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Quality Assessment of Some Rice Varieties Newly Adopted in Nepal

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Five rice varieties newly adopted in Nepalwere studied for their varietal differences in relation to quality characteristics such asphysicochemical and cooking qualities. In physical analysis bulk density, density,thousand kernel weight and length to breadth ratio were recorded as highest in 'Lumle-2' (0.60gm/ml), 'UPLRI-5' (1.40gm/ml) 'Lumle-2' (27.28gm),and 'IET-16775' (4.73) varieties respectively. The milling and head rice recovery were recorded maximum in 'Lumle-2' (78.76%) and 'UPLRI-5' (78.27%) respectively. Protein, fat, amylose, crude-fiber and total-ashwere ranged from 8.28-12.85%, 1.14-1.86%, 24.57-27.48%, 0.70-1% and 0.79-1.39% respectively.Iron, phosphorous and calcium content were estimated in the range 1.08-2.47mg/100g, 203.28-337.05mg/100g and 16.17-28.77mg/100g respectively.From organoleptic test, 'IET-16775' variety was scored as strongest aroma. 'Lumle-2', 'Chhomrong', 'Machapuchhre-3' varieties were shown as intermediate gelatinization-temperatureand 'UPLRI-5' and 'IET-16775' varieties were recorded as high gelatinization-temperature. Water uptake ratio, cooking time, elongation ratio and gruel loss werefound in the range 1.72-2.67, 18-25minutes, 1.29-1.63, and 2.50-6.12% respectively.

Keywords: Amylose, Cooking qualities, Gelatinization, Rice varieties

Introduction

Rice (*Oryza* spp.) is a member of the grass family (*Poceae*). Two species (out of about 22 recognizable species) are cultivated: *Oryza glaberrima* in West Africa and *Oryza sativa* in the rest of the world. *O. sativa* may be derived from the wild annual forms (*Oryza nivara*) in northeastern and eastern India, northern Southeast Asia, and southern China (Anonymous, 1999) and its domestication is considered to have occurred between 15,000 and 10,000 B.C. (Heiser, 1973; Harlan, 1975). In contrast, African rice almost certainly domesticated from the wild annual species common to West Africa, with *O. barthii* the most likely candidate (Harlan, 1975; Anonymous, 1999).

The rice plant (*Oryza sativa)* is one of the major food crops of the world. Some 90% of the world's rice is grown in a small area ('rice country') in Asia. Yet rice feeds the largest number of people in the world. At the same time rice is very flexible and grows practically all over the world (Bhattacharya, 2011). Rice is an important cereal grain which feeds nearly half of the world's population. Rice is usually consumed as a whole grain after milling and cooking, and in regular Asian diet, can contribute for 40-80% of total calorie intake (Bhat*et al.*, 2013). Being a major cereal grain, evaluating the physiochemical, nutritional and cooking qualities of rice has been given highest priority (Tan *et al.*, 1999; FAO, 2004). Consumer's preference varies based on the type of rice and their origin (Azabagaoglum *et al.*, 2009). It has been opined that the variations in composition and cooking quality of rice to mainly depend on the genetic as well as the surrounding environmental factors where they are grown (Singh *et al.*, 2005). Rice grain quality is reported to be influenced by the various physiochemical characteristics that determine the cooking behavior as well as the cooked rice texture (Bocevska *et al.*, 2009). Additionally, amylose content as well as gelatinization temperature and gel consistency can highly influence cooking and eating qualities of rice, which can vary based on the varieties (Juliano, 1972). Providing adequate information on the quality of newly developed rice varieties is important for the farmers, millers as well as to the consumers. Based on these facts, the main objective of the present study was to compare and provide detail on the proximate composition, physiochemical properties and cooking quality of different new rice varieties developed for Nepal.

