Effect of Parboiling on the Quality of Processed Degan Rice (*Oryza Spp*)

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Abstract

A study conducted to determine the perception of stakeholders in the production of parboiled rice in the Tamale metropolis of Ghana. It also sought to assess the effect of parboiling on Degan processed rice with respect to quality parameters such as physic-chemical and functional properties as well as eating characteristics. During the study a survey and laboratory work were done. Economic analysis of parboiled rice was also done. The analysis of results of the data collected from farmers showed that all (100%) of the respondents were women in the parboiling industry with many years of experience in parboiling. The farmers indicated that parboiled rice has much more foreign matter. The study revealed that parboiling was effective in improving the physic-chemical properties of rice such as head rice yield, percent whole grain, percent adulterants and weight of 1000 grains. Parboiling had varied effect on functional properties. These are swelling power, Water Absorption Capacity (WAC), Oil Absorption Capacity (OAC) and Least Gelation Capacity (LGC).Economic analysis of parboiled rice showed that parboiling has the potential of improving the economic well-being of farmers if combined with new existing technology.

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It is recommended that improved technology be adopted in the parboiling industry to improve rice quality and subsequently improve financial status of farmers.

Keywords: Parboiling; Degan; Quality; Rice; Milling; Gelatinization.

1. Introduction

Rice (*