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CHIA SEED (*SALVIA HISPANICA L.*) – A NEW AGE FUNCTIONAL FOOD

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ABSTRACT

A review has been made on chia seeds (Salvia hispanica L.), a non-conventional seed which is increasingly being recognized as a novel food and is receiving scientific attention. Chia is an annual herb. It is a good source of omega-3/omega-6 fatty acids, soluble dietary fiber and contains appreciable amount of proteins and phytochemicals. It thus has nutritional attributes which support the prevention of several non-communicable diseases such as obesity, hypertension, cardio-vascular disease (CVD's), cancer and diabetes. This review presents an overall yet comprehensive view of the present state of knowledge regarding the history, structure, nutritional composition and physiochemical properties of Chia. It critically brings forth the effects of consumption of Chia seeds on human physiology.

In this systematic literature review (with no meta- analysis) scientific research and review papers (N=50) were collected via several electronic databases such as Medline (Pub-Med Version), NLIST (Programme of INF LBNET) and DELNET (Developing library network) under the keywords "Chia seeds", "Salvia hispanica", "Hypertension", "Origin", "Hyperglycemia", "Cardiovascular risk", Triglycerides", Omega-3 fatty acids", "Nutraceutical", "Dietary fiber", "Fatty acids", "Physicochemical properties", "Functions", "Viscosity", "Mucilage", "Antioxidants", "Phenolic compounds", "Viscosity", "Morphology", "Applications", "Gelling", "Plasma levels", "Clinical trials", "Insulin Resistance", "Adiposity".

Keywords: Antioxidant, Chia Seeds, Non- Communicable Disease,Novel food, Omega-3 fatty acid.

I. INTRODUCTION

Chia seeds *or Salvia hispanicaL.* belong to the Lamiaceae (Mint) family. Chia is an annual herb, native to Mexico and Northern Guatemala which blooms in summer season[1, 2]. Salvia hispanica was used as food as early as in 3500 BC and gained importance as a crop between 1500 BC and 900 BC in central Mexico. It was used as a staple crop by Aztecs and was also offered to Gods in religious ceremonies. This ancestral seed has been known for its medicinal and nutritional properties from ancient timebecause of its high content of omega-3 fatty acids. While chia seeds were used as food, chia oil was used in cosmetics and paintings by Aztecs [3]. Nowadays chia seeds are commercially grown in Mexico, Bolivia, Argentina, Ecuador and Guatemala [4].

II. STRUCTURE AND COMPOSITION

Chia seeds are generally small, flat and oval shaped. The seeds are 2.0 - 2.5 mm long, 1.2 - 1.5 mm wide and 0.8 – 1.0 mm in thickness**.** The chia plant is sensitive to day light and produces black and white seeds. Black colored chia seeds are more common. The black and white colour seeds are slightly different from each other. White seeds are larger, thicker and broader than the black seeds. The average moisture content of black and white seeds is 7.2 per cent and 6.6 per cent respectively. The oil yield of white seeds and black seeds is about 33.8 per cent and 32.7 per cent respectively. Protein and fatty acid composition of both the seeds varies significantly**[**1, 3].

Chia seeds are a good source of fatty acids, dietary fiber, protein, minerals and antioxidants. Chia seeds can be used as whole, milled or grounded. Oil extracted from chia seeds can also be used in food [2, 5].

III. NUTRITIONAL COMPOSITION OF CHIA SEEDS

The nutrient composition of chia seeds have been assessed and studied by several researchers and organizations. The seeds are considered to be of nutritional significance in view of their fatty acid composition as well as the fiber and protein content. TABLE 1 gives the detailed macro-nutrient composition of chia seeds.

TABLE 1: Comparison of the meannutritional composition of chia seeds with other grains/seeds.

