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BIOLOGICAL PROPERTIES AND BIOACTIVE COMPONENTS OF CHIA SEEDS: FOCUS ON POTENTIAL BENEFITS IN THE TREATMENT OF OBESITY AND RELATED COMORBIDITIES

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ABSTRACT

Chia (*Salvia* hispanica L.) is a small seed that comes from an annual herbaceous plant, *Salvia hispanica* L. In recent years, usage of chia seeds has tremendously grown due to their high nutritional and medicinal values. Chia was cultivated by Mesopotamian cultures, but then disappeared for centuries until the middle of the 20th century, when it was rediscovered. Chia seeds contain healthy -3 fatty acids, dietary fibers, proteins, vitamins, and some minerals. Besides this, the seeds are an excellent source of polyphenols and antioxidants, such as caffeic acid, rosmarinic acid, quercetin, and others. This article provides a review of the most important information concerning the potential application of chia seeds in food production. The chemical composition of chia seeds is presented and the effect of their consumption on human health is discussed. Technological properties of chia seeds are shown and current legal regulations concerning their potential use in the food industry are presented.

1. INTRODUCTION:

The search for new tools against obesity is one of the main challenges of pharmaceutical research in the last decades [1]. Despite a variety of studies focusing on the management of this disease, its global incidence is raising, resulting in enormous social costs [2]. Adequate nutrition is an important element in the prevention of many civilization-related diseases such as diabetes, cardiovascular disease and obesity. Both state institution and non-governmental organization issue nutritional recommendations to protect human health, inhibit the development of selected diseases and alleviate their symptoms [3]. An increasingly health-promoting role is ascribed to bioactive food components. They were defined by Biesalski and co-workers as nutritional Components or non-nutritional compounds naturally found in the raw material or formed in the Product in the course of technological processes which may enhance, inhibit or modify physiological and metabolic functions of the organism [3-4]. The American Dietetic Association supplements this Definition by additionally stressing the importance of health safety of bioactive food. Bioactiva Compounds include, e.g., polyphenols, carotenoids, phytoestrogens, sterols, stanols, vitamins, dietary fibre, fatty acids, probiotics, and bioactive peptides[4-6].

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. The genus Salvia consist 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 SouthEast Asia [7-11]. As reported in the Literature, chia today is not only cultivated in Mexico and Guatemala, but also in Australia, Bolivia, Columbia, Peru, Argentina, America, and Europe. Nowadays, Mexico is recognized as the world's Largest chia producer [8].

Salvia hispanica L. (figure 1) 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 wide. Chia seeds are Generally very small, oval-shaped, 2 mm long, 1 to 1.5 mm wide, and less than 1 mm thick[8,11,12]. In recent years, Chia seeds have become one of the world's most recognizable foods based on their Nutritional properties and medicinal value. Coorey et al. reported that Chia is an excellent Ingredient since it contains the highest known amount of á-linolenic acid and can be easily added to Commercial food. 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 [9-12,13-15].

Chia is an oilseed, with a powerhouse composed of fats, carbohydrates, dietary fiber, proteins, vitamins (A, B, K, E, D), Minerals, and antioxidants. The advantage of using chia seeds as a nutritional supplement are enormous – positive benefits include supporting the digestive system, promoting healthy skin, stronger bones and muscles, reducing the risk of heart disease, Diabetes, and so on [8,9,11,16]. However, more research on the real properties and benefits of chia seed is still required because in this way the new knowledge would help to pronote cultivation of this attractive seed adding to it extra value and increase its potential commercialization market.

