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Physico Chemical and Functional Properties of Lotus (*Nelumbo nucifera*) Seed

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Abstract

The purpose of the current research was to identify the physical, chemical and functional properties of lotus (*Nelumbo nucifera*) seed. The physical characteristics of the lotus seeds without and with seed coat such as 1000 seeds weight, length and width are ranging from 118.43 to 209.06g, 1.68 to 2.32cm and 1.27 to 1.43cm, respectively. The L*, a* and b* values for lotus seeds to its flour ranging from 83.30 to 88.53, 2.50 to 1.08 and 20.50 to 15.02, respectively. The pH of the lotus flour is 7.43. The water holding capacity, oil holding capacity, emulsifying activity, emulsifying stability, foaming capacity and foaming stability of the lotus seed flour are 4.67ml/g, 2.01ml/g, 60.0%, 81.48%, 12.50% and 60.15%, respectively. Inline, lotus seed flour has a good amount of protein, crude fibre and carbohydrates respectively. Hence, lotus seed flour has a greater potential for exploitation in food and pharmaceuticals.

Keywords : Functional properties, Lotus seed, Lotus seed flour, Nutritional composition, *Nelumbo nucifera*

Lotus (*Nelumbo nucifera*) is an aquatic perennial vegetable belongs to the family Nelumbonaceae. It is also known as water lilly, sacred lotus or Indian lotus which is mainly found throughout the Asian continent (China, India, Sri Lanka, Thailand, Japan and Russia) and in Northern parts of Australia and North America. Almost every part of this plant can be used, with the rhizome (sometimes called root) and seeds being the main consumption parts. Lotus seeds and their processing by-products are widely consumed in Asia (China, Japan, India and other Southeast Asian countries), Americans and Oceania for their high content of physiologically active substances (Mukherjee *et al.,* 2009).

Among all plant parts, the lotus seed has attracted special attention from researchers due to its richness in major food components (lipid, protein, starch, vitamins and minerals) and bioactive compounds. The seed contains 61-62 per cent of carbohydrates, 16-21 per cent of total protein, 2.40 - 3 per cent of crude fat with 5-9 per cent of moisture content (Sathithon & Yan-bin, 2012; Shahzad *et al*., 2021). One of the dominant components of carbohydrates present in lotus seed is starch. The retrograded starch or resistant starch of lotus seed demonstrated strong prebiotic effects by stimulating the growth of beneficial microbes in the gut (Zeng *et al.,* 2018).

Lotus seeds have been used as a vegetable, functional food and medicine for 7,000 years. These are low caloric, a rich source of multiple nutrients and bioactive constituents, which make them a unique therapeutic food (Arooj *et al.,* 2021). Lotus seeds are consumed in many forms as raw or cooked, ripened or un-ripened and are mostly used in desserts (Chen *et al.,* 2019). These seeds can also be used as roasted/ ground, raw and boiled into syrups (Moro *et al*., 2013). Lotus seed contains a diverse range of phytochemicals including alkaloids, flavonoids, polysaccharides, essential oils, glycosides, polyphenols, triterpenoids, etc., which have a wide range of pharmaceutical properties (Chen *et al*., 2012; Huang *et al*., 2010 and Zhenjia *et al*., 2010).

Flour and starches are important ingredients in the food industry. As new food products are developed, starches or flours with specific properties are necessary to impart functionally desirable attributes. However, unfortunately, little data has been reported on the physicochemical and functional characteristics of lotus seed flour. Therefore, the study was undertaken to determine the physical, chemical and functional properties of lotus (*Nelumbo nucifera*) seed flour. Results of the present study will help to explore the possibilities of utilizing the lotus seed flour for the development of value-added products as a potential ingredient.

MATERIAL AND METHODS

The study was conducted in the Department of Food Science and Nutrition, University of Agricultural Sciences, GKVK, Bengaluru.

Selection and Collection of Sample

The fresh lotus seeds were obtained from the states of Karnataka and Tamil Nadu. The lotus seeds were extracted from the lotus seed heads and used for further processing (Fig. 1).

