# Comparative Analysis of the Physicochemical Qualities of Milled Rice Processed with Traditional and Improved Parboiling Methods in Nigeria

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***Abstract*— A comparative study of the effects of traditional and improved parboiling methods on the physical and chemical properties of three commonly grown rice varieties in Nigeria was carried out. Samples of the rice varieties FARO 44, FARO 52 and FARO 60 were parboiled using the traditional and improved methods. The dry parboiled samples were milled in the laboratory and the physical and chemical qualities of the milled rice were determined. The traditional method of rice parboiling produced milled rice with lower head rice yield and higher percentage of broken rice. Traditional method of parboiling produced milled rice with higher grain hardness; 67.3N for FARO 44, 69.4N for FARO 52 and 63.8N for FARO 60. The grain colour improved with the use of the improved method of parboiling. The parboiling method did not significantly alter the classification of the amylose content of the rice grain. The amylose content for the three varieties was generally high at between 25% and 29% when processed by traditional method and between 27% and 34% when processed by improved method. The pasting temperature, however increased when FARO 44 and FARO 52 rice varieties were parboiled by improved method while a decrease was observed in FARO 60 rice variety when parboiled with improved method. A maximum increase of about 2.4% in the crude protein content was observed when the rice varieties were parboiled with improved method. The use of traditional method of rice parboiling should therefore be discouraged for the processing of rice especially, the three varieties used in this study in Nigeria.**

***Keywords*— Parboiling methods, milled rice, physicochemical properties, head rice yield, proximate composition.***

## I. INTRODUCTION

Nigeria is presently the largest producer of rice in Africa producing about 4.5 million tonnes out of the Africa average of about 14 million tonnes. Nigeria is presently producing more than half of its national demand presently estimated at about 6 million tonnes annually [1]. Rice is a very important commodity in Nigeria and its demand has increased in Nigeria in recent years, both as food security and cash commodity crop [2] [3].

Locally processed rice is generally significantly inconsistent in all physical characteristics. It has an undesirable colour and contains quite a number of foreign materials [4]. The overall quality is low, with a high percentage of broken grains owing to inappropriate parboiling process and parboiling equipment [5] [6]. Because rice is consumed cooked and as whole grains, it is therefore very important that quality consideration is considered for rice [7]. The quality of the rice grain describes both the genetic and acquired characteristic of the rice kernel and relates to the physical, chemical and also the cooking properties of the grain [8].

Rice grain quality especially the cooking characteristics and hence the eating quality is determined by its physical and chemical properties [9]. The physical appearance largely determines the market value of milled rice [10]. The physical qualities of rice include head rice which describes the rice kernels that are at least two third of the whole kernel [8] [11]. Head rice yield is a very important consideration in the paddy processing [10]. The colour of the rice grain is also very important and is usually measured as the degree of whiteness of the drain. Grain colour depends on the variety, other physical characteristics and the degree of parboiling and milling. The whiteness and translucence of rice is important as a commercial quality [12]. Grain hardness is a measure of the strength of the grain when compressed against a hard surface along its length. Hardness is an important physical property as it affects the head rice yield during milling and reduces mould development by the grains [13].

The amylose content is related to the cooking and eating qualities [14] [15]. On cooking, high amylose content rice is firm and dry, intermediate amylose content variety cooks softer and appears sticky while rice with low amylose content is sticky and very soft. Japonica rice has low amylose, while indica rice can either be low, intermediate of high amylose variety. During cooking, amylose leaches from the expanded starch granules of the grains. The leached amylose crystalises as the rice cools in a process referred to as retrogradation and the rice grains become harder [15]. The Gelatinization temperature (GT) which is the temperature at which irreversible swelling of starch granules take place when heated in excess water is an important chemical characteristic of rice grain and it affects the cooking time of milled rice [9] [16]. Rice with low and intermediate GT is generally preferred as it cooks to a softer texture and retrogrades less than rice with a high GT [17]. The Alkali Spreading Value (ASV) is used to estimate the GT of starch. The alkali spreading method uses a seven-point (1-7) scale to rate the degree at which whole rice grain is dispersed in dilute alkali solution [18]. The higher the score, the lower the GT. Grain with a score of 1-2.5 is classified as high and estimated to have GT of >74 ºC. Score of 2.6-3.4 indicates intermediate - high GT; 3.5-5.4 is classified as intermediate with an estimated GT of between 69 and 74 ºC) while ASV of 5.5 - 7.0 is classified as low with gelatinization temperature of 55 – 69 ºC [18] [19] [20]. The proximate composition of the grain describes the amounts of fat, protein, ash and greater amount of carbohydrates in the rice grain [21]. The level of ash content is significant to estimating the presence of essential minerals [15]. Protein content is important because it has a direct influence on the cooking time and cooked rice texture and direct impact on the nutritional value. Higher protein content causes longer cooking time and firmer texture. High protein content is negatively correlated with reduced overall palatability, smoothness, taste and stickiness in some short grain varieties [22].

