Some cooking properties of germinated brown rice of Indian varieties

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Abstract: Effects of germination process on selected cooking properties of germinated brown rice (GBR) made from Swarna and Lalat Indian varieties were studied. The germination process comprised of draining the excess water after soaking the rice for 12 h and then covering the rice with a clean dishtowel. After 18 h, small sprouts appeared. The dried GBR (DGBR) was obtained by drying wet GBR (WGBR) in a tray dryer at 50℃ for 9 h to make moisture content be lower than 13% (wet basis). Solid loss in gruel and cooking time were observed to be less in WGBR and DGBR than brown rice (BR) for both of Swarna and Lalat varieties. Whiteness of BR was found not significantly different from that of DGBR; however, WGBR was whiter than BR for both of the varieties.

Keywords: germinated brown rice, soaking, cooking properties, Swarna, Lalat

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1 Introduction

Rice is one of the leading food crops of the world. It is a staple food in many parts of the world especially in the East, South and South East Asia, which makes it the world's second-most consumed cereal grain. Today, consumers prefer to eat unpolished rice because of the nutrient value in the bran. Therefore, demand for BR is increasing because of its reputation for nutritional excellence and health benefits. However, BR has some disadvantages such as slower absorption of liquid into the kernel because of the bran in BR contains fiber, which leads to prolonged cooking time (Parnsakhorn and Noomhorm, 2008). However, now this problem is overcome by germination process of BR.

The structure of BR consists, from the topmost layer, of the rice bran layer that comprises of three layers such as pericarp, testa and aleurone layer. The embryo occupies a small portion of the base of the rice grain, and the endosperm occupies most of the remaining part. The endosperm, filled dominantly with starch, is the edible rice portion (Kim, Park and Byun, 2007).

Cooking time is important since it determines tenderness of cooked rice as well as stickiness to a great extent (Anonymous, 1997). Pre-soaking of Basmati rice before cooking in excess water reduced the time of cooking from 20 to 10 min, and increased the dimensional changes due to cooking (Hirannaiah, Bhashyam and Ali, 2001). High volume expansion of cooking is still considered to be of good quality by the working class people who do not care whether the expansion is lengthwise or crosswise. Urban people, on the other hand, prefer the varieties that expand more in length than in breadth (Choudhury, 1979).

Effects of soaking and cooking on various varieties of cereals, pulses, etc. have been studied by researchers worldwide including India (Singh, Sharma, and Nagi, 2007). Irregular cracks in rice are caused by hot-air drying, but wetting of paddy tends to get healed upon long soaking (Swamy and Bhattacharya, 2009).

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In view of the economic importance of the rice grain in food industry, it is imperative to determine the relevant cooking properties of BR and GBR grains. Little or no information is available on the cooking properties of GBR of these varieties. We hope such studies will pave way for more research on GBR, so that the cooking properties thereof can be unraveled. Hence, the specific objective of this study was to determine the cooking properties of two Indian varieties viz. Swarna and Lalat.

2 Materials and methods

2.1 Materials

The medium grain local varieties of paddy viz. Lalat and Swarna used in the present study were obtained from the farm of Orissa University of Agriculture and Technology, Bhubaneswar in 2010. Paddy was aspirated in an aspirator and then was cleaned manually to remove all foreign materials, broken or immature grains.

2.2 Preparation of BR and white rice (WR)

Paddy samples of Swarna and Lalat varieties were passed through a Satake made Lab model rubber roll sheller cum aspirator to remove hulls from kernels to produce BR. The obtained BR was put into a plastic jar and then stored at room temperature for further analysis.

The BR obtained from rubber roll sheller was polished in a Satake made Lab model polisher to obtain polished or white rice. All the samples were milled on the basis of 6% degree of polishing with respect to BR. The milled samples were aspirated in a Satake made aspirator for 30 to 60 s to clean the rice by removing any loose bran remaining on the surface of the kernels after milling.

2.3 Germination process of BR

The germination process of BR consisted of the following steps:

1) Required amount of BR was rinsed several times until the water is clear.

2) The rice was placed in a bowl and covered well with filtered water.

3) Keep being soaked for 12 h or overnight.

4) After soaking, the water was drained out and rice was covered with a clean dishtowel.

5) Every 6 h, the rice was rinsed well.

6) After 16 to 18 h, small sprouts appeared.

7) Dried germinated brown rice (DGBR) was obtained by drying wet germinated brown rice (WGBR) in a tray dryer at 50℃ for 9 h to a moisture content of lower than 13% (wet basis).

