowpea (*Vigna unguiculata* L.) in a field study [92].

Studies have also shown that ginger is effective in managing pests like hoppers, root-knot nematodes, aphids, American bollworm, thrips, and mango anthracnose, among others [93]. In a study under both field and laboratory environments, the residues taken from the water extraction process of ginger was found to be active at the rate of about 25–30% in suppressing the oviposition process and development of matured flea beetle of okra (*Callosobruchus maculatus* F.) on the field and in storage [94].

7. Other useful properties of ginger

It has been reported that an ethanolic essence of ginger ultimately reduces the sugar level of blood when given orally to a rat suffering from diabetes. Oral intake of 100 mg/kg of ginger extract, dissolved in 80% of alcohol, gave 38% suppression of yeast-associated fever among rats [95, 96]. 6-Gingerone helps to control obesity by inhibiting and reducing of fats buildup and weight gain among mice [97]. 10-Gingerol exhibited an excellent performance against the growth of *Angiostrongylus cantonensis* larvae, a type of nematode of an economic importance in some regions of the Pacific and Asia [98]. Several studies in recent times have identified ginger as a suppressive medicinal material, which influences recollection ability of the minds and is capable of relieving or preventing neuron inflammations that may help to control infections associated with debasement of neurons [99, 100]. Ginger plays a preventive role against rapid multiplication of cell and growth of cancer-affected cells [101, 102]. Ginger has also been reported to have a good antagonistic action against the virulence of the hepatitis C virus [61, 103].

8. Conclusions

This particular review tried to bring together various research findings and reports of the past, on the therapeutic characteristic properties of ginger. The review also comments on the numerous applications of ginger in the traditional medicine and its pharmaceutical importance. A good number of therapeutic reactions of ginger have been identified, which include anti-inflammatory actions, anti-cancer properties, antioxidant actions, anti-pesticidal properties, cytotoxicity, gastrointestinal actions, antimicrobial effects, and other conventional uses of ginger in plants, animals, and human health. Ginger is a recognized plant in the world of medical and health sciences. It contains gingerols as its primary bioactive compound with high flavonoid and phytochemical and pharmacological effects. Several studies in vivo, in vitro, and clinical analysis have over the years been conducted out and, thus, affirmed ginger's therapeutic properties which cannot be overlook.

Conflict of interest

The authors declare no conflict of interest.

