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Evaluation of Cooking and Physico-Chemical Properties of Rice

P. Abhilasha, U.S. Pal, M.K. Panda and K. Rayaguru
Odisha University of Agriculture and Technology, Bhubaneswar-751 003, India
.E-mail: abhilashaparamesh@gmail.com

***Abstract*:** A study was undertaken to compare cooking properties, physico-chemical parameters and sensory quality attributes of white rice, brown rice, quick cooking white rice and quick cooking brown rice. Freshly harvested paddy of *Prativa* variety was milled in rubber roll sheller and polished in laboratory polisher to get brown rice and white rice. Quick cooking white rice and brown rice were prepared by pressure cooking followed by refrigerated storage at 4°C for 24 h and drying at 90°C. The decrease in cooking time of quick cooking brown rice (9.66 min) and quick cooking white rice as compared to brown rice (25.66 min) and white rice respectively was due to gelatinization of starch during cooking and development of cracks and porous structure during drying. Higher water uptake ratio and volumetric expansion ratio with lower solid loss were observed in quick cooking white rice and quick cooking brown rice as compared to corresponding white rice and brown rice sample. The minimum peak viscosity of quick cooking brown rice was less (726cP) which was followed by quick cooking white rice respectively. The bio-chemical parameters of quick cooking brown rice were found to be more than quick cooking white rice.

***Keywords*:** Brown rice, Quick cooking rice, Pasting properties, Amylose content, Gamma-aminobutyric acid

Demand for brown rice (BR) is increasing because for nutritional excellence and health benefits. BR contains numerous nutritional and bioactive components including dietary fiber, functional lipids, amino acids, vitamins, phyto-sterols, phenolic compounds, gamma-aminobutyric acid (GABA) and mineralsbecause the presence of intact bran and embryo. In rice, polyphenols are mainly associated with the pericarp, which is removed during processing to obtain polished grain (Zhou et al 2003).Gamma-aminobutyric acid (GABA), which is a non-protein free amino acid having high biological activity including pharmacological functions and neuro-transmitter in the brain and spinal cord of mammals (Tiansawang et al 2016). Bahadur (2003) reported that it is better to eat unpolished (brown) rice, because the outer bran layer of the rice grain, which is removed during the milling process, is rich in fiber, iron, vitamins and minerals. Though brown rice contains more nutritional components, white rice (WR) is primarily consumed by the people (Lamberts et al 2007). Brown rice is not favourite to consumers due to its poor cooking and eating qualities with dark colour and unpalatable texture, which are attributed to the presence of tough fibrous bran layer (Das et al 2008). There is significant increase in the consumption of ready-to-eat rice and the market for such product is growing fast. The accelerated pace of modern life has promoted new ways to consume rice in the form of instant or quick cooking rice, which is fully or partially cooked and dehydrated. Instant rice is pre-cooked rice which is rehydrated or cooked before being served and quality of rice after rehydration is very important for consumer acceptability. Rice kernels are soaked before cooking to reduce cooking time, then cooked for starch gelatinisation and dried to a low stable moisture content to produce instant rice. Soaking, cooking and drying process affected the physical and cooking qualities of quick cooking rice (Sirisoontaralak et al 2015). Quick cooking white and brown rice are novel convenient rice product which can be prepared with improved cooking, eating and nutritional quality to cater the need of modern food market. Though many works have been carried out on quality evaluation of white rice and brown rice, study on comparison of quick cooking white rice and brown rice is scanty. So, the present study was undertaken to compare the cooking and physico-chemical qualities of white rice, brown rice, quick cooking white rice and quick cooking brown rice.

MATERIAL AND METHODS

Freshly harvested paddy of *Prativa* variety was collected from the Central Farm of Odisha University of Agriculture and Technology, Bhubaneswar. Paddy was first cleaned and graded in a cleaner-cum-grader to remove all foreign matters and immature grains. Paddy samples were dehusked using rubber roll sheller (MG make) followed by aspiration to obtain brown rice. The brown rice (BR) was polished to 6% degree of polish in a laboratory rice polisher (Satake make) and aspirated for 30 to 60 seconds to obtain white rice (WR). The obtained brown rice and white rice were cooked in a domestic pressure cooker at 1 bar gauge pressure until 90 % gelatinization was obtained. The cooked white and brown rice were washed and kept at 4°C for 24 h inside a household refrigerator. The samples were then taken out, tempered for 1 h and subsequently dried in hot air dryer at 90°C to get quick cooking white (QCWR) and brown rice (QCBR). The rice samples obtained were analysed for cooking and physic-chemical quality parameters for comparison.