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Materials and Methods

Paddy samples of *Lumle-2*, *Chhomrong* and *Machhapuchre-3* varieties were obtained from Regional Agricultural Research Centre, Lumle, Kaski, Pokhara and the samples of *UPLRI-5* and *IET-16775* varieties were obtained from National Rice Research Programme, Hardinath, Dhanusha. Samples were analyzed in the laboratory of Food Research Division, NARC, Khumaltar. The paddy samples were shelled in the Otake Rice Sheller (impeller husker, FCS type, Otake Co., Oharu, Japan) to obtain brown rice and polished in Yamamoto Rice polisher (friction type, VP-31T, Yamamoto Co., Tendou, Japan) to obtain milled rice of 6%degree of milling for further analysis.

Physical analysis

Shape (Length to breadth ratio), thousand kernels weight and Bulk density

Length and breadth measurement was done by using Vernier Caliper (0.02mm). Ten random samples of rice kernel were taken for the measurement. L/B ratio was then calculated from thedata obtained by dividing length by breadth. For thousand kernel weight, one thousand rice kernels were randomly selected and weighed.

Bulk density was determined by taking the direct weight of paddy in the 500 ml beaker and expressed in g/ml. Rice grains were dropped into a 500 ml beaker from a constant height (30 cm) (Bhattacharya, 2011). Similarly, density of paddy was determined by using toluene displacement method. Certain gram of rice was weighted and was put into the toluene in the graduated measuring cylinder. The volume displaced is measured and density is calculated using following formula.

Density (g/ml) = weight of rice/ volume displaced.

Milling recovery and head rice yield was calculated as follows:

Milling recovery % = (Weight of milled rice/ Weight of paddy) ×100%

Head rice yield % = (Weight of head rice/ Weight of milled rice) ×100%

Proximate composition

Determination of moisture content (Hot air oven method), crude protein (Micro-Kjeldahl, N×6.25), crude fat (Ether extraction method), crude fiber and total ash were done based on Rangana (1997) standard methods. Total carbohydrate content was determined by difference.

Carbohydrate (%) = 100% - (% Moisture + Protein + Fat + Ash)

Minerals content (Iron, Phosphorous and Calcium) were determined based on Rangana (1997) standard methods.

Amylose content

Amylose content in the rice samples were determined based on the iodine-binding procedure as described by Juliano (1971). In brief, rice was milled and passed through 100-mesh sieve. 100 mg of samples was weighted and 1 ml of ethanol (95%) and 9ml of standardized 1N NaOH were added. The samples were heated for 10 minutes on the boiling water bath to gelatinize the starch, cooled and transferred quantitatively and made up volume 100ml with distilled water. 5 ml of the solution was pipette into another 100 volumetric flask, 1 ml of 1N acetic acid and 2 ml of iodine solution (0.2 g Iodine and 2 g potassium iodide in 100 ml aqueous solution) were added. The solution was made up 100 ml with distilled water and let stand for 20 minutes. Absorbance of the solution at 620 nm was measured in the UV-Spectrophotometer setting absorbance 0 for blank. The Amylose content in samples were determined referring to the standard curve prepared using standard amylose (amylose extracted from potato, Sigma Aldrich co. USA).

Aroma

Aroma content in the rice samples were determined as per the method prescribed by Bhattacharya, (2011).

Cooking quality of rice

Gelatinization temperature: Gelatinization temperature was calculated on the basis of alkali spreading and clearing score.

Alkali spreading and clearing scores: Six kernels of each rice samples were spread in a Petridish resting on a black surface containing 10 ml of 1.7% KOH solution and left undisturbed for 23 hours at room temperature. Then the samples were scored for spreading and clearing according to seven point scales with refrence to the standard alkali spreading and clearing photograph (Bhattacharya, 2011).

Minimum cooking time: Rice samples (2 g) were cooked on a tube at around 90^0c with distilled water (20 ml) in a boiling water bath. The minimum time required for cooking was estimated by pressing the cooked rice samples between two glass slides (till no white core was left) by observing few cooked rice samples at regular time intervals (Bhat *et al.*, 2013).

Water uptake ratio: Two grams of rice samples were cooked in 20ml of distilled water for a minimum cooking time in a boiling water bath. The cooked rice were strained to drain the excess cooking water and the adhering superficial water present on the cooked rice was removed by lightly pressing the cooked rice samples between filter paper.

