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Effect of Physico-chemical Characteristics on Cooking Quality of Aerobic Nutri Rich Rice Varieties

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ABSTRACT

Background: Rice (*Oryza sativa* L.) is important staple food of the Asia. Six genotypes HPR-565, HPR-801, HPR-814, HPR-930, HPR-1241 and HPR-1630 were procured to assess physico-chemical and cooking characteristics in comparison with a pre released check variety HP-9 (Paustic-9).

Methods: Physical and chemical characteristics are assessed based on standard procedures. The Amylose content in the rice varieties was estimated using Iodometry method. The degree of spreading by alkali score and cooking quality traits were determined by standard procedures.

Result: Results revealed HPR 801, 814 and HP 9 had lower amylose content (10.35-12.26) which leads to softer texture of cooked grains. Higher alkali score value and lower gelatinization temperature of HPR 801 and 814 determine softer cooked grains. Cooking time ranged from 23 to 27 minutes which was more compared to check variety (22 mins). Positive correlation was observed between higher amylose, GT and water uptake ratio.

Key words: Aerobic rice, Cooking quality, Correlation, Physico-chemical, Sensory acceptability.

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food crop (Smith and Bruce 1998). India is the largest rice growing country accounting for about 2/3rd of world acreage under rice crop (Kennedy and Burlingame, 2003). Enrichment of protein in rice would have a positive impact to enhance the protein availability to combat protein energy malnutrition and hidden hunger which is a global health burden. Long term research of breeding on segregating generations with protein rich local landrace parents with popular local rice variety to boost the total grain protein content under aerobic situation was carried out by the Department of Genetics and Plant Breeding, UAS, GKVK, Bengaluru resulting in increased protein around 4.5 per cent from present cultivating varieties without affecting the regular yield. High-protein rice with balanced amino-acid profile enhances nutrition of poor families having rice as staple food (Li *et al*., 2004). The rice quality can be determined by milling characteristics, physico-chemical properties, drying and storage conditions, processing factors and cooking methods (Lyon 1999). The economic value of rice depends on its cooking quality such as water uptake ratio, grain elongation, per cent curled grains and cooking time. The quality of cooked rice was more precisely measured by a combination of physical and chemical properties. Hence the study was undertaken to assess the physico-chemical characteristics of newly developed nutri rich aerobic rice varieties in comparison with released check variety (HP-9 or Paustic-9) and effects on cooking quality of cooked rice grains.

MATERIALS AND METHODS

Procurement of sample

Six nutri rich aerobic rice varieties (HPR-565, HPR-801, HPR-814, HPR-930, HPR-1241, HPR-1630) and one check variety (HP-9) which are high in protein (RIL'S) were procured from MASLAB, Department of Genetics and Plant Breeding, UAS, GKVK, Bengaluru and analyzed for the physico chemical and cooking qualities using standard procedures and analytical grade chemicals.

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Study location and study period

Study was carried at Department of Food Science and Nutrition, UAS, GKVK, Bengaluru during the year 2018-2020.

Processing of the sample

Primary processing of paddy sample

Procured Paddy samples were cleaned thoroughly using winnower to remove the chaff and other foreign matters and dried in hot air oven up to 12-14% moisture content and dehulled using a rubber roll paddy sheller in the AICRP on Post-Harvest Technology, UAS, GKVK, Bengaluru.

Evaluation of physico-chemical characteristics

Amylose content in the rice varieties was estimated using Iodometry method (McGrance *et al.,* 1998) and Amylopectin was determined by difference method (Oko *et al.,* 2012). The Alkali score was assessed by degree of spreading of individual milled rice kernel in a weak alkali solution (1.7% KOH) at room temperature (27-30°C) on a 7-point numerical scale (Cagampang *et al*., 1973). Gel consistency was done by recording measurements using graph paper following the standard procedure (Bhonsle and Sellapan, 2010).

Cooking quality test

Cooking time

Two gram sample in duplicate was placed in test tubes containing 20 ml water and cooked in boiling water bath at 100°C, the optimum cooking time was determined by pressing the kernels betw

Water uptake ratio (WUR)

Water Uptake Ratio was determined by cooking two gram rice kernels of each genotypes in 20 ml distilled water for a minimum cooking time in a boiling water bath and draining the superficial water. 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).

Grain elongation during cooking

The difference of Initial grain length (L0) before cooking and grain length (L1) after cooking was taken as grain elongation (Oko *et al.,* 2012).

Dispersed solids (DS)

Solids leached out into the cooking water was determined by drying the water drained out after cooking the rice. Per cent dispersed solids was measured by difference in weight of leached out solids after drying along with petri dish with initial petri dish weight using the standard formula (Sarita, 2008).

