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# Role of bioactive compounds in Ocimum sanctum and Gingiber officinale conferring immunity against Covid -19 .Review article .

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***Abstract***
*The coronavirus pandemic has turned the world's attention to the immune system* ***.Ocimum sanctum and Gingiber officinale*** *has an abundant amount of* ***bioactive compounds*** *which boost our immunity . Both fresh and dried* ***Ocimum sanctum*** *and* ***Gingiber officinale*** *have a beneficial effect. They are natural immunity boosters and keeps infections at bay. They are being used for the medical care and avoidance of respiratory diseases in the past. They showed to contribute as anti-carcinogenic, anti-diabetic, anti-tumor , Immunomodulator activities. Here we focused on the Ocimum and ginger* ***bioactive compounds*** *as an Immunomodulator against covid -19. Covid -19 has became now global pendamic .As covid -19 disease is directly or indirectly related to our immune system . There are many advantages and benefits associated with the use of* ***Ocimum sanctum*** *and* ***Gingiber officinale*** *as medicinal plants, the main ones being their cost-effectiveness and global availability.*

***Key words****: Bioactive compounds ,Covid -19 , ,Gingiber Ocimum ,Immunomodulator.*

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## I. Introduction

In the last 8 months, the novel coronavirus (COVID-19) has spread over the globe infecting more than 15 million populations leading to more than 600 thousand deaths. Individuals suffering from infectious and non-infectious diseases of the lungs are found to be more risk from this viral infection due to the lower immune system. Hence, enhancing the immunity (natural body system) may possess the major contribution as a prophylactic measure against multiple pathogenic conditions as well as maintaining optimum health (Nicholson LB 2016 ).The coronavirus disease (COVID-19) pandemic is unique and unprecedented in several aspects and has challenged health care systems across the globe. The coronavirus pandemic has turned the world's attention to the immune system, the body's defence force against disease-causing bacteria, viruses and other organisms that we touch, ingest and inhale every day (Cain -2020). Our immune systems will need to adapt unaided to COVID-19, until a potential vaccine is available. Hence, in the present study, it is proposed to elucidate the probable interaction of the phytoconstituents from Ocimum sanctum and Gingiber officinale which help to boost the immune system .The use of medicinal plants in traditional medicine has been described in literature dating back several 1000 years (Chang et al 2016). Books on Ayurvedic medicine, written in the Vedic period (3500–1600 B.C.) describe practices, including the use of medicinal plants, that formed the basis of all other medical sciences developed on the Indian subcontinent (Pattnayak et al 2010). *Ocimum sanctum*, Tulsi, or Holy Basil from the family Lamiaceae has been described as the "Queen of plants" and the "mother medicine of nature" due to its perceived medicinal qualities (Singh et al 2010). It has been one of the most valued and holistic herbs used over years in traditional medicine in India and almost every part of the plant has been found to possess therapeutic properties (Singh et al 2010 ). On the other hand Ginger is also loaded with bioactive compounds . It is an important herbal medicine. From the last century, more research has been performed on ginger extracts from producing new avenue for identifying the treatment of harmful diseases. Ginger and its pungent isolated compounds are known to have many potent biological activities. It has the potentiality to modulate the enzymatic profile and act as the prevention of diseases. It possesses various medicinal activities including anti inflammation, anti-tumor, insect repellent, anti-bacterial, anti-mutagen, anti-carcinogenic and antioxidant properties. Gingerol is responsible for its characteristic aroma and taste. It was known as the most prominent active components such as anti-oxidant, anti-inflammatory, analgesic, and antipyretic properties in ginger with various pharmacological effects.