Cooked rice samples were weighed and the water uptake ratio was calculated (determined as increase in weight of the rice samples after cooking) **(**Bhattacharya, 2011).

Gruel solid loss: To measure the gruel solid loss, the gruel liquor obtained during the experiment for water uptake ratio was drained on tarred crucible and was evaporated on boiling water bath and placed into the hot air oven until it was completely dry. The dry solid obtained was weighedand percentage of gruel solid loss was calculated.

Elongation ratio: To determine elongation ratio, twenty random kernels of each rice sample were taken, their length were measured and cooked to the minimum cooking time. The cooked kernels were taken out and placed on blotting paper with the help of bent wire to absorb excess water. The length of cooked rice kernels were measured by spacing on graph paper.

The kernel elongation ratio was calculated as;

KER = length of cooked kernels/ length of raw kernels

Statistical analysis

All the analysis were performed in triplicates and all the data were calculated using Microsoft Excel (2007) and reported as mean ±SD (standard deviation). The statistics significance was evaluated by Analysis of Variance (one way ANOVA) with the help of data analytical software GenStat Discovery edition 4. The means of the data were compared with least Significant Difference (LSD) at 5% level of significance ($p < 0.05$).

Results and Discussions

Physical properties

Physiochemical properties of a rice variety are evaluated to provide important facts in determining their appropriate uses (Majzoobi *et al.,* 2008). A significant difference among varieties existed (Table 1).

In paddy, highest 1000-kernel weight was recorded in variety '*Lumle-2'* (27.82±0.63g) followed by '*Chhomrong*' (27.28±1.14 g) respectively. The lightest 1000-kernel weight was recorded for the variety 'UPLRI-5' (22.53±0.09 g). From the observation, '*Lumle-2'* and '*Chhomrong*' varieties were found to be extra heavy type rice since the thousand kernel weight was more than 25 gm; '*Machapuchhre-3'*, 'UPLRI-5' and 'IET-16775' varieties were found to be heavy type rice since, the thousand kernel weight was between 20 to 25 gm (FAO, 1972).

There was significant difference in shape (l/b ratio); highest l/b ratio was recorded for the 'IET-16775' (4.73±0.11) and lowest was recorded for '*Machapuchre-3'* (2.39±0.02) respectively. From the observation, '*Lumle-2'*, 'Chhomrong' and '*Machapucchre-3'* varieties were found to be medium type rice varieties since l/b ratio was found to be between 2 to 3; 'UPLRI-5' and 'IET 16775' varieties were found to be slender type rice varieties since, the l/b ratio was found to be more than 3 (FAO, 1972).

Among the different varieties, bulk density was found to be highest (0.60±0.01 g/ml) in '*Lumle-2'* and lowest was (0.51±0.01g/ml) in *Machapuchhre-3* variety. Similarly, the variation in density ranged from (1.05±0.02 to 1.40±0.13) gm/ml. The density of the paddy was found to be highest in 'UPLRI-5' (1.40±0.13g/ml) and lowest (1.05±0.02g/ml) was in '*Machapuchhre-3'* respectively.We can conclude from these data that there is substantial air space in the paddy grain inside the husk and the medium type variety of paddy contains more air space than slender varieties.

Milling characteristics

The varieties differed significantly for husk content, milling recovery and head rice yield (see Table 1). The highest husk content was in 'UPLRI-5' (20.93±1.26%) and the lowest was in 'Lumle-2' (16.56±0.20%). The highest milling recovery was in 'Lumle-2' (78.76±0.71%) and lowest was in 'UPLRI-5' (74.74±0.05%), highest head rice yield was in 'UPLRI-5' (78.27±0.21%), while the lowest was in '*Machapuchhre-3'* (61.44±0.32%) varieties respectively.

