Review Article

# Medicinal, Nutritional and Industrial Applications of *Salvia* species: A Revisit

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**ABSTRACT**

*Salvia* species have been used for culinary, medicinal, nutritional and pharmacological purposes. In recent years, studies have highlighted the effect of *Salvia* plants in preventing and controlling various diseases naturally in a more safe manner. They have many biologically active compounds like essential oils and polyphenolics, which have been found to possess antimicrobial, anti-mutagenic, anticancer, anti-inflammatory, antioxidant and anti-cholinesterase properties. Currently, the demand for these plants and their derivatives has increased in food and pharmaceutical industries because they are recognized as safe products. This review summarizes the nutritional, medicinal and industrial applications of genus *Salvia.*

**Keywords:** *Salvia* species, Essential oil, Polyphenolic compounds, Medicinal applications.

## INTRODUCTION

*Salvia*, a member of the mint family 'Lamiaceae' comprises the largest genus of the family. The genus has complex and rich diversity with healing qualities of different species occurring throughout the world. The genus *Salvia* is derived from the Latin word "Salvare" meaning "to heal" or "to be safe and unharmed" referring to the medicinal properties of the genus. It encompasses about 900 species, widespread throughout the world with three distinct region of diversity: central and South America (500 species), Central Asia/Mediterranean (250 species) and Eastern Asia (90 species)[1]. The center of origin of this genus has been reported to be Afghanistan and Soviet Central Asia. Although Mexico has the highest number of species (about 250), *Salvia* species have been used against common cold, bronchitis, tuberculosis and menstrual disorders. It is used as herbal tea, food flavors, cosmetics, perfumery and the pharmacy[2]. Diverse medicinal applications such as antimicrobial, antioxidant, antitumor, antidiabetic, anti-inflammatory, antiseptic, sedative, analgesic are attributed to pharmacologically active compounds. The present review aims to critically analyze the medicinal, nutritional and industrial applications of the *Salvia* species and to present a comprehensive account of the scientific studies conducted.

### Medicinal Applications

Medicinal applications of *Salvia* are attributed to different phytochemicals present in various species. These are well known for their antiseptic, antipyretic, analgesic, antimicrobial, antioxidant, anticholinesterase and anti-inflammatory properties. The main bioactive compounds of these medicinal species can be divided into (1) essential oil, which contains a mixture of oxygenated compounds such as phenolics, terpenes and hydrocarbons (2) nonvolatile phenolic compounds such as flavonoids and phenolic acids[3]. Essential oils are mixture of several hundred constituents, which can be categorized into monoterpene hydrocarbons, oxygenated monoterpenes, sesquiterpene hydrocarbons, diterpenes and polyphenols further classified into two subgroups: phenolic acid and flavonoids. The major components of essential oil from *Salvia* comprise 1, 8-cineole, β-pinene, α-pinene, camphene, borneol, α-thujene, caffeic acid, rosmarinic acid, flavonols, camphor, salvimanolic acid whichare responsible for different pharmacological properties[4]. Terpenes possess anti-allergic, anti-histaminic properties, while α-pinene, β-pinene andborneol are responsible for antibacterial and antifungal activity[5]. Compositions of the essential oils diverge in species owing to environmental, phytopathological and genetic factors.

### Volatile Compounds (Essential oils)

Essential oils are intricate mixtures of volatile substances, insoluble in water and soluble in organic solvents. They contain mixture of terpenes (mono and di) aliphatic hydrocarbons, acid alcohols, aldehydes, acyclic esters or lactones etc.[6] The essential oil composition in different *Salvia* species varies from one species to another. These essential oils possess various pharmacological activities. Therapeutic effects attributed to essential oils of genus *Salvia* are discussed below:

### Antimicrobial activity

The antimicrobial activities of essential oils have been well recognized since ancient times. These were used in clinical microbiology and for food preservation[7]. Volatile mono terpenoids, the major constituents of *S. officinalis*, *S. lavandulifolia* and *S. fruticosa* show strong antibacterial activity. The antibacterial efficacy of essential oils against different bacteria varies with the oil composition[8]. Essential oils of *S. cryptant* has been active against *C.*

*albicans*, *C. krusei*, *M. smegmatis*, *A. lwoffii*, *S. pneumoniae* and *C. perfringens* microorganisms with MIC (Minimal inhibitory concentration) values ranging from 2.25 to 18 mg/ml and *S. multicaulis* hasbeen activity against *S. pneumoniae*, *C. krusei*, *C. perfringens*, *M. smegmatis*, *C. albicans* and *S. aureus* with MIC values from 2.25 to 36 mg/ml[9]. *S. chloroleuca* extract exhibited moderate to high anti-microbial activity especially against *Bacillus subtilis*, *Staphylococcus epidermidis* and *S. aureus* with MIC values of3.75, 3.75 and 7.5 mg/ml respectively[10]. The essential oils of *S. officinalis*, *S. fruticosa*, *S. santolinifolia*, *S. hydrangea* and *S.mirzayanii* display remarkable bacteriostatic and bactericidal activities against *Bacillus cereus*, *B.subtilis*, *B.megaterium*, *Aeromonas sobria, Klebsiella oxytoca*[11]. The essential oil of *Salvia* species not only possesses antibacterial activity but also exhibit antifungal and antiviral activity.

