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Evaluation of cooking characteristics of different brown rice varieties grown in the Konkan region

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Abstract
Rice (*Oryza sativa* L.) is the most important cereal crop after wheat. Rice is the main food for more than half of the world's population. The study was conducted on the cooking characteristics of seven rice varieties at Dapoli. The varieties used namely Karjat 4, Karjat 8, Karjat 9, Ratnagiri 2, Ratnagiri 5, Ratnagiri 6, and Ratnagiri 8 respectively. Depending on classification Karjat 4, Karjat 8, and Ratnagiri 5 were found to be short slender and Ratnagiri 2 was short bold type grain whereas Karjat 9, Ratnagiri 6, and Ratnagiri 8 were found to be medium slender grain. Results showed that optimum cooking time, water uptake ratio, elongation ratio, breadth expansion ratio, and cooked length to breadth ratio were significantly different. It was observed that variety Karjat 9 had the longest cooking time and highest water uptake ratio while elongation, expansion, and cooked length to breadth ratio were found to be highest in Karjat 8. The study of cooking characteristics is expected to be useful for further study, classification, and grading of rice varieties. Also, these results are useful in the preparation of new rice-based food products.

Keywords: Rice varieties, cooking, elongation ratio

1. Introduction
Rice (*Oryza sativa* L.) is the most important cereal crop after wheat. Rice is the main food for more than half of the world's population (Alhendi *et al*. 2019) [2]. It belongs to the Poaceae family and its domestication began in ancient civilization native to Southeast Asia. Rice is mainly consumed as a whole grain after cooking which contributes about 40% to 80% of the calorie intake of human. Paddy is cultivated globally being the most important cereal crop in the world. As per USDA global rice market, total production for the year 2020-21 was recorded as 501.5 million tons on a milled basis. (Anonyms[1], 2020) [3]. India is the world's second-largest producer of white and brown rice. In the year 2020-21 the total production of rice in India is 122.27 million tonnes and rice is cultivated in the largest area of 45.07 M ha (Anonyms[2], 2021). In Maharashtra, the production of rice is recorded as 30.27 Lakh metric tonne (Anonyms[3], 2021). Konkan is a coastal region of Maharashtra state in which rice is a lead crop of Konkan region. The area under rice cultivation in Konkan is about 23.71 percent of the total cultivated area in Maharashtra (Meshram *et al.* 2020) [13]. It is the predominant rice growing belt with average productivity in 2020-21 is 2.66 t/ha (Anonyms[4], 2021). The rice produced in different parts of India varies significantly in composition and cooking quality.
Brown rice is unrefined, coarse, and unpolished whole grain rice which is directly obtained by removing the husk. It consists of a bran layer of 6 -7 % of its total weight, an embryo of 2-3% and an endosperm is about 90%. It contains more nutritional components such as minerals, vitamins proteins, and dietary fibers compared to white rice (Ramasamy and Siddharth, 2015) [16]. Brown rice is a local food that must be intensified because it has nutrition and more health benefits. Brown rice is beneficial for people with diabetes and prevents increased blood glucose levels which can lead to diabetes (Wijaya *et al*. 2021) [18].
Cooking is a unit operation that involves the heating of food to make it edible and suitable for consumption. The cooking quality of rice also determines its economic value can be measured in terms of cooking time, grain elongation ratio, water uptake ratio, and cooked length-breadth ratio. Cooking time is important since it determines the tenderness of cooked rice as well as stickiness to a great extent. There is a need to determine the cooking characteristics of different varieties of rice produced in the Konkan region. This will assist the awareness of consumers about the quality of rice they consume.

2. Material and Method

2.1 Material

Seven varieties of paddy were procured from the Department of Agronomy, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli. The varieties developed by DBSKKV such as Ratnagiri 2, Ratnagiri 5, Ratnagiri 6, Ratnagiri 8, Karjat 4, Karjat 8, and Karjat 9 were used for the experiments of performance evaluation of rice pounding machine and also determined cooking properties of produced rice.

2.2 Methods

2.2.1 Dehulling

Paddy samples of different varieties were dehulled on a CAET developed rice pounding machine. The brown rice samples obtained were used for further experiment.

2.2.2 Sample Preparation

Whole rice samples were separated from broken rice for the evaluation of the cooking properties of produced rice.

2.2.3 Physical dimension and grain classification

Length and breadth measurement was done by using a vernier caliper. Twenty random samples of rice kernel of each variety were taken for the measurement. The L/B ratio was then calculated from the data obtained by dividing the length by breadth. According to Singh *et al.* (2012) [17] grain is classified by length and L/B ratio.

