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Chavan VR
Department of Food Process Technology, MGM College of Food Technology, Aurangabad. Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Kale RV
Department of Food Process Technology, MGM College of Food Technology, Aurangabad. Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Raut GS
Department of Food Process Technology, MGM College of Food Technology, Aurangabad. Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Gadhe KS
Department of Food Process Technology, MGM College of Food Technology, Aurangabad. Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Correspondence
Chavan VR
Department of Food Process Technology, MGM College of Food Technology, Aurangabad. Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Studies on extraction and characterization of functional properties and viscosity behavior of chia seed gel

Chavan VR, Kale RV, Raut GS and Gadhe KS

Abstract
In the present investigation attempts have been made to optimize the conditions for extraction of chia seed gel from Chia seed and studied for the proximate copostion, Funnctional Properties and Viscosity Behaviour of optimised treatments. Proximate composition of chia seed (*Salvia hispanica* L.) revealed that it contains moisture 6.76%, ash 4.38%, protein 24.06%, fat 29.50%, carbohydrate 12.35% and crude fibre 22.91%. Various time intervals were used to get maximum yield of chia seeds gel. The maximum yield obtained was 6.09 % with optimum extraction time of 2 hrs., and water to seed ratio 40:1 at 80 ^{0}C temperature. The functional properties of chia seed gel was helpful in judging the purity and quality of chia seed gel. Water holding capacity of chia seed gel was found to be 266.60/g and Oil holding capacity is 58.56/g. The Line spread test value of chia seed gel was found to be 5.10 mm and emulsifying ability and emulsifying stability of chia seed gel is 61.50% and 69.83%. The freeze thaw stability of chia seed gel was found to be 0% it help to prevent create ice crystals which cause water separation after thawing.

Keywords: Chia seed, chia seed gel, functional properties, viscosity

Introduction
'Chia' is a name of Spanish origin, which is used for several species of genus Salvia, usually for *Salvia hispanica* L. The genus *Salvia* L. belongs to the *Lamiaceae* family and shows about 900 species distributed worldwide, mainly in the areas of the Mediterranean, Southeast Africa and Central and South America (Delamare *et al.*, 2007) [7]. *Salvia hispanica* is a flowering plant native to central and southern Mexico and Guatemala. The name 'chia' is derived from the Nahuatl word 'chian' meaning oily, a word taken up by Spanish conquistadors and more recently adopted in English (Anonymous, 2000) [1]. It is called 'sabza', in Hindi.

Chia is known as super food as it contains highly concentrated amounts of essential fatty acids, dietary fibers, vitamins and antioxidants (Weber *et al.*, 1991) [7] Weber. In one ounce (28 g) sample, chia seeds contain 9 per cent of daily value for protein, 13 per cent oil (57 per cent of which is ω -linolenic acid abbreviated as 3ALA) and 42 per cent dietary fiber. The seeds also contain the essential minerals, phosphorus, manganese, calcium, potassium and sodium (Anonymous, 2010) [2]. the recovery of oil from chia seed is more than 90% and it hightest bearing source of omega 3 linoleinic acid among the plant sources, the chia seed contains around 58% omega 3 linolenic acid (Ayerza, 1995) [3].

The gel extracted from chia seed showed similar characteristics to that of flax and basil seed. The properties of mucilagenous gel extracted from flax and basil seed could be utlized in various food product as astabilizer.

Hydrocolloids or food gums are key ingredients in food processing and the industry is always on the lookout for new ingredients with enhanced and/or different performance characteristics for use in novel food product development. Information on the chia gel functional properties/characteristics is essential in identifying potential food applications. The objective of the present research was to study the effect of temperature, time and water to seeds ratio on extraction of gel from chia seed and the functional properties of extracted chia seed gel.

