Nutritional and functional properties chia (Salvia hispanica L.) seeds

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Abstract
In this chapter, a review is made on various aspects of chia seed in order to provide an overall, yet comprehensive view, about this important commodity with the aim of updating the current state of knowledge on its composition, possible nutraceutical properties, and potential benefits for human health. Based on this approach, the discussion includes some comments on the main historical aspects, morphology of the seed, its importance in the diet of humans and stresses the main results issued from investigations on its three main components; lipid, protein, and fiber. The chapter closes with a discussion on the potential benefits for human health, highlighting the contradictions that still exist in this area and the need for continued research in this direction and considerations on the role of chia seed as a functional food.

Keywords: Nutritional, functional properties chia, Salvia hispanica L.

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:

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<tr>
<td>Subkingdom</td>
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<td>Superdivision</td>
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Salvia is an excellent paniard colonizers, and opper (Beltran et al., 1996). One of the main 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].

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 become 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). It was named “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].

Health benefits of chia seeds
There is renewed interest in the use of chia as an excellent source of omega-3 fatty acids and dietary fiber for healthy diets. Additionally, these highly unsaturated oils are also useful starting materials for many renewable chemicals. The increasing concern for public health worldwide demands the development of functional foods with multiple health benefits. The use of medicinal food from folk medicine to prevent diseases such as diabetes, obesity, and cardiovascular problems is now gaining momentum among the common people. Seeds from Salvia hispanica L., frequently known as chia, are a traditional food in central and southern America. This grain is widely consumed for various health benefits to maintain healthy serum lipid levels, particularly for the presence of the phenolic acids and omega 3/6 oil. Although the presence of active ingredients in chia seed contributes to health benefits, safety, and efficiency of this medicinal food or natural product need to be validated by scientific protocols, since clinical studies on the safety and efficiency of chia seed are still limited and those reported have not shown conclusive results. Recent studies show that chia (Salvia hispanica L.) is a remarkably complete nutritional source, providing protein, magnesium, phosphorus, and essential fatty acids. According to Connor, (2000) 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. Another study done by 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. Ayerza and Coates, (2011) [11] proved that chia
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 or substitute egg, fat or gluten. The increase of oil stability and applications as food thickener in novel food applications are of high importance too. As different chia fractions give various options for applications the utilization of chia for further food products will increase significantly in the 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) 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. Munoz et al. (2012) 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. This mucilage of chia seeds have a potential source of hydrocolloids with different and attractive functional properties such as, water absorption capacity, emulsifying and foaming properties and due to these properties chia is highly soluble in cold and hot water. 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. In the study of Timilsena et al. (2016) Australian chia seeds was used for protein isolation and converted into powders using spray, freeze and vacuum drying methods, to investigate the effect of drying methods on physicochemical and functional attributes of chia-seeds protein isolate. It was found that there was no significant difference in the proximate composition between all three drying method; however vacuum dried chia seeds protein isolate had the highest bulk density and oil absorption capacity, whereas spray dried powder demonstrated the highest solubility, water absorption capacity and lowest surface hydrophobicity. Foaming capacity and foam stability of chia-seeds protein isolate were found to increase with increasing pH and protein concentration. Findings of the study are expected to be useful in selection of a drying process to yield chia seeds protein powders with more desirable functionality. Henry Lazaro et al. (2018) in their study on assessment of rheological and microstructural changes of soluble fiber from chia seeds during an in vitro micro-digestion revealed that mucilage of chia seeds maintained the structure in a food matrix and could be used to develop structured foods. Mucilage of chia could be a possible functional element with valuable characteristics for food and nutraceutical industries.

Chia as a functional food

Chia can be considered as a “functional food” because apart from contributing to human nutrition, it helps to increase the satiety index, prevents CVDs, inflammatory and nervous system disorders, and diabetes, among others. 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). At present, chia seed is used as a healthy oil supplement for humans and animals. Human consumption of chia in diet is mainly from the extracted oil through its incorporation into cooking oil, confections, or supplements. According to Borneo et al. (2010) chia gel can replace as much as 25 per cent of oil or eggs in cakes while yielding a more nutritious product with acceptable sensory characteristics. According to Balakrishnan, (2012) 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. Coorey et al. (2012) 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-Villalobos et al. (2012) chia seeds did not affect the sensory properties of the tortillas and incorporating chia increases the nutritional quality of the tortillas. The effects of chia seeds powder incorporation on the physicochemical and sensorial characteristics, as well as starch digestibility of corn tortillas formulated with chia seeds (Salvia hispanica L.) were evaluated by Rendon-Villalobos et al. (2012). Result revealed that no significant difference (p≥0.05) was obtained among the different variations (5, 10, 15, and 20%) of chia flour and the control. The 5 per cent incorporation of chia seeds flour was most preferred for all attributes. The nutritional analysis showed a significant (p≤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.

Conclusions
The importance of chia seed as a staple food in pre-Hispanic Mexico is undeniable, but owing to several reasons the consumption of the seed after the arrival of Spaniards to this country was considerably reduced and remained practically restrained to local regions; mainly those where the seed grown wild. Scientific research carried out mainly in the last 25 years has revived the interest in the seed because of its recognized attributes and properties as a good source of different components like unsaturated fatty acids, proteins, antioxidants, dietary fiber, and nutrients that now make it attractive worldwide as a functional food with clear nutritional impact but with benefits not as yet as clear to human health that still require to be investigated. Scientific data allow evaluating the seed and its main components on the basis of quantitative and objective data and criteria that together make possible to better understand and identify the benefits, limitations of the seed, and potential applications of its components. Research at all levels on chia seed and its components will continue in the future, but one of the aspects that deserves special attention is in the area of human health to clarify the role of the different components and definitively establish their actual beneficial effects based on scientific evidence instead of cultural traditions, personal beliefs, or even inaccurate advertising.

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