PROXIMATE COMPOSITION AND FUNCTIONAL PROPERTIES OF NELUMBO NUCIFERA (LOTUS STEM) POWDER

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Nelumbo nucifera (Lotus) stem have an abundance of potential for utilization in many food applications because they have so many medicinal, physiological, and health advantages. The purpose of this study was to assess the proximate and functional properties of lotus stem powder (LSP). Dehydration Ratio (DR) was calculated to analyse the efficacy of drying which was found to be 3.5:10. Moisture content and yield for lotus stem powder were found to be 10.85% and 35% respectively. Low moisture content and dehydration ratio revealed that LSP has a longer shelf life. The relative composition of LSP per 100g for moisture, protein, fat, ash, fibre, and carbohydrates was estimated which was found to be 10.85g, 3.54g, 0.31g, 18.53g and 75.7g per respectively. Water and oil absorption index was higher due to the presence of high fibre content. Thus based on these properties, it was concluded that LSP can be added, substituted, or replaced in a variety of foods.

Keywords: cookies, *Nelumbo nucifera,* crude fiber, iron, calcium, water absorption capacity

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1. INTRODUCTION

Nelumbo nucifera is a member of the Nelumbonaceae family, often known as the sacred lotus, Chinese water lily, and Indian lotus. The stem of the lotus plant is rich in nutrients, including Vitamin B_1, Vitamin B_2, and Vitamin C, as well as protein, amino acids, dietary fibre and starch. Lotus stem is an excellent source of complex carbohydrates and fibre, which lowers blood sugar levels and is beneficial for people seeking to lose weight **(Ogle et al. 2001).** It possesses anti-diarrheal, anti-inflammatory, antioxidant, antipyretic, and hypoglycaemic properties **(Bhardwaj and Modi 2016).** Lotus stem also possess anti-bacterial effect against *Staphylococcus aureus*, *Escherichia coli, Bacillus subtilis, B. pumilis*, and *Pseudomonas* while the ethanol extract possesses hypoglycaemic qualities. Lotus stem is rich in nutrients therefore it helps in safeguarding against osteoporosis, protein energy malnutrition, and anaemia. It also contributes significantly to the prevention and treatment of anaemia because it contains the highest concentration of iron, which is an important source of iron for vegetarians when combined with food rich in Ascorbic acid. **(Dungarwal, 2019; Khushboo et al., 2020).**

Lotus stem has been considered healthy and nutritious since it contains lot of nutrients. The high lipid content of seeds suggested their significant calorie content. It is advised for pregnant women and those who frequently have constipation, to consume lotus stem, which is low in calories, high in dietary fibre, and high in complex carbohydrates to help lower blood sugar levels. Lotus stem is also beneficial for those who strive to lose weight **(Ogle et al. 2001).** As reported by (**Shad et al. 2011)**, the lotus stem flour proximate composition (g/100g flour) was ash (1.10±0.66), total nitrogen (1.36±0.04), total protein (8.48±0.25), total sugar (19.08±0.01) and free amino acids (0.78±0.035). (**Park et al. 2009)** studied the cultivars of lotus stems (Inchisa, Muan, Garam, and Chungyang) had high amounts of bioactive compounds present in it: total phenols between 7.95±0.8 and 4.21±0.3 mg of gallic acid equivalents (GAE)/g dry weight, ascorbic acid between 15.8±1.1 and 22.3±1.7 mg/g dry weight.
Lotus stem is still an under-utilized and unexplored food component despite its importance in nutrition and medicine. Therefore, it is necessary to use the powder of lotus stem to prepare novel value added food products. It is crucial to assess LSP quality in order to determine its effectiveness and safety. As a result, this study was undertaken to examine the proximate and functional properties of lotus stem powder to determine its incorporation in different foods.

2. MATERIALS AND METHOD

2.1 Processing of lotus stem powder

Preparation of LSP was carried out at Department of Food and Nutrition, Era University, Lucknow. Fresh lotus stems with measurements ranging from 45.0–57.0 cm in length and 4.0– 5.0 cm in width were purchased from local market of Lucknow, Uttar Pradesh. Fresh lotus stem was properly cleaned and broken, useless, inedible and brownish pieces were removed. They were properly cleansed with distilled water to remove any residual surface contaminants, peeled with a stainless steel peeler, and spread out on filter paper to absorb any extra water.
Lotus stem was manually cut into 0.002 cm thick slices, blanched and then dried in hot air oven at 50±5°C until it acquired its constant weight. The dried pieces were ground into a fine powder using an electric grinder, and the powder was subsequently preserved in Low Density Poly Ethylene (LDPE) bags for its further use in analysis.

Fig1: Preparation of *Nelumbo nucifera* (Lotus) stem powder

2.2 Proximate Analysis of LSP

The term "proximate composition," which refers to the six major food components viz: moisture, ash, fat, protein, carbohydrate, and fibre, is frequently used in the field of feed and food. Proximate analysis of LSP was conducted by the methods described in the AOAC 2019 standard procedure. This entailed estimating the amount of moisture, ash, protein, fat, and crude fibre as well as Calcium, Iron, Phosphorus, and Vitamin C.