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References

- [1] Ravindran PN, Nirmal Babu K. Ginger, the Genus *Zingiber*. Kerala, India: CRC Press; 2005
- [2] Haniadka R, Saldanha E, Sunita V, Palatty PL, Fayad R, Baliga MSA. Review of the gastroprotective effects of ginger (*Zingiber officinale* Roscoe). *Food and Function*. 2013;**4**(6):845-855. DOI: 10.1039/c3fo30337c
- [3] Ali BH, Blunde G, Tanira MO, Nemmar A. Some phytochemical, pharmacological and toxicological properties of ginger (*Zingiber officinale* Roscoe): A review of recent research. *Food and Chemical Toxicology*. 2008;**46**:409-420. DOI: 10.1016/j.fct.2007.09.085
- [4] Tapsell LC, Hemphill I, Cobiac L, Patch CS, Sullivan DR, Fenech M, et al. Health benefits of herbs and spices: The past, the present, the future. *Medical Journal of Australia*. 2006;**185**:4-24
- [5] Transparency Market Research. Ginger Market (Form—Fresh, Dried, Pickled, Preserved, Crystallized, and Powdered; Distribution Channel—Modern Grocery Retail, Traditional Grocery Retail, and Non-Grocery Retail; Application—Culinary, Soups and Sauces, Snacks & Convenience Food, Bakery Products, Alcoholic Beverages, Non-Alcoholic Beverages, and Chocolate and Confectionery)—Global Industry Analysis, Size, Share, Growth, Trends and Forecast 2017—2022. Available online: <https://www.transparencymarketresearch.com/ginger-market.html> [Accessed: 11/10/2019]
- [6] Bijaya BB. Ginger processing in India (*Zingiber officinale*): A review. *International Journal of Current Microbiology and Applied Sciences*. 2018;**7**(4):1639-1651. DOI: 10.20546/ijcmas.2018.704.185
- [7] Akinyemi AJ, Faboya OL, Paul AA, Olayide I, Faboya OA, Oluwasola TA. Nephroprotective effect of essential oils from ginger (*Zingiber officinale*) and turmeric (*Curcuma longa*) rhizomes against cadmium-induced nephrotoxicity in rats. *Journal of Oleo Science*. 2018;**67**(10):1339-1345. DOI: 10.5650/jos.ess18115
- [8] Rialita T, Rahayu WP, Nuraida L, Nurtama B. Aktivitas antimikroba minyak esensial jahe merah (*Zingiber officinale* var. *Rubrum*) dan lengkuas merah (*Alpinia purpurata* K. Schum) terhadap bakteri patogen dan perusak pangan. *Agrı*. 2015;**35**:43-52
- [9] Agrahari P. A brief study on *Zingiber officinale*, a review. *Journal of Drug Discoveries and Therapeutics*. 2015;**3**:28. DOI: 10.1016/j.ddstr.2013.05.001
- [10] Jeevani Osadee Wijekoon MM, Karim AA, Bhat R. Evaluation of nutritional quality of torch ginger (*Etilingera elatior* Jack.) inflorescence. *International Food Research Journal*. 2011;**18**(4):1415-1420
- [11] Pandotra P, Gupta AP, Khan S, Ram G, Gupta S. A comparative assessment of ISSR, RAPD, IRAP, & REMAP molecular markers in *Zingiber officinale* germplasm characterization. *Scientia Horticulturae*. 2015;**194**:201-207
- [12] World Health Organization (WHO). WHO Traditional Medicine Strategy 2002-2005. Available at: <<http://www.wpro.who.int/healthtechnology/bookwho/traditionalmedicinestrategy.2000;2002-2005.pdf>> [Accessed: 14/04/2014]
- [13] Gupta S, Pandotra P, Gupta AP, Dhar JK, Sharma G, Ram G, et al. Volatile (As and Hg) and non-volatile (Pb and Cd) toxic heavy metals analysis in rhizome of *Zingiber officinale* collected from different

- locations of North Western Himalayas by atomic absorption spectroscopy. *Food Chemistry and Toxicology*. 2010;**48**(10):2966-2971
- [14] United States Department of Agriculture. National Nutrient Database for Standard Reference Release 26 Full Report (All Nutrients). Nutrient data for Spices. Ginger. 2013
- [15] Badreldin HA, Blunden G, Tanira MO, Nemmar A. Some phytochemical, pharmacological and toxicological properties of ginger (*Zingiber officinale* Roscoe): A review of recent research. *Food Chemistry and Toxicology*. 2008;**46**:409-420. DOI: 10.1080/10942912.2015.1084633
- [16] Dhanik J, Arya N, Nand VA. Review on *Zingiber officinale*. *Journal of Pharmacognosy and Phytochemistry*. 2017;**6**(3):174-184
- [17] Koh EM, Kim HJ, Kim S, Choi WH, Choi YH, Ryu SY, et al. Modulation of macrophage functions by compounds isolated from *Zingiber officinale*. *Planta Medica*. 2009;**75**:148-151. DOI: 10.1055/s-0028-1088347
- [18] Cho KJ, Kim JW, Choi IL, Kim JB, Hwang YS. Isolation, identification and determination of antioxidant in ginger (*Zingiber officinale*) rhizome. *Agricultural Chemistry and Biotechnology*. 2001;**44**:12-15. DOI: 10.1017/S1742170510000189
- [19] Grzanna R, Lindmark L, Frondoza CG. Ginger—An herbal medicinal product with broad anti-inflammatory actions. *Journal of Medicinal Food*. 2005;**8**(2):125-132. DOI: 10.1089/jmf.2005.8.125.11
- [20] Bernard MM, McConnery JR, Hoskin DW. [10]-Gingerol, a major phenolic constituent of ginger root, induces cell cycle arrest and apoptosis in triple-negative breast cancer cells. *Experimental and Molecular Pathology*. 2017;**102**:370-376. DOI: 10.1016/j.yexmp.2017.03.006
- [21] Chen H, Lv L, Soroka D, Warin RF, Parks TA, Hu Y, et al. Metabolism of [6]-shogaol in mice and in cancer cells. *Drug Metabolism and Disposition*. 2012;**40**(4):742-753. DOI: 10.1124/dmd.111.043331
- [22] Tahir AA, Sani NFA, Murad NA, Makpol S, Ngah WZW, Yusof YAM. Combined ginger extract & Gelam honey modulate Ras/ERK and PI3K/AKT pathway genes in colon cancer HT29 cells. *Nutrition Journal*. 2015;**14**:31. DOI: 10.1186/s12937-015-0015-2
- [23] Kukic J, Petrovic S, Niketic M. Antioxidant activity of four endemic *Stachys* taxa. *Biological and Pharmaceutical Bulletin*. 2006;**29**:725-729. DOI: 10.1248/bpb.29.725
- [24] Dai J, Mumper R. Plant phenolics: Extraction, analysis and their antioxidant and anticancer properties. *Molecules*. 2010;**15**:7313-7352. DOI: 10.3390/molecules15107313
- [25] Takahashi M, Inouye S, Abe S. Anti-Candida and radical scavenging activities of essential oils and oleoresins of *Zingiber officinale* Roscoe and essential oils of other plants belonging to the family Zingiberaceae. *Drug Discoveries and Therapeutics*. 2011;**5**(5):238-245. DOI: 10.5582/ddt.2011.v5.5.238
- [26] Sasidharan I, Menon AN. Comparative chemical composition and antimicrobial activity fresh & dry ginger oils (*Zingiber officinale* Roscoe). *International Journal of Current Pharmaceutical Research*. 2010;**2**(4):40-43
- [27] Yuva B. Total antioxidant activity and antimicrobial potency of the essential oil and oleoresin of *Zingiber officinale* Roscoe. *Asian Pacific Journal*