Various plant and human pathogenic fungi including yeast are found to be susceptible to essential oils. The effectiveness of inhibition varies with the target organism and the composition of oil[12]. *S. fruticosa* shows antifungal activity against various plant pathogenic fungi including *Rhizoctonia solani*, *Sclerotinia sclerotiorum* and *Fusarium* spp. due to 1, 8- cineole and camphor components. Mycelial growth of *R.solani* was completely inhibited by essential oil of *S. fruticosa* at concentration of 2000 µl/l[13]. However, the oil showed no antimicrobial activity against human pathogenic bacteria or fungi at concentration up to 200µg/ml. Crude extract of *S. officinalis* contain 2-abietane diterpenoids which showed a potent antiviral activity. Safficinolide[14] and sageone showed virus inactivation activity against Vesicular Stomatitis Virus and Herpes simplex virus[15].

**Antioxidant activity**

In recent years, there is an upswing in the areas related to newer developments in prevention of disease especially highlighting the role of free radicals and antioxidants. Free radicals have been implicated in the aetiology of various diseases. Antioxidants can protect against the damage induced by free radicals acting at various levels. Antioxidant based formulation for prevention and treatment of complex diseases like atherosclerosis, Alzheimer's disease, etc. have appeared in last few years. Free radicals are responsible for oxidative stress which causes damage to cellular macromolecules and bio membranes that results in brain dysfunction, cancer, aging, diabetes, heart disease, immune system decline, Alzheimer's disease, asthma, Parkinson disease [7]. Cellular balance of free radicals is maintained by diverse antioxidants [16]. The antioxidant activities of the methanolic extracts of *Salvia* species (*S. caespitosa*, *S. candidissima*, *S. euphratica*, *S. aethiopsis*, *S. sclarea* and *S. hypargeia*) from Turkey were examined and it was found that the most active plant which exhibited highest antioxidant activity was *S. euphratica* with IC50 value of 20.7±1.22 µg/ml[9]. The antioxidant activities of 16 *Salvia* species of South Africa were evaluated by using 2,2-azinobis (3-ethyl-benzothiazoline-6-sulfonic acid) (ABTS) and 2,2- diphenyl-1-picrylhydrazyl (DPPH) methods and it was reported that extract of *S. schlechteri* was most favourable for DPPH and extract of *S. miurii* was most active for ABTS[17]. *S. sclarea*, *S. lavandulifolia*, *S. officinalis* Purpurascens, *S. officinalis* Tricolor and *S. officinalis* Icterina antioxidant activity were evaluated by DPPH method. It was found that *S. officinalis* tricolor showed highest (92.07%) and *S. sclarea* showed lowest (79.48%) activity[18].

**Antimutagenic and anticancer activity**

Naturally occurring anti mutagenic effects especially of plant origin, have recently become subject of intensive research. Most members of Lamiaceae family possess broad range of biological and pharmacological activities that may protect tissues against genotoxic effects of environmental toxicants and therefore, lower the risk of human chronic disease. Anti-mutagenic effects of essential oils may be confined due to their ability to inhibit penetration of mutagens inside the cells, free radical scavenging activity and activation of antioxidant enzymes[19].Chloroform and n- Hexane extracts of *S. officinalis* repressed UV induced SOS response in *S.typhimurium* TA1535/psk1002[20]. Tanshinones[14] (Figure 1) isolated from ether extract of *S. miltiorrhiza*, were recognized to be modulators of Trp-P-1 and BP mutagenic activities in *S.typhimurium* TA98[21].

