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SALVIA HISPANICA (CHIA) SEEDS – A REVIEW ON PHARMACOLOGICAL BENEFITS, NUTRACEUTICAL PROPERTIES, EXTRACTION METHOD AND APPLICATIONS

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ABSTRACT: The plant *Salvia hispanica* belongs to the family Lamiaceae, a highly valued medicinally important seed, commonly known as chia seeds. About 75% of the fats in chia seeds consist of omega-3 alpha-linolenic acid (ALA), while about 20% consist of omega-6 fatty acid. Omega-3s play an important role in sharpening memory and improving mood. Chia seeds also contain polyunsaturated fatty acids, dietary fiber, proteins, vitamins (A, C, E, niacin, thiamine), and minerals. Besides this, the seeds are an excellent source of polyphenols and antioxidants, such as caffeic acid, rosmarinic acid, myricetin, quercetin, and others. These antioxidants exhibit the capacity to scavenge free radicals. Chia's health benefits as a dietary supplement and efforts are underway to promote it as 'functional food' owing to the presence of α-linolenic acid, an essential precursor fatty acid of physiologically significant polyunsaturated fatty acids. Chia seeds also possess various pharmacological activities like anti-inflammatory, antihypertensive, anti-diabetic, anti-cancer and it also reduces the risk factors of heart disease. It is commonly used for weight loss. And it also shows a neuroprotective effect. These studies reveal that *Salvia hispanica* is a source of medicinally active compounds and have various pharmacological benefits. This article aims to present the Nutritional and Pharmacological benefits of chia, its extraction method and its applications in the food and pharmaceutical industries.

INTRODUCTION: *Salvia hispanica* L., also known as chia, is an annual herbaceous plant originally from Southern Mexico and Northern Guatemala. It belongs to the order Lamiales, mint family Labiate, subfamily Nepetoideae and genus Salvia.

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The genus *Salvia* consists of approximately 900 species, which have been widely distributed for thousands of years around several regions of the world, including Southern Africa, Central America, North and South America and South-East Asia.

As reported in the literature, chia today is cultivated in Mexico and Guatemala and Australia, Bolivia, Columbia, Peru, Argentina, America, Europe, and some parts of India. In India, it is largely produced in Kerala & some parts of Maharashtra. Nowadays, Mexico is recognized as the world's largest chia producer. Furthermore, the word chia comes from the Spanish word "chian",

which means oily. Chia, *Salvia hispanica* L. exists as an ancient food, providing balanced amounts of minerals, high content of antioxidants, proteins with amino acids in excellent quantity, high omega-3 &6 fatty acids and insoluble fiber.

The chia plant and seeds are shown in **Fig. 1**. The chia seed coat comes with mucilage, which aids in the protection of the seed nutrients entirety, as well as participates in the foods' water retention process [35].

Thus, this seed forms a crucial source of α-linoleic, which is among the most beneficial ω-3 fatty acids. For the chia seed storage proteins, in most cases, they constitute glutelin fractions, prolamin, albumin, and globulin. The seed's main phenolic compounds include gallic, caffeic and rosmarinic acids [31].

Thus, due to its outstanding benefits, chia seed has attracted industry, researchers, and nutritionists' attention and scholarly interest. In the 21st century, this seed continues to be recognized due to the provision of invaluable nutraceutical benefits, examples being antioxidant and antihypertensive functions.

Salvia hispanica L. is mainly grown for its seeds and produces white and purple flowers, which are 3 to 4 mm small and hermaphrodites. The plant itself is sensitive to daylight, it can grow up to 1 m tall, its leaves are reverse petiolate and serrated, and are 4 to 8 cm long and 3 to 5 cm wide.

Chia seeds are generally very small, oval-shaped, 2 mm long, 1 to 1.5 mm wide and less than 1 mm thick. The color of the seed varies from black, grey, or black-spotted to white. Already reported, there is such a marginal difference between black and white Chia seeds that most consider them equal [33].

Nutritional values are similar protein content in black Chia seeds is 16.9%, and fiber content is 32.6%. In white Chia seeds, the protein content is reported to be 16.5% and the fiber content 32.4%. A slight difference is only in morphology; white seeds are larger, thicker and broader than black ones. It is worth mentioning that when black chia seeds are cultivated, around 5% to 8% of white chia seeds are grown simultaneously. Cultivating only white chia seeds gives white chia seeds only [11].