Statistical analysis

Data obtained was statistically analyzed using the statistical package for social science (Version 17.0, SPSS Inc., Chicago, USA) and results were expressed as mean and standard error mean with student's t-test (two tailed) and analysis of variance (ANOVA) analysis. Difference was considered significant at a probability level of 5 per cent ($p<0.05$) and highly significant at 1 per cent ($p<0.01$).

RESULTS AND DISCUSSION

Physico-chemical characters of nutri rich aerobic rice genotypes

The amylose content is a great determinant of rice cooking quality and sensory characteristics. The per cent amylose content of rice genotypes studied ranged from 12.26 to 33.1 g, whereas the check variety had the least *i.e.* 10.85 g per cent (Table 1). The varieties having higher amylose content had lower amylopectin content with a range of 66.90 to 87.74 g per cent and Check variety with highest amylopectin content (89.15 g). HPR 565 and HPR 1630 did not differ significantly ($p<0.05$) with regard to amylose content and no significant variation between HPR 801 and HPR 814. Rice genotypes with high amylose content (25-30%) tends to cook firm and dry, whereas rice with a intermediate amylose content (20-25%) tends to be softer and stickier with a low amylose content (<20%) is generally quite soft and sticky, while rice varieties with high amylose content become hard and fluffy on cooking. It is noteworthy that rice varieties with greater proportion of starch in the form of amylose tend to have a lower glycemic index. Amylopectin is composed of glucose molecules with branched links and less resistant to digestion leading to glycemic index. Hence, in the present study, HPR 801, HPR 814 and check variety HP 9 contain lower amylose (10.85 to 12.26 g) lead to softer texture of grain after cooking may not be ideal for people with high serum glucose levels. Inversely, genotypes having more than 25 per cent amylose content namely HPR 930 and HPR 1241 might be suitable to control serum glucose and lipids which needs to be clinically investigated. Amylose and amylopectin are significantly correlated inversely which is evident in the present study.

Gelatinization temperature (GT) which determines the time taken to cook the rice and also influences other parameters such as the water uptake, volume expansion and linear kernel elongation. The GT of the rice varieties is known to vary between 50 to 79°C and classified as low (55-69°C) intermediate(70-74°C) and high(75-79°C). Sharma (2005) assessed twelve upland rice varities for their physico chemical parameters, all the varieties had high to intermediate gelatinization temperature and alkali score of 1-5.Higher the alkali score more is the grain starch disintegration which consequently indicates lower gelatinization temperature. Gelatinization temperature is negatively related to alkali score value (Jennings *et al*., 1979). low-GT rice variety requires less amount of water and cooks faster than one with high GT. Check variety with high alkali score value exhibited least gelatinization temperature of 65.38±0.23°C, when compared to other rice genotypes. HPR 930 and HPR 1241 had zero alkali score value with highest gelatinization temperature of 74.8°C which are also high in amylose content in comparison with studied rice genotypes. HPR 801 and HPR 814 had higher alkali score value *i.e.* 3 exhibiting lower gelatinization temperature (70°C) which may result in grains of very soft and mashy nature as the endosperm gelatinizes first then pericarp by exhibiting slightly more starch degradation with alkali. Medium and hard type of gel obtained by HPR 930 and HPR 1241 supported the observations with lesser gel length which is inversely correlated with higher gelatinization temperature. These observations were in concurrence with findings of Oko *et al.* (2012) and Nesreen *et al.* (2014) . Richa *et al*, (2021) studied the effect of incorporation of black rice flour to chicken nuggets resulted in no adverse effect on physico

Table 1: Physico-chemical characteristics of nutri rich aerobic rice genotypes.

Rice genotypes	Amylose (g)	Amylopectin (g)	Alkali score value (ASV)	Gelatinization temperature (°C)	Gel length (mm)	Gel type
HPR 565	24.4±0.78^{c}	75.60±2.85^{b}	2±0.06^{c}	71.66±0.99^{ab}	52.62±0.13^{c}	Medium
HPR 801	12.26±0.37^{d}	87.74±1.66^{a}	3±0.12^{b}	70.09±2.65^{b}	81.6±0.07^{b}	Soft
HPR 814	12.57±0.52^{d}	87.43±3.63^{a}	3±0.12^{b}	70.09±2.36^{b}	65.23±1.64^{c}	Soft
HPR 930	31.70±0.88^{b}	68.30±2.71^{c}	0	74.8±0.13^{a}	48.25±1.47^{f}	Medium
HPR 1241	33.10±0.14^{a}	66.90±2.89^{c}	0	74.8±1.82^{a}	36.5±0.03^{g}	Hard
HPR 1630	23.86±0.25^{c}	76.14±0.55^{b}	2±0.07^{c}	71.66±1.35^{ab}	58.52±0.10^{d}	medium
HP 9	10.85±0.32^{e}	89.15±2.97^{a}	6±0.02^{a}	65.38±0.23^{c}	91.6±3.30^{a}	Soft
Mean	21.85	78.75	2.29	71.33	62.05	-
F value	*	*	*	*	*	-
SEm±	0.31	3.55	0.04	0.78	0.767	-
CD @ 5%	0.96	4.21	0.13	2.37	2.38	-

