www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(3): 2253-2256

www.thepharmajournal.com
Received: 07-12-2021
Accepted: 16-01-2022

Ambrish Ganachari
Assistant Professor, Department of Agriculture Engineering, College of Agriculture, Kalaburagi, UAS Raichur, Karnataka, India

Police Patil AS
Assistant Professor, Department of Agronomy, College of Agriculture, Kalaburagi, UAS Raichur, Karnataka, India

Mallikarjun Reddy
Assistant Professor, Department of Agriculture Engineering, College of Agriculture, Kalaburagi, UAS Raichur, Karnataka, India

Mathad PF
Assistant Professor, Department of Processing and Food Engineering, CAE, UAS Raichur, Karnataka, India

Hasan Khan
Assistant Professor, Department of Genetics and Plant Breeding, College of Agriculture, Kalaburagi, Karnataka, India

Sharan Bhoopal Reddy
Assistant Professor, Department of Soil Science and Agriculture Chemistry, College of Agriculture, Bhimarayanagudi, Karnataka, India

Corresponding Author:
Ambrish Ganachari
Assistant Professor, Department of Agriculture Engineering, College of Agriculture, Kalaburagi, UAS Raichur, Karnataka, India

Physical properties of Chia (*Salvia hispanica* L.) seeds required for the design of equipment

Ambrish Ganachari, Police Patil AS, Mallikarjun Reddy, Mathad PF, Hasan Khan and Sharan Bhoopal Reddy

Abstract
The important physical properties of white and black coloured Chia seeds relevant to the design of processing equipment were determined as per the standard procedure. The important physical properties *viz.*, size, shape, geometric mean diameter, sphericity, aspect ratio, bulk density, true density, porosity and thousand grain weight were determined at moisture content of 11.12% and 10.30% on wet basis, respectively for white and black coloured chia seeds. The mean value of characteristic dimensions, length, width and thickness were 1.982±0.097, 1.274±0.037 and 0.802±0.038 mm for white and 1.860±0.102, 1.220±0.028 and 0.868±0.014 mm for dark seed, respectively. The geometric mean diameter of white seed was 1.264±0.027 mm and 1.253±0.029 mm for black seed. The aspect ratio of white and black coloured seeds was 0.644±0.038 and 0.658±0.043, respectively. The sphericity values were found to be 0.639±0.029 and 0.674±0.024, respectivsssely for white and dark chia seeds predicting the shape as ellipsoid. The average values of bulk density, true density and porosity were 0.661±0.038 g/cc, 0.990±0.010 g/cc and 33.23% for white seeds and 0.742±0.008 g/cc, 1.130±0.020 g/cc and 34.34% for dark seeds, respectively. Thousand grains weight was 1.299±0.057 g for white and 1.338±0.024 g for dark seeds.

Keywords: Physical, Chia, equipment, design, *Salvia hispanica* L.

Introduction
Salvia hispanica L., commonly known as Chia, is herbaceous plant belongs to family Lamiaceae (Arctos Specimen Database, 2018) [2] and cultivated in tropical to subtropical regions. It was found to be native of southern Mexico and northern Guatemala (Busilacchi *et al*., 2013) [9]. The chia plant produces small white and dark coloured seeds. Their shape is oval, measuring 2.0mm× 1.5mm (Rulfo, 1937 cited by Ayerza and Coates, 2005) [5]. It has a smooth and shiny peel and colouring that can be black, brown, grey, black-spotted, or white (Police Patil *et al*. 2020) [23].

Chia seed is widely used in many countries for food and medicinal purpose due to its enormous nutritional and therapeutic potential (Fernandez *et al*. 2006) [12] and known for its nutraceutical value (Ayerza and Coates, 2006) [4]. Chia seed is composed of crude protein (15–25%), carbohydrates (26–41%), total fat (30–33%), dietary fibre (18–30%), ash (4-5%), minerals, vitamins along with the higher amount of antioxidants (Ixtaina *et al*., 2008) [17]. They also contain a high concentration of essential fatty acids (29-32%), polyunsaturated fatty acids, Omega-3 and Omega-6 (Peiretti and Gai, 2009) [22] and has a low cation exchange capacity (CEC) that increases the availability of proteins, minerals and vitamins in the human body (Reyes-Caudillo *et al.*, 2008; Ayerza, 2013) [24, 6]. Recently, chia seed has become important crop in respect of human health and nutrition because of its high contents of omega-3 fatty acid which promotes beneficial effects on health (Vuksan *et al.*, 2010) [31]. The ALA (alpha-linolenic fatty acid) present in Chia seed is the only known essential Omega-3 fatty acid that the human body can't produce on its own. Because of these unique quality characteristics, the production of chia has rapidly increased worldwide.