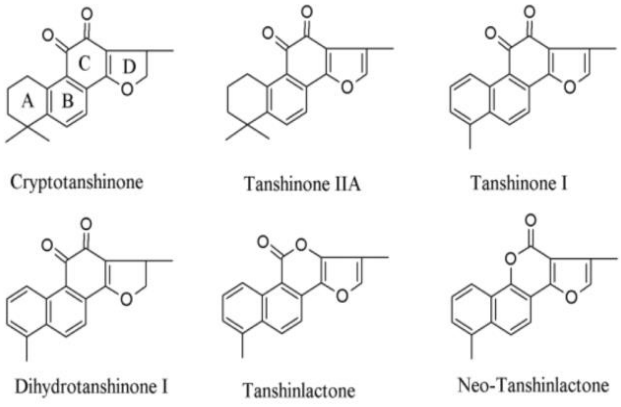


**Figure1:** Structures of Tanshinones compounds

Several biological studies have demonstrated that *Salvia* species have potent anticancer activity against diverse types of malignancies like gastric cancer, breast cancer, glioma, human liver tumor, colon cancer and leukaemia. Hence, such molecules are useful in prevention and therapeutic strategies[22].Antioxidant activity of essential oils interferes with mitochondrial functions of mammalian cells; as a consequence essential oil diminishes metabolic events like amplified cellular metabolism, permanent oxidative stress etc. which are characteristics of malignant tumor development[23].

Essential oil of *S. officinalis* inhibited the growth of renal cell adenocarcinoma with IC50 of 1000.70 µg/ml and human cell carcinoma cell line of oral cavity with IC50 of 135 µg/ml[24] but it did not reduce the expansion of human

breast cancer cells (MCF-7) and hormone dependent prostate carcinoma cell (LNCaP)[25]. Synergistic effect of 3 bioactive compounds, such aslinalyl acetate, terpeniol and camphor present in essential oil isolated from *S. libanotica* was observed[26]. Combination of these compounds caused significant growth suppression of HCT116 p53 +/+ cells in Pre G1 (64%) phase. *S.leriifolia* and *S.acetabulosa* extracts exhibited a strong inhibitory activity on renal adenocarcinoma ACHN, large cell carcinoma COR –L23, malignant melanoma A 375 and amelonotic melanoma but they were not able to exert anti proliferative activity against human skin fibroblast[27].

**Anti-inflammatory activity**

Inflammation is associated with detrimental properties in a broad range of disorders including those of the CNS. There is an increasing evidence for a role of immune and chronic inflammatory mechanisms in the neurodegeneration related with Ischaemia and Alzheimer's disease (AD). Some non-steroidal anti-inflammatory drugs (Aspirin) are reported to have a declined risk of developing AD[28]. Essential oil of *S. lavandulae folia, S. aethioposis, S. miltiorrhiza* and *S. officinalis* plants possess anti-inflammatory potential[29]. Their activities are mediated through mechanism such as inhibition of lipoxygenase, inhibition of bio inflammatory cytokines and cox-2 enzyme, interleukin-1β and tumor necrosis factor-α (TNF-α)[16]. During the oxidation burst of inflammatory reaction there is formation of reactive oxygen species (ROS). Among a variety of mechanisms known to be involved in inflammation preventive activity of essential oil [16]. Some strong natural anti-oxidants like carnosol[14] were found to demonstrate anti-inflammatory effect with consider to tumor initiation activity in mice. Essential oil isolated from leaves of *S.officinalis* and roots of *S.aethiopsis* also exhibited anti-inflammatory activity[29,30]. Borneol compound isolated from *S.officinalis* showed anti-inflammatory activity against TNBS induced colitis in mice[31] and naphthoquinone derivatives of *S. aethiopsis* have been reported to have a similar pharmacological profile as NSAI substances with regard to reducing oedema induced by carrageenan and contraction induced by phenyl-p-quinone[29]. Other anti-inflammatory constituents comprise the flavonoids carvacrol, cirsimaritin, quercetin, rosmarinic acid, luteolin, eugenol, terpenoids thymol, genkwanin and α and β-pinene[32].

**Anti-cholinesterase activity**

The aetiologies of cognitive problems with signal transduction across synapses has become a significant area of research. The chemical inhibition of acetyl cholinesterase is a potent strategy for addressing signal related neuropathology and natural products are potential sources of compounds with such properties. Several synthetic drugs such as galantamine[14] (Figure 2) can be toxic, offering a constricted therapeutic window and are often allied with a number of deleterious side effects[33].