2.4 Cooking quality evaluation

2.4.1 Cooking time determination

The cooking time of BR, WR, WGBR and DGBR was determined by the procedure described by Bhattacharya and Sowbhagya (1971). A rice sample of 10 g was cooked in distilled water of 70 mL at the temperature of 97℃ to 99℃. After cooking for 10 min, the samples were taken at every 2 min intervals for testing until the end of the cooking cycle. Ten grains were randomly taken 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. The rice was then allowed to simmer for about another 2 min to ensure that the core of all grains has been gelatinized. Optimum cooking time included the additional 2 min of simmer.

2.4.2 Volume expansion ratio

The volume of raw milled rice and cooked rice was determined by water displacement method using a measuring cylinder. The volume expansion was calculated with the method suggested by Sidhu, Gill, and Bains (1975). A sample of 5 g rice grains was taken in water of 15 mL and the total volume was measured. Rice grain sample was cooked for 20 min in a boiling water bath. Then, the cooked rice was dipped into 50 mL water. The volume of cooked rice after dipping in water was measured. The volume expansion ratio was calculated by using Equation (1).

$$Volume\exp ansion\, ratio = {(X-50)}\Big/{(Y-15)} \qquad (1)$$

where, (X–50) is the volume of cooked rice (mL); and (Y–15) is the volume of raw rice (mL).

2.4.3 Kernel elongation ratio

Twenty five whole milled kernels were measured lengthwise and were soaked in 20 mL distilled water for 30 min. The samples were placed in a water bath and the temperature was maintained at 98℃ for 20 min. The cooked rice was transferred to a Petri dish lined with filter paper. Ten cooked whole rice grains were selected randomly and their length was measured in a photographic enlarger. The proportionate elongation is the ratio of the average length of cooked rice grains to the average length of raw rice grains (Azeez and Shafi, 1966).

2.4.4 Water uptake ratio

The water uptake ratio was determined by cooking 2 g whole rice kernels from each rice sample in 20 mL of distilled water for the determined minimum cooking time in a boiling water-bath. The content was drained and the superficial water on the cooked rice was sucked by pressing the cooked samples in filter paper sheets. The cooked samples were then weighed accurately and the water uptake ratio was calculated as the ratio of final cooked weight to the uncooked weight (Singh et al., 2005).

2.4.5 Gruel solid loss

The amount of total solid lost in cooking water (gruel) was determined by cooking 2 g milled rice in 20 mL of water for 20 min. The gruel was taken in a Petri dish and oven dried at 105℃ until its weight becomes constant. Total gruel solid was calculated by taking the difference in the weights and reported on dry basis (Sidhu, Gill, and Bains, 1975).

2.4.6 Alkali spreading value

Six polished whole rice kernels of each variety were placed evenly on Petri dishes of 9 cm diameter containing 10 mL of 1.7% potassium hydroxide solution. The Petri dishes were covered and left undisturbed at the room temperature for 23 h. The samples were then rated visually for the degradation of kernel on a scale of one to seven (Little, Hilder, and Dawson, 1958). Average score of the six kernels was taken as the alkali score of the sample.

2.5 Measurement of color

Hunter Lab Color Measurement System “Color Flex” (Hunter Associates Laboratory Inc., Virginia, USA) was used for all color determinations. Prior to color measurements, the instrument was calibrated with a white and black calibration tile. The colorimeter was set to an illuminant condition D65 (medium daylight) and a 10° (field of view) standard observer. Color measurements were made at least in five folds on samples placed in a clear Petri dish. Each sample was covered with a white plate. L^* is a measure of the brightness from black (0) to white (100). Parameter a^* describes red-green color with positive a^* values indicating redness, and negative a^* values indicating greenness. Parameter b^* describes yellow-blue color, with positive b^* values indicating yellowness, and negative b^* values indicating blueness (Good, 2002).

2.6 Statistical analysis

The experiment was laid out in completely randomized design (CRD) with eight treatments (four each for Lalat and Swarna varieties). Each treatment had three replications. Thus, total of 24 experiments were conducted with data on cooking time, elongating ratio, volume expansion ratio, water uptake ratio, solid loss gruel and alkali spreading value as dependent variables and each treatment as an independent variable. The analyses of variance (ANOVA) for means of different treatments of both the varieties at 5% level of significance using Statistical Package for Social Sciences (SPSS) were worked out. The effects of two treatments differ if P-value is strictly less than the assumed type-I error of the experiment, i.e. 0.05 and are not significant vice versa. Finally, Duncan’s Multiple Ratio Test (DMRT) has been used to find the homogeneous subsets of treatments at the same level of significance (Table 1).