- of Tropical Diseases. 2014;**4**(1):40-44. DOI: 10.1016/S2222-1808(14)60311-X
- [28] Zhang F, Zhang J, Qu J, Zhang Q, Prasad C, Wei Z. Assessment of anti-cancerous potential of 6-gingerol (Tongling white ginger) and its synergy with drugs on human cervical adenocarcinoma cells. *Food Chemistry and Toxicology*. 2017;**109**:910-922. DOI: 10.1016/j.fct.2017.02.038
- [29] Cotelle N. Role of flavonoids in oxidative stress. *Current Topics Medicinal Chemistry*. 2001;**1**:569-590. DOI: 10.2174/1568026013394750
- [30] Zhang G, Nitteranon V, Chan LY, Parkin KL. Glutathione conjugation attenuates biological activities of 6-dehydroshogaol from ginger. *Food Chemistry*. 2013;**140**:1-8
- [31] Tomasz B, Anna O. Extraction methods for the isolation of isoflavonoids from plant material. *Open Chemistry*. 2017;**15**:34-45. DOI: 10.1515/chem-2017-0005
- [32] Ghayur MN, Gilani AH. Pharmacological basis for the medicinal use of ginger in gastrointestinal disorders. *Digestive Diseases and Sciences*. 2005;**50**(10):1889-1897. DOI: 10.1007/s10620-005-2957-2
- [33] Khaki AA, Khaki A. Antioxidant effect of ginger to prevent lead-induced liver tissue apoptosis in rat. *Journal of Medicinal Plants Research*. 2010;**4**:1492-1495. DOI: 10.5897/JMPR09.397
- [34] Suekawa M, Ishige A, Yuasa K, Sdo K, Aburada M, Hosoya E. Pharmacological studies on ginger. I. Pharmacological actions on pungent constituents, (6)-gingerol and (6)-shogaol. *Journal of Pharmacobiodyn*. 1984;**7**(11):836-848. DOI: 10.1248/bpb1978.7.836
- [35] Kim JK, Kim Y, Na KM, Surh YJ, Kim TY. [6]-Gingerol prevents UVB-induced ROS production and COX-2 expression 'in vitro' and 'in vivo'. *Free Radical Research*. 2007;**41**(5):603-614. DOI: 10.1080/10715760701209896
- [36] Asnani V, Verma R. Antioxidative effect of rhizome of *Zingiber officinale* on paraben induced lipid peroxidation: An 'in vitro' study. *Acta Poloniae Pharmaceutica*. 2007;**64**(1):35-37
- [37] Chohan M, Forster-Wilkins G, Opara E. Determination of the antioxidant capacity of culinary herbs subjugated to various cooking and storage processes using the ABTS (+) radical cation assay. *Plant Foods for Human Nutrition*. 2008;**63**(2):47-52. DOI: 10.1007/s11130-007-0068-2
- [38] Tao Q, Xu Y, Lam R, et al. Diarylheptanoids and aminoterpenoid from the rhizome of *Zingiber officinale*: Antioxidant and cytoprotective properties. *Journal of Natural Products*. 2008;**71**(1):12-17. DOI: 10.1021/np070114p
- [39] Herrmann K. Antioxidativ wirksame pflanzenphenole sowie carotinoide als wichtige inhaltsstoffe von Gewürzen. *Gordian*. 1994;**4**:113-117
- [40] Chen IN, Ng CC, Wang CY, Chang TL. Lactic fermentation and antioxidant activity of Zingiberaceae plants in Taiwan. *International Journal of Food Science and Nutrition*. 2009;**60**(2):57-66. DOI: 10.1080/09637480802375531
- [41] Portnoi G, Chng LA, Karimi-Tabesh L, Koren G, Tan MP, Einarson A. Prospective comparative study of the safety and effectiveness of ginger for the treatment of nausea and vomiting in pregnancy. *American Journal of Obstetrics and Gynecology*. 2003;**189**(5):1374-1377. DOI: 10.1067/s0002-9378(03)00649-5
- [42] Heitmann K, Nordeng H, Holst L. Safety of ginger use in pregnancy:

