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Development of Value Added Products from Rice Using Parboiling and Puffing Technologies

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ABSTRACT

Rice is originated from the grass species of Oryza sativa (Asian rice) or Oryza glaberrima (African rice). It is the most widely consumed staple food. The present study was carried out on parboiling and puffing characteristics and nutritive value estimation for selected bold rice varieties MTU1001 and MTU3626 in comparison with normal rice variety 7029. The results obtained for parboiling characteristics of the two varieties 1001 and 3626 showed that the alkaline spread value, head rice recovery and the percentage of broken grains of the bold varieties were significantly different when compared to normal rice variety. The total milling recovery of bold varieties was on par with normal variety. The results obtained for puffing characteristics of the two varieties 1001 and 3626 showed that significant difference existed among rice varieties in terms of puffed yield, expansion volume and expansion ratio when compared to those characteristics of puffed rice obtained from normal rice variety. The puffing characteristics were better in bold varieties when compared to normal rice variety. Using the two bold varieties selected for the study, four recipes were prepared. Pulihora and Fried rice were prepared using parboiled rice obtained from both varieties 1001 and 3626. Ugani and mixture were prepared using puffed rice obtained from both varieties 1001 and 3626. The recipes were subjected to sensory evaluation. The results of sensory evaluation showed that the recipes, Pulihora and Fried rice prepared using parboiled rice of bold varieties were acceptable on par with the recipes prepared using parboiled rice obtained from normal rice. Similarly, the recipes, Ugani and Mixture prepared using puffed rice of bold varieties were acceptable on par with the recipes prepared using puffed rice obtained from normal rice.

Keywords: *Parboilling, Puffing, Rice.*

Rice (*Oryza sativa* L.) is a staple food crop in India and many parts of the world. The pre-gelatinized and puffed flour is also utilized as ingredients for cakes, desserts and sweets, formulated baby foods, soups, stews, crackers, noodles, puddings, bread, fermented foods like idli, dosa, dhokla, rice vinegar, wine etc. Rice is naturally fat, cholesterol and sodium free.

Food security, the condition of having enough food to provide adequate nutrition for a healthy life, is a critical issue in the developing world.

Products of rice are used for a number of different purposes such as fuel, thatching, industrial starch, and art work. The Asian varieties are high yielding varieties and are used for medicinal purposes as well as food. Because of its importance in food security, income generation and political stability, the Food and Agricultural Organization (FAO) declared the year 2004 as the International year of rice**.** There are over 7,000 varieties of rice around the world. Before the rice grain is consumed, paddy undergoes several post harvest operations. The parboiling is defined as partial boiling of rice involving immersing of paddy in water, boiling of immersed paddy and sun drying of paddy. This is followed by milling. In order to enhance the hydration rate of raw rice, wetting agents such as sodium bisulfite and metabisulfite were used during soaking (Luh and Mikus 1980).

The preference for the parboiled rice appears to be increasing in the world. Parboiling is the popular agro based industry in Sri Lanka and about 70% of the total production of paddy rice grains is parboiled. There is good or emerging evidence that parboiling changes nutrition composition in rice. Various methods have been followed for preparation of parboiled rice. A parboiled method starting from dehulled rice instead of raw rice was proposed by Kar *et al.* (1999). Parboiled rice is rich in niacin, vitaminB6 and minerals like zinc, calcium, iron, magnesium, potassium. Many products are produced from parboiled rice like idli, dosa, dhokla, pulihora, biryani, fried rice, etc. In case of white rice during processing the bran is removed. In parboiling steaming causes migration of vitamins and minerals from bran to rice kernel. Parboiling rice helps to produce neurotransmitters. Parboiled rice is rich in folate which metabolizes amino acids and nucleic acids thereby reducing the risk of cardiovascular diseases.

Puffed rice is one of the products made from rice grain. Puffed rice is very popular snack product in many countries as breakfast cereal. It is prepared from hydrothermal treated rice and by heating in sand, oil or in microwave oven (Hoke *et al*., 2005). Puffing processes including hydrothermal (cooking starch in the presence of water), cooling, drying and explosive expansion of starch pellets, are used to engineer

structures with an airy, light and crispy texture to puffed products (Nath and Chattopadhyay, 2008).

Puffed rice is also commonly used in cereal drinks, ready-to-eat breakfast cereal and infant food as main ingredient. Puffed rice is not only a staple in the diet as a major source of carbohydrate, but it also contributes beneficial nutrients including phytochemicals, vitamins, minerals and dietary fiber which have been linked to reduce disease risk (Maisont and Narkrugsa, 2009). During puffing, the size of rice kernels increase and a fully heat treated crisp, porous and ready to eat product is created. Puffed rice is very low in calories. It only contains carbohydrates and a few B vitamins. It is used along with other ingredients in snack preparation. The variety and composition and degree of gelatinization affects the puffing quality of grains significantly proposed by (Maisont and Narkrugsa, 2010).

MATERIAL AND METHODS

Sample preparation

Two bold rice varieties namely MTU 1001 and MTU 3626 were procured and dehulling was done at RARS, Maruteru, West Godavari District.