Cooking properties: In a 20ml of distilled water, 2g of sample is taken, kept for boiling recording the time when 9-10 kernels of the rice samples were fully gelatinized then cooking time of the sample is determined(Singh et al 2005). Water uptake ratio of the rice is calculated by the ratio of increase in weight to the initial weight of the sample (Singh et al 2005). The gruel was taken in petridish and oven dried at 105°C until constant weight to determine the solid loss (Singh et al 2005). The volume expansion ratio was calculated by taking the ratio of volume of cooked rice sample to that of initial volume of uncooked rice measured by water displacement method (Patil and Khan 2012)

Physical Properties

Pasting properties: The pasting properties of the rice samples were measured using a rapid viscoanalyer (MCR 72, Anton Paar, Austria) (Klein et al (2013). Rice samples were ground in a willey mill to 100 micron size and 3 g of rice powder in 25ml distilled water was taken in the aluminium canister. The samples were held at 50° C for 1 min, heated from 50 to 95°C in 3.5 min, held at 95°C for 2.5 min followed by cooling to 50°C in 4 min, and finally held at 50°C for 2 min. the pasting properties namely peak viscosity, peak temperature and Final viscosity were recorded.

Scanning electronic microscopy (SEM): Starch granule morphology and size distribution were determined using a scanning electron microscope (s-3400-II, Hitachi, USA) at 2.125 keV. The samples were placed on an SEM stub by double-backed cellophane tape. The stub and sample were coated with gold-palladium, then examined and photographed (Ghasemi et al 2009).

Determination of bio-chemical parameters: About 0.5 g of rice sample was soaked for 30 minutes and cooked for 15 minutes in 3 ml of water. Amino acids were extracted from the cooked rice paste by 2.5 ml of ethanol: deionized water (7:3).Standard GABA solution and sample solutions were applied to the 10 cm x 10 cm high-performance standard silica gel plate in HPTLC. The scanned areas of the all rice samples were matched with the scanned area of the standard GABA solution and GABA content was calculated based on concentration of the standard solution (Babu et al 2011).Amylose content of rice was determined by the method reported by Williams et al. (1958). The phenolic content of the samples were quantified by the Folin-Ciocalteu methodology (Iqbal et al 2005; Singleton et al 1999) by measuring absorbance in a spectrophotometer at 765 nm and comparing with standard Gallic acid. About 0.3 g of sample was taken and 5 ml of diacid was added and kept it in the digestion chamber. Digestion tubes were heated at 150°C until the production of red NO_2 fumes ceased. The completion of digestion was confirmed when the liquid became colourless. After cooling of digestion tubes, the content was filtered through Whatman no 1 filter paper and the volume was made 50 ml by adding distilled water. Aliquotes of this solution were used for the determination of Calcium, Iron, Zinc and Magnesium content by using ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometer).

RESULTS AND DISCUSSION

Cooking properties: Brown rice (9.66min)acquired the longest time to cook due to the presence of an unbroken strong bran layer. The gelatinization of starch during cooking and the creation of cracks and porous structure after drying resulted in a reduction in cooking time for QCBR and QCWR when compared to BR and WR, respectively. Because of the bran layer, the cooking time of QCBR was much longer than that of QCWR. Due to the presence of an impermeable bran layer, the water uptake ratio of BR (2.17) was found to be higher than that of WR (3.38). In QCBR and QCWR, there was a significant increase in WUR. In comparison to WR (2.66), leaching of soluble compounds from the bran layer resulted in increased solid loss from BR (6.26). Solid loss from QCBR and QCWR was found to be lower than the raw sample, which could be attributed to starch gelatinization during cooking, which seals cracks. The leaching of a significant amount of amylose and other soluble chemical components before during the cooking process of quick cooking rice preparation may account for the significant drop in solid loss values of QCBR as compared to BR.

The volume expansion ratio of different rice samples varied significantly from each other ($p < 0.05$). The lowest volume expansion was observed in BR (2.17±0.06) as the intact bran layer restricted expansion of kernel. Volume expansion ratio of QCWR (4.45±0.05)and QCBR were found to be significantly higher than WR and BRrespectively is presented in Table 1.

Physical Properties of Rice Samples

Pasting properties: Pasting viscosity of starch relates to the cooking and eating quality of rice. The amylographs of flours from WR, BR, QCWR and QCBR are shown in Figure 1. The peak viscosity (PV) of white rice (2119cP) was highest followed by QCWR (1091), BR (1044) and QCBR (726) (Table 2). Break down (BD) viscosity was absent in QCWR and QCBR due to the presence of degraded starch. However, Break down viscosity of BR (187.5 cP) was less than white rice (828.1 cP). Peak viscosity and final viscosity values of BR were less than WR due to the presence of bran which is rich in fat content.Peak viscosity decreased in all quick cooking rice samples due to the presence of gelatinized starch. Setback viscosity of quick cooking white rice was found to be more than WR. Similar results of higher peak viscosity and lower setback viscosity in white rice than brown rice was also reported by Wu et al (2018).

