



## Therapeutic Potential of *Ocimum sanctum* in Prevention and Treatment of Cancer and Exposure to Radiation: An Overview

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### ABSTRACT

Extensive studies, experimental and clinical prove that Tulsi possess anti-stress/adatogenic, antioxidant, immunomodulator and anti-radiation properties which also may help it to play major role in prevention and treatment of cancer. As Tulsi has health benefitting effects by reducing stress and improving both cellular and humoral immunity, its role in prevention and treatment of cancer cases may be a new approach in therapy of cancer and in prevention of ill effects of radiation. Studies in biological models like fibrosarcoma cell culture, papilomas in the skin of albino mice, mice having sarcoma - 180 solid tumors etc. provide proof for its anticancer activity. As it has been shown that Tulsi exhibit anticancer activity in animal models, studies were carried out in human cancer *in vivo* like human cell fibrosarcoma and *in vitro* in human cervical cancer cell line (HeLa) and human laryngeal epithelial carcinoma cell line (HEp-2) and it was found effective. Thus, this review is a concise version of Tulsi's anti-cancer effect. The aim is to stimulate research in this field, prevent and treat human carcinoma by initiating detailed studies in this field. It will be a novel agent, safe and effective for humans suffering with cancer in general and as a specific agent. The research work which is going on this direction is a proof of benefits by reducing toxicity of chemo and radio therapies and providing better and healthier life style by Tulsi. Therefore, it was worthwhile to review its anticancer properties to give an overview of its status to scientist both modern and ancient (Ayurvedic).

**Keywords:** *Ocimum sanctum*, chemical constituents, anticancer, adaptogen/ antistress, antioxidant, anti-radiation, immunomodulator.

### INTRODUCTION

Cancer is a dreaded disease which is best characterized by abnormal cell division and is caused by mutation of genes involved in the control of cell division. Cancer grows out of normal cells in the body. Normal cells multiply when the body needs them, and die when the body doesn't need them. Cancer appears to occur when the growth of cells in the body is out of control and cells divide too quickly. There are various factors involved in the genesis of cancer like toxic chemicals, excessive use of alcohol, exposure to environmental toxins, some poisonous plants like mushrooms and exposure to excessive sunlight, genetic problems, radiation, viruses, etc. However, the cause of many cancers remains unknown. The current standard approach of western medicine for treatment of cancer consists of an attempt to eradicate established tumor with combined treatment such as surgery, chemotherapy and radiation. However, this therapy

has failed in many respects. In many cases it makes human life miserable and usually reduces the span of life. The patient remains sick due to toxic effects of radio and chemotherapies as these do not kill only cancer cells but normal cells also and produce low hematological picture and low immune syndromes making the patient prone to opportunistic infections, reduce strength and vitality. The failure of modern therapies has prompted complementary and alternative medicine scientists to investigate the plant derived safe and effective therapeutic agents. The present situation has become too controversial that some oncologists themselves claim that cancer is not a disease, the anaerobic cell growths are meant to absorb the toxins which kill the patients. However, by surgery, chemotherapy and radiotherapy we destroy the protective mechanism and metastasis from one organ to other organ is common. Here Andreas Moritz<sup>[1]</sup>, 2008 in his book "CANCER IS NOT A DISEASE" has quoted experienced Oncologist Professor, Dr. Jones, who says "My studies have proven conclusively those cancer patients who refuse chemotherapy and radiation actually live up to four times longer than treated cases, including untreated breast cancer cases." Further, cancer as disease of toxins usually can happen 4-6 times in an

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individual's life but due to strong immune system everyone does not develop the disease. However, those whose immunity is compromised may develop this disease. In view of the above facts, herbal adaptogens/anti-stress and immunomodulators may be searched as a safe tool in the treatment of malignancy also.

