

## RESEARCH ARTICLE

# Formulation and sensory evaluation of water chestnut flour laddoo

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## ABSTRACT

After chestnut flour was used to prepare Ladoo by incorporating processed water chestnut through sun drying, water chestnut flour Ladoo was standardized with different percentages of water chestnut flour. The percentages used were 0% (T0 as control), 5% (SDT1), 10% (SDT2), 15% (SDT3), and 20% (SDT4), respectively. Water chestnut flour incorporated Ladoo with 0% water chestnut flour was treated as the control. The nutritional contents of the sun-dried water chestnut flour were evaluated using AOAC methods. The proximate composition of SDT (sun-dried water chestnut flour treatment) for moisture content, protein, fat, total ash, crude fiber, and carbohydrate were 11.02 g, 12.42 g, 3.44 g, 2.93 g, 0.54 g, and 70.19 g, respectively. Water chestnut flour is a potential source of potassium and calcium, with levels of 1298.64 mg/100g and 89.26 mg/100g, respectively. The water chestnut flour showed good antioxidant content. In the evaluation of sensory characteristics of water chestnut Ladoo, a significant difference ( $P < 0.05$ ) was found among all treatments (SDT1, SDT2, SDT3, and SDT4). The differences were observed in terms of appearance/color, texture, taste, flavor, and aftertaste. The various products were also found to be a good source of nutrients, particularly in terms of protein, carbohydrate, minerals, and antioxidants. The incorporation of sun-dried water chestnut flour Ladoo with 10% was found to be effective in maintaining better health conditions for everyone.

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## INTRODUCTION

In recent years, the worldwide demand for nutrient-rich fruits and vegetables has increased day by day. People are more aware of the health benefits that fruits offer, which has led to a great thrust for their regular consumption as part of a balanced diet, especially after the COVID-19 pandemic. Some underutilized fruits can be used not only as fresh fruit but also for medicinal purposes, providing significant nutrients. Most indigenous underutilized fruits, such as water chestnut, aonla, phalsa, ber, kair, and lasora, are a rich source of vitamins, minerals, antioxidants, and phytonutrients compared to many commercial fruit crops. These underutilized fruits are not popular and are sold at very low prices in local markets due to the lack of awareness among people regarding their nutritional importance and limited research.

Water chestnut is an aquatic plant that belongs to the "Trapaceae" family and is popularly known as "Singhara" or "Paniphal" in India. Singhara grows in tropical, temperate, or subtropical zones. Europeans in ancient times frequently used singhara as food.

Singhara is found in slow-moving lakes, ponds, and marshes (Krishnaiya et al., 2016). Water chestnut species *Trapa bispinosa* and *Trapa quadrispinosa* are commonly found in India. In India, the plant has been grown for its nutritious seeds, with the fruits eaten raw, boiled, or roasted, and the stems and leaves eaten raw or cooked as vegetables. The fruit of the water chestnut is a nut with both nutritional and therapeutic properties (Singh et al., 2022).

Dried water chestnut kernels are sold as nuts and flour for various products like cookies, laddoo, muffins, breads, chapatis, and other baked and cooked products. Chestnut fruit has a carbohydrate level similar to wheat and rice grains. The water chestnut fruit contains vitamins B, A, and C, as well as minerals (K, Mg, Fe, Mn, P, Cu). It contains a lot of fiber and vital amino acids. Furthermore, it has a high antioxidant content, low-fat content, and no cholesterol, all of which contribute to an increase in nutritional value and have a positive effect on health (Gupta and Awasthi, 2021). The edible portion of the water chestnut plant possesses many therapeutic properties, such as antimicrobial activity, antidiabetic activity, analgesic activity, anti-inflammatory activity, antileprotic agent, urinary discharges, sore throat, anemia, osteoporosis, and bronchitis (Krishnaiya et al., 2016).

## MATERIALS AND METHODS

### Procurement of raw materials

The fresh water chestnut (*T. natans*) was purchased from the local farmers' fields in Jaipur, Rajasthan. Other raw materials required for the development and preparation of value-added food products were collected from the local market in Jaipur city.

### Pre-treatment of water chestnut

Whole mature and fresh water chestnut fruits collected from the farmers in the Jaipur area were peeled manually. The peeled kernels were sliced into small parts and immediately dipped into a 0.5% KMS solution for 20 minutes. Then, they were stored safely for further drying process.

