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Physico, Chemical and Functional Properties of Different Millets and their Suitability for Preparation of Enhanced Nutritious Laddu

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Abstract

Millets are a nutrient-rich staple meal for the world's poor, and increasing the nutrient bioavailability is one of the key strategies for promoting their use. To enhance the edible, nutritive, and sensory qualities of millets, they are often prepared using conventional processing methods. Thus an attempt was made with an objective to assess the physical and functional properties of sprouted and unsprouted millets and to observe the acceptability of the laddu prepared from sprouted and unsprouted millets. Physical and functional properties for both sprouted and unsprouted grain and flour were analyzed using standard techniques. These properties were studied in 4 different millets i.e. kodo millet, finger millet, little millet, and sorghum. Physico-chemical properties have shown that sprouted millets have some of the good cooking properties and sensory evaluation has also show to be more acceptable.

Keywords: Millets; Soaking; Sprouting; Unsprouted; Laddu; Physical And Functional Properties; Nutrient Composition

Introduction

One of the most often consumed cereal grain is millet. More than one-third of people on the planet consume millets. It ranks as the sixth most significant cereal crop when it comes to worldwide agricultural production [1]. These seven varieties are: kodo millet (*Paspalum setaceum*), little millet (*Panicum sumatrense*), finger millet (*Eleusine coracana*), proso millet (*Penicum miliaceum*), barnyard millet (*Echinochloa utilis*), and pearl millet (*Pennisetum glaucum*) [2,3]. Millets have been known as "future cereals" due to their long-term viability and little environmental impact [4]. All millets have nutritious values that are three to five times higher than those of regularly consumed grains like rice and wheat. Millets have several nutritional and health benefits, and they can help treat diseases including diabetes mellitus, hyperlipidemia, and other illnesses [1]. India's top millet-producing state is Karnataka [5].

Millets are exceptional for their nutritional and medicinal benefits, but they are underutilised due to its poor cooking quality, insufficient knowledge in processing, and low nutrient bioavailability[6]. It has been found that processing methods like soaking, sprouting, and cooking increase plant grains nutritional value. *In vitro* digestibility and mineral availability are improved by sprouting method and it also helps in lowering the anti-nutritional components[7]. Studies in the past have emphasised the significance of sprouting because it increases the nutrients bioavailability in a variety of dietary grains, which has a significant impact on nutritional quality[7–9].

There is a little information on how the raw and sprouting of millets differs with respect to nutritional and physical-functional properties. Thus this study was aimed at minimizing this gap of knowledge by studying these properties on raw and sprouted millets and seeing the difference and developing a healthy traditional product laddu.

Materials and methods

- **Source of Data:** This was a study conducted in the Department of Clinical nutrition and dietetics in Sri Devaraj Urs Medical College from November 2021 and March 2022. Approval from institutional ethics committee was taken.
- **Study Period:** November 2021 and March 2022.

Procurement and the processing of millets

The study is carried out by using 4 millet grains such as kodo millet, little millet, finger millet and sorghum. The millets were collected from the local market of Kolar. After procurement, grains were sieved to remove the small sand particles, dust, broken seeds and other extraneous materials. The grains were dived into 2 sections where 1st portion was allowed for sprouting and the 2nd portion was unsprouted. The millets that was separated to sprout was washed under running tap water and were soaked for 24 hours then it was tied in a moist muslin cloth to sprout at room temperature for 24, 48 and 72 hours. After sprouting, the grains were allowed for sun drying. Both the sprouted and unsprouted samples were divided into 2 sections where 1st section was mechanically ground into powder and the other section was not ground these were packed separately in airtight plastic bags and was stored for the further analysis.

Determination of physico-functional properties

The study was carried out in 2 phases where in 1st phase unsprouted and sprouted millet grains were used and in 2nd phase unsprouted and sprouted millet flours were used to see the physical- functional properties.