## II. Bioactive compounds of Ginger

The chemical studied of ginger found that it has over 400 different constituents. The major pungent compounds from the lipophilic rhizome extract have yielded potentially active gingerols, which can be converted to shogaols, zingerone and paradol. Dried or extracted products have a high amount of zingerone, and

shogaols compared with fresh ginger. The important compounds are carbohydrates (50–70%), lipids (3–8%), phenolic acids, and terpenes in ginger rhizomes. In addition, phytosterols, amino acids, raw fiber, ash, protein, vitamins (vitamin A, and nicotinic acid), and minerals are also existed . The primary bioactive compounds of gingers are 6-gingerol, 6-shogaol, zingerone with phenolics and flavonoids. 4-, 6-, 8-, and 10-gingerdiols, 6- and 10-gingerdiones, 6-methylgingerdiol, 6-hydroxyshogaol, 6-, 8-, 10-dehydroshogaols, diarylheptanoids and zingerone have also been investigated as gingerol, and shogaol related compounds. These minor constituents only contribute from one to 10% of the overall gingerols and shogaols ( Sang, S et al 2009. )

Ginger plant, rhizome, and active components (6-gingerol, 6-paradol, and 6-shogaol) . The aromatic properties include zingiberene and bisabolene, however, the pungent contents are known as gingerols and shogaols. The potential key flavor of gingers is due to the mixture of volatile oils like shogaols and gingerols. Z. officinale has various antioxidants such as ascorbic acid, alkaloids, beta-carotene, polyphenols, and terpenoids. It has also key volatile oils such as oleoresins, bisabolene, cineol, phellandrene, citral, borneol, and citronellol. For instance, essential oil of ginger was investigated for testing the anti-inflammatory effect in rats. Moreover, proteolytic enzymes (zingibain), vitamin B6, vitamin C, and linoleic acid also have been investigated in the ginger. 6-gingerol (Prasad, S., Tyagi, A.K. 2015). Gingerol is responsible for its characteristic aroma and taste. It was known as the most prominent active components such as anti-oxidant, anti-inflammatory, analgesic, and antipyretic properties in ginger with various pharmacological effects (Dugasani et al 2010). It has been investigated that 6-gingerol induced apoptosis through the upregulation of the G1 cell cycle and NAG-1 arrest by downregulation of cyclin D1 (Lee, et al 2008) 6-gingerol has been identified as having the anti-cancerous effects . It has a potential role in the suppression of the hyperproliferation, inflammatory processes, and transformation that engaged in various steps of angiogenesis and metastasis. In addition, matrix metalloproteinase-9 expression inhibits cell invasion reduction, 6-shogaol show anti-cancer activity against breast cancer (Ling, H., et al 2010) .Moreover, 6-shogaol used to human colorectal carcinoma cells to induce apoptosis through the production of ROS ( Pan, et al 2008) Terpenoid compounds Ginger has a rich source of terpene compounds. It has terpenes (monoterpenes, sesquiterpenes, and sesquiterpene alcohols) composed of 20%–25% . Terpene compounds of ginger such as zingiberene, $\beta$-bisabolene, $\alpha$-farnesene, $\beta$-sesquiphellandrene, and $\alpha$-curcumene (Prasad, S 2015).It has been identified that ginger has monoterpenes (such as $\alpha$-pinene, camphene, myrcene, and $\alpha$-phellandrene), as well as oxygenated monoterpenes (geranial, citronellal, neral, linalool, borneol, and alphaterpineol). Ginger oil has a high amount of sesquiterpene hydrocarbons as well as sesquiterpene alcohols, primarily zingiberene (30%) and β-bisabolene (10-15%). In addition, ginger possesses sesquiterpenes ($\alpha$-farnesene, ar-curcumene, cadinene, copaene, zingiberene, and zingiberenol) in extract.(Koch et al 2017)

