# Cooking Qualilites and Nutritional Contents of Parboiled Milled Rice

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**ABSTRACT---** ***The project was implemented to determine the cooking qualities and sensory attributes of parboiled rice. Seven (7) local rice varieties, namely: NSIC 216, NSIC-238, RC-122, Selection 64, Rc 158, Rc 218 and Rc 18 were collected from four (4) provinces of Agusan del Sur, North Cotabato, Palawan and Orriental Mindoro. The rough rice was parboiled using soaking temperature, soaking time and steaming time of 60$^{o}$C, 3 hours and 15 minutes at a pressure of 15 psi, respectively. Likewise, five (5) water ratios 1:2, 1:2.25, 1:2.5, 1:2.75 and 1:3 and three (3) cooking methods ie.,ordinary boiling, soaking before boiling and pre-boiling, were followed in the cooking experiment. The physico-chemical properties, proximate composition, vitamins and mineral content of parboiled rice was compared to milled rice.***

***Results showed that cooking of parboiled milled rice required 1:2.50 – 1:3.00 water ratio using ordinary boiling method with an average cooking time of 27.86 minutes. The physico-chemical properties such as water absorption, volume expansion, and grain elongation ratio of parboiled rice were higher than non-parboiled milled rice. In terms of proximate composition energy and nutrient content, parboiled rice obtained an ash content of 1.002% ± 0.02, crude fiber (0.453% ± 0.01), crude fat (1.57% ± 0.19), crude protein (6.17% ± 0.20), calcium (5.385% ± 0.27), calories (360.55 kcal ± 0.55), thiamine (0.20% ± 0.01) and niacin (1.19% ± 0.13) were higher than the mean values of milled rice.***

**Keywords**--- parboiled milled rice, cooking qualities, chemical properties, nutritional contents

## 1. INTRODUCTION

Parboiling is the pregelatinization of rice within its husk. Parboiled rice is the product of parboiling wherein paddy is steeped, steamed and dried before milling. According to Kaur (1991), parboiling treatment increased elongation ratio and reduced the losses of solids and gruel upon cooking. Likewise, Roseline et.al. (2009) reported that parboiling results in significant changes in the physico-chemical and cooking characteristics of rice grain. Parboiling fills the void spaces and cements the cracks inside the endosperm, making the grain harder and minimizing internal fissuring and thereby breakage during milling (Correa et.al., 2006). Besides milling yield, it was also the realization of the health benefits of parboiled rice compared to brown rice. Sareepuang (2008) concluded that parboiled rice as considered as a functional food.

Parboiled rice is a kind of processed rice, which is produced in some countries of Asia, principally India as well as in Africa, Europe and America (Itoh, et.al., 1985). Filipinos are very much accustomed on overmilled or white rice making the nationwide campaign for the consumption of undermilled rice unsuccessful. They are very much adapted to it even knowing that most of the vitamins and minerals are lost in the form of bran. In some Western and Asian countries, grains are usually treated with chemicals to retain the nutrient contents, and the most significant discovery on food technology is parboiling-gelatinization of starch into the grain.

The NFA was a recipient of a commercial parboiling plant granted by the Food and Agriculture Organization (FAO) of the United Nations in 1981. However, three decades after, reports show that the parboiling plants were unutilized for quite a long time. Dr. Del Rosario (1987) recommended that further work on the parboiling process be done to minimize the objections to the use of product.

Today, the Philippine government is establishing parboiling plants on selected regions with PHilMech as collaborator with the primary responsibility of optimizing the soaking and steaming conditions for parboiling of local rice

varieties under the Phase I and evaluation of the cooking qualities and sensory evaluation of the parboiled rice under the Phase II of the project. The optimized conditions will be used to verify reports that parboiled rice results in significant changes in the cooking characteristics of rice grain (Roseline et.al., 2009). And as confirmed by Heinemman et.al., (2006), there are very few reports in the literature about the acceptability and consumer attitude towards parboiled rice.

The general objective of the study was to evaluate the cooking qualities and nutritional contents of parboiled milled rice.

