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Optimization of Soaking Duration and Temperature for Two Nigerian Rice Cultivars

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ABSTRACT

Optimization of soaking duration and temperature for two Nigerian rice cultivars were evaluated. Temperatures of 50°C, 70°C and 90°C were used for both long and short grain rice paddy. Each treatment had three replicates of 12, 18 and 24 h of soaking durations. The physical analysis of the long/short rice paddies were 1000 kernel volume 24.3/22.3 cm^3, 1000 kernel weight 24.2/24.3 g, density 1.3/1.1 gcm^3, length, 9.9/8.2 mm, width, 2.95/3.3 mm, water absorption rate of 34/11% and moisture content of 14/11% respectively. Sensory evaluation of the long/short grain rice yield based on colour and general acceptability showed that significant differences existed among the samples with colour 8.05/7.85, general acceptability 8.10/7.80 respectively. The long/short grain percentage breakages were 2.7/1.2% and total yield 70/67%, respectively. At 70°C long grain rice yield increased as soaking duration increased, and at 90°C, short grain rice yield increased as soaking duration increased. The best quality was achieved by soaking the long grain at 70°C for 24 h and short grain at 90°C for 24 h.

Keywords: Temperature, soaking duration, processing, rice cultivars.

Introduction

Rice is a staple food for about 2.6 billion people in the world. The global output shows that the Asian continent accounts for about 92 per cent, while American and Caribbean account for 5 per cent and 3 per cent for Africa (Spore, 2005). The Nigerian food sub-sector parades a range of crops, but of all these, rice has gained prominence. Food and Agricultural Organisation (FAO) (2007) reported that Nigeria is the largest producer of rice in West Africa, producing over 46% of the region's total production. According to the report of FAO (2007), in the last 30 years, production has increased sixfolds with Nigeria producing 3.6 million tons of paddy rice in 2000 and 2005 respectively. Nigeria is equally the largest importer of rice and its importation figure stood at 1 million tons costing over $300 million by 1998, which is one third of sub-region total (Fashola, 2007).

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In response to the prevailing rice supply deficit situation in the country, successive Nigerian governments have intervened in the rice sub-sector by increasing tariff on rice importation so that local production could be encouraged. This was expected to widen the home market of local rice. Of the twenty known species of rice, only two are cultivated, the widely grown Asian rice *Oryza sativa* and the harder African rice *Oryza glaberrima*.

The chemical composition of the rice grains varies considerably depending upon the genetic factor of plant variety and upon such environmental influences as location and season in which they are grown, degree of milling and conditions of storage. On the average, however, a sample of milled rice grain will contain about 80% starch, 6.8 – 8% protein, 0.5% ash, 0.2% fibre, 11% moisture and 398 cal/100 g energy (Okaka, 1997).

Rice is used for a variety of food and non-food products. Foods include "masa" – a fermented puff batter (Nkama, 1993; Ezeama, 2004; Ayo *et al*., 2008), "garabia" – a traditional snack food (Mamudu *et al*., 2009), "Tuwon shinkafa" – a thick gruel (Danbaba *et al*., 2007) and cooked rice breakfast cereals. Rice is also used in beer and in sake, a Japanese fermented brew. The inedible rice hull is used as fuel, fertilizer and insulation, while the bran is a source of cooking oil (Ihekeronye and Ngoddy, 1985). Straw from the leaves and stems is used as bedding for animals and for weaving roofs, hats, baskets and sandals (Hynes, 2007).

Many methods have been employed to process rice; these include the traditional method, brine solution method, sodium chromate method and the steaming methods (Bolaji, 2004). Before rice can be used for human consumption, it must be processed and the hope for better nourishment will depend on the development and method used in processing rice varieties.

Rice processing is the treatment of harvested threshed and dried paddy rice to remove the foreign material such as stalk, sand, stones and so on, which is followed by soaking, parboiling, drying and milling in order to produce a clean rice kernel as close as possible for consumption purposes (Pursegrove, 1972). The aims and objectives of this study were to determine the best water temperature and soaking periods for processing rice varieties using the steaming method and to determine their effects on total rice yield.

Materials and Methods

Sample preparation and collection

The rice paddies, long grain (FARO 44) and short grain (Ex-china) were brought from Bauchi State Agricultural Development Project and Bayara market, Bauchi, Nigeria.

The long grain rice paddy (FARO 44) and short grain (Ex-china) were used. Equal quantities of long grain (FARO 44) and short grain (Ex-china) were measured, cleaned and shared into three groups. Each group was subjected to different temperatures of 50^{o}C, 70^{o}C and 90^{o}C, while soaking period were for 12, 18 and 24 h respectively. After the expiration of the soaking periods, the pH value of the water was taken using a pH metre. The paddy was steamed using steaming method, dried, weighed, milled and re-weighed and stored for analysis at room temperature (25 + 3^{o}C).

