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# A Comprehensive Review on Chia Seeds (*Salvia hispanica* L.)

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**Abstract**
A few decades ago chia seeds were rediscovered as a most promising plant genus that may provide high-quality protein, dietary fibre, omega 3 and various other valuable constituents. Since then research has focused on various aspects of these seeds and has been rapidly expanding, and a large number of reports have been published. In this chapter, a review is made on nutritional and functional properties of chia seed in order to provide comprehensive knowledge about this seed. The aim of this paper is to update the current state of knowledge on its physicochemical composition and potential health benefits for human health. On the basis of this, the discussion includes botanical and taxonomic description, historical aspects, health benefits, physiochemical properties, its uses and application. The chapter closes with a discussion on the potential benefits for human health as a functional food and the need for continued research in this direction.

**Keywords:** Chia seeds, Nutritional, Physicochemical, Functional food

## Introduction
The search for novel foods is a relevant practice worldwide. Chia also known as *Salvia hispanica* L. is a species of flowering plant in the mint family native plant of Central and Southern Mexico and North of Guatemala that belongs to Lamiaceae family (Ayerza, 2010) [1]. The chia was classified by the Swedish botanist Carl Von Linneo in 1753, who named it Salvia means cure and hispanica (Spanish word) that in Latin means Spanish plant used to cure or save (Urbina, 1887) [30]. In Mayan, chia word is used for "strength" and their warriors consumed these seed to last on long hunts, due to its high nutritional value. The history of chia is fascinating because it was the third most important crop in Mexico for 5,500 years, and in only 260 years it became an almost unknown species. After the Spanish conquest of the Aztec Empire, the first situation that chia faced was the ban of its use for 260 years (between 1550-1810) and Spanish forced to the Aztecs nation that the existence of chia would depend as domestic species. The drastic reduction in chia cultivation was due to the cultural conflicts after Spanish colonization but after 260 years, chia is experiencing a renaissance and reintegrated as a food source into the contemporary diet with five-fold growth in consumer demand in 2012. Recently, chia has been identified as a new crop particularly due to its high oil and highest omega-3 fatty acid, protein and dietary fibre content among productive oilseeds (Cahill, 2003) [10]. 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 promote cultivation of this attractive seed adding to it an extra value and increase its potential commercialization market.

## Botanical and taxonomic description of chia seeds
Hentry *et al.* (1990) [19] reported that chia plants comes under the category of Lamiaceae family, which in turn is part of the mint family. Its taxonomic description is as follows:

| | | |
|---|---|---|
| Kingdom | : | Plantae |
| Subkingdom | : | Tracheobionta - Planta vascular |
| Superdivision | : | Spermatophyta - Planta de semillas |
| Division | : | Magnoloiphyta - Planta con flores |
| Class | : | Magnoliopsida – Dicotiledónea |
| Subclass | : | Asteridae |
| Order | : | Lamiales |
| Family | : | Lamiaceae |
| Genera | : | Salvia |
| Specie | : | Hispanica |

Chia is an herbaceous plant with opposite, serrated leaves approximately one and half to three inches in length and 1 to 2 inches in width. Seeds are oval and approximately in length 2 mm (0.08 inches) long and in width 1 mm (0.04 inches) wide. The shiny seeds coat varies in color from cream to charcoal grey and the seeds have darker irregular markings or specks on them (Ayerza and Coates, 2005) [2]. Chia (*Salvia hispanica* L.) is an annual herb that blooms during the summer months. It is approximately a meter tall, with opposite, petiolate and serrated leaves that are 4 to 8 cm long and 3 to 5 cm wide. The flowers are hermaphrodite and grow in numerous clusters in a spike protected by small bracts with long pointed tips and purple in colour. The seeds are oval, smooth and shiny, and are mottle coloured with brown, grey, white, and dark red and are generally found in groups of four (USDA, 2008) [32]. The word chia was adapted by Spanish word chian and its pural form is chien meaning "oily", which comes from Nahuatl, which is in the language of the Aztecs. The name "chia" was adopted by the Swedish botanist Karl Linnaeus. The former territory of Nahuatl Chiapan, meaning "River of Chia", took its name from the plant, and on the banks of the Grijalva River the plant has been grown since ancient times. The pre-Columbian population also used chia in the preparation of "chia fresca" (fresh chia) a popular beverage, which is still consumed today (Munoz, 2012) [23].