**Biological activities of Ginger :**

**Immuno-modulatory activity** :Probably the immune-boosting properties of the ginger have the beneficial effects in the treating coughs, colds and flu (Khaki et al.,2004). Immunomodulatory activity of ginger have examined in few studies. Non-specific immunity was increased in rainbow trout eating a diet containing 1% of a dried aqueous ginger extract for three weeks (Dugenci et al.,2003). Higher haemagglutinating antibody titre and plaque forming cell counts, consistent with improved humoral immunity, found in mice fed a 50% ethanolic ginger extract (25 mg/kg) for seven days (Puri et al.,2004). Ginger suppressed lymphocyte proliferation, found in-vitro study which was mediated by decrease in IL-2 and IL-10 production (Wilasrusmee et al.,2000) Aqueous ginger extract significantly increased the production of IL-1β, IL-6 and TNF-α in activated peritoneal mouse macrophages and splenocyte proliferation and cytokine production.Ginger rhizome diet for 12 weeks showed increased haematocrit, haemoglobin, erythrocyte, MCH, MCHC, WBC values and neutrophils percentage. Ginger essential oil showed improvement in humoral and cell mediated immune response in immune suppressed mice .

**Antimicrobial activity**: Among the different viruses which cause the common cold, Rhinovirusis one. In plaque reduction test, the dried rhizome of ginger has been investigated for anti-rhino-viral activity. Fractionation by solvent extraction, solvent partition and repeated chromatography guided by bioassay, allowed the isolation of several sesquiterpenes with anti-rhino-viral actiuvity. The most effective activity of these was β-sesquiphellandrene (Denyer et al.,1994).Gingerol and related compounds have been examined for antimicrobial activities. 10-gingerol has been stated as active inhibitor of Mycobacterium aviumand Mycobacterium tuberculosis[34]. Ginger inhibits aspergillus, a fungus identified for production of aflatoxin, a carcinogen . Ethanolic extract of ginger showed widest zone of inhibition against Salmonella typhi and also clear inhibitory actions against Candida albicans . The ethanolic extracts of emprit, gajah and red ginger varieties have different abilities to inhibit the growth of acne-origin bacteria.

**Gastrointestinal activity :** Ginger has been noted as being beneficial in preventing post-operative nausea and vomiting in humans ( Phillips S et al 1993) without a significant result on gastric emptying (Phillips S et al 1993) There is proof that ginger rhizome (root) increases stomach acid production. It may interfere with

antacids, sucralfate (Carafate), H2 antagonists, or proton pump inhibitors. The powdered rhizome of ginger has long been used in traditional medicine for improving the symptoms of gastrointestinaltract illnesses (Afzal et al 2001) . Active constituents of ginger (gingerols) are effective in vitro against Helicobacter pylori, the primary etiological factor associated with dyspepsia, peptic ulcer disease and increase of gastric and colon cancer [41]. Ginger-free phenolic and hydrolyzed phenolic fractions of ginger were both potent inhibitors of gastric cell proton potassium ATPase activity and H. pylori growth, and advised that the two fractions could be low-cost multistep blockers against ulcer (Siddaraju MN and Dharmesh SM 2007).

**Anti-biotic activity**

Together with the leaf and root extract of ginger showed anti-bacterial activity. In addition, it can be used as conventional antibiotics to fight against infections. For instance, the more antibacterial activity against Staphylococcus aureus and Streptococcus pyogenes has been seen in ginger extracts .(Phillips S,1993) In addition, 10% of ethanol ginger extract was investigated to have antimicrobial action against microorganisms ( Afzal M, et al 2001 ). Ginger extracted essential oil and oleoresin showed potential antimicrobial activity (Nostro A et al 2006)

**Anti-mutagenic and anti-cancer activity**

Ginger also worked as an anti-tumor activity by modulating of genetic pathways. It helps for the activation of suppressing gene of the tumor. Furthermore, inhibition of vascular endothelial growth factor and modulation of apoptosis can be done by ginger. For instance, it has been identified that the terpenoids, compound of ginger has been induced apoptosis in endometrial cancer cells via the activation of tumor protein p53 It has been discovered that for the treatment of prostate cancer whole ginger extract has been proved in vitro and in vivo experiment . On the other hand, ginger extract (100 mg/kg body weight) treatment expressed the highest performance of TNF-α in rats' liver cancer blockage .Moreover, ginger has an anti-cancer effect against pancreatic cancer .It has experimented with the anti-carcinogenic effect of breast cancer .