Rice parboiling is a major post-harvest handling processes of rice. It involves soaking the rough rice in hot or cold water over a period of time and steaming the soaked paddy to achieve gelatinization of the starch [21] [23] [24] [25]. Parboiling causes the starch and protein in the endosperm to gelatinize and disintegrate respectively. The starch expands and fills the internal air spaces in the grains [23] [25]. Paddy parboiling results to more translucent grain kernels, higher milling yield, and increased swelling when cooked [25].

The qualities of parboiled milled rice depend mainly on the quality of the rough rice (paddy) and the parboiling method [25]. Good and effective parboiling process produces milled rice with desirable qualities. The objective of this study was therefore to determine the physical and chemical qualities of milled rice parboiled by traditional and improved methods.

## II. MATERIALS AND METHODS

Three rice varieties, FARO 44, and FARO 52 and FARO 60 which are commonly grown varieties in Nigeria were used for this study. Rough rice samples were obtained from the rice Breeding Division of National Cereals Research Institute (NCRI), Badeggi, Nigeria. The rice samples were dried, cleaned and stored in jute bags at room temperature.

### *A. Parboiling by traditional method*

Rough rice samples of the selected improved varieties (FARO 44, FARO 52 and FARO 60) were provided to a local rice processor and member of the Akpajeshi Rice Processing Cooperative Society in Passo Village, along Gwagwalada – Dobi Road, North Central Nigeria. The samples were processed traditionally using the methods practiced in the area. The parboiling process employed by the local processor was monitored.

The paddy was soaked in an open cooking pot at an initial soaking temperature of about 75 $^{0}$C. for 20 hours and steamed between 33 minutes and 42 minutes. Parboiled paddy was sun dried on clean tarpaulin sheets. Samples of the dry parboiled paddy were collected from the local rice processor, and husking, milling and grading were done in the laboratory with Test Husker THU35B, (SATAKE Corporation, Japan), Test Mill TM05C, (SATAKE Corporation, Japan) and Test Grader TRG05B (SATAKE Corporation Japan)..

Soaking Steaming Drying

Plate I: Traditional method of paddy parboiling

The milled rice obtained from samples of the three rice varieties parboiled with traditional method were subjected to quality evaluation in the laboratory using standard procedures

### *B. Parboiling by improved method*

Rough rice samples were soaked in plastic containers for 12 hours at 75$^{0}$C. Plastic containers were used to reduce heat loss across the wall of the containers according to [23] (Plate II). Steaming of the paddy was achieved using a laboratory mini rice parboiler [26]. The steamed paddy was dried uniformly at room temperature to a moisture content of 13%. Husking and milling of the dry parboiled paddy were done in the laboratory using Test Husker THU35B, (SATAKE Corporation, Japan) and Test Mill TM05C, (SATAKE Corporation, Japan). The milled rice obtained were subjected to quality evaluation in the laboratory using standard procedures.

Plate II: Soaking of rice samples in plastic containers

### *C. Laboratory analysis of samples*

*1)Head rice yield*

Head rice yield was determined by separating grains longer than three quarters of the whole kernel with Test Rice Grader TRG 05B (Satake Corporation, Hiroshima, Japan) and weighed. The head rice yield (HRY) was calculated as follows:

$$HRY = \frac{Weight\ of\ whole\ grain\ rice}{Weight\ of\ dry\ parboiled\ paddy} X\ 100 \qquad (1)$$

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*2) Percentage broken rice*

The broken rice was collected from the Test Rice Grader and the percentage broken rice (PBR) was also determined as follows:

$$PBR = \frac{weight\ of\ broken\ rice}{Wweight\ of\ dry\ parboiled\ paddy} x\ 100 \qquad (2)$$

*3) Grain Hardness*

Grain hardness was measured using a Hardness Tester (Fujiwara Seisakusho Ltd. Japan) according to [27] as the force measured in Newton (N) at the bio-yield point during compression of the grain.

$$PBR = \frac{weight\ of\ broken\ rice}{Wweight\ of\ dry\ parboiled\ paddy} x\ 100 \qquad (3)$$

*4) Grain Colour*

Grain colour measured by whiteness value in relation with whiteness of standard white plate having a whiteness value of 85.5 was determined using a Rice Whiteness Tester C-600 (Kett Electric Laboratory, Japan. The mean of three different tests of a sample was recorded.