2.4 Cooking characteristics

2.4.1 Optimum Cooking Time (OCT)

Optimum cooking time was determined by the procedure described by Sanusi *et al.* (2017) [20]. A brown rice sample of 10 gm was cooked with 100 mL distilled water at around 100 ºC temperature in a boiling water bath. After cooking for 10 min, the sample was taken at different time intervals and pressed between two clean glass plates. Cooking time was recorded when at least 90 % of the grains no longer had opaque core or uncooked centers.

2.4.2 Water uptake ratio (WUR)

It was calculated by the process suggested by Sanusi *et al.* (2017) [20]. A Brown rice sample of 10 g was cooked in 100 mL distilled water for a minimum cooking time in a boiling water bath. After cooking of sample the water was drained out and remaining water the of the cooked rice was removed using absorbent paper. The cooked samples were then weighed accurately and the water uptake ratio was calculated as the ratio of the final cooked weight of the brown rice sample to the uncooked weight of the brown rice sample.

2.4.3 Elongation ratio (ER)

The elongation ratio was determined by the process described by Sanusi *et al.* (2017) [20]. Twenty kernels of brown rice of each rice variety were taken, and their length was measured and cooked to the minimum cooking time. The cooked kernels were taken out and placed on blotting paper to absorb excess water. The length of cooked rice kernels was measured by vernier caliper. The kernel elongation ratio was calculated as:

$$\text{Elongation Ratio (ER)} = \frac{\text{length of cooked rice}}{\text{length of raw rice}} \quad \ldots (2.1)$$

2.4.4 Breadth expansion ratio (BER)

The breadth expansion ratio was determined by the process described by Pachalsiya *et al.*, (2017). Twenty kernels of brown rice of each variety were taken, and their breadth was measured and cooked to the minimum cooking time. The cooked kernels were taken out and placed on blotting paper to absorb excess water. The breadth of cooked rice kernels was measured by the vernier caliper. The kernel expansion ratio was calculated as:

$$\text{Breadth Expansion ratio (BER)} = \frac{\text{Breadth of cooked rice}}{\text{Breadth of raw rice}} \ldots (2.2)$$

2.4.5 Cooked length–breadth ratio (CLBR)

The cooked length-breadth ratio was determined by the process described by Sanusi *et al.* (2017) [20] in which dividing the length of 20 cooked kernels by the breadth of the same cooked kernels.

$$\text{Cooked Length / Breadth Ratio} = \frac{\text{Length of cooked rice}}{\text{Breadth of cooked rice}} \ldots (2.3)$$

2.4.6 Statistical analysis

All the analysis were performed in triplicate and all the data were calculated using Microsoft Excel. Mean score were subjected to analysis of variance at the significance level of 5 % to determine if there were significant differences between the various parameters between the rice samples.

4. Result and discussion

4.1 Physical dimension and grain classification

The physical dimension and grain classification of the different rice varieties are shown in Table 1. Rice is classified based on the length and breadth of the kernel. The dimensions (Length, breadth, and L/B ratio) and type of grains were determined. Depending on this classification Karjat 4, Karjat 8, and Ratnagiri 5 were found to be short slender and Ratnagiri 2 was short bold type grain whereas Karjat 9, Ratnagiri 6, and Ratnagiri 8 were found to be medium slender grain. Grain length was classified according to (Singh *et al.* 2012) [17] as extra-long (>7.50). Long (6.61-7.5 mm), medium (5.51-6.60 mm), or short (<5.50 mm). Grain shape based on length-width ratio was classified as slender (>3.00), medium (2.01-3.00), bold (1.1-2.0), and round (<1.1). There is a significant difference in the L, B, and L/B ratio of different rice varieties at $p < 0.05$ significance level**.** The values of the L/B ratio are useful for determining the grain shape of the variety.

Table 1: Classification of rice grain based on the length and length-breadth ratio

Sr. No.	Variety	Length (mm)	Breadth (mm)	L/B ratio	Grain type
1	Karjat 4 (K4)	4.88	1.60	3.05	Short slender
2	Karjat 9 (K9)	5.52	2.04	2.71	Medium slender
3	Ratnagiri 6 (R6)	5.23	1.85	2.83	Medium Slender
4	Ratnagiri 2 (R2)	5.75	2.55	2.26	Short Bold
5	Karjat 8 (K8)	5.15	1.60	3.22	Short Slender
6	Ratnagiri 8 (R8)	5.67	2.03	2.80	Medium Slender
7	Ratnagiri 5 (R5)	5.24	1.67	3.13	Short Slender

4.2 Cooking characteristics

The cooking characterises of seven rice varieties obtained by rice pounding machine were measured. Cooking characteristics include optimum cooking time, water uptake ratio, elongation ratio, expansion ratio and cooked length/breadth ratio respectively. Brown rice samples of seven varieties were collected from a rice pounding machine.