2. Salvia HispanicaL : Botany, distribution and Phytochemistry :

2.1 Botanical composition :

Salvia hispanica L., was an important staple Mesoamerican food and medicinal plant in pre-Columbian times. Unlike other Mesoamerican pseudocereal crops such as Amaranthus and Chenopodium, it has received comparatively little research attention [16]. Initially, chia was grown in tropical and subtropical Climates. At present, it is grown worldwide, particularly in Argentina, peru, Paraguay, Ecuador, Mexico, Nicaragua, Bolivia,Gautemala and Australia. In Europe, it is grown in greenhouses. Chia is not frost-resistant. In nature, it grows mainly in mountainous regions. Salvia hispanica develops itself properly in sandy loam and clay loam soils with good drainage conditions [17-20]. The reported seed yield from selected commercial fields located in Argentina and Colombia ranges from 450 to 1250 kg/ha [21]. Chia seed is composed of protein (15-25%), fats (30-33%), carbohydrates (26-41%), high dietary fiber (18-30%), Ash (4-5%), minerals, vitamins, and dry matter (90-93%). It Also contains a high amount of antioxidants. Heavy metal analysis showed that chia seed contains them at safe levels, Not exceeding the maximum metal levels for food safety, and the seed is also free from mycotoxins [22]. Recent studies on chia seeds have focused on phytochemicals and their extractions from the seed. Only very little studies have focused on in vivo or clinical evaluate the safety aspects of chia seed. The aim of this paper is to critically evaluate the health benefits, phytochemical contents, methods of oil extraction, and the current market potential of chia seed as a health food supplement.

Fig.1 *Salvia Hispanica*L..plant with purple flower and large leaves

2.2. Chemical composition in chia seeds

The chemical composition of chia seeds has been analysed in many studies. Detailed data on basic chia seeds composition is presented in fig. 2. Chia seeds are ascribed high nutritive value particularly thanks to their high contents of dietary fibre and fat Chia seeds contain approximately 30–34g dietary fibre, of which the insoluble fraction (IDF) accounts for approximately 85–93 %, While soluble dietary fibre (SDF) is approximately 7–15%[23,24]. In terms of dietary fibre content, chia seeds exceed dried fruits, cereals or nuts (figure 3). The fatty acid profile is of particular interest. It is characterize by high contests of polyunsaturated fatty acid, mainly α-linolenic acid (ALA), which accounts for approximately 60% all fatty acid. Linoleic, Oleic and palmitic acids are found in lower amounts. Chia seeds have greater contents of omega-6 to omega-3 acids, which is approximately 0.3:0.35[25-29]. Chia seeds are also a good sourceof plant protein, which accounts for approximately 18-24% their mass [8]. Analyses of the amino acid composition (Table 2) confirmed the presence of 10 exogenous amino acids, among which the greatest contents were for arginine, leucine, phenylalanine, valine and lysine. Proteins in chia seeds are also rich in endogenous amino acids, mainly glutamic and aspartic acids, alanine, serine and glycine [26,30,31]. It needs to be stressed that chia seeds are gluten-free and as such may be consumed by celiac patients [17]. Moreover, chia seeds supply many minerals, with phosphorus (860-919 mg/100g), calcium (456-631 mg/100 g), potassium (407-726 mg/100g) and magnesium (335-449 mg/100 g) found in greatest amounts [34,36]. Studies also confirmed the presence of some vitamins, mainly vitamin B1 (0.6 mg/100g), vitamin B2 (0.2 mg/100g) and niacin (8.8 mg/100g) [30,32].

Protein content:

The Protein content of chia seeds is around 17%, greater than the protein content in all other cereals (for instance, in corn the proteins content is 9.4%, rice is 6.5%, quinoa 14.1%, and in wheat 12.6%) [9, 33, 34]. The amount of proteins in chia seeds depends mainly upon environmental and agronomical factors [9]. The U.S. Department of Agriculture has confirmed that 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 glycine [35]. For example, the content of amino acids serine is 1.05 g/100 g, Glutamic acid 3.50 g/ 100 g, Glycine 0.95 g/100 g, alanine 1.05 g/100 g, lysine 0.97 g/100 g, histidine 0.53 g/100 g [9]. The major protein in chia seeds is globulin which constitutes about 52% of the total protein with mostly 115 and 75 proteins ans molecular size ranged from 15 to 50 kDa. Albumins and globulins revealed a better thermal stability, albumins, globulins, prolamins and glutenins denatured at 103, 105, 85.6 and 91 C. Seeds revealed a good balance of essential and non-essentail amino acid [36].

