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An Ecological, Traditional and Pharmacological Importance of *Salvia hispanica* L. (Lamiaceae) Chia Seeds

Muhammad Shafiq[1*], Muhammad Zafar Iqbal[2], Mohammad Athar[3]

[1]Department of Botany, University of Karachi, Karachi, 75270, Pakistan.

**Corresponding author: email address:* shafiqeco@yahoo.com

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Abstract

Chia, *Salvia hispanica* L. is a flowering and an annual desert plant species which produces consumable small white and black seeds and has long association with human beings. Published research articles results showed that Chia is originating from south America, Mexico and now spreading to desert region. Chia as oil crop is getting an attractive cultivation demand in recent years because it can be grown for high nutrition values and to produce oil for food, and pharmaceutical and industrial sectors. The seeds of Chia are an excellent and proving a significant source of economic and health benefits which, helps in decreasing the different types of ailments such as, heart diseases, laxative, inflammation, reduce cholesterol levels, digestive system, blood pressure, blood sugar and intestinal health issues. The research interest on Chia has increased due to its numerous nutritional and health benefits to human beings and it has promising future in future studies and cultivation.

The goal of this review was structured in three parts as ecological, traditional and pharmaceutical to search and analyzed the research articles available on *S. hispanica* through different electronic search engine data bases likewise, e-Marefa data base; google; google scholar, NIH (National Library of Medicine), PubMed and science direct covering period of 2000-2026. The key words such as cosmetics; diseases; ecology; food crop; folk medicine; health issues; phytochemicals; traditional values were used. The analysis of data would be helpful for researchers, environmental manager, farmer awareness, field management, pharmaceutical, agro industrial sectors engaged in regional and international levels.

Keywords: bioactive compounds, ecology; food crop; health issues; phytochemicals; salinity, chia seed.

1. Introduction

The chia seed market is estimated at USD 1,958.4 Mn in 2026 and by 2033 expected to reach its value 4,494.5 Mn showing growth rate of 12.6% during this period [1]. The high in Omega-3s in Mamma chia seeds virtually boost the nutritional profile and celebrated and recognized as National Chia day on 23 March [2]. The botanical name of Chia is *Salvia hispanica* L. and belongs to mint family. The fruits of *S. hispanica* called chia seeds. Chia is native from northern Mexico and Guatemala [3-5]. Chia are small seeds and black and white in color (Fig. 1). *S. hispanica* used in folk medicines, food, cosmetics, religious rituals in perspective of historical records point of view [6]. Chia cultivated in global regions such as, America, Columbia, Europe, Southwest Germany due to presence of essential amino acids, ingredient for food, cosmetics and ancient crop [7-11] and in industrial application [12]. The Chia seeds reported the nutraceutical properties and potential of a dietary oil and pharmaceutical resource [13-14].

The chia word derived from the Spanish word “chian”, and has valuable food ingredient [15-16]. The microstructural features of the *S. hispanica* were explained [17].

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Figure 1. Chia seeds

Dubois *et al.,* [18] reported that Chia contains the sufficient known amount of α-linolenic acid. The biomass production and quality of Chia crop was affected by environment [19]. The Glutenfree pasta, fiber, flour, oil along with health promoting properties investigated from Chia seeds [20-23]. The phytochemicals and biological characteristics, fatty acids, polyphenols, essential oils, mucilage, amino acids characterization was investigated [24-30].

Chia seed is chemically composed of oil, fat, ash, moisture, amino acids, lipids, carbohydrates, protein, soluble and insoluble fiber, dietary fiber [31-36] and feed can produce healthier pork [37]. Chia seed mucilage mainly forms a branched polysaccharide [38]. Gelato is the name of the Italian-style artisanal ice cream, a nutritious product from chia and widely consumed over around the world [39-42]. In another study, the phytochemical content in chia seeds products was isolated for lipids [43-44]. Coelho and Salas-Mellado [45] extracted protein content from 70.9%, 74.1%, and 49.7%, respectively. Chia seed found useful for the treatment of blood pressure, blood glucose, cardio protective, and type 2 diabetes [46-48].

Table1: Botanical description of Chia.