In recent years, Chia seeds have become one of the world's most recognizable foods based on their nutritional properties and medicinal values. Lye and Amin reported that Chia is an excellent ingredient since it contains the highest known amount of α-linolenic acid and can be easily added to commercial food [12].

It has been reported in several studies that chia seeds, due to the high percentage of fatty acids present, can be crucial for health, antioxidant, and antimicrobial activity. And it is also added to various food beverages.

Salvia genus **Fig. 1** has around 900 species growing worldwide, most of which are grown as ornamentals and for oilseeds. Chia grows in tropical to temperate zones from planes to hilly regions. However, recently there is a revived interest in Chia as an agricultural crop owing to the nutrition value of the seed oil [34].

Epidemiological and experimental evidence establishes a strong relationship between dietary fat and the incidence of coronary heart disease, cancer, diabetes, and depression. Cardiovascular diseases contribute to 20% of total clinical mortality among Indians every year and economically cost around 54.5 million annually.

Increased dietary intake of long-chain fatty acids derived from α- linolenic acid is associated with a reduced risk of cardiovascular diseases [14]. PUFAs have been used successfully in rheumatoid arthritis and bronchial asthma. Epidemiological studies suggest that dietary fatty acids are rich in α-linolenic acid-enhanced childhood teaching and behavior ability, leading to a decrease in the burden of psychiatric illnesses in adults.

Chia seeds contain about 25-38% oil and have the highest known percentage (60%) of alpha-linolenic fatty acid (ALA). The three main omega-3 fatty acids are alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA).

EPA and DHA with Δ6 and Δ5 desaturase enzymes and, hence, can be substituted for fish oils. Therefore, the dietary ALA could exert similar physiological effects as in the case of EPA and DHA from dietary fish oils [32].

FIG. 1: CHIA PLANT AND SEEDS

Extraction Procedure: Oil from Chia seeds is extracted using one of the three methods generally used for any oil seeds; the compression method involves pressing the seeds at 4 ℃ or 25 ℃ in the dark. This results in the preservation of antioxidant contents; however, oil recovery is limited Solvent extraction–involves the Soxhlet method using organic solvents like hexane. Though functional characteristics like absorption capacity and emulsifying stability are favored, this method is least preferred as it poses health issues from the use of hexane. Supercritical fluid extraction–is the preferable method that uses carbon dioxide at 80 ℃ resulting in a better purity of ALA. The oil yield is increased with high pressure it is known that the usage of different extraction methods is causing variation in the extraction yields, quality, and content of fatty acids, as well as the content of dietary fibers, antioxidant content, *etc*. The extraction of chia oil is conventionally by Soxhlet extraction. Non-polar conventional organic solvents such as n-hexane or ether are used. The advantages of using conventional solvent (CS) extraction are mainly the simplicity of the method, relatively high extraction yield, and suitable functional characteristics of the oil (such as water-holding, absorption capacity, organic molecule absorption, molecule stability). Meanwhile, the disadvantages are decreased antioxidant activity due to the decomposition of thermolabile antioxidants and the environmental and health concerns involved in using n-hexane. Masa & Zelijko studied the properties of chia oil extracted using different solvents (ethyl acetate, isopropanol, and n-hexane). It was considered that concerning the oil extraction, higher yields were obtained with n-hexane and ethyl acetate. Moreover, the solvent properties did not affect the properties of the oil, and the water-holding capacity was not affected by the extraction process [2].

A more suitable extraction method that has been used recently is supercritical fluid extraction (SFE), where carbon dioxide (CO_2) is the most used solvent. Entering into the supercritical state depends on both temperature and pressure. A "supercritical" solvent exhibits the features of both a liquid and a gas. It can slide into porous materials as well as dissolve them. The advantages of using SFE compared to other techniques are the usage of a solvent with low density, viscosity, surface tension, and mild conditions of temperature and pressure, which leads to no degradation of the compounds. Not only CO_2 but also other solvents can be used for SFE. Meanwhile, CO_2 has beneficial properties such as a low temperature (31 ◦C) and low critical pressure. Supercritical extractions using CO_2 are common for the extraction of Chia oil. Subcritical extractions are also performed regularly, mostly by using propane in its subcritical state. The differing methods accomplish different goals. The pressure is maintained while the temperature is taken below the supercritical threshold. The solvent still maintains some of the hydrophobic extraction properties, but the lower temperatures protect the fragile constituents from denaturing [2].