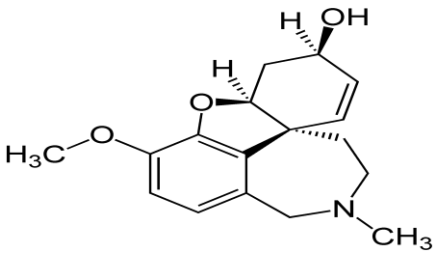


**Figure 2:** Structure of Galantamine compound

The advantage with the *Salvia* species, *S. lavandulae folia* and *S. officinalis,* is that both are edible, nontoxic and have long histories of secure usage. These species have been in use since historical times in the treatment of a variety of disorders related to nervous system particularly for the therapy of dementia, cognitive decline and depression[34]. Volatile constituents of *Salvia* species readily cross blood- brain barrier due to their small molecular size and lipophilicity. Alzheimer's disease is the universal form of neurodegenerative disorder. A consistent neuropathological finding associated with the memory loss is a cholinergic deficit, in which the enzyme acetyl cholinesterase (AChE) is responsible for degradation and inactivation of acetyl choline neurotransmitter involved in the signal transferring between the synapses. AChE inhibitor drugs act by counteracting the acetyl choline deficit and enhancing the acetyl choline levels in the brain[35]. The main terpenoids of *S. lavandulae folia* essential oil (1, 8-cineole and α-pinene) exhibited strong inhibition of human erythrocyte AChE with IC50 values of 0.67mM and 0.63 mM respectively[36]. Essential oil of *S. officinalis* has been shown to inhibit 46% of AChE activity at a concentration of 500µg/ml and also illustrates improvement in alertness, calmness and contentedness[37]. *S. Pseudeuphratica*, *S. hydrangea* and *S.divaricata* essential oils demonstrated the most potent AChE inhibitory effect [50% inhibition concentration ($IC_{50}$) = 26.00 ± 2.00 µg/mL, 40.0 ± 4.00, 64.68 ± 4.16, respectively]. The essential oil of *S. pseudeuphratica* demonstrated the highest inhibitory activity against AChE and BuChE among the tested *Salvia* essential oils[38]. Essential oils from *Salvia* have also been investigated to see their effect on cognition, mood and stress. Volatile compounds of *S. lavandulaefolia*[39] have been reported to possess inhibitory activity against AChE, leading to improved memory performance, alertness, contentedness and calmness[39, 36].

**Nonvolatile Compounds (Polyphenolic compounds)**

*Salvia* species are a rich source of polyphenolic compounds. This group is classified according to structures into 2 sub-groups: phenolic acids and flavonoids[40] (Figure 3).

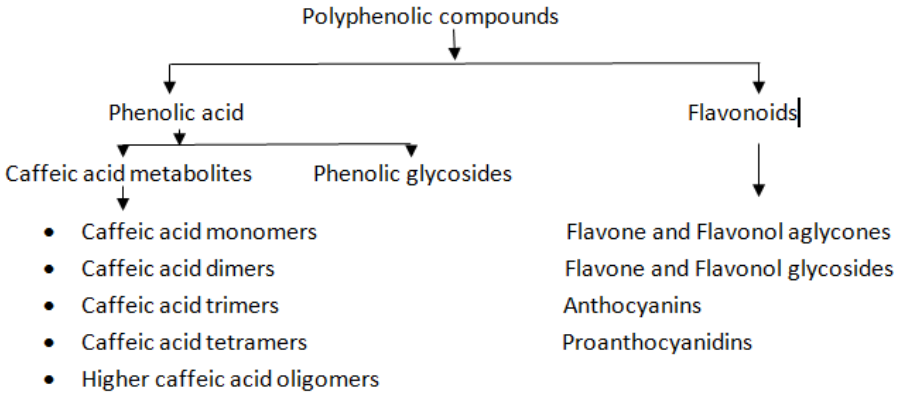


**Figure 3:** Classification of Polyphenolic compounds

The polar phenolic acids constitute the major part of the water soluble components of *Salvia* decoction. The majority of the phenolic acids in *Salvia* species are caffeic acid derivatives which play a central role in the biochemistry of *Salvia*. Caffeic acid occurs predominantly in conjugated form as rosmarinic acid[41]. In *Salvia* species, caffeic acid is the building block of a variety of plant metabolites, ranging from the simple monomers to multimers[40]. Rosmarinic acid is the most copious caffeic acid conjugate and has been reported to be the foremost phenolic compound which shows antithrombotic, antiplatelet and antiwrinkle activity [32] in *Salvia* species[40].These phenolic and flavonoids compounds have been demonstrated to possess various biological activities like antioxidant, anti-microbial, anti-cancer, anti-inflammatory, antimutagenicetc[40]. *S. albicaulis, S. runcinata* and *S. muirii* are rich in rosmarinic acid and *S. verbenaca* is the only species devoid of rosmarinic acid[42]. Carnosic acid and carnosolwere abundant in *S. aurita*, *S. chamelaeagnea*, *S.namaensis* and *S. stenophylla* but salvigeninacid are abundant in *S. disermas*[42].