Kingdom	***Plantae***
Family	*Lamiaceae* or mint family
Order	*Lamiales; Salvia*
Genus name	*Salvia*
Scientific name	*Salvia hispanica* L.
Common Name	Chia, Spanish sage; black chia.
Life span	Annual
Mature height	1 m
Leaves	Opposite and serrated.
Stem	Quadrangular stems that are ribbed and hairy.
Soil Type	Well drained, prefers clay or sandy
Temperature	16 and 26 °C.
Tolerance	Drought tolerance
Light requirement	Best in full sun light and tolerant to heat.
Water requirement	Drought tolerant
Bloom Time	Early summer
Stem	Stem quadrangular, ribbed, hairy
Harvesting time	Seeds harvesting time ready within 3 to 4 months from the planting date. The harvest time begins when most petals start to fall off the bloom.
Propagation	Prepare the soil bed in the fall. Sprinkle the seeds lightly over a well draining growing medium and cover them lightly. Keep the soil slightly moist and place them in a spot that gets bright and indirect light.
Seed microstructure	Spherical.
History	Ancient Mesoamerican cultures.
Economic uses	Gel, gum, high oil contents, minerals including manganese, selenium, phosphorous, and copper. Gum in food industry. Food, medicine, immune boosting properties, blood pressure, blood lipid, blood glucose profile, paints, antimicrobial potentials, Chia seeds were ingested as food and food ingredient, Bioactive peptide.
Microbe issues and threat	Virus attack. *Arbuscular mycorrhiza* (AM) inoculation. Ensilability characteristics.
Geographical distribution	America, Argentina, Australia, Bolivia, Brazil, Chile, China, Columbia, Ecuador, Europe, France, Germany, Guatemala, Mexico, Netherland, Nicaragua, Peru, Sweden.
References [49-65].	

Therefore, this review structured with the aim to identify the ecological and the pharmacological potential of Chia along with the medicinal health benefits on human beings with the help of different research articles published in national and international journals (Table 1-3). The topic related sound published articles, book chapter, review articles data was searched through different research English data bases search engines, such as e-Marefa data base; google; google scholar, NIH (National Library of Medicine), PubMed and science direct. The search findings and analysis of Chia data would be helpful in increasing the awareness among ecologist, land manager, farm manager, pharmaceutical, agro-industrial chia residue waste, environmental manager engage in increasing the

more cultivation and production of Chia.

2. Review data collection methodology

The scientific peer reviewed research papers were majorly targeted from the research articles published between 2000 to June, 2026 using different keywords such as were included. The key words 'nutritional', 'phytochemical' 'pharmaceutical' 'health benefits' Chia seeds' included. This review was searched through different English data bases search engine such as, e-Marefa data base; google; google scholar, NIH (National Library of Medicine), PubMed and science direct. The data was gathered from the published research articles available for the last twenty five years. Subsequently, the publication was examined individually and eliminated the duplicate papers. The papers published before 2000 was excluded. A total number of 720 research papers was surveyed and 185 research papers were selected from the different web sites and analyzed with reference to topic of studies. The AMA style of references citation was used. The included articles for understanding were divided into the introduction, review methodology, ecological importance, Chemical / Phytochemical composition of Chia, pharmaceutical properties, and conclusion.

3. Ecological relevance

Chia is healthy agro food crop [66-68]. The chia cultivation limited to the tropics (0°- 20°) and subtropics (20° - 40°) geographically [69]. The invasive characterization of chia was noticed [70-71] and low chia seed yield might be due to application of inadequate nitrogen fertilization [72]. The mean moisture content on dry basis was found 7% [73]. Similarly, the variable effect of chia seed coat color on white and black spotted chia seeds grown together at five locations of Ecuador was also observed [74]. The possibility of carrying out the cultivation of Chia species at (33º14´ S, 61º2´ W) in the south area of Santa Fe province – Argentina- for plant height, crop cycle length, ear weight was evaluated for different sowing dates. The differences were found between early and late sowings, suggested that early January was ecologically more suitable for the cultivation in the different Argentinean regions [75]. Ayerza [76] conducted a study in between 2007-2010 period, on seeds commercially grown in Bolivia (Sub-Humid Chaco Ecosystem) and Ecuador (Tropical Forest Ecosystem) on crop year effect on the growing cycle length and seed yield. The Tropical Forest Ecosystem showed higher maximum and average yields at each year crop, than the Sub-Humid Chaco Ecosystem. Rodríguez-Abello *et al*.,[77] examined the effect of sowing time on the growth of Chia plant. The results showed decrease in growth due to influence of photoperiod.