- Results from a large population-based cohort study. *European Journal of Clinical Pharmacology*. 2013;**69**(2):269-277. DOI: 10.1007/s00228-012-1331-5
- [43] Stoilova I, Krastanov A, Stoyanova A, Denev P, Gargova S. Antioxidant activity of a ginger extract (*Zingiber officinale*). *Food Chemistry*. 2007;**102**(3):764-770. DOI: 10.1016/j.foodchem.2006.06.023
- [44] Ippoushi K, Azuma K, Ito H, Horie H, Higashio H. [6]-Gingerol inhibits nitric oxide synthesis in activated J774.1 mouse macrophage and prevents peroxynitrite-induced oxidation and nitration reactions. *Life Sciences*. 2003;**73**(26):3427-3437. DOI: 10.1016/j.lfs.2003.06.022
- [45] Zhang M, Viennois E, Prasad M, Zhang Y, Wang L, Zhang Z, et al. Edible ginger-derived nanoparticles: A novel therapeutic approach for the prevention and treatment of inflammatory bowel disease and colitis-associated cancer. *Biomaterials*. 2016;**101**:321-340. DOI: 10.1016/j.biomaterials.2016.06.018
- [46] El-Ashmawy NE, Khedr NF, El-Bahrawy HA, Mansour HE. Ginger extract adjuvant to doxorubicin in mammary carcinoma: Study of some molecular mechanisms. *European Journal of Nutrition*. 2018;**57**(3):981-989. DOI: 10.1007/s00394-017-1382-6
- [47] Liu CM, Kao CL, Tseng YT, Lo YC, Chen CY. Ginger phytochemicals inhibit cell growth and modulate drug resistance factors in docetaxel resistant prostate cancer cell. *Molecules*. 2017;**22**(9):1477. DOI: 10.3390/molecules22091477
- [48] Liu Y, Whelan RJ, Pattnaik BR, Ludwig K, Subudhi E, Rowland H, et al. Terpenoids from *Zingiber officinale* (ginger) induce apoptosis in endometrial cancer cells through the activation of p53. *PLoS One*. 2012;**7**(12):153-178. DOI: 10.1371/journal.pone.0053178
- [49] Brahmabhatt M, Gundala SR, Asif G, Shamsi SA, Aneja R. Ginger phytochemicals exhibit synergy to inhibit prostate cancer cell proliferation. *Nutrition and Cancer*. 2013;**65**(2):263-272. DOI: 10.1080/01635581.2013.749925
- [50] Dias MC, Spinardi-Barbisan AL, Rodrigues MA, DeCamargo JL, Teran E, Barbisan LF. Lack of chemopreventive effects of ginger on colon carcinogenesis induced by 1,2-dimethylhydrazine in rats. *Food Chemistry and Toxicology*. 2006;**44**(6):877-884. DOI: 10.1016/j.fct.2005.11.015
- [51] Habib SH, Makpol S, Abdul-Hamid NA, Das S, Ngah WZ, Yusok YA. Ginger extract (*Zingiber officinale*) has anti-cancer and anti-inflammatory effects on ethionine-induced hepatoma in rats. *Clinics*. 2008;**63**(6):807-813. DOI: 10.1590/s1807-59322008000600017
- [52] Jiang Y, Turgeon DK, Wright BD, Sidahmed E, Ruffin MT, Brenner DE, et al. Effect of ginger root on cyclooxygenase-1 and 15-hydroxyprostaglandin dehydrogenase expression in colonic mucosa of humans at normal and increased risk for colorectal cancer. *European Journal of Cancer Prevention*. 2013;**22**(5):455-460. DOI: 10.1097/CEJ.0b013e32835c829b
- [53] Kim EC, Min JK, Kim TY, Lee SJ, Yang HO, Han S, et al. [6]-Gingerol, a pungent ingredient of ginger inhibits angiogenesis 'in vitro' and 'in vivo'. *Biochemical and Biophysical Research Communications*. 2005;**335**(2):300-308. DOI: 10.1016/j.bbrc.2005.07.076
- [54] Ling H, Yang H, Tan SH, Chui WK, Chew EH. 6-Shogaol, an active constituent of ginger, inhibits breast cancer cell invasion by reducing matrix metalloproteinase-9 expression via blockade of nuclear