Fig.2. Chia Seeds

Lipids:

Lipids are one of the primary supplements of the human eating regimen, and are of extraordinary significance to Purchasers and sustenance industry. Seeds oils establish a Noteworthy piece of the standard eating regimen since they are a wellspring of vital basic supplements, for example, Unsaturated fats, tocopherols, and phytosterols. Wellbeing Cognizant shoppers order industry to give oil and oilseeds which are wealthy in gainful mixes including omega-3 unsaturated fats, tocopherols, and sterols. Strength oils have supreme lipid segments with interesting dietary properties, and possess high esteem a specialty advertise. Among lipid segments, linolenic corosive, Forerunner of the long chain n-3 unsaturated fats in human, cell reinforcements, and phytosterols get the most thought as dietary fixings adequately bringing down danger of heart illnesses [41].

Omega 3 Alpha – linolenic Corrosive :

Basic unsaturated fat compensation is bringing down cholesterol levels, which results towards low circulatory strain and heart linked ailments. Anti-fiery action, Hepatic protective and Cardio defensive exercises are appeared by redistribution of lipid far from instinctive liver and fat. It have anti diabetic activity and protection against anti-tumor and joint inflammation potential [42].

Unsaturated fat:

Salvia hispanica is particularly alluring on the ground that very well may be developed to deliver oil for both industry and substance. The unsaturated fats of chia oil are exceedingly unsaturated, with their principle segments being Linoleic (17-26%) and linolenic (50-57%) acid. Chromatographic examination of the oil organization demonstrated the nearness of linolenic, linoleic, stearic, oleic and palmitic unsaturated fats in the seed from all areas [27].

Table 1 [23] Protein Content

Cereal	Protein Content %
Chia	20.70
Oats	16.89
Barley	12.48
Corn	9.42
Rice	6.50

Fibre content:

The dietary fibre contained in food and especially in whole grains is an important biocomponent due to its potential health benefit. A large number of research studies have shown the effect of fibre consume such as the decrease of risk for coronary heart disease, risk for diabetes mellitus type 2, and several types of cancer [24]. On other hand, the consumption of dietary fibre has been associated with the increases of post meal satiety and decreases subsequent hunger. According to the American dietetic association dietary fibre has demonstrated benefits for health maintenance and disease prevention [37]. Chia seed contains between 34 and 40 g of dietary fibre per 100 g, Equivalent to 100% of the daily recommendations for the adult population; the defatted flour possesses 40% fibre, 5-10% of which is soluble and forms part of the mucilage [38]. This fibre content is higher than quinoa, flaxseed, and amaranth, even grater compared with other dried products. Therefore, chia seed can be used in the prevention of many cardiovascular diseases and diabetes, among others, as demonstrated by a number of epidemiological studies (Table 1,2)

Table 2.U.S. Department of Agriculture (2011)

Food	Fibre g/100g
Chia	34.4
Flax Seed	27.3
Amarnath	6.7
Quiona	7.0
Amond	12.2
Peanuts	8.5
Soybean	9.6
Dried Plums	7.1
Dried Fig	9.8
Dried Apple	8.7

Fibre content of some foods

 # Minerals :

Additionally, chia seeds contain minerals like calcium, phosphorus, potassium, magnesium, and vitamins (A,B,K,E,D, mainly vitamins B1, B2, niacin) (Table 1). The content of calcium, for instance, is greater than in rice, barley, corn, and oats. The content of other minerals such as magnesium, potassium, and phosphorus is greater in chia seeds as well than in other cereals [9,34].

 # Phenolic Compounds:

Various active ingredients including essential fatty acids and phenolic compounds have been identified in chia seed. Focusing on phenolic content, dry chia seeds contain 8.8% of phenolic compounds. Besides that, high levels of caffeic acid, chlorogenic acid, querecetin, rosmarinic acid, gallic, cinnamic, myricetin, kaemferol are also reported. Furthermore, Isoflavones , such as daidzein, glycitein, and genistein, are found in small amounts [39]. Reported that rosmarinic acid and daidzein are the major components found in chia seeds, along with caffeic acid, mycertin, quercetin, etc. Besides, in the same study, vitamins A, B1, B2, and B3 were identifiedin chia seeds for the first time. The flavonoids quercetin, chlorogenic acid, and caffeic acid are proven to have anti-cancerogenic, anti-hypertensive, and neuron protective effects [11].