*Significant (p<0.05); NS- Non-significant (p>0.05); HP 9- Check variety.

Means in the same column followed by different superscript letters differ significantly.

chemical parameters. Usha *et al*. (2011) analyzed kappakar (indigenous rice variety) for tits physico chemical properties belongs to long bold rice with satisfactory cooking and physico chemical properties.

Cooking characteristics of nutri rich aerobic rice genotypes

Results obtained for cooking characteristics are depicted in Table 2. Among the rice genotypes, a range of 23 to 27 minutes of cooking time was observed; check variety had less time comparatively (22 minutes). HPR 1241 took largest minimal cooking time of 27 minutes with maximum water uptake ratio of 5.7. Minimum cooking time was taken by check variety HP 9 *i.e.* 22 minutes followed by HPR 801 and HPR 814 (23 min). These values are positively correlated with amylose content which had shown highest gelatinization temperature for the genotypes having highest cooking time and water uptake ratio. Hence lower amylose content in check variety and HPR 801 cooked faster with less water uptake ratio. There was significant difference among the HPR 565, HPR 930 and HPR 1241. Varieties HPR 801, HPR 814 and HP 9 did not differ significantly with respect to cooking time. All the genotypes varied significantly with water uptake ratio (p<0.05) except HPR 565, HPR 801 and HPR 1630 which did not differ among themselves. Zhang *et al.* (2004) found similar findings that the cooking period was more for bold rice varieties and was positively correlated with starch gelatinization temperature for milled rice of similar grain thickness.

Significant difference was found among the HPR 565, HPR 930 and HPR 1241 and there was no significant variation between with respect to cooking time. Varieties HPR 801, HPR 814. All the genotypes varied significantly with water uptake ratio (p<0.05) except HPR 565, HPR 801 and HPR 1630 which did not differ among themselves. Similar finding were reported by Thomas *et al.* (2013) and Verma *et al*. (2015) Oko *et al.* (2012) observed significant positive correlation between gelatinization temperature and cooking time. According to Bhattacharya and Sowbhagya (1972) cooking time is primarily related to the surface area of milled rice and unrelated to other grain properties.

Highest elongation of grain after cooking was recorded for HPR 565 (5 mm) which took 26 minutes to cook. Check variety exhibited moderate elongation of grain *i.e*. 3.5 mm with least cooking time of 22 minutes. The range of grain elongation of rice genotypes during cooking was 3.0 to 5.0 mm but there was not much significant variation observed among genotypes. Percent curled grains were maximum in HPR 930 (58%) followed by HPR 1630 (52%) both of which had higher gelatinization temperature and formed medium gel type with moderate gel length. Check variety (HP 9) found to have 38 per cent of curled grains and HPR 814 had least value (30%). All the rice genotypes differed significantly with respect to percent curled grains. Similar study conducted by Pavithra (2007) revealed that cooking time ranges from 15 to 18 minutes, water uptake ratio 31 to 41, kernel elongation ratio 1.3 to 1.5, per cent curled grains 15 to 99 per cent among aerobic rice varieties.

Hirannaiah *et al*. (2001) observed the quality characteristics of rice grains varied on the basis of apparent water uptake ratio, kernel elongation ratio and L: B ratio. Harder gel consistency was associated with harder cooked rice and this feature was particularly evident in high amylose rice, lead to grains of less sticky in nature. Gel consistency of milled rice or rice starch found to be a good measure of gel viscosity and an index of cooked rice texture.

Per cent dispersed solid a quality of aerobic rice genotype indicating stability of cooked rice showed that HPR 814 and HPR 1241 had highest gruel solids (2.4 %) followed by HPR 1630 (2.1%) where check variety (HP 9) had least (1.7%). This property is positively correlated with higher L: B ratio which offers larger surface to contact with water while cooking. These results are on par with Ravi *et al.* (2012). Thomas *et al.* (2013) and Gopika (2016). It was evident that dispersed solids (%) values of HPR 1241, HPR 814 and HPR 1630 genotypes did not show significant difference. Other genotypes did not differ significantly (p<0.05) among themselves. By cooking quality traits, it was evident that

Table 2: Cooking characteristics of nutri rich aerobic rice genotypes.

