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Determination of Physical and Cooking Properties of Bamboo Rice

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The preference, choice and the economy of rice largely depends on its physical and cooking properties. 5 parameters of physical properties and 7 parameters of cooking properties were evaluated based on the standard protocols. The results showed that length and breadth were highest for white rice (6.63 mm and 3.00 mm respectively) than Bamboo rice (6.58 mm and 2.38 mm respectively). Whereas L/B ratio, 1000 kernel weight and bulk density were highest for Bamboo rice (2.76, 13.68 g and 1.65 g/ml respectively) than white rice (2.21, 10.24 g and 1.62 g/ml respectively). Cooking parameters results showed that Alkali spreading value, gel consistency and dispersed solids were highest for white rice (3.0, 55.33 and 6.33% respectively) than bamboo rice (2.0, 49.80 and 4.64% respectively) whereas, gelatinization temperature, minimum cooking time, optimum cooking time and water uptake ratio were found to be highest for bamboo rice (71.66^{o}C,

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56.80 min, 58.75 min and 4.48 respectively) than white rice (70.09°C, 13.50 min, 15.80 min and 2.68 respectively). The information on physical and cooking properties of bamboo rice can be exploited by nutritionists and utilized for practical applications in food technology.

Keywords: Bamboo rice; bulk density; cooking properties; gel consistency; gelatinization temperature; physical properties.

1. INTRODUCTION

"Bamboo plant is one of the precious plant resources of the earth. It has played a significant role in human civilization and is still contributing to the subsistence of over 2 billion people living in the tropical and sub-tropical belts in Asia. Bamboo rice is special rice that is grown out of a dying bamboo shoot. When the bamboo shoot breathes its last, it flowers in to a rare variety of rice seeds, which are known as bamboo rice" (Rana, 2017). "In bamboo, the fruit is one seeded structure that does not split when ripe" (Wong, 2004). "When the bamboo seeds are matured, the tribals clean the ground around the plant and patch the floor by using cow dung. Every morning and evening they collect the seeds that fall from plants on this clean floor. Mostly women and children are actively engaged in the collection of bamboo seeds. Excess seeds are sold in the adjoining forest areas. Seeds of Bamboo a collected by villagers are sold to the forest department, as well as for domestic consumption. It helps to empower and improve the economy of the tribal people. The collected seeds were cleaned in water and boiled like rice and consumed with fish curry and vegetables by indigenous people as a substitute of rice. Bamboo rice is known for its high nutritional qualities and rich medicinal values" (Kiruba et al., 2007). Bamboo rice is not commonly available since their flowering pattern is highly unpredictable and it may vary from a few years to up to 100 years for a bamboo plant to flower.

"Around 8.96 million ha of the total 63.3 million ha forest area of India is estimated to be covered by bamboo" (Yengkopam, 2013). "Among the 136 exotic and indigenous species recorded in India, 50% of the total *Bambusa* sp. is being found in the North- Eastern states like Arunachal Pradesh, Sikkim, Mizoram, Manipur, Nagaland, Meghalaya and Assam followed by state of West Bengal (North Bengal, Himalaya)" (Juliano et al., 1964).

"Bamboo is a giant, fast growing, wood like grass and one of the earth's oldest and most precious plant materials. It has benefited human societies since times before recorded history. Today, it helps more than two billion people to meet their basic needs, and as a widespread, renewable, productive, versatile low or no-cost, easily accessed environment enhancing resource. Bamboo is a versatile multipurpose forest product which plays a vital role in domestic and individual economy. Bamboo has age old connection with the people which serves as pillars, beams for the houses and provides materials for doors and windows, walls, basket making, agricultural implements, weaving accessories, bows and arrows and musical instruments. Bamboo is rightly called "Green gold"" (Saikia et al., 2012).

"The nutritional value of bamboo rice is very remarkable. It is healthier to have bamboo rice than the rice from paddy. Recently some news and researchers said that eating bamboo rice increases fertility. Its powder is very useful in cough, cold asthma etc., the bamboo rice is pungent, sweet, strong, and nutritious. It cures Kapha, pitta dosha, removes toxic substances from the body and cures the disease in which the vital humors of the body are excreted through urine. Bamboo rice like any other rice is rich in various nutrients including carbohydrates, fiber and protein. It is believed that bamboo rice has low glycemic index compared to other varieties of rice, which is considered to be a healthier option for diabetics. The rice has low or no fat and is rich in vitamin B. The tribes in Kerala use this rice to cure joint pain owing to the presence of immense calcium and phosphorus content. Bamboo rice may not be very popular in the India, but considering its origination and benefits, looks like it may soon become a staple across the country and add to the list of other varieties of rice" (Rana, 2017).