**Historical aspect of chia seeds**

Since 5,500 years ago, chia (*Salvia hispanica* L.) crop is used in Mexico as a food ingredient. Today chia is considered one of the most important sources of omega 3 polyunsaturated fatty acids. The history of chia (*Salvia hispanica* L.), is fascinating because although for 5,500 years it was the third most important food crop along corn, bean and amaranths in the Mexico, after the Spanish conquest the restriction on its use by around 260 years led to became a virtually unknown specie because the traditional use of chia seeds as a food and medicine was not fully conveyed in at least six generations. However, chia is native to Mexico and was introduced to Spain after Hernan Cortes settled in Mexico (Ortiz de Montellano, 1978). Chia (*Salvia hispanica* L.) is a seed with special significance in Latin America, mainly because it has been consumed since ancient times by Mesoamerican people and the name chia is attributed to these populations. This is well documented by historians, by Spaniard colonizers, and by natives themselves. It was key in the diet of more than eleven millions of inhabitants Aztec. Tenochtitlan, capital of Aztec empire consumed chia seeds between four and fifteen thousand tons per year (Cahill, 2003) [10]. Ayerza and Coates, (2007) stated that chia (*Salvia hispanica* L.) seeds are commonly known as chia is an ancestral crop that was domesticated during 3,500 years BC and up until the arrival of the Spaniards along with corn, bean and amaranth. Peiretti and Gai, (2009) [26] also suggested that chia seeds was one of the staple foods for the Mayan and Aztec civilization. In Mayan, the meaning of chia is "strength". Mayan warriors consumed chia seeds to last on long hunts, because these seeds contains proteins, energy, fiber, polyunsaturated fatty acids and antioxidants in large amount (Dorsey-Kockler, 2011) [16].

**Physiochemical properties of chia seeds**

The physiochemical composition of the chia seeds is variable and depends on the region where it grows (Ayerza, 1995) [3]. Grown nearer to the equator increases seed oil content and shortens seed-to-harvest period, allowing for double and triple crops but the plant grows better in tropical and subtropical regions, chia plants can also be cultivated in mild climates (Coates and Ayerza, 1996, Coates and Ayerza, 1998) [4, 5]. Nevertheless, USDA, (2004) [31] reported that chia seed contains approximately 5.80 per cent moisture, 16.54 per cent protein, 30.74 per cent total lipids, 34.40 per cent total dietary fiber, 42.12 per cent total carbohydrates, and high contents (335-860 mg/100 g) of calcium, phosphorus, potassium, and magnesium; and to a lesser extent sodium, iron, and zinc (4.58-16 mg/100 g). The seeds is high in vitamin thiamine and riboflavin and a good source of vitamin A, C and niacin (Bushway *et al.* 1981; Beltran-Orozco and Romero, 2003; Valdivia-Lopez and Tecante, 2015) [9, 7]. One of the main properties of this seed is the fact it is a natural source of omega-3, which represents 75 per cent of the total oil content of chia (Taga *et al.* 1984) [28]. It also has a significant amount of dietary fiber, found in greater proportions compared to other fruits and seeds that the digestive system cannot digest (Vazquez-Ovando *et al.* 2009). The seed coat contains mucilage that protects all seed nutrients and is involved in water retention in foods due to the higher water retention capacity, consumption of this aids in digestion (Salgado-Cruz *et al.* 2005). Regarding mineral content it contains six times more calcium, eleven times more phosphorus and four times more potassium than 100 ml of milk, besides possessing magnesium, iron, zinc and copper (Beltran-Orozco and Romero, 2003) [7]. It contains 13 to 354 times more calcium, 2 to 12 times more phosphorus, and 1.6 to 9 times more potassium than 100 g of wheat, rice, oats and corn. The iron content of chia is also quite high compared to most other seeds: it has six times more iron than spinach, 1.8 times more than lentils, and 2.4 times more than liver (Bushway *et al.* 1981; Beltran-Orozco and Romero, 2003) [9, 7].

**Health benefits of chia seeds**

Recent studies show that chia seeds are nutritionally rich package due to their high protein, calcium, fibre, magnesium, phosphorus and essential fatty acids content. Today, demands for development of designer health foods using functional ingredients has been increasing due to their health benefits. The use of underutilized and traditional food to prevent diseases such as diabetes, obesity, and cardiovascular problems is now gaining momentum among the common people nowadays. For instance, Dweck, (2000) [17] revealed that chia seeds were used for medicinal purposes for the treatment of boils and to relieve pain in the knee and injured feet due to presence of omega 3 fatty acid. Essential fatty acids, such as ALA, are important for human health as they cannot be synthesized by the human body. Connor, (2000) stated that high concentration of omega-3 is associated with reduction in the risk of coronary artery disease, type 2 diabetes, hypertension, rheumatoid arthritis, autoimmune disorders, and cancer. Antioxidants found in chia seeds are one of the most important among the variety of compounds. Antioxidant present in chia seeds are phenolic in nature and Ayerza and Coates, (2011) [11] proved that chia seeds have a good source of polyphenolic compounds like quercetin, myricetin, kaemferol, flavonol glycosides, caffeic acid, and chlorogenic acid. Due to high antioxidant activity of chia seeds it can be used as a functional food ingredients in human diet to prevent cardiovascular diseases and cancer. Recent study showed that higher intake of dietary fibre is associated with a reduced risk of diverticular disease (Crowe *et al.* 2014) [15]. Vuksan *et al.* (2007) [34] concluded that high amount of α-linolenic acid and dietary fibres are the main nutritional

components of chia seeds that are responsible for attenuating cardiovascular and some other risk factors. Mobley *et al.* 2014 [20] reported that fiber has the potential to play an important role in improving public health.

