

# Effect of Pre-Boiling on the Chemical, functional and Pasting Properties of Rice

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The study investigated the effect of pre-boiling on the chemical, functional and pasting properties of three (3) rice varieties . The rice varieties are local Abakaliki, caprice and the most preferred American rice – par excellence. Results of chemical analysis showed that pre-boiling and washing had a significant differences ( $p<0.05$ ) with treatment in amylose, amylopectin, protein, sugar, ash, starch and starch damage. There was a marked decrease in value in all chemical parameters except amylopectin and degree of starch damage that had increased values. Functional properties such as dispersibility, water absorption capacity, swelling power, solubility, and colour indices showed a significant ( $p<0.05$ ) difference in all parameters evaluated between the samples and treatment Results of pasting properties showed a significant ( $p<0.05$ ) difference in all rice samples. Cooking, pre-boiling and washing of rice varieties significantly resulted in nutrient depletion especially in its chemical properties due to leaching, varietal differences, environmental factors, storage and processing methods.

**Key words:** Pre-boiling, washing, rice, chemical, functional, pasting.

## INTRODUCTION

*Oryza sativa* (rice) is the most important food crop in the world. It is the staple food for 3 billion people, constituting over half of the world's population (Central and Reeves 2002, Davidson *et al.*, 1979). Rice is a cereal grain belonging to the gramminaece, a large monocotyledonous family of some 600 genera and about 10,000 species. It originated from South East of Asia but is grown today in other parts of Asia, America and Africa (Matz and Beachell 1969). Rice is an economic crop, which is important in household food security, nutritional diversification, income generation and employment (Perez *et al.*, 1987).

Rice is cherished by both adults (especially women) and children and used as a meal of choice in almost all occasions. Conventionally, rice is cooked by washing and pre-boiling in water for about 10 minutes and then rewashed for final cooking. This is a usual practice is most household in Nigeria. Despite the fact that rice is cultivated in all etiological zones of Nigeria, there has been an upsurge in the influx of foreign rice into the country Nigeria, which includes amongst others caprice, tomato, mama gold and mama Africa etc.

These different types of rice is believed to behave differently when cooked in comparison to the locally cultivated (Abakaliki) rice in Nigeria, in respect of cooking time, nutrient content, water absorption rate and swelling power. A lot of work has been done on rice in terms of breeding, harvesting, on-farm and off farm processing and storage. However, there are less information on the effect of cooking method on the

nutrient content of cooked rice. This work is therefore aimed at determining the effect of cooking method such as straight boiling and pre-boiling and washing on the chemical, functional and pasting properties of local Nigerian rice (Abakaliki), a population foreign rice (caprice) in Nigeria and the most preferred American rice (par excellence).

## MATERIALS AND METHODS

**Materials:** Three rice samples (Abakaliki, caprice and par excellence) were used for this study. Abakaliki and caprice were bought from the Mile III Market in Port Harcourt, Nigeria. While par excellence rice was bought from a food mart in North Carolina USA. Samples were labeled accordingly and stored for further analysis.

**Sample Preparation:** Samples were divided into three parts. 300g of each rice sample was milled raw and stored for analysis. Another three sets of rice samples (300g each) were washed two times, cooked straight until soft. The last set of three rice samples were washed, pre-boiled for 10 minutes in 500ml of water, after which rice samples were rewashed and cooked finally in 500ml of water until soft.

**Methods:** Chemical analysis of rice samples such as ash and protein were determined by the AOAC (1990). Ash was done using 3g sample each inside a muffle furnace at a temperature of 600°C for 8 hours while protein was

done using the micro-kjeldahl method with 1g sample each. Starch damage was determined by the method described by Mc-Dermott (1980), using 0.5g of sample with 20ml of preheated extractant at 30°C in a water bath for 15mins and 1ml of iodine solution added and kept at room temperature. Absorbance was read at 600nm. Amylose and colour were determined by the methods of Williams *et al.*, (1970) and Francis (1998) respectively. Amylose was done using 0.1g sample plus 1ml of 95% ethanol and 9ml NaOH. Mixture was heated in water bath for 10mins. 1ml of extract was used to prepare a 1:10 dilution and 0.5ml of diluents used for analyses and absorbance was read at 620nm. While colour was determined using a colour meter that operates on the CIE L\*, a\*, b\* colour scheme. Multiple measurement at several points on samples were made.

