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# Physical and cooking characteristics of biofortified (iron and zinc) aerobic rice varieties

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Biofortification is a process of breeding staple food crops that are rich in micronutrients. Since it do not produce methane, one of the major 'greenhouse gases' that contributes to global warming hence, it is considered as eco-friendly. Grain quality is one of the important parameter that determines the overall acceptability and profitability of a variety. Rice is a cereal that is consumed mainly as whole milled and boiled grain. An experiment was conducted to study milling, physical and cooking characteristics of six biofortified aerobic rice varieties. The head rice recovery ranged from 79.93 per cent to 92.70 per cent, grain length 5.40 to 6.43 mm, breadth 2.0 to 2.21 mm, L/B ratio 2.40 to 3.21 mm and grain width 2.13 to 2.71 mm, 1000 grain weight 15.03 to 17.06 g and bulk density 0.77 to 0.88 (g / ml). As per dimensional classification Karidaddi, Makam IVT (SHW) 91, Badshahbhog and control sample were of fine type and BI 43 common type. Cooking time ranged from 16 to 20 minutes, per cent increase in weight 168 to 210, per cent increase in volume 226 to 260, water uptake ratio 29.80 to 40.29, kernel elongation ratio 1.27 to 1.57, per cent curled grain 29 to 53 and dispersed solids 2.6 to 5 per cent. Cooking time, per cent increase in weight, per cent increase in volume, water uptake ratio, L/B ratio and dispersed solids were positively correlated with sensory mean scores and whereas length, breadth, kernel elongation ratio and per cent curled grains were negatively correlated with sensory mean scores.

**Key Words** : Biofortification, Aerobic rice, Physical and cooking characteristics, Milling, Sensory evalution

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## INTRODUCTION

Rice is the seed of the monocot plant of the genus *Oryza* and of the grass family Poaceae (formally Graminae) which includes twenty wild species and two cultivated ones, *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice). Grain quality has become an important issue affecting domestic consumption and international trade of rice. Rice is a cereal that is consumed mainly as whole, milled and boiled grain. The desired properties may vary from one ethnic group or geographical region to another and may vary from country to country. Quality of rice may, therefore, be considered from the viewpoint of milling quality, grain size, shape, appearance and cooking characteristics.

Rice production system, without constant standing water in non-puddled soils, referred to as 'aerobic rice' is considered to be one of the most promising technologies in terms of water saving. Aerobic rice cultivation helps to reduce labour costs particularly where irrigation water is not a constraint and weeds can effectively be controlled. The biofortification strategy seeks to take advantage of consistent daily consumption of large amounts of food staples by all family members, including women and children who are most at risk for micronutrient malnutrition.

Rice varieties greatly differ in milling, physical and cooking characteristics. Varietal differences in terms of milling, physical and cooking characteristics need to be investigated. Hence, a study on milling, physical, and cooking characteristics of different varieties of biofortified aerobic rice (*Oryza sativa* L.) in comparison with a control sample (BI 33) was undertaken.

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## METHODOLOGY

Six varieties of paddy, five biofortified aerobic rice varieties and one control sample were procured from the department of Genetics and Plant breeding, University of Agricultural Science, Bengaluru. Milling, physical, cooking and sensory characteristics were assessed in comparison with the control sample.

**Milling:**

Paddy samples were cleaned and dried in sun and then de-husked using a grain man miller at the Department of Post-harvest Technology, G.K.V.K., Bengaluru. The brown rice was subjected to 2-4 per cent polishing and the milling fractions which include brown rice, head rice and broken rice were recorded for all the varieties.

**Physical characteristics:**

The parameters studied under physical characteristics includes grain length, breadth, width, l/b ratio, 1000 kernel weight, bulk density, chalkiness, and dimensional classification of rice. Grain length (mm), breadth (mm) and width (mm) was determined by using vernier calipers holding the single grain lengthwise, breadth wise and widthwise, respectively. Length breadth (L/B) ratio was obtained by dividing the length of a single kernel by the corresponding breadth. 1000-Kernel weight (g): one thousand kernels each of the milled rice variety were counted randomly in duplicate and weighed in an electric balance. Bulk density (g/ml): the volume of 100g of each sample (ml) was determined by gently pouring the grain into a 250 ml graduated cylinder. (Bhattacharya and Pushpa, 2000). chalkiness: the per cent area of endosperm chalkiness was determined by using a scale suggested by Anonymous (1991). Dimensional classification of rice for marketing: surface area per gram rice was calculated by measuring the length and breadth in mm and weight in mg, respectively for a single grain and using the equation S" = 20(LB/W) (cm^2/g) (Bhattacharya *et al.,* 1982)

**Cooking characteristics:**

The method suggested by Bhattacharjee and Kulkarni (2000) was followed to evaluate the cooking quality of different varieties. Weighed sample (2g) was placed in test tubes containing boiling water (20 ml) and heated on boiling water bath. The characteristics like cooking time, water uptake ratio, kernel elongation ratio, per cent curled grains, dispersed solids, and aroma were evaluated.

