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Physical Parameters, Functional Properties and Cooking Quality of Barnyard (*Echinochloa frumentacea*) and Kodo (*Paspalum scrobiculatum*) Millet

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ABSTRACT: Barnyard (*Echinochloa frumentacea* L.) and kodo (*Paspalum scrobiculatum* L.) millets are important minor millets of tropical and subtropical countries. These millets are small seeded and highly nutritious containing high dietary fibre and mineral content. Presently, a detailed study was carried out to analyse the physical parameters, functional properties and cooking quality barnyard and kodo millet. Barnyard millet DhBM 93-2 and kodo millet were cleaned, sorted and analysed for physical, functional and cooking quality. All the analysis were carried out in triplicates. Student '*t*' test was applied using SPSS software (version 16.0). Results indicated that weight (4.57±0.02 g) and volume (3.33±0.01ml) of 1000 grains of kodo millet was significantly higher than barnyard millet (weight-2.27±0.07g, volume-1.80±0.01ml). The hydration and swelling capacity of kodo millet per 1000 grains were 0.74±0.06 g and 2.13±0.02 g respectively whereas that of barnyard millet were 1.52±0.06 g and 2.52±0.08 g respectively. Cooking time for barnyard and kodo millet was 12 and 10 minutes respectively. Cooked weight and volume were significantly higher for barnyard millet with percent increase of 170 and 105 respectively. Solid loss of barnyard millet was 20.95 per cent and that of kodo millet was 21.72 per cent. These physical parameters, functional properties and cooking quality of barnyard and kodo millet are further useful in understanding the acceptability of the millets and product development process.

Keywords: Barnyard millet, kodo millet, hydration capacity, swelling capacity, cooking time.

INTRODUCTION

Millets are small sized grains commonly used for food, feed or forage purpose. Millets are staple foods for the people of African and Asiatic region. In the developing countries like Asia and Africa roughly 90 per cent millet production can be seen. Millets are also grown globally for various purpose and are having many advantages in cultivation practices such as diverse adaptation, short-duration, less affected by biotic and abiotic stresses like drought tolerance (Pandarinathan and Geethanjali 2023). Millets are highly nutritious, non-glutinous and non-acid forming foods. They are the least allergenic and most digestible grains. Millet grains are nutritionally comparable and even superior to major cereals with respect to protein, energy, vitamins and minerals. Based on the size of the millet grains, they are classified as major millet and minor millet. Among them barnyard millet (*Echinochloa frumentacea*) and kodo millet (*Paspalum scrobiculatum*) are minor millets.

Barnyard millet *(Echinochloa frumentacaea)* is a multi-purpose crop which is cultivated for food and fodder. Barnyard millet is also called as *ooda, oadalu, sawan, sanwa, and sanwank.* It is important minor millet in Japan, China, India and other South East Asian countries. Nutritionally barnyard millet is an important crop. It is a fair source of protein, which is highly digestible. Barnyard millet contains 57 g of carbohydrates, 11 g of protein, 3.5 g of fat, 13 of g fibre, 4 g of ash and around 300 kcal of energy per 100 g grain (Kumar *et al*., 2010). Kodo millet [*Paspalum scrobiculatum* (L.)] is a tropical small millet crop, indigenous to India and grown for grain and fodder purpose. The local names of kodo millet are*kodra, kodonharka, koduain, varagu and arikelu.* Kodo millet is highly nutritious and a good substitute to rice or wheat. The grain is composed of 66.6 g of carbohydrates, 8.3 g of protein, 3.6 g of fat, 2.6 g of minerals, 9 g of fibre and 353 kcal of energy per 100 g which is comparable to other millets (Muthamilarasan *et al*., 2015).

Sandhya (2021) studied physical parameters and functional properties of barnyard millet. The 1000 kernel weight, 1000 kernel volume and bulk density were 3.35 g, 2.5 ml and 1.3 gm/ml respectively. Functional properties of barnyard millet such as hydration capacity, swelling capacity, hydration index and swelling index were 0.81 g, 1.1 ml, 24.17 (g/1000 kernels) and 44 (ml/1000 kernels) respectively. Muragod *et al.* (2019) studied physical and functional properties of kodo millet. Results reported that the hydration capacity (g/1000 grains), hydration index (%), swelling capacity (ml/1000 grains), swelling index (%) and swelling power (g/g) of kodo millet grains were 0.51, 24.52, 0.55, 42.30 and 9.73 respectively.

These physical parameters are very essential for the better understanding the millets, they play a very important role in understanding grain dimensions, appearance, acceptance by consumers and in addition to promote marketability. Functional properties play an important role in the physical behaviour of grains/food during preparation, processing and storage which affects the sensory characteristics. Cooking quality is essential in understanding acceptability of millet grains. Hence, the present study was conducted with the objective to analyze the physical parameters, functional properties and cooking quality of barnyard and kodo millet.

MATERIAL AND METHOD

Procurement and processing of the sample: Barnyard millet DhBM-93.2 was procured from Seed Unit, University of Agricultural Sciences, Dharwad. Dehusked kodo millet was procured from Millet Processing Unit, Timmapur, Haveri District. Barnyard millet was destoned and dehusked at Millet Processing Unit, Timmapur, Haveri District. Barnyard and kodo millet were cleaned to remove dirt, stones and unhulled millets. Cleaned millets were used for the analysis.