Some researchers reported that the chemical composition and nutritional values may vary due to climatic conditions, geographic location, nutrients, and year of cultivation. For example, the composition of fatty acids may vary according to climate change and the altitude of the plant – the colder and higher the region, the higher the content of ω-3 unsaturated fatty acid [12].

3. Salvia Hispanica: Biological activities confirmed by scientific research

3.1. Hypoglycemic, Hypotensive, Hypolipemic, Hepatoprotective, and Fat-reducing Effects.

3.1.1. Animal Model Studies

Researchers from the University of Campinas (Campinas, Sao Paulo, Brazil) assessed the impact of consumed chia seeds on the metabolic rates of selected carbohydrates. They found that rats fed with a high – fat, fructose – rich diet, in which soybean oil was replaced by chia seed oil, or a high – fat, high-fructose diet containing 13.3% of chia seeds showed greater tolerance to both high glucose and high insulin levels compared to rats fed with a standard high-fat, high-fructose diet. In addition, the group of animals consuming S. hispanicaseedsshowed a decrease in blood concentrations of non-esterified fatty acids. Furthermore, these animals showed a decrease in the level of hepatocyte damage markers namely, alanine transaminase (ALT) and Aspartate transaminase (AST), both of which tend to be increased by high-fat and high-fructose diets [40].

A study conducted at the university of litoral (Santa Fe, Argentina) demonstrated the beneficial effects of S. hispanica seeds on the lipids profile in rats. Rats fed with a high-sucrose diet containing 2.6% of chia seeds had lower concentrations of triglycerides (TGs), Non-esterified fatty acids, and total cholesterol (TC) compared to rats fed with the same diet lacking chia seeds. The levels of blood glucose were not altered in the studied rats. Additionally, a reduction in the thickness of visceral adipose tissue was observed in rats consuming chia seeds [43,44,45].

A study by Marineli et al. aimed to evaluate the effect of S. hispanica seeds and seed oil in the diet on total plasma antioxidant potential (TAS) and liver in obese rats. It was found that among rats consuming chia seeds or seed oil, there was statistically significant increase in the activities of plasma antioxidant enzymes, i.e., catalase (CAT) and glutathione Peroxidase (GPx), as well as increase in glutathione (GSH) concentration, compared to the control group (receiving a standard diet rich in fat and fructose). In rat livers, glutathione Reductase (GRd) activity was increased while CAT and Gpx activities were unchanged. In addition, blood concentration of lipid peroxidation biomarkers were decreased in animals receiving seed or seed oil diets:8- isoprostane and TBARS (thiobarbituric acid Reactive substances formed as a byproduct of lipid peroxidation) compared to the control group. The assayed antioxidant capacity in plasma and liver was higher in rats receiving *S. hispanica* seeds and seeds oil by 35% and 47%, respectively, compared to the control group [46].

3.1.2 Clinical studies:

Study conducted at the Appalachian State University (Kannapolis, North Carolina, USA) Assessed the effect of chia seed consumption on the blood levels of selected fatty acids in postmenopausal women. The results shows that daily intake of 25g of chia seeds for 7 weeks resulted in an increase in the blood levels of ALA (by 138%) and eicosapen–Taenoic acid (by 30%) in the studied women. No differences were observed in the levels of Docosapentaenoic and docosahexaenoic acids [47].

Researchers from the Federal University of Paraiba (Joao Pessoa, Brazzil) investigated the effects of dietary supplementation with S. hispanica seed flour on blood pressure and the related cardiometabolic factors in treated and untreated hypertensive people. Hypertensive patients were randomly assigned to one of the following groups: group treated with the drug, untreated group and placebo group. All patients consumed 35 g chia seed flour or placebo daily for 12 weeks. The subjects who were treated with the drug and consumed *S. hispanica* seed flour – supplemented diet showed a decrease in mean blood pressure from 111.3 to 100.1 mmHg. The subjects who were not treated but consuming the flour – supplemented diet showed a mean decrease in systolic blood pressure from 146.8 to 137.3 mmHg. The placebo group showed no changes in blood pressure [48].