Thus, the knowledge on engineering properties of chia seeds for the development of equipment for handling, drying, storage, transportation and other processing operations for optimum utilisation of the crop became imperative. However, little information on engineering properties of Chia seed is available in the literature and the investigation was undertaken.

Materials and Methods
The Chia (*Salvia hispanica* L.) seeds were procured M/s. Nutri Planet Foods Pvt. Ltd.

Bengaluru, Karnataka for evaluating the physical properties required for design of handling and processing equipment. The grains of white and black colour were cleaned manually and used for experiment. The properly mixed seeds of about one kg of each were sampled for this study. The moisture content of the seed was estimated in hot air oven with three replications at, 103 ºC for 72 h (ASAE, 2001) [3]. The samples were cooled, weighed, and then the moisture content of each seed was calculated. The important physical properties *viz.*, size, geometric mean diameter, sphericity, true density, bulk density, porosity and 1000 grain weight were estimated.

The characteristic dimensions, length, width and thickness were measured by the method explained by Ganachari *et al*., (2010) [13] using a digital micrometre (Mitutoyo, 293-821, Illinois, USA) to an accuracy of 0.01 mm. The measurement was carried out for 20 grains selected randomly and the average of the replications was recorded (Shivabasappa *et al.*, 2012) [26]. The geometric mean diameter (GMD) and the sphericity of the seed were calculated using the measured three characteristic dimensions by the equations given by Mohsenin, (1986) [21]. The grain shape is the very substantial property of the grain, which is mostly defined by the aspect ratio. The aspect ratio is basically the ratio of the length to the width of the seed and generally measured in millimetre (Maduako and Faborode, 1990) [19]. The shape of the Chia seed was determined by comparing the measured dimensions with the shapes described in the standard chart (Balasubramanian and Viswanathan, 2010) [7].

The bulk density is estimated using a container of the known volume. The seed sample filled into the container of the known volume was weighed and the bulk density was calculated by ratio of weight to volume (Mohsenin, 1986) [21]. The true density (ρt) is determined by toluene displacement method in a measuring cylinder of known volume and pouring the known weight of grain sample. The true density of the grain was calculated by dividing weight by volume (Mohsenin, 1986) [21]. The porosity was determined using the bulk and true density values as explained by Mohesenin, (1970) [20]. The weight of 1000 grains was calculated by randomly selected hundred grains weighted using an electronic balance of accuracy of 0.001 g (Ghadge and Prasad, 2012) [14]. The average weight of 100 grains was used to calculate the weight of 1000 grains (Ixtaina *et al*. 2008) [17].

Statistical analysis

The experiments were conducted in three replications for each property unless stated otherwise, and the average values with their minimum, maximum and standard deviations were reported. The data of various parameters were analyzed statistically at the 5% level of confidence in one-way Anova.

Results and Discussion

The moisture content of the white and dark coloured seed sample were determined as per the procedure explained and found to be 11.12% and 10.30%, respectively on wet basis. The important physical properties relevant for the design of processing equipment were determined for the white and dark coloured chia seeds and the results are presented in Table.1. The average dimensions of seed length, width and thickness were 1.982±0.097, 1.274±0.037 and 0.802±0.038 mm for white coloured chia seeds and 1.860±0.102, 1.220±0.028 and 0.868±0.014 mm for dark chia seeds, respectively. The value of length varied from 1.830 to 2.090 mm for white and 1.690 to 1.940 mm for dark Chia seed whereas, width and thickness from 1.210 to 1.300 mm and 0.760 to 0.850 mm for white and 1.170 to 1.240 mm and 0.850 to 0.890 mm for black coloured chia seeds, respectively. The dimensions reported by Ixtaina *et al*. (2008) [17] and Suleiman *et al* (2019) [27] for Chia seeds were in the same range. It can be observed that the size different was very small but the size of white seeds are found to be larger than the black ones (Ayerza and Coates, 2005 [5]; Ixtaina *et al.*, 2008) [17]. The dimensions of chia seed were observed to be higher than amaranth seeds (Abalone *et al.*, 2004) [1] and lessor than the pearl millet (Jain and Bal, 1997), sesame (Tunde-Akintunde and Akintunde, 2004) [29] and coriander (Coskuner and Karababa, 2007) [10].

