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Promising Roles of *Zingiber officinale* and its Derivatives on Promoting Health and Protecting from Disorders

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ABSTRACT

Background: Ginger (*Zingiber officinale*) have gained great attention across the globe since ancient times or decades ago to be utilized as a delicacy spice or remedy to promote health and protect from ailments.

Methods: Supplementing ginger and active phytochemical constituents to mammalian species for spicing foods and protecting cells from disorders during stressful conditions.

Result: Supplementing ginger and active phytochemical constituents during stressful conditions might be helpful to overcome the stressors and increase productive and reproductive performances. Mammalian species during stressful conditions as transitional period, pregnancy, peak of lactation, heat stress andbody ailments require ginger and active phytochemical constituents to alleviate stress and promote body function. Ginger plant contains chemical compounds including amaldehyde, gingerol, shogaol and paradol, which are beneficial to the body health and have a wide range of pharmacological properties. Hence, the review article was designed to shed light of ginger and active phytochemical constituents' supplementation on promoting health and protecting from disorders in human and animals.

Key words: Embryos, Feed utilization, Ginger, Growth, Immunity, Oocytes, Reproduction.

INTRODUCTION

Ginger (*Zingiber officinale)* is the most perennial common herb used all over the world, which originated in highest ranking countries; India, China, Nepal, Indonesia and Nigeria, respectively. Ginger is spice used to give beautiful aroma to food and has a pivotal role as distinct medicinal properties (Park and Pezzuto, 2002; Mukjerjee and Karati, 2022). Ginger is widely used to treat a number of diseases due to varied phytochemistry that has large health benefits (Sayed *et al.,* 2020; Yang *et al.,* 2024). Ginger contains more than 60 active phytochemical constituents as carbohydrates, proteins, lipids, non-volatile pungent scaffolds (Gingerols, Zingerone, Shogaols and Paradols), sesquiterpene (Zingiberene, β-Sesquiphellandrene and β-Bisabolene), monoterpenoid (β-phelladrene, cineol and Citral), vitamins (B5, B6 and E) and minerals (calcium, phosphorus, magnesium, sodium, iron and manganese) (Mukjerjee and Karati, 2022). Several body functions were modulated through ginger supplementation. Sayed *et al.* (2020) found that ginger supplementation to rats resulted in reduced body weight gain and improved energy expenditure, which may avoid surgery for weight loss due to the risk factors and high cost in human. Besides, blood metabolites and immunity were modulated upon ginger supplementation (Zhang *et al.,* 2009; Rajan *et al.,* 2013; Banji *et al.,* 2014). Therefore, this review is designed to shed the light on the various ginger and pharmacological properties in promoting body functions and alleviating diseases of both animals and human as well.

MATERIALS AND METHODS

The current study was carried out according to the procedure approved by Deanship of Scientific Research, King Faisal University, Saudi Arabi from October to March (2024). The seminal articles concerning the effects of ginger and active phytochemical constituents were collected form SciencDirect, PubMed and Google Scholar. Therefore, our targets are to highlight key aspects of ginger and active phytochemical constituents on body functions, productive and reproductive performances and serum metabolites. In addition, the pharmacological significance of ginger and active phytochemical constituents concerning antioxidant, anti-inflammatory, immunomodulatory, antidiarrhoeic, antiemetic and lipolytic activities were used.

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RESULTS AND DISCUSSION

Morphology, origin, distribution and ginger oil

Ginger is believed to be originated in tropical Southeast Asia, possibly in the Indian subcontinent. It has been cultivated for thousands of years and is now grown in tropical and subtropical regions around the world. The fifth top ginger producing countries include India, China, Nepal, Indonesia and Nigeria, respectively (Mukjerjee and Karati 2022). Ginger belongs to the family Zingiberaceae, which also includes turmeric (Curcuma longa), cardamom (Elettaria cardamomum) andgalangal. The ginger (Z. *officinale*) is a flowering perennial plant reached 1-3 feet height. The rhizome, or ginger root, is the most important part of the plant andit is the part that is used as a spice or medicine. The rhizome is knobby and has a brown skin. It has a pungent, spicy flavor and a warm aroma. Components of ginger oil, originated from roots, were varied according to the area, protocol of extraction and roots condition (Ibtisham *et al.,* 2019). It is well-known that ginger oils are considered safe and used of great importance for improvement of respiratory and gastrointestinal functions. Ginger and its derivative compounds could be used as a promising alternative to antibiotics in livestock and poultry feed (Abd El-Hack *et al.,* 2020).

