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Determination of physicochemical properties of chia seeds (*Salvia hispanica* L.)

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Abstract
The present study was conducted to determine the physicochemical properties of chia seeds. The results of the investigation indicate that the color of the chia seeds is blackish brown, the mean length, width, thickness, geometric mean diameter, surface area, sphericity, porosity, aspect ratio, 1000 seed weight of the chia seeds were 2.12 mm, 1.31 mm, 0.82mm, 1.32 mm, 5.41 mm2, 64.2%, 28.4%, 62.5, 1.384 gm respectively. The chemical and mineral content of the chia seeds was determined. The results show that the moisture content, total fat, total carbohydrate, total protein, total ash and crude fiber were 6.93%, 30.52%, 41.68%, 16.49%, 4.38% and 21.1% respectively. The iron and zinc content are 99.72 and 52.44 mg/1000 gm respectively. Copper and manganese are present in small amount.

Keywords: Physical properties, chemical properties, Chia seeds, (*Salvia hispanica* L.)

Introduction
Chia (*Salvia hispanica* L.) is an herbaceous plant that belongs to the order Lamiales, family Lamiaceae, subfamily Nepetoideae, and genus Salvia (Arctos Specimen Database, 2018) [4]. The Salvia genus is considered the most numerous in the family Lamiaceae. The name chia is come from a Spanish word chian which means oily, chia is oilseed, which contain high amount of omega-3 fatty acids, high quality protein, high amount of dietary fibres, minerals, vitamins and also contains wide range of polyphenolic antioxidants which protect the chia seeds from chemical and microbial oxidation (Cahill, 2003) [14]. Chia seeds contains 30-33% fat, 15-25% protein, 41% carbohydrates, 18-30% dietary fibre, 4-5% ash and 90-93% dry matter and wide range of polyphenols. Chia seeds contains high amount of the essential fatty acid alpha-linolenic acid (ALA 18:3(n-3)), which is required for maintaining certain physiological functions (Chicco *et al*., 2009, Fernandez *et al*., 2008, and Meester *et al*., 2008) [10, 16, 24]. Omega- 3 fatty acids also can block calcium and sodium channel dysfunctions, which results in hypertension (Leaf and kang 1998) [22]. It is found that chia does not have any anti-nutritional anti-allergic and toxic effect on the human health. There are different foods like pasta, yoghurt, Biscuits, snacks, cake, and cereal bars are commonly supplemented with chia seed (The Chia Company 2009; Borneo *et al*., 2010) [30, 9]. Chia seed gum has many applications in food industry due to its slimy properties, which are evident even in very low concentration, and because the plant is native to America, it grows well in semiarid regions that have few practical plants. Gum Extracted from chia has a slimy, mucilaginous character at very low concentrations, which makes it potential food in a variety of industrial applications, especially in certain foods products and food preparations. According to Coelho and Salas-Mellado (2015) [12] bread crumb containing whole chia seeds was softer in texture than that contains chia flour. The addition of chia flour increased the total antioxidant activity of wheat bread. The chia plant height is about 1 m and it has simple leaves, which are 4 to 8 cm in length and 3 to 5 cm wide, having oval-elliptical shape, pubescent, and has acute apex. A chia seed is quasi-oval in shape, having length between 1 and 2 mm, a diameter is between 0.8 and 1.3 and a has width between 0.8 and 1.4 mm. Its peel is smooth and shiny and can be black, brown, gray, black-spotted or white in colour. The chia seeds contains mucilage present inside the epidermal cells of mature chia seeds and when chia seeds come into contact with water it absorbs water and immediately expands which rupture the primary cell layer that emerged from these epidermal cells which surrounding the seed, which results in increases its size and characteristic gel appearance of chia is formed (Munoz, Cobos, Diaz, and Aguilera, 2012) [26] In some recent years, chia became more popular because it has become one of the main sources of oil that contains high level of Poly unsaturated fatty acid. Chia is generally eaten as salad from chia sprouts, added in beverages, cereals, and salad dressings seed is used, or chia