2. MATERIALS AND METHODS

2.1 Procurement of Materials

Bamboo rice required for research was procured from organic store and other samples were procured from local market Bengaluru, Karnataka, India.

2.2 Physical Properties of Bamboo Rice

The physical characteristics like length, Breadth, L/B ratio, 1000 kernel weight, volume and bulk density were analyzed for White rice and Bamboo rice. Cooking properties like alkali spread value, gelatinization temperature, gel consistency, cooking time, water uptake ratio and dispersed solids were determined.

2.2.1 Grain length (mm) and breadth (mm)

These parameters determined by using vernier caliper holding the single grain lengthwise and breadthwise respectively (Murugesan and Bhattacharya, 1994).

2.2.2 Length by breadth (L/B) ratio

Ratio of length and breadth gave L/B ratio. It was obtained by dividing the length of a single kernel by the corresponding breadth. A mean of 10 replications is reported (Juliano and Pascual, 1980).

2.2.3 1000 Kernel weight (g)

Weight of thousand grains was randomly selected in triplicates and weighed using electronic weighing balance. Mean weight per grain was expressed in gram.

2.2.4 Bulk density

Rice kernels from different cultivars were poured into a 50 ml measuring cylinder from a fixed height and mass of samples occupying the volume was determined.

Ratio was calculated as g/ml (Singh et al., 2005).

2.3 Cooking Properties of Bamboo Rice

2.3.1 Alkali spreading value (ASV)

This test is extensively employed in seed quality studies as an indirect estimate of gelatinization temperature. The extent of degradation observed was expressed as a numerical score and found to be inversely related to the gelatinization temperature of the grain variety. Six whole milled rice kernels were completely immersed in 10 mL of 1.5% KOH solution in a Petri dish and arranged so that the grains did not touch each other. The Petri dishes were then covered. After 23 h of incubation at room temperature, each grain was visually examined for its level of intactness and assigned a numerical score by 3 trained human inspectors: “1” for not affected kernel; “2” for swollen kernel; “3” for swollen kernel, with incomplete or narrow collar; “4” for swollen kernel, with complete and wide collar; “5” for split or segmented kernel, with complete and wide collar; “6” for dispersed kernel, with merging collar and “7” for completely dispersed and intermingled kernel (Bhattacharya et al., 1982).

2.3.2 Gelatinization temperature

Finely powdered bamboo rice sample (2.0g) was placed in five test tubes. 10 ml of distilled water was added to each test tube and shaken vigorously to obtain uniform solution. It was heated on a hot plate at 90^{o}C with continuous stirring until gelatinization (starch granules have absorbed water and expanded during heating) was completed. The temperature was noted down and repeated in triplicates (Juliano et al., 1964).

2.3.3 Gel consistency

100 mg of rice flour was taken in test tube (2×19.5 cm), from pipette 0.2 ml of ethanol containing 0.25 % thymol blue and 2.0 ml of 0.2 N of KOH were added and kept in boiling water-bath for 8 min, cooled, mixed well and kept in ice bath for 20 min. Later the test tubes were laid horizontally for one h and measurements were made using graph paper. The degree of disintegration of kernel was evaluated using a 7point scale. The varieties were classified on the basis of gel consistency (gel length) as hard (27–40 mm), medium (41–60 mm), and soft (over 60 mm) gel types (Saikia et al., 2012).

2.3.4 Cooking time

It was determined for each sample by the glass plate white centre method (Ranghino, 1966). Distilled water (100 ml) was heated to boiling in a 250 ml beaker before 5g of milled rice was added. After 10 min of boiling, samples of 10 grains were withdrawn every minute with a spatula and pressed between two glass plates. Minimum cooking time (MCT) is the time when at least 90 per cent of the pressed grains no longer exhibited opaque or uncooked centers. Optimum cooking time (OCT) equals the minimum cooking time plus two minutes (Juliano et al., 1981).

2.3.5 Water Uptake Ratio (WUR)

This was determined by cooking 2.0 g of whole rice kernels from each treatment in 20 ml distilled

water for a minimum cooking time in a boiling water bath and draining the superficial water from the cooked rice. The cooked samples were then weighed accurately and the water uptake ratio was calculated as the ratio of final cooked weight to uncooked weight (Oko et al., 2012).

$$\text{Water uptake ratio} = \frac{\text{Weight of cooked rice}}{\text{Weight of uncooked rice sample}}$$

2.3.6 Dispersed solids (DS)

This was determined by drying an aliquot of the cooking water in a tarred evaporating dish to evaporate the water as steam (Oko et al., 2012). The weight of the empty Petri dish was measured and recorded (W1). This was followed by measuring the weight of the Petri dish and aliquot (W2). The weight of the Petri dish and the dry aliquot was measured (W3).