The geometric mean diameter was observed to be 1.264±0.027 mm and 1.253±0.029 mm for white and black and white seeds, respectively and the values were within the same range to those reported for Chia seeds by Ixtaina *et al*. (2008) [17]. The aspect ratio was found to be 0.644±0.038 and 0.658±0.043 for white and dark chia seeds, respectively. The sphericity was calculated to be 0.639±0.029 and 0.674±0.024 for white and dark chia seeds, respectively. The lower aspect ratio and sphericity would indicate the property of seed to slide on flat surfaces rather than roll. The results reported were in agreement with Ixtaina *et al*. (2008) [17] for chia seeds but slightly higher than those reported by Suleiman *et al*. (2019) [27] for chia seeds. Furthermore, the shape of the chia seeds cannot be considered as spherical because of their low sphericity value (Suleiman *et al*., 2019 [27]; Hauhouot-O'Hara *et al*., 2000) [16]. The shape indices based on the three unequal semi-axes and sphericity indicated that the chia seed may be treated as ellipsoid in shape. Similar shape was expressed by Ixtaina *et al*. (2008) [17] for chia seeds.

The mean bulk density values were 0.661±0.038 g/cc and 0.742±0.008 g/cc for white and dark coloured chia seeds, respectively. It can be observed that the bulk density values were lower than the dark seeds and may be attributed to its smaller size. Similar results were reported by Ixtaina *et al*. (2008) [17] and Suleiman *et al*. (2019) [27] for chia seeds. The true density and the porosity values for white and dark coloured chia seeds were reported to be 0.990±0.010 g/cc and 1.130±0.020 g/cc, and 33.23 and 34.34%, respectively. The true density values reported by Ixtaina *et al*. (2008) [17] were similar but the porosity was lower. The true density and porosity values are important parameters to determine the resistance for movement of air during aeration or drying operations. The average weight of 1000 grains determined for white coloured chia seed was 1.299±0.057 g and 1.338±0.024 g for dark coloured seeds. The values reported were similar to those reported by Ixtaina *et al*. (2008) [17] for chia seeds but lower than those reported by Vilche *et al*., (2003) [30] for quinoa and higher than amaranth seeds (Abalone *et al*. 2004) [1].

The colour values determined for white and black coloured chia seed were presented in Table.1. The *L** value is the measure of degree of lightness was found to be 60.46±0.038 for white seed and 34.95±0.21 for dark coloured chia seeds. The *a** value was observed to be 4.20±0.08 and 3.01±0.07 for white and dark coloured chia seeds, respectively with higher value indicating colour towards reddish. Likewise, the value of *b** was recorded to be 13.08±0.46 and 8.07±0.21 for white and dark coloured chia seeds, respectively indicating the more yellowish for white coloured seeds compared to dark coloured seeds. The colour values reported by Suleiman *et al*. (2019) [27] were slightly lesser and this might be due to seed sample selected was mixture of white and dark seeds.

Table 1: Physical properties of white and black coloured chia seeds at the moisture content of 11.12% (w.b.) and 10.30% (w.b.), respectively