**Sensory evaluation:**

Six varieties of rice samples were subjected to sensory evaluation in the cooked form to a panel of ten judges and not more than two samples were presented at a time. Parameters evaluated by judges include colour, grain size, texture, taste and overall acceptability. A five point hedonic scale was used to evaluate the samples.

**Statistical analysis:**

The results were analyzed using a Completely Randomized Design (CRD) to compare the variance. Suitable tests were applied to know the significant differences among the selected rice varieties at $P \leq 0.05$ (Gomez and Gomez, 1986).

## OBSERVATIONS AND ASSESSMENT

Milling qualities of rice such as milling yield, head rice yield, broken per cent and degree of polish are presented in Table 1.

Among biofortified aerobic rice varieties Badshahbhog had highest head rice recovery (92.70%) least being in BI 43 (79.93%).

Varietal differences with respect to grain length, breadth, L/B ratio, grain width, 1000 kernel weight, bulk density and endosperm chalkiness are presented in Table 2.

Long grains are more accepted than short grains, whereas wider varieties are less acceptable. Lower the 1000 grain weight and bulk density, finer will be the grain. Chalkiness is an undesirable physical characteristic. All the biofortified aerobic rice varieties including BI 33 (control sample) had less than

**Table 1.** Milling characteristics of biofortified aerobic rice varieties

| Varieties | Milling yield (%) | Head rice yield (%) | Broken yield (%) | Polishing (%) |
|---|---|---|---|---|
| Karidaddi | 77.10 | 91.40 | 8.59 | 2.50 |
| Makam | 77.02 | 88.89 | 11.09 | 3.20 |
| IVT (SHW) 91 | 77.40 | 91.60 | 8.30 | 2.30 |
| Badshahbhog | 80.50 | 92.70 | 7.20 | 2.10 |
| BI 43 | 83.03 | 79.93 | 20.05 | 3.83 |
| BI 33 | 83.00 | 80.20 | 19.78 | 3.60 |
| F value | * | * | * | * |
| S.E. $\pm$ (P=0.05) | 0.30 | 0.28 | 0.14 | 0.05 |
| C.D. (P=0.05) | 0.94 | 0.86 | 0.45 | 0.16 |

10 per cent except Makam had 10 to 20 per cent endosperm chalkiness.

Varietal difference with respect to cooking characteristics such as cooking time, aroma, per cent increase in weight, per cent increase in volume etc are presented in Table 3.

Cooking time ranged between 16 to 20 minutes, per cent increase in weight 168 to 210, per cent increase in volume 226 to 260, water uptake ratio 29.80 to 40.29 and kernel elongation ratio 1.27 to 1.57. Significant difference was observed between the varieties for cooking characteristics like per cent increase in weight, per cent increase in volume, water uptake ratio, length, L/B ratio, per cent curled grains and dispersed solids. Similar study was conducted by Hirannaiah *et al.* (2001) and Chaubey *et al.* (1988) who evaluated quality of rice on the

