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Processing, Physical, and Functional properties of Lotus Stem and Jamun Seed Flours

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ABSTRACT: Lotus stem and Jamun Seed flours have a high potential for use in various food applications as they possess many health, functional and therapeutic benefits. This study aimed to evaluate both the flour's physical and functional properties. The yield of both flours is 73.56% and 86.74% respectively. Moisture content and water activity indicated that the flours have a longer shelf life. Lotus stem powder exhibited a greater inferior ability than Jamun seed flour in terms of physical properties. The presence of fibre in lotus stem powder led to higher Water and Oil Absorption Index than in Jamun Seed flour. Swelling Index and Foaming capacity were higher in Jamun seed flour indicating the presence of higher protein. Lotus Stem powder did not form strong gel even at 20% concentration whereas, Jamun seed powder formed strong gel at 10% only. Based on these properties both flours can be incorporated/substituted/ replaced into different foods.

Keywords: Lotus stem, Jamun seed powder, Functional properties, Swelling Index, Foaming capacity.

INTRODUCTION

Nelumbo nucifera belongs to the family of Nelumbonaceae, which is called by names like Indian lotus, Chinese water lily, and sacred lotus. Lotus stem is full of nutrition, it contains an abundant amount of protein, amino acids, dietary fiber, starch, and Vitamin C, Vitamin B_1 and Vitamin B_2 and has some tremendous health benefits. Lotus stem is a rich source of fibre with complex carbohydrates, which helps lower the blood glucose level and is also good for weight loss seekers (Ogle *et al*. 2001). Lotus stem powder possesses anti-diarrhea, anti-inflammatory, antioxidant, antipyretic and hypoglycemic activities (Bhardwaj and Modi 2016). It has an antibacterial effect against *Staphylococcus aureus*, *Escherichia coli, Bacillus subtilis, B. pumilis*, and *Pseudomonas aeruginosa* and the ethanol extract has hypoglycemic properties. Additionally, LSP plays a major role in preventing and treating anemia because the highest amount of iron is a key source of iron for vegetarians when consumed with vitamin C-rich foods (Dungarwal, 2019; Khushboo *et al.*, 2020). This overall profile of the lotus seed makes them potential nutraceutical and bioactive food ingredients. Utilizing this low-cost horticultural waste for producing value-added products is a novel step in its sustainable utilization (Bangar *et al.*, 2022).

Syzygium cumini (Family Myrtaceae) is also known as *Syzygium jambolana and Eugenia cumini*. Jamun seeds are widely used for their antimicrobial and antioxidant properties, which help protect against several cancers (Vasi and Austin 2009). Jamun seeds are abundant sources of tannins, phenolics, and terpenoids which are health-promoting properties of Jamun seeds (Liu *et al*., 2017a, b). Their amount is large because they constitute 10–47% of the total weight of the fruit (Din *et al*., 2020). Besides having multiple benefits seeds are going to waste after fruit usage.

Jamun seeds are potential sources of bioactive compounds like tannins, phenolic acids, flavonoids, other phenolics, terpenoids, and saponins, which have been projected for biological activities, such as antidiabetic, anticancer, anti-inflammatory, antihyperlipidemic, and antihypercholesterolemic, cardioprotective, and neuroprotective properties. Apart from this these seeds have high contents of carbohydrates, dietary fiber, minerals, and ascorbic acid have also been found in Jamun seeds (Yamini *et al.*, 2022).

Despite their nutritional and medicinal importance, the lotus stem and Jamun Seed powders remained an underutilized and unexploited ingredient in food use. Therefore, there is a need to exploit these powders for the development of value-added products. Hence, this study was taken up to investigate the powder properties, for which the critical evaluation of its functional behavior is crucial to know the applicability of these powders in foods.

MATERIALS AND METHOD

Processing of lotus stem and Jamun Seed powder: Lotus stems with an average length of 45.0-57.0 cm and width of 4.0- 5.0 cm were purchased from the local market of Chennai. They were thoroughly washed with water to remove the surface impurities, peeled, and washed again. Lotus stem was manually cut into thin slices of 0.002 cm thickness and dried in a hot air oven at 70°C for 6 h. Dried lotus stem flakes were milled by a laboratory pulverizer and then passed through a sieve of 450 µm (Chen and Tengku, 2020; Saeed *et al*., 2020) Fig. 1.

Jamun fruits were procured from Chennai. Rightly matured disease-free and good Jamun fruits were selected. The seeds of the Jamun fruit were separated from the pulp. Then the seeds were washed in water, sliced and dried in a Hot air oven at 60°C for 48 hours. Seeds were grounded in a pulverizer to fine powder of particle size 450 µm Fig. 1.

Fig. 1. Lotus Stem and Jamun Seed Powder.