Grains/Seeds **Nutrients Amount per 100g**	**Chia Seeds**	**Flax seeds**	**Quinoa seeds**	**Sunflower seeds**	**Mustard seeds**	**Guar Gum seeds**	**Oats***
Energy(Kcal)	486	534	368	584	508	332	374
Protein(g)	16.54	18.29	14.12	20.78	26.08	4.60	13.6
Fat(g)	30.74	42.16	6.07	51.46	36.24	0.50	7.6
Carbohydrates (by difference; g)	42.12	28.88	64.16	20.0	28.09	77.3	66.27
Moisture (g)	5.80	6.96	13.28	4.73	5.27	15	8.22

Source: USDA National Nutrient Database for Standard Reference Release 28, 2011[6] and *NIN, Nutritive value of Indian Foods [7]

Different ecosystems have variable significant effects on the nutrient composition of *Salvia hispanica* especially itsprotein and oil content and also the fatty acid composition. The environmental factors which have been found to influence composition of chia seeds include temperature, light, soil composition and type/variety [8].Analysis of chia seeds grown commercially in three different ecosystems namely Argentina (T_1 - Semi Arid Chaco Ecosystem), Bolivia (T_2 - Sub Humid Chaco Ecosystem) and Ecuador (T_3 - Inter- Andean valley) has indicated that the protein content decreases as altitude increases.Chia seeds grown in the sub humid chacoecosystem (T_2)have been found to contain 61per cent more protein than other two ecosystems i.e. the semi-arid chaco and the inter-andean valley ecosystem. Oil content does not show any significant difference among the different ecosystems but its composition varies. Chia seeds cultivated in ecosystem T_3 contain higher concentration of

alpha linolenic acid (56.9per cent to 64.8per cent) which is the main constituent of oil. Since chia seeds are the richest source of omega-3 fatty acids among plant foods and are a good source of fiber and phytochemicals, they can be considered as functional food[9].

3.1 Protein

The average protein content varies from 15per cent to 23per cent according to the location where the seeds have been grown [10]. Chia seeds (per 100g) contain higher amount of protein (16.54 g) as compared to other grains like wheat (11.8 g), oats (13.6 g), barley (11.5 g), rice (6.8 g) and corn (11.1 g) [3, 6,7]. The protein content of defatted chia flour as assessed by dry fractionationis about 446.2g/kg of proteins [11]. TABLE 2 gives the detailed amino acid composition of chia seeds.

TABLE 2: Average amino-acid composition of chia seeds

Amino acid (g per 100g)		Amino acid (g per 100g)	
Arginine	2.143	Phenylalanine	1.016
Glutamic acid	3.500	Tyrosine	0.536
Threonine	0.709	Histidine	0.531
Tryptophan	0.436	Valine	0.950
Isoleucine	0.801	Alanine	1.044
Leucine	1.371	Glycine	0.943
Methionine	0.588	Aspartic acid	1.689
Lysine	0.970	Proline	0.776
Cystine	0.407	Serine	1.049

Source: USDA National Nutrient Database for Standard Reference Release 28, 2011 [6].

A comparison of the amino acid profile of chia seeds with other seeds is given in fig. 1 [6,12].

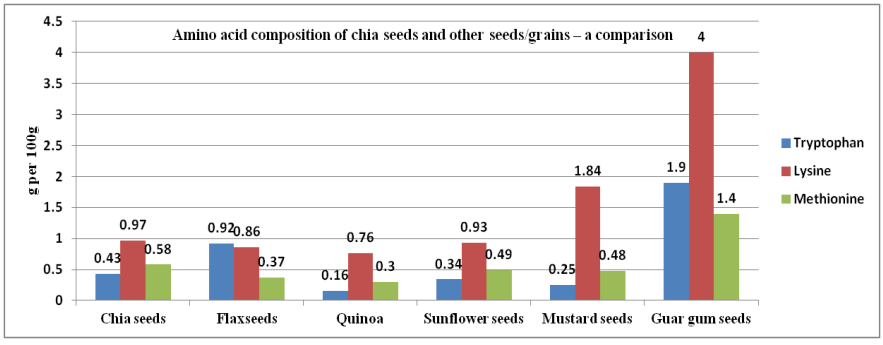

Figure 1: Amino acid composition of chia seeds and other seeds/grains – a comparison