The viscosity-time curves of white rice and brown rice flour were of similar pattern, whereas quick cooking rice from WR and BR showed similar behavior. The viscosity decreased slightly after attaining a peak value during heating phase in WR and BR, whereas the depression was not observed in quick cooking rice from WR and BR. Cold paste viscosity were found to be more in QCWR (89.9 cP) and QCBR (50.4 cP) as compared to corresponding WR (23.6 cP) and BR (25.4 cP) indicating higher soluble compounds at low temperature. Lower pasting time and temperature were observed in quick cooking white rice as compared to other rice samples.The results are in agreement with

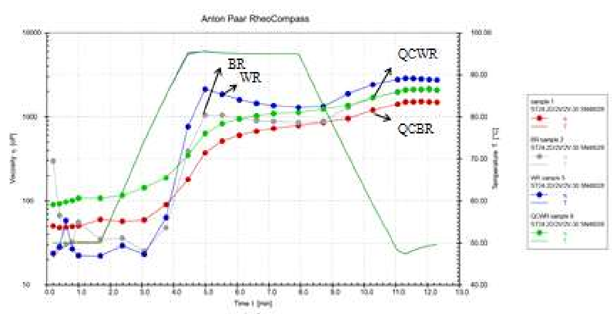

Fig. 1. Amylograph of different rice samples (A- Whiterice, B- Brown rice, C-Quick cooking white and D- Quick cooking brown rice)

Sirisoontaralak et al (2015), Cheevitsopon and Noomhorm (2015) and Hu et al (2017). Viscosity profile of QCWR and QCBR attained peak at hot paste viscosity and breakdowns were not visible in the QCWR and QCBR pasting profiles (Sirisoontaralak et al 2015, Hu et al 2017).

Surface morphology: Morphological features of the rice samples were vary from each other at micro level (Fig. 3). The surface of white rice was rough due to the presence of irregular coarse bran layer that was removed during polishing, whereas it was smooth for brown rice due to the presence of intact bran layer. The surface of the QCWR and QCBR were be porous with higher number of voids and developed cracks which accounted for its high water uptake ratio and less cooking time. In QCBR and QCWR, the net structure between starch and protein were destroyed, reconstructed and internal texture of rice was changed greatly with fusion of starch granules into a coherent mass. During cooking of WR and BR, there was swelling, gelatinization and agglomeration of starch granules due to effect of heat treatment on moist starch granules. The starch morphology of quick cooking brown rice and white rice exhibited differences from those of brown rice and white rice due to gelatinization and retrogradation of starch during processing.

Bio-chemical Parameters

Gamma-amino butyric acid content: There was significant difference ingamma-aminobutyric acid (GABA) content among the entire rice sample. GABA content of WR, BR, QCWR and QCBR were 6.82, 11.91, 4.66 and 5.21mg/100 g d.m. (Table 3). GABA content in BR and QCBR were higher than WR and QCWR, respectively because of the presence of bran layer. Decrease in GABA content in QCWR and QCBR might be due to leaching loss during cooking process and subsequent drying. Loss of GABA content was

Table 1. Cooking properties different rice samples

Sample	Cooking time (min)	Water uptake ratio	Solid loss (%)	Volume expansion ratio
WR	12.33±1.74	3.38±0.24	2.66±0.11	4.09±0.24
BR	25.66±1.14	2.17±0.06	6.26±0.61	2.17±0.06
QCWR	2.66±1.77	3.76±0.06	2.27±0.25	4.45±0.05
QCBR	9.66±1.22	2.82±0.10	3.97±0.90	2.24±0.10

Table 2. Pasting properties different rice samples

Sample	Cold paste viscosity, cP	Pasting time, min	Pasting Temp. °C	Peak viscosity, cP	Peak time, min	Hot paste viscosity, cP	Breakdown viscosity, cP	Final viscosity, Cp	Setback viscosity, cP
WR	23.6	3.1	74	2119	4.99	1291.6	828.1	2751.4	632.4
BR	25.4	3.1	74	1044	4.99	856.8	187.5	2049.5	1005.5
QCWR	89.9	2.4	61.9	1091	7.15	1091	0	2085.3	994.3
QCBR	50.4	3.1	74	726	7.15	726.1	0	1490.3	764.3