- factor- κ B activation. *British Journal of Pharmacology*. 2010;**161**(8):1763-1777. DOI: 10.1111/j.1476-5381.2010.00991.x
- [55] Dugasani S, Pichika MR, Nadarajah VD, Balijepalli MK, Tandra S, Korlakunta JN. Comparative antioxidant and anti-inflammatory effects of [6]-gingerol, [8]-gingerol, [10]-gingerol and [6]-shogaol. *Journal of Ethno-pharmacology*. 2010;**127**(2):515-520. DOI: 10.1016/j.jep.2009.10.004
- [56] Gull I, Saeed M, Shaukat H, Aslam SM, Samra ZQ, Athar AM. Inhibitory effect of *Allium sativum* and *Zingiber officinale* extracts on clinically important drug resistant pathogenic bacteria. *Annals of Clinical Microbiology and Antimicrobials*. 2012;**11**:8. DOI: 10.1186/1476-0711-11-8
- [57] Srivastava KC. Aqueous extracts of onion, garlic and ginger inhibit platelet aggregation and alter arachidonic acid metabolism. *Biomedica Biochimica Acta*. 1984;**43**(8-9):335-346
- [58] Yamahara J, Rong HQ, Naitoh Y, Kitani T, Fujimura H. Inhibition of cytotoxic drug-induced vomiting in *Suncus* by a ginger constituent. *Journal of Ethno-pharmacology*. 1989;**27**(3):353-355. DOI: 10.1016/0378-8741(89)90010-x
- [59] Malhotra S, Singh AP. Medicinal properties of ginger (*Zingiber officinale* Roscoe). *Natural Products Radiance*. 2003;**2**(6):296-300
- [60] Nanjundaiah S, Annaiah H, Dharmesh S. Gastroprotective effect of ginger rhizome (*Zingiber officinale*) extract: Role of gallic acid and cinnamic acid in H⁺, K⁺ATPase/H. pylori inhibition and antioxidative mechanism. *Evidence-Based Complementary and Alternative Medicine*. 2011;**1**(1):1-13. DOI: 10.1093/ecam/nep060
- [61] Chaiyakunapruk N, Kitikannakorn N, Nathisuwan S, Leeprakobboon K, Leelasettagool C. The efficacy of ginger for the prevention of postoperative nausea and vomiting: A meta-analysis. *American Journal of Obstetrics and Gynaecology*. 2006;**194**(1):95-99. DOI: 10.1016/j.ajog.2005.06.046
- [62] Sontakke S, Thawani V, Naik MS. Ginger as an antiemetic in nausea and vomiting induced by chemotherapy; a randomized, cross-over, double blind study. *Indian Journal of Pharmacology*. 2003;**35**(1):32-36
- [63] Rajesh KM, Anil K, Ashok K. Pharmacological activity of *Zingiber officinale*. *International Journal of Pharmaceutical and Chemical Sciences*. 2012;**1**(3):1073-1078
- [64] Ajay M, Gilani AU, Mustafa MR. Effect of flavonoids on vascular smooth muscles of the isolated rat thoracic aorta. *Life Sciences*. 2003;**74**(5):603-612. DOI: 10.1016/j.lfs.2003.06.039
- [65] Fischer-Rasmussen W, Kjaer SK, Dahl C, Asping U. Ginger treatment of hyperemesis gravidarum. *European Journal of Obstetrics, Gynecology and Reproductive Biology*. 1991;**38**(1):19-24. DOI: 10.1016/0028-2243(91)90202-v
- [66] Jung HW, Yoon CH, Park KM, Han HS, Park YK. Hexane fraction of *Zingiberis rhizoma* crudus extract inhibits the production of nitric oxide and proinflammatory cytokines in LPS-stimulated BV2 microglial cells via the NF κ B pathway. *Food Chemistry and Toxicology*. 2009;**47**(6):1190-1197. DOI: 10.1016/j.fct.2009.02.012
- [67] Srivastava KC, Mustafa T. Ginger (*Zingiber officinale*) in rheumatism and musculoskeletal disorders. *Medical Hypothesis*. 1992;**39**(4):342-348. DOI: 10.1016/0306-9877(92)90059-1
- [68] Janet LF, Jennifer BF, Janice NO, Jianling C, Huaping Z, Barbara NT. Anti-inflammatory effects of the essential oils of ginger (*Zingiber*