Rice genotypes	Cooking time (Min.)	Water uptake ratio	Grain elongation during cooking(mm)	Per cent curled grains	Dispersed solids (%)
HPR 565	26±0.717[ab]	4.5±0.04[c]	5.0±0.11[a]	39±1.52[c]	1.7±0.1[b]
HPR 801	23±0.26[c]	4.2±0.15[d]	3.7±0.51[bc]	35±2.51[d]	1.8±0.20[b]
HPR 814	23±0.91[c]	4.6±0.04[c]	4.4±0.11[ab]	30±2.0[e]	2.4±0.37[a]
HPR 930	26±0.96[ab]	5.4±00.19[b]	3.8±0.65[bc]	58±2.08[a]	1.7±0.37[b]
HPR 1241	27±0.53[a]	5.7±0.01[a]	3.0±0.47[c]	25±2.08[f]	2.4±0.15[a]
HPR 1630	25±0.90[b]	4.4±0.10[cd]	3.9±1.24[bc]	52±2.51[b]	2.1±0.64[ab]
HP 9	22±0.23[c]	3.8±0.03[e]	3.5±0[bc]	38±2.0[cd]	1.7±0.05[b]
Mean	24.57	4.66	3.91	40.33	2.01
F value	*	*	*	*	*
SEm±	0.42	0.061	0.34	1.22	0.17
CD @ 5%	1.28	0.186	1.04	3.72	0.53

*Significant (p<0.05); NS- Non-significant (p>0.05); HP 9- Check variety.

Table 3: Correlation coefficient between various physico-chemical and cooking characteristics of nutri rich aerobic rice genotypes.

No.	Variables	V1	V2	V3	V4	V5	V6	V7	V8	V9
V1	L:B ratio	1								
V2	1000 grain weight	-0.189	1							
V3	Amylose	0.209	0.211	1						
V4	Gelatinization temperature	0.050	0.331	0.774**	1					
V5	Gel length	-0.220	-0.338	-0.917**	-0.814**	1				
V6	Cooking time	0.141	0.123	0.919**	0.685**	-0.894**	1			
V7	Water uptake ratio	0.061	0.647**	0.853**	0.769**	-0.883**	0.774**	1		
V8	Elongation during cooking	-0.041	-0.279	-0.134	0.090	-0.014	-0.026	-0.235	1	
V9	Dispersed solids	0.366	0.445*	0.099	0.207	-0.310	0.051	0.309	-0.223	1

**Correlation is significant at the 0.01 level; *Correlation is significant at the 0.05 level other values are non-significant.

most of the genotypes had less per cent curled grains and lower leached out solids and good grain elongation ratio which is highly desirable rice grain quality. Statistically not much variation was observed among the genotypes and also with check variety. The genotypes of high gelatinization temperature will require long cooking time and more water.

Correlation coefficient between various physico-chemical and cooking characteristics showed that L/B ratio is positively correlated with amylose content (AC), gelatinization temperature (GT), cooking time (CT), water uptake ratio (WUR) and percent dispersed solids (Table 3). There was negative correlation with grain elongation, 1000 grain weight and gel length which was not significant (p<0.05). A significant positive correlation was observed between amylose content and gelatinization temperature, cooking and water uptake ratio (p<0.01). A significant negative association was observed for gel length with L/B ratio, 1000 grain weight, amylose, gelatinization temperature (p<0.01). Water uptake ratio is significantly related to 1000 grain weight, amylose content and gelatinization temperature and cooking time. Per cent dispersed solids was positively correlated with 1000 grain weight (p<0.05). It can be observed that physico-chemical characteristics are positively related to cooking quality characteristics. Pathak *et al.* (2017) studied fourteen pigmented hill rice cultivars along with a non-pigmented one were for ascertaining the extent of their nutritionl and genetic diversity observed significant correlation amongst the different parameters of rice genotypes analyzed.

CONCLUSION

The study indicated rice genotypes studied exhibited good physico-chemical and cooking characteristics. It was evident that most of the genotypes had less per cent curled grains and lower leached out solids and good grain elongation which is highly desirable rice grain quality. There is a positive correlation with higher amylose, GT and water uptake ratio with cooking quality. Hence, these varieties may be suitable for table purpose. There is a need to popularize these genotypes to combat protein energy malnutrition.

Conflict of Interest: None.

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