Dispersibility of rice flour were determined using the method described by Kulkarni *et al.*, (1991), 10g sample in a measuring was made up to the 100ml mark with distilled water, stirred and allowed to stand at room temperature. Volume of the settled sediment was recorded as shown on the measuring cylinder and result calculated. Swelling power and solubility were determined by the methods of Takashi and Sieb (1988) while water absorption capacity was determined by the method of Sosulski (1962). This involved using 1g of sample added in 15ml of water in a pre-weighed centrifuge tube. Content was centrifuged at 5,000rpm for 30mins after agitation for 5mins. Supernatant was discarded and sediment weighed. Pasting properties were determined using the Rapid Visco-analyzer (RVA Model) Newport Scientific Warriewood, Australia).

**Statistical Analysis:** Differences between means were assessed by analysis of variance and means separated by Duncan's Multiple range test according to the method of steel and Torrie (1981).

## RESULTS AND DISCUSSION

### Chemical Composition of Rice Samples

Table 1 shows the chemical properties of raw, straight cooked and pre-boiled samples of local Abakaliki rice, caprice and par-excellence rice. Amylose content

ranged from 33.45-35.57%, 34.46-41.47% and 31.01-40.36% for local, caprice and par-excellence rice respectively. While amylopectin increased with a decrease in amylose. Starch content of samples reduced with pre-boiling in all three varieties. Pre-boiled caprice sample had the least starch content of 31.8% while the American par-excellence rice had the highest starch content of 33.31%. Starch the principal component of rice is a mixture of amylose and amylopectin, and variations in amylose content has significant effect on cooking and eating qualities of rice (Juliano 1990). The decrease in amylose and starch are expected because rice being a carbohydrate food has soluble starch that is capable of leaching in water. This finding is in agreement with the work of Juliano (1985) who stated that most water-soluble nutrients in rice are easily dissolved in water and that discarding such water results in very serious losses of nutrient and calories necessary for the normal functioning of the body.

Protein content decreased with cooking and even more with pre-boiling, with caprice having the highest value of 7.75-9.35% and local Abakaliki rice the least protein value of 7.15-7.35%. The protein content in the present study falls within the range (6.3-9.5%) recorded by Derycke, *et al.*, (2005). The difference observed may be due to varieties differences. Sugar ranged from 0.79-1.4% for local rice, 1.34-1.60% for caprice and 1.02-1.92% for American rice, with the American rice having the highest value and local rice the least. Cooking reduced sugar content and much more with pre-boiling. Rice samples showed significant ( $P < 0.05$ ) difference with treatment in amylose, amylopectin, protein, sugar and starch as shown in table 1. Degree of starch damage increased with cooking in all three varieties of rice. Local Abakaliki rice had the least starch damage of 1.49-1.5% while American rich had the highest value of 1.59-1.74%. Pre-boiled samples had more damage than the straight cooked and the raw sample. The extent of starch damage may have been as a result of processing during milling (cell exposure) damage and effect of heat (cooking and drying). Furthermore the increase in starch damage may be attributed to cell disruption by heating.

Ash content reduced with cooking and decreased further with pre-boiling. Starch damage and ash showed no significant ( $P > 0.05$ ) difference within treatments and varieties as shown in table 1