Property		**White seeds**				**Black seeds**			
		Mean	**Min.**	**Max.**	**S.D.**	**Mean**	**Min.**	**Max.**	**S.D.**
Size	L	1.982	1.830	2.090	0.097	1.860	1.690	1.940	0.102
	w	1.274	1.210	1.300	0.037	1.220	1.170	1.240	0.028
	t	0.802	0.760	0.850	0.038	0.868	0.850	0.890	0.014
GMD (mm)		1.264	1.238	1.308	0.027	1.253	1.209	1.283	0.029
Aspect ratio		0.644	0.617	0.710	0.038	0.658	0.615	0.728	0.043
Shape		**Ellipsoid**							
Sphericity (%)		0.639	0.622	0.691	0.029	0.674	0.655	0.715	0.024
Bulk density (g/cc)		0.661	0.653	0.670	0.008	0.742	0.734	0.750	0.008
True density (g/cc)		0.990	0.980	1.000	0.010	1.130	1.110	1.150	0.020
Porosity (%)		33.232				34.336			
1000 seed mass (g)		1.299	1.200	1.343	0.057	1.338	1.300	1.360	0.024
Colour	L*	60.46	59.95	60.95	0.50	34.95	34.73	35.15	0.21
	a*	4.20	4.11	4.26	0.08	3.01	2.95	3.09	0.07
	b*	13.08	12.61	13.53	0.46	8.07	7.82	8.20	0.21

Conclusions

The conclusions drawn from the investigation on engineering properties of chia seeds at an average moisture content of 11.12% (w.b) for white and 10.30% (w.b) for black chia seeds are presented below. The size of the white chia seed was slightly larger compared to the black seed with an average geometric mean size values of 1.264±0.027 mm and 1.253±0.029 mm, respectively. The sphericity and aspect ratio indicated the shape of chia seed resembled ellipsoid. The bulk density, true density and porosity were 0.661±0.038 g/cc, 0.990±0.010 g/cc and 33.23% for white seeds and 0.742±0.008 g/cc, 1.130±0.020 g/cc and 34.34% for dark seeds, respectively indicating more bulkiness for black chia seeds. Colour values *L* a** and *b** showed higher lightness for white coloured seeds with yellowish ting compared to black coloured seeds. The angle repose, hardness and terminal velocity were determined to be 21.30°, 1499.9±254.37 g and 3.87±0.04 m/s for white seeds and 20.30°, 4040.36±293.78 g and 3.98±0.06 m/s for dark coloured chia seeds, respectively. In brief, the reported results enlarge the knowledge about the properties of chia seeds providing useful data for its industrial processing.

References

1. Abalone R, Cassinera A, Gaston A, Lara MA. Some physical properties of Amaranth seeds. Biosyst. Eng. 2004;89:109–117.
2. Arctos Specimen Database. Collaborative collection management solution. Retrieved from http://arctos.database.museum/name/Salvia%20hispanica #Arctos Plants, 2018. Accessed: September, 10, 2019
3. ASAE (American Society of Agricultural Engineers). Moisture measurement unground grain and seeds. In: ASAE Standards 2000, ASAE, St. Joseph, MI, 2001. Online available at: http://www.asabe.org (accessed on 11. 10. 2014).
4. Ayerza R, Coates W. Chía, redescubriendo un olvidado alimento de los Aztecas. Del nuevo extremo S.A. Buenos Aires, Argentina, 2006, 205.
5. Ayerza R, Coates W. Chia: Rediscovering a forgotten crop of the Aztecs. USA: University of Arizona Press. ISBN 10: 0816524882 ISBN 13: 9780816524884, 2005.
6. Ayerza R. Seed composition of two chia (*Salvia hispanica* L.) genotypes which differ in seed color. Emirates Journal of Food and Agriculture. 2013;25(7):495-500.
7. Balsubramanian S, Vishwanathan R. Influence of moisture content on physical properties of minor millets. Journal of Food Science and Technology. 2010;47(3):279-284. DOI: 10.1007/s13197-010-0043-z
8. Bhupender SK, Rajneesh B, Baljeet SY. Physicochemical, functional, thermal and pasting properties of starches isolated from pearl millet cultivars. International Food Research Journal. 2013;20(4):1555-1561.
9. Busilacchi H, Quiroga M, Bueno M, Di Sapio O, Flores V, Severin C. Evaluacion de salvia hispanica l. cultivada emelsur de santafe ´ (Republica Argentina). Cultivos Tropicales. 2013;34(4):55–59. Retrieved from http://scielo.sld.cu/pdf/ctr/v34n4/ctr09413.pdf
10. Coskuner Y, Karababa E. Physical properties of corianderseeds (*Coriandrum sativum* L.). J Food Eng. 2007;80:408–416.
11. De Figueiredo AK, Baümler E, Riccobene IC, Nolasco SM. Moisture-dependent engineering properties of sunflower seeds with different structural characteristics. Journal of Food Engineering. 2011;102(1):58-65. doi:10.1016/j.jfoodeng.2010.08.003
12. Fernandez IR, Ayerza W, Coates SM, Vidueiros NC, Pallaro AN. Nutritional characteristics of chia. Actualización en Nutrición. Tucson, Arizona 85706, USA. Office of Arid Lands Studies, the University of Arizona. 2006;7:23-25.
13. Ganachari A, Thangavel K, Ali SM, Nidoni U, Ananthacharya. Physical properties of Aonla fruit relevant to the design of processing equipments. International Journal of Engineering Science and Technology. 2010;2:7562-7566.
14. Ghadge PN, Prasad K. Some Physical Properties of Rice Kernels: Variety PR-106. J Food Process Technol. 2012;3:175. doi:10.4172/2157- 7110.1000175
15. Gouda GP, Sharanagouda H, Nidoni U, Ramachandra CT, Naik N, Ananada N, *et al*. Studies on engineering properties of foxtail millet [*Setaria italica* (L.) Beauv.]. J Farm Sci. 2019;32(3):340-345.
16. Hauhouot-O'Hara M, Criner BR, Brusewitz GH, Solie JB. Selected physical characteristics and aerodynamic properties of cheat seed for separation from wheat. Agric. Eng. Int., 2000.
17. Ixtaina VY, Nolasco SM, Tomás MC. Physical properties of Chia (*Salvia hispanica* L.) seeds. Ind. Crops and Prod. 2008;28(3):286-293.