Effects of ginger on body functions

Ginger has many health benefits due to the several bioactive compounds (Yang *et al.,* 2024) (Fig 1 and Table 1). The variety of bioactive compounds has antioxidant, anti-inflammatory, immunomodulatory, antidiarrhoeic, antiemetic and lipolytic activities resulting in improvement of blood metabolites, productive and reproductive performances (Akhlaghi *et al.,* 2014; Sorrenti *et al.,* 2023). Zingerone is produced by thermal degradation of gingerols or shogaols or during drying of ginger directly. It has been stated that ginger oil chemical composition is influenced by rhizome origin, freshness or dehydration status and procedures of extraction (Abd El-Hack *et al.,* 2020).

Zingerone is absent in fresh ginger but is formed through heating or cooking to transform gingerol to zingerone, which present 9.25% of ginger (Zhang *et al.,* 2012). Zingerone has potent pharmacological activities including antidiabetic, antilipolytic, antidiarrhoeic, anti-inflammatory and antispasmodic activities . In addition, zingerone displays the properties of immune stimulation and enhancing growth. Besides, zingerone inhibits the reactive nitrogen species (RNS), which is important to cause Alzheimer's disease.

Effect of ginger on productive performance and serum metabolites under heat-stress condition

Heat stress is known to severely effect on feed utilization and body weight gain (Ibtisham *et al.,* 2019). Therefore, improving the negative effects of heat stress in the animal and poultry industry is extremely important (Al-Mufarji *et al.,* 2022a,b). Heat stress can lead to oxidative stress, which causes lipid peroxidation and oxidative damage to cellular membranes. Feed intake and digestibility and production were improved due to ginger supplemented diet in addition to significantly higher glucose versus lower triglycerides and cholesterol values. Furthermore, nitric oxide, glutathione peroxidase and total protein values were significantly improved due to ginger supplemented diet (Ibtisham *et al.,* 2019). It has been showed that ginger can stimulate the secretion of gastrointestinal fluid and promote feed digestion (Amerah and Ravindran, 2015). Many

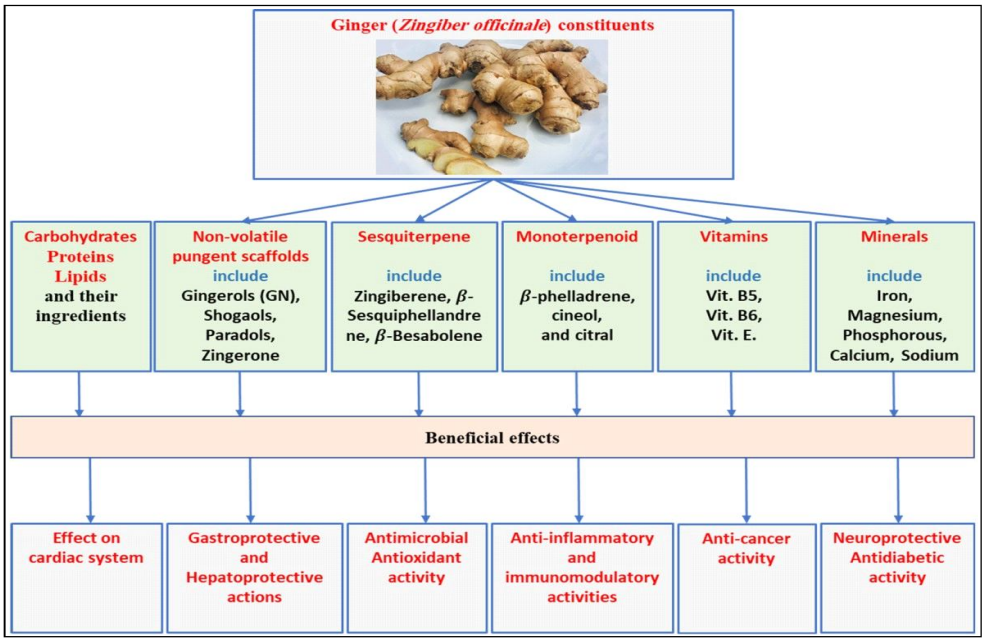

Fig 1: Effects of ginger active phytochemical constituents on body functions

Table 1: Roles of ginger active phytochemical constituents on body functions.