Neutraceutical Properties: The chemical composition of Chia seeds has been analyzed by many researchers. Chia seeds contain high content of fats (30-33%), carbohydrates (26-41%), dietary fiber (18-30%), proteins (15-25%), vitamins, minerals, and antioxidants [24]. The active constituents of chia seed, their chemical structure, and respective pharmacological activity is shown in **Table 1**. Pointing out, the major constituents of Chia oil are polyunsaturated fatty acids (PUFAs: α linolenic (ALA, ω-3 fatty acid) and linoleic (LA, ω-6 fatty acid) acids). Chia seeds contain 39% of oil (mass of dry seed), which consists of up to 68% of ω-3 and 19% of ω-6 fatty acid. The ratio between ω-6 and ω-3 fatty acids is 0.3:0.35 [25].

Lipid Content: Lipids are bioactive substances that the human organism needs to accumulate energy, form structural elements of cell membranes and regulate physiological functions. If there are no enzymatic systems capable of forming double bonds at positions n-3 and n-6, the organism cannot synthesize fatty acids, such as ω-3 alpha-linolenic acid and ω-6 alpha-linoleic acid. Therefore, it is necessary to provide the organism with a supply of lipids in food. Chia seeds contain 25 - 40% of fat, most of which is in the form of polyunsaturated fatty acids, such as ω-3 alpha-linolenic acid and ω-6 alpha-linoleic acid. As a result of desaturation and elongation processes, these acids are converted into long-chain polyenoic acids, such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). In chia seed oil, the ratio between ω-6 and ω-3 acids is 0.32-0.35. The high content of ω-3 acids in chia seed oil enables the reduction of the share of ω-6 acids in daily food rations [8]. Apart from that, an adequate supply of unsaturated fatty acids reduces the risk of ischaemic heart disease and increases the immunity of the organism.

PUFA's: The chia seed contains important quantities of protein, minerals, fiber, polyphenols, and polyunsaturated fatty acids (PUFAs) and is currently known as one of the best plant sources of the omega-3 (n-3) fatty acid, α-linolenic acid (ALA)One of the unique characteristics of chia seeds is their high content of heart-healthy omega-3 fatty acids. About 75% of the fats in chia seeds consist of omega-3 alpha-linolenic acid (ALA), while about 20% consist of omega-6 fatty acids. These two major PUFAs show pharmacological benefits in anti-inflammatory effects, antidiabetic, anticancer effect *etc* [19].

Protein Content: Proteins, peptides, amino acids, being different matrices, are necessary cell components enabling the normal function of the organism. The protein content of Chia seeds is around 17% - 26%; it is greater than the protein content in all other cereals (for instance, in corn, the protein content is 9.4%, rice is 6.5%, quinoa 14.1%, and in wheat 12.6%). The amount of the proteins in Chia seeds depends mainly upon environmental and agronomical factors. Most of the proteins in chia seeds are prolamins (538 g/kg of crude protein), followed by glutelins (230 g/kg of crude protein), globulins (70 g/ kg of crude protein), and albumins (39 g/kg of crude protein) the absence of protein gluten makes Chia seeds highly valued to patients who have the coeliac disease; moreover, food rich in proteins is highly recommended to the people who are fighting the weight loss [13]. Chia seeds contain more proteins than rice, maize, barley, or oats seeds. According to

the United States Department of Agriculture data, chia seeds contain 18 amino acids, including 7 exogenous amino acids, which are considered indispensable [3]. Chia seeds contain some exogenous amino acids (arginine, leucine, phenylalanine, valine, and lysine) and some endogenous amino acids (glutamic and aspartic acid, alanine, serine, and serine glycine). For example, the content of amino acid serine is 1.05 g/100 g, glutamic acid 3.50g/100 g, glycine 0.95 g/100 g, alanine 1.05 g/100 g, lysine 0.97 g/100 g, and histidine 0.53 g/100 g. The study by Orono and Paredes revealed that glutamic acid, which is responsible for the proper functioning of the brain, is the predominant amino acid in chia seeds [10].