3.2 Dietary fiber

Fiber is one of the important components of healthy diet. Intake of adequate amount of dietary fiber is associated with the prevention of cardiovascular diseases like stroke, myocardial infarction, vascular diseases, obesity, hypertension, hyperglycemia, and hyperlipidemia. Dietary fibers cannot be digested and absorbed by the small intestine but get fermented in the large intestine. On the basis of their physio-chemical properties and functions, dietary fibers are classified in two forms- insoluble fibers which exhibit bulking action and soluble

dietary fibers which get fermented partially/completely in the colon [13, 14].The total dietary fiber content of chia seeds ranges from 36 to 40 g per 100g which is much higher than that present in several grains, vegetables and fruits such as corns, carrot, spinach, banana, pear, apple, kiwi [5, 11]. Insolubleand soluble dietary fiber varies from 23 to 46 per cent and 2.5 to7.1 per cent respectively [15]. Chia contains about 5 per cent mucilage whichcan also act as soluble fiber [16]. The insoluble dietary fibre of chia is capable of retaining water several times of its weight during hydration and thus provides bulk and prolongs the gastro-intestinal transit time. Increased gastro-intestinal time is directly related to gradual increase in post-prandial blood glucose levels and decrease in insulin resistance over a period of time [16].

TABLE 3: Dietary fiber content of different foods

Food stuff	Chia seeds	Flax seeds	Quinoa seeds	Guar gum seeds
Amount per 100g	34.4g	27.3g	7.0g	77.3g

Source: USDA National Nutrient Database for Standard Reference Release 28, 2011 [6].

3.3 Total Fats

Salvia hispanica contain on an average 30.74 per cent of total lipids [6]. Several researchers have assessed the fatty acid composition of chia seeds and variable results have been obtained. For example, in a study carried out by Marineli et al (2014) alpha linolenicfatty acid was found to be in most abundance (62.80g/100g) followed by linoleic acid (18.23g/100g), palmitic acid (7.07g/100g), oleic acid (7.04g/100g) and stearic acid (3.36g/100g) [17].This fatty acid composition however varies from that given by United States Department of Agriculture. Refer TABLE 4 for the fatty acid composition given by USDA(2011). Chia seeds contain on an average, 40 per cent of their total weight as oil. Their oil contains nearly 60 per cent omega-3 unsaturated fatty acids [5]. Omega-3 unsaturated fatty acids are helpful in the prevention and management/treatment of hyperlipidemia, hyperglycemia and hypertension [2, 18, 19]. Chia seeds contain higher concentration of omega-3 fatty acid (63.8per cent) as compared to flaxseeds (57.5per cent) and menhaden fish oil (1.5per cent) [20].

TABLE 4: Average fatty acid composition of chia seeds

Total Saturated fatty acids (g/ 100g)	3.330g	**Total Monounsaturated fatty acids (g/ 100g)**	2.309g	**Total Polyunsaturated fatty acids g/100g)**	23.665g
14:0	0.030g	14:1	0.030g	18:2 n-6	5.835g
15:0	0.030g	16:1	0.029g	18:3	17.830g
16:0	2.170g	17:1	0.000g	**Trans fatty acids**	0.140g
17:0	0.063g	18:1	2.203g	**Cholesterol**	0mg
18:0	0.912g	20:1	0.046g		
20:0	0.093g				
22:0	0.032g				

Source: USDA National Nutrient Database for Standard Reference Release 28, 2011 [6].

The comparison of the omega 3 and omega 6 fatty acid contents of chia seeds with other seeds and grains has been given in fig. 2.