Flavonoids are broadly disseminated in *Salvia* species and they are mainly present as flavonols, flavones and their glycosides[40]. Antibacterial activity in *S.chamela eagnea* is attributed to phenolic hydroxyl compounds like rosmarinic acid and caffeic acid[43].Flavonoids have been proved to be effective against Gram positive and Gram negative bacteria. Cirsimaritin[14], a flavonoid of *S. palaestina* leaves showed a soaring activity against *S.aureus* (MIC=31.25 µg/ml), *S. epidermidis* (MIC=62.5 µg/ml), *E.coli* (MIC= 45 µg/ml), *P.aeruginosa* (MIC=31.25 µg/ml) and *Klebsiella pneumoniae* (MIC=45 µg/ml)[44]. The flavonoid isolated from *S. radula* (salvigenin) was tested against the MCF-7 cells and it exhibited moderate activity. *S. miltiorrhiza* and *S. yunnanensis* contain over 50 chemical constituents which can be classified as phenolic acids such as salvianolic acid B and lithospermic acid and alkaloids (salviamines A-F)[45]. The aqueous extract of polyphenols and their derivatives have been shown to reduce HIV 1 integrase activity *in vitro* and viral replication *in vivo*. Since salvianolic acid B and lithospermic acid are the major biological active constituents, the activity against HIV virus indicate their potential as novel therapeutic drugs for AIDS[46].

Phenolic compounds of *S. plebeia* have been reported to inhibit the growth of human gastric carcinoma cell lines, acting as potent immune modulator[47]. It also possesses antiangiogenic, anti-inflammatory, antifungal, antioxidant, antiuretic, antipyretic activities[48]. Antioxidant activity in *Salvia*is highly correlated with the amount of phenolic compounds (carnosic acid, caffeic acid and rosmarinic acid and their derivative) and flavonoids present in these species[49].The antioxidant activity of *S. lanigera* poir using DPPH and FRAP methods indicated the free radical scavenging activity, which is attributed to phenolic components mainly carvacrol[14].Carnosol isolated from *S. chamela eagnea* also showed antioxidant activity using the DPPH assay with IC50 values of 6.10±0.6[42].

Some important medicinal species of the *Salvia* genus and their medicinal properties are listed below (Table I).

**Nutritional Properties**

*Salvia* species are most significant sources of natural antioxidants with not only medicinal application but also nutritional importance. There is growing interest in natural antioxidant products for use as food additives. Vitamin C, vitamin E, and carotenoids are some of these commonly used as natural antioxidants. *Salvia* species is a rich source of vitamins. Several species of *Salvia* were evaluated for vitamin C content and it was found that *S.fruticosa* (80.6µg/g), *S. virgata* (36.0µg/g) and *S. candidissima* (27.74µg/g) possess the highest level while *S. verticillata* (17.0µg/g) has the lowest level of vitamin C[54].

Dietary minerals are accredited as an essential part of the human diet with various beneficial physiological functions. Major dietary minerals include calcium, phosphorus, potassium, sulphur, sodium, chlorin e and magnesium and minor elements are iron, cobalt, copper, zinc, manganese, iodine, bromine and selenium.

**Table 1:** Medicinal properties of different *Salvia* species.

| Plant name | Local name | Parts used | Medicinal properties | References |
|---|---|---|---|---|
| ***S. africanalutea*** | Golden salvia | leaves, extract | Treatment for cold, tuberculosis. Also used as respiratory ailments, influenza, fever, headaches. | 42 |
| ***S. divinorum*** | Diviner sage | dried plant | Used to treat hallucinogen, also used as analgesic. | 50 |
| ***S. dominica*** | Dominica sage | extract | Inhibit TTL activity in cancer cells | 51 |
| ***S. elegans*** | Pineapple sage | leaves, flowers | Treatment of anxiety, lowering bp; have antidepressant properties. | 51 |
| ***S. fruticosa*** | Greek sage | flower, fruit, extracts | Antimicrobial activity, antioxidant activity, anti cholinesterase activity | 4 |
| ***S. hians*** | Himalayan sage | Roots | Used as stimulant, remedy for dysentery | 51 |
| ***S. hispanica*** | Chia | Seeds, leaves, extracts | Anti-inflammation activity, anti oxidant activity, Strengthens the immune system, help in weight loss, normalized blood sugar level, Anti cancerous activity | 52 |
| ***S. indica*** | Two-lip spotted sage | extracts, leaves, branches | Leaves and branches inhibit pathogenic fungal colonies such as stemphylium and mucor. | 51 |
| ***S. lavandulifolia*** | Spanish sage | leaves, extracts | Improves word recall in healthy young adults and cognitive performance and mood. | 4 |
| **S. miltiorrhiza** | Chinese sage, tan shen, danshen | root, leaves, extract | Treatment of cardiovascular and cerebrovascular disease; treatment of chronic renal failure | 53 |
| **S. officinalis** | garden sage, common sage | plant extract, leaves | Healing properties; used for respiratory ailments like asthma. Extract are used to treat hyperlipidemia, Alzheimer's disease, anti-inflammatory activity. | 27 |
| **S. sclarea** | Clary sage | seeds, oil | Oil is used in aromatherapy for relieving anxiety and fear; also used for menstrual related problem, reducing work related stress | 51 |
| **S. umbratica** | Shady sage | Herbs, seeds | Used to treat irregular menstruation. | 40 |
| **S. viridis** | Blue clary | leaves | Used for sore gums, powdered leaves are used for snuff. | 52 |