- Phase 1
  - **Thousand grain weight:** Three sets of 1000 grains were randomly selected and the mean weight was expressed in g/1000 grains.
  - **Thousand grain volume (ml)**: Water displacement method was used measure the volume of millet grains. Thousand grains were randomly selected and put in measuring cylinder with known volume of water. The volume was recorded in ml. then the volume of millet was calculated by subtracting the initial volume from final volume.
  - **Bulk density:** Weight by volume of was used to calculate the bulk density.
- Phase 2
  - **Particle size:** Weighed hundred gram of flour was passed from bigger to smaller mesh size. The sample left on the mesh was weighed and recorded and the percentage was calculated.
  - **Tapped bulk density (g/ml):** Tapped bulk density was measured by taking a standard graduated cylinder of 100ml capacity. Initially, the empty measuring cylinder was measured and noted, to it 20g of flour was added and tapped for 20-25 times to tightly pack the flour materials and the volume of the weighed sample was recorded. The tapped bulk density (TBD) of flour was determined by following formula[10].

$$\text{Tapped bulk density (g/ml)} = \frac{\text{weight of the sample at recorded volume (g)}}{\text{volume of sample (ml)}}$$

- – **Loose bulk density:** The flour sample was poured into a 10ml of measuring cylinder. When the sample volume reached 1 ml the sample weight was measured. The weight and the volume was divided and calculated to obtain loose density[10].

$$\text{Loose bulk density (g/ml)} = \frac{\text{weight of the flour at 1ml}}{\text{volume of the sample (1ml)}}$$

- **Water absorption capacity: Quin and Paton** (1983) method was used to measure water absorption capacity. Centrifuge tube was weighed (W1) to it five grams of flour was added and stirred for 5 min using glass rod. For 30 mins the contents were allowed to stand and then it was centrifuged for 25 min at 11000 rpm. The free liquid was poured off. Tissue paper was used to wipe the inner side of tube. The centrifuge tube was weighed again (W_2). The water absorption capacity was calculated using the formula;

$$\text{Water absorption capacity, WAC (\%)} = W2 - W1 \times 100/5$$

- **Oil absorption capacity:** Oil absorption capacity was assessed by using[11]. Centrifuge tube was weighed (W1) to it 1 gram of flour and 10 ml of refined oil was added and stirred for 1 min for the complete dispersion of sample. The sample was centrifuged for 25 min at 3000 rpm. The oil that was separated was removed and the remaining oil was drained off by inverting the tube on an absorbent paper prior to reweighing (W_2). The absorption capacity was calculated using formula;

$$\text{Oil absorption capacity, OAC } (\%) = \frac{w^2 - w1}{1} \times 100$$

Swelling power: Schoch (1964) method was used to measure swelling power and solubility. Five hundred milligram (W_1) of the sample was poured in a centrifuge tube and weighed (W_2) to it twenty ml of distilled water was added (V_E). Water bath was used to heat this at a temperature of 90^0C for 30 mins, with occasional stirring, the tubes were cooled and centrifuged at 5000 rpm for 10 min. The supernatant was poured into a pre-weighed (W_4) petriplate and dried at 105^0C and weighed (W_5). The inner side of the centrifuge tube was wiped, dried and weighed (W_3). Per cent swelling power were calculated using the following formulae

$$\text{Swelling power } (g/g) = \frac{W_3 - W_2}{W_1} \times 1$$

- **Percent Dispersibility:** 100 ml of stoppered measuring cylinder was taken to it 10 grams of sample and 100ml of distilled water was added and stirred vigorously and was allowed to settle for three hours. The settled particles volume was recorded and subtracted from 100. The difference was recorded as per cent dispersibility[12].
- **Wettability:** A beaker was taken to it 2 grams of sample and 80 ml water was added. The behavior of the sample was observed on the water surface immediately after adding the sample. After 30 min of observation, magnetic stirrer was used to stir the material. The stirring was fast enough to form a vertex that reached the bottom of the beaker and this continued for one min, after which the grades were described and recorded as excellent, good, fair and poor according to the time and behavior of the dispersion.
- **Flowability [Carr Index (CI)]:** The flowability of flour was expressed as Carr Index (CI) in terms of tapped density (pT) and bulk density (pB) as described by[13].

$$\text{CI} = \frac{pT(\text{ Tapped density } - pB(\text{ bulk density })}{pT(\text{ Tapped density })} \times 100$$

Table 1. Classification of flour flowability based on Carr Index (CI)

CI%	Flowability
< 15	Very good
15-20	Good
20-35	Fair
35-45	Bad
>45	Very bad

- **Cohesiveness (Hausner Ratio):** Cohesiveness of the flour was evaluated in terms of Hausner ratio (HR), calculated from bulk density (pB) and tapped density (pT) as suggested by[13].