Physical properties of the rice cultivars

A thousand kernel weight was determined according to the procedures described by Jideani and Akingbala (1993). A thousand kernel volume was determined using Archimedes principle. Grain density was determined using the method of Sefa-Dedeh and Stanley (1979). The major and minor diameters were measured with the vernier caliper and the micrometer screw guage as described by Nkama (1993). The percentage of water absorbed was determined using Gomez *et al.* (1997) method. The method of AOAC (2000) was adopted for moisture determination. The pH value of the sample was determined using electronic pH metre (Ele International (UK) as described by Nkama (1993).

Determination of total rice yield

The paddy rice was weighed initially, steamed and re-weighed, milled and re-weighed. The weight of the broken grain and percentage yield were taken to know the total percentage yield after milling.

$$\text{Yield } \% = \frac{\textit{Weight of milled rice}}{\textit{Weight of paddy rice after steaming}} \text{ x } 100\%$$

$$\text{Broken } \% = \frac{\textit{Weight of broken grain}}{\textit{Weight of total rice yield}} \text{ x } 100\%$$

Sensory evaluation of the dehulled rice

Nine samples each of long (FARO 44) and short grains were placed in coded polyethylene bags. Twenty (20) panelists were randomly selected based on their familiarity with the product to evaluate the product using a 9-point hedonic scale ranging from like extremely (9) to dislike extremely (1) (Ihekoronye and Ngoddy, 1985). The attributes evaluated were based on colour and general acceptability. Although the panelists were not trained, their selection was based on the basic requirements of a panelist, such as availability for the entire period of evaluation, interest, willingness to serve, good health (not suffering from colds), not allergic or sensitive to the products evaluated (Penfield and Campbell, 1990). The results obtained were analyzed by analysis of variance (ANOVA) and the results were separated using Tukey test.

Results and Discussion

Physical analysis of the rice cultivars

The physical analyses of both long and short grains are shown in Table 1. The short paddy rice had a lower moisture content of 11%. According to Bor (1990) and Ihekoronye and Ngoddy (1985), rice paddy must maintain a moisture content of between 11 and 13% (dry basis) to protect it from fungi and insects. The water absorption rate of the short paddy rice was also low at 11% which affected the steaming time. The volume of the two samples (long and short grain rice paddy) was the same, with slight variations in their weights, which was due to the slenderness of the long grains (Hynes, 2007). The variations in the density, length and width conformed to Hynes (2007), who reported the bulk raw rice density of 1.0 g/cm^3 and length/width of brown rice to be 7 mm/5.5 mm respectively.

Table 1: Physical analysis of long and short paddy rice[a]

Parameters	Long paddy rice	Short paddy rice
1000 kernel volume (cm^3)	24.30 ± 0.58	22.30 ± 0.58
1000 kernel weight (g)	24.20 ± 0.21	24.30 ± 1.15
Density (g/cm^3)	1.30 ± 0.38	1.10 ± 0.06
Length (mm)	9.90 ± 0.42	8.20 ± 0.26
Weight (mm)	2.95 ± 0.33	3.30 ± 0.14
Water absorption rate (%)	34.00 ± 2.83	11.00 ± 1.41
Moisture content (%)	14.00 ± 0.58	11.00 ± 0.29

[a] Values are mean ± standard deviation of triplicate values

Physical properties for processing the rice cultivars

The physical properties for processing both long and short paddy rice are shown in Table 2. The physical properties for processing both samples showed that yield increased as the soaking duration increased for both long and short grain rice paddy. Also, the broken grains decreased as the soaking duration increased for both long and short grain rice paddy. The long grain (FAV) at 70^{o}C for 24 h gave the highest yield and best quality of 67%, while the short grain (RAV) gave the best quality at 90^{o}C for 24 h. This conformed to Bor (1990) who reported that as long as the water temperature is kept below the gelatinization temperature of the starch in the rice, the rice will eventually reach an equilibrium value for its water content and time taken to reach the value being dependent on the water temperature and if the water content is raised above this temperature, it is likely that the rice will split open due to the effects of the absorption of the water. However, if the water content after steeping is significantly lower, then the final product of the process will contain a large number of white bellies (which are grains in which the starch is not fully gelatinized).