**Uses and Application**

Besides the nutritional benefits of chia incorporation in food products the application of chia in baked goods is beneficial not only to improve the nutritional value but acting as hydrocolloid, emulsifier or substitute egg, fat or gluten. Various properties of chia seeds can be utilized for food product development in future. According to Alvarez-Chavez *et al.* (2008) chia seeds were either roasted and mixed with water as gruel or were ground and used as flour for baking purpose. Doesey-Kockler, (2011) [16] suggested that chia seeds can be consumed in four different forms i.e. whole, ground, flour, and in oil form. Consumption of whole chia seeds is most common and recommended because it can be added directly into any type of food in a dry form. Study also concluded that adding water in chia seeds in a 1:6 or 1:8 ratio, they obtain gelatinous properties that can be added to foods such as puddings and smoothies. According to Borneo *et al.* (2010) [8] chia gel can replace as much as 25 percent of oil or eggs in cakes while yielding a more nutritious product with acceptable sensory characteristics. Munoz *et al.* (2012) [23] revealed that *Salvia hispanica* L. seeds have a great potential to be used as a source of nutrients and nutraceutical in food engineering. Mucilage of chia is mainly composed of polysaccharides located in the three layers forming the seeds coat and can be easily removed after hydration. Study also concluded that mucilage of chia seeds can incorporated into different food and formulations, and has ability to produce edible film in combination with proteins, which improved mechanical and functional properties of the films. Stabilizer used in commercial formula possibly replaced by mucilage from chia seeds due to its various functional properties. According to Mohd-Ali *et al.* (2012) the food industry of various countries around the world including the United States, Chile, Canada, New Zealand, Australia, and Mexico has widely used chia seeds and its oil for different applications such as breakfast cereals, cookie snacks, bars, fruit juices, yogurt, and cake.

**Chia as a functional food**

Recent studies showed that chia seeds can be used as a "functional ingredients" as it has a beneficial effects in human health because it prevents cardiovascular disease, inflammatory disease and diabetes. According to Balakrishnan, (2012) [6] in terms of nutritional properties, chia muffin contains 5.9 g of fiber and 3.6 g α linoleic acid compared with control muffin which has 1 g of fiber and less than 1 g α linoleic acid. The study also conclude that chia seeds enhanced satiety value as the subjects felt fuller after eating chia incorporated muffins than control. Today, chia seed offers an enormous potential for the industries of health, food, animal feed, pharmaceuticals, and nutraceuticals, due to its functional components (Munoz *et al.* 2013) [24]. Coorey *et al.* (2012) [14] prepared high protein, high dietary fibre, gluten free and omega-3 fatty acid rich chips using different levels of whole chia flour (5, 10, 12, and 15%) revealed that there were no significant differences in appearance, colour, flavour and overall liking between a commercial chip sample and the 5 per cent chia chips. Result on chemical analysis indicated that all four combination of chips are excellent sources of omega-3 and the baking process has a limited impact on their nutritional profile. According to Rendon-Villalobes *et al.* (2012) chia seeds did not affect the sensory properties of the tortillas and incorporating chia increases the nutritional quality of the tortillas. Five percent incorporation of chia seeds flour was most preferred for all attributes. The nutritional analysis showed a significant ($p \leq 0.001$) increase in fiber, lipid and protein content compared to the control sample. Physicochemical analysis showed a significant decrease in the rate of digestion and decrease in glycemic index values as the concentration of chia seeds flour increased. Study concluded that tortilla containing chia seeds can be labelled as a nutraceutical food product because the addition of chia seeds flour improves the nutritional value and chia seeds should be considered as a new staple ingredient.

So it can be concluded that apart from contributing to human nutrition, chia seeds can helps to increase the satiety index, prevents cardiovascular diseases, cancer and diabetes due to the presence of beneficial component.

**Conclusions**

It emerged that the significance of chia seed as a staple food in pre-Hispanic Mexico is undeniable, but owing to several reason the consumption of the seeds after the arrival of Spaniards to this country was considerably reduces and remained practically restrained to local regions. Different researches carried out revived the interest in this seeds because of its attributes and properties like high in proteins, antioxidants, omega 3 fatty acids, dietary fiber, minerals and some other nutrients that now make it attractive throughout the world as a functional and nutraceutical food items. Research at all levels on chia seed and its components will be last in the future but special attention should be given to assess the beneficial effects of chia seeds on human health as there are less studies available on this area and these studies will provide accurate data on beneficial effects of this seeds with regards to its different component.

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