HR = pT/Pb

Table 2. Classification of flour cohesiveness based on Hauser Ratio (HR)

Hauser ratio	Cohesiveness
<1.2	Low
1.2-1.4	Intermediate
>1.4	High

- **Gelation temperature:** Six per cent aqueous solution of flour/starch was prepared into a beaker. Boiling water bath was used to heat the solution and the solution was stirred continuously until the solution gets gelatinized. At the point of gelatinization, the temperature was noted with thermometer. Time required for the initiation of gelatinization was recorded.
- **Percent sag:** Six per cent starch/flour solution was prepared and cooked. The gelatinized solution was poured into a cup and it was placed in refrigerator for one hour. After cooling the height of the gel was measured in the cup with toothpick and scale. Cooled gel was inverted on flat surface; again height was measured with toothpick and scale. The per cent sag was calculated using the formula

$$\text{Percent sag } = \frac{\text{Initial height in cup-final height on flat surface}}{\text{initial height in cup}} \times 100$$

- **Paste clarity:** A 0.5 per cent (dry basis, w/v) aqueous suspension of starch/flour was prepared and heated in boiling water bath for 30 min with constant stirring. The mixture was cooled to room temperature. The transmittance of the paste was measured at 650nm against a water blank using spectrophotometer[14].
- **Viscosity:** Viscosity for five per cent aqueous solution of sample was determined using Brookfield viscometer (VII), spindle No.2 and speed 60 RPM at 31^0C and viscosity was expressed as centipoises (cP). Viscosity was also measured for hot slurries after heating them at 70^0C for 15 min.

Product preparation

Method of preparation

Add 100g of millet flour and ghee in a pan and combine it well. Roast it till nice aroma is obtained

Add 92g of Jaggery, 5g of powdered cardamom and cashews almonds to the roasted millet flour and mix well

Add 4g of milk powder and combine it take 15g of mixture and give it a shape

Results

The results of the general characteristics of the millets are presented below in the Tables 1, 2 and 3. Sprouted millets are found have higher TKW, TKV, bulk density except in sorghum, PS except in finger millet, TBD except in little millet, LBD except in finger millet. Except in sprouted kodo millet, all the other sprouted millets are found to have lower WAC, OAC in sprouted millets is found to be lower in all four millets, SWP is found to be higher in all four types of sprouted millets, PD is lower in sprouted millets, wetability is found to be fair in sprouted and unsprouted kodo millet and sprouted little millet, whereas, unsprouted little millet, sprouted and unsprouted finger millet and sorghum is found to have good wettability, cohesiveness is found to be low in all the millets, gelation temperature is found be higher in sprouted millets except in sprouted little millet, percent sag is found to be lower in sprouted kodo millet and higher in sprouted finger millet and sorghum, paste clarity is found to be higher in sprouted millets and viscosity is found to be higher in sprouted millets except in sprouted sorghum.

The sensory quality parameters namely, appearance, texture, flavor, taste, aroma, and overall acceptability of the both ladoos values are listed in the Table 4. It is observed that the panelist could not find any significant difference ($p < 0.05$) between USML and SML in appearance, flavor, taste, aroma, and overall acceptability. Although, in this study, the SML variation had higher acceptability in terms of organoleptic quality when compared to the USML.

Discussion

Understanding the physicochemical characteristics of millet cultivars is crucial from a processing and nutritional security perspective. One of the key factors in food processing, packing, storage, and transportation operations, as well as in a number of post-harvest processes involving cereal grains, is physicochemical qualities[15]. The various physical properties is observed and shown in Tables 1, 2 and 3.