18. Jain RK, Bal S. Physical properties of Pearl millet. J Agric. Eng. Res. 1997;66:85-91.
19. Maduako JN, Faborode MO. Some physical properties of cocoa pods in relation to primary processing. Ife J Technol. 1990;2:1-7.
20. Mohsenin NN. Physical Properties of Plant and Animal Materials. New York, N.Y.: Gordon and Breach Science, 1970.
21. Mohsenin NN. Physical Properties of Plant and Animal Materials, 2nd edition. Gordon and Breach Science Publishers, New York, 1986.
22. Peiretti PG, Gai F. Fatty acid and nutritive quality of chia (*Salvia hispanica* L.) seeds and plant during growth. Animal Feed Science and Technology. 2009;148:267-275.
23. Police Patil AS, Ambrish G, Reddy SB, Reddy BS. Importance of Chia (*Salvia hispanica*) Cultivationin Indian Agriculture. Vigyan Varta. 2020;1(6):17-19.
24. Reyes-Caudillo E, Tecante A, Valdivia MA, López MA. Dietary fibre content and antioxidant activity of phenolic compounds present in Mexican Chia (*Salvia hispanica* L.) seeds. Food Chemistry. 2008;107:656-663.
25. Sahay, Singh. Unit operations of Agricultural processing. Vikas Publishing house Pvt Ltd, New Delhi, 2001.
26. Shivabasappa, Roopa RS, Sridevi, Sharanagouda H, Udaykumar N. Engineering properties of finger millet (*Eleusine coracana* L.) grains. International Journal of Agricultural Engineering. 2012;5(2):178-181.
27. Suleiman R, Xie K, Rosentrater KA. Physical and Thermal Properties of Chia, Kañiwa, Triticale, and Farro Seeds as a Function of Moisture Content. Applied Engineering in Agriculture. 2019;35(3):417-429. doi:10.13031/aea.13142
28. Sunil CK, Venkatachalapathy N, Shanmugasundaram S, Akash Pare, Loganathan M. Engineering properties of foxtail millet (*Setaria italic* L): variety- HMT 1001. International Journal of Science, Environment and Technology. 2016;5(2):632-637
29. Tunde-Akintunde TY, Akintunde BO. Some physical properties of Sesame seed. Biosyst. Eng. 2004;88:127-129.
30. Vilche C, Gely M, Santalla E. Physical properties of quinoa seeds. Biosyst. Eng. 2003;86:59-65.
31. Vuksan V, Jenkins AL, Dias AG. Reduction in postprandial glucose excursion and prolongation of satiety, possible explanation of the long-term effects of whole grain Salba (*Salvia hispanica* L.). Euro. J Clin. Nutr. 2010;64:436-438.