Materials and Methods
Gel extraction
The extraction of gel from chia seed was carried out as per the method descibed by Bruno *et al.*, (2016). Three different water to sample ratios (1:20, 1:30 and 1:40) were used for gel extraction. The chia seeds mixed with distilled water using an overhead mixer at 1920 rpm for 3 h. The mixture was then centrifuged using an Eppendorf 5810R centrifuge at 3220 RPM for 50 min at 37 °C to separate the gel. After 50 min three layer was obtained.

The top layer which was excess water, removed. The gel at middle layer was collected and the seeds are settled at the bottom. The chia seed gel was then partially dried for 30 min at 40º and stored in air tight containers at room temperature. The extraction of gel was carried by various treatments viz. Varrying degree of temperature, keeping seed water ration constant, by varring the extraction time, keeping time constant etc.

Functional Properties of chia seed gel

Viscosity

Viscosity was carried out as per the method described by Coorey R *et al.*, 2013 [6]. Viscosity was determined to check the flowing nature, thickness or viscosity (resistance to flow) of drink which is one of the quality criteria of chia seed gel was determined by using the Brookfield viscometer DV-E at constant speed 100 rpm and at constant temperature with a spindle number S-63 and it was expressed in terms of centipoises (cP). Parameters used for viscosity measurement chia seed gel was as follows; Spindle – S 63, Shear rate – 4.699cP, 7.689 cP, 12.71 cP, 21.06 cP and 34.99 cP. Speed – 100 rpm, Temperature – 25 ^{0}C.

Line spread test

Line spread test l was carried out as per the method described by Nicosia and Robbins 2007 [12]. Using Plexiglas with premeasured concentric circles (2-mm apart) template on a level counter. An open ended tube filled with 25 mL of 1% sample was placed in the middle of the template. The tube was lifted and the sample allowed to spread for 1 min and reading taken at the 4 points of the template where the sample had reached/spread after 1 min.(Nicosia and Robbins 2007) [12].

Water and oil holding capacity

The water and oil holding capacity of chia seed gel was carried out as per the method described by Olivos-Lugo *et al.*, 2010 [13]. 0.2 g of sample was added to 45 ml of water then shaken for 1 h in a shaking water bath and centrifuged using Eppendorf 5810R at 2500 × *g* for 30 min at 25 °C. The water layer was removed and the remaining sample and water held by the sample within the centrifuged tube was weighed. The results were expressed as the mass (g) of retained water per mass (g) of sample. Oil Holding Capacity was conducted using the same method as Water Holding Capacity. (Olivos-Lugo *et al.*, 2010) [13].

Freeze thaw stability

The freez thaw stability of chia seed gel was carried out as per the method described by Tressler *et al.*, 1968 [17] and Baker and Rayas-Duarte 1998 [4]. Fifteen millilitres of 5% (w/w) solution of chia gel in water was transferred to graduated 50-mL centrifuge tube and frozen at –18 °C for 22 hrs. It was then placed in water bath at 30 °C for 1.5 h and was centrifuged using Eppendorf 5810R for 15 min at 900 × *g*. The amount of separated water was measured using the graduated centrifuge tube. The tube was then placed back inside the freezer. This method was repeated for the second freeze–thaw cycles. The functional properties of the extracted chia gel were compared against commercial food hydrocolloids guar gum and gelatine. Guar gum and gelatine were chosen since they are from different sources, guar gum being plant sourced polysaccharide and gelatine being animal based protein (Tressler *et al.*, 1968 and Baker and Rayas-Duarte 1998) [17, 4].

Emulsifying ability and stability

The Emulsifying ability and stability of chia seed gel was carried out as per the method described by Coorey *et al.*, 2013 [6]. 100 ml of 1% (w/w) solution of chia in water was made in 100 mL volumetric flask and transferred into a 250 ml measuring cylinder. The solution was then homogenized with 100 ml of canola oil at 24000 rpm for 10 min. The samples were centrifuged at 3000 rpm for 15 min. The volume of the emulsified layer was measured (Coorey *et al.*, 2013) [6]. The result of Emulsifying ability was expressed as a percentage Emulsifying ability and calculated using following formula:

Emulsifying ability (%) = 100 × (total emulsified layer mL/ total volume of suspension mL).