Physical properties

Moisture content and water activity: The initial pulp and final powder moisture contents were analyzed by the Hot air oven method at 105°C ± 2°C until constant weights are achieved. The water activity of the fruit powders was analyzed by Lab swift portable - water activity meter.

Bulk and Tapped Density: The bulk densities of the flours were calculated by following the formula and method described by Vijayakumar *et al*. (2014). Bulk density was measured by the volume occupied by a 1gm sample which was placed in a 10 ml graduated measuring cylinder. Bulk density is calculated by the formula:

$$\text{Bulk Density } (\rho b) = \frac{\text{Weight of flour (g)}}{\text{Volume of the flour (ml)}}$$

$$\text{Tapped Density } (\rho t) = \frac{\text{Weight of flour (g)}}{\text{Volume of the flour (ml)}}$$

1g of flour sample was measured in a 10 ml graduated cylinder. The cylinder was tapped vigorously by hand. The volume of flour in the cylinder was noted. The tapped density (ρt) is calculated by the following formula.

Carr compressibility index and Hausner ratio: The flow characteristics of the flour samples were measured by calculating the Carr Index (Carr, 1965) and the Hausner ratio (Hausner, 1967) from bulk density and tapped density values. The compressibility index derived from the Carr index has an inverse relation with flowability, i.e. the more compressible the material is the less flowable.

$$\text{Carr Index (CI)} = \frac{\text{Tapped density } (\rho t) - \text{Bulk Density } (\rho_b)}{\text{Tapped density } (\rho t)} \times 100$$

$$\text{Hausner Ratio (HR)} = \frac{\text{Tapped density } (\rho_t)}{\text{Bulk Density } (\rho_b)}$$

Functional properties of flours and fruit powders: Functional properties are the indispensable characteristics of powders that relate to the constitutions, compounds integrations of ingredients between the configuration, and the behavior during processing and preparation (Joshi *et al*., 2015).

Water and oil absorption capacity (WAC and OAC): The water/oil absorption capacity of flour was evaluated by the method explained by Chandra *et al*. (2015). 1g of sample was mixed with 10 ml water/soybean oil and allowed to stand at ambient temperature (30±2°C) for 30 min, centrifuged for 30 min at 300 rpm. The volume of water/oil used was measured. The water/oil absorption power was calculated by the following formula

$$\text{Water/ Oil Absorption Capacity (\%)} = \frac{W_2 - W_1}{W_S}$$

Where, W_s - Weight of the sample (g),
W_1 - Weight of tube plus sample (g),
W_2 - Weight of the tube plus the sediments (g).

Swelling Index: The swelling Index was determined by the method described by Shad *et al.* (2011). The flour (0.2 g) was homogenously dispersed in distilled water (10mL) and the slurry was heated at 60^{o}C in the thermally controlled water bath. The mixture was cooled at room temperature and centrifuged at 2200 rpm for 15 min. The residue obtained after centrifugation along with retained water was reweighed and SI was calculated using the following formula

$$\text{Swelling Index (\%)} = \frac{\text{Weight of the sample along with retained water}}{\text{Weight of the sample}} \times 100$$

Foam capacity (FC) is determined as described by Narayana and Narsinga Rao (1982) with slight modification. The 1.0 g flour sample is added to 50 mL distilled water at 30 ± 2°C in a graduated cylinder. The suspension is mixed and shaken for 5 min to foam. The volume of foam at 30 s after whipping is expressed as foam capacity using the formula:

$$\frac{\text{Volume of foam AW - Volume of foam BW}}{\text{Volume of foam BW}} \times 100$$

Where, AW = after whipping BW = before whipping

Emulsion Activity (EA): The sample (2 g) was incorporated in cold distilled water (20 mL). To this mixture sunflower oil (10 mL) was added 20 minutes of stirring and 10 min centrifugation at 4000 rpm were carried out (Elkhalifa and Bernhard 2018). The peak formed out emulsion layer was mentioned. EA was calculated using the formula:

$$\text{Emulsifying Activity (\%)} = \frac{\text{Height of Emulsion layer}}{\text{Height of the whole layer}} \times 100$$

Least gelation capacity: The least gelation concentration (LGC) is evaluated using the method of Coffman and Garcia (1977). The sample powders at 2, 4, 6, 8, 10, and 20 % (w/v) concentrations were added to 5 mL distilled water are heated at 90°C for 1 h in a water bath. They are cooled under tap water and kept for 2 h at 10 ± 2 °C. The least gelation concentration is determined using the method given as that concentration when the sample from the inverted tube does not slip.

Statistical analysis: All the data were statistically evaluated by one-way analysis of variance (ANOVA). All the values are mean ±S.Ed for n=6.