*5) Gelatinisation temperature (GT)*

This was estimated by determining the Alkali Spreading Value (ASV) of the flour of the milled rice samples. The ASV was scored on a grade of 1-7. The ASV score is inversely proportional to the GT. Grain with a score of 1-2.5 is classified as high and estimated to have GT of >74 ºC. Score of 2.6-3.4 indicate intermediate - high GT; 3.5-5.4 is classified as intermediate with an estimated GT of between 69 and 74 ºC) while ASV of 5.5 - 7.0 is classified as low with gelatinization temperature of 55 - 69 ºC.

*6)Amylose content*

Amylose content was determined according to the method of [14]. Rice flour (0.1g), 1N sodium hydroxide (9 ml) and ethanol (1 ml) were mixed in a 100 ml volumetric flask. The starch in the sample was gelatinized by heating the samples for 10 minutes in boiling water bath and then cooled to room temperature. Iodine solution (2 ml) and 1N acetic acid (1.0 ml) were added to about 5 ml of the gelatinised sample in a separate 100 ml volumetric flask. Distilled water was then added to the 100 ml mark and the absorbance (A) read with a UV- spectrophotometer.

*7) Proximate Composition* The proximate analysis was done using the methods described in [28]. The percentage content of protein, fat, moisture, ash and fibre in the rice grain were determined and carbohydrate content was calculated by difference as:

*Carbohydrate content (%)* =
100 – (%Protein + %Moisture + %Fat + %Ash + %Fibre) (3)

## III RESULTS AND DISCUSSION

The physical properties (Head rice yield, Broken rice ratio, Grain hardness and Colour) of milled rice of FARO 44, FARO 52 and FARO 60 rice varieties parboiled by traditional and improved methods are presented in Table 1. The traditional method of rice parboiling produced milled rice with low head rice yield and high broken rice yield. This may be as a result of prolonged steaming of the paddy as the paddy tends to absorb more water and if not well dried may lead to breakage [29]. Also, long period of soaking as practiced in traditional paddy parboiling leads to over hydration of the rice kernels. The percentage broken rice produced by the improved method was significantly lower due to the efficiency of the parboiling equipment. Heat and steam were evenly distributed in the improved parboiling equipment and there was complete and uniform starch gelatinisation in the rice kernels. This is not the case in the traditional parboiling pot. Parboiling has been reported to impart grain hardening and hardness is an important and most important quality characteristic of milled rice [11]. It results in less infested grain and increases head rice yield [11] [30] [31]. For the three rice varieties, traditional method of parboiling produced milled rice with higher grain hardness; 67.3N for FARO 44, 69.4N for FARO 52 and 63.8N for FARO 60. This was expected as the soaking and steaming duration was higher in the traditional method than the improved method. The severity of parboiling (steaming) has been reported to increase the hardness of the rice grain [11].

Table 1. Physical properties of milled rice parboiled by traditional and improved methods

| | **Traditional method** | | | | **Improved method** | | | |
|---|---|---|---|---|---|---|---|---|
| **Variety** | **HRY (%)** | **Broken rice (%)** | **Hardness (N)** | **Colour** | **HRY (%)** | **Broken rice (%)** | **Hardness (N)** | **Colour** |
| **FARO 44** | 62.3 | 10.00 | 67.30 | 23.20 | 69.10 | 1.10 | 67.00 | 26.50 |
| **FARO 52** | 67.1 | 8.40 | 69.40 | 25.50 | 68.80 | 2.20 | 63.10 | 26.30 |
| **FARO 60** | 65.8 | 8.80 | 63.80 | 24.30 | 70.98 | 0.40 | 61.00 | 25.70 |

HRY- Head rice yield

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This result is also in agreement with [32] that reported increase in the grain hardness with increase in soaking duration. The grain colour improved with the use of the improved method of parboiling. Lighter grains of lightness values of 26.5, 26.3 and 25.7 were obtained in improved method for FARO 44, FARO 52 and FARO 60 respectively. For the traditional method the corresponding values are 23.2, 25.5 and 24.3 respectively. The severity of steaming is a major factor for this difference.