## 2. MATERIALS AND METHODS

Selection and Preparation of Samples

Fifty (50) kg each of the seven (7) newly harvested rice varieties commonly grown in the four pilot provinces of Palawan, Oriental Mindoro, Agusan Del Sur and North Cotabato were used in the experiments.

Parboiling of Samples

Rough rice was cleaned then soaked in warm water ($60^oC$) for three (3) hours. Water temperature was monitored using a fluke datalogger (SFER Scientific Portable Datalogger, SN 050405182). Samples were taken out from the soaking container after three (3) hours of soaking and drained. Immediately after soaking, the samples were steamed for 15 minutes at a pressure of 15 psi using an autoclave (All American Pressure Cooker, Model No.941, Philippines). The steamed paddy samples were dried at 60°C temperature using a laboratory type flatbed dryer. The parboiled paddy samples were dehusked using a rubber roll husker (Hiansha, Model JLGJ 2.5, China) and polished using a laboratory rice polisher (Model JGMJ8098, China). Parboiled and non-parboiled milled rice samples were stored in a chiller (Fujidenzo, SUD 220 AADF, Philippines) at 4°C while waiting for further analysis and evaluation (Tuates et. al., 2014).

Determination of water ratio and and cooking method of parboiled rice

The water ratio and cooking time of parboiled rice were determined following the procedures used by Revilla et.al. (1998). Five (5) water ratios 1:2, 1:2.25, 1:2.5, 1:2.75 and 1:3 and three cooking methods (ordinary boiling, soaking before boiling and pre-boiling) were used in the experiment.

Two hundred (200) grams of each of the parboiled milled rice was cooked using an electric rice cooker (Standard, Model SRG-1.8L, SN 13009318). After 10 minutes of boiling, 10 grain kernels were randomly selected from the rice cooker every minute with a ladle. The 10 grain kernels were pressed between two outer surfaces of petri dishes and checked if the opaque centers of the cooked grains has diminished. The end point of cooking was determined using parallel glass plate method (Chakkaravarthi et.al, 2007). The samples were considered cooked when 9 out of 10 grains has no longer opaque centers. The time of cooking was strictly recorded according to the rice-to-water ratio. The onset was start when the rice cooker switched on and end when switched to automatic warming.

Determination of physico-chemical properties of parboiled and non-parboiled milled rice

Measurements of water absorption, volume expansion, grain elongation ratio and water activity were conducted at Bioprocess Engineering Laboratory following the standard procedures. Likewise, amylose content and gel consistency were determined and analyzed by the Rice Chemistry and Food Science Division of the Philippine Rice Research Institute (PhilRice) following what stardard analyical procedure.

*Water absorption and volume expansion*

Fifty (50) grams each of the parboiled and non-parboiled milled rice samples were weighed and placed in a 250 mL capacity glass beaker. The height of the samples in a beaker without water was measured using a foot rule. The parboiled milled rice was cooked following the established cooking method and rice to water ratio. Likewise, non-parboiled milled rice samples was cooking using existing practice of water to rice ratio. After cooking, the cooked sample with the beaker was weighed and the height of the cooked sample was measured. Water absorption and volume expansion of the cooked samples were calculated using the following formula:

$$\text{Water absorption} = \frac{\text{Weight of cooked rice} - \text{weight of raw rice}}{\text{Weight of raw rice}} \text{ x } 100$$

$$\text{Volume Expansion} = \frac{\text{Height of cooked rice} - \text{Height of raw rice}}{\text{Height of raw rice}} \text{ x } 100$$

*Grain elongation ratio*

The cooked samples used in the water absorption and volume expansion tests were used to determine the grain elongation ratio of the rice samples. Fifteen grains were randomly selected from each replicate. The length of the cooked and un-cooked grains were measured using a digital vernier caliper (Thomas, et.al. 2013). Grain elongation ratio was calculated using the formula:

$$\text{Elongation Ratio} = \frac{\text{Length of cooked rice}}{\text{Length of raw rice}}$$

*Water activity*

The water activity of the cooked parboiled and non-parboiled milled rice was measured using a digital water activity meter (Rotronics, SN 60750224) set at Bio-Process Engineering Laboratory at PHilMech .