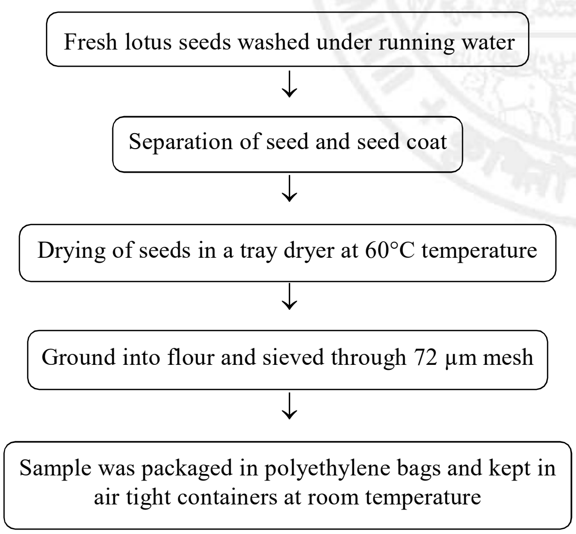

Fig. 1 : Flowchart of Processing of Lotus seed flour

Physical Properties of Lotus Seeds

Physical characteristics *viz.,* seed length, width was assessed by using a vernier calliper and 100 seed weight was calculated using a digital weighing balance.

The Colour was estimated using a reflecting colorimeter (Chroma meter CR-300). The samples were kept in a colorimeter petri dish and readings were taken in triplicates. The L*, value is a measure of lightness/brightness, ranging from 0 (black) to 100 (white). The a* value is a measure of greenness/ redness, ranging from –60 (green) to +60 (red) and the b* value is a measure of bluishness/yellowness, ranging from –60 (blue) to +60 (yellow).

Bulk Density (Loose and Packed Bulk Density) : The preweighed (W1) bulk density of the flour was determined using the Akpapunam and Markakis (1981) method. A measured amount of flour was deposited in a preweighed (W1) measuring cylinder and both the weight of the cylinder (W2) and the volume of the flour (V1) were recorded.

The loose bulk density (LBD) was calculated as LBD = W2 – W1 ÷ V1.

The flour in the cylinder was gently tapped to remove any air pockets between the flour particles. The sample's new volume (V2) and mass (W3) were recorded and the packed bulk density (PBD) was calculated as PBD = W3 – W1 ÷ V.

TSS (total soluble solids) were measured with a digital hand refractometer and expressed as degrees Brix (°Brix).

Chemical Properties of Lotus Seed Flour

pH was analyzed using a digital Cole Parmer pH meter

The moisture, protein, fat, crude fibre and ash contents were determined by using standard AOAC, 2005 techniques to determine moisture, protein, fat, crude fibre and ash contents. The differential method was used to calculate carbohydrate content. The energy was also determined using the computing method and all values were expressed as % w/w, based on a dry weight.

CHO (g/100g) = 100- [Protein(g) + Fat(g) + Fibre(g) + Ash(g) + Moisture(g)]

Energy (kcal) = [Protein (g) × 4] + [Carbohydrate (g) × 4] + [Fat (g) × 9]

Functional Properties of Lotus Seed Flour

Water Holding Capacity

Water holding capacity was calculated using a method developed by Gould and others (1989), with minor adjustments. 3 g of the flour sample (dry) was weighed into a centrifuge tube, adding 30ml distilled water and mixed for 30 seconds with a cyclo mixer. The sample was allowed to hydrate at room temperature for 2 hours. This was followed by a 10-minute centrifugation at 2800 rpm. The supernatant was discarded and the hydrated sample was weighed. The findings were expressed as,

$$\text{Water holding} = \frac{\text{Weight of hydrated sample (g) - weight of dry sample (g)}}{\text{Capacity (g / g) weight of dry sample (g)}}$$

Oil Holding Capacity

The oil holding capacity was calculated using the approach of Caprez and others (1986), with minor adjustments. A sample of 3 g dried flour was weighed into a centrifuge tube, combined with 30 mL of corn oil, then mixed for 30 seconds with a cyclo mixer. The sample was allowed to stand at room temperature for 1 hour. This was followed by 10 minutes of centrifugation in a benchtop centrifuge at 2800 rpm. The pellet was weighed after the supernatant was drained. The findings were expressed as,

$$\text{Oil holding} = \frac{\text{weight of pellet (g)-weight of dry sample (g)}}{\text{capacity (g/g) weight of dry sample (g)}}$$

Emulsion Activity and Stability

The emulsion activity and stability determined by Yasumatsu *et al.* (1972) were followed and the emulsion (1 g sample, 10 ml distilled water and 10 ml sunflower oil) was prepared in a calibrated centrifuge tube. The emulsion centrifuged at 2000 × g for 5 min. The ratio of the height of the emulsion layer to the total height of the mixture was calculated as emulsion activity in percentage. The emulsion stability was estimated after heating the emulsion contained in the calibrated centrifuged tube at 80°C for 30 min in a water bath, cooling for 15 min under running tap water and centrifuging at 2000 × g for 15 min. The emulsion stability expressed as a percentage was calculated as the ratio of the height of the emulsified layer to the total height of the mixture.