Emulsifying stability was tested similar to the Emulsifying ability method but after the solution was homogenized, it was heated to 85 °C for 30 min using a shaking water bath then cooled to room temperature (20 ±2 °C) using a cold water bath and centrifuged at 3000 rpm for 15 min (Coorey *et al.*, 2013) [6]. The emulsified layer was measured and the mulsifying stability calculated using the following formula

Emulsifying stability (%) = 100 × (total heated emulsified layer mL total volume of heated suspension mL).

Result and Discussion

Extraction of Chia seed gel

Hydrocolloids or food gums are key ingredients in food processing and the industry is always on the lookout for new ingredients with enhanced and/or different performance characteristics for use in novel food product development. Information on the chia gel functional properties/characteristics is essential in identifying potential food applications.

Effect of different varables on extraction of Chia seed gel

Table 1: Effect of Temperature on yield of chia seed gel at constant water to seed ratio and time

Treatment	Temperature	Water: seed ration	Time(hr.)	Yield (%)
T1	50	20:1	2	5.19
T2	60	20:1	2	5.60
T3	70	20:1	2	5.91
T1	80	20:1	2	5.21
T2	80	30:1	2	5.4
T3	80	40:1	2	6.01
T1	80	40:1	1	5.46
T2	80	40:1	1.5	5.68
T3	80	40:1	2	6.09

* Each value represents the average of three determinations.

The variation in yield with extraction temperature, extraction time and water: seed ratio was presented in the Table 8, 9 and 10. The highest extraction yield was obtained at high temperatures and short extraction times. At higher temperatures, the viscosity of the gel decreased and made the seeds less sticky. As a result, the gel was easily released and the extraction yield increased (Koocheki *et al.*, 2010) [10].

The highest extraction yield obtained was 6.09g/100 g, at 80 ºC, 2 hrs. and 40:1 (water: seed ratio), while Munoz *et al.*, (2012) obtained a value of 6.97 g/100 g for an extraction temperature of 80 ºC, a water: seed ratio of 40:1 and an extraction time of 2 hrs. These results are in good agreement with the results reported by Bruno *et al.*, (2016).

Chemical composition of chia seed gel

Chemical compositions of chia seed gels are presented in Table 2. The chemical composition of chia seed was determined on dry basis.

The data presented in Table-2 describes composition of major constituents of chia seed gel. The moisture content of sample was observed to be 5.74 per cent, while the ash value was found to be 5.09 per cent. The protein, fat and carbohydrate content chia seed gel was found to be 11.62, 3.20 and 17.49 per cent, respectively.

Table 2: Proximate composition of Chia seed gel

Chemical constituent (%)	Result
Moisture	5.74
Protein	11.62
Lipids	3.20
Ash	5.09
Crude fiber	57.84
Carbohydrates	17.49

* Each value represents the average of three determinations

Crude fibre content was observed to be 57.84 per cent, the similar results of chia seed gel for protein and lipid contents were obtained by Capitani *et al.*, (2012) [5], but the ash content obtained was higher, probably caused by the extraction conditions, due to the force applied by the mixing blade's on the seeds, causing the removal of the seed outer layers and increasing the impurities of the gel.

Viscosity behavior of Chia seed gel

Chia seed gel being a hydrocolloid has property to improve viscosity of solution. The viscous behavior of chia seed gel varies with different share rates and concentrations. In order to understand behavior of chia seed gel and its viscosity profile, the viscosity of chia seed gel at different levels were determined and the results are presented in Table 3.

The data presented in Table 3 show the viscosity of chia seed gel at different concentration. Viscosity tends to decrease when the spindle speed increases. This type of Non-Newtonian behaviour is classified as pseudo-plastic behaviour or shear thinning (Garcia-Ochoa and Casas 1992;) [9]. Such pseudoplastic behaviour is apparent at higher concentration (0.3% to 0.4%) in chia seed gel. Moreira *et al.*, (2012) [11] reported similar reduction in viscosity with increased shear for chia flour containing dough.