The experimental studies conducted with *Ocimum sanctum* (OS) extract on fibrosarcoma cells in culture have demonstrated that *Ocimum sanctum* exhibits anticancer activity.<sup>[2]</sup> Most of the modern research on therapeutic uses of Tulsi (*Ocimum sanctum*) has confirmed that Tulsi contains hundreds of phytochemicals which possess antioxidant, adaptogenic and immune-enhancing properties. Tulsi meets the three requirements for an agent to become an adaptogen: being innocuous in nature, promotes physiological functions and induce a state of non-specific increased resistance (SNIR) in the body. Dr. Singh<sup>[3]</sup> presented its possible clinical benefits at "Continuing Education Program on Herbal Drug Research", INMAS; New Delhi (2005). The anti-radiation effect of Tulsi is particularly relevant to persons exposed to excess radiation such as working with radio- diagnosis and therapy (e.g. nuclear medicine, angiography, operation under X-ray control), receiving radiography for malignomas, working in atomic reactors and other units with exposures to radiation, high altitude solar radiation (e.g. airline personnel), TV and computer screens. Thus, Tulsi uses not only apply as an adaptogen/ antistress agent, but can safely be used in prevention of ill effects of radiation in persons exposed to various radiations<sup>[4]</sup>. As this herb has health benefitting effects by reducing stress and improving both cellular and humoral immunity, its role in prevention & treatment of cancer cases may be a new approach in therapy of cancer. This review presents studies on biological models and clinical cases for evaluation of the efficacy of OS in prevention and treatment of cancer, also its effects on radiation induced changes.

#### Botanical classification

<b>Kingdom</b>	: Plantae
<b>Division</b>	: Magnoliophyta
<b>Class</b>	: Magnoliopsida
<b>Order</b>	: Lamiales
<b>Family</b>	: Labiatae
<b>Genus</b>	: <i>Ocimum</i>
<b>Species</b>	: <i>sanctum</i>

#### Chemical constituents

Several bioactive molecules and nutrients have been found in *O. sanctum* L. The quantity of these constituents depends on the nature of soil, harvesting, processing and storage techniques. Different phytochemicals present in the plant are described below.

#### Essential oil from leaves<sup>[5-29]</sup>

$\alpha$ - Thujene, Octane, Nonane, Benzene, (Z)-3-hexanol, Ethyl 2- methyl butyrate,  $\alpha$ -pinene,  $\beta$ -pinene, Toluene, citronellal, Camphene, Sabinene, Dimethyl benzene, Myrcene, Ethyl benzene, Limonene, 1,8,-cineole, cis- $\beta$ -ocimene, p-cymene, Terpinolene, Allo-oc-imene, Butyl-benzene,  $\alpha$ -cubebene, Linalool, Eugenol, Methyl eugenol,  $\beta$ -elemene, (E)-cinnamyl, Lactate, Isocaryophyllene,  $\beta$ -caryophyllene, Iso-eugenol,  $\alpha$ -guaiane,  $\alpha$ -amorphene,  $\alpha$ -humulene,  $\gamma$  - humulene, 4,11-seinadiene,  $\alpha$ -terpeneol, Isoborneol, Carvacrol, Borneol, germacrene-D,  $\alpha$ -selinene,  $\beta$ -selinene, Myrtenylformat,  $\alpha$ -muroloene, cadinene,  $\delta$  - Cuparene, Calamene, Geraneol, Nerolidol, Caryophyllene oxide, Iedol, Humulene oxide,  $\alpha$ -

guaiol,  $\tau$  - cadinol,  $\alpha$ - bisbolol, (EZ)-famesol, Cis-sesquainene hydrate, Elemol, Tetradecanal, Selin-11-en-4- $\alpha$ -ol, 14-hydroxy- $\alpha$ -humulene.

#### Alcoholic extract of leaves / aerial parts<sup>[8, 10-12, 30-31]</sup>

Urosolic acid, Apigenin, Luteolin, Apigenin-7-O-glucuronide, Luteolin-7-O-glucuronide, Isorientin, Orientin, Molludistin, Stigmasterol, Triacontanol ferulate, Vicenin-2, Vitexin, Isovitexin, Aesculetin, Aesculin, Chlorogenic acid, Galuteolin, Circineol, Gallic acid, gallic acid methyl ester, Procatechuic acid, Vallinin acid, 4-hydroxybenzoic acid, Caffeic acid, Chlorogenic acid, Phenylpropane glucosides,  $\beta$ -Stigmasterol, urosolic acid.

#### Fixed Oil from Seeds<sup>[32-33]</sup>

Palmitric acid, Stearic acid, Linolenic acid, Oleic acid, Sitosterol, Dilinolenol-linolins, Linodilininol, Hexourenic acid.

#### Mineral Content/ 100 gram<sup>[34-35]</sup>

Vit. C (83 $\mu$ g), Carotene (2.5 $\mu$ g), Ca (3.15%), P (0.34%), Cr (2.9 $\mu$ g), Cu (0.4 $\mu$ g), Zn (0.15 $\mu$ g), V (0.54 $\mu$ g), Fe (2.32 $\mu$ g), Ni (0.73 $\mu$ g).