may be eaten in its raw form (Baughman and Jamieson, 1929) [7]. The Europian Commission has set the limit of not more than 5% of chia seed in bread products**.** Chia seeds and its oil is widely used for different applications other than bread such as bars, breakefast cereals, cookie snacks, cake, fruit juices and yoghurt in the food industry of various countries around the world including US, Canada, Chile, Australia, New Zealand, and Mexico (The Chia Company, 2010 and Borneo *et al*., 2010) [31, 9]. According to recent research chia seeds contain high antioxidants (phenolic compounds). The phenolic compounds in chia seeds may reduce the growth of cancer cells and improve the health (Valdivia and Tecante, 2015) [34]. Chia seeds are also being used in cake formulations as healthy oil supplements, (Borneo, Aguirre, and Leon, 2010) [9]. Chia seeds contain high fat (over 30 g oil/100 g) with a low amount of saturated fatty acids, and it contain higher levels polyunsaturated fatty acid like linoleic acid (60.5–67.8 g/100 g fat) (Coates and Ayerza 1996; Ixtaina *et al*., 2011; Martinez *et al*., 2012) [11, 18, 25]. The protein-rich fraction which is obtained from the chia seeds has shown high thermal stability, between 70.4 and 125.0°C, and also it has shown good oil- holding (4.04 g/g) and water-holding (4.06 g/g) capacities (Olivos-Lugo, Valdivia-L opez, and Tecante, 2010) [28]. This high stability of chia seeds is related with hydrophobic interactions between amino acids (Olivos-Lugo *et al*., 2010) [28]. These characteristics of chia seeds indicate that the proteins of chia seed are promising food additives which can help in improving food quality and extend the shelf-life of food products (Valdivia-L opez and Tecante, 2015) [34]. The dietary fibers present in chia seeds and mainly in whole grains is an important biocomponent because it has may potential health benefits. Many research studies have shown the effect of consuming fibers such as the decrease of risk for diabetes mellitus type 2, several types of cancer and coronary heart disease (Lattimer and Haub, 2010; Steinmetz and Potter, 1996; Kaczmarczyk *et al*., 2012) [23, 29, 19]. Chia seeds are rich in vitamins such as niacin (8.83 mg/100 g), thiamine (0.62mg/100 g) and riboflavin (0.17 mg/100 g), and these vitamins are at levels above than those of other seeds (Munoz *et al*., 2012) [26]. Chia seeds are also high in concentrations of phosphorus (585 mg/100 g), iron (8.54 mg/100 g), calcium (455 mg/100 g), magnesium (340 mg/100 g), zinc (3.70mg/100 g) and potassium (585 mg/100 g) (da Silva *et al*., 2017) [15]. The calcium is in high concentration in chia seeds than that found in milk, as well as the concentration of iron is also higher than that found in good sources of iron such as liver (Ullah *et al*., 2016) [32].

Chia seeds are widely used in many food products to increase their nutritional content. The utilization of 30% chia seed flour (w/w) in a gluten- free noodle formulation has shown to increase the content of protein, antioxidant activity, fat, and total phenolic compounds as compare to the control sample. Phytate phosphorus and phytic acid content increased 250.81 and 889.39 mg/100 g, respectively. The content of Ca, Mg, K, P, Zn and Fe, increased in noodles containing chia seed and there was a decrease of appearance, surface smoothness, and chewiness score of raw and cooked noodle samples (Levent, 2017) [21].

Materials and methods

Chia seeds were purchased from the local market. Chemicals and reagents will be obtained from laboratory, Department of Food Engineering, College of Food Technology, VNMKV, Parbhani.

Physical properties of chia seeds

Physical properties of chia seeds such as length, width, thickness, mean geometric diameter, surface area, sphericity, and aspect ratio were measured by using Vernier calliper and electronic weighing balance.

To measure physical properties, 100 gm of chia seeds were measured.Dimensions of the chia seeds (their length (L), width (W), and thickness (T)) were measured using a DC-515, Taiwan digital caliper with the precision of 0.01 mm. Then, the geometric mean diameter,equivalent diameter and sphericity were calculated using equations 1, 2 and 3 respectively.

$$Dg = (LWT)^{1/3} \quad (1)$$

The volume of the seed is determined.

$$V = \left(\frac{m}{\rho t}\right) 10^3$$

$$De = \left(\frac{6V}{\pi}\right)^{1/3} \quad (2)$$

$$\square\square = \left(\frac{De}{L}\right) X\ 100 \quad (3)$$

Bulk density (ρb), 1000 seed weight (AOAC, international 1990) [2], true density (ρt), porosity (ε) were determined by using different formulae.

Porosity is determined using following equation

$$\varepsilon = \left(\frac{\rho t - \rho b}{\rho t}\right) X\ 100$$

Dg is the geometric mean diameter, Da is the arithmetic mean diameter and Ø is the sphericity of the Chia seeds. The surface area (S) and the aspect ratio (Ra) of the chia seeds were obtained through Equations 4 and 5.

$$S = \pi D_g^2 \quad (4)$$

$$R = \frac{W}{L} X\ 100 \quad (5)$$

Proximate composition of chia seeds

Proximate composition of chia seeds *viz*., moisture, crude protein, fat, ash, total carbohydrates and crude fiber was determined according procedure of AOAC (2005) [1]. All the determinations were carried out in triplicate and the results are obtained as average value.