3 Results and discussion

3.1 Cooking properties of different types of rice

Table 1 shows cooking qualities of WR, BR before and after the germination for Lalat and Swarna varieties in terms of cooking time, elongation ratio, volume expansion ratio, water uptake ratio, solid loss and alkali spreading value. The BR requires the longest cooking time of 19.2 min for Lalat and of 20 min for Swarna variety as compared with the rest of samples. With the fibrous bran layer removed from the caryopsis, it was easy for the starchy endosperm to cook faster due to higher diffusion of water into the kernel (Juliano and Bechtel, 1985). This is possible only in WR due to the removal of bran layer and not in BR. This problem is overcome by germination. Due to germination, pores are created on the surface of the rice kernel. Then, the diffusion of water into the BR kernel is possible only after germination. Therefore, GBR takes less time to cook than BR does.

Table 1 Cooking qualities of BR before and after germination for Lalat and Swarna variety

Variety	Type of rice	Cooking time /min	Elongation ratio	Volume expansion ratio	Water uptake ratio	Solid loss gruel/%	Alkali spreading value
Lalat	BR	19.2±0.26[a]	1.12±0.08[c]	2.14±0.07[c]	2.17±0.08[c]	11.45±0.83[a]	2.33±0.52[c]
	WR	14.5±0.36[c]	1.72±0.09[a]	3.75±0.07[a]	3.38±0.10[a]	2.65±0.60[b]	4.40±0.63[b]
	WGBR	13.4±0.36[d]	1.42±0.08[b]	2.43±0.10[b]	2.24±0.06[c]	3.85±0.35[b]	5.00±0.89[ab]
	DGBR	16.5±0.26[b]	1.45±0.07[b]	2.52±0.03[b]	2.58±0.12[b]	3.65±0.56[b]	5.50±0.55[a]
CD		0.84	0.10	0.19	0.25	1.62	1.10
Swarna	BR	20.0±0.62[a]	1.19±0.07[c]	2.00±0.08[c]	2.21±0.06[c]	9.75±0.56[a]	1.67±0.52[b]
	WR	15.0±0.46[b]	1.71±0.10[a]	3.43±0.08[a]	3.04±0.06[a]	3.35±0.55[b]	4.50±0.41[a]
	WGBR	13.2±0.26[c]	1.29±0.08[b]	2.68±0.09[b]	2.29±0.11[c]	3.05±0.66[b]	5.20±0.52[a]
	DGBR	18.5±0.30[a]	1.32±0.08[b]	2.71±0.08[b]	2.67±0.03[b]	3.50±0.49[b]	5.00±0.55[a]
CD		1.16	0.11	0.21	0.18	3.34	0.85

Note: Values within a column followed by same lowercase superscript letters are not significantly different at 5% level of significance by DMRT. CD stands for critical difference.

Upon cooking, germinated rice significantly expanded in length. If rice elongates more length-wise it gives a finer appearance, and if it expands girth-wise, it gives a coarse look (Anonymous, 1997). However, as wet germinated kernels increased in size during germination, the outer layer bran became softened, and it absorbed water easily. Therefore, it made the GBR easier to cook. When cooked, they showed more water uptaking and volume expansion compared with those of control (i.e. BR). The present results demonstrated that the germination improved the cooking qualities by reducing the cooking time and solid loss.

GBR of both varieties showed higher elongation ratio than the BR and lower than WR. The WR of the Lalat and Swarna varieties showed the highest elongation ratio i.e. 1.72 and 1.71 respectively. It was reported that higher elongation ratio of the cooked rice is preferred by the consumer than that with lower elongation ratio (Shahidullah et al., 2009). In case of both Lalat and Swarna varieties, the GBR has higher value of volume expansion ratio than BR whereas for both the varieties, WR has more value than the rest of samples due to its higher water absorption. WR showed lowest gruel solid loss of 2.65% for Lalat whereas that for WGBR was 3.05% for Swarna variety. Solid loss in gruel and cooking time were observed to be less for WGBR and DGBR than BR for both varieties.

Because of the upper bran layer of BR, it is very difficult to cook. If it is cooked, then the vapor pressure inside the grain increases during the cooking and grain is burst. Therefore, the solid loss was more in cooked BR. But in GBR, the grains do not burst since after germination, very small pores occur on the upper layer of rice kernel. Due to these pores, the vapor pressure inside the grain cannot increase. Therefore, the solid loss in GBR was lower than BR. GBR was softened by saccharification. After drying process, DGBR was very porous and it allowed boiling water to rehydrate very fast (USA Rice Federation, 2001).