The WAC measures how much water a starch can hold compared to its weight. The degree of starch gelatinization is indicated by higher WAC. Because millets have a higher WAC, they may be more useful for generating flours that can be used to make a variety of foods that need a good

Table 3. Physical analysis in different millets

Properties	Millets							
	Kodo millet		Little millet		Finger millet		Sorghum	
	USM	SM	USM	SM	USM	SM	USM	SM
TKW	6.2±0	7.01±0.00	3.1±0.2	3.37±0.45	3.9± 0.02	4.3±0.25	38.2±0.2	47.9±0.01
P<0.005	0		0.453		0.085		0	
TKV	11.5±0	12.5±0.11	5.6±0.1	6.33±0.15	6.0±0.04	6.5±0.43	38.2±0.2	78.8±0.11
P<0.005	0.005		0.016		0.172		0	
BD	0.5±0	0.55±0.00	0.5±0	0.52±0.08	0.6±0.0	0.66±0.01	0.7±0	0.6±0
P<0.005	0.074		0.637		0.199		0.001	

USM-unsprouted millets SM-sprouted millets TKW-Thousand Kernel Weight TKV-Thousand Kernel Volume BD – Bulk density

Table 4. Physical properties of flour of different millets

Properties	Millets							
	Kodo millet		Little millet		Finger millet		Sorghum	
	USM	SM	USM	SM	USM	SM	USM	SM
PS	0.30±0.15	1.87±0.09	1.05±0.03	1.21±0.08	0.81±0.08	0.78±0.1	0.03±0.04	2.8±0.19
P<0.005	0.001		0.151		0.744		0.002	
TBD	0.62±0.07	0.68±0.02	0.72±0.02	0.68±0.05	0.56±0.02	0.68±0.02	0.71±0.01	0.78±0.03
P<0.005	0.005		0.016		0.172		0	
LBD	0.33±0.03	0.43±0.03	0.33±0	0.34±0.02	0.45±0.02	0.43±0.02	0.24±0.05	0.43±0.03
P<0.005	0.099		0.423		0.038		0.054	

USM-unsprouted millets SM-sprouted millets PS-particle size TBD-tapped bulk density LBD-loose bulk density

Table 5. Functional properties of flour of different millets

Properties	Millets							
	Kodo millet		Little millet		Finger millet		Sorghum	
	USM	SM	USM	SM	USM	SM	USM	SM
WAC	109.13±2.95	111.26±3	110.46±4.12	107.03±4.9	114.1±12.6	98.37±8.27	101.24±7.4	98.6±7.59
P<0.005	0		0.13		0.029		0.016	
OAC	84.73±0.37	83.65±1.3	91.2±0.20	90.53±1.35	92.23±0.40	91.23±2.65	93.13±0.89	88.86±0.05
P<0.005	0.373		0.403		0.608		0.015	
SWP	6.76±0.49	8.36±.0.32	7.56±0.40	8.10±0.16	9.08±0.05	9.23±0.25	6.79±0.08	9.69±0.08
P<0.005	0.058		0.243		0.44		0	
PD	77.06±0.40	76.46±0.05	78.77±0.41	78.66±0.57	78.35±0.51	76.6±0.36	80.43±0.5	80±0.3
P<0.005	0.151		0.847		0.007		0.423	
Wettability	Fair	Fair	Good	Fair	Good	Good	Good	Good
Flowability	Very bad	Bad	Very bad	Very bad	Fair	Bad	Very bad	Bad
Cohessiveness	Low	Low	Low	Low	Low	Low	Low	Low
Gelation temp	76.19±0.36	81.7±1.41	80.82±0.28	75.33±4.05	92.02±2.6	92.5±2.62	84.38±3.0	83.74±2.70
P<0.005	0.018		0.14		0.642		0.848	
Percent sag	13±1	8.36±0.50	22.76±2.8	20.70±2.47	14.3±1.1	16.59±3.49	8.16±0.2	13.08±1.99
P<0.005	0.013		0.189		0.399		0.169	
Paste clarity	64.27±3.2	78.06±2.43	64.0±2.6	65.33±0.30	68.13±1.97	72.1±1.67	62.5±1.3	77.03±2.05
P<0.005	0.001		0.471		0.002		0.017	
Viscosity	4.09±0.90	4.13±0.10	4.09±0.84	4.46±0.08	3.3±0.05	6.64±0.71	5.3±0.1	3.97±0.90
P<0.005	0.954		0.54		0.017		0.146	