Par boiling

Parboiling is an hydrothermal treatment in which rice kernels are soaked in water which involves partial boiling before milling in order to increase its nutritional value. It is completed in three steps namely, soaking, steaming and drying.

Parboiling Characteristics

Total Milling Recovery

Milling recovery was estimated by dividing weight of milled rice recovered by weight of paddy using the below equation:

$$MR(\%) = \frac{WHR}{WP} X\ 100$$

Where,

MR is milled recovery (%),
WHR is weight of milled rice (g) and
wp is weight of paddy (g).

Alkaline Spread Value

A solution of KOH (10 ml, 1.7% concentrated) was taken in glass petri dishes. The petri dishes were placed on a black surface. Six whole kernels of each treated rice and raw rice were dropped in separate petri dishes. The petri dishes were covered and kept undisturbed for 24hours at room temperature. After 24 hours, samples were observed minutely and rated for spreading according to following 7 point scale for dispersed, intermingled, split, swollen and unaffected kernels.

Head Rice Recovery

The head rice recovery of the kernel was calculated using the formula given below,

$$\text{Head Rice Recovery} = \frac{\text{Weightj of head rice}}{\text{Weight of milled rice}} \times 100$$

Broken Grains

Broken rice was calculated using the given below formula,

$$\text{Broken rice (\%)} = \frac{\text{Weight of broken rice}}{\text{Weightj of milled rice}} \times 100$$

Gelatinization Properties

Samples of about 950 mg (water + rice flour), with water as the reference, were loaded into 1 mL tantalum ampoules. Sample and reference pans were balanced within 1 mg. Rice flour samples (30% flour, 70% water, w/w) from 15, 30, 45, 60 and 120 min hot soaked paddy were scanned from 35 to 98^0C at a heating rate of 1^0C min)1 . A sample of raw rice flour (without parboiling treatment) was also included as a control. All samples were then cooled at the same cooling rate to observe any thermal transition on cooling the gelatinized starch. A ratio of 1:2.33 between milled rice grain and water provides a moisture content of 70% in the cooked rice. At this moisture level all the starch granules in the rice flour are fully cooked and gelatinized. However, different concentrations of rice flour as well as different rates of heating were also used for comparison. The degree of starch gelatinization was determined by comparing the enthalpy change of parboiled rice (ΔHpar) to that of raw rice (ΔHraw) using the following calculations.

Ungelatinized starch (%) = (ΔHpar/ ΔH raw) x 100

Starch gelatinization (%)= [1- (ΔHpar/ ΔH raw) x 100

Puffing

Puffed rice is prepared by sand roasting immersion of tempered and milled paddy.

Puffing Characteristics

Puffed Yield

The husk and unpuffed paddy rice were separated by hand picking and weighed. Puffed yield or the puffing ability of the paddy rice was evaluated by dividing the heated product into two shapes, namely fully puffed and small puffed rice. The puffed yield of the rice was expressed as a weight percentage, as determined by Simsrisakul (1991).

Expansion volume

Expansion volume of puffed rice was determined as follows: puffed rice was placed in a beaker with known volume. The remaining space in beaker is filled with black sesame of known volume. The volume of puffed rice was calculated by subtracting the volume of black sesame from beaker volume. Expansion volume was calculated by using equation given below:

$$\text{Expansion Volume} = \frac{\text{Volume of puffed rice (ml)}}{\text{Volume of paddy (ml)}} \times 100$$

Expansion ratio

A fluidized bed is formed when a quantity of a solid particulate substance (usually present in a holding vessel) is placed under appropriate conditions to cause the solid/fluid mixture to behave as a fluid. Fluidization is known to increase the heat and mass transfer as product surface area is uniformly exposed to the heating medium, therefore, fluidized bed high temperature short time (HTST) puffing is more efficient than hot air or conduction roasting or puffing process. Surface heat transfer coefficient is an important parameter in fluidized bed puffing. The temperature ranging from 240°C to 270°C with corresponding exposure time of 7 to 9.7 s was found to be optimum for higher expansion ratio (8.5 to 10) and better colour of the product.

Expansion ratio was calculated by using equation given below:

$$\text{Expansion Ratio (ml)} = \frac{\text{Volume of puffed rice (ml)}}{\text{Volume of milled rice (ml)}} \times 100$$

Standardization of recipes

Four commonly used rice based recipes were developed with parboiled and puffed rice made from bold rice varieties 1001 and 3626. Pulihora and Fried rice were standardized with parboiled while Ugani and Mixture were standardized with puffed rice.

Sensory evaluation of developed value added products

Sensory evaluation of developed value added products using parboiling and puffing technologies was carried out by panel of trained judges from Department of Foods and Nutrition , College of Home Science, Acharya N.G. Ranga Agricultural University, Guntur. The judges were asked to evaluate samples in terms of appearance, colour, taste, texture, flavor and overall acceptability using 9 point hedonic scale.

Statistical analysis

The statistical significance was tested by using t test the significant difference between the varieties at $p<0.05$ level. The statistical analysis was done using SPSS software.

RESULTS AND DISCUSSION

The two varieties of rice were subjected to parboiling and puffing. Data pertaining to parboiling and puffing characteristics is presented in Table 1 and Table 2 respectively.