The potential effect of functional food plant extracts, namely, extracts of chia on basic mare ovarian cell functions and their response to the environmental contaminant toluene in an in vitro study [78]. Mare granulosa cells were incubated with and without toluene (0, 0.02, 0.2 or 2.0 μg/mL) in the presence of chia extracts (10 μg/mL). Markers of cell proliferation (accumulation of proliferating cell nuclear antigen, PCNA) and apoptosis (accumulation of bax), viability (Trypan blue extrusion) and the release of progesterone (P), oxytocin (OT) and prostaglandin F2 alpha (PGF) were measured. The authors concluded that the Toluene reduced all other measured parameters except OT release. The physical properties of chia seeds for white and dark seed characteristics was recorded by light and scanning electron microscopy stem pigmentation, and shattering was examined [79-80].

3.1. Seed germination and seedling growth potential to some environmental factors

Germination vigor is driven by the ability of the plant embryo, embedded within the seed, to resume its metabolic activity in a coordinated and sequential manner whereas, the main contributor of seed germination success depends on the quality of the messenger RNAs which is stored during embryo maturation on the mother plant [81]. Chia responded differently to different environmental factors likewise temperature, light, moisture and water absorption influence on seed germination and seedling vigor performances [82-86]. The treatment of insufficient and excessive optimal amount of water (4 mL/100 seeds), optimum temperature 25 °C, showed negative effect on the seed germination of chia seeds [87].

3.2. Salinity toxicity and tolerance

The high salinity and shortage of water limits the crop production in arid and semiarid areas. The farmers use saline water and treated sewage effluent as alternate to some extent. This is consider due to an economic substitute for other common field crops. The effects of salt stress (saline water) on seed germination percentage of chia was evaluated [88-90].

The role of halo tolerant bacteria isolated from the stressful environment and the plant growth promotion potential on chia and quinoa seedlings under saline stress was evaluated [91]. The treatments had the highest growth parameters and RGI values in presence of high salinity in chia (50 and 100 mmol/L NaCl) and quinoa (200 and 400 mmol/L NaCl). *S. hispanica* could be cultivated in saline agro ecosystems. The salinity tolerance of chia at seven levels of NaCl solutions 0, 20, 40, 60, and 80, 100 and 150 mM was evaluated [92] and 150 mM significantly affected stomatal conductance, photosynthesis and transpiration rate.

4. Environmental pollution, heavy metals toxicity, tolerance and accumulation

Environmental pollution is a global problem that needs more efforts to overcome the increase of environmental pollution rates and the threat of ecosystem stability. The presence of metallic element (Pb, Cd, Cr, Cu, Ni, Zn) in the environment influence on the growth of living organisms. The removal capacity of Cd^{2+} and Zn^{2+} by a biomineralizing and denitrifying bacterium *Ochrobactrum* sp. was employed [93]. The results showed that strain GMC12 reduced Ca^{2+}, Cd^{2+}, Zn^{2+}, and nitrate by 83.38, 98.89, 98.95, and 100% (2.09, 0.29, 0.55, and 0.79 mg L−1 h−1), respectively, over 96 h continuous determination experiments. The concentration gradient test revealed that strain GMC12 would effectively remove Cd^{2+} and Zn^{2+} by 99.80 and 99.91% (0.67 and 1.35 mg L−1 h−1), respectively, under the synergistic effect of gum (1.0%, w/v).

Cadmium (Cd) accumulation is one of the serious global issues among the multitude of food security challenges and physiological and metabolic behaviors of plants to toxic elements varied. The effectiveness of salicylic acid (SA) spraying in alleviating Cd toxicity in chia seedlings for some growth traits, photosynthetic pigments, anthocyanin, antioxidant defense system, malondialdehyde (MDA), and certain osmoregulatory molecules was examined [94]. The results showed that the chia seedlings exposed to Cd showed a substantial decline in growth, especially in shoot and root length and number of leaves 25.5, 21.5, and 22.6%, respectively. The authors on the basis of obtained results showed that the exogenous SA used in the right amounts could alleviate Cd induced stress and boost chia seedlings' growth.

5. Chemical / Phytochemical composition of Chia

The Chia plant has many phytochemical compounds and available in soluble and insoluble forms (Fig. 2).

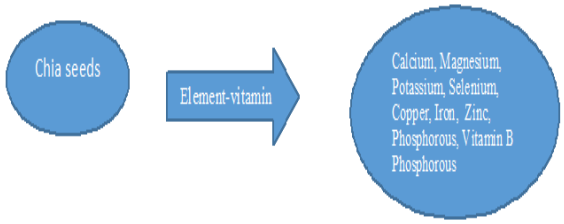

Figure 2: Chia seeds a wonderful source of macro elements.