RESULTS AND DISCUSSION

Moisture content, water activity and yield: This data was represented in Table 1.After pulverizing, lotus stem powder's moisture content and water activities are 4.86% and 0.221. Hussain *et al*. (2016) reported a slightly higher value of moisture content (5.90%) in lotus rhizome flour. 3.28% of moisture and 0.286 water activity were recorded in Jamun seed powder. A similar value was reported by Neha *et al.* (2015) in Jamun seed powder. A study by Kirthy Reddy *et al*. (2017) observed 4.8% in date seed powder. The water activity value of both powders is depicted as chemically and microbially safe for storage thereby increasing the shelf life of the powders. Lotus stem yielded 73.56% of the flour and 86.74% of powder was obtained from Jamun seed.

Table 1: Moisture content, water activity and powder yield.

Parameters	Lotus stem powder	Jamun Seed Powder
Moisture content	4.86±0.09	3.28±0.29
Water Activity	0.221±0.12	0.206±0.15
Powder yield	73.56%	86.74%

Physical properties: These results were presented in Table 2. The bulk and tapped density of LSP and JSP were 0.62±0.01, 0.72±0.01 and 0.82±0.01, 0.88±0.01 respectively. It is generally preferable to have a higher bulk density of flour for easier dispersibility and to reduce paste thickness (Jadhav *et al.*, 2017). The HR and CI are an indirect measurement of powder or particle flow property cohesive in the sample is more if HR and CI are high (Olawoye and Gbadamos 2020). This is an excellent measure indicating the compactness mechanism during processing. Carr's Index and Hausner's Ratio of the powders indicate an inferior flowability as both the indices are reported high. The values obtained in our study agree with the results of Leite *et al*. (2020) in cocoa powder. Dadi *et al*. (2019) reported that as temperature increased CI and HR also increased.

Table 2: Physical properties of Powders.

Physical properties	Lotus stem powder	Jamun Seed Powder
Bulk Density	0.62±0.01	0.72±0.01
Tapped Density	0.82±0.01	0.88±0.01
Carr's Index	25.52±0.50	18.64±1.23
Hausner's Ratio	1.32±0.02	1.23±0.03

Table 3: Functional properties of Powders.

Functional properties	Lotus stem powder	Jamun Seed Powder
Water Absorption Index (%)	263.52±1.29	100.71±0.94
Oil Absorption Capacity (%)	104.67±1.40	88.13±1.67
Swelling Index (g/g)	3.32±0.01	5.63±0.02
Foaming capacity (%)	9.82±1.34	15.54±1.12
Emulsifying Activity (%)	48.93±1.02	45.06±0.08
LGC	14	10

Functional properties: These results were presented in Table 3. TheWater Absorption Index percentage of LSP is 263.52%. High WAI in LSP is due to the presence of crude fiber content and raw fiber swelling during drying the orientation of residual amino acids changes. The higher the amount of starch and fiber in the flour, the higher will be the water absorption capacity of the flour. This was correlated with the study by Hussain *et al*. (2016) on lotus rhizome flour. JSP recorded a WAI of 100.71%. A similar value was absorbed in Camachile seed powder by the study of Saha *et al*. (2021). The above value is correlated with the study by Maruf *et al.* (2019) where the WAC of JSP was 101.34%. OAC of both the powders were 104.67 and 88.13% respectively. A similar trend was recorded in JSP of 85.6% of OAC by Maruf *et al.* (2019). These values of OAC show that Jamun seed powder could play an important role in food processing since fat acts on flavor retainers and increases the mouth feel of foods. Additionally, the capacity of JS to absorb oil could improve the palatability, flavor retention, and shelf life of various foods, especially bakery and meat products, along with ready-to-serve food formulations. Swelling Index was recorded as high in the case of LSP (3.32 g/g) when compared to that of JSP (5.63 g/g). The increase in the Swelling Index in JSP may be attributed to the fact that the outer membranes of the starch granules ruptured during the process of milling and swell up in the form of a gel by absorbing water during heating. The highest foaming capacity in JSP (15.54%) indicates the presence of high protein content than LSP (9.82%). The low foamability of LSP indicates the presence of highly ordered globular protein molecules which increase the surface tension. Emulsifying activity is higher in the case of LSP (48.93%) when compared to JSP (45.06%). Weak gels are formed at 14% concentration for LSP whereas, at 10% JSP formed strong gel. The ability of flour to provide a structural matrix for holding water and other water-soluble materials.

CONCLUSION AND FUTURE SCOPE

The yield of the powder is high in both powders but they exhibited inferior flowability. Lotus stem powder has the highest amount of fibre which can be used as fibre substitute in many foods. Jamun Seed can be used in ready-to-serve processed foods. Both powders provide many therapeutic, health, and functional benefits incorporation levels, and in vivo and in vitro studies can be exploited. These powders can be used as potential substitutes and replacements in various foods.

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