Dietary Fiber: Dietary fiber is an important component of everyday diet. Optimal consumption of dietary fiber, *i.e.*, 25-30 g/day, has a positive influence on health Fibre content in Chia seeds is very high. Chia seeds contain between 34 g and 40 g of dietary fiber per 100 g. In this specific amount, the insoluble fraction (IDF) represents approximately 85- 93%, while the soluble fraction (SDF) represents between 7-15% of the fiber content in chia seeds depending on the cultivation region's climate [3]. Chia seeds contain about twice as much fiber as bran, 4-5 times more than almonds, soy, quinoa, or amaranth. The high amount of fiber decreases the risk of coronary heart disease, the risk for diabetes type 2 and several types of cancer, kidney stones, hemorrhoids, and metabolic disorders; furthermore, a high amount of dietary fiber in daily meals decreases subsequent hunger.

Vitamins and Minerals: Vitamins and minerals are necessary for the normal function of the organism. An adequate supply of these elements enables optimal control of the number of hormones, growth regulators, and differentiation of cells and tissues. It also protects the organism from oxidative stress.

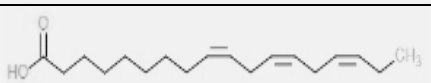
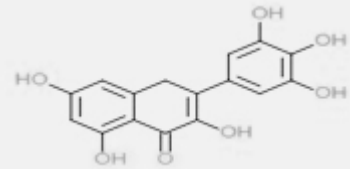
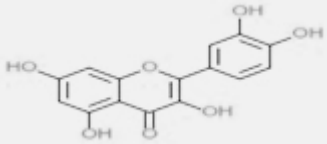
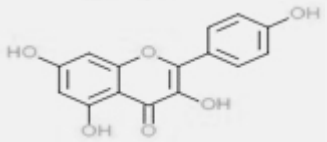
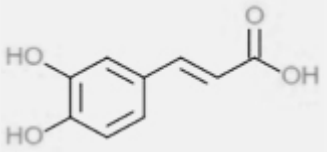
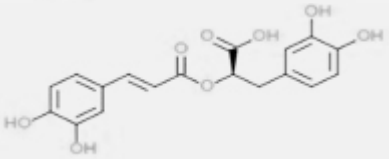
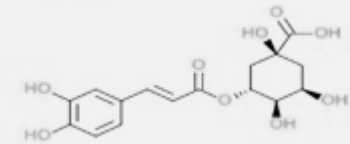
Chia seeds are a source of B vitamins: thiamine (0.62 mg/100 g), riboflavin (0.17 mg/100 g), niacin (883 mg/100 g), and folic acid (49 mg/100 g). Compared with rice and maize seeds, chia seeds contain more niacin and comparable amounts of thiamine and riboflavin. Apart from that, chia seeds are a source of minerals [23]. They contain 6 times more calcium, 11 times more phosphorus and 4 times more potassium than cow's milk.

Antioxidants: Chia seeds and their oil contain many natural antioxidants such as tocopherols, phytosterols, carotenoids, and polyphenolic compounds; polyphenolic compounds are the most important complexes that contribute to the antioxidant activity of Chia seeds. It is well known that they can scavenge free radicals, chelate ions, and donate hydrogens. Oxidation is an important biological process, which is indispensable for producing energy in the human organism. During metabolism, molecular oxygen is reduced to water. When electrons are being transferred, free reactive forms of oxygen are generated, such as hydrogen peroxide, hydroxyl, and peroxide radicals. Free radicals are considered the cause of neurological diseases, inflammations, immunodeficiency, aging, ischaemic heart disease, strokes, Alzheimer's and Parkinson's diseases, and cancers. ω-3 fatty acids can block calcium and sodium channel dysfunctions, which can cause hypertension, improve heart rate variability, and protect ventricular arrhythmia. Chia seeds have detected the following substances: tocopherols, sterols (approx. 50% β-sitosterol), and polyphenolic compounds, such as protocatechuic acid gallic and p-coumaric acids, caffeic acid, chlorogenic acid, as well as epicatechin, quercetin, kaempferol, rutin, and apigenin [26]. The total content of vitamin E in chia seeds is 238- 427 mg/kg, and it is comparable to peanut oil (398.6 mg/kg), but it is lower than in linseeds (588.5 mg/kg), sunflower (634.4 mg/kg) or soybean (1,797.6 mg/kg).