USM-unsprouted millets SM-sprouted millets WAC-Water Absorption Capacity OAC-Oil Absorption Capacity SWP- swelling power PD- percent dispersibility

Table 6. Sensory evaluation of sproutedand unsprouted millet ladoo

	Colour	Texture	Taste	Aroma	Overallacceptabiliy
USML	7.6±0.6	7.7±0.6	8±0.9	7.6±0.8	8.0±0.8
SML	7.9±0.8	8±0.7	8.5±0.6	7.9±0.7	8.5±0.6

USML- unsprouted millet ladoo, SML-sprouted millet ladoo

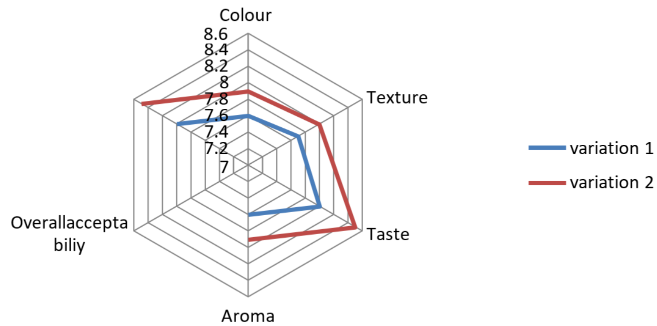

Fig 1. Radar chart representing the results of sensory evaluation of sprouted and unsprouted millet ladoo

viscosity[16]. No significant differences are found between unsprouted and sprouted millets. Higher WAC was found in sprouted kodo millet and unsprouted finger millet compared to other millets. The presence of fewer hydrophobic amino acids can be linked to decreased OAC[17]. Significant differences are observed in sprouted and unsprouted millets. Sprouting led to the significant reduction in the OAC. Significant differences in swelling power is observed in little millet and finger millet. Several studies have confirmed the inverse relationship between swelling power and moisture content, i.e. that as flour absorbs more water, its swelling power decreases[17]. Compressibility index, commonly known as Carr's index, is a measurement of the flowability of flour; specifically, flour with CI less than 15 has acceptable flowability, whereas flour with CI exceeding 35 demonstrates bad Flowability[17]. Flowability is found to be very bad in unsprouted kodo millet, unsprouted sorghum and in both sprouted and unsprouted little millet. Fair flowability in unsprouted finger millet. Gelatinization is an irreversible phase transition phenomenon that happens when starch is subjected to high temperatures and water. Gelatinization temperatures are important for choosing particular starch qualities in accordance with needs in a variety of food applications[18]. Significant differences is observed in little millet, finger millet and sorghum. No significant differences is observed in paste clarity except in little millet. Paste clarity of starches is an important property of starch pastes because it affects the desired consistency of food products such as jellies and fruit pastes[18]. One of the variables that may affect the overall characteristics of reconstitution and/or mixing is wettability. Due to their low specific surface area, texture/microstructure, and chemical makeup, many typical dry sample powders take a long time to saturate, indicating poor wettability. The capacity of a powder to absorb water is measured by its wettability. Therefore, the wettability decreases as the wetting time increases[19]. Both sprouted and unsprouted kodo millet and sprouted little millet is found to have fair wetability whereas the other millets is found to have good wetability.

In the sensory evaluation it is found that ladoo prepared from sprouted millets to have more overall acceptability when compared to the ladoo prepared from unsprouted millets.

Conclusion

The present study concludes that the sprouted millets have a some of the good cooking properties than unsprouted millets and sensory evaluation also showed that ladoo prepared from sprouted millets were more acceptable than the ladoo prepared from unsprouted millets.

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