Sensory evaluation of the dehulled rice

The sensory evaluation in terms of colour and general acceptability as shown in Table 3 showed that long grain (FAV) at 70^{o}C for 24 h was mostly accepted with mean of 8.05/7.85 respectively, while the short grain (RAV) at 90^{o}C for 24 h was mostly accepted with mean of 8.1/7.8 respectively. The samples were significantly different from each other ($p < 0.05$). The sensory evaluation result conformed to the physical properties result shown in Table 2.

Conclusion

It has been shown that sample (FAV) for long grain at 70^{o}C and sample (RAV) for short gain at 90^{o}C with soaking periods of 24 h each proved the best quality in terms of colour and general acceptability. The moisture content and water absorption rate for the short grain were lower which meant more steaming time, water temperature and soaking periods. Chalky appearances disappeared as the soaking period increased and the colour of the rice changed to deep yellow; the chalky appearance were more with temperature of 50°C for both long and short grain rice.

Table 2: Physical properties for processing long/short grain paddy rice

Samples	Temp. (°C)	Soaking period (h)	Initial weight of paddy rice (g)	Weight of paddy rice after steaming (g)	Weight of total yield after milling (g)	Weight of broken rice after milling	Weight of recovered yield after milling	Total weight milled (g)	% of broken grain	% of recovered yield after milling
					Long grain paddy rice					
AAV	50	12	2000	1500	60	186.52	750	900	12.4	50
BAV	"	18	2000	1550	70	319.87	700	1100	20.6	45
CAV	"	24	2000	1550	70	55.95	1000	1100	3.5	65
DAV	70	12	2000	1600	66	99.77	1000	1050	6.2	63
EAV	"	18	2000	1650	67	30.20	1050	1100	1.8	64
FAV	"	24	2000	1650	70	7.24	1100	1150	0.4	67
GAV	90	12	2000	1650	67	20.06	1050	1100	1.2	64
HAV	"	18	2000	1650	67	17.18	1050	1100	1.0	64
IAV	"	24	2000	1650	73	21.52	1050	1200	1.3	64
					Short grain paddy rice					
JAV	50	12	2000	1850	67	28.30	1150	1250	1.5	62
KAV	"	18	2000	1900	68	28.90	12.50	1300	1.5	66
LAV	"	24	2000	1850	68	6.48	1200	1250	0.4	65
MAV	70	12	2000	1850	68	97.08	1050	1150	5.4	58
NAV	"	18	2000	1800	61	7.93	1100	1150	0.4	58
OAV	"	24	2000	1750	69	20.71	1150	1200	1.2	66
PAV	90	12	2000	1850	73	57.85	1300	1350	3.1	70
QAV	"	18	2000	1950	67	11.70	1250	1300	0.6	64
RAV	"	24	2000	1950	72	53.33	1300	1400	2.7	67

Key = 1kg = 1000g

Table 3: Sensory evaluation of the dehulled rice paddy for both long and short rice[a, b]

Products	Temp (°C)	Soaking periods (h)	Colour	General acceptability
	Long	**Grain**		
FAV	50	12	8.05 ± 1.73[a]	7.85 ± 1.89[a]
GAV	"	18	7.55 ± 1.09[b]	7.25 ± 1.09[a]
EAV	"	24	6.25 ± 1.41[c]	5.65 ± 1.69[b]
DAV	70	12	5.65 ± 1.81[d]	5.40 ± 1.60[b]
HAV	"	18	5.50 ± 1.64[d]	5.40 ± 1.43[b]
IAV	"	24	5.35 ± 1.35[d]	5.30 ± 1.43[b]
CAV	90	12	4.40 ± 1.69[e]	4.15 ± 1.79[c]
BAV	"	18	3.65 ± 1.66[f]	3.45 ± 1.67[d]
AAV	"	24	3.25± 2.17[f]	3.05 ± 2.01[d]
	Short	**Grain**		
RAV	50	12	8.10 ± 1.17[a]	7.80 ± 2.02[a]
PAV	"	18	7.20 ± 1.15[b]	7.40 ± 1.42[a]
GAV	"	24	6.15 ± 1.93[c]	6.05 ± 1.50[b]
MAV	70	12	6.05 ± 1.93[c]	5.65 ± 1.76[b]
OAV	"	18	5.55 ± 1.73[d]	5.45 ± 1.70[b]
KAV	"	24	5.30 ± 2.62[d]	4.60 ± 1.70[b]
LAV	90	12	4.30 ± 1.87[e]	4.35 ± 1.69[c]
NAV	"	18	4.25 ± 1.48[e]	3.95 ± 1.69[d]
JAV	"	24	3.90 ± 2.57[f]	3.95 ± 1.85[d]

[a] Values are mean ± standard deviation of 20 panelist
[b] Means with different superscript within the same column differ significantly ($p < 0.05$) using Tukey's test

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