Phenolic Content: Focusing on phenolic content, dry Chia seeds contain 8.8% of phenolic compounds. Besides that, high levels of caffeic acid, chlorogenic acid, quercetin, rosmarinic acid, gallic, cinnamic, myricetin, and kaemferol are reported. Also, isoflavones, such as daidzein, glycitein, genistein are found in small amounts. Thomas reported that rosmarinic acid and daidzein are the major components found in Chia seeds, with the presence of caffeic acid, myricetin, quercetin, *etc.* Besides, in the same study, the vitamins A, B1, B2 and B3 were identified in Chia seeds for the first time [15]. Flavonoids quercetin, chlorogenic acid, and caffeic acid are proved to have anti-cancerogenic, antihypertensive and

neuron protective effects. Thomas, Rehman, and Nadeem mentioned that Chia seeds have no potentially toxic mycotoxins and gluten present. Furthermore, Rahman and Nadeem described that Chia seeds are a great example of food rich in antioxidants [6].

TABLE 1: ACTIVE CONSTITUENTS PRESENT IN CHIA AND THEIR BIOLOGICAL ACTIVITY

S. no.	Active compounds in *Salvia hispanica* L. seeds	Chemical structure	Biological activity
1	Omega-3 fatty acid, ω-3 fatty acid, ω-3 ALA		anti-inflammatory - antidiabetic -anticancer
	Flavonoids		
2	Mycertin		antioxidant
3	Quercetin		antioxidant - anti-cancerogenic - anti-hypertensive
4	Kaempferol		antioxidant
5	Caffeic acid		antioxidant - anti-cancerogenic - anti-hypertensive
6	Rosmarinic acid		antioxidant
7	Chlorogenic acid		antioxidant - anti-cancerogenic - anti-hypertensive
8	Vitamins	A, B1, B2, B3, C, D, E, K	Healthy skin for synthesizing ATP for normal nervous and digestive system working

Applications of Chia Seeds:

Food Industry: Several studies have been performed on the usage of chia seeds in the food industry. In the food industry, chia seeds can be used in different shapes: whole, ground, in the form of flour, oil, and gel. In 2000, the US Dietary guidelines suggested that chia can be used as primary food, but in a limited amount; consumption of no more than 48 g/daily is recommended. Chia seeds can be added or mixed into biscuits, pasta, cereals, snacks, and cakes as supplements.

Due to their hydrophilic properties, chia seeds can be used as substitutes for eggs and fat. They can absorb 12 times their weight in water. Chia gel may be used as a substitute for oil or eggs in baked products[7]. It was shown that chia oil could replace 25% of the egg in cakes. The nutritional value of butter can be increased by mixing it with chia oil in a proportion from 6.5% to 25% when the concentration of ω-3 fatty acid in chia fortified butter increases from 4.17% to 16.74%. Besides, recent studies showed that mucilage from chia

seeds could be used as a functional coating with improved functional properties [27].

Chia Mucilage: Chia mucilage could be employed in the food industry as a foam stabilizer, suspending agent, emulsifier, adhesive, or binder due to its water holding capacity and viscosity. Recent studies showed that mucilage from chia seeds could be used as a functional coating with improved functional properties. Compared with other hydrocolloids such as gum arabic, modified starch, and cellulose, chia mucilage has a low EAI emulsifying activity index. The mucilage showed a significant ability to stabilize emulsions; however, the emulsion's composition affected the potency [20]. The fact that the mucilage has such an ability to stabilize emulsions may be due to its capacity to adsorb in the solid or liquid interface and stabilize emulsions without chemical or enzymatic variations[7]. The mucilage obtained from chia seeds is a novel source of polysaccharides and could potentially generate interesting polymer blends for edible films and coating.

Edible films based on polysaccharides are potential substitutes for synthetic packaging. Mucilage can form edible films, but they are very slight and brittle. The addition of plasticizers may be carried out to advance the mechanical characteristics of edible films. Different plasticizers, such as polyols, have been applied to increase the flexibility and workability of such films. Amongst the plasticizers, glycerol is one of the most widely applied in film-making techniques. The chia mucilage hydrocolloid is an interesting constituent that may be applied to design new film-forming solutions [9]. The addition of glycerol to extracted hydrocolloids from the chia seed to make chia mucilage films was essential to provide homogenous and flexible films and is crucial to achieving suitable physicochemical, barrier, and mechanical properties [16]. The solubility of chia mucilage films can be fine-tuned by the glycerol content and improved with a higher proportion of glycerol. Water solubility in the chia mucilage films plasticized with different concentrations of glycerol increased considerably.