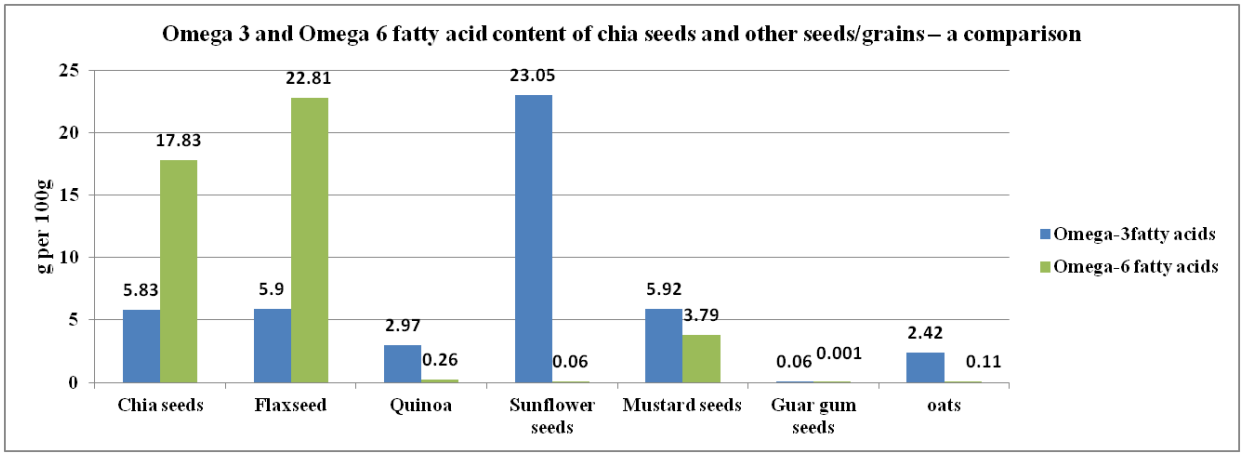

Figure 2: Omega 3 and Omega 6 fatty acid content of chia seeds and other seeds/grains – a comparison

3.4 Antioxidants

Chia seeds are high in phenolic compounds which have been scientifically proven to exhibitantioxidant related functions. Antioxidants and phenolic compounds have been found to have health promotive properties and also confer protection from degenerative diseases such as cardio vascular diseases, cancers, diabetes and diverticulosis [21].Chia seeds and oil also contain several bioactive compounds namely quercetin, myricetin, kaempferol, cholorgenic acid and 3,4dihydroxyphenylethanol- elenolic acid dialdehyde (DHPEA-EDA**).** Several in-vitro assays have confirmed that these polyphenols possess high antioxidant capacity and their presence is associated with lower levels of lipid autoxidation. Therefore, chia seeds can be used as a functional ingredient in the formulation of products for commercial applications. TABLE5 gives the total phenol content of chia seeds as reported in different research studies [2, 5, 17, 22, 23,24].

TABLE 5: Mean total phenol content of Chia Seeds

Chia seeds of different origin	**Jalisco, (Mexico)[5]**	**Sinaloa, (Mexico)[5]**	**Chia seeds (Chile) [15]**
Total Phenols(gallic acid equivalent /g)	0.92 mg	0.88 mg	0.94 mg

3.5 Vitamins and Minerals

Chia has also been found to be a good source of several vitamins and minerals particularly niacin, zinc, calcium, phosphorus and magnesium. Niacin content of chia is higher than other cereals (corn, soybeans and rice), whereas the riboflavin and thiamin content is similar to that present in corn and rice. Chia contains six times more calcium, eleven times more phosphorus and four times more potassium than 100g of milk [16, 25].

TABLE 6: Average vitamins and minerals content of chia seeds

Vitamins (per 100g)		Minerals (per 100g)	
Ascorbic acid (mg)	1.6	Calcium (mg)	631
Thiamin (mg)	0.62	Iron (mg)	7.72
Riboflavin (mg)	0.17	Magnesium (mg)	335
Niacin(mg)	8.83	Phosphorus (mg)	860
Vitamin-A (IU)	54	Potassium (mg)	407
Vitamin-E (mg)	0.50	Potassium (mg)	407
		Sodium (mg)	16
		Zinc (mg)	4.58

Source: USDA National Nutrient Database for Standard Reference Release 28, 2011 [6].

IV. PHYSIOCHEMICAL PROPERTIES AND APPLICATIONS IN THE FOOD INDUSTRY

Moisture influences the structure and physical properties of chia seeds significantly. The physical properties of chia seeds have been studied by several researchers. The mean moisture content of white seeds is 7.2 per cent while that of black seeds is 6.6 per cent. The white seeds possess lower bulk density than black seeds, which could be attributed to their larger size. Bulk density signifies the storage and transport capacity of seeds. No significant difference has been found between the true density and porosity of both black and white seeds [1,16]. TABLE 7 gives the moisture density related physical properties of chia seeds.

TABLE 7: Moisture - dependent physical properties of black and white chia seeds

Physical property	Black seeds	White seeds
Bulk density (g cm^{-})	0.772 g cm^{-}	0.667 g cm^{-}
True density (g cm^{-})	1.009 g cm^{-}	0.999 g cm^{-}
Porosity (per cent)	28.2 per cent	33.1 per cent