*Salvia* species are rich in both major and minor dietary minerals with nutritional properties. *S. officinalis* is rich source of various elements like As, Cd, Co, Cr, Hg, Li, Mo, Ni, Pb, Zn, Ca, Fe, Cu, Mg both in fresh or dried forms but it has a low concentration of nitrogen (0.68%) and phosphorous (0.1-0.8%) in comparison to *S. reflexa* (2.82%) and *S. glutinoseherba*[55]. Ca, Mg, and S contents of *S.halophila, S. tomentosa, S.heldreichiana* and *S. dichroantha* were found to be low compared to K and P levels[56]. Fe was found to be present in highest level (782 mg/kg) in *S. tomentosa* and lowest (179 mg/kg) in *S. heldreichiana*. These variations probably depend on growing conditions, fertilizer concentration, climatic factor, harvest time and species.

One of the most important characteristic of seeds of *Salvia* species is high content of saturated, monounsaturated and polyunsaturated fatty acids. Polyunsaturated fatty acids (PUFA): linoleic acid (C18:2 n-6) and α-linolenic acid (C18:3 n-3) are essential nutrients

required for various metabolic processes in human body and must be supplied in diet since it cannot be synthesized[57]. n-6 PUFA/ n-3 PUFA in ratio (3:1) are required for smooth functioning of various metabolic processes in the body. Contrary to this, our diet contains high amounts of saturated fatty acid and low content of PUFA's (15:1), which increases the risk of heart disease[58]. In *Salvia*, the proportion of unsaturated fatty acid (USFA) (93.2-96.1%) is much higher as compared to saturated fatty acids. The main fatty acids found in *S. coccinea* are linoleic acid (33.1%), linoleic acid (25.2%), oleic acid (13.3%) and stearic acid (12.5%), while other fatty acids are found in insignificant proportions[59]. Fatty acid profile is highly significant in several *Salvia* species like *S. syriaca, S. virgata, S. halophila, S. bracteata, S. limbata*and *S. aucherri*. USFA content in these *Salvia* species was found to be very high (87.5%-92.9%) compairing to the total saturated fatty acid composition which ranged between 6.79-12.4% [60].Restriction on the use of in-feed antibiotics in many countries has fueled the interest in alternative products. A group of natural products known as phytogenics alternatively referred as phytobiotics or botanicals has been the area of interest in current years[61]. Functional foods are generally considered to offer various benefits that may promote optimal health or reduce the risk of disease. The high level of bioactive compounds in the *Salvia* species makes it a potentially valuable material for the formulation of additives and supplements with high nutritional value to meet the current demand for natural, nutraceutical, and fiber-rich products. Since ancient times, *Salvia* species have been sold commercially not only for use in therapy but also as a spice to flavor meats, sausage and poultry[62]. It contains a complex mixture of terpenes, mono-di terpenes, aliphatic hydrocarbons, acid, alcohol, cumarines, phenolic acid, flavonoid[6], which are used as food additive, seasoning, spice, condiment and herbal tea[63]. *S. lanigera*, *S. officinalis*, *S. horminum*, *S. sclarea* and *S. hispanica* containthymol that imparts a characteristic taste to foods and drinks. Besidethymol, other compounds such as cedrol, linalool and myrtenol present in *Salvia* are used to prepare soft drinks and food additives to improve the quality of liquor and wines[64]. *Salvia* species were an important component of herbal tea mixtures prior to the discovery of antibiotics. The species namely *S. triloba*, *S. lanigera*, *S. serotina*, *S. repens*, *S. Africana-lutea*, *S. officinalis*and *S. miltiorrhizabge* (Danshen) are recommended to patients with coughs, cold, fever, tuberculosis, chronic bronchitis, female ailments, asthma, depression, excessive sweating skin and many other disorders[65]. Many plants and their extracts have been added in a range of foods to enhance their sensory characteristics and expand shelf life due to their high antioxidant capacity[66] and natural antimicrobial substances which may be used as bio preservatives to present food spoilage through retardation of microbial development on foods especially meat products[67].