**Anti-diabetic activity**

Diabetes endocrine dysfunctions are characterized by defects in insulin secretion or action of a human. The prevalence of diabetes is on the inflation in accordance with the World Health Organization. Ginger is recommended as a potential drug in the treatment of diabetes. Ginger and their components showed a crucial role in the control of diabetes and its complications to

antihyperglycemic effect. Ginger is also worked for reducing the sugar level for the diabetic patient and also reduced the cholesterol levels in the blood.

**Anti-inflammatory activity**

Ginger and its components show a prominent role as anti-inflammatory processes. For instance, it has experimented that ginger oil (33 mg/kg), oral administration to rats for 26 days which reduced the paw and joint swelling related with acute chronic adjuvant arthritis.. For investigating the anti-inflammatory effect, in the cell wall of streptococcal induced rheumatoid arthritis model in female Lewis arthritis ginger essential oil has been applied by oral dose. It has been shown that it inhibited acute joint pain. Moreover, inhibition of cyclooxygenase (COX) and inhibition of nuclear cause NF-kappaB (κB) has been studied in vitro, which is shown to have anti-inflammatory effects .In addition, ginger extracts have shown that it can help from relief to the pain of osteoarthritis in the knee .It is also reduce the pain of rheumatoid arthritis by improving the joint movement

**Bioactive compounds of Ocimum sanctum :**

The chemical composition of Tulsi is highly complex, containing many nutrients and other biologically active compounds, the proportions of which may vary considerably between strains and even among plants within the same field. Furthermore, the quantity of many of these constituents is significantly affected by differing growing, harvesting, processing and storage conditions that are not yet well understood.The nutritional and pharmacological properties of the whole herb in its natural form, as it has been traditionally used, result from synergistic interactions of many different active phytochemicals. Consequently, the overall effects of Tulsi cannot be fully duplicated with isolated compounds or extracts. Because of its inherent botanical and biochemical complexity, Tulsi standardization has, so far, eluded modern science. The leaf volatile oil contains eugenol (1-hydroxy-2-methoxy-4-allylbenzene), euginal (also called eugenic acid), urosolic acid (2,3,4,5,6,6a,7,8,8a,,10,11,12,13,14b-tetradecahydro-1H-picene-4a-carboxylic acid), carvacrol (5-isopropyl-2-methylphenol), linalool (3,7-dimethylocta-1,6-dien-3-ol), limatrol, caryophyllene ,methyl carvicol (also called Estragol: 1-allyl-4-methoxybenzene) while the seed volatile oil have fatty acids and sitosterol; in

addition, the seed mucilage contains some levels of sugars and the anthocyans are present in green leaves. The sugars are composed of xylose and polysaccharides.

**Immunomodulatory effect**

Immunotherapeutic potential of aqueous extract of O. sanctum L. leaf in bovine sub-clinical mastitis (SCM) was investigated after intramammary infusion of aqueous extract. The results revealed that the aqueous extract of *O. sanctum* L. treatment reduced the total bacterial count and increased neutrophil and lymphocyte counts with enhanced phagocytic activity and phagocytic index.

In another study, the immunomodulatory effect of *O. sanctum* L. seed oil (OSSO) was evaluated in both non-stressed and stressed animals. *Osimum* sanctum L. seed oil (3 ml/kg, Ip ) produced a significant increase in anti-sheep red blood cells (SRBC) antibody titer and a decrease in percentage histamine release from peritoneal mast cell of sensitized rats (humoral immune responses) and decrease in food pad thickness and percentage leucocyte migration inhibition (cell-mediated immune responses). Co-administration of diazepam (1 mg/kg, Sc), a benzodiazepine (BZD) with OSSO (1 mg/kg, IP) enhanced the effect of OSSO on resistant stress induced changes in both humoral and cell-mediated immune responses. Further, flumazenil (5 mg/kg, IP) a central BZD receptor antagonist inhibited the immunomodulatory action of OSSO on resistant stress induced immune responsiveness. Thus, OSSO apparatus to modulate both humoral and cell-mediated immune responsiveness and these immunomodulatory effects may be mediated by GABAnergic pathway.