Chia gum: Chia seeds are a starting material in the food industry for their dietary fiber. Gum can be extracted from the dietary fiber fraction by using water as an additive to control viscosity, stability, and texture. The chemical composition, molecular structure, and derived properties such as thermal stability or gelling ability are important factors determining the appropriateness of a polysaccharide in the food and pharmaceutical industries. The gum is also stable at high temperatures, way up to 224 °C. Maira and Norma investigated the chemical and functional properties of chia seed gum [21]. They showed that chia gum contains 26.2% fat and when submitted to fat extraction, two gum fractions can be produced: gum with fat (FCG) and gum partially defatted (PDCG). They confirmed that PDCG has a higher content of protein, ash, and carbohydrate than FCG. Chia seed gum is a novel promising material [4]. However, due to limited information on the structural composition, it has not yet been industrially applied. Few investigations have been carried out on its thermal stability and functionality [28]. Understanding these characteristics will significantly broaden the potential of industrial application.

Pharmaceutical use: Chia oil can be incorporated into oil-in-water (O/W) emulsions as ω-3 fatty acid delivery systems in food matrices. Sodium caseinate content and lactose addition strongly influence the stability and rheological properties of chia O/W emulsions. Moderate stability of chia O/W emulsions and Newtonian behavior is achieved by stabilization with a certain amount of emulsifier. Chia O/W emulsions have demonstrated low levels of primary and secondary oxidation products.

A recent study reports that spray-dried chia seed oil (CSO) microcapsules were prepared by using chia seed protein isolate (CPI), chia seed gum (CSG), and a CPI-CSG complex coacervate as shell materials. The CPI-CSG complex coacervate was found to be suitable for the delivery of CSO to the intestinal stage of digestion since almost all the unencapsulated oil was hydrolyzed, whereas only 60% of the oil encapsulated in the CPI-CSG shell was hydrolyzed during in vitro digestion [9]. It is reported that the leaves of Salvia hispanica L. contain an essential oil that comprises β-caryophyllene, globulol, β-pinene, α-humulene, and widdrol. Those compounds are believed to have strong repellent characteristics to a wide spectrum of insects [29].

Pharmacological Benefits of Chia Seed:

Anticancer Property: Nutrition has a significant role in the initiation and progression of cancer. Dietary PUFAs have been shown to play an important alleviating role in various forms of human cancers. Several studies demonstrate the cytotoxic ability of PUFAs against different types of cancer cells and may act synergistically with current chemotherapeutic drugs. Arachidonic acid (20:4, n-6) derived from ALA induces apoptosis of tumor cells by converting sphingomyelin to ceramide that triggers the release of pro-apoptotic proteins. In addition, eicosanoids derived from AA act as active carcinogens or tumor promoters because of their pro-inflammatory actions and thus participate in cancer development [1]. Moreover, peanut oil rich in linoleic/oleic derived PUFAs protects against murine mammary cancer development by modulating tumor membrane fatty acids composition, lipoxygenase (LOX), and cyclooxygenase (COX) enzyme. Hence, it is hypothesized that chia seed oil, as it contains all the derived of α-linolenic, linoleic/oleic in good balance, may produce the same effect.

In Atherothrombotic disease: ALA (C18:3) is the primary fatty acid derived from the lipid fraction of chia seeds. Once inside the human system, ALA, an essential fatty acid, is converted to EPA and DHA by the sequential activities of Δ6 and Δ5 desaturases and carbon chain elongation with an intermediate docosapentaenoic acid (DPA). The primary conversion site is the liver, followed by enterocytes. After ALA conversion, very-low-density lipoproteins transport newly synthesized EPA/DPA/DHA away from the liver to other parts of the body[18]. During the conversions of ALA, PUFA derived from linoleic and linolenic fatty acids compete for metabolic enzymes; interestingly, this competition exists during esterification into plasma phospholipids and triglycerides. Moreover, an increased concentration of dietary C18:2 caused a decrease in the synthesis of long-chain PUFA derived from ALA (C18:3) and vice versa. The diet low achieves optimal conversion of ALA to EPA/DPA in both linoleic and linolenic and their derived fatty acids. Interestingly the extent of conversion of EPA to DPA to DHA varies between men and women [22]. An elevation in plasma C-reactive proteins (CRP) is strongly associated with clinical definitions of atherothrombotic disease. CRP possesses a direct pro-inflammatory effect on human endothelium exhibits synergy with hypercholesterolemia to increase CVD risk [17]. PUFAs suppress pro-inflammatory cytokine production by peripheral blood cells and inhibit lymphocyte proliferation, reducing the chances of initiation of atherothrombosis. Patients with higher CRP levels are associated with a diminished cholesterol-lowering response (29%), increasing cardiovascular risk. In patients receiving diabetes therapy, chia seeds reduced systolic blood pressure and CRP concentrations and increased serum ALA/EPA concentrations, however, they did not affect body weight.