**TABLE 1 CHEMICAL PROPERTIES (%) OF RAW, STRAIGHT COOKED AND PRE-BOILED RICE**

Sample Code	Ash	Amylose	Amylopectin	Protein	Sugar	Starch	Starch Damage
LR	1.32a	35.57 <sup>c</sup>	64.93 <sup>f</sup>	7.35 <sup>c</sup>	1.4 <sup>b</sup>	32.48 <sup>b</sup>	1.49 <sup>a</sup>
LSC	1.05a	33.96 <sup>e</sup>	67.05 <sup>c</sup>	7.45 <sup>c</sup>	1.19 <sup>b</sup>	32.43 <sup>b</sup>	1.54 <sup>a</sup>
LPB	0.74a	33.45 <sup>f</sup>	66.54 <sup>e</sup>	7.15 <sup>c</sup>	0.79 <sup>b</sup>	31.11 <sup>c</sup>	1.54 <sup>a</sup>
CR	1.00a	41.47 <sup>a</sup>	59.03 <sup>h</sup>	9.35 <sup>a</sup>	1.92 <sup>a</sup>	32.41 <sup>b</sup>	1.59 <sup>a</sup>
CSC	0.82a	34.66 <sup>d</sup>	66.04 <sup>d</sup>	8.15 <sup>c</sup>	1.76 <sup>a</sup>	33.05 <sup>a</sup>	1.64 <sup>a</sup>
CPB	0.6a	34.46 <sup>cd</sup>	65.84 <sup>e</sup>	7.45 <sup>c</sup>	1.02 <sup>b</sup>	31.8 <sup>c</sup>	1.64 <sup>a</sup>
AR	1.12a	40.36 <sup>b</sup>	60.14 <sup>g</sup>	8.95 <sup>b</sup>	1.6 <sup>a</sup>	32.14 <sup>b</sup>	1.59 <sup>a</sup>
ASC	0.85a	32.54 <sup>g</sup>	67.96 <sup>b</sup>	8.55 <sup>b</sup>	1.59 <sup>a</sup>	33.31 <sup>a</sup>	1.64 <sup>a</sup>
APB	0.67a	31.01 <sup>h</sup>	69.49 <sup>a</sup>	7.75 <sup>c</sup>	1.34 <sup>b</sup>	32.09 <sup>b</sup>	1.74 <sup>a</sup>

Means on the same column bearing the same superscript are not significantly different ( $P>0.05$ ).

**Key:** LR = Local raw rice  
 LSC = Local rice straight cooked  
 LPB = Local rice pre-boiled  
 AR = American rice raw  
 ASC = American raw straight cooked  
 APC = American raw pre-boiled  
 CR = Caprice Raw  
 CSC = Caprice straight cooked  
 CPB = Caprice pre-boiled

## FUNCTIONAL PROPERTIES OF RICE SAMPLES

Table 2 shows the functional properties of raw, straight cooked and pre-boiled rice. Dispersibility values ranged from 56-66% for local rice, 50-70% for caprice and 52-60% for American rice. The percentage dispersibility gives an indication of water absorption capacity. In the present study, the ratio of dispersibility to water absorption is ratio 1:3 meaning that the higher the dispersibility the higher the water absorption capacity. Kulkarni *et al.*, (1991) stated that the higher the dispersibility, the better the starch reconstitutes in water to give a fine and consistent paste.

Water absorption capacity for local price, caprice and American rice ranged from 166.20-256.93%, 140.09-236.77% and 199.396.43% respectively with American rice having the highest and caprice the least. Niba, *et al.*, (2001) described water absorption capacity as an important processing parameter that has implications for viscosity. Further more water absorption capacity is important in bulking and consistency. Water absorption capacity increased with processing in all varieties studied.

Generally, swelling power ranged from 8.52-10.42% with straight cooked American rice having the highest and pre-boiled caprice having the least value.

The swelling power of a starch based food is an indication of the strength of the hydrogen bonding between the granules (Safo-Kantanka and Acquistuccil 1996). Further more Rickard *et al.*, (1991), described swelling power as a factor of the ratio of amylose to amylopectin, the characteristics of each fraction in terms of molecular weight/distribution, degree/length of branching and conformation. While solubility ranged from 14.53-15.76% for local rice, 14.21-16.06% for caprice and 15.45-17.38 for American rice. Solubility increased with cooking and was more with the pre-boiled samples. Pre-boiled American rice had the highest value for solubility, while the unprocessed caprice samples had the least. Solubility is attributed to the presence of low molecular weight carbohydrate present in rice and maize. The increase in solubility would result from the shortening of the chain length of the starch molecules with a corresponding weakening of the hydrogen bonds holding the granules together (Sapade and Gryns 1991).

**Colour:** Indices for local rice, caprice and American rice ranged from 76.82-82.75%, 81.55-83.44% and 81.14-84.67% respectively. The colour of rice improved with cooking in all cases with the pre-boiled samples having high colour values. This could be attributed to the washing done after pre-

boiling. Moorthy (1985) reported that the colour of starch will determine its clarity when cooked and that clarity depends on the associative bonds between the starch molecules in the granules. He further stated that tuber

starches have better clarity than cereal starches due to weaker associative forces. This could also be responsible for the lower values obtained for colour in the present study.

Functional properties showed a significant ( $P < 0.05$ ) difference in all parameters evaluated between the samples and treatments (see table 2).