- officinale* Roscoe) in experimental rheumatoid arthritis. *PharmaNutrition*. 2016;**4**(3):123-131. DOI: 10.1016/j.phanu.2016.02.004
- [69] Flynn DL, Rafferty MF, Boctor AM. Inhibition of 5-hydroxyeicosatetraenoic acid (5-HETE) formation in intact human neutrophils by naturally occurring diarylheptanoids: Inhibitory activities of curcuminoids and yakuchinones. *Prostaglandins Leukotrienes and Medicine*. 1986;**22**(3):357-360
- [70] Kiuchi F, Iwakami S, Shibuya M, Hanaoka F, Sankawa U. Inhibition of prostaglandin leukotriene biosynthesis by gingerols and diarylheptanoids. *Chemical and Pharmaceutical Bulletin*. 1992;**40**(2):387-391. DOI: 10.1248/cpb.40.387
- [71] Chrubasik S, Pittler MH, Roufogalis BD. *Zingiberis rhizoma*: A comprehensive review on the ginger effect and efficacy profiles. *Phytomedicine*. 2005;**12**(9):684-701. DOI: 10.1016/j.phymed.2004.07.009
- [72] Giriraju A, Yunus GY. Assessment of antimicrobial potential of 10% ginger extract against *Streptococcus mutans*, *Candida albicans*, and *Enterococcus faecalis*: An 'in vitro' study. *Indian Journal of Dental Research*. 2013;**24**(4):397-400. DOI: 10.4103/0970-9290.118356
- [73] Sivasothy Y, Chong W, Hamid A, Eldeen IM, Sulaiman S, Awang K. Essential oil of *Zingiber officinale* var *rubrum* theilade and their antibacterial activities. *Food Chemistry*. 2011;**124**(2):514-517. DOI: 10.1016/j.foodchem.2010.06.062
- [74] Norajit K, Laohakunjit N, Kerdchoenchuen O. Antibacterial effect of five Zingiberaceae essential oils. *Molecules*. 2007;**12**:2047-2060
- [75] Ody P. *The Complete Guide Medicinal Herbals*. London: Dorling Kindersley; 2000. p. 75
- [76] Chakotiya AS, Tanwar A, Narula A, Sharma RK. *Zingiber officinale*: Its antibacterial activity on *Pseudomonas aeruginosa* and mode of action evaluated by flow cytometry. *Microbial Pathogenesis*. 2017;**107**:254-260. DOI: 10.1016/j.micpath.2017.03.029
- [77] Gupta S, Ravishankar S. A comparison of the antimicrobial activity of garlic, ginger, carrot and turmeric pastes against *Escherichia coli* O157:H7 in laboratory buffer and ground beef. *Foodborne Pathogens and Disease*. 2005;**2**:330-340. DOI: 10.1089/fpd.2005.2.330
- [78] Wang W, Li CY, Wen XD, Li P, Qi LW. Simultaneous determination of 6-gingerol, 8-gingerol, 10-gingerol and 6-shogaol in rat plasma by liquid chromatography-mass spectrometry: Application to pharmacokinetics. *Journal of Chromatography B: Analytical Technologies in the Biomedical and Life Sciences*. 2009;**877**:671-679. DOI: 10.1016/j.jchromb.2009.01.021
- [79] Sowley ENK, Kankam F, Afari D. Evaluation of neem (*Azadirachta indica*) seed and ginger (*Zingiber officinale*) as potential control agents of yam (*Dioscorea rotundata* Poir.) tuber rot fungi. *Archives of Phytopathology and Plant Protection*. 2013;**46**(17):2117-2124. DOI: 10.1080/03235408.2013.785659
- [80] Yeni IJ. Inhibitory effects of two indigenous plant extracts (*Zingiber officinale* and *Ocimum gratissimum*) on postharvest yam (*Dioscorea rotundata* Poir.) rot 'in vitro'. *Journal of American Science*. 2011;**7**:43-47
- [81] Ficker C, Smith ML, Akpagana K, Gbeassor M, Zhang J, Durst T, et al. Bioassay-guided isolation and identification of antifungal compounds from ginger. *Phytotherapy Research*. 2003;**17**(8):897-902. DOI: 10.1002/ptr.1335