Dispersibility

Dispersibility was determined by the method described by Kulkarni *et al.* (1991) modified by Akanbi *et al.* (2009). 10g of flour was suspended in a 100 ml measuring cylinder and distilled water was added to reach a volume of 100 ml. The setup was stirred vigorously and allowed to settle for 3 hrs. The volume of settled particles was recorded and subtracted from 100. The difference was reported as percentage dispersibility.

Foaming Capacity

The foaming capacity of the flour was determined by the known method (Coffman & Garcia, 1977). Seed flour (2 g) was dispersed in distilled water (100 mL) and homogenized properly for two minutes using the cyclo mixer. The volumes were recorded before and after homogenization and the per cent increase in the volume was calculated as foaming capacity using the following formula:

$$\text{Foaming capacity (\%)} = 100\ (V2 - V1 \div V1)$$

where,

V1 = initial volume

V2 = volume of solution after homogenization

Foaming Stability

The foam was allowed to stand for 8 hours at room temperature and the foam stability (FS) was expressed as the percentage retention of the initial foam volume as:

$$\text{Foaming stability (\%)} = 100\ (Vt \div V_0)$$

where,

V_0 = initial foam volume and

Vt = foam volume after time (t)

Statistical Analysis

The data were subjected to analysis of variance (ANOVA) for testing the significance of variation using SPSS (Statistical Package for Social Sciences) software 16.0.

RESULTS AND DISCUSSION

Physical Properties of Lotus Seeds

The physical properties of the lotus seed is as summarized in Table 1. Results revealed that the mean scores of 100 seeds weight, length and width of lotus seeds without and with seed coat ranges from 118.43 to 209.06g, 1.68 to 2.32cm and 1.27 to 1.43cm, respectively. It's indicating that the whole seed weighs more compared to the seed alone. Whereas the loose bulk density and packed bulk density of lotus seeds to lotus seed flour ranges from 1.8 to 0.5 and 1.8 to 0.58, respectively. Similar results were obtained in the study conducted by Shad *et al.,* 2011 for lotus rhizome flour. Also, the present findings were found to be comparable to those reported for wheat and sweet potato flour blends (Adeleke and Odedeji, 2010). Bulk density values help to develop suitable nutrient dense products and it mainly depends on the density or particle size of the flour. TSS of the lotus seed flour is 6.50 °Brix.

TABLE 1

Physical properties of lotus seed

Parameters	Without seed coat	With seed coat
100 seeds weight (g)	118.43 ± 3.41	209.06 ± 4.37
Length (mm)	1.68 ± 0.04	2.32 ± 0.19
Width (mm)	1.27 ± 0.01	1.43 ± 0.05
Parameters	**Lotus Seed**	**Lotus seed flour**
Bulk density (g/mL)		
Loose Bulk Density	1.80	0.5
Packed Bulk Density	1.80	0.58
TSS (°Brix)	-	6.50

Colour Analysis of Lotus Seeds and its Flour

The colour analysis of the lotus seeds and its flour results were depicted in Table 2. Results revealed that, L*, a* and b* values for lotus seeds to its flour ranges from 83.30 to 88.53, 2.50 to 1.08 and 20.50 to 15.02, respectively. It shows that there is a significant difference among all the parameters *viz.,* L*, a*, and b*. The L* values of both lotus seeds and its flour indicate white in colour. The value for a* was found to be high in lotus seeds compared to lotus seed flour which means both are red and the values ranges from 2.50 to 1.08. The b* values are also high in lotus seeds when compared to lotus seed flour. However, the b* values of both the lotus seeds and its flour are yellow in colour. It also observed that there is a significant difference among all the parameters *viz.,* L*, a* and b* in both lotus seed as well as lotus seed flour. Similar results were obtained in the study conducted for Thai lotus seed flour by Singthong and Meesit, 2017. The present results are on par with the study conducted by Ham *et al.* (2017) because they subjected the seeds to different cooking and drying methods.