Godhwani *et al*. investigated the immunoregulatory profile of methanolic extract and an aqueous suspension of *O. sanctum* L. leaves to antigenic challenge of *Salmonella typhosa* and sheep erythrocytes by quantifying agglutinating antibodies employing the Widal agglutination and sheep erythrocyte agglutination tests and E-rosette formation in albino rats. The data of the study indicate an immunostimulation of humoral immunogenic response as represented by an increase in antibody titer in both the Widal and sheep erythrocyte agglutination tests as well as by cellular immunologic response represented by E-rosette formation and lymphocytosis.

**Antidiabetic**

Ethanolic extract of *O. sanctum* L. significantly decreases the blood glucose, glycosylated hemoglobin and urea with a concomitant increase in glycogen, hemoglobin and protein in streptozotocin-induced diabetic rats. (Narendhirakannan RT et al 2006) This extracts also resulted in an increase in insulin and peptide levels and glucose tolerance.

The constituents of *O. sanctum* L. leaf extracts have stimulatory effects (Hannan J.M *et al* 2006 ) on physiological pathways of insulin secretion, which may underlie its reported antidiabetic action.

Grovel *et al*. suggested that treatment with *O. sanctum* L. extract for 30 days to normal rats fed with fructose for 30 days significantly lowered serum glucose level Grovera J.K *et al* 2005 in comparison with control group. However, *O. sanctum* L. extract has no significant effect on hyperinsulinemia.

Ghosap *et al*. unravel the possible mechanism of glucose-lowering activity of *O. sanctum* L. in male mice. The study suggested that *O. sanctum* L. decreases the serum concentration of both cortisol and glucose and also exhibited antiperoxidative effect. Therefore *O. sanctum* L. may potentially regulate corticosteroid-induced diabetic mellitus.

In another study the effect of *O. sanctum* L. on three important enzymes of carbohydrate metabolism glucokinase (gk), hexokinase (hk) and phosphofructokinase (PFK) along with glycogen content of insulin-dependent (skeletal muscle and liver) and insulin-independent tissues (kidneys and brain) was studied by (Vats *et al 2004)*, in streptozotocin (STZ, 65 mg/kg)-induced model of diabetes for 30 days in rats. Administration of *O. sanctum* L. extracts 200 mg/kg for 30 days lead to decrease in plasma glucose levels by approximately 9.06 and 24.4% on 15th and 30th day. *O. sanctum* L. significantly decreased renal but not liver weight (expressed as % of body weight) *O. sanctum* L. glycogen content in any tissue; also *O. sanctum* L. partially corrected the activity of glucokinase (gk), hexokinase (hk) and phosphofructokinase (PFK) distributed in the diabetic control.

Tulsi (*O. sanctum* L.) leaf powder (Ravi V et al 1997) was fed at the 1% level in normal and diabetic rats for a period of one month and the result indicated a significant reduction in fasting blood sugar urogenic acid, total amino acids level. This observation indicates the hypoglycemic effect of *O. sanctum* L. in diabetic rats.

Chattopadyay also reported that oral administration of alcoholic extract of leaves of *O. sanctum* L. led to marked lowering of blood sugar (Chattopadhyay 1993) level in normal, glucose-fed hyperglycemic and streptozotocin-induced diabetic rats. Furthermore, the extract potentiates the action of exogenous insulin in normal rats. The activity of the extract was 91.55 and 70.43% of that of Tolbutamide in normal and diabetic rats, respectively.

**Cardiac activity**

Oral feeding of hydroalcoholic extract of *O. sanctum* L. (100 mg/kg) to male Wister rats subjected to chronic-resistant stress (6 h/day for 21 days) significantly prevented the chronic-resistant stress/induced rise in plasma cAMP level, myocardial superoxide dismutase and catalase activities Sood et al 2005 as well as the light microscopic changes in the myocardium.