The chemical properties of milled rice of FARO 44, FARO 52 and FARO 60 rice varieties parboiled by traditional and improved methods are shown in Tables 2, 3 and 4. The amylose, lipid and protein content are major determinants of the eating and cooking quality of the rice grain [15] [18]. The amylose content for the three varieties was generally high at between 25% and 29% when processed by traditional method and between 27% and 34% when processed by improved method. The parboiling method did not significantly alter the classification of the amylose content of the rice grain. This may be due to the fact that the amylose content of rice is an intrinsic property of rice and is dependent on the variety and the environment [20]. The pasting temperature, however increased when the FARO 44 and FARO 52 rice varieties were parboiled by improved method while a decrease was observed in FARO 60 rice variety when parboiled with improved method. This may be due to the change in the composition and structure of the rice starch as a result of the thermal effect of parboiling. The pasting temperature is that temperature at which the viscosity of the rice starch begins to rise when exposed to heat in excess water [33]. According to [33], pasting properties of rice which also describe the rheological properties is genotypic and can be ascribed to the varietal composition. However, the increase in the pasting temperature observed in this study when parboiled with improved method may be due to incomplete gelatinization of the starch molecules. More heat is therefore needed to achieve complete gelatinization before the onset of pasting and increase in viscosity of the disintegrated starch granules.

The proximate composition of the rice samples parboiled by traditional and improved method as presented in Tables 3 and 4 respectively showed an increase in the protein and carbohydrate contents of the rice grains when parboiling was done with improved method. The crude protein content increased from a maximum of 9.35% when parboiled with traditional method to a maximum of 11.73% when parboiled with improved method. The increase in the protein content when parboiled with improved method was due to the reduction in the soaking and steaming durations compared with the traditional method. Prolonged soaking leads to leaching of the grain constituents including protein molecules [29].

Table 2. Chemical properties of milled rice parboiled by traditional and improved methods

| | Traditional method | | | | Improved method | | | |
|---|---|---|---|---|---|---|---|---|
| **Variety** | **Pasting Temp (°C)** | **Amylose content (%)** | **ASV** | **GT Classification** | **Pasting Temp (°C)** | **Amylose content (%)** | **ASV** | **GT Classification** |
| **FARO 44** | 88.78 | 21.69 | 5 | Intermediate | 94.78 | 32.18 | 4 | Intermediate |
| **FARO 52** | 87.65 | 25.89 | 2 | High | 94.83 | 33.59 | 6 | Low |
| **FARO 60** | 94.08 | 28.95 | 2 | High | 90.53 | 27.22 | 3 | Intermediate |

ASV – Alkaline spreading value GT – Gelatinisation temperature

Table 3. Proximate properties of milled rice parboiled by traditional method

| Variety | Moisture Content (%) | Ash (%) | Crude protein (N) | Crude Fibre (%) | Oil Extract (%) | Carbohydrate (%) |
|---|---|---|---|---|---|---|
| **FARO 44** | 12.200 | 0.950 | 9.350 | 0.520 | 0.930 | 76.050 |
| **FARO 52** | 11.930 | 0.950 | 8.966 | 0.520 | 0.930 | 76.704 |
| **FARO 60** | 11.800 | 0.900 | 7.863 | 0.520 | 0.932 | 77.985 |

Table 4. Proximate properties of parboiled milled rice parboiled with improved method

| Variety | Moisture Content (%) | Ash (%) | Crude protein (N) | Crude Fibre (%) | Oil Extract (%) | Carbohydrate (%) |
|---|---|---|---|---|---|---|
| **FARO 44** | 11.900 | 0.500 | 9.800 | 0.640 | 1.055 | 76.109 |
| **FARO 52** | 12.400 | 0.950 | 10.850 | 0.530 | 0.839 | 74.431 |
| **FARO 60** | 11.800 | 0.500 | 11.725 | 0.530 | 1.066 | 74.379 |

## IV. CONCLUSION

The traditional method of rice parboiling produced milled rice with low head rice yield and high broken rice yield. The percentage broken rice produced by the improved method was significantly lower due to the efficiency of the parboiling equipment. Heat and steam was evenly distributed in the improved parboiling equipment and there was complete and uniform starch gelatinisation in the rice kernels. Traditional method of parboiling produced milled rice with higher grain hardness; this was expected as the soaking and steaming duration was higher in the traditional method than the improved method. The grain colour improved with the use of the improved method of parboiling. The parboiling method did not significantly alter the classification of the amylose content of the rice grain. The pasting temperature, however increased when the FARO 44 and FARO 52 rice varieties were parboiled by improved method while a decrease was observed in FARO 60 rice variety when parboiled with improved method. The use of traditional method of rice parboiling should therefore be discouraged for processing of rice especially, the three varieties used in this study in Nigeria, this will improve both the quality and quantity of parboiled milled rice in Nigeria.

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