**Novel food supplement- Chia seeds**

Nowadays, there is a rapidly growing interest in an alternative cereal based products. Great possibilities lie in non-traditional components, which have great nutritional composition and possible beneficial effect on human health. Chia seeds are one of the natural products which are used as a food supplements. *Salvia hispanica*, commonly known as Chia is an annual herbaceous plant, natively cultivated in Mexico and Guatemala. Its nutritional importance is that it contains a high fat content (30-33%), protein (16-26%), unsaturated fatty acid (linolenic and linoleic acid) and dietary fiber (37-41%) beneficial to human health[52].It is one of the most significant natural sources of omega-3 fatty acid which reduces the level of tri glycerides, moderately increases blood levels of HDL cholesterol and lowers levels of LDL cholesterol. By preventing the formation of clots in the arteries, it helps prevent cardio vascular disease[68].Some of most important applications of the seeds include their use as a nutritional supplement and as an ingredient in cereal bars, biscuits, pasta, bread, snacks, cakes and yogurt, among others, that include their use even in increase meat quality[69, 52](Figure 4).

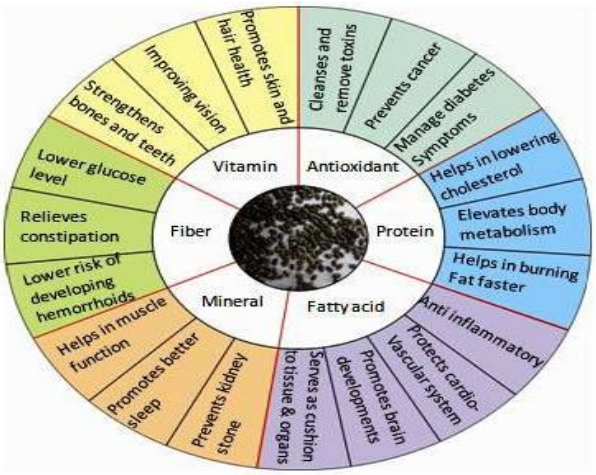


**Figure 4:** Health benefits of seeds of *Salvia hispanica*

**Industrial Applications**

In addition to nutritional uses, plants belonging to genus *Salvia* have found their way as industrial products in cosmetics and toiletries[2]. Diversity, versatility and safety in comparison to synthetic materials, natural compounds have attained special interest in pharmaceutical industry. Biological activities are ascribed to the presence of chemical compounds, particularly secondary metabolites which are natural bioactive compounds. The presence of these may assist in treatment of various diseases. *Salvia* species are very rich source of phytochemical compounds and thus pharmaceutical industries target these species to produce safer and effective novel drugs with no side effects[40]. Essential oils and poly phenolic compounds exhibit a variety of biological activities including- anti cancer, antibacterial, anti-inflammatory,antioxidant[15, 70], antifungal, anti-septic [40], carminative, diuretic, hypoglycemic, sedative and against menstruation disorders [71](Figure 5).