> The amount of solid in cooking water was now calculated as: W3 – W1

Where

W1 = weight of empty Petri dish,
W2 = weight of empty dish + dry aliquot (W3).

2.4 Statistical Analysis

The data reported in the tables are the average of triplicate observations. The data was analyzed and the result was presented as mean ± standard deviation. Statistical analysis was done using student's't' test measured at 5 per cent significant level (Juliano et al., 1964).

3. RESULTS AND DISCUSSION

3.1 Physical Properties of Bamboo Rice

Rice grain characteristics include length, breadth, L/B ratio, 1000 kernel weight and Bulk density. The results are presented in Table 1.

Table 1 depicts the physical characteristics of white rice and bamboo rice. It is evident from the results that the `length and breadth found to be higher (6.63 mm and 3.00 mm) in white rice compared to bamboo rice (6.58 mm and 2.38 mm). Further the other three measurements L/B ratio, 1000 kernel weight and bulk density indicates bamboo rice showed better values as against the response on the white rice. The data subjected for t-test revealed the significant difference statistically at 5 % level on breadth, L/B ratio and 1000 kernel weight ($p<0.05$). However length and bulk density implied non-significant findings ($p>0.05$) (Sastry, 2008).

Dipti and her co-workers studied on physico-chemical properties of six fine rice varieties. The highest length was found in khazar (6.5 mm) and highest length breadth ratio was found in khazar and superfast. Lowest grain length (3.6 mm) and length breadth ratio were found in Badshabog and bashmati 4488 varieties (Dipti et al., 2002).

The physico-chemical properties of dehusked and milled bamboo seeds was analyzed by Singh and his co-workers. The weight of 1000 kernel weight was high in the case of dehusked grains (12.9 g), as it contains bran along with the endosperm and the weight of the milled grain reduced (11.5 g), as it was made free of aleurone, pericarp and the seed coat layers. Length and thickness for milled rice were 5.2 mm and 1.4 mm respectively (Singh et al., 2011).

The results of the present study equipotential with study conducted by (Ganavi, 2022), who reported that highest length was found in Burma black (7.05 mm) and lowest found in Thanu (5.49 mm), breadth was found highest in Navali sale (2.88 mm) and lowest in Burma black (2.14 mm) , L/B ratio found highest in Burma black (3.29) and lowest was found in Navali sale (2.06) , 1000 kernel weight found highest for Karijaddu (23.89 g) and lowest was found in Thanu (14.32 g) and bulk density found highest in Vanasu (6.18 g/ml) and lowest found in Thanu (14.32 g/ml) among ten pigmented rice varieties.

Lum reported highest thousand kernel weight in white rice variety (20.90 g) followed by brown rice (20.50 g), aromatic rice (19.90 g) and least was in black rice (15.30 g) (Lum, 2017). Singh and his co-workers analysed twenty-three Indian rice cultivars for thousand kernel weight and were in the range of 13.3 to 19.9 g which was higher than the present result (Singh et al., 2005).

3.2 Cooking Characteristics of Bamboo Rice

Cooking quality of rice is one of the important factors influencing the acceptability of rice by the consumers. Cooking quality of rice mainly depends on Amylose content and gelatinization temperature. Bamboo rice was studied for cooking characteristics such as alkali spreading value (ASV), gelatinization temperature (GT), gel

consistency (GC), minimum cooking time (MCT), optimum cooking time (OCT), water uptake ratio (WUR) and dispersed solids (DS) (Saikia et al., 2012).

Cooking characteristics of white rice and bamboo rice depicts in Table 2. The results revealed that the alkali spread value, gel consistency, dispersed solids found to be higher (3.00, 55.33 and 6.33% respectively) in white rice compared to bamboo rice (2.00, 49.80 and 4.64% respectively). Further the other measurements gelatinization temperature, minimum cooking time, optimum cooking time and water uptake ratio indicates bamboo rice showed better values as against the response on the white rice. The data subjected for T-test reveals the non-significant difference statistically at 5 per cent level on ASV and GC ($p<0.05$). However remaining 5 characteristics *i.e*., GC, MCT, OCT and WUR implies significant difference statistically at 5 per cent level ($p>0.05$).

Diako and his co-workers studied on cooking characteristics of some scented rice varieties in Ghana. The results revealed that minimum cooking time ranged between 15.31 to 23.27 min and water uptake ratio ranged between 1.72 to 2.08 (Diako et al., 2011). Further, maximum cooking time were required in the bashmati 4488 rice (25 min) variety and minimum cooking time were required for badshabog (14.5 min) rice variety. Results were obtained out of 6 fine rice varieties reported by Dipti and her co-workers (Dipti et al., 2002).