Chia seeds have the unique property of forming a gelatinous mass when soaked in water. This is due to the presence of high amount of mucilages and gums. Studies indicate that chia seeds can absorb water up to 12 times their weight [16]. This property makes it useful in the food industry. Chia seeds could therefore also be friendly for the gut health because soluble fiber prolongs the gastro-intestinal transit time that aids in improved digestion. Dry chia seeds can be stored for longer period because of significantly higher concentration of natural antioxidants in them. Antioxidants prevent auto-oxidation of fatty acids present in chia-seed[26, 16].Chia seeds are exceptionally rich in mucilage. The mucilage of chia seeds contains about 71.22 per cent polysaccharides which is comparable to the polysaccharides in mucilage of flaxseeds (75per cent). But quite lower to that of mustard seeds (80 per cent) and xanthum gum (98 per cent) [27, 28, 29, 30]. Mucilage of chia seeds can be extracted by hydrating whole seeds at 20^0C for 2 hours in the 1:40 seed and water ratio. After hydration a gelatinous solution gets formed, which can be collected and dried when kept at 50^0 C for 10 hours in an air convection heat oven. Dried mucilages can be separated from the seeds over a 40 mesh screen via abrasion procedure. This extracted mucilage has been found to retain moisture up to 27 times of its weight on hydration, which shows its exceptionally high water holding capacity. It can also form highly viscous solution at lower

concentration (0.3per cent) which is similar to xanthum gum.Solubility of chia mucilages has beenfound to be 100 per centwhen examined at different concentrations i.e. 0.15, 0.25 and 0.5 per cent at temperatures (30, 60, 70 and 90^0 C respectively) and also in different centrifugation (800 and 2000g) conditions [16]. Studies have indicated that, mucilages can replace oil and egg content up to 25g/100g in cake preparations; greater incorporation has been found to unfavorably alter the sensory properties of cake [31].Another study suggests that chia mucilage can be used as an emulsifier and stabilizer in an ice cream after completing the texture, overrun and melting tests. Extracted mucilage of chia has been used to improve/maintain the quality of ice creamduring storage [32].

Protein rich fractions of defatted chia flour produced by dry fractionation method have been found to exhibit good emulsifying properties as compared to foaming properties. Emulsion stability (95per cent) of chia seed has been found to be higher at alkaline pH [33].According to Coorey et al (2014),the water holding capacity (WHC: 266g of water/g of sample), oil holding capacity (OHC: 58.6g of water/g of sample) and emulsion stability (69.83per cent) of extracted chia seed gel is found to be better than that of guar gum (WHC- 24.83g, OHC-0.87g and emulsion stability-35.17per cent) which is used for commercial purposes. Compared to the chia seeds gel, chia flour gel has been found to have good potential to be used as a thickening agent because of its functional properties and also becausethe former retains more amounts of omega-3 and omega-6 fatty acid after extraction. Freeze – thaw stability of chia seed gel makes it suitable as a commercially potential ingredient to be used in frozen products [34].

Attempts have been made to develop several products by incorporating chia seeds/ its flour or gel. In a study, whole chia flour was taken in fourdifferent proportions (5per cent, 10per cent, 12per cent and 15per cent) for preparing gluten-free, omega-3 and fibre rich chips. Chips with 5 per cent of chia seeds flour had highest consumer acceptability. No significant variations in the sensory characteristics (appearance, color, flavor and overall liking)were seen in the chips (5 per cent chia flour) when compared with commercially available ones [35]. Breads have also been prepared by incorporation of chia seeds.In the preparation of bread, when wheat flour is substituted with chia seeds(11.0g/100g)and chia flour(7.8g/100g) there is a resultant reduction in the saturated fatty acid (27 to 24per cent) content. There is also an increase in the polyunsaturated-saturated fatty acid ratio in the bread with chia seed (288.1per cent) and with chia flour (206.9per cent). Breads prepared from chia seeds/chia flour are a good source of fiber and omega-3 fatty acids as compared to breads available in the market which are prepared from refined wheat flour/ whole wheat flour.It has been reported by Coelho et al (2015) that bread with chia flour has an acceptability index of 90per cent. It was found that the consumer preference to buy such breads was 60 per centin the “surely buy the product” category and 35per cent in the category of “likely to buy the product”. Hence the preference for purchasing the breads with chia is fairly high [36]. Zettel et al (2014)prepared a gel of grounded chia seeds with 5g and 10g/g water respectively and concluded that dough with 2 per cent of chia gel tends to be softer in consistency.The quality of bread also improves in terms of storage, when mixed with 5g/g of water (optimal dosage). Breads with chia gel are found to be more nutritious and could be used as a functional food [37].Inclusion of whole chia flour (0-20 per cent) and vital gluten (0-4 per cent) in bread for the development of functional product indicated that addition of 10 per cent whole chia flour and 2per cent Vital Gluten would provide more amount of protein (19 per cent), ash

(11 per cent) and 26 per cent more lipids than standard loaf. However, the addition of whole chia flour in the dough reduces the protein network which results in a denser product [38].