Chemical composition

The results obtained for chemical composition of different rice varieties investigated in this study are depicted in Table 2. Significant differences were recorded in the proximate composition between different varieties of rice evaluated. Moisture content, which plays significant role in determining the shelf-life (Webb, 1985) was recorded to vary between 12.35±0.19 to 14.47±0.43%.The total ash content was highest in '*Machapuchhre-3'* (1.39±0.05%) and lowest in 'UPLRI-5' (0.79±0.11%). Protein content ranged between 8.28±0.13 to 12.85±0.48%, highest protein content was found in 'UPLRI-5' followed by '*Lumle-2'* (11.30±0.65%), hence these rice varieties are found to be a good source of protein.Herefat content ranged between 1.14±0.04 to 1.86±0.08%. For crude fiber, the values were in range of 0.70±0.02 to 1±0.06%. Carbohydrate content was high in all varieties (>70%) and hence can be considered to be a good source of carbohydrate. From the analysis iron, phosphorous and calcium content were found in the range of (1.08±0.05 to 2.27±0.16) mg/100g, (203.28 to 337.05±0.86) mg/100g and (16.17±0.27 to 28.77±1.21) mg/100g respectively, hence '*Machapuchhre-3'* variety was found to have higher minerals content than other varieties.

Amylose content

Amylose content can play a significant role in determining overall cooking, eating and pasting properties of a rice variety (Adu-Kwarteng *et al.*, 2003). Apart from the amylose content, the cooking quality of rice can also be influenced by components such as: proteins, lipids and amylopectin (Cai *et al.*, 2011). During this study, a positive correlation was observed wherein; rice varieties which had higher amylose content, required shorter cooking time (Table 3). The results are on par with observation made earlier by Thomas *et al.*, (2013). In our study amylose content among the rice varieties was found in the range of 24.57±0.26 to 27.48±0.38% so it can be concluded that all the five varieties are non-waxy varieties having high amylose content (Juliano *et al.*, 1964).

Aroma

From the organoleptic test, '*Lumle-2*', '*Chhomrong*', '*Machapuchhre-3*' and 'UPLRI-5' varieties were found to be non-aromatic, and 'IET-16775' variety was found to be aromatic rice with pleasant aroma.

Cooking properties

The cooking properties (Table 3) are important as rice is consumed almost immediately after cooking. Rice being major staple food for half of the world's population, reduced cooking time can be beneficial especially when fuel consumption is of concern. The alkali digestion values have been employed as an estimate of gelatinization temperature. The alkali spreading and clearing scores of, '*Lumle-2*', '*Chhomrong*', '*Machapuchhre-3*', 'UPLRI-5'and 'IET-16775' varieties were (S-4, C-2,3), (S-3,4,5, C-2), (S-4, C-2,3), (S-2,3, C-1,2) and (S-2,3, C-2) respectively.

From the observation, '*Lumle-2*', '*Chhomrong*', '*Machapuchhre-3*' varieties were found to have intermediate gelatinization temperature (70-74^{o}C) and 'UPLRI-5', 'IET-16775' varieties were found to have higher gelatinization temperature (above 74^{o}C).

The minimum cooking time among the varieties ranged between 18±1 to 25±1 minutes. The relationship between amylose content and cooking time between various varieties investigated in this study are depicted in (Figure 1). With the increase in amylose content significant reduction on cooking time was observed.

Water uptake ratio is an important parameter while cooking rice. If the bulk density is higher, then corresponding water uptake ratio will also be high. This has been attributed to the compact structure of a rice variety (Bhattacharya *et al.*, 1971). In this study, highest water uptake ratio was found in '*Lumle-2*' (2.67±0.13) and lowest was found in '*Machapuchhre-3*' (1.72±0.08). Generally, breadth wise increase of rice on cooking is considered undesirable trait, while high quality rice are characterized and preferred based on increase in length during cooking (Danbana *et al.*, 2011). Elongation of rice may be influenced by both l/b ratio and amylose content (Singh *et al.*, 2005). In our study elongation ratio ranged from 1.29±0.10 to 1.63±0.31. All the varieties had elongation ratio lower than 2, suggesting that these varieties were not properly elongated during cooking (Ahmad *et al.*, 2006), the lower elongation could be due to freshly harvested samples (insufficient ageing). All the rice varieties have poor cooking quality immediately after harvest and become progressively better with age (Grist, 1975).