Moisture

The moisture content (MC) of the chia seeds will be determined by oven drying at 105°C for 2 h until the moisture content comes to constant point (AOAC, 2005).

$$\% \text{ Moisture content} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

Protein

Protein content of the chia seeds was determined using AOAC (2005) [1] method. Nitrogen Percentage and protein calculated by the following equations:

$$\% \text{ Nitrogen} = \frac{TS - TB \times \text{Normality of acid} \times 0.014}{\text{Weight of sample}} \times 100$$

Where, Ts = Titre volume of the sample (ml), TB = Titre volume of Blank (ml), 0.014= M eq. wt. of N2.
% Protein = Nitrogen × 6.25 Fat
Crude fat content of the chia seeds was determined using Soxhlet's apparatus (AOAC 2005) [1]. The percent of crude fat was expressed as follows:

$$\% \text{ Crude Fat} = \frac{\text{Weight of dried ether soluble material}}{\text{Weight of sample}} \times 100$$

Ash
Sample (chia seeds) is dried at 100 0C in hot air oven and charned over an electric heater. It was then ash in muffle furnace at 550 0C for 5 hrs (AOAC 2005) [1]. The ash content of the sample was then calculated using the following formula:

$$\% \text{ Ash content} = \frac{AW}{IW} \times 100$$

Where, AW = Weight of Ash and IW= Initial weight of dry matter. Total

carbohydrate
Total carbohydrate content of the chia seeds was determined as total carbohydrate by difference that is by subtracting the measured moisture, protein, ash and fat from 100 phenol sulphuric acid method as given by AOAC (2005) [1].

Result and Discussion

Physical properties of chia seeds

Physical properties such as color, length, width, thickness, geometric mean diameter, surface area, true density, bulk density, porosity, sphericity, aspect ratio and thousand seed weight of chia seeds were evaluated and results obtained are presented in Table 1.

Table 1: Physical properties of chia seeds

Physical	Observation
Colour	Blackish brown
Length(cm)	2.12
Width(cm)	1.31
Thickness(cm)	0.82
Geometric mean diameter (cm)	1.32
Surface area (mm2)	5.41 mm2
True density(g/cm3)	1.007
Bulk density(g/cm3)	0.723
Porosity (%)	28.4
Sphericity (%)	64.2
Aspect ratio	62.5
1000 seed weight(gm)	1.384

*Each value represents the average of three determinations

The physical properties of chia seeds were determined. The similar results were obtained by Ixtaina *et al*., (2008) [17].

Table 2: Chemical composition of chia seeds

Chemical Parameters	Mean Value*
Moisture (%)	6.93
Total Fat (%)	30.52
Total carbohydrates (%)	41.68
Total Protein (%)	16.49
Ash	4.38
Crude Fiber	21.12

*Each value represents the average of three determinations

The table. 2 indicates that the moisture, total fat, total carbohydrates, total protein, total ash, crude fiber is 6.93%, 30.52%, 41.68%, 16.49%, 4.38%, 21.12% respectively. The similar results were obtained by (USDA, 2011) [33], Kibui *et al*., (2018) [20] and (Ayerza and coates, 2009; Wright *et al*., 2002; Alvarez-Jubete *et al*., 2010; Morris, 2007) [6, 35, 3, 27].

Mineral composition of chia seeds

The mineral content of chia seeds is presented in table 3.

Table 3: Mineral content in chia seeds

Minerals	Average value (mg/1000g)
Copper	13.88
Manganese	26.92
Iron	99.72
zinc	52.44

*Each value is an average of three determinations

The table 3. showed that the iron content was 99.72 mg/1000gm. The zinc content of chia seeds found to be 52.44mg/1000gm. The manganese and copper are also present in small amounts. Similar results were obtained by (U. S. D. A.,2011) [33].

Conclusion

The physicochemical properties are important in preparation of various food products. Physical properties are important in equipment design for various processes. The physical properties such as true density and bulk density are used in packaging and transportation of food products. The chemical properties are important in preparation of different nutritious food products. This research shows that chia seeds are highly nutritious and make it potentially useful in preparation and value addition of food products. Chia seeds can be used in different products such as noodles, pasta, bread, cookies etc. to raise their nutritive value and make it healthy food choice.

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