Anti Inflammatory Effect: The inflammatory disorder is associated with pain, redness, and swelling, the severity of which leads to loss of vital functions. An interdependent chain of reactions is mediated by inflammatory molecules released from leukocytes. The key inflammatory mediators, including linoleic, derives eicosanoids, prostaglandin E2, and leukotriene B4, are derived from arachidonic acid [1]. However, lower risks of pro-inflammatory reactions are demonstrated with the Chia seed oil diet. The n3 PUFA in Chia seed oil is suggested to compete with arachidonic acid to incorporate into the membrane [22]. Hence, generate slightly modified prostaglandins and eicosanoids *viz.*, LTE5, LTB5, and PGE3, which induce a lesser extent of inflammation via reduced induction of COX-2 as shown in **Fig. 2.**

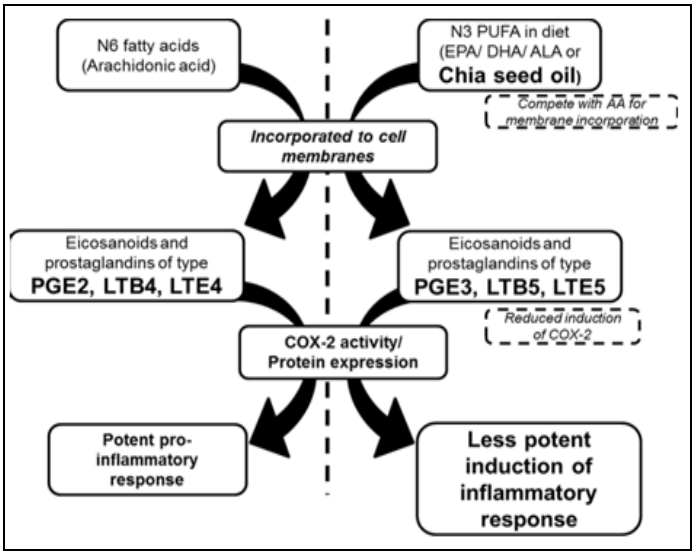


FIG. 2: ANTI-INFLAMMATORY EFFECT BY CHIA SEED OIL

Antidiabetic Effect: A few reports demonstrated Chia's potentially beneficial physiological effects against the risk factors for Type 2 diabetes in experimental animals. In a 6-month crossover study type, 2 diabetic subjects consuming Chia daily (37g/d) demonstrated lower blood pressure, lower pro-inflammatory markers, and coagulation factors. In another study, there was a significant reduction in waist circumference in healthy individuals after a month of Chia supplementation, however, there was no change in body weight, suggesting the specific loss of fat mass. In an achronic treatment regime, dietary chia seed reduced the visceral adiposity and insulin resistance among sucrose-induced diabetic rats suggesting its role in lipid and glucose homeostasis [30]. In a separate study, Chia enriched diet modulated dyslipidemia, liver TAG, fatty acid oxidase, acetyl-CoA carboxylase and glucose-6- phosphate dehydrogenase. Protein levels of PPARα increased, and the increased mature form of SREBP-1 (Sterol regulatory element-binding protein-1) levels in the sucrose-rich diet (SRD) was normalized by chia [34]. This study attributed some key mechanisms to the biological effects of dietary chia seed in preventing and normalizing/improving dyslipidemia and liver steatosis in an insulin-resistant rat model.