Gruel solid loss varied from 2.50±0.03% in 'UPLRI-5' to 6.12±0.06% in '*Machapuchhre-3*' variety. The high gruel solid loss is due to freshly harvested samples. All the varieties have poor cooking quality immediately after harvest, on cooking they are about to become pasty, fail to swell, properly lose more solids in solution and fragmentation, the grains are more cohesive and have a tendency to disintegrate. These characteristics become progressively less with age (Grist 1975). The stored rice needs longer time for coking, the volume expansion and water absorption increases and total solids in cooking water decreases as compared to fresh rice (He, 1989).

Table 1. Physical and milling properties of the rice varieties investigated in the study

Sample	Bulk density (gm/ml)*	Density (gm/ml) *	Thousand kernel weight (gm) *	L/B ratio*	Milling recovery %*	Head rice yield %*	Husk %*
Lumle-2	0.60±0.01^{a}	1.12±0.20^{a}	27.82±0.63^{a}	2.60±0.01^{a}	78.76±0.71^{a}	74.33±0.33^{a}	16.56±0.20^{a}
Chhomrong	0.59±0.01^{a}	1.08±0.03^{a}	27.28±1.14^{a}	2.45±0.05^{b}	77.52±0.48^{b}	67.93±0.09^{b}	19.53±0.11^{b}
Machapuchhre-3	0.51±0.01^{b}	1.05±0.02^{a}	23.43±0.50^{b}	2.39±0.02^{c}	76.03±0.63^{c}	61.44±0.32^{c}	20.28±0.64^{b}
UPLRI-5	0.57±0.02^{c}	1.40±0.13^{b}	22.53±0.09^{b}	3.70±0.10^{d}	74.74±0.05^{d}	78.27±0.21^{d}	19.93±0.98^{b}
IET-16775	0.53±0.01^{b}	1.17±0.02^{a}	23.92±0.63^{b}	4.73±0.11^{e}	74.85±0.12^{d}	69.54±0.33^{e}	19.30±0.61^{b}

*Values with different superscripts on the same column are significantly different at 5% level of significance

*Values are means ±standard deviation of triplicate samples.

Table 2. Chemical composition of the rice varieties investigated in this study

sample	Moisture%*	Protein% (db)*	Fat % (db)*	Crude fiber% (db)*	Total Ash % (db)*	Carbohydrate % (db)*	Amylose % (db)*	Iron mg/100g(db)*	Phosphorous mg/100g (db)*	Calcium mg/100g (db)*
Lumle-2	14.46±0.18^{a}	11.30±0.65^{a}	1.86±0.08^{a}	1±0.06^{a}	1.32±0.05^{a}	71.06±0.65^{a}	26.82±0.19^{a}	1.08±0.05^{a}	236.06±1.82^{a}	17.20±0.26^{a}
Chhomrong	14.47±0.43^{a}	8.28±0.13^{b}	1.71±0.02^{b}	0.94±0.01^{a}	1.39±0.14^{a}	74.15±0.40^{b}	27.48±0.38^{b}	1.16±0.03^{a}	203.28±1.02^{b}	16.17±0.27^{a}
Machapuchre-3	13.70±0.41^{b}	9.56±0.42^{c}	1.63±0.06^{b}	0.95±0.02^{a}	1.36±0.05^{a}	73.75±0.94^{b}	24.57±0.26^{c}	2.47±0.16^{b}	333.26±2.57^{c}	28.77±1.21^{b}
UPLRI-5	12.92±0.29^{c}	12.85±0.48^{d}	1.14±0.04^{b}	0.70±0.02^{a}	0.79±0.11^{b}	72.30±0.21^{c}	27.11±0.24^{b}	1.15±0.08^{a}	281.70±1.86^{d}	16.84±0.13^{a}
IET-16775	12.35±0.19^{c}	9.56±0.10^{c}	1.16±0.06^{b}	0.84±0.09^{a}	0.80±0.05^{b}	76.14±0.15^{d}	27.33±0.21^{b}	1.30±0.05^{a}	337.05±0.86^{e}	20.66±0.78^{c}

*Values with different superscripts on the same column are significantly different at 5% level of significance
*Values are means ±standard deviation of triplicate samples.