The results obtained for parboiling characteristics of the two varieties 1001 and 3626 respectively were: alkaline spread value 7.0 and 7.0, head rice recovery 61.5 and 59.2%, broken grains 9.5 and 11.8%, total milling recovery of 71 and 71.1 %. The alkaline spread value, head rice recovery and the percentage of broken grains of the bold varieties were significantly different when compared to normal rive variety. The parboiling characteristics of bold rice varieties were almost on par with the normal rice variety. The total milling recovery of bold varieties was on par with normal variety.

The results obtained for puffing characteristics of the two varieties 1001 and 3626 respectively were: Puffed yield 76.3 and 77.1%, expansion volume was 1.75 and 1.87mm^3 and the expansion ratio was 7.04 and 7.54. The results showed that significant difference existed among rice varieties in terms of puffed yield, expansion volume and expansion ratio when compared to those characteristics of puffed rice obtained from normal rice variety. The puffing characteristics were more in bold varieties when compared to normal rice variety.

Sensory evaluation of the recipes

The four recipes that were prepared using both the varieties of parboiled and puffed rice were subjected to sensory evaluation by a trained panel of judges. The scores were obtained for all the sensory attributes including appearance, colour, taste, texture, flavor and overall acceptability.

The mean scores of sensory evaluation of the recipes prepared using parboiled rice are presented in Table 3.

The results of sensory evaluation showed that both the recipes made using parboiled rice varieties MTU 1001 and MTU 3626 were well accepted by all the panel members. The acceptability of the recipes was on par with the recipes prepared using normal rice. The results of ANOVA of the mean scores of sensory evaluation of the recipes showed no significant difference between the mean scores of all the recipes for all the sensory attributes.

The mean scores of sensory evaluation of the recipes prepared using puffed rice are presented in Table 4.

Table 1. Parboiling characteristics of rice

S.No	Parboiling Characteristics	Normal Rice 7029	MTU 1001	MTU 3626
1	Total Milling Recovery (%)	71	71	71.1
2	Alkaline Spread Value	3.1	7	7
3	Broken Grains (%)	6	9.5	11.8
4	Head Rice Recovery (%)	65	61.5	59.2
5	Gelatinization properties (^{O}C)	Medium to High	Low	Low

Table 2. Puffing characteristics of rice varieties

S.No	Puffing Characteristics	Normal Rice -7029	MTU 1001	MTU 3626
1	Puffed yield	72.2	76.3	77.1
2	Expansion volume	1.68	1.75	1.87
3	Expansion ratio	6.85	7.04	7.54

Table 3. Mean scores of sensory evaluation of recipes prepared using parboiled rice

Sensory parameters	Mean Sensory Scores (9 point scaling)					
	Pulihora			Fried rice		
	Normal rice 7029	MTU 1001	MTU 3626	Normal rice 7029	MTU 1001	MTU 3626
Appearance	6.2	6.3	5.6	5.8	5.9	6.3
Colour	8.0	5.7	5.8	5.7	5.2	5.4
Taste	5.5	5.9	6.0	4.9	7.1	6.5
Texture	6.8	6.0	5.4	5.4	5.6	5.6
Flavor	6.0	5.7	6.7	5.6	6.3	6.0
Overall acceptability	5.6	6.0	6.0	6.5	6.7	7.0
Results of ANOVA						
F cal value	*63.57*					
F tab value	*1.63*					

Table 4. Mean scores of sensory evaluation of recipes prepared using puffed rice

Sensory parameters	Mean Sensory Scores (9 point scaling)					
	Poha			Masala snack		
	Normal rice 7029	MTU 1001	MTU 3626	Normal rice 7029	MTU 1001	MTU 3626
Appearance	7.0	6.5	6.1	6.1	6.0	6.0
Colour	6.5	6.4	6.4	7.0	7.4	5.9
Taste	6.5	6.4	6.3	6.9	6.4	6.5
Texture	6.2	6.4	5.9	5.8	6.1	6.3
Flavor	7.0	6.2	6.1	6.5	6.8	6.0
Overall acceptability	6.8	6.2	6.1	7.0	6.3	6.1
Results of ANOVA						
F cal value	*0.5507*					
F tab value	*1.63*					

The results of sensory evaluation showed that both the recipes made using puffed rice varieties MTU 1001 and MTU 3626 were well accepted by all the panel members. The acceptability of the recipes was on par with the recipes prepared using normal rice. The results of ANOVA of the mean scores of sensory evaluation of the recipes showed no significant difference between the mean scores of all the recipes for all the sensory attributes.

CONCLUSION

Parboiling characteristics such as alkaline spread value, head rice recovery and the percentage of broken grains of the bold varieties were significantly different when compared to normal rice variety. The total milling recovery of bold varieties was on par with normal variety. Significant difference existed among rice varieties in terms of puffed yield, expansion volume and expansion ratio when compared to those characteristics of puffed rice obtained from normal rice variety. The bold varieties exhibited superior puffing characteristics. The products prepared using parboiling and puffed rice obtained from bold varieties were well accepted for all the sensory attributes.

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