2.2.1 Moisture Content

5g of the sample was accurately measured in a porcelain dish and put in a hot air oven for 2 hours and the temperature was maintained at 105°C±20°C. After cooling the dish in a desiccator, it was weighed again, and again put in hot air oven and cooled in desiccator and weighed until the difference between the two measurements was less than 0.0002g. The lowest weight was observed, and the moisture content was calculated by the following formula:

$$\text{Moisture \%} = \frac{W_1 - W_2}{W_1 - W} \times 100$$

Where,
W=Weight of the dish
W_1=Weight of the dish with sample
W_2= Weight of the dish + sample after keeping in oven

2.2.2 Total ash content

5g sample was weighed into a silica crucible, which was placed in a muffle furnace. It was kept in a muffle furnace at 500^0C to 550°C for 7 hours. It was weighed after cooling in desiccators until two successive weights were constant. The difference in weight between the initial and final weight was used for determining the percent ash by the following formula:

$$\text{Ash \%} = \frac{W_2 - W}{W_1 - W} \times 100$$

Where,
W_1=Weight of the crucible + sample before drying
W_2=Weight of the crucible + sample after drying
W= Weight of the crucible

2.2.3 Crude protein content

It was estimated by micro-Kjeldahl method, where 0.5 g of the sample was digested with concentrated sulfuric acid containing a pinch of the catalyst mixture K_2SO_4: HgO: $CuSO_4$, 99:4.1:0.8). Using a mixed indicator (methyl red: bromocresol green, 1:5), the digested solution was then distilled with 40% NaOH and the released ammonia was collected in 4% boric acid. Protein percentage in the sample was estimated using the formula below and multiplied by a factor of 6.25 to determine the percent nitrogen.

$$\text{\% Nitrogen} = \frac{(\text{Titre reading-blank}) \times N \text{ of } H_2SO_4 \times \text{Volume made of dig} \times 100}{\text{Aliquot of weight taken} \times \text{weight of sample taken} \times 100}$$

$$\text{\% Protein} = \text{\% Nitrogen} \times 6.25$$

Where,
N= normality
H_2SO_4= Sulphuric acid

2.2.4 Crude Fat content

2g sample was carefully weighed in a thimble and defatted with petroleum ether using Soxhlet apparatus for 5 hours at 70^0C. To remove any remaining ether, the resulting ether extract was evaporated, and the lipid content was calculated by the formula given below:

$$\text{Fat \%} = \frac{W_2 - W_1}{W} \times 100$$

Where,
W=Weight of sample
W_1=Weight of flask
W_2=Weight of flask + fat
$W_2 - W_1$= Weight of flask + fat) – (Weight of flask)

2.2.5 Total carbohydrate content

The total amount of carbohydrates was estimated using the difference method that is by subtracting the sum of the percentage of protein, fat, ash, and moisture as follows:

Carbohydrate (g) =100 - [Moisture (%) + Ash (g) + fat (g) + Protein (g)]

2.2.6 Crude fibre

Dry, fat-free sample was effectively boiled with acid and alkali for a specific period of time before filtering. After drying, the residue was ignited. Crude fibre content was estimated using the weight loss through ashing by the formula given below:

$$\text{Crude fibre \%} = \frac{(W_1 - W_2) - (W_2 - W_1)}{2} \times 100$$

Where,
W=Weight of the crucible
W_1=Weight of crucible + residue
W_2=Weight of residue

2.2.7 Vitamin C, Calcium, Iron and Phosphorus
Titration method was used to estimate Vitamin C content. This procedure involves reducing the dye (2-6-dicglorophenolindophenol) in an ascorbic acid-acid solution. The extract of the sample's reducing capacity directly correlates with the amount of Vitamin C. Titration method was used to determine calcium. Using an atomic absorption spectrometer, other minerals like phosphorus and iron were estimated. The process is based on forming phosphomolybdate with the addition of molybdate, then reducing the complex with hydrazine in a solution of aqueous sulfuric acid. By passing samples with known strengths through an atomic absorption spectrophotometer, the standard curve was formed. Using the corresponding standard curve formed for each mineral, the mineral contents of unknown samples were determined.