Antihyperlipidemic and anti-hypercholesterolemia: Chia seed diet in rats reduced dyslipidemia and visceral adiposity. The chia diet caused lower triacylglycerol levels, increased HDL cholesterol and linolenic, and derived fatty acids in rat serum. The blending of chia seeds and different types of oils are reduced oxidative stress *in-vivo* in obese Wistar rats. In addition, stearoyl-CoA desaturase-1 products were depleted in the heart, liver, and adipose tissue of chia seed-supplemented rats. In a separate study, dietary chia seeds prevented the onset of dyslipidemia and insulin resistance (IR) in the rats fed with the sucrose-rich diet [6]. Dietary chia seed also reduced the visceral adiposity. In addition, Chia oil also reduced adipocyte hypertrophy, lipolysis, and the anti-lipolytic action of insulin among high sucrose rats. Interestingly, chia-fed pigs and rabbits resulted in an increase of PUFA in meat fats as well as aroma and flavor [35]. The combination of different seeds mixtures has been shown to increase PUFA levels in the plasma and liver of experimental animals and the anti-atherogenic, hypolipidemic, and immune modulator effects, which may attribute to the antioxidant potential of unsaturated fatty acids especially ALA present in the seed mixture [8].

Antioxidant Effect: Chia seed is a potential source of antioxidants with chlorogenic acid, caffeic acid, myricetin, quercetin, tocopherol, phytosterol, carotenoid, phenolic compounds, and kaempferol which are believed to have cardiac, hepatic protective effects, anti-aging, and anti-carcinogenic characteristics. Several reports demonstrate the potent antioxidant property of chia seeds among *in-vitro* assays. Among the obesity model of rats, dietary chia oil induced the expression of HSP70 and HSP25 in skeletal muscle and restored superoxide dismutase and glutathione peroxidase expression [5]. In addition, extended treatment with chia seed and short treatment with chia oil restored peroxisome proliferator-activated receptor-γ coactivator-1α (PGC-1α) expression.

Neuroprotective Effect: The study, "Neuroprotective effect from Salvia hispanica peptide fractions on pro-inflammatory modulation of HMC3 microglial cells," was published in the Journal of Food Chemistry. Microglia are a type of brain cell that play important roles in nervous system immunity. While these cells are crucial for protecting the brain from infectious invaders, once over-activated, they can also help drive inflammation in the brain [8]. This neuroinflammation is believed to contribute to numerous neurological conditions, including Parkinson's disease. "A byproduct during the production of chia oils is the protein portion, which is a promising source of bioactive peptides [small proteins], with application in the prevention and treatment of chronic metabolic diseases," the researchers wrote in the study to examine this, the researchers investigated the effect of proteins extracted from chia seeds on microglia[1]. Specifically, they used the HMC3 cell line. This line of microglia has been immortalized (engineered to divide indefinitely), which makes the cells easier to study in dishes in a lab. Because microglia become activated in response to infection, the researchers also treated the HMC3 cells with a bacterial molecule called lipopolysaccharide (LPS) that activates them. In response to LPS treatment, the HMC3 cells

produced increased levels of ROS, as well as other pro-inflammatory molecules, including nitric oxide, tumor necrosis factor-alpha, and various interleukins [31].

Pre-treatment with the chia protein fractions significantly decreased all LPS-induced inflammatory processes. The greatest reductions across all of these inflammatory markers were seen after pre-treatment with the 1-3 kDa fraction. This study supports the anti-inflammatory action of proteins in chia seeds, particularly peptides in the 1-3 kDa fraction. This fraction is an important study target for future research on the neuroprotective effect"

CONCLUSION: Seeds of *Salvia hispanica L*. (Chia), traditional food in Mexico, is currently consumed in Kerala and some parts of Maharashtra for various health benefits. Recently, there have been many discussions and studies about the health benefits and use of this seed. Chia seeds contain a high-fat content, carbohydrates, dietary fiber, proteins, vitamins (A, B1, B2 and B3), minerals, and antioxidants. Furthermore, chia seeds contain flavonoids, quercetin, chlorogenic acid and caffeic acid, which are proven to have anti-cancerogenic, antihypertensive and neuron protective effects. Furthermore, chia seeds are a rich source of nutrients such as polyunsaturated omega-3 fatty acids that protect from inflammation, improve cognitive performance and lower the level of cholesterol.

Chia seeds contain antioxidant compounds that reduce the risk of chronic diseases (cancer and heart attack) and offer protection against some disorders such as diabetes, Alzheimer's and Parkinson's disease. Moreover, the high amount of fiber decreases the risk of coronary heart disease, the risk for diabetes type 2, and several types of cancer.

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