Table 3: Viscosity at different concentrations of chia seed gel solution at different shear rate

Shear rate (S^{-1})	Viscosity of chia seed gel at varying concentrations (mPa.s)			
	0.2%	0.4%	0.6%	0.8%
4.699	391.5	838.7	1243.2	1663.3
7.689	283.8	712.3	893.6	1241.8
12.71	212.6	659.4	776.1	915.5
21.06	185.2	595.1	698.7	867.2
34.99	171.9	527.8	613.3	786.9
SE	92.37	118.85	141.76	169.94
CD @ 5%	272.08	341.36	412.58	501.21

* Each value represents the average of three determinations.

The maximum viscosity of chia seed gel was in 0.8 percent the apparent viscosity is measured at the shear rate 4.69 s^{-1} (1663.3 mPa.s). The minimum apparent viscosity was observed in case of 0.2 percent concentration at the shear rate 34.99 s^{-1} (171.9 mPa.s). As shown from the Table- 3, all the gel solutions were susceptible to shear thinning, a characteristic of pseudoplastic foods and therefore the apparent viscosities decreased with increasing shear rate. Similar results are reported by Ranil *et al.*, (2014) [16].

Functional Properties of chia seed gel.

Chia seed gel had approximately 60% more crude fiber content compared to other gel, based on this, it could be expected that Chia seed gel could have functional properties important in food applications similar to polysaccharide-based gums.

Table 4: Different functional Properties of chia seed gel.

Functional Properties	Result
Water holding capacity	266.60/g
Oil holding capacity	58.56/g
Line spread test	5.10 mm
Emulsifying ability	61.50%
Emulsifying Stability	69.83%
Freeze-thaw stability	0%

* Each value represents the average of three determinations

The data presented in Table-4 represent the functional properties of chia seed gel. Chia seed gel had the highest water holding capacity 266.60g of water/g of sample. According to Galla and Dubasi (2010) [8], water holding capacity depends on a number of factors including ingredient and water interactions, number of hydration positions and protein configuration. High water holding capacity of chia seed gel can be explained by its higher protein and fiber contents as these components could bind water as stated by Ragab and others (2004) [15].

Chia seed gel had the highest oil holding capacity 58.6 g of oil/g of sample. The gel would have greater space in it spongy structure to absorb and trap the oil. Such sponge-like structures are not formed by gelatine and guar gum.

Chia seed gel had the spread value 5.10 mm in 1 percent concentration of gel at ambient temperature. The lower spread value represents higher gel consistency, due to its ability to hold its structure and limit the spread at a given (test) temperature.

Emulsion activity measures the ability of an emulsifying agent to form a water-in-oil dispersion whereas the emulsion stability measures its break down over time. Table 4 shows that emulsion activity of chia seed gel which is 61.50 percent. The chia seed gel had the highest (69%) emulsion stability. Chia seed gel not only has good emulsification activity but also forms stable emulsions compared to the other tested samples including commercially used guar gum and gelatine.

The good freeze–thaw ability and stability of chia seed gel (0 percent) can be explained from its high water holding capacity which reduced the amount available water that able to create ice crystals which cause water separation after thawing (Pongsawatmanit and Srijunthongsiri 2008) [14]. The functional properties of chia seed gel results are similar to the results given by Ranil *et al.*, (2014) [16]. This analysis done by using standard methods of gel analysis.

Conclusion

The data obtained in present investigation are enough to draw conclusion that Various time intervals were used to get maximum yield of chia seeds gel. The maximum yield obtained was 6.09 % with optimum extraction time of 2 hrs. and water to seed ratio 40:1 at 80 ^{0}C temperature. The extracted gels from chia seed performed better in terms of proximate composition that increase nutrition value of the prepared product. Due to the better functional properties and viscosity behaviour of the chia seed gel it has the potential to be used as stabilizing agent in food formulations.

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