Chemical and Functional Properties of Lotus Seed Flour

Table 3 depicts the chemical and functional properties of lotus seed flour. Results revealed that pH is 7.43. It

TABLE 2

Colour analysis of lotus seeds and its flour

Samples	L*	a*	b*
Lotus seed	83.30 ± 0.88	2.50 ± 0.64	20.50 ± 2.95
Lotus seed flour	88.53 ± 0.06	1.08 ± 0.0	15.02 ± 0.11
Mean ± SD	85.91 ± 2.91	1.79 ± 0.87	17.76 ± 3.53
F value	*	*	*
SEM	0.36	0.26	1.2
CD @ 5%	1.41	1.01	4.74

TABLE 3
Chemical and functional properties of lotus seed flour

Parameters	Values
pH	7.43
Water holding capacity (g water/g dry sample)	4.67
Oil holding capacity (g oil/g dry sample)	2.01
Emulsifying activity (%)	60.00
Emulsifying stability (%)	81.48
Dispersibility (%)	30.50
Foaming capacity (%)	12.50
Foaming stability (%)	60.15

indicates that lotus seed flour was neutral. The pH of the present study was neutral compared to the study conducted for wheat and sweet potato flour by Adeleke and Odedeji, 2010 and it indicates that wheat and sweet potato are slightly acidic when compared to the lotus seed flour. The water holding capacity and oil holding capacity of the lotus seed flour are 4.67ml/g and 2.01ml/g, respectively. The WHC and OHC results were in line with the study conducted by Kayitesi *et al.,* 2012 for tapioca flour. Whereas, the WHC and OHC of the present study are slightly higher than the study reported for Thai lotus seed flour, tiger nut flour, wheat and sweet potato flour, respectively (Singthong & Meesit, 2017; Oladele & Aina, 2007; Adeleke & Odedeji, 2010 and Muttagi *et al.,* 2017). WAC and OAC values of seed flours indicate the ability of the protein to absorb and retain water or oil and may help to improve binding of the structure, flavour retention and mouthfeel and reduce moisture and fat losses in extended meat products and baked products (Maninder *et al.,* 2007 and Bhat & Sridhar, 2008). The Emulsifying activity and emulsifying stability, dispersibility, foaming capacity and foaming stability of the lotus seed flour are 60.00, 81.48, 30.50, 12.50 and 60.15, respectively. The results of emulsifying activity and emulsifying stability of the present study are in line with the study of (Singthong & Meesit, 2017 and Bhat *et al.,* 2009), respectively. Lotus seed flour can be used as stabilizer in the production of sausage, soup, mayonnaise, salad dressing and bakery products (Singthong and Meesit, 2017). Also, the results of foaming capacity and foaming stability of the lotus seed flour are in line with the study of Singthong and Meesit, 2017 and Oladele & Aina, 2007, respectively. Increased protein concentration has been found to facilitate enhanced protein-protein interactions at the air-water interface and promote the formation of a highly viscoelastic multilayer film that offers resistance to the coalescence of bubbles (Adebowale and Lawal, 2003).

Nutritional Composition of Lotus Seed Flour

The nutritional composition of lotus seed flour is shown in Table 4. The results revealed that the moisture, protein, fat, ash, crude fibre, carbohydrate and energy contents were 4.59 per cent, 19.25g, 1.66g, 5.23g, 4.25g, 65.02g and 352.02 kcal, respectively. The present results were in line with the study conducted by Singthong & Meesit, 2017; Shukla & Chaturved, 2015; Antarkar *et al.,* 2019 and Shahzad *et al.,* 2021. However, the protein and moisture content are more in the study conducted by Jirukkakul and Sengkhamparn, 2018. It might be due to the differences in the cultivar, growing zone and climatic condition of the seeds. The proximate composition of the lotus seed in the present study indicates that the utilization of lotus seed flour will help to develop value-added products and bakery products with high protein and carbohydrates.

TABLE 4
Nutritional composition of lotus seed flour per 100g

Nutrients	Lotus seed flour
Moisture (%)	4.59 ± 0.25
Protein (g)	19.25 ± 0.24
Fat (g)	1.66 ± 0.30
Ash (g)	5.23 ± 0.04
Crude fibre (g)	4.25 ± 0.09
Carbohydrates (g)	65.02 ± 0.15
Energy (Kcal)	352.02 ± 0.44

The results of the present study showed that lotus seed flour is a good source of protein, fibre and carbohydrates. Also, it had better functional properties like water holding capacity, oil holding capacity and emulsion properties. Hence, utilization of lotus seed and its flour will help to develop value added functional and bakery products. Hence, the present results of the study will provide basic information about the lotus seed and its flour.

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