According to literature survey, the chemical and nutritional values may vary. There are different types of conventional and modern methodology used for phytochemical analysis of Chia [95-96]. Chia cultivation is becoming popular due to pharmacological properties in many countries. Chia seeds oil is rich in polyunsaturated fatty acids, amino acids, antioxidant potential, quercetin, and others [97-98].

Chia seeds produce mucilage with functional qualities that allow their application in diverse areas of the food industry for emulsions, coatings, and films that can protect and prolong the functionalities of loaded compounds [99]. Chia flour is a source of dietary fiber, alpha-linoleic fatty acid (ALA), bioactive peptides, phenolic, promoting health benefits and analyzed the chia flour's effect on gut micro biota modulation and intestinal health in adult male Wistar rats fed a high fat and high fructose (HFHF) diet [100]. The results further showed that the consumption of chia flour increased the ALA (3.24 ± 0.24), immunoglobulin A (IgA) levels (1126.00 ± 145.90), goblet cells number (24.57 ± 2.76), crypt thickness (34.37 ± 5.86), crypt depth (215.30 ± 23.19), the longitudinal muscle layer (48.11 ± 5.04) and cecum weight (4.39 ± 0.71). Khatri *et al.*, [101] designed the study for the health benefits of chia seeds to develop gluten free pasta using different combinations of chia seed flour. The pasta was prepared by replacing quinoa flour with different levels of chia seed flour (7.5%, 10%, 12.5%, 15%, and 17.5%) for nutritional, color, and textural properties of the optimized product to compare with commercial durum wheat pasta. The results showed that pasta prepared using 15% chia seed flour with quinoa flour showed the best results in terms of cooking and sensory characteristics.

Chia seed (CS) expeller was hydrolyzed by 6 proteases (Alcalase, Neutrase, Protamex, Papain, Flavourzyme, Trypsin) in different hydrolytic patterns to improve bioavailability and explore the structure-enzyme active site relationship [102]. Furthermore, hydrolysates of CS meal presented a varying bioactivity (antioxidant, hypoglycemic, hypotensive, hypolipidemic, anti-alcoholic activity).

5.1.Fibre – mineral – vitamins and gum content

A gluten free, antioxidant, calcium, dietary fibre rich and contain the highest level of omega-3[103]. The chia based food products are currently available as healthy alternative to the common healthy chips. Chia seeds are good source of iron, natural oxidant, protein, vitamins, natural gum, nutritive extruded, and dietary fiber [104-109].

5.2.Phenolic and polyphenol compounds profile

Phenolics exist in the soluble and insoluble bound forms in Chia seeds. Literature supports the presence of the compounds in chia seeds, likewise, daidzein, and polyphenols ving rise to prophylaxis or possibly even to a cure for several prevailing human diseases [110].

5.3.Oil yield performances

Chia seed (from Brazil seeds and stabilized flour, Sweden and the Netherlands) oil was obtained with regard to fatty acid (FA) composition, antioxidant properties (ABTS, DPPH and FRAP), Peroxide Index (PI), TBARS (thiobarbituric acid reactive substances) and tocopherol [111]. The yield of the extracted oil was found 25.7-32.2% with CSE and 27.8-31.8% by SC-CO_2. The authors revealed that chia seed oil could be an interesting functional food ingredient. The oil extraction from chia seeds was obtained [112]. Chia oil constitutes a vegetal source of ω-3 polyunsaturated fatty acids (PUFAs) and natural antioxidants although it is susceptible to the oxidation process and can be incorporated into oil in water emulsions in food matrices [113]. Chia seed offers essential oil as protein from Chia plants [114-115].

Table 2. Bioactive compound from different parts (seed, leaves, whole parts) of Chia.