Statistical analysis: All the analysis were carried out in triplicates. Student '*t*' test was applied using SPSS software (version 16.0).

Physical parameters.

Weight (g): Weight of randomly selected thousand grains were recorded in grams using electronic balance with a sensitivity of 0.01 mg.

Volume (ml): Thousand randomly selected grains were dropped in a measuring cylinder containing known volume of distilled water. The difference in volume was recorded in ml.

Bulk density: Bulk density was calculated using the formula:

$$\text{Bulk density (g/ml)} = \frac{\text{Grain weight (g)}}{\text{Grain volume (ml)}}$$

Length (mm), breadth (mm) and L/B ratio of grains: The average length and breadth of the randomly picked ten grains were measured in mm with a help of vernier calipers.

Colour determination: Colour determinations will be carried out for millet grains using a Minolta colorimeter (Minolta CR- 400, Konica Minolta Sensing, Inc., Osaka, Japan), and results will be expressed in accordance with the Hunter Lab colour scale. The parameters determined will be L* (L=0 [black] and L=100 [white]), a* (−a=greenness and +a=redness), b* (−b=blueness and +b=yellowness).

Functional Properties

Hydration capacity: Thousand grains were soaked in distilled water for 12 hours. The water is drained. The adhering water to the grains was removed by gently pressing with blotting paper. The increase in weight before and after soaking was noted. Hydration capacity (g/1000 grains) was calculated using the formula (Anon., 2000).

$$\text{Hydration capacity} = \frac{\text{Grain weight after soaking} - \text{Grain weight before soaking}}{\text{Grain weight before soaking}} \times 100$$

Hydration index was calculated using formula (Anon, 2000)

$$\text{Hydration index} = \frac{\text{Hydration capacity}}{\text{Weight of 1000 grains}} \times 100$$

Swelling capacity: Thousand grains were soaked in distilled water for 24 hours. The water is drained. The adhering water to the grains was removed by gently pressing with blotting paper. The increase in weight before and after soaking was noted. Swelling capacity (g/1000 grains) was calculated using the formula (Anon, 2000)

$$\text{Swelling capacity} = \frac{\text{Grain weight after soaking} - \text{Grain weight before soaking}}{\text{Grain weight before soaking}} \times 100$$

Swelling index was calculated using formula (Anon, 2000)

$$\text{Swelling index} = \frac{\text{Swelling capacity}}{\text{Weight of 1000 grains}} \times 100$$

pH determination: Ten g of sample was mixed in100 ml of CO_2 free distilled water. The mixture was allowed to stand for 15 min, shaken at 5 min interval and filtered with Whatman No. 14 filter paper. The pH of the filtrate was measured using a pH meter (Anon, 2000).

Cooking quality of barnyard and kodo millets

Cooking time (minutes): A known quantity of millet grains (50 g) was dropped in boiling water and cooking time was noted by pressing the cooked grain between the glass slides and the time taken for disappearance of opaque core of millet rice grain was taken as cooking time.

Cooked weight and volume (%): Weight and volume of millet grains before and after was noted. Increase in weight and volume of millet grains were calculated by using the formula

$$\text{Increase in weight of the millets} = \frac{\text{Weight after cooking} - \text{Weight before cooking}}{\text{Weight before cooking}} \times 100$$

$$\text{Increase in volume of the millets} = \frac{\text{Volume after cooking} - \text{Volume before cooking}}{\text{Volume before cooking}} \times 100$$

Solid loss (%): Solid loss was determined by drying an aliquot of cooking water in a petri dish at 110°C in a hot air oven until completely dried.

RESULTS AND DISCUSSION

Physical parameters of barnyard and kodo millets are presented in Table 1. Shape of both the millets *i.e.* barnyard millet and kodo millet were oval. Kodo millet (4.57±0.02 g) weighed significantly higher than barnyard millet (2.27±0.07 g). Volume of kodo millet was 3.33±0.01 ml significantly higher than barnyard millet (1.80±0.01 ml). Bulk density of kodo millet was 1.37 g/ml which was significantly higher than that of barnyard millet (1.24 g/ml). Length and width of barnyard millet was 1.51±0.05 mm and 0.99±0.04 mm respectively, whereas kodo millet was significantly longer (2.27±0.09 mm) and wider (1.42±0.07 mm). The length and width ratio of kodo millet (1.59) was significantly higher than that of barnyard millet (1.53) at $p<0.05$. Higher values for kodo millet were because the grains of kodo millet were bigger in size compared to that of barnyard millet.