3.2 Action against kidney stones:

Saleem et al. in their study used a rat model of urolithiasis that was induced by the application of ethylene glycol. Added with ammonium chloride, Ethylene glycol administered for three days accelerated the induction of urolithiasis in albino rats. Thirty-six rats were divided into six groups, the first group was the control, the second group had ethylene glycol (0.75% v/v) administered, the third group received standard drug–Cystone. (Himalaya Drug Company, India) (750 mg/kgb.w.), the remaining groups were administered methanolic extracts of chia seeds (100, 300, and 700 mg/kg b.w., orally). In addition, there was a reduction in urinary calcium, oxalate, and phosphate levels, indicating that the chia seeds extract prevented calcium oxalate stone formation by inhibiting the intial stages of CaOx crystal formation, including nucleation, aggregation, and growth Phases. The authors suggested that flavonoids present in chia seeds are responsible for this activity, mainly quercetin, which through its antioxidant potential prevents the precipitation of kidney stones [49,50-52].

3.3 Antioxidant and antimicrobial activity:

Chia seeds and their oil contain a large number of natural antioxidants, such as tocopherols, Phytosterols, carotenoids, and polyphenoliccompounds .Polyphenoliccompouds are the most important complexes that contribute to the antioxidant activity of chia seeds. It is well known that they have ability to scavenge free radicals, to chelate ions, and to donate hydrogens [16]. Antioxidant compounds reduce the risk of chronic diseases (cancer and heart attack) and they offer protection against some disorders such as diabetes, Alzheimer's, and Parkinson's disease [8]. ω-3 fatty acid have capability to block calcium and sodium channel dysfunctions, which can cause hypertension, as well as improve heart rate variability and protect ventricular arrhythmia [53].

Scientists at the National Autonomous University of Mexico (Mexico) and also investigated the antioxidant activity of chia seed ingredients. They confirmed the antioxidant activity of chia seeds by the ABTS test, and through the inhibition of lipid peroxidation as well as Β-carotene oxidation in the β-carotene and linoleic acid model system. The antioxidant capacity of S. hispanica seeds was found to be comparable to that of Trolox used as the reference substance. This study also confirmed the antioxidant activity of *S.hispanica* seed used in a model food emulsion of the water/oil tyoe [24]. Several authors investigated the positive effects of the polyphenolic compounds in chia seeds using different analytical techniques. Chemical compounds, such as caffeic acid, Ferulic acid, Chlorogenic acid, rosmarinic acid, and flavonoids (quercetin, kaempferol, daidzein,etc.) have been mainly investigated by different analytical techniques, where UHPLC (ultra-high performance liquid chromatography), HPLC (high performance liquid chromatography), and UPLC (ultra-performance liquid chromatography) particularly stand out. Their biological activities vary from antioxidant, Anti-aging, and antihypertensive to anti-cancerogenic and anti-inflammatory. In comparing chia seeds to other cereals mentioned in this work, the antioxidant activity of rice, corn, wheat, quinoa and amaranth have been also investigated and reported [54-58].

3.4. Improving the function of the digestive tract :

The use of soluble extracts from plants rich in dietary fibre, including chia seeds, may have a positive effect on gastrointestinal motility, improving absorption of vitaminandminerals[59-62]. soluble extracts are obtained by isolating prebiotics from food matrices, which mostly consists of water soluble dietary fibre. studies shows that the use of such extracts improves the absorption of nutrients by regulating the expression of specific proteins of the intestinal brush-border membrane, in addition to an increase in the surface area of the intestinal villi and increased mucilage production[63]. Administration of seeds extracts causes increased fermentation process in intestines, production of short-chain fatty acids by intestinal bacteria, which contributes to lowering of PH and creation of conditions unfavourable for pathogenic intestinal bacteria. when a soluble extract of plant origin is administered, there is an increased in the absorption of minerals, especially an increase in the bioavailability of zinc and iron is observed[64].