Table 3. Cooking properties of rice varieties investigated in this study.

Sample	Minimum cooking time (minutes)*	Water uptake ratio*	Elongation ratio*	Gruel solid Loss %*
Lumle-2	21±0.50^{a}	2.67±0.13^{a}	1.30±0.05^{a}	4.92±0.10^{a}
Chhomrong	18±1^{b}	2.41±0.09^{b}	1.43±0.10^{a}	5.93±0.05^{b}
Machapuchre-3	25±1^{c}	1.72±0.08^{c}	1.29±0.14^{a}	6.12±0.06^{c}
UPLRI-5	20±0.82^{a}	2.17±0.11^{d}	1.39±0.14^{a}	2.50±0.03^{d}
IET-16775	19±1^{ab}	2.16±0.06^{d}	1.43±0.31^{a}	4.87±0.08^{a}

*Values with different superscripts on the same column are significantly different at 5% level of significance
*Values are means ±standard deviation of triplicate samples.

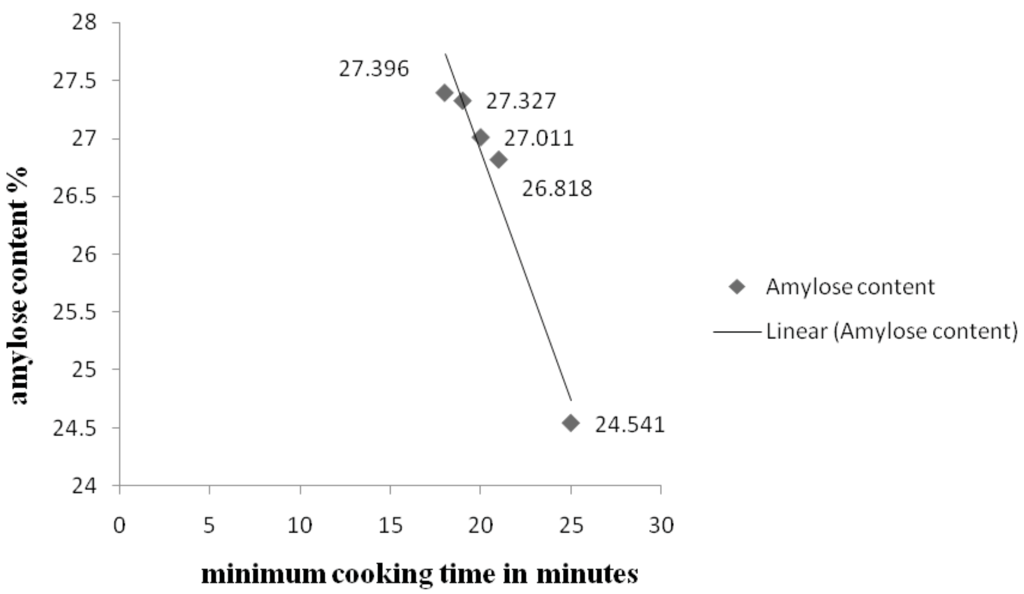

Figure 1. Positive correlation between amylose content and minimum cooking time

Conclusion

Investigation conducted on five rice varieties newly adopted in Nepal, provided information on their quality attributes. It also indicated differences in the physical, chemical and cooking properties. Among the five rice varieties, '*Lumle-2'*, '*Chhomrong*' and '*Machapuchhre-3'* were found to be medium to bold type rice variety and other two 'UPLRI-5' and 'IET-16775' were found to be slender variety. '*Lumle-2'* and '*Chhomrong*' varieties were found to be extra heavy type rice and '*Machapuchhre-3'*, 'UPLRI-5' and 'IET-16775' were found to be heavy type rice. '*Lumle-2'* and 'UPLRI-5' varieties were found better in terms of milling and head rice recovery. From the organoleptic test 'IET-16775' was found of good aroma. There was positive correlation between amylose content and minimum cooking time. Rice varieties with higher amylose content had short cooking time. Results obtained from this study are expected to be useful for further study, classification and grading of rice varieties and for preparation of rice based food products, based on the individual requirements.

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