Color determination of millet grains revealed that barnyard millet had values of L* = 65.46 ± 0.95, a* = 3.95 ± 0.42 and b*= 17.23 ± 0.75, whereas the L*, a* and b* values of kodo millet were 52.52 ± 1.23, 7.02 ± 0.88 and 13.56 ± 1.28 respectively. Barnyard millet was significantly lighter than kodo millet flour. Redness value (+a) was significantly higher for kodo millet whereas yellowness value (+b) was significantly higher for barnyard millet. The difference in color values were because visually barnyard millet was lighter (whiter) in color compared to kodo millet which was brownish in color. The values for physical parameters of barnyard and kodo millet reported in the study were comparable with those reported by Nazni and Devi (2016); Srilekha *et al.* (2019) whereas the values for barnyard millet were higher in the study reported by Reddy (2016). Slightly higher values may be due to varietal differences, geographic conditions, agronomic and cultivation practices (Nithyashree and Vijayalaxmi 2023).

Functional properties of millets are shown in Table 2. The hydration capacity, hydration index, swelling capacity and swelling index of barnyard millet was significantly higher than that of kodo millet ($p<0.05$). The hydration and swelling capacity of kodo millet per 1000 grains were 0.74±0.06 g and 2.13±0.02 g respectively whereas that of barnyard millet were 1.52±0.06 g and 2.52±0.08 g. Hydration index of kodo millet was 17.02±1.02 and that of barnyard millet was 37.12±1.13. Swelling index of kodo and barnyard millet were 56.05±1.11 and 62.43±1.08 respectively. pH of kodo millet was 7.6±0.01 which was significantly higher than that of barnyard millet 7.2±0.02. Table 3 shows cooking quality of millet grains. Barnyard millet needed more time to cook *i.e.* 12 minutes compared to that of kodo millet (10 minutes). Increase in cooked weight and volume was higher for barnyard millet (170±0.95 and 105±2.15 respectively) compared to that of kodo millet. Solid loss of barnyard millet was 20.95 per cent and that of kodo millet was 21.72 per cent. The hydration capacity, swelling capacity and cooking time of millets are influenced by factors such as crude fibre, insoluble dietary fibre, total dietary fibre and total starch content of millets. Similarly, Patil *et al.* (2022) stated that difference in values of functional properties and cooking time are attributed to the higher total starch, high dietary fibre content especially insoluble dietary fibre which absorbs water and swells.

Table 1: Physical parameters of millets.

Parameters		Barnyard millet	Kodo millet	t value
Shape		Oval	Oval	-
Weight (g/1000 grain)		2.27±0.07	4.57±0.02	99.49**
Volume (ml/1000 grain)		1.80±0.01	3.33±0.01	107.63**
Bulk density (g/ml)		1.24±0.03	1.37±0.01	10.92**
Length (mm)		1.51±0.05	2.27±0.09	24.56**
Width (mm)		0.99±0.03	1.42±0.04	22.49**
Length: Width		1.53	1.59	2.15*
Color values	**L***	65.46±0.95	52.52±1.23	14.42**
	a*	3.95±0.42	7.02±0.88	5.45**
	b*	17.23±0.75	13.56±1.28	4.29*

Note: Values are expressed as mean ± standard deviation of three replications
*Significant at 5% level, **Significant at 1% level, L* (L=0 [black] and L=100 [white])
a* (−a=greenness and +a=redness), b* (−b=blueness and +b=yellowness).

Table 2: Functional properties of millet grains.

Parameters	Barnyard millet	Kodo millet	t value
Hydration capacity (g/1000 grains)	1.52±0.06	0.74±0.06	15.33*
Hydration index	37.12±1.13	17.02±1.02	22.36*
Swelling capacity (g/1000 grains)	2.52±0.08	2.13±0.02	33.12*
Swelling index	62.43±1.08	56.05±1.11	7.13*
pH	7.6±0.01	7.2±0.02	18.33*

Note: Values are expressed as mean ± standard deviation of three replications; *Significant at 5% level

Table 3: Cooking quality parameters of millets.

Parameters	Barnyard millet	Kodo millet
Initial weight (g)	50±0.75	50±0.50
Cooked weight (g)	135±1.10	110±0.90
Increase in weight (%)	170±0.95	120±0.60
Initial volume (ml)	40±1.00	37±1.50
Cooked volume (ml)	82±1.10	74±1.15
Increase in volume (%)	105±2.15	100±3.10
Cooking time (mins)	12±0.50	10±0.40
Solid loss (%)	20.95±0.25	21.72±0.30

Note: Values are expressed as mean ± standard deviation of three replications

CONCLUSIONS

The shape of both barnyard millet and kodo millet were oval. Weight, volume and bulk density of kodo millet was significantly higher than that of barnyard millet. Color determination revealed that barnyard millet was lighter (L* = 65.46±0.95) compared to that of kodo millet (L* = 52.52 ± 1.23). The hydration and swelling capacity of barnyard millet was significantly higher than that kodo millet. The time required for complete cooking of barnyard and kodo millet were 12 and 10 minutes respectively. Cooked weight and volume of barnyard millet was significantly higher than that of kodo millet. All these parameters such as physical, functional properties and cooking quality of millets are useful in understanding the behaviour of millets during product development process.

FUTURE SCOPE

The present study will be a route map for the scholars and scientists willing to work in the field of millets. The physical parameters and cooking quality studied will help the farmers to choose the variety for cultivation. The study will guide consumers to consume millets over other cereals.

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Conflict of Interest. None.

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