#### Structure of some important bio-molecules present in *O.*

*sanctum* L.<sup>[36]</sup>

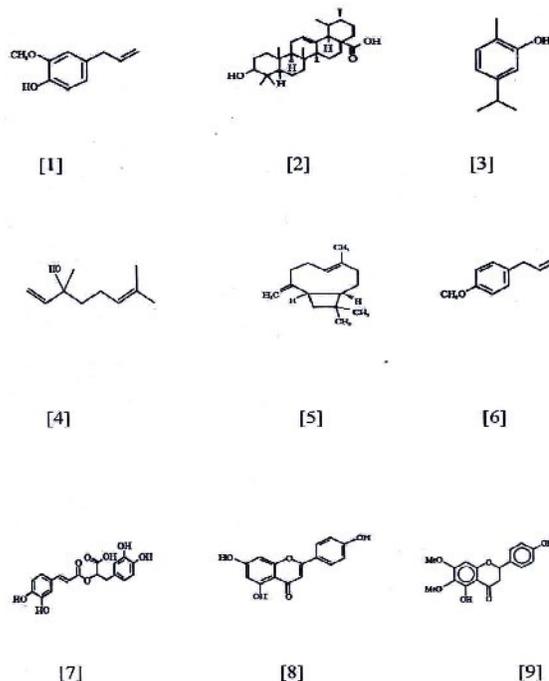


Fig: [1] Eugenol , [2] Urosolic acid, [3] Carvacrol, [4] Linalool, [5] Caryophyllene, [6] Estragol, [7] Rosamarinic acid, [8] Apigenin, [9] Cirsimartin.

#### Anticancer property of *Ocimum sanctum*

The experimental studies carried out on biological models using OS extract on fibrosarcoma cells in culture have demonstrated that *Ocimum sanctum* exhibits anticancer activity.<sup>[2]</sup> The fresh leaf of the *Ocimum sanctum* has been shown to enhance the immunity and also to possess anti-carcinogenic properties in experimental animals.<sup>[37]</sup> Besides above, *Ocimum sanctum* has also been demonstrated to exhibit rejuvenating properties anti-septic and anti-allergic effects.<sup>[38]</sup> Tulsi has many beneficial properties with negligible toxicity, and is an ideal antistress/adaptogenic

agent for the promotion of health and the prevention and treatment of disease. Life without health was well described by Herophilus in 300 BC.<sup>[39]</sup> Methanolic extract of *Ocimum* varieties have been shown to possess cancer preventive activities through reduction of excess amount of nitric oxide.<sup>[40]</sup> Tulsi has been found to decrease the incidence of benzo (a) pyrene-induced neoplasia and 3-methyl di-methyl amino azobenzene, induced hematomas in experimental animals.<sup>[41]</sup> Topical treatment with the ethanolic tulsi leave extract has been found to produce significance reduction in the values of tumor incidence (Papillomas) in the skin of albino mice.<sup>[42]</sup> A similar activity was observed for eugenol, a flavonoid present in many plants, including Tulsi.<sup>[43]</sup> Antimetastatic activity has also been observed in ethanol extract of OS through activation of antioxidative enzymes such as superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GSH-Px) in a concentration dependent manner.<sup>[44]</sup> Kathirvel P and Ravi S<sup>[45]</sup> conducted the studies to identify the chemical composition and *in vitro* anticancer activity of the essential oil from *Ocimum basilicum* Linn. The major constituents were found to be methyl cinnamate (70.1%), linalool (17.5%),  $\beta$ -elemene (2.6%) and camphor (1.52%). The results revealed that this plant may belong to the methyl cinnamate and linalool chemotype. A methyl thiazol tetrazolium assay was used for *in vitro* cytotoxicity screening against the human cervical cancer cell line (HeLa), human laryngeal epithelial carcinoma cell line (HEp-2) and NIH 3T3 mouse embryonic fibroblasts. The IC<sub>50</sub> values obtained were 90.5 and 96.3 $\mu$ g/ml, respectively, and the results revealed that basil oil has potent cytotoxicity. The studies conducted to evaluate the chemopreventive potential of the seed oil of *O. sanctum* against subcutaneously injected 20-methylcholanthrene induced-fibrosarcoma tumors in the thigh region of Swiss albino mice revealed that supplementation of maximal tolerated dose (100  $\mu$ l/kg body weight) of the oil significantly reduced 20-methylcholanthrene induced tumor incidence and tumor volume. Further, the enhanced survival rate and delay in tumor incidence were observed in seed oil supplemented mice. Liver enzymatic (superoxide dismutase, catalase, glutathione-S-transferase), non-enzymatic antioxidants (reduced glutathione) and lipid peroxidation end product, malondialdehyde levels were significantly modulated with oil treatment as compared to untreated 20-methylcholanthrene injected mice which suggests that the potential chemopreventive activity of the oil is partly attributable to its antioxidant properties.<sup>[46]</sup> Eugenol (1-hydroxy-2-methoxy-4-allylbenzene), the active constituent present in *Ocimum sanctum* L., has been found to be largely responsible for the therapeutic potentials of Tulsi in treatment of various chronic diseases including cancer.<sup>[47]</sup> Ranga *et al.*<sup>[48]</sup> observed anticancer and chemo-preventive properties of *Ocimum tanuflorum*. Topical application of *Ocimum* extract has been found to significantly reduce the cumulative number of papillomas in 7, 12-dimethylbenz (a) anthracene-induced skin papillomagenesis in rats and it was found that the ethanolic extract of leaf of *ocimum* inhibited the proliferation and angiogenesis related protein through the down-modulation of Bcl-2 and Vascular endothelial growth factor (VEGF) expression and over expression of capase-3 during N-methyl-N'-nitro-N-nitrosoguanidine induced gastric cancer bearing rates.<sup>[49-50]</sup> Similar effects were also noted with reduction in tumor cell size and an increase in