Attempts have been made to incorporate chia in other bakery products as well. In a study, Inglett et al (2014)prepared four types of cookies – standard, chia - nutrim, chia - whole oat flour (WOF), chia - oat bran composite (OBC)to study the physical properties of chia –oat composites, dough and cookies. Addition of 20 per cent composite improved the Water-Holding Capacity (WHC) of cookies as compared to those prepared by the standard (non-chia) recipe.This study indicated that substituting wheat flour with Chia-Wheat oat flour and Chia-Oat bran composites will not possess any impact on texture of cookies. Fibre content and omega-3 enriched cookies proved to be very beneficial if used commercially [39]. Incorporation of the chia seeds in frankfurters was studied by Pintado et al (2016). Reformulated frankfurters with *Salvia hispanica* contained higher amount of protein, minerals, insoluble dietary fibers along with high levels of monounsaturated fatty acids and omega-3 fatty acids. [40].

The above discussed studies support the technological view point that, chia seeds possess many important functional properties(water-holding capacity, oil holding capacity, solubility, viscosity, emulsion stability and foaming stability) which prove its potential to be used as a thickening agent, gel forming agent, chelator, foam enhancer, emulsifying agent, clarifying agent, rehydrating agent and as suspension formers in the formulation of food products at both home and commercial level. All these properties make chia a promising functional food for the future.

V. EFFECTS ON HEALTH AND PREVENTION OF DISEASE

Several animal and human studies have been carried out to study the effects of consuming chia seeds on health. Some of the studies have been discussed below.

5.1 Effect of chia on animal health

Five thousand four hundred 1-day old male broiler chicks were fed on two different diets containing 10 per cent and 20 per cent of chia seeds for 49 daysand at the end of the study, a remarkable fall in saturated fatty acid, polyunsaturated fatty acid: saturated fatty acid ratios and omega 6 – omega 3 ratios of white and dark meats were seen in comparison to meats of chicks fed on control diet [41].Another trial was conducted by Coorey et al (2014) on 48 Isa Brown hens divided into 4 groups(six each). Theywere fed with 8 different diets [control diet, control with flax seeds(15g, 20g, 30g/100g of control),chia seeds(20g, 30g, 40g) and fish oil(1.5 ml/100g of control] for 4 weeks. Researcher concluded that the omega-3 fatty acid content of egg yolk of hen that were fed with 30 per cent chia seeds was highest as compared to others without compromising the flavor of egg. Eggs with higher omega-3 fatty acid content may exhibit anti-hypercholestrolemic effects when consumed by humans [42].

Chicco and his colleagues (2009) examined the effect of alpha linolenic acid and fiber rich chia seedson dyslipidemia and insulin resistance in 72 Wistar rats, which were divided into 3 groups and assigned with three diets for three weeks in one experimental design. In another experimental design of the same study 96 rats which had been earlier fed with sucrose rich diet for 3 months were divided into two groups; one group continued with sucrose – rich diet while second group was provided with sucrose rich diet along with chia seeds.

It was noted that, chia seeds prevented the onset of dyslipidemia, peripheral insulin resistance and reduced the visceral adiposity in rats without producing changes in blood glucose levels [43].Marineli et.al (2015)conducted a trial on 36 Wistar rats(induced obesity) to examine the effect of chia seeds and oil on their plasma and liver oxidative status. Ratswere divided into 6 groups and fed with two diets – one standard and another high fructose high fat diet (soybean oil, lard and fructose). Two treatments;one long treatment (12weeks) and one small treatment (6 weeks), were followed for incorporation of chia seeds and oil in their diets. The feeding trial resulted in increased plasma catalase activity and increased plasma thiol (GSH) as compared to high fructose high fat diet. No significant effect was observed on the liver lipid peroxidation [44]. In yet another study, 48 Wistar rats were fed withan innovativelydeveloped omega-3 enriched chocolate milk and its effect was examined on the muscle damage and blood lipid profile. Reduction in the muscle damage with lower levels of total cholesterol and triacylglycerols were seen which indicate that intake of omega- 3 enriched beverage alters the post exercise soreness of muscle. No side-effects were noted on lungs, spleen, liver, heart and kidney afteringesting the beverage for 15 days [45].