- [82] Imanishi N, Andoh T, Mantani N, et al. Macrophage mediated inhibitory effect of *Zingiber officinale* Roscoe, a traditional oriental herbal medicine, on the growth of influenza A/Aichi/2/68 virus. *American Journal of Clinical Medicine*. 2006;**34**:157-169
- [83] Schnitzler P, Koch C, Reichling J. Susceptibility of drug-resistant clinical herpes simplex virus type 1 strains to essential oils of ginger, thyme, hyssop, and sandalwood. *Anti-Microbial Agents Chemotherapy*. 2007;**51**:1859-1862. DOI: 10.1128/AAC.00426-06
- [84] Nerilo SB, Rocha GHO, Tomoike C, Mossini SAG, Grespan R, Mikcha JMG, et al. Antifungal properties and inhibitory effects upon aflatoxin production by *Zingiber officinale* essential oil in *Aspergillus flavus*. *International Journal of Food Science and Technology*. 2016;**51**:286-292
- [85] Moon Y, Lee H, Lee S. Inhibitory effects of three monoterpenes from ginger essential oil on growth and aflatoxin production of *Aspergillus flavus* and their gene regulation in aflatoxin biosynthesis. *Applied Biology and Chemistry*. 2018;**61**:243-250. DOI: 10.1007/s13765-018-0352-x
- [86] Supreetha S, Sharadadevi M, Sequeira P, Jithesh J, Shreyas T, Amit M. Antifungal activity of ginger extract on *Candida albicans*: An in-vitro study. *Journal of Dental Sciences and Research*. 2011;**2**(2):1-5
- [87] Okigbo RN, Nmeka IA. Control of yam tuber rot with leaf extracts of *Xylopiya aethiopica* and *Zingiber officinale*. *African Journal of Biotechnology*. 2005;**4**(8):804-807
- [88] Rizvi SAH, Hussain S, Rehman SU, Jaffar S, Rehman MFU. Efficacy of ecofriendly botanical extracts of ginger (*Zingiber officinale*), garlic (*Allium sativum*) and tobacco (*Nicotiana tabacum* L) for the control of cabbage looper (*Trichoplusia binotalis*) under agro ecological conditions of Peshawar, Pakistan. *Journal of Entomology and Zoology Studies*. 2016;**4**(1):88-90
- [89] Li F, Nitteranon V, Tang X, Liang J, Zhang G, Parkin KL, et al. *In vitro* antioxidant and anti-inflammatory activities of 1-dehydro-[6]-gingerdione, 6-shogaol, 6-dehydroshogaol and hexahydrocurcumin. *Food Chemistry*. 2012;**135**(2):332-337. DOI: 10.1016/j.foodchem.2012.04.145
- [90] Kumar A, Goyal R, Kumar S, Jain S, Jain N, et al. Estrogenic and anti-Alzheimer's studies of *Zingiber officinalis* as well as *Amomum subulatum* Roxb.: The success story of dry techniques. *Medicinal Chemistry Research*. 2015;**24**(3):1089-1097
- [91] Duarte MC. Antileishmanial activity and mechanism of action from a purified fraction of *Zingiber officinalis* Roscoe against *Leishmania amazonensis*. *Experimental Parasitology*. 2016;**166**:21-28. DOI: 10.1016/j.exppara.2016.03.026
- [92] Isirima CB, Umesi N, Nnah MB. Comparative studies on effects of garlic (*Allium sativum*) and ginger (*Zingiber officinale*) extracts on cowpea insect pests attack. *World Rural Observations*. 2010;**2**(2):65-71. Available at: <http://www.sciencepub.net/rural>
- [93] Sridhar S, Arumugasamy S, Saraswathy H, Vijayalakshmi K. *Organic Vegetable Gardening*. Chennai: Centre for Indian Knowledge System; 2002
- [94] Amuji CF, Echezona BC, Dialoke SA. Extraction fractions of ginger (*Zingiber officinale* Roscoe) and residue in the control of field and storage pests. *Journal of Agricultural Technology*. 2012;**8**(6):2023-2031
- [95] Sharma M, Shukla S. Hypoglycaemic effect of ginger. *The Journal of Research in Indian Yoga and Homoeopathy*. 1977;**12**:127-130