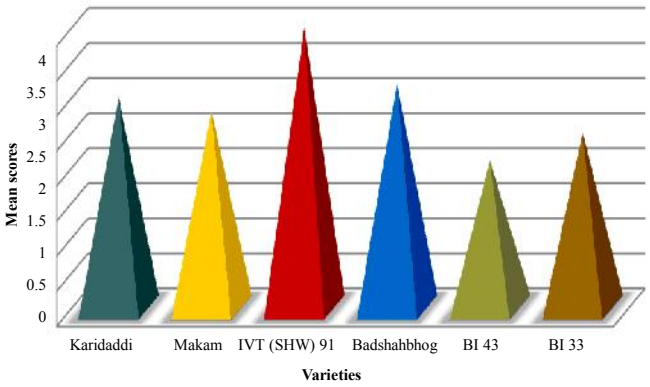


**Fig. 1.** Mean sensory scores of raw biofortified aerobic rice varieties

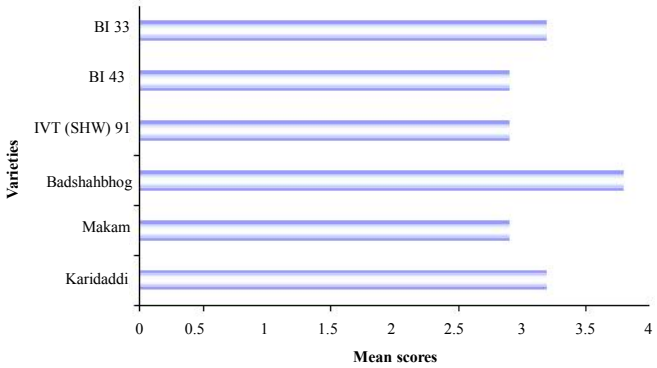


**Fig. 2.** Mean sensory scores of cooked biofortified aerobic rice varieties

**Table 2.** Physical characteristics of biofortified aerobic rice varieties

| Varieties | Grain length (mm) | Breadth (mm) | L/B | Width (mm) | 1000 grain weight (g) | Bulk density (g / ml) | Endosperm chalkiness (scores) |
|---|---|---|---|---|---|---|---|
| Karidaddi | 5.82 | 2.20 | 2.64 | 2.42 | 15.03 | 0.77 | 1 |
| Makam | 5.40 | 2.10 | 2.57 | 2.71 | 15.04 | 0.79 | 5 |
| IVT (SHW) 91 | 6.43 | 2.00 | 3.21 | 2.13 | 15.72 | 0.81 | 1 |
| Badshahbhog | 5.94 | 2.10 | 2.82 | 2.69 | 15.65 | 0.88 | 1 |
| BI 43 | 5.92 | 2.21 | 2.45 | 2.43 | 17.06 | 0.80 | 1 |
| BI 33 | 5.64 | 2.01 | 2.40 | 2.40 | 15.55 | 0.77 | 1 |
| F value | * | NS | * | NS | * | NS | * |
| S.E. ± | 0.15 | 0.06 | 0.13 | 0.14 | 0.05 | 0.08 | 0.52 |
| C.D. (P=0.05) | 0.47 | 0.19 | 0.41 | 0.45 | 0.18 | 0.25 | 1.62 |

*indicates significance of value at P=0.05 NS – Non-significant BI 33 - control

**Table 3.** Cooking characteristics of biofortified aerobic rice varieties

| Varieties | Cooking time (min.) | Aroma | Per cent increase in weight | Per cent increase in volume | Water uptake ratio | Length (cm) | Breadth (cm) | L / B | Kernel elongation ratio | Per cent curled grains | Dispersed solids (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Karidaddi | 20 | Faint | 175 | 238 | 32.00 | 0.72 | 0.24 | 3.00 | 1.46 | 29 | 4.3 |
| Makam | 16 | Faint | 168 | 226 | 29.80 | 0.84 | 0.23 | 3.65 | 1.27 | 44 | 4.0 |
| IVT (SHW)91 | 17 | Faint | 210 | 260 | 40.29 | 0.90 | 0.22 | 4.09 | 1.57 | 34 | 5.0 |
| Badshahbhog | 17 | Faint | 195 | 244 | 39.10 | 0.90 | 0.23 | 3.91 | 1.48 | 48 | 3.5 |
| BI 43 | 18 | Faint | 190 | 240 | 38.80 | 0.99 | 0.28 | 3.53 | 1.36 | 53 | 2.6 |
| BI 33 | 18 | Faint | 188 | 233 | 38.10 | 0.86 | 0.30 | 2.86 | 1.48 | 39 | 3.0 |
| F value | NS | | * | * | * | * | NS | * | NS | * | * |
| S.E.± | 1.00 | | 2.41 | 0.70 | 0.23 | 0.06 | 0.02 | 0.23 | 0.15 | 5.08 | 0.96 |
| C.D. (P=0.05) | 3.08 | | 7.44 | 2.17 | 0.73 | 0.1 | 0.08 | 0.72 | 0.46 | 15.66 | 2.96 |

*indicates significance of value at P=0.05 NS- Non-significant BI 33-control

basis of apparent water uptake ratio, L/B ratio and kernel elongation ratio.

Mean scores for selected sensory characteristics such as colour, grain size, texture, taste and overall acceptability for raw and cooked rice samples of biofortified aerobic rice varieties are presented in Fig. 2 and 3.

IVT (SHW) 91 had the highest sensory mean scores for overall acceptability among biofortified aerobic rice varieties in raw form and cooked form.

Correlation between sensory mean score and cooking characteristics like per cent increase in volume, water uptake ratio, length, L/B ratio and kernel elongation ratio are presented in Table 4.

**Table 4.** Correlation co-efficient of mean sensory scores with cooking characteristics

| Cooking characteristics | Correlation co-efficient ( r ) |
|---|---|
| Cooking time (min.) | $0.08^{NS}$ |
| Per cent increase in weight | $0.41^{NS}$ |
| Per cent increase in volume | $0.35^{NS}$ |
| Water uptake ratio | $0.54^{NS}$ |
| Length (cm) | -0.98* |
| Breadth (cm) | $-0.34^{NS}$ |
| L/B | $0.23^{NS}$ |
| Kernel elongation ratio | -0.70* |
| Per cent curled grains | -0.89* |
| Dispersed solids (%) | $0.56^{NS}$ |

Sensory quality of the cooked rice was positively correlated with the cooking characteristics like cooking time, per cent increase in weight and volume, water uptake ratio, L/B ratio and dispersed solids whereas negatively correlated with length, breadth, kernel elongation ratio and per cent curled grains. The present results are in conformity with Meena (2008) and Sarita (2008) who found a significant correlation between the cooking characteristics and sensory qualities of aerobic and aromatic rice genotypes, respectively.

**Conclusion:**

Rice is the main cereal grown and consumed in India. With increase in water scarcity for farm use aerobic rice varieties will be a better option. In the recent era with increasing use of wide hybridization and biotechnology in rice breeding to improve the grain quality of the aerobic rice varieties will monitor the desirable traits being incorporated into the rice grain and stabilization of the varieties for all possible uses.

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