4. Physico-chemical properties of chia oil :

For Chia seed oil, studies have also focused on its phenolic contents, Tocopherols, unsaponifiable matter, fatty acid composition, and physico-chemical properties from the affirmations, Chia oil has shown better saponification, iodine and peroxides values, as well as better overall quallity. for sterol fractions, they have been observed to be rich in 5 avanasterol(3.55%), campesterol(3.77%) and stigmasterol(4.83%). Also, omega-6 fatty acids (60.93%) has been found to be the main fatty acid Chia seed oil. However, upon measuring the serum contents (for low and High-Density lipoproteins, total cholesterol, and total lipids) and conducting kidney and liver tests (for alkaline phosphates activities, alanine amino transferase, and aspartate amino transferase), it has been established that chia oil does not yield significant effects on serum contents and kidney and liver function[65]. Hence, Chia oil is only rich in essential fatty acids.

5. Pharmacological Benefits of Chia Seeds:

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 active carcinogens or tumors promoters Because of their po-inflammatory actions and thus participate in cancer development[66]. Moreover, peanut oil rich linoleic/oleic derived PUFAs protects against murine mammary cancer development by modulating tumor membrane fatty acids composition, lipoxygenase(LOX), and Cyclo-oxygenase(COX) enzyme. Hence, it is Hypothesized that chia seeds oil, as it contains all the Derived of linoleic/oleic in good Balance, may produce the same effect[66].

In Atherothrombotic disease:

ALA (18:3) is the primary fatty acid derived from the lipid fraction of chia seeds. once inside the human system, ALA an essential fatty acids, is converted into EPA and DHA by the sequencial activities of delta 6 and delta 5 desaturases and carbon chain elongation with and 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[67]. During the conversion of ALA, PUFA derived from linoleic and linolenic fatty acid complete for metabolic enzymes; interestingly, this competition exist during Esterification during plasma phospholipids and triglycerides. Moreover, an increased concentration of dietary C18:2 caused a decreased in the synthesis of long chain PUFA derived from (18:3) 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[68]. 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[69].

Antihyperlipidemic and anti-Hypercholesterolemia:

Chia seed diet in rats reduced dyslipidemia and visceral adiposity. The Chia 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. Addition, stearoyl-CoA desaturase-1 products were depleted in the Heart, liver, and adipose tissue of chia seed-supplemented rats. In a seperate study, Dietary chia seeds prevented the onset of dyslipidemia and insulin resistance (IR) in the rats fed with the sucrose rich diet[70]. Dietary chia seed also reduced the visceral adiposity. In addition, Chia oil also reduced adipocytes 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[71]. The combination of different seeds mixture 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 the antioxidant potential of unsaturated fatty acids especially ALA present in the seed mixture[72].

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 industry. 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[72]. This Neuroinflammation is believed to contribute to numerous neurological conditions, including parkinson's disease. "A by product during the production of chia oil is the protein portion, which is promising source of bioactive peptides [small proteins], with application in the prevention and treatment of chronic metabolic diseases," the Researcher wrote in the study to examine this, the Reasearchers investigated the effect of proteins extracted from chia seed on microglia[66]. Specifically, they used the HMC3 cell line. This line of microglia has been immortalized (engineered to divide indefinetely), 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[73].

6. Application Of Chia Seeds And Derived Product:

Over recent years, functional foods have gained remarkable consideration World-wide due to the Wave of healthy lifestyle changes. Contemporarily, chia seeds is used as a healthy oil supplement for humans and animals.

6.1. 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 [11]. In 2000, the US Dietary guidelines suggested that chia can be used as primary food, but in limited Amount; consumption of no more than 48 g/daily is recommended. chia seeds can be added or mixed into biscuits, pasta, cereals, snack, and cakes as supplements. Due to their hydrophilic properties, chia seeds can be used as substitutes for eggs an fat. They can absorb 12 times their weight in water [11]. Chia gel may be used as substitutes for oil or eggs in baked products. it was shown that chia oil can replace 25% of egg in cakes [74].

The nutritional value of butter can be increased by mixing it with chia oil in proportion from 6.5% to 25%, when the concentration of fatty acids in the chia fortified butter increases from 4.17% to 16.74% [9]. Besides, recent studies showed that mucilage from chia seeds can be used as a functional coating with improved functional properties [9].