### Method of preparation of water chestnut flour by sun drying process

The pre-treated water chestnut kernels were dried in direct sunlight for 48 hours. Then, the dried sle was ground into flour using a mixer and grinder and stored at room temperature (25-30°C).

### Estimation of proximate principles

All analyses of the nutritional composition of dried water chestnut flour were done using standard procedures. Moisture, protein, fat, ash, crude fiber, and carbohydrates were measured using the AOAC method (1990). Carbohydrates were calculated using the difference method. The energy value of the food sle can be calculated by multiplying the figures for the percentage of protein, fat, and carbohydrate by 4, 9, and 4 respectively, and adding the obtained figures. Energy was calculated using the following formula:

$$\text{Calorific value (Kcal/g)} = (\% \text{ Protein} \times 4) + (\% \text{ Fat} \times 9) + (\% \text{ Carbohydrate} \times 4)$$

### Mineral estimation

**Calcium:** Calcium in the sle was assessed using the standardized procedure of AOAC (2000).

**Potassium:** The potassium was estimated by flame photometry (AOAC, 2000).

## Antioxidant activity of sundried water chestnut flour

### Preparation of extracts

Each 0.3 g sle was taken and dissolved in 20 ml of 70% methanol. After stirring for 2 h by a magnetic stirrer, then centrifuged at 3500 rpm for 10-15 min. The supernatant was filtered and stored at -18°C.

### Total phenolic content

Total phenolic content (TPC) was evaluated by Folin–Ciocalteu's spectrophotometric method with some changes. The results were expressed as Gallic acid equivalents (g GAE/1000 g) of the sle (Jan et al., 2015).

### DPPH (2,2-diphenyl-1-picrylhydrazyl) scavenging activity

DPPH scavenging activity of the extracts was evaluated according to the method explained by Baba et al. (2014). The absorbance at 517 nm was measured after incubating the sles for 30 min. A lower absorbance of the reaction mixture indicates higher free radical scavenging activity. Percentage inhibition was determined and calculated using the formula:

$$\% \text{ inhibition} = \left[ \frac{\text{Acontrol517} - \text{Asle517}}{\text{Acontrol517}} \right] \times 100$$

Where Acontrol517 is the absorbance of the control, and Asle517 is the absorbance of the extract.

### Preparation of water chestnut flour incorporated laddoo

The Ladoo were prepared by incorporating Water Chestnut Flour, which was prepared through a sun drying process, in various percentages.

### Details of treatments

This experimental study had a control group (T0) where standardized and prepared products were made without incorporating water chestnut flour prepared by the sun drying process. Four treatments, labeled SDT1, SDT2, SDT3, and SDT4, were used, and three replications were carried out for each treatment. The four treatments of Ladoo were tried three times and evaluated using the sensory evaluation method by experts. The Ladoo treatment was prepared using the following combination:

**Table. 1: Treatment and Replication of the Ladoo Food Product.**

Treatment	Sun Drying (SD)
T0	0%
SDT1	5%
SDT2	10%
SDT3	15%
SDT4	20%

### Preparation of water chestnut flour incorporated laddoo

Ladoo, preparation and evaluation Ladoo were prepared by adding different percentages of processed water chestnut flour to gram flour, then roasting the mixture of flour with 1 spoon of desi ghee on low heat until the flour changes color. After that, sugar powder was mixed into the roasted flour mixture to make small round balls to prepare the Ladoo. The control was prepared using

the same process, but without mixing water chestnut flour. The Ladoo were cooled to room temperature and packed in airtight containers for further analysis.

**Table 2: Water chestnut Flour based Ladoo ingredients.**

Ingredients	T0 (Control)	SDT1	SDT2	SDT3	SDT4
Begal gram flour (g)	80	75	70	65	60
Sugar (g)	10	10	10	10	10
Ghee (g)	07	07	07	07	07
Water chestnut flour (g)	-	05	10	15	20
Almonds	03	03	03	03	03
Total	100	100	100	100	100

### Organoleptic evaluation of water chestnut laddoo

Water chestnut flour Ladoo were subjected to sensory evaluation by a trained or semi-trained sensory panel consisting of 10-12 people. The sensory panel rated the quality characteristics of each sle on a nine-point hedonic rating scale. The judges evaluated randomly coded water chestnut laddoo in terms of color/appearance, texture, flavor, taste, and aftertaste.