Table 3. Bio-chemical parameters of rice samples

Sample	Phenolic content, mg GAE/100 g d.m.	Amylose content, %	GABA content, mg/100g d.m.	Mineral content, mg/100 g d.m.			
				Ca	Fe	Mg	Zn
WR	122.55	26.88	6.82	2.244	0.446	1.453	0.073
BR	370.2	23.81	11.91	2.343	0.926	2.958	0.084
QCWR	42.3	19.95	4.66	2.446	0.348	1.143	0.076
QCBR	107.7	19.12	5.21	2.413	0.715	2.742	0.081

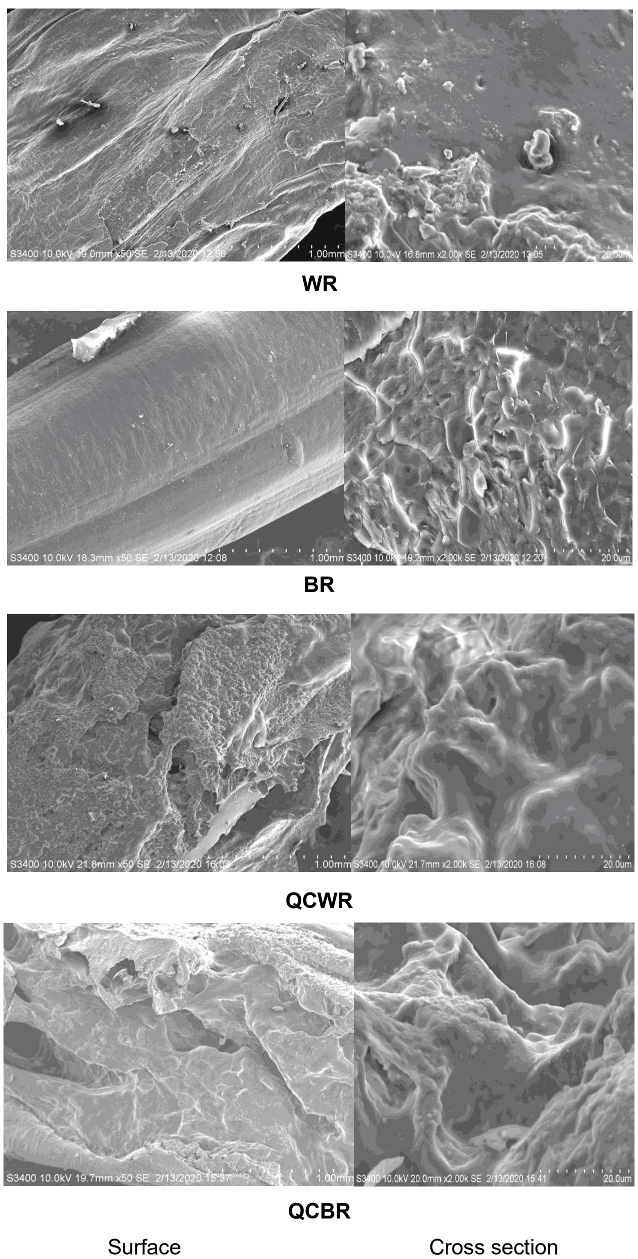

Fig. 2. Scanning electron micrographs of the surface and cross section of different rice samples

dependent on processing temperature (Komatsuzaki et al 2007) and Sirisoontaralak et al (2015) reported decrease in GABA content during cooking.

Mineral composition: Iron, Zinc and Magnesium content were more in BRdue to the presence of the bran layer. There was no significant difference in Calcium and Zinc content among the rice samples. Less mineral content in QCBR as compared to BR might be due to the loss during cooking process. Though mineral content of QCBR were less than BR, they were found to be more than WR and QCWR and presented in Table 3. Brown rice is rich source of minerals which are important for human health.

Amylose content: Amylose content of BR was less than WR due to the presence of bran layer. The lower values of amylose content in QCWR and QCBR samples were probably due to the leaching loss of amylose during cooking process (Table 3).

Phenolic content: The phenolic content of BR was highest (370.2mg GAE/100g) followed by WR, QCWR and QCBR. The lower value in WR was due to the removal of bran layer. However, lower value of phenolic content in QCBR and QCWR as compared to corresponding BR and WR samples was probably due to leaching loss during cooking process (Table 3).

CONCLUSION

When compared to brown rice, quick cooking brown rice took less time to cook. In comparison to the WR and BR samples, the QCWR and QCBR samples had higher water uptake ratios and volumetric expansion ratios, as well as decreased solid loss. White rice has the highest viscosity values, but breakdown viscosity was missing in the QCWR and QCBR samples. The net structure between starch and protein were destroyed, reconstructed and internal texture of rice was changed greatly with fusion of starch granules into a coherent mass in QCBR and QCWR. Though mineral content of QCBR were less than BR, they were found to be more than WR and QCWR. Phenolic content and GABA content of QCBR were higher than QCWR.

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