Table 2: Cooking characteristics of different rice varieties

Sr. No.	Variety	OCT	WUR	ER	BER	CLBR
1	Karjat 4	30	2.70	1.32	1.31	3.06
2	Karjat 9	49	2.90	1.31	1.26	2.83
3	Ratnagiri 6	46	2.37	1.32	1.25	3.00
4	Ratnagiri 2	44	2.47	1.38	1.31	2.37
5	Karjat 8	36	2.60	1.38	1.35	3.28
6	Ratnagiri 8	47	2.80	1.31	1.27	2.87
7	Ratnagiri 5	26	2.40	1.37	1.34	3.20

4.2.1 Optimum cooking time (OCT)

The optimum cooking time for seven brown rice varieties was shown in Table 2. It ranged from 26 to 49 min with the highest cooking time observed in Karjat 9 i.e.49 min and the lowest cooking time observed in Ratnagiri 5 i.e. 26 min respectively. Ratnagiri 2, Ratnagiri 6, Ratnagiri 8 and Karjat 9 cooked for longer than the other varieties. The variation in cooking time as shown in fig 1 is due to the outer intact bran layer that affects the penetration of water and due to varietal difference. A similar trend of results was observed in Das *et al.* (2008) [11] and Cui *et al.* (2010) [10]. They found the OCT was 45 min and 39 min; also Chanu *et al.* (2020) [8] found a similar trend of results ranging from 26.67 to 32.37 min; similarly, Chapagai *et al.* (2020) [8] reported the OCT was 29 to 35 min for brown rice respectively.