### Statistical analysis

Analysis of Variance (ANOVA) and significant differences among means of water chestnut-incorporated Ladoo were examined by a one-way ANOVA using Microsoft Excel 2007.

## RESULTS AND DISCUSSION

### Proximate analysis and mineral estimation

Table 3 illustrates the data related to the Proximate and Mineral Estimation of Water Chestnut Flour prepared by shade drying process (SHD). The results reveal that the mean score of proximate composition of sun-dried water chestnut flour is 11.02 g, 12.42 g, 3.44 g, 2.93 g, 0.54 g, and 70.19 g for moisture, protein, fat, ash, crude fiber, and carbohydrates, respectively. These values show some similarity and variation as found by other researchers.

The mineral estimation of water chestnut flour has been done, and the results are depicted in Table 3. Water chestnut is a fruit with a good source of micronutrients like minerals, and the mineral estimation of prepared water chestnut flour shows that shade-dried water chestnut flour provides about 1298.64 mg/100g of calcium and 89.26 mg/100g of potassium.

A similar study by Alfasane et al. (2011) shows that the dried form of water chestnut contains 10.80-11 g/100g of protein, 1.85-1.9 g/100g of fat, 71-72 g/100g of carbohydrates, 6.3-6.4 g/100g of fiber, 102-103 mg/100g of calcium, and 320-330 mg/100g of phosphorus. Another study by Demirkesen et al. (2010) investigated that chestnut flour contains 10.79% moisture, 47.80% starch, 21.51% sugar, 9.50% dietary fiber, 3.80% fat, 4.61% protein, and 1.99% ash. In the context of nutritional composition, it is stated that chestnut flour contains a high protein content, a high amount of sugar (20-32%), starch (50-60%), dietary fiber (4-10%), essential amino acids (4-7%), and a low amount of fat (2-4%). It is also rich in vitamins B, C, and E, as well as potassium, magnesium, and phosphorus (Sacchetti et al., 2004; Chenlo et al., 2007). The evaluation of proximate contents in the present study was found to be varied in comparison to other studies. This variation is due to various reasons such as the drying process and the variety of water chestnut from which it is derived (Adkar et al., 2014).

**Table 3: Nutritional composition of sun-dried water chestnut flour**

S. No.	Parameters	Sun Dried water Chestnut Flour
Proximate Analysis (g/100)		
1.	Moisture	11.02
2.	Protein	12.42
3.	Fat	3.44
4.	Total Ash	2.93
5.	Crude Fibre	0.54
6.	Carbohydrates	70.19
Mineral Estimation (mg/100)		
7.	Calcium	1298.64
8.	Potassium	89.26
Antioxidant Activity		
9.	Total Phenolic Content (mg/100)	15.70
10.	Antioxidant Activity (%)	9.0

### Antioxidant activity

Table 3 presents the data regarding the Antioxidant Activity of Water Chestnut Flour prepared by the sun-drying process (SD). According to Table 1, the Total Phenolic Content of Water Chestnut Flour was determined as 15.70 mg/100g in Sun-Dried Flour. In the context of Antioxidant Activity, Water Chestnut Flours were assessed as 9.0% in Sun-Dried Flour.

Similarly, different studies have been reported by researchers about the Antioxidant Activity of Water Chestnut Flour. These studies have stated that water chestnut flour is not only rich in starch but also has a high flavonoid content. Water chestnut Flour possesses strong antioxidant, antimicrobial, and anticancer activities, which have been attributed to their bioactive components, such as polyphenols, flavonoids, and alkaloids (Yu et al., 2013). Water chestnut extracts are also reported to have high inhibitory activity against glycolytic enzymes such as  $\alpha$ -amylase, which inhibits blood glucose elevation. This is a unique feature of reducing insulin secretion and hence can be effective food additives in managing type 2 diabetes (Yasuda et al., 2014).