**TABLE 2: FUNCTIONAL PROPERTIES (%) OF RAW, STRAIGHT COOKED AND PRE-BOILED RICE**

Sample Code	WAC	Swelling Power	Solubility	Colour	Dispersibility
LR	166.20 <sup>f</sup>	10.17 <sup>c</sup>	14.53 <sup>h</sup>	76.82 <sup>h</sup>	66.0 <sup>d</sup>
LSC	256.93 <sup>b</sup>	9.26 <sup>g</sup>	15.16 <sup>g</sup>	81.64 <sup>g</sup>	56.0 <sup>e</sup>
LPB	178.68 <sup>b</sup>	10.26 <sup>b</sup>	15.76 <sup>e</sup>	83.75 <sup>e</sup>	60.0 <sup>e</sup>
CR	140.09 <sup>g</sup>	9.68 <sup>d</sup>	14.21 <sup>i</sup>	81.55 <sup>i</sup>	70.0 <sup>a</sup>
CSC	236.69 <sup>c</sup>	9.57 <sup>e</sup>	15.81 <sup>d</sup>	82.58 <sup>d</sup>	58.0 <sup>e</sup>
CPB	236.77 <sup>c</sup>	8.52 <sup>h</sup>	16.06 <sup>c</sup>	83.44 <sup>c</sup>	50.0 <sup>g</sup>
AR	199.39 <sup>d</sup>	9.57 <sup>e</sup>	15.45 <sup>f</sup>	81.14 <sup>f</sup>	60.0 <sup>c</sup>
ASC	306.40 <sup>a</sup>	10.42 <sup>a</sup>	10.88 <sup>b</sup>	83.96 <sup>b</sup>	56.0 <sup>e</sup>
APB	306.43 <sup>a</sup>	9.28 <sup>f</sup>	17.38 <sup>b</sup>	84.67 <sup>a</sup>	52.0 <sup>f</sup>

Means on the same column bearing the same superscript are not significantly different ( $P > 0.05$ ).

**Key:** LR = Local rice raw CR = Caprice Raw  
LSC = Local rice straight cooked CSC = Caprice straight cooked  
LPB = Local rice pre-boiled CPB = Caprice pre-boiled

AR = American raw rice  
ASC = American raw straight cooked  
APB = American raw pre-boiled

### PASTING PROPERTIES OF RICE SAMPLES

Pasting properties are the most commonly assessed set of quality characteristics probably because the methods are well established and have been proven to be a reliable predictor of rice quality.

Table 3 shows the pasting properties of rice samples. The peak viscosity of rice samples ranged from 12.70RVU - 21.74RVU for local rice, 10.87RVU-19.38RVU for caprice, and 10.03RVU-19.98RVU for American rice, with the local rice having the highest value. Peak viscosity is indicative of the strength of pastes, which are formed from gelatinization during processing in food applications. It also reflects the extent of granule swelling (Liang and King 2003).

Trough ranged from 10.89RVU-16.32RVU, 11.19RVU - 13.62RVU and 9.97RVU - 16.13RVU for local rice, caprice and American rice respectively. Trough values also decreased with cooking. Breakdown viscosity, final and set back viscosities for the three rice

samples decreased with cooking. Breakdown ranged from 1.8RVU-6.48RVU for local rice, 1.47RVU-5.41RVU for caprice and 2.87RVU-3.48RVU for American rice. Breakdown viscosities reflects the stability of the paste during cooking. Final viscosity ranged from 18.6RVU-41.25RVU, 19.35RVU-36.05RVU, and 19.2RVU-21.95RVU for local rice, caprice and American rice respectively. Final viscosity indicates at 50°C the stability of the cooked paste. In agreement with the above statement, Niba *et al.*, (2001) stated that final viscosities are important in determining ability of the sample material to form a gel during processing.

Set back viscosity ranged from 14.40-25.15RVU for local rice, 12.10RVU-22.64RVU for caprice and 12.89RVU-13.05RVU for American rice. Local Abakaliki rice had the highest set back viscosity while American rice had the least. Set back viscosity indicates gel stability and potential for retrogradation (Niba, *et al.*; 2001; Liang and King 2003). The lower the set back viscosities the higher the

potential for retrogradation in food products.