6.1.1. chia mucilage:

Chia mucilage could be employed in the food industry as a foam stabilizer, a supending agent, Emulsifier, adhesive, or binder as a result of its water holding capacity, and viscosity. Recent studies showed that mucilage from chia seed can be used as 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 potency was affected by the emulsion's composition. the fact that the mucilage has such an ability to stabilize emulsion may be due to its capacity to absorb in the solid or liquid interface and stabilize emulsions without chemical or enzymatic variations. Mucilage obtained from chia seeds is a novel source of polysaccharides and could potentially generate interesting polymer Blends for edible films and coating[9].

Edible films based on polysaccharides are potential substitutes for synthetic packaging. Mucilage has the ability to 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 constitute that may beapplied for the design of new film-forming solutions. The addition of glycerol to extracted hydrocolloid from the chia seeds to make chia mucilage films was essential to provide homogenous and flexible films and is crucial to achieve the suitable physicochemical, barrier and mechanical properties. 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 [75].

6.1.2. chia gum:

Chia seeds are believed to be a starting material in the food industry for their dietary fiber. Gum can be extracted from the dietary fibre fraction by using water as an additive to control viscosity, stability, and texture. The chemical composition, molecular structure, and the derived properties such as thermal stability or gelling ability represent important factors which determine the appropriateness of a polysaccharide in food and pharmaceutical industries. The gum is also stable at high temperatures, way up to 224c[7]. investigated the chemical and functional properties of chia seed gum. They showed that chia gum contains 26.2% fat, and when submitted to fat extraction, Two fractions of the gum 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 seeds gum is novel promising material. 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. Understanding of these characteristics will significantly broaden the potential of industrial application [76].

6.2: Pharmaceutical use:

Bilayer emulsion have potential as delivery systems of 3 fatty acids from chia oil which represents a high potential in pharmaceutical applications and the food industry since the emulsions can be used directly or subjected to a drying process to obtain powders. Due to the relative ease of synthesis and economic feasibility, conventional oil-in-water (O/W) emulsions are usually the first Choice considered to deliver bioactive lipids. Chia oil an be incorporated into oil-in-water (O/W) Emulsion as ω-3 fatty acid delivery system in food matrices. Sodium caseinate content and lactose Addition strongly influence the stability and rheological properties of chia O/W emulsions. A 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 [77]. In the study of M. Julio and co-authors, chia bilayer O/W emulsions were obtained by applying the layer -by-layer deposition technique. it consisted of the elctrostatic deposition of a positively charged chitosan on negatively charged oil droplets. these were stabilized using modified sunflower lecithins(deoiled or phosphatidyl choline-enriched) in the presence or absence of maltodextrin [78].

A recent study [78] 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 coacervates was found to be suitable for delivery of CSO to the intestinal stage of digestion, since almost all the unencapsulated oil washydrolysed, whereas Only 60% of the oil encapsulated in CPI-CSG shell was hydrolysed during in vitro digestion. It is reported that the leaves of *salvia hispanica*L. contain an essential oil that compromises B-caryophyllene, Globulol, B-pinene, alpha-humoleno, and widdrol. Those compounds are believed to have strong repellent characteristics to a wide spectra spectrum of insects [9].

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 fibre, 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, Anti-hypertensive and neuronprotectives effects. Furthermore, chia seeds are a rich source of Nutrients such as polyunsaturated ω-3 fatty acids that protect from inflammation, improve cognitive performance and lower the level of cholesterol.

Chia seeds are already used in the food and pharmaceutical industry. In the food industry, chia seeds can be used in different forms: as the whole seed, ground, in the form of flour, oil and gel. Chia oil is one of the most valuable oils on the market today. Nanoemulsion-based delivery systems are prospectives application to encapsulated lipophilic bioactive components in food, personal care, and pharmaceutical applications. Chia seed oil nanoemulsion delivery system represents a possibility for the further applications of chia seed oil emulsion oil in beverages and the functional food industry Which requires only a slightly turbid or even transper entappearence. Chia seed mucilage represents a promising alternative to synthetic polymers in nanoencapsulation. In conclusion, chia seeds (*Salvia hispanica*) are a valuable raw material whose technological properties and health-promoting properties can be widely used in the food industry.

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