- [96] Mascolo N, Jain R, Jain SC, Capasso F. Ethno-pharmacologic investigation of ginger (*Zingiber officinale*). Journal of Ethnopharmacology. 1989;27(1-2):129-140. DOI: 10.1016/0378-8741(89)90085-8
- [97] Okamoto M, Irii H, Tahara Y, Ishii H, Hirao A, Udagawa H, et al. Synthesis of a new [6]-gingerol analogue and its protective effect with respect to the development of metabolic syndrome in mice fed a high-fat diet. Journal of Medical Chemistry. 2011;54(18):6295-6304. DOI: 10.1021/jm200662c
- [98] Lin, Chen CY, Chung LY, Yen CM. Larvicidal activities of ginger (*Zingiber officinale*) against *Angiostrongylus cantonensis*. Acta Tropica. 2010;115(12): 69-76. DOI: 10.1016/j.actatropica. 2009.12.007
- [99] Park G, Kim HG, Ju MS, Ha SK, Park Y, Kim SY, et al. 6-Shogaol, an active compound of ginger, protects dopaminergic neurons in Parkinson's disease models via anti-neuroinflammation. Acta Pharmacologica Sinica. 2013;34:1131-1139
- [100] Huh E, Lim S, Kim HG, Ha SK, Park H, Huh Y, et al. Ginger fermented with *Schizosaccharomyces pombe* alleviates memory impairment via protecting hippocampal neuronal cells in amyloid beta (1-42) plaque injected mice. Food Function. 2018;9:171-178. DOI: 10.1039/C7FO01149K
- [101] Saraswat M. Antiglycating potential of *Zingiber officinalis* and delay of diabetic cataract in rats. Molecular Vision. 2010;16(165-66):1525-1537
- [102] Nasri H, Nematbakhsh M, Ghobadi S, Ansari R, Shahinfard N, Rafieian-Kopaei M. Preventive and curative effects of ginger extract against histopathologic changes of gentamicin-induced tubular toxicity in rats. International Journal of Preventive Medicine. 2013;4(3):316-321
- [103] Kubra IR, Murthy PS, Rao LJ. In vitro antifungal activity of dehydrozingerone and its fungitoxic properties. Journal of Food Sciences. 2013;78(1):64-69. DOI: 10.1111/j.1750-3841.2012.03009.x