The results obtained in the present investigation were in concurrence with the results reported by Subedi who reported that minimum cooking time ranged from 18.00 to 21.00 mm, water uptake ratio was ranged from 1.72 to 2.67 for white rice (Subedi et al., 2016). Further, the similar finding for bamboo rice were in good accordance with results reported by Shabna who reported that cooking time of 70 min was taken for obtaining optimum cooked bamboo seed. Since prolonged cooking was noted for bamboo seed in ordinary cooking, pressure cooking was tried. Cooking time of 18 min was taken for bamboo seed in pressure cooking (Shabna, 2010).

Gopika exploited the cooking characteristics of 20 traditional rice varieties. Results found that Karimuruga (2.33) recorded least and Anandi (4.67) recorded highest alkali spread value among all the varieties. Karimuruga (71.14° C) showed highest gelatinization temperature and lowest was recorded by Anandi (67.47° C). Malgudi sanna (30.33 min) required more minimum cooking time and Nagabatta (17.67 min) required less cooking time. Mysore mallige (3.77) showed significantly higher water uptake ratio and least was observed in Kagisaale (2.48). Among all the rice varieties Karimundaga (6.33%) showed highest value and Rajkaime showed lowest value (1.55%) for Dispersed solids (Muttag, 2016).

Table 1. Physical characteristics of white rice and bamboo rice

Sl. no	Measurements	Mean ± SD		Student's 't' test
		White rice	Bamboo rice	
1	Length (mm)	6.63 ± 0.04	6.58 ± 0.03	NS
2	Breadth (mm)	3.00 ± 0.09	2.38 ± 0.11	*
3	L/B ratio	2.21 ± 0.06	2.76 ± 0.08	*
4	1000 kernel weight (g)	10.24 ± 0.80	13.68 ± 1.20	*
5	Bulk density (g/ml)	1.62 ± 0.04	1.65 ± 0.03	NS

** Significant at 5% level, NS- Non- significant*

Table 2. Cooking characteristics of white rice and bamboo rice

Sl. no	Characteristics	Mean ± SD		't' test
		White rice	Bamboo rice	
1	Alkali spreading value (ASV)	3.00 ±0.56	2.00 ± 0.51	NS
2	Gel consistency (GC)	55.33 ±2.11	49.80 ± 2.01	*
3	Gelatinization temperature (GT) (ºC)	70.09± 0.78	71.66 ± 0.71	NS
4	Minimum cooking time (min) (MCT)	13.50 ± 4.71	56.80 ± 6.25	*
5	Optimum cooking time (min) (OCT)	15.80 ±4.56	58.75 ±9.25	*
6	Water uptake ratio (WUR)	2.68±0.72	4.48 ±0.81	*
7	Dispersed solids % (DS)	6.33 ±0.62	4.64 ± 0.71	*

** Significant at 5% level, NS- Non- significant*

Priya evaluated the cooking characteristics of two rice genotypes (MSN 100 and MSN 104). Results reported that alkali spread value was high for MSN 100 (3.50) genotype and low for MSN 104 (3.17). Whereas, other characteristics like gelatinization temperature (69.83 ◦C), gel consistency (66.53 mm), minimum cooking time (45.00 min), optimum cooking time (48.00 min), water uptake ratio (3.16) and dispersed solids (2.80%) were highest for MSN 104 and lowest for MSN100 (69.36 ◦C, 61.13 mm, 42.83 min, 45.17 min, 3.01 and 2.20% respectively) rice genotype. Highly polished rice is more vulnerable to loose gruel solids than brown rice during cooking (Priya, 2022).

A study conducted to know the physical and cooking properties of Rajmudi and Sona masoori rice varieties by Meghana. The results showed that length, breadth and bulk density were lower when compared with present study. Alkali spread value was higher and gelatinization temperature was lower when compared with the present study (Meghana, 2022).

4. CONCLUSION

Bamboo rice being one of the less familiar and less explored cereals compared to other cereal grains. The results showed that white rice had higher values in length and breadth whereas, L/B ratio, 1000 kernel weight and bulk density was high in bamboo rice. Breadth, L/B ratio and 1000 kernel weight shows statistical difference ($p<0.05$) between white rice and bamboo rice but there is no significant difference ($p>0.05$) was observed for length and bulk density. Alkali spread value and gel consistency was high in white rice (3.0 and 55.33 respectively) than the bamboo rice (2.0 and 49.80 respectively). As gelatinization temperature increases, cooking time also increases. Bamboo rice had highest gelatinization temperature so cooking time and water uptake ratio also increases. There is a significant difference was observed for all characteristics except alkali spread value and gelatinization temperature which were non-significant. The findings emphasize the fact that bamboo rice can aid in improving the nutrient intake of vulnerable population especially the indigenous population residing in the south western ghats of India, where there is a better availability and consumption of Bamboo rice.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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