5.2 Effect of Chia on Human health

Very few studies have been done on human volunteers to assess the impact of consuming chia seeds on health. A randomized, placebo- controlled clinical trial on 76 adults found no significant reduction in body weight, lipid profile, inflammatory markers and blood sugar levels even after ingesting 50g chia seeds per day for 12 weeks. Elevation in plasma alpha linolenic acid (24.4 per cent) was noted as compared to the control group [46]. Effect of ingesting 25g milled chia seeds for seven weeks was examined on 10 postmenopausal healthy women. The ingestion of chia seeds resulted in significant increase in the eicosapentaenoic acid (EPA) andalpha linolenic acid (ALA) levels in plasma by 30 per cent and 138 per cent respectively. However, no significant change was seen on body massindex [47]. Higher intake of omega-3 fatty acids in diet through both marine (EPA and DHA) and plant sources (ALA) are strongly associated with decreasing the risk of death due to cardiovascular diseases which is a major cause of mortality in the world nowadays [19].

A randomized, placebo- controlled clinical trialwasconducted by Vuksan et al (2007) on twenty type-2 controlled diabetics(with medication)who were provided 37g chia seeds daily (added in white bread). The results indicatedthat high fiber content of chia helped in controlling hyperglycemia and reducing systolic blood pressure. ALA and EPA levels were found to increase with consumption of chia.Anticoagulant and anti-inflammatory effect of chia seeds may help in preventing strokes and heart attacksin type-II diabetic patients[48].Few studies indicate that chia seeds exhibitpositive effects on health such as reduction of post-prandial blood glucose levelsand systolic blood pressure [49, 18, 50].In a double-blind placebo controlled trial sixty seven adults (divided into two groups) with excess body weight and metabolic syndrome weregiven 4g chia seeds mixed with oats, palm and soy powder diluted in 250 ml of water two times per day for two months along with some caloric modifications in the daily diet. The study results indicated a significant reduction in the body weight, waist circumference and basal metabolic rate of experimental group in comparison to placebo group. Significant reduction in insulin resistance, triglycerides levels and C- reactive protein werenoted. However, no significant change was seen in the total cholesterol, blood sugar and total plasma insulin levels [21].

VI. SIDE EFFECTS OF CHIA SEEDS

European Parliament and Council of Europe approved chia seeds as a Novel Food in 2009. Till date no study has revealed any adverse toxic, allergic or anti-nutritional effects after ingesting whole or ground chia seeds. The food safety and standards act (2006) and its regulations (2011) do not provide any information regarding the prohibition of chia seeds. Chia seeds may thus beconsidered safe for human consumption and has a promising future as functional food [51, 52, 53]. However, more clinical trials on animals and humans need to be done to ascertain the safety aspects of chia seeds.

VII. CONCLUSION

Chia seeds are not new to mankind. They have been used even in the pre-colombian time by Aztecs as foodstuff and in religious ceremonies. Chia seeds are an excellent source of dietary fiber (insoluble and soluble), omega-3 fatty acids, proteins and bioactive compounds or phytochemicals. Chia possesses many important physiochemical and functional properties which makes it more suitable in the food industry. Chia acts as a good thickener, gel former, chelator, foam enhancer, emulsifier, suspension formers, clarifying agent and as a rehydrating agent. Therefore it can be used commercially for the development of new products enriched with omega-3, protein, soluble/insoluble fiber and phenolic compounds. Chia seeds may help in the prevention, treatment and management of several non-communicable diseases, improving immunity and perhaps modifying the blood clotting mechanism. Chia also helps in improving the post-prandial blood glucose levels in blood by slowing down the digestion of carbohydrates. It can be incorporated in frozen products, bakery, beverages, sweets, baby foods, pasta, sausages etc. Researches done in *vivo* and *vitro* have supported the fact that that it is safe for human consumption and also exhibits wide range of health benefits. There is scope for research on chia seeds with respect to the food industry and nutraceuticals. Chia can thus be considered as a functional food which could help in improving the health of the masses.

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