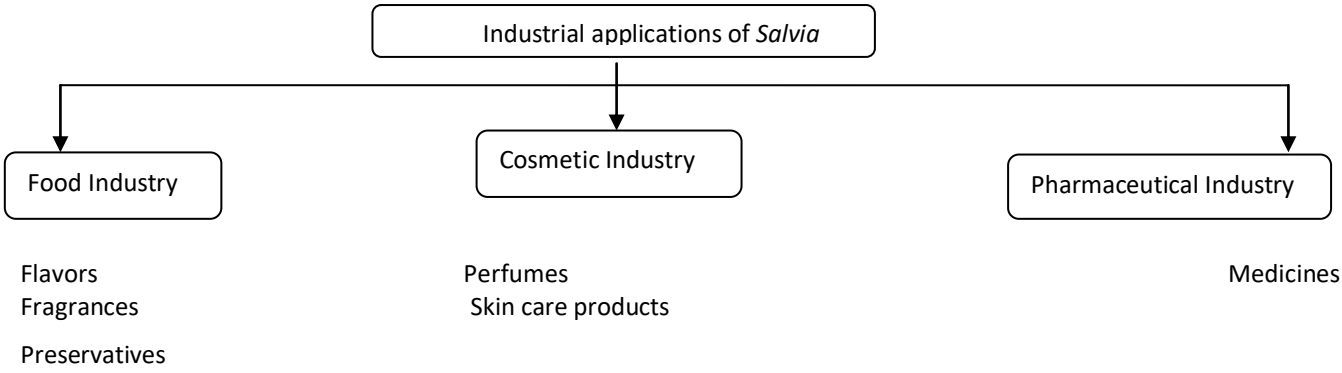


**Figure 5:** Industrial applications of *Salvia* species

It is considered as one of the most valuable and effective group of plants containing essential oils and bioactive compounds of therapeutic significance which are used in formulation of safe, effective and novel cosmetic products[72]. In cosmetics and toiletries, hydro alcoholic extracts of *S. officinalis*, *S. lavandulaefolia* and *S. plebeian* have astringent, antimicrobial and antifungal properties providing protection to skin against microbes. It is non-irritating and non-sensitizing to human skin and non-phototoxic [73] and is used for soap formation and treatment of skin problems[74]. Alluring aroma effect of essential oils of *S. sclarea* flower has been exploited by many manufactures in the hygiene and cosmetic industry[75] in which the diterpene sclareolis used to impart fragrance to household cleaning products such as soaps, lotions, perfumes and creams. It is valuable starting material for semi synthesis of numerous commercial substances including production of Ambrox® and related ambergris substitutes used in the formulation of high end perfumes. Some other components of *S. libanotica* and *S. hispanica* used in perfume industry are camphol, pinene, linalyl acetate, omega-3 fatty acid[69]. Essential oil of *S. hispanica* obtained from its seeds contain high levels of linolenic acid, linoleic acid, omega-3 and 6 fatty acid known to suppress melanin biosynthesis that are used in several skin creams including creams for hyper pigmentation[76].

Some important natural bioactive compounds of the *Salvia* species used in pharmaceutical industries are listed below (Table II).

## CONCLUSION

*Salvia* represents a treasured source of various phytochemicals including essential oils, phenolic compounds, flavonoids and phenolic acids. In this review, an attempt was made to analyze and thoroughly document nutritional, medicinal and industrial applications of this botanical genus. Essential oils present in various species of *Salvia* along with other bioactive compounds could have potential applications in food, health industry as food stabilizers, neutraceuticals etc. These phytochemicals complexes may act as scaffold to synthesize novel molecules for therapeutic purposes. However, there is a need to investigate the safety and efficacy of these molecules. Moreover, further research and efforts require to be directed towards the use of automated and high throughput screening to search for novel bioactivities of these natural components.

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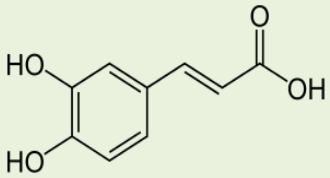
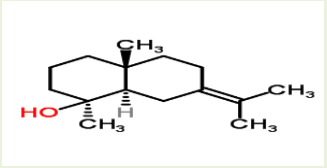
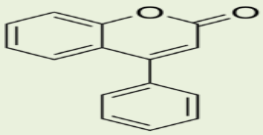
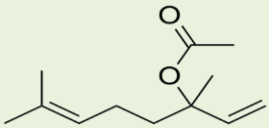
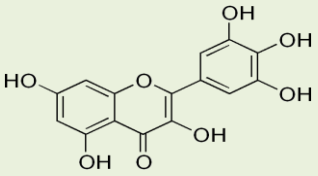
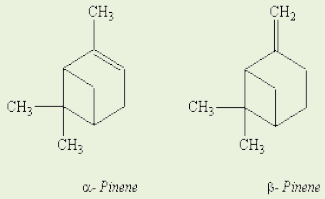
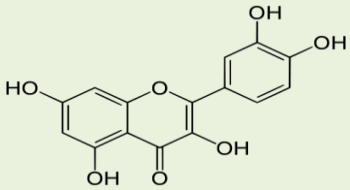
**Table 2:** Bioactive compounds of *Salvia* species.

| Active compounds in *Salvia* species | Chemical structure | Activities | References |
|---|---|---|---|
| **Caffeic acid** |  | Antioxidant; anti-inflammatory; anti-cancer; antithrombotic activities; anti-bacterial; | 17 |
| **Camphor** |  | Antipyretic;antiseptic; carminative; antitussive agent; reduces cough | 26 |

| | | | |
|---|---|---|---|
| **Flavonoids** |  | Anti-cancerous; anti-oxidant; anti-bacterial; anti-pyretic | 40,49 |
| **Linalyl acetate** |  | Anti-cancer; antispasmodic; sedative property; anti-bacterial; anti-inflammatory | 26 |
| **Myricetin** |  | Antioxidant; anti-inflammatory; anti-cancer; antithrombotic; anti-mutagenic activity | 49 |
| **Omega 3 α-linolenic acid** |  | Anti-inflammatory; antidiabetic; anti-cancer; Lowering cholesterol levels; Cardioprotective; hepatoprotective | 68 |
| **Omega 3 α-linolenic acid** |  | Anti-inflammatory; antidiabetic; anti-cancer; Lowering cholesterol levels; Cardioprotective; hepatoprotective | 68 |
| **Omega 6 linolenic acid** |  | Anti-inflammatory; hypertensive; thrombotic activities; It works with ALA to maintaining good health | 68 |
| **Pinene** |   | Anti-bacterial; anti-fungal; anti-inflammatory; anti-cholinesterase activity | 32,36 |
| **Phenolic glycoside** |  | Anti-cancer; anti-fungal; anti-uretic; anti-oxidant; anti-inflammatory | 40 |
| **Quercetin** |  | Antioxidant; anti-inflammatory; anti-cancer; antithrombotic activities | 32 |

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