Wister rats fed with fresh leaf homogenate of *O. sanctum* L. (50 and 100 mg/kg body weight) daily 30 days inhibit isoproterenol-induced changes in myocardial superoxide dismutase, glutathione peroxidase and reduced glutathione.

In another study effect of pre- and co-treatment of hydroalcoholic extract of *O. sanctum* L. at different doses (25, 50, 75, 100, 200 and 400 mg/kg) was investigated against isoproterenol (ISO, 20 mg/kg, Sc) myocardial infarction Sharam M et al 2001 in rats. *O. sanctum* L. at the dose of 25, 50, 75 and 100 mg/kg significantly reduced glutathione (GSH), superoxide dismutase and LDH levels. In this study, it was observed that *O. sanctum* L. at the dose of 50 mg/kg was found to demonstrate maximum cardioprotective effect.

The generation of drug-induced oxygen radicals in heart cells led to cardiac lipid Balanehruu S et al 1992 membrane peroxidation. Urosolic acid(UA) isolated from *O. sanctum* L. have been identified as a protector against Adriamycin (ADR)-induced lipid peroxidation. Protection with UA was 13 and 17% in liver and heart microsomes, respectively. On combination with oleanolic acid (OA) isolated from *Eugenia jumbolata* , it increased to 69%.

**Wound healing activity**

Shetty *et al* evaluated the wound healing effect of aqueous extract of *O. sanctum* L. in rats. Wound-breaking strength in incision wound model, epithelization period and percent wound concentration in excision wound model were studied owing to increased per cent wound contraction. *Ocimum sanctum* L. may be useful in the management of abnormal healing such as keloids and hypertropic scars.

Ethanolic extract of leaves of *O. sanctum* L. was investigated for normal wound healing and dexamethasone-depressed healing. The extract significantly increased the wound breaking strength, wound epithelializes fast and wound contraction was significantly increased along with increase in wet and dry granulation tissue weight and granulation tissue breaking strength. The extract also significantly decreases the anti-healing activities of dexamethasone in all wound healing models.

**Antimicrobial**

Singh *et al* 2005 in his study suggested that higher content of linoleic acid in *O. sanctum* L. fixed oil could contribute towards its antibacterial activity. The oil show good antibacterial activity against *Staphylococcus aureus, Bacillus pumius* and *Pseudomonas aeruginosa*, where *S. aureus* was the most sensitive organism.

Geeta *et al* 2001 studied that the aqueous extract of *O. sanctum* L. (60 mg/kg) show wide zones of inhibition compared to alcoholic extract against *Klebsiella, E. coli, Proteus, S. aureus* and *Candida albicans* when studied by agar diffusion method. Alcoholic extract showed wider zone for *Vibrio cholerae*.

## III. Conclusion

The present study utilized the system biology tools to assess the immunomodulatory effect of *Gingiber officinale* and *ocimum sanctum as a* prophylactic approach against COVID-19.Bioactive compounds present in these herbs play a vital role . The health-promoting perspectives of ginger and tulsi are well known. They can treat a wide range of diseases via immunonutrition and anti-inflammatory responses. As a result of anti-inflammatory effect of ginger, it can reduce muscle pain after intense physical activity. Likewise, the anticancer potential of ginger is well documented and its functional ingredients like gingerols, shogaol, and paradols are the valuable ingredients which can prevent various cancers, angiogenesis and metastasis, induction of apoptosis, and inhibition of cell-cycle progression. Besides these, it improves cardiovascular disorders, diabetes mellitus, and gastrointestinal health.