*Amylose content*

The Amylose content in rice samples were determined based on the iodine-binding procedure as described by Juliano (1971). One hundred (100) miligram of rice flour, one (1) mL of ethanol (95 %) and nine (9) mL of 1N NaOH were added in a 100 mL volumetric flask followed by thorough mixing. Five (5) milliliters of gelatinized starch solution was then transferred to a 100 mL volumetric flask followed by addition of one (1) mL of 1N acetic acid and two (2) mL of iodine solution, then volume of the solution was adjusted to 100 mL with distilled water. All the contents were thoroughly mixed using a vortex and allowed to stand for 20 minutes. The absorbance was measured at 620 nm using a UV-Spectrophotometer (Model FD-TP40, China). The amylose content in samples was determined based on the standard curve prepared using potato amylose.

*Gel Consistency*

Gel consistency of parboiled and non-parboiled milled rice was determined by gel length tests as described by Juliano (1982). One hundred (100) miligram of samples were grinded and mixed thoroughly with 0.2 ml thymol blue. Two mL of 0.2 NKOH was added to the samples and mixed for three seconds using vortex mixer. After mixing, the samples were placed in a boiling water for eight (8) minutes. After heating, the length of the gel from the bottom to the top was measured.

Determination of proximate composition, vitamin and minerals

The proximate composition, vitamin and mineral contents of parboiled and non- parboiled milled rice were determined and analyzed by the Regional Standards and Testing Laboratory (RSTL) of the Department of Science and Technology (DOST) Regional Office IV-A located at Los Banos, Laguna. All samples for analysis were prepared by PHilMech.

**Table 1.** Proximate composition, vitamins and mineral content and method of determination

| Parameter | Method of determination |
|---|---|
| Calories and carbohydrate | By computation |
| Crude fiber | Weendee method |
| Ash | Gravimetric, AOAC |
| Crude Protein | Semi-micro Kjeldahl |
| Calcium | Microwave Digestion AAS |
| Moisture content | Gravimetry |
| Crude fat | Acid hydrolysis |
| Thiamine and niacin | High Performance Liquid Chromatography |

Experimental Design

Data on percent cooked parboiled grains were arranged in Two Factors Factorial in Completely Randomized Design (CRD) while data on physical properties, proximate composition, vitamin and minerals were analyzed usinf simple CRD. Differences were statistically significant at $P \leq 0.05$ using the Duncan's Multiple Range Test (DMRT).

## 3. RESULTS AND DISCUSSION

Description of samples

Three (3) varieties from North Cotabato, two (2) from Oriental Mindoro, and one (1) each from Palawan and Agusan del Sur as shown in Table 2. Half of each batch of samples were parboiled while the other half was dried without parboiling treatment.

**Table 2.** Local rice varieties and sources

| Variety | Source | Code Used |
|---|---|---|
| NSIC 216 | Palawan | Pal216 |
| RC-122 | Agusan del Sur | ADS122 |
| NSIC-238 | North Cotabato | NC238 |
| Local Selection 64 | North Cotabato | NCS64 |
| RC-158 | North Cotabato | NC-158 |
| RC-218 | Oriental Mindoro | ORMIN218 |
| RC-18 | Oriental Mindoro | ORMIN18 |

Cooking and water ratio of parboiled milled rice

Tables 3 shows the proportion of cooked parboiled rice at different methods of cooking and rice to water ratio. The proportion of cooked grain increased as the rice to water ratio increased regardless of the cooking methods employed. This behavior can be attributed to the available heat from water during cooking, which is a direct function of mass during vaporization process resulting to physicochemical changes of the product. This is in agreement with Billiris et.al. (2012) who reported that cooking duration increased linearly with water-to-rice ratio. Likewise, the average cooking time of parboiled milled rice was higher at 27.86 minutes compared to non-parboiled milled rice at only 14.57 minutes.