Figure 1 shows changes of rice kernel in alkaline solution, expressed as alkaline spreading value, ranging from level 1-7. The values of alkaline spreading of BR, WR and GBR for Lalat and Swarna varieties are shown in Table 1. These are 2.33, 4.40, 5.00 and 5.50, respectively for BR, WR, WGBR and DGBR for Lalat variety. The values for BR, WR, WGBR and DGBR for Swarna variety are 1.67, 4.50, 5.20 and 5.00, respectively. The alkaline spreading value is used to measure gelatinization of rice and has been used for many years to categorize cooked rice properties. When put in alkaline solution, rice grains readily altered in shape indicate lower gelatinization temperature. The results imply that GBR is easier to cook since it can be cooked at lower gelatinization temperature compared with that of BR. From the ANOVA test, it is observed that the values for cooking qualities of BR and GBR show significant differences for both varieties.

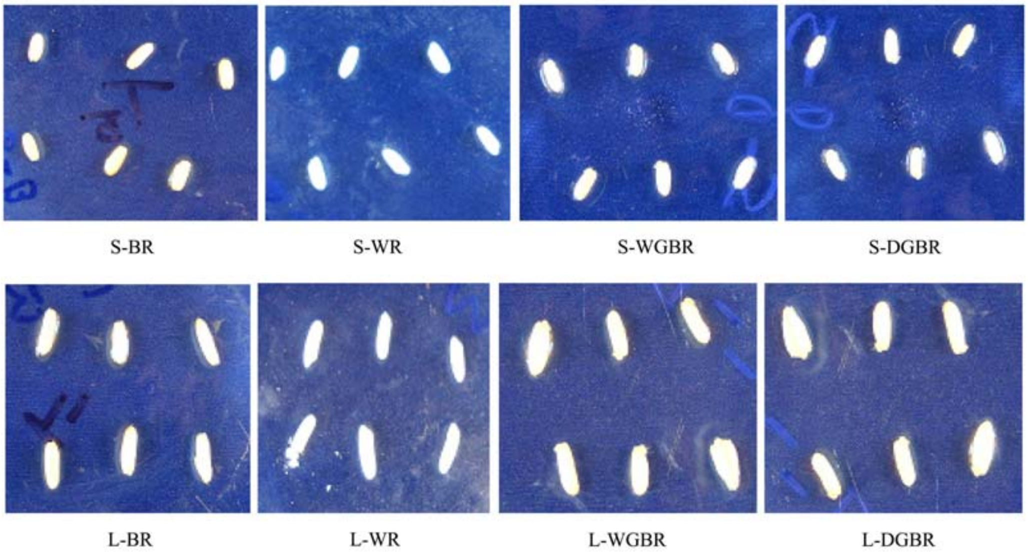

Figure 1 Alkaline spreading value (In Figure S is for Swarna variety and L is for Lalat variety)

3.2 Color measurement

Color values of non-cooked BR, WR, WGBR and DGBR are shown in Table 2 and those of cooked products are shown in Table 3. The L^* values of BR, WR, WGBR and DGBR were 62.66 ± 0.59, 76.70 ± 0.63, 65.95 ± 0.41 and 64.57 ± 0.32, respectively for Lalat variety. For Swarna variety, the corresponding values were 63.79 ± 0.88, 74.71 ±0.27, 66.70 ± 0.62, and 64.59 ± 0.45, respectively. Whiteness of BR was not significantly different from that of DGBR. However, WGBR and DGBR were whiter than BR. As L^* values of BR and WGBR were significantly different from that of DGBR, it implied that drying had effect on whiteness of WGBR to become darker. In cooked products, for Lalat variety it seems there is significant difference among BR, WGBR and DGBR, but for Swarna variety, there is not significant difference among them.

Table 2 Color measurement values of non-cooked products

Variety	Sample	L^*	a^*	b^*
Lalat	BR	62.66 ± 0.59^d	4.67 ± 0.06^a	22.50 ± 0.06^a
	WR	76.70 ± 0.63^a	0.57 ± 0.39^c	16.32 ± 0.65^c
	WGBR	65.95 ± 0.41^b	2.93 ± 0.04^b	19.47 ± 0.14^b
	DGBR	64.57 ± 0.32^c	4.31 ± 0.07^a	21.80 ± 0.29^a
Swarna	BR	63.79 ± 0.88^c	5.23 ± 0.11^a	24.10 ± 0.26^a
	WR	74.71 ± 0.27^a	1.37 ± 0.23^c	17.85 ± 0.20^c
	WGBR	66.70 ± 0.62^b	3.92 ± 0.09^b	21.36 ± 0.53^b
	DGBR	64.59 ± 0.45^c	5.33 ± 0.24^a	23.69 ± 0.18^a

Note: Values within a column followed by same letters are not significantly different at 5% level of significance by DMRT.