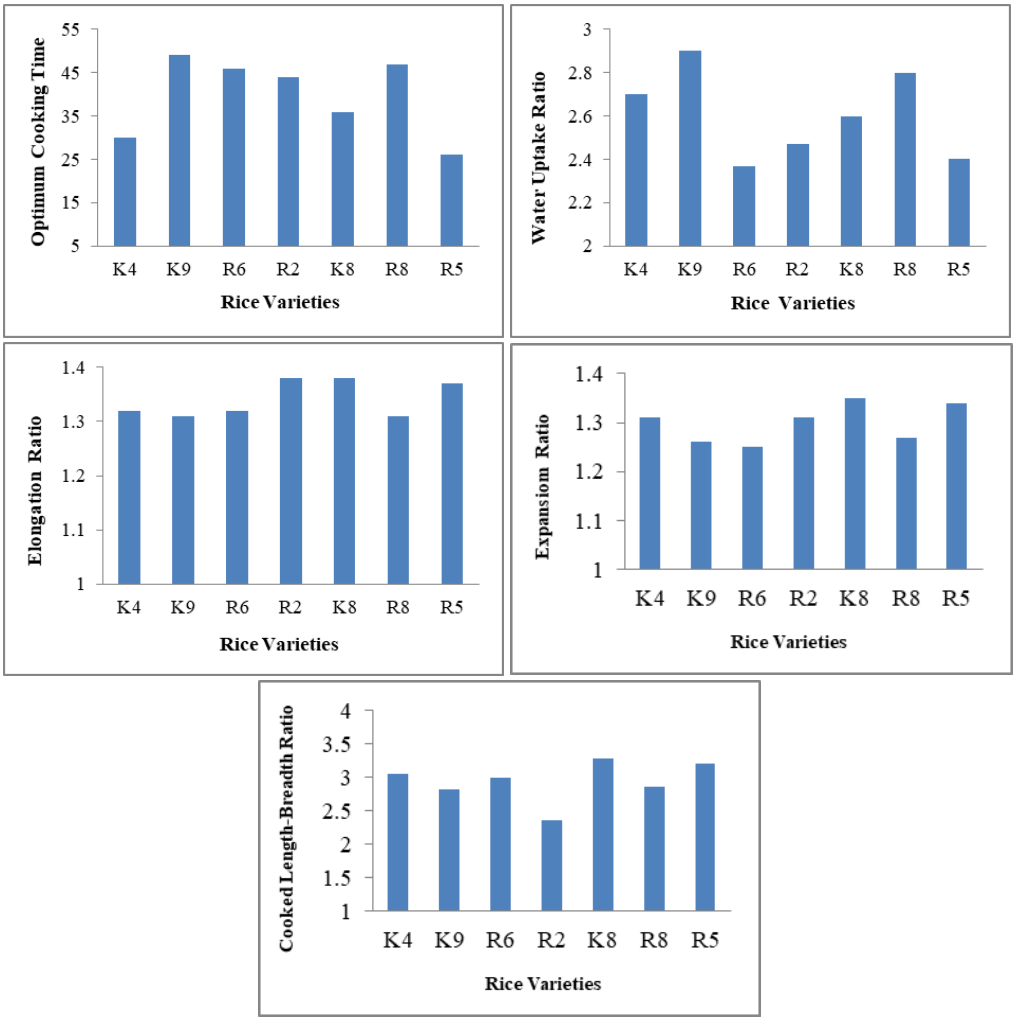

Fig 1: Cooking characteristics of different brown rice varieties

4.2.2 Water uptake ratio (WUR)

The variation in water uptake ratio shown in fig 1. It was observed that the water uptake ratio varies significantly with varieties at a 5% level of significance. The water uptake ratio for seven varieties ranged from 2.37 to 2.90 (Table 2) The result showed that the highest WUR was observed in Karjat 9 i.e., 2.90, and the lowest WUR was observed in Ratnagiri 6 i.e., 2.37. WUR of minimally milled rice is much lower than white rice. This is due to the presence of the outer bran layer which slows down moisture diffusion. A similar trend of the result was found by Singh *et al.* (2005) [22] i.e., 2.37 to 4.45 for 23 varieties of milled rice.

4.2.3 Elongation ratio (ER)

The elongation ratio is a better index of cooking quality. The variation in length elongation ratio shown in fig 1. From Table 2, results revealed that the range of elongation ratio during cooking varied from 1.31 to 1.38. The result shows that the higher elongation ratio was observed in Karjat 8 and Ratnagiri 2 i.e., 1.38 followed by Ratnagiri 5 and the lowest elongation ratio was observed in karjat 9 and Ratnagiri 8 i.e., 1.31. It was observed that the elongation ratio varies significantly with varieties at a 5% level of significance. Less elongation was observed in minimally milled rice because is covered with a bran layer which contains oil so that elongation ratio was less in brown rice. A similar trend of results was found by Singh *et al.* (2012) [17] i.e., 1.26-1.57; Hossain *et al.* (2009) [12] i.e., 1.51-1.82; also found by Chapagai *et al.* (2020) [8] i.e., 1.1-1.4.

4.2.4 Breadth expansion ratio (BER)
The variation in breadth elongation ratio shown in fig 1. From Table 2, the result revealed that the breadth expansion ratio ranged from 1.25 to 1.35. It was observed that the expansion ratio was highest in Karjat 8 i.e., 1.35 and lowest in Ratnagiri 6 i.e., 1.25. High expansion breadth wise is not a desirable quality attribute in high-quality rice. It was observed that the expansion ratio varies significantly with varieties at a 5% level of significance.

4.2.5 Cooked length-breadth ratio (CLBR)
The variation in Cooked length-breadth ratio shown in fig1. The result obtained from the rice pounding machine was given in Table 2 which revealed that the length-breadth ratio of cooked kernel ranged from 2.37 to 3.28 respectively. From Table 2, it was observed that the cooked length-breadth ratio was highest in Karjat 8 i.e., 3.28 and lowest in Ratnagiri 2 i.e., 2.37. It was observed that the cooked length-breadth ratio varies significantly with varieties at a 5% level of significance. The cooked length-breadth ratio is greater than the length-breadth ratio of raw rice which is presented in table 1. Similar trend of cooked length-breadth ratio of brown rice found in Singh *et al*. (2012) [17] i.e., 2.24-4.25.

5. Conclusion
The investigation was conducted on the cooking characteristics of seven rice varieties grown in the Konkan region. The study showed that the varietal difference was observed in cooking characteristics such as optimum cooking time, water uptake ratio, elongation ratio, breadth expansion ratio and cooked length to breadth ratio. The variation occurred between grain length and shape which is important information for designing of milling machinery. This study revealed that the variety karjat 8 showed the best grain quality, cooking characteristics so people can prefer this variety. The elongation and expansion ratio was found to be highest in Karjat 8. The variety Karjat 9 has the longest cooking time and WUR was found to be highest in Karjat 9. Results obtained from this study are expected to be useful for further study, classification and grading of rice varieties. Also, this results are useful in the preparation of new rice-based food products.

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