2.3 Functional Properties
2.3.1 Water and oil absorption capacity (WAC and OAC)
The ability of a product to associate with water in conditions where water is restricted is represented by its water absorption capacity **(Singh et.al. 2001).** The ability of flour to absorb water increases with the quantity of starch and fibre it contains**.** (**Sosulski et al. 1976)** method was used to determine the water absorption capacity of LSP. One gram of the sample was mixed with 10 ml of distilled water, left to stand for 30 min at room temperature ($30^0C \pm 2°C$), after standing the sample for 30 minutes at room temperature, the sample was centrifuged for 25 minutes at 3000 x g. After the supernatant was completely removed, the sediments were weighed. The amount of water absorbed per gram of powder was measured **(Sosulski et al. 1976)**. Same method was also used to determine the oil absorption capacity. One gram of sample was homogenized with 10 mL of soybean oil (Specific Gravity: 0.9092), let to stand for 30 min in a pre-weighted centrifuge tube at room temperature ($30^0C \pm 2°C$) and then proceeded further as described for WAC. The following formula was used to compute the water/oil absorption power:

$$\text{Water/ Oil Absorption Capacity (\%)} = \frac{W_2 - W_1}{W} \times 100$$

Where,
W =Weight of the sample
W_1=Weight of tube + sample
W_2 =Weight of the tube + sediments

3. RESULTS AND DISCUSSION

3.1 Moisture content and yield:
Table 1 depicts moisture content and yield for lotus stem powder which were found to be 10.85% and 35% respectively. Dehydration Ratio (DR) was calculated to analyse the efficacy of drying. In lotus rhizome flour; (**Hussain et al. 2016)** reported a somewhat lower value of moisture content (5.90%). LSP shelf life is prolonging because of low moisture content and dehydration ratio, which was depicted to be chemically and microbiologically safe for storage. DR was calculated by the following formula:

$$\text{Dehydration Ratio} = \frac{W_1}{W_2}$$

Where,
W_1=Weight of the sample after drying
W_2=Weight of the sample before drying

W_1=350g W_2=1000g DR=0.35:1 or 3.5:10
Dehydration percentage-35%

Table 1: Moisture content and Powder yield of LSP

Components	LSP Values
Moisture Content	10.85%
Powder yield	35%

3.2 Proximate analysis of LSP
Sample readings were compared to the dried lotus stem standard nutritional values **(Gopalan C, et al., NIN, ICMR, 1989)** which is shown in Table 2. The sample's moisture content was considerably greater than the dry lotus stem. The sample's total ash content, which was 9.58 g/100 was marginally less than the standard values. The sample's protein content was 3.54 g per 100 g of LSP, which was less than the standard, and its fat content was 0.31 g per 100 g of LSP, which was also less than the standard values of dry lotus stem. The amount of carbohydrates in LSP was 75.7 g. In comparison to the standard, crude fibre was 6.47 g less per 100 g in the sample. The sample's Vitamin C content was found to be 8 mg per 100 g higher than the standard values of dry lotus stem. 100.09mg, 83.28mg, and 27.05 mg of calcium, iron, and phosphorus were found in 100g of LSP respectively. As a result, the LSP was found to be suitable for fortification because it contained sufficient amounts of micro and macronutrients.

Table 2: Comparison of the standard nutritive values of lotus stem (dry) with LSP

Nutrients	Lotus stem ICMR Nutritive values	LSP estimated values
Moisture (%)	9.5	10.85
Total Ash (%)	8.7	9.58
Protein (g)	4.1	3.54
Fat (g)	1.3	0.31
Carbohydrate (g)	51.4	75.7
Crude Fibre (g)	25	18.53
Vitamin C (mg)	3	11
Calcium (mg)	405	100.09
Iron (mg)	60.6	83.28
Phosphorus (mg)	128	27.05

3.2 Functional properties

The ability of flour to absorb water increases with the amount of starch and fibre it contains. The LSP capacity to absorb water and oil was found to be 235.36% and 98.62% respectively. This was less than what (**Hussain et al. 2016)** and (**M. Kirthy Reddy 2022)** reported for their studies on lotus rhizome flour, which gave WAC values of 245.9% and 263.5%, respectively. Table 3 illustrates these results. The presence of crude fibre and raw fibre swelling during drying causes the orientation of remaining amino acids to change, which results in high WAC in LSP. The study conducted by (**Maruf et al. 2019)** and the above values are related. OAC of LSP was estimated to be 98.62%, which was somewhat less than (**Kirthy Reddy 2022),** who estimated OAC of LSP to be 104.67. These OAC values indicate that LSP could potentially play a significant role in the food processing sector.

Additionally, the ability of LSP to absorb oil may enhance the flavour retention, shelf life, and palatability of a variety of meals, including bread and meat items, as well as ready-to-serve food formulations.

Table 3: Water Absorption and Oil Absorption Capacity of LSP

Functional Properties	LSP Values
Water Absorption Capacity (%)	235.36±1.88
Oil Absorption Capacity (%)	98.62±1.84

Value=mean ± SE, n=5

4. CONCLUSION AND FUTURE SCOPE

According to the latest researches, there is a trend towards incorporating novel sources of protein, fat, vitamins, and minerals in bakery products in order to reduce the amount of wheat flour used, by adding different nutritional sources which are locally available.

Although the LSP powder had a high yield, it had poor flow-ability. The largest concentration of fibre is found in LSP which may be utilized as fibre substitute in many dishes. LSP can be utilized in processed foods that are ready to eat. LSP have numerous therapeutic, health, and functional benefits that can be used into both in vivo and in vitro investigations. Also it is concluded that LSP is a nutritious potential substitute and can be replaced in various foods.

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6. CONFLICTS OF INTEREST

Declared none.

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