### Organoleptic evaluation

The sensory evaluation of Ladoo prepared from sun-dried water chestnut flour (T0 (Control), SDT1, SDT2, SDT3, and SDT4) was evaluated (Table 4) and found that in terms of color/appearance, texture, flavor, taste, and aftertaste, water chestnut flour with 10% incorporation (SDT2) was found to be more acceptable in appearance than the other three treatments. Similarly, the taste, aftertaste, and flavor were more acceptable in water chestnut flour Ladoo with 10% incorporation compared to the other treatments and control as well. However, in the context of texture, the SDT4 with 20% water chestnut flour incorporated Ladoo was the best among the other treatments. A significant difference ( $P < 0.05$ ) was demonstrated among all the treatments of water chestnut flour incorporated Ladoo.

**Table 4: sensory Evaluation of Ladoo prepared from sundried water chestnut flour.**

Sle Name	Color/ Appearance	Texture	Flavour	Taste	After Taste	Total
T0	7.7±0.71	7.7±0.71	7.9±0.84	7.80±0.85	7.70±0.78	38.8
SDT1	7.5±0.50	7.50±0.58	7.29±0.49	7.50±0.50	7.57±0.53	37.36
SDT2	7.57±0.61	7.57±0.73	7.50±0.41	7.71±0.57	7.71±0.57	38.07
SDT3	7.43±1.27	7.64±1.11	7.29±1.07	7.36±1.18	7.29±1.11	37.00
SDT4	7.29±1.07	7.79±1.15	7.50±1.29	7.43±1.24	7.50±1.32	37.50



Fig. 1: Ladoo prepared by utilization of water chestnut flour.

The comparative study of the data shows that Treatment T2 (10% incorporation) and T1 (5% incorporation) show acceptable sensory scores from the panel of judges. This shows that the addition of Sun Water Chestnut Flour improves the sensory attributes of LADDOO in terms of Texture, Flavor, Taste, and After Taste. A similar study was reported by Hussain et al., (2020), in which they prepared a Low Glycaemic Index cracker by incorporating different proportions of water chestnut flour.

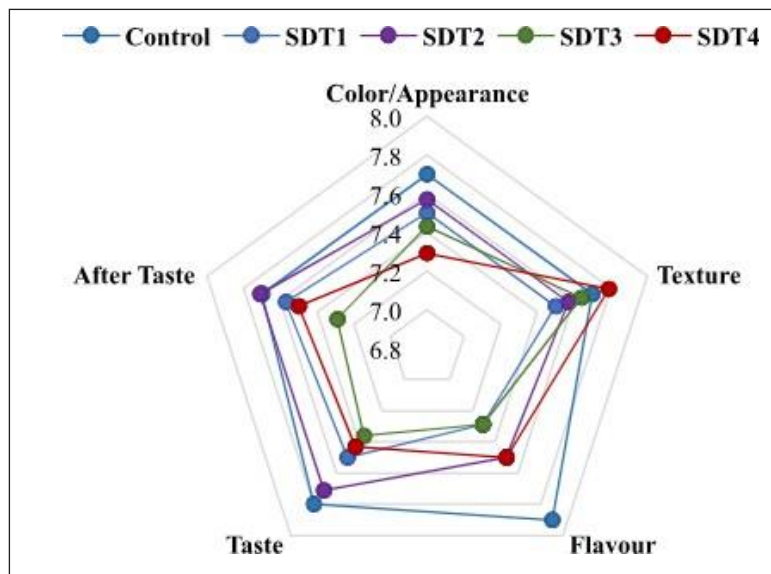


Fig. 2: Sensory evaluation of Ladoo prepared from Water chestnut flour.

Water chestnut fruits are gluten-free, low in fat, cholesterol-free, low in sodium, high in potassium, rich in minerals including calcium, iron, zinc, and phosphorous. They contain average amounts of fibers and are good sources of energy (Adkar et al., 2014). Drying fresh water chestnut kernels increases their shelf life and nutritional composition, as condensation of nutrients occurs through moisture removal. Sun drying water chestnut flour is the most suitable way to reduce post-harvest losses and increase its utilization in daily diet.



## CONCLUSION

The conclusion of this study is that 10% water chestnut flour is more acceptable in terms of sensory characteristics as well as nutritionally. Hence, it is used in various food products to improve their nutritional composition, benefiting the health of human beings. It is a significant source of nutrients such as potassium, calcium, and protein. Thus, water chestnut flour-enriched Ladoo is beneficial for all age groups. Besides being nutritious, water chestnut flour-based Ladoo is economical to prepare compared to other nutrient snacks that are priced higher and not accessible to those below the poverty line.

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