lifespan of mice having Sarcoma-180 solid tumors.<sup>[51]</sup> Similar results were also obtained with OS in Lewis- lung carcinoma in animal models. It has been shown that the active phytochemicals namely urosolic acid and oleanic acid present in tulsi plants have potential to exhibit anticancer property.<sup>[52]</sup> The alcoholic extract has also been shown to increase the activities of cytochrome p450, cytochrome b5, aryl hydrocarbon hydroxylase and glutathione S-transferase, which play an important role in the detoxification of carcinogens and mutagens.<sup>[49, 53]</sup> Furthermore, the anticancer activity of OS has been reported against human fibrosarcoma cells culture. The results of the study demonstrated that morphologically, the cells showed shrunken cytoplasm and condensed nuclei and the DNA was found to be fragmented on observation in agarose gel electrophoresis.<sup>[54]</sup> Several studies have shown that OS possess prominent anticancer activity.<sup>[55-58]</sup> The experimental study conducted on animal models have indicated that OS has capability to decrease the incidence of benzo(a)pyrene induced neoplasia of forestomach of mice and 3-methyl-4-dimethylaminoazobenzene induced hepatomas in rats.<sup>[59]</sup> The alcoholic extract of the leaves of OS was shown to have an inhibitory effect on chemically induced skin papillomas in mice.<sup>[60]</sup> Oral treatment of fresh leaves paste of Tulsi may have the ability to prevent the early events of 7, 12-Dimethylbenz (a) anthracene (DMBA) induced buccal pouch carcinogenesis.<sup>[61]</sup> Leaf extract of OS has been found to block or suppress the events associated with chemical carcinogenesis which might be due to inhibition of metabolic activation of the carcinogen.<sup>[49]</sup> The anticancer activity of OS was observed in Swiss albino mice bearing Ehrlich ascites carcinoma (EAC) and S 180 tumours.<sup>[62]</sup> The ethanolic *O. sanctum* leaf extract has been found to inhibit 7, 12-dimethylbenz[a]anthracene (DMBA)-induced genotoxicity and oxidative stress by modulating xenobiotic-metabolizing enzymes, reducing the extent of lipid and protein oxidation and up-regulating antioxidant defenses.<sup>[63]</sup> Manikandan P *et al.* studied the combinatorial chemopreventive efficacy of *Azadirachta indica* (AI) and *Ocimum sanctum* (OS) against N-methyl-N'-nitro-N-nitrosoguanidine (MNNG)-induced gastric carcinogenesis, based on changes in oxidant-antioxidant status, cell proliferation, apoptosis and angiogenesis in a rat forestomach carcinogenesis model and found that AI and OS combination may be mediated by their antioxidant, antiangiogenic, antiproliferative and apoptosis inducing properties.<sup>[64]</sup> The studies have shown that the chemopreventive effect of OS leaf extract might be mediated through the induction of hepatic/extrahepatic GST in mice.<sup>[65]</sup> Significant antiproliferative and chemopreventive activities were observed in mice with high concentration of OS seed oil.<sup>[66]</sup> The potential chemopreventive activity of seed oil has been partly attributed to its antioxidant activity.<sup>[46]</sup>