Table 3 Color measurement values of cooked products

Variety	Sample	L^*	a^*	b^*
Lalat	BR	69.42 ± 0.17^b	2.52 ± 0.09^a	19.45 ± 0.13^a
	WR	81.23 ± 0.38^a	-1.01 ± 0.09^c	7.75 ± 0.26^c
	WGBR	67.67 ± 0.39^c	1.89 ± 0.05^b	17.42 ± 0.40^b
	DGBR	65.78 ± 0.69^d	2.73 ± 0.33^a	19.76 ± 0.21^a
Swarna	BR	68.88 ± 0.52^{bc}	3.11 ± 0.16^b	22.21 ± 0.02^a
	WR	80.71 ± 0.11^a	-0.58 ± 0.16^c	10.78 ± 0.06^c
	WGBR	68.48 ± 0.31^c	3.25 ± 0.12^{ab}	21.73 ± 0.49^{ab}
	DGBR	68.7 ± 0.23^b	3.36 ± 0.03^a	20.86 ± 0.29^b

Note: Values within a column followed by same letters are not significantly different at 5% level of significance by DMRT.

From a^* value, for Lalat variety it was observed that BR was significantly more red than WGBR and DGBR, but for Swarna variety, DGBR was significantly more red than others. Table 2 shows a^* values of BR, WR, WGBR and DGBR for Lalat variety which were 4.67 ± 0.06, 0.57 ± 0.39, 2.93 ± 0.04 and 4.31 ± 0.07, respectively. Those values for Swarna variety were 5.23 ± 0.11, 1.37 ± 0.23, 3.92 ± 0.09 and 5.33 ± 0.24, respectively. Conversely to non-cooked products, DGBR was significantly more red than cooked BR and cooked WGBR for both varieties, and a^* values of cooked BR, WR, WGBR and DGBR for Lalat variety were 2.52 ± 0.09, -1.01 ± 0.09, 1.89 ± 0.05 and 2.73 ± 0.33, respectively. For Swarna variety, a^* values of cooked BR, WR, WGBR and DGBR were 3.11 ± 0.16, -0.58 ± 0.16, 3.25 ± 0.12 and 3.36 ± 0.03, respectively.

After germination process, GBR was significantly less yellow than BR but after drying process, DGBR was significantly more yellow than WGBR. However, yellowness of DGBR was significantly less than that of BR. DGBR was discolored and became yellow, and this discoloration seemed to be affected mainly by non-enzymatic browning of the Maillard type. The *b** values of BR, WR, WGBR and DGBR for Lalat variety were 22.50 ± 0.06, 16.32 ± 0.65, 19.47 ± 0.14 and 21.80 ± 0.29, respectively. Those for Swarna variety were 24.10 ± 0.26, 17.85 ± 0.20, 21.36 ± 0.53 and 23.69 ± 0.18, respectively. For cooked products, BR and DGBR had almost the same yellow values, but WGBR was significantly less yellow than DGBR for Lalat variety. For Swarna variety, BR had the highest yellow value, but DGBR was significantly less yellow than WGBR. Change in *b** value of parboiled brown rice was mainly caused by Maillard type non-enzymatic browning (Pillaiyar and Mohandas, 1981). The *b** values of cooked BR, WR, WGBR and DGBR for Lalat variety were 19.45 ± 0.13, 7.75 ± 0.26, 17.42 ± 0.40 and 19.76 ± 0.21, respectively and for Swarna variety, those were 22.21 ± 0.02, 10.78 ± 0.06, 21.73 ± 0.49 and 20.86 ± 0.29, respectively.

4 Conclusions

Striking differences were found in cooking properties of GBR compared with BR. Effects of germination on cooking properties of cooked rice were more pronounced when rice was soaked and germinated for a proper period. Water absorbed by kernels during germination resulted in length, width and thickness expansion. Germinated rice is easier to cook and requires less cooking time. Solid loss in gruel was observed to be less in GBR than BR. Whiteness of BR was found not significantly different from that of DGBR. However, WGBR were whiter than BR. Results from this study may be used to promote a greater consumption of BR in spite of WR.

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