Generally, pasting time ranged from 6.83min-7.07min while pasting temperature ranged from 50.20 - 91.93°C, with the raw American rice having the highest values and the straight cooked American rice the least in both cases. The pasting temperature (PT) is the temperature at which the viscosity starts to rise (Swinkels, 1985, Liang and King; 2003). Usually, pasting temperature is higher than the gelatinization temperature, meaning that the starch granules are gelatinized before the viscosity begins to rise and be detected by RVA.

Lower pasting temperature as shown in the present study indicates faster swelling.

There were significant differences ( $P < 0.05$ ) in all the pasting properties of the rice samples (table 3). This may be as a result of the predominant genotype differences in pasting profiles.

Cooking and pre-boiling of these rice varieties significantly resulted in nutrients depletion, especially in its chemical properties. These losses in nutrients may be due to leaching and the effect of heat: However, varietal differences, environmental factors, storage and processing methods may contribute to variations in the chemical, functional and pasting properties of the rice varieties.

**TABLE 3: PASTING PROPERTIES (RVU) OF RAW, STRAIGHT COOKED AND PRE-BOILED RICE**

Samples	Peak Viscosity (RVU)	Trough	Break down Viscosity	Final Viscosity	Setback Viscosity	Pasting Time (Min)	Pasting Temp O <sub>c</sub>
LR	21.74 <sup>a</sup>	16.32 <sup>a</sup>	6.48 <sup>a</sup>	41.25 <sup>a</sup>	25.15 <sup>a</sup>	7.0 <sup>c</sup>	51.55 <sup>b</sup>
LS <sub>C</sub>	19.73 <sup>b</sup>	10.89 <sup>e</sup>	5.42 <sup>b</sup>	18.6 <sup>h</sup>	17.75 <sup>d</sup>	7.01 <sup>c</sup>	51.33 <sup>c</sup>
LP <sub>s</sub>	12.79 <sup>d</sup>	13.39 <sup>b</sup>	1.8 <sup>e</sup>	27.65 <sup>c</sup>	14.4 <sup>e</sup>	6.95 <sup>c</sup>	50.35 <sup>d</sup>
C <sub>R</sub>	19.38 <sup>b</sup>	13.62 <sup>b</sup>	5.41 <sup>b</sup>	36.05 <sup>b</sup>	22.64 <sup>b</sup>	7.03 <sup>b</sup>	50.13 <sup>e</sup>
C <sub>SC</sub>	13.57 <sup>c</sup>	11.19 <sup>d</sup>	2.09 <sup>d</sup>	19.36 <sup>a</sup>	18.45 <sup>c</sup>	7.03 <sup>b</sup>	50.23 <sup>e</sup>
C <sub>Pb</sub>	10.87 <sup>f</sup>	12.16 <sup>c</sup>	1.47 <sup>e</sup>	22.95 <sup>d</sup>	12.1 <sup>h</sup>	7.0 <sup>c</sup>	50.23 <sup>e</sup>
A <sub>R</sub>	19.98 <sup>b</sup>	10.13 <sup>f</sup>	3.48 <sup>c</sup>	21.95 <sup>e</sup>	13.05 <sup>g</sup>	7.07 <sup>a</sup>	51.93 <sup>a</sup>
AS <sub>C</sub>	11.03 <sup>e</sup>	9.97 <sup>f</sup>	3.39 <sup>c</sup>	20.2 <sup>f</sup>	12.8 <sup>g</sup>	6.83 <sup>c</sup>	50.20 <sup>e</sup>
AP <sub>b</sub>	10.03 <sup>f</sup>	10.0 <sup>f</sup>	2.87 <sup>d</sup>	19.2 <sup>g</sup>	12.95 <sup>a</sup>	7.05 <sup>a</sup>	50.38 <sup>d</sup>

Means on the same column bearing the same superscript are not significantly different ( $P > 0.05$ ).

**Key:** LR = Local rice raw CR = Caprice raw  
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## CONCLUSION

The study showed that different varieties of rice behaved differently under heating. Pre-boiling and washing showed a significant difference in chemical, functional and pasting properties of rice. There was a specific influence pattern observed regarding the pre-boiling effect on the properties evaluated. Generally there was a reduction in evaluated parameters signifying a loss in nutrients and quality which is not advisable and should be avoided. It is also important to note that the local Abakalika rice competed favourable with the popular caprice and the American rice despite the fact that these

foreign once may have been fortified with additional nutrients during processing. The results of this study has also provided additional information about the functional and pasting properties of raw and cooked rice of different varieties.

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