Compounds	**References**
Linoleic acid.	[116]
Fatty acids.	[117]
Gums and mucilages.	[118]
Dietary fatty acids.	[119]
Chia (*Salvia hispanica* L) gel.	[120]
Oil	[121]
Fatty acid.	[122]
Chia seed: the new omega-3 powerhouse.	[123]
Argentinean chia seed oil	[124]
Polyunsaturated fatty acids.	[125]
high content of α-linolenic fatty acid.	[126]
ntioxidant substances such as α-linolenic acids.	[127]
The essential fatty acid.	[128]
Presence of phenolic acid.	[129]
Oil generation potential.	[130]
mucilage exudation.	[131]
Gum.	[132]
Mucilage.	[133]
vitamins and phenolic compounds.	[134]
A phenolic compounds.	[135]
Phenolic and polyphenolic.	[136]
A powerhouse of ω-3 fatty acids.	[137]
Super food, fat	[138]
The mucilage.	[139]
Variation in oil quality.	[140]
Phenolic compounds.	[141]
Caffeic acid.	[142]
Seed oil	[143]
Protein and polyunsaturated fatty acids.	[144]
Mucilage.	[145]
Seed gum.	[146]
Chia oil industry.	[147]
C-Flavonoids	[148]
The phenolic composition.	[149]
Lipids.	[150]
Phytosterol	[151]
Rich in oil.	[152]
The Tiny Powerhouse of Omega-3 and Fiber.	[153]

6. Pharmaceutical properties

The use of medicinal product to prevent diseases problems since ancient times and now is gaining acceptance among the public. The chia seeds are widely consumed for various health benefits and recommended for the treatments of diabetes, to lower cholesterol, blood triglycerides, blood lipid profile, heart diseases, blood pressure, serum lipid level and dietary supplement confirmed [154]. The antioxidant activity of chia green part are limited [155]. The Chia is a source of nutraceutical potential [157].

The peptides from Chia present antibacterial – antimicrobial activities [176-177]. In another studies, bioactive peptides and antimicrobial activity of chia and genetic diversity among chia varieties was determined [178-180]. The findings of da Silva *et al.*, [181] Chia seed showed good protein quality. The reports are available about the potential of chia seeds proved as an anti-inflammatory agent [182].

The consumption of chia offer a valuable based source of proteins, healthy lipids, fiber, micronutrients and solve gastrointestinal problems [183].

Table 3. Ethnomedicinal uses from Chia

Plant treatment	References
The significant improvements in skin hydration	[158]
Increased HDL content.	[159]
Normalises hypertriacylglycerolaemia.	[160]
Changes risk factors of overweight adults.	[161]
The efficacy of renal dysfunction.	[162]
Reduction in postprandial glucose excursion.	[163]
Increases plasma ALA and EPA in postmenopausal women.	[164]
The altering disease risk factors in overweight, postmenopausal women.	[165]
Its importance as a medicinal dietary product.	[166]
Treatment on postprandial glycemia	[167]
Able to decrease the blood pressure in hypertensive individuals.	[168]
in the treatment of overweight and obese patients with type 2 diabetes.	[169]
Chia seeds beneficial for the blood lipid profile.	[170]
Evidence for the treatment of Psoriasis vulgaris disease.	[171]
An inhibition activity towards skin-aging enzymes.	[172]
Blood glucose level, breast, colorectal, liver, and pancreatic.	[173]
antioxidant potential by chia oil.	[174]
Chia seeds incorporated into cookies, reduce postprandial glycemic variability.	[175]

6.1.Antidiabetic and anti-cardiovascular and Metabolic syndrome activities

The whole grain consumption of chia helps in reductions in the postprandial glycemia for type 2 diabetic and solving the health problems associated with insulin, glucose intolerance [184].

6.2.Sports activities

The performance of sports event lasting >90 minutes enhance the athletes activities using chia seeds [185].

Conclusion

Chia is used since ancient times as whole seed, flour, mucilage, oil, medicinal, beverage and additionally Chia has special interest of application potential proved in different food products. The survey of literature supports the positive role of Chia as having many dietary and pharmacological properties. Chia seeds obtained from the *S. hispanica* are traditionally in use since thousands of years especially as medicine for the treatment of many diseases, food production, agricultural and pharmaceutical industrial sectors. Chia crop cultivation required a special ecological attention. Chia fruits are a potential source of raw materials for the food, feed and pharmaceutical industry. An efforts was addressed on the chemical composition, biological and ecological properties. The findings gathered from the published articles of different researchers on Chia presented an enormous nutritional potential of chia seeds. Furthermore the findings could be helpful for plant ecologist, farm manager, land manager and farmers working for the increase in cultivable areas to meet the increasing demand of Chia on global scale.

Author Contributions

MS performed an extensive literature search and draft this review paper; **MZI** supervised and **AT** revised the content of the review. All authors have read and agreed to the published version of the manuscript.

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