Vitamins	Functions	References
Non-volatile pungent scaffolds		
Gingerols	Exhibits biological activities including antioxidant, anticancer, anti-inflammatory and antimicrobial activities	Masuda et al., 2004 Mukjerjee and Karati 2022
Zingerone	Exhibit biological activities including antidiabetic, antilipolytic, antidiarrhoeic, anti-inflammatory, antispasmodic activities	Ahmad et al., 2015
Shogaols	Exhibits reduced pain symptoms	Fajrin et al., 2020
Paradols	Exhibit a potential therapeutic agent to suppress gastric cancer	Wang et al., 2023
Sesquiterpene		
Zingiberene	Exhibit anticancer, antihypertension, reduction of heart diseases and maintaining digestion and blood circulation	Rasool et al., 2022
??-Sesquiphellandrene	Exhibit antibacterial and antioxidant potential	Yousfi et al., 2021
??-Bisabolene	Exhibit anti-adipogenic and antibacterial activities	Li et al., 2023
Monoterpenoid		
??-phelladrene	Exhibits cardioprotective efficacy of alternative and complementary therapeutics	Mukjerjee and Karati 2022
Cineol	Exhibits biological activities including antioxidant, anticancer, anti-inflammatory and antimicrobial activities	Arora et al., 2013
Citral	Exhibits estrogen actions	Kiyama 2020
Vitamins		
Vitamin B5 (pantothenic acid)	Synthesis of coenzyme A (CoA) and acyl carrier protein, which are necessary for fatty acid synthesis and and degradation	Sweetman 2010
Vitamin B6 (pyridoxine)	Helps the body release sugar from stored carbohydrates for energy and create red blood cells	McCormick 2006
Vitamin E	Assists immune function and acts as an antioxidant that protects cells from damage	Luan et al., 2023
Minerals		
Calcium	Necessary for proper structure and function of bones and teeth. Assists in muscle function and blood vessel contraction	Rani et al., 2021
Phosphorus	Part of bone and cell membrane structure	Senosy et al., 2018
Magnesium	Assists with over 300 enzyme reactions, including regulation of blood pressure	Lobo et al., 2023
Sodium	Electrolyte that aids fluid balance and maintenance of blood pressure	Teresa Rejas et al., 1988
Iron	Helps provide oxygen to muscles and assists in the creation of certain hormones	Say et al., 2002
Manganese	Assists in carbohydrate, amino acid and cholesterol metabolism	Gad 2023

compounds found in ginger can bind to serotonin receptors, which in turn might influence gastrointestinal functions and can be used as growth promoter (Ashayerizadeh *et al.,* 2009). Therefore, the effect of ginger on serum metabolites might be due to a number of different mechanisms including direct effects on enzymes, activation of signaling pathways and altering gut microbiota. Ginger has shown various pharmacological effects including immunomodulatory and anti-inflammatory effects (Zhao *et al.,* 2011) due to several compounds as gingerol and shogaols that possess antioxidant activity.

Effects of ginger on reproductive performances

There are great evidences that ginger enhance male and female reproductive performances (Abdelfattah *et al.,* 2023). Because of ginger properties concerning presence of active phenolic compounds and androgenic activity, it improves semen quality through reducing oxidative stress and altering the levels of LH, FSH andandrogen hormones (Gholami-Ahangaran *et al.,* 2021). The antioxidant and androgenic properties of ginger give the sperm normal morphological structures, viability and increase sperm fertility characters. Ginger contains gingerol, gingerdiol and gingerdione, which may promote the functioning of the

antioxidant defense system (Baliga *et al.,* 2011). Additionally, the adjuvant impacts of antioxidants on ovarian follicle development, oocyte maturation and embryo development of mammalian species has been indicated (Mohammed *et al.,* 2024a).

Antioxidants improve female reproductive performances through the significant increase in reproductive hormone values, numbers and sizes of ovarian follicles in addition to increase of ovulation rate and corpora lutea development (Mohammed and Al-Suwaiegh 2016, 2023; Senosy *et al.,* 2017, 2018, 2019; Mohammed 2018; Ali *et al.,* 2021; Al-Mufarji *et al*., 2022a,b; Chen *et al.,* 2023; Mohammed *et al.,* 2024a,b,c). In addition, antioxidant supplementation to in vitro maturation media of oocytes promotes maturation and further embryonic development (Yao *et al.,* 2023). The antioxidants improved the quality of embryos and stimulated their mitochondrial function (Gomes da Silva *et al.,* 2023). Therefore, it is expected, due to the high antioxidant content of ginger, promotion of female reproductive performances. The short term with low dose of ginger (100 mg/5-day) was increased the antral follicle count and ovarian stromal vascular endothelial growth factor (Yilmaz *et al.,* 2018). The citral compound of ginger was found to exhibits estrogen actions (Kiyama, 2020). Hence, we could expect in assisted reproductive techniques promotion of ovarian follicle development andembryo development either *in vivo* or *in vitro* upon ginger supplementation. Moreover, the surgical assisted techniques used in reproduction as vasectomy, embryo transfer, ovarian transplantation and et cetera might promote recovery and enhance reproductive performance.