*Ocimum sanctum*, Tulsi, or Holy Basil from the family Lamiaceae has been described as the "Queen of plants" and the "mother medicine of nature" due to its perceived medicinal qualities (Singh et al., 2010). It has been one of the most valued and holistic herbs used over years in traditional medicine in India and almost every part of the plant has been found to possess therapeutic properties (Singh et al., 2010). Traditionally, Tulsi is used in different forms; aqueous extracts from the leaves (fresh or dried as powder) are used in herbal teas or mixed with other herbs or honey to enhance the medicinal value. Traditional uses of Tulsi aqueous extracts include the treatment of different types of poisoning, stomach-ache, common colds, headaches, malaria, inflammation, and heart disease (Pattanayak et al., 2010). Oils extracted from the leaves and inflorescence of Tulsi have been claimed to have numerous useful properties, including as expectorants, analgesics, anti-emetics, and antipyretics; stress reducers and inflammation relievers; and as anti-asthmatic, hypoglycemic, hepatoprotective, hypotensive, hypolipidemic, and immunomodulatory agents (Singh et al., 2010).In Ayurveda several treatment

options are available for enhancing immunity against respiratory illnesses, these include certain immunomodulators (known as Rasayana), local and systemic interventions.(Balasubramani et al 2011) Local prophylaxis measures such as herbal decoctions, consumptions of hot water, gargling with medicated water, and steam inhalation described in Ayurveda for respiratory illnesses (Chandran et al 2018). These interventions can be quickly implemented on large scale with the advantages of simplicity, affordability, and acceptability. This is clearly evident that such traditional measures can positively influence mental health and immune function through modulating psychoneuroimmune pathways. Presently, several allopathic drugs are under investigations for prophylactic use against COVID-19 and it seems current prophylactic measures are insufficient. In ancient cultures, medical practitioners focused on herbs for promoting the immune systems of body. In many countries ginger , Ocimum and their products are used to raise the immune system, **t**hese herbs boost the immune system to combat COVID-19.

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## List of Phytochemicals in ginger and tulsi and their pharmacological action

**TABLE 1: PHYTOCHEMICALS FROM GINGER AND TULSI AND THEIR OBSERVED PHARMACOLOGICAL ACTION**

| **Natural herb / Phytochemical/ Bioactive compounds** | **Pharmacological action** |
|---|---|
| **Biological source /*Gingiber officinale*** | |
| Ginger extract | Induction of Nrf2 and ARE gene activity |
| Ginger extract | Decrease in MDA level Increase in CAT activity |
| Ginger extract | Radical scavenging activity |
| Components of ginger (6- gingerol, 6-shogaol 6- paradol) | COX inhibitory activity |
| 6- gingerol | Inhibition of LTA4H activity |
| Gingerol, shogaol | Inhibition of 5-$HT_{1A}$ |
| 6- gingerol | Decrease in plasma triglycerides, total cholesterol,Plasma insulin |
| 10- gingerdione | Inhibition of 1KKβ activity |
| Ginger extract | Inhibition of GFAT 1/β – HSD1,S1RT6,GLUT4 |
| 6- shogaol | Inhibition of elF2α |
| Geraniol derivative | Inhibition of Tyrosine kinase receptor |
| Ginger components | Inhibition of AChE |
| **Biological source / *Ocimum sanctum*** | |
| Tulsi extract | Reduced peroxidised lipid levels |
| Methanolic /Ethanolic leaf extract | Antioxidant activity |
| Hydroalcoholic extract of tulsi leaves | Decreased MDA levels |
| Hydroalcoholic extractof tulsi leaves | Decreased lipid peroxidation, increased SOD, CAT, GPx activity |
| Tulsi leaf paste | Anti-inflammatory activity |
| Eugenol | Anti-inflammatory activity |
| Aqueous extract of tulsi | Anti-inflammatory activity |
| Ocimum sanctum fix oil | Inhibition of COX and lipoxygenase pathways |

| | |
|---|---|
| Aqueous and ethanolic extract of tulsi | Reduction in solid tumors |
| Ethanolic extract of tulsi | Anti stress activity |
| Bioactive components of tulsi | Encapsulation of bioactive component by β-cyclodextrin |
| Various phytochemicals from tulsi | Inhibition of GST |
| Linalool | Binding with odorant binding protein of C. quinquefasciatus |
| Eugenol esters | Inhibition of 15-lipoxygenase enzyme |

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