**Table 3.** Percent of cooked parboiled grains at different methods of cooking and rice:water

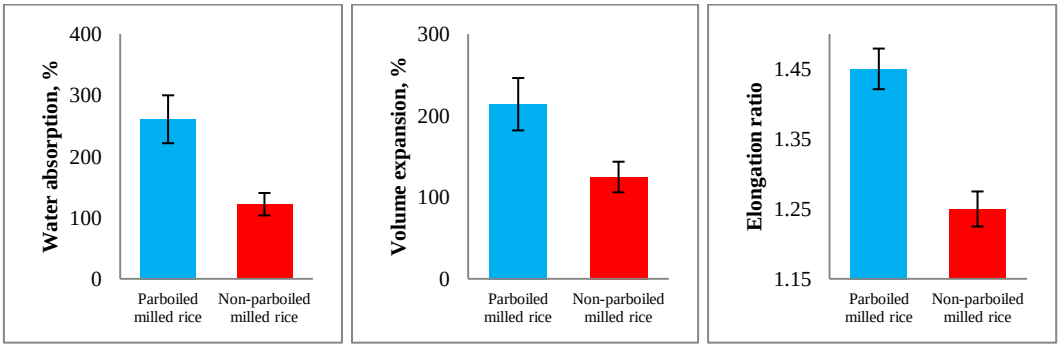
| **Method of cooking** | **Rice:Water ratio** | | | | | **AVE.** |
|---|---|---|---|---|---|---|
| | **1:2** | **1:2.25** | **1:2.5** | **1:2.75** | **1:3** | |
| | | | *V1-NSIC 216* | | | |
| Ordinary boiling | 36.67±5.77 | 56.67±5.77 | 80.00±0.00 | 93.33±5.77 | 96.67±5.77 | 72.67±4.62 |
| Soaking before boiling | 40.00±0.00 | 56.67±5.77 | 83.33±5.77 | 96.67±5.77 | 100.00±0.0 | 75.33±3.46 |
| Pre-boiling | 36.67±5.77 | 50.00±0.00 | 80.00±0.00 | 93.33±5.77 | 100.00±0.0 | 72.00±2.31 |
| **AVERAGE** | **37.77$^{d}$** | **54.44$^{c}$** | **80.00$^{b}$** | **94.44$^{a}$** | **98.88$^{A}$** | 73.33±3.46 |
| | | | *V2-RC 122* | | | |
| Ordinary boiling | 43.33±5.77 | 66.67±5.77 | 90.00±0.00 | 96.67±5.77 | 96.67±5.77 | 78.67±4.62 |
| Soaking before boiling | 46.67±5.77 | 70.00±5.77 | 90.00±0.00 | 96.67±5.77 | 100.00±0.0 | 80.67±3.46 |
| Pre-boiling | 43.33±5.77 | 53.33±5.77 | 80.00±0.00 | 93.33±5.77 | 100.00±0.0 | 74.22±3.46 |
| **AVERAGE** | **44.44$^{d}$** | **63.33$^{c}$** | **86.66$^{b}$** | **95.55$^{a}$** | **98.88$^{a}$** | 77.85±3.85 |
| | | | *V3-NSIC 238* | | | |
| Ordinary boiling | 26.67±5.77 | 43.33±5.77 | 56.67±5.77 | 80.00±0.00 | 93.33±5.77 | 60.00±4.62 |
| Soaking before boiling | 23.33±5.77 | 33.33±5.77 | 46.67±5.77 | 76.67±5.77 | 93.33±5.77 | 54.67±5.77 |
| Pre-boiling | 23.33±5.77 | 40.00±0.00 | 63.33±5.77 | 80.00±0.00 | 93.33±5.77 | 59.99±3.46 |
| **AVERAGE** | **24.44$^{e}$** | **38.33$^{d}$** | **55.55$^{c}$** | **78.88$^{b}$** | **93.33$^{a}$** | 58.22±4.62 |
| | | | *V4-Local Selection 64* | | | |