**Adaptogenic/ antistress properties**

OS has been found to be a powerful adaptogenic / antistress agent, helpful in preventing and reducing stress: mental, emotional, physical, and environmental stress.<sup>[67-80]</sup> The immunostimulant capacity of OS may be responsible for the adaptogenic action of plant.<sup>[38]</sup> The experimental studies on animal models have shown that *O. sanctum* leaves produced significant increase in the levels of enzymatic (superoxide dismutase) and nonenzymatic (reduced glutathione) antioxidants which suggest that the

potential antistressor activity of *O. sanctum* is partly attributable to its antioxidant properties.<sup>[81]</sup>

#### Antiradiation activity

OS has the ability to protect the DNA of the body from dangerous radiation.<sup>[3, 82-83]</sup> It is significant to mention that the flavonoides namely orientin and vicenin isolated from OS leaves showed better radioprotective effect as compared with synthetic radioprotectors. They have shown significant protection to the human lymphocytes against the clastogenic effect of radiation at low, non toxic concentrations.<sup>[84]</sup> The combination of OS leaf extract with WR-2721 (a synthetic radioprotector) resulting in higher bone marrow cell protection and reduction in the toxicity of WR-2721 at higher doses, suggested that the combination would have promising radioprotection in humans.<sup>[85]</sup>

Bhartiya US *et al.*<sup>[86]</sup> investigated radio-protective effect of aqueous extract of *O. sanctum* L. (40 mg/kg, for 15 days) in mice exposed to high doses (3.7 MBq) of oral 131 iodine by studying the organ weights, lipid peroxidation and antioxidant defense enzyme in various target organs like liver, kidney, salivary glands and stomach at 24 h after exposure. The results of the studies indicated that the pre treatment with *O. sanctum* L. in radioiodine-exposed group showed significant reduction in lipid peroxidation in both kidney and salivary glands and in liver, reduced glutathione (GSH) levels showed significant reduction after radiation exposure while pretreatment with *O. sanctum* L. exhibited less depletion in GSH level even after 131 iodine exposure. However, no such changes were observed in the stomach. The results indicate the possibility of using aqueous extract of *O. sanctum* L. for ameliorating 131 iodine induced damage to the salivary glands.

Subramanian M *et al.*<sup>[87]</sup> have observed that two polysaccharides isolated from *O. sanctum* L. have capability to prevent oxidative damage to liposomal lipids and plasmid DNA induced by various oxidants such as iron, 2,2-azobis (2-amidino-propane) dihydrochloride (AAPH) and gamma radiation. Vrinda *et al.*<sup>[88]</sup> reported that two water-soluble flavonoids, Orientin (Ot) and Vicenin (Vc), isolated from the leaves of *O. sanctum* L. provide significant protection against radiation, lethality and chromosomal aberration *in vivo*. The effect of aqueous extract (OE) of leaves of *O. sanctum* L. against radiation lethality and chromosome damage was studied by radiation-induced lipid peroxidation in liver and the results have shown that aqueous extract itself increased the GSH and enzymes significantly above normal level, whereas radiation significantly reduced all the values and significantly increased the lipid peroxidation rate, reaching a maximum value at 2 h after exposure (3.5 times of control).<sup>[89]</sup> In another study, the aqueous extract of OS has been found to reduce the lipid per oxidation and to accelerate recovery to normal levels in experimental animals and Ocimum flavonoids produced promising anti-radiation effects.<sup>[90]</sup> Ganasoundari *et al.*<sup>[91]</sup> investigated the radio-protective effect of the leaf extract of *O. sanctum* L. (OE) in combination with WR-2721 (WR) on mouse bone marrow and observed a significant decrease in aberrant cells as well as different types of aberrations. The antiradiation effect of Tulsi is particularly relevant to person exposed to excess radiation such as working with radio diagnosis and therapy (e.g. nuclear medicine, angiography, operation under X-ray control), receiving radiography for malignomas, working in atomic reactors and other units with exposures to radiation,

regularly exposed to high altitude solar radiation (e.g. airline personnel), chronically exposed to TV and computer screens. Thus, Tulsi can safely be used in prevention of ill effects of radiation in persons exposed to various radiations.<sup>[4]</sup>