Effect of ginger on pharmacological significance

Ginger and its constituents are known to provide beneficial properties to the body functions. They have been recognized to inhibit the oxidation of various free radicals and the production of nitric oxide. Ginger has been shown to have a number of positive effects on the cardiac system including reduction of blood pressure, lowering cholesterol levels, preventing blood clots, improving blood circulation andprotecting against heart disease by reducing inflammation and oxidative stress (Patil and Patil, 2021; Daniels *et al.,* 2022; Mukjerjee and Karati, 2022). Besides, ginger has been shown to have a number of potential neuroprotective effects as reduction of oxidative stress, reducing inflammation, improving cognitive function andprotecting against neurodegenerative diseases. These effects might be due to a number of different mechanisms including direct effects on brain cells, activation of signaling pathways andmodulation of gut microbiota (Shanmugam *et al.,* 2011; Zhang *et al.,* 2018; Mukjerjee and Karati, 2022). Furthermore, a number of gastroprotective effects of ginger has been indicated as reduction of gastric acid secretion, protecting the gastric mucosa, promoting gastric healing andrelieving nausea and vomiting (Stewart *et al.,* 1991; Ernst and Pittler, 2000). Besides, ginger has been shown to have a number of hepatoprotective effects including protecting the liver from damage caused by toxins, reducing liver inflammation, promoting liver regeneration and improving liver function (Stagos *et al.,* 2012; Fahmi *et al.,* 2019). In addition, a number of potential benefits for people with osteoarthritis due to ginger supplementation includes reducing pain, reducing inflammation and slowing disease progression (Altman and Marcussen 2001). These beneficial effects of ginger might be due to a number of anti-inflammatory, immunomodulatory, antioxidant, antiemetic and prokinetic effects.

Effect of ginger on antioxidant, anti-inflammatory and immunomodulatory activities

Ginger and its constituents have the ability to degrade free radicals generated from food products due to phenolic compounds including gingerols, shogaols andparadols. These compounds effectively scavenge free radicals, which are unstable molecules that can damage cells and DNA. By neutralizing free radicals, ginger helps protect the body from oxidative stress, a cellular imbalance that contributes to various chronic diseases (Stoilova *et al.,* 2007; Rajan *et al.,* 2013; Banji *et al.,* 2014).

The antioxidant properties of ginger have been linked to its potential health benefits. Ginger's ability to protect against oxidative stress may contribute to its anti-inflammatory (Lantz *et al.,* 2007), anticancer (Li *et al.,* 2013; El-Ashmawy *et al.,* 2018) andneuroprotective (Shanmugam *et al.,* 2011) effects. Additionally, ginger has been shown to improve blood sugar (Ahmad *et al.,* 2015) control and protect against cardiovascular diseases (Mukjerjee and Karati 2022), both of which are associated with oxidative stress (Banji *et al.,* 2014).

Effect of ginger on antidiarrhoeic, antiemetic and lipolytic activities

Ginger and its constituents have been shown to have antidiarrheal effects in both animal and human studies. It is thought to work by several mechanisms including inhibiting the production of prostaglandins, reducing inflammation, stimulating the production of mucus and blocking the action of serotonin (Chen *et al.,* 2007; Iwami *et al.,* 2011). Besides, nausea and emesis are the side effects after treatment regime (Pillai *et al.,* 2011). Zingerone can be used to treat cytotoxic chemotherapy induced emesis and postoperative nausea and vomiting (Sharma *et al.,* 1997). Furthermore, ginger and its bioactive compounds, gingerols and shogaols, have been indicated to provide a positive effect on lipolysis both *in vitro* and *in vivo*. The worldwide obesity rate since 1980 has nearly doubled. The World Obesity Federation predicts one in seven men and one in five women will have obesity by 2030. According to the WHO organization, four million people die each year as a result of obesity. The effect of ginger on lipolysis is likely due to several mechanisms as increasing the activity of hormone-sensitive lipase,

inhibiting the expression of adipocyte protein 2, upregulating the expression of peroxisome proliferator-activated receptor á (Han *et al.,* 2008; Thunchomnang *et al.,* 2012). Ginger may have potential as a weight loss purpose. However, more studies are still needed to confirm the long-term safety and efficacy of ginger for this purpose.

CONCLUSIONS

The ginger supplementation improves gastrointestinal function, nutrient digestibility andblood and plasma profiles. Such enhancement over ginger supplementation might lead to improvement of body weight gain, reproductive performance including ovarian follicle numbers and quality of their oocytes, embryos and newborns. The continuous progress of ginger and its active constituent's supplementation is necessitated for both animals and human health. Therefore, the future approach of beneficial effects during transitional stage and/ or heat stress condition is a target for improving productive and reproductive performances and body health in ruminants through ginger and its active constituent's compounds.

Conflicts of interest

There is no conflict of interest for authors to declare.

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