| Ordinary boiling | 23.33±5.77 | 46.67±5.77 | 60.00±0.00 | 83.33±5.77 | 93.33±5.77 | 61.33±4.62 |
| Soaking before boiling | 26.67±5.77 | 40.00±0.00 | 53.33±5.77 | 83.33±5.77 | 93.33±5.77 | 59.33±4.62 |
| Pre-boiling | 16.67±5.77 | 36.67±5.77 | 60.00±0.00 | 83.33±5.77 | 90.00±0.00 | 57.33±3.46 |
| **AVERAGE** | **22.22$^{e}$** | **41.11$^{d}$** | **57.77$^{c}$** | **83.33$^{b}$** | **92.22$^{a}$** | 59.33±4.23 |
| | | | *V5-RC 158* | | | |
| Ordinary boiling | 43.33±5.77 | 70.00±0.00 | 90.00±0.00 | 93.33±5.77 | 100.00±0.0 | 79.33±2.31 |
| Soaking before boiling | 53.33±5.77 | 80.00±0.00 | 93.33±5.77 | 96.67±5.77 | 100.00±0.0 | 84.66±3.46 |
| Pre-boiling | 46.67±5.77 | 66.67±5.77 | 83.33±5.77 | 90.00±0.00 | 100.00±0.0 | 77.33±3.46 |
| **AVERAGE** | **47.77$^{d}$** | **72.22$^{c}$** | **88.88$^{b}$** | **93.33$^{b}$** | **100.00$^{a}$** | 80.44±3.08 |
| | | | *V6-RC 218* | | | |
| Ordinary boiling | 46.67±5.77 | 73.33±5.77 | 90.00±0.00 | 96.67±5.77 | 100.00±0.0 | 81.33±4.62 |
| Soaking before boiling | 56.67±5.77 | 80.00±0.00 | 96.67±5.77 | 100.00±0.0 | 100.00±0.0 | 86.66±2.31 |
| Pre-boiling | 53.33±5.77 | 70.00±0.00 | 90.00±0.00 | 93.33±5.77 | 100.00±0.0 | 81.33±2.31 |
| **AVERAGE** | **52.22$^{d}$** | **74.44$^{c}$** | **92.22$^{c}$** | **96.66$^{ab}$** | **100.00$^{a}$** | 83.11±3.08 |
| | | | *V7-RC 18* | | | |
| Ordinary boiling | 43.33±5.77 | 76.67±5.77 | 90.00±5.77 | 93.33±5.77 | 100.00±0.0 | 80.67±4.62 |
| Soaking before boiling | 53.33±5.77 | 83.33±5.77 | 96.67±5.77 | 100.00±0.0 | 100.00±0.0 | 86.66±3.46 |
| Pre-boiling | 50.00±0.00 | 66.67±5.77 | 86.67±5.77 | 93.33±5.77 | 100.00±0.0 | 79.33±3.46 |
| **AVERAGE** | **48.88$^{d}$** | **75.55$^{c}$** | **91.11$^{b}$** | **95.55$^{ab}$** | **100.00$^{a}$** | 82.22±3.85 |

*Means not sharing letter in common differ significantly at 0.05 level of significance by DMRT*

Analyis of variance showed there is no significant differences on the method of cooking of parboiled milled rice. However, there are significant differences on the water ratio. The water ratio for NSIC 216 is 1:2.75, RC 122 (1:2.5), NSIC 238 (1:3), Local Selection 64 (1:3), RC 158 (1:2.5), RC 218(1:2.5) and RC 18(1:2.5).

Physical properties of parboiled and non-parboiled milled rice

Figures 1a, 1b and 1c show the water absorption, volume expansion and elongation ratio of parboiled rice and non-parboiled milled rice. The percent water absorption, volume expansion and elongation ratio of parboiled rice and milled rice were 261 % & 122%, 214% & 125%, and 1.45 & 1. 25, respectively. This can be associated to the parboiling process which in turn affects gelatinization and hardens kernel .

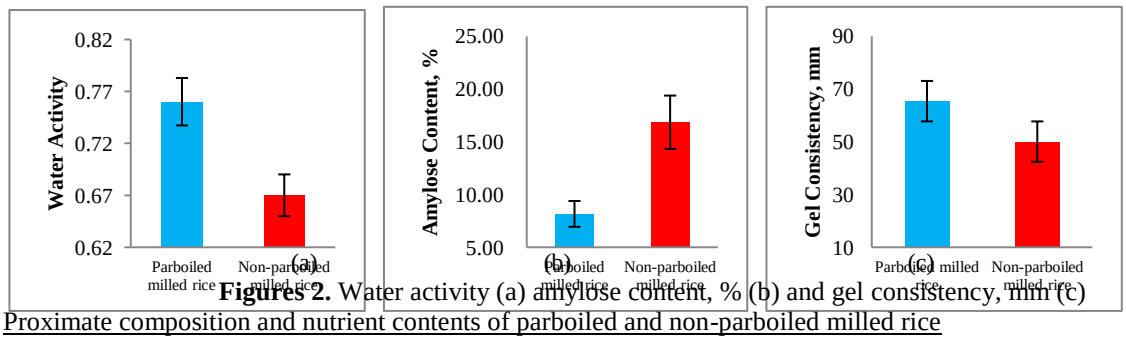



(a) (b) (c)

**Figures 1.** Water absorption (a) volume expansion (b) and elongation ratio (c) of parboiled and non-parboiled milled rice

Chemical properties of parboiled and non-parboiled milled rice

Figures 2a, 2b and 2c show the water activity, amylose content and gel consistency of parboiled and milled rice. The cooked parboiled rice obtained higher water activity than the cooked milled rice with a value of 0.76 and 0.65, respectively (Fig. 2a). Likewise, the pathogenic bacteria cannot grow below a water activity of 0.85-0.86. The amylose content of parboiled rice is 50 % lower than milled rice. The decrease in amylose content can be attributed to the starch solubilisation and leaching of the amylose molecules into the surrounding water during soaking and subsequent steaming during parboiling. Likewise, the gel consistency of parboiled was higher than non-parboiled milled rice by 11.32 mm.




(a) (b) (c)

**Figures 2.** Water activity (a) amylose content, % (b) and gel consistency, mm (c)

Proximate composition and nutrient contents of parboiled and non-parboiled milled rice

Table 4 shows that all proximate composition and nutrient contents of parboiled r were higher than non-parboiled milled rice. During polishing, the thiamine content of rice was removed. Likewise, niacin content of parboiled rice tripled more than milled rice. This can be attributed that, parboiling treatment of rice retained the available nutrient contents of bran layer.

**Table 4.** Average proximate composition and nutrient content

| Proximate and nutrient composition | Parboiled milled rice | Non-parboiled milled rice |
|---|---|---|
| Ash, g/100g | 1.002 [a] | 0.497 [b] |
| Crude fiber, g/100g | 0.453 [a] | 0.372 [b] |
| Crude fat, g/100g | 1.57 [a] | 0.99 [b] |
| Crude protein, g/100g | 6.177 [a] | 5.587 [b] |
| Calories, kcal | 360.65 [a] | 353.31 [b] |
| Total carbohydrate, g/100g | 80.46 [a] | 80.51 [a] |
| Calcium, mg/100g | 5.385 [a] | 3.891 [b] |
| Thiamine, mg/100g | 0.203 [a] | 0.000 [b] |
| Niacin, g/100g | 1.189 [a] | 0.410 [b] |

*Means not sharing letter in common differ significantly at 0.05 level of significance by DMRT*

## 4. CONCLUSIONS

Based from the results of the study, the following conclusions are drawn:

1. Parboiled milled rice required 250-300% of water relative to the amount of rice in order to be cooked. Likewise, parboiled milled rice required a minimum of 27 minutes to be cooked while 14 minutes for non-parboiled milled rice.
2. Parboiled rice absorbed more water resulting to higher volume expansion and grain elongation during cooking. However, it takes a longer cooking time due to slower water uptake.
3. Parboiled milled rice has higher physico-chemical and nutrient contents than milled rice.

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