#### Antioxidant Activity

The antioxidant activity of OS has been reported by many workers.<sup>[55-58]</sup> The antioxidant properties of flavonoids and their relation to membrane protection have been observed.<sup>[92]</sup> Antioxidant activity of the flavonoids (orientin and vicenin) *in vivo* was expressed in a significant reduction in the radiation induced lipid peroxidation in mouse liver.<sup>[84]</sup> OS extract has significant ability to scavenge highly reactive free radicals.<sup>[93]</sup> The phenolic compounds, viz., irsilineol, cirsimaritin, isothymusin, apigenin and rosmarinic acid, and appreciable quantities of eugenol (a major component of the volatile oil) from OS extract of fresh leaves and stems possessed good antioxidant activity.<sup>[30]</sup> The antioxidant capacity of essential oils obtained by steam hydro distillation from *O. sanctum* L. was evaluated using a high-performance liquid chromatography (HPLC) based hypoxanthine/xanthine oxidase and DPPH (1,1-Diphenyl-2-picrylhydrazyl) assays and it has been observed that in hypoxanthine/ xanthine oxidase assay, strong antioxidant capacity was evident from *O. sanctum* L.<sup>[94]</sup> In another study, the aqueous extract of *O. sanctum* L. was found to significantly increase the activity of anti-oxidant.<sup>[95]</sup> Oral feeding also provides significant leaver and aortic tissue protection from hypercholesterolemia-induced peroxidative damage.<sup>[96]</sup>

#### Immunomodulatory Activity

The studies have demonstrated that OS has potential to modulate the humoral immune responses by acting at various levels in the immune mechanisms such as antibody production, release of mediators of hypersensitivity reactions, and tissue responses to these mediators on the target organs.<sup>[97-98]</sup> Essential oil of leaves of OS and fixed oil of tulsi seed have been shown to exhibit humoral and cell mediated immune responses in non stressed and stressed animal.<sup>[99-100]</sup> Mukherjee R *et al.*<sup>[101]</sup> have found immunotherapeutic potential of aqueous extract of *O. sanctum* L. leaf in bovine sub-clinical mastitis (SCM) which was investigated after intra-mammary infusion of aqueous extract and 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, Mediratta PK *et al.*<sup>[100]</sup> have investigated the immunomodulatory effect of *O. sanctum* L. seed oil (OSSO) on some immunological parameters in both non-stressed and stressed animals and evaluated that OSSO appears to modulate both humoral and cell-mediated immune responsiveness and these immunomodulatory effects may be mediated by GABAnergic pathway.

Godhwani *et al.*<sup>[38]</sup> 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 results 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.

## DISCUSSION

Cancer continues to be a worldwide killer despite of great advances made in modern system of medicine during the past decades. According to recent statistical data cancer is second most common cause of death after heart disease.<sup>[103]</sup> Cancer is hyper-proliferative disorder that involves transformation, dysregulation of apoptosis, proliferation, invasion, angiogenesis and metastasis.<sup>[104]</sup> The process of cancer development (carcinogenesis leading to advanced metastasized cancer) in humans takes many years through initiation, promotion and progression. Oncologists have observed that advanced metastasized cancers are almost impossible to treat. The underlying mechanism leading to cancer development is not exactly known and some oncologists even claim that cancer is not a disease, the anaerobic cell growth are meant to absorb the toxins which kill the patients. However, by surgery, chemotherapy and radiotherapy we destroy the protective mechanism and metastasis from one organ to other organ is common. Here, Andreas Moritz, 2008 in his book "CANCER IS NOT A DISEASE" has quoted experienced oncologist Professor, Dr. Jones who says "My studies have proven conclusively that cancer patient who refuse chemotherapy and radiation actually live up to four times longer than treated cases, including untreated breast cancer cases".<sup>[1]</sup> There is great potential for the use of medicinal herbs and plant derived products in the fight to prevent onset or delay the progression of the carcinogenic process.

Traditionally, Tulsi leaves and decoction have been used as adaptogen helping the body and mind to adopt and cope with a wide range of physical, emotional and chemical stress, it is this property of being anti-oxidant and non specific immune stimulant, which has found a possible application as a radiation protector. Tulsi is a rich store of chemicals like eugenol, carvicol, methyl eugenol, caryphyllene and flavonoids. Naturally a wide spectrum of therapeutic application has been found over 5000 years. Tulsi needs a comprehensive evaluation for it has immense therapeutic possibilities.

*O. sanctum* (Tulsi) is a well known plant grown all over India and considered sacred by many Indians. Several medicinal properties have been attributed to the plant in the traditional system of medicine.<sup>[105-107]</sup> Pharmacological studies carried out by various workers<sup>[108-112]</sup> during the last few decades indicate the presence of anabolic, hypotensive, cardiac depressant, smooth muscle relaxant and anti-fertility properties in this plant. OS is well known for its other biological activities like bronchial asthma,<sup>[76, 113-114]</sup> antioxidant activities in bronchitis,<sup>[115]</sup> hypertension,<sup>[116]</sup> protection against viral encephalitis,<sup>[117]</sup> anti-ulcer,<sup>[118]</sup> anti-stress/ adaptogenic activity,<sup>[119-121]</sup> improvement in NIDDM (non-insulin-dependent diabetes mellitus),<sup>[122-123]</sup> protection against mouth and dental infection,<sup>[124]</sup> fatigue syndrome,<sup>[125-126]</sup> protection against tropical pulmonary eosinophilia in children,<sup>[127]</sup> antimicrobial activity against mycobacterial tuberculosis,<sup>[128]</sup> hepatoprotective activity.<sup>[129-131]</sup> The results of the studies mentioned above reflect that OS and its phytochemicals are beneficial in prevention and treatment of different kind of cancer. At clinic of International Institute of Herbal Medicine (IIHM), Lucknow, we are conducting clinical studies to evaluate the efficacy of organic Tulsi

(combination of *O. sanctum* & *O. gratissimum*) in prevention and treatment of various type of cancer. It is heartening to mention that *Ocimum sanctum* and *Withania somnifera* in combination with wheat grass are providing better results in cancer patients.<sup>[132]</sup> Our clinical studies suggest its use as antistress/adaptogenic, antiulcer, liver protective, antiradiation, antidiarrheal, antiasthmatic, anti-inflammatory, antipyretic, antidiabetic, anabolic, anti-aggressive, prevention against viral encephalitis, cell mediated and humoral immune response, antifatigue, anti-AIDS, antibacterial, antitubercular, anticancer, cardiovascular, antifertility, antifilarial, antifungal, etc.<sup>[4,133- 134]</sup> Dr. Singh is first to conceive the anti-radiation effects of Tulsi and initiated studies with Prof. Uma Devi, Kasturba Medical College, Manipal, Karnataka<sup>[135]</sup> Later Prof. Uma Devi's research work showed isolated chemicals responsible for anti-radiation effects. However, Dr. Singh's holistic approach allows only whole herb for human use in radiation exposure therapy in humans as isolated chemicals may be potent but are usually toxic to human systems. Recent holocaust of nuclear hazards in Japan and may be at other places demand Tulsi use in protection of humans from the ill effects of radiation. The anti-cancer property of OS might be due to the synergistic interaction of many different active phytochemicals present in it and its combined multifactorial properties as described above. Further, Tulsi meets the three requirements for an agent to become an adaptogen: being innocuous in nature, promotes physiological functions and induce a state of non-specific increased resistance (NSIR) in the body. There is a great possibility of Tulsi as a holistic agent in prevention and treatment of the ill effect of nuclear holocaust or accidental exposures such as in recent crisis of nuclear leak in Japan. Although there are great possibilities of such an effect, yet, the herbs should be used in large number of such cases to prove this fact. As using this herb in no way can be harmful as it in any case improves NSIR against any disturbed physiological process. Therefore, OS being powerful immunomodulator, adaptogen/ anti-stress, antioxidant and anti-radiation agent can be used as a novel, safe and effective therapeutic agent in the treatment of human cancer as such or along with radiotherapy and chemotherapy where medicinal herb *Ocimum sanctum* reduces the ill effects of both and improve life span and life style.<sup>[4, 134-134]</sup> However, multicentric long term clinical studies are needed on OS to prove our contention. Further, in present time detailed anti-radiation effect of OS needs to be evaluated through in large number of cases exposed or with possibility to expose radiation. It must be studied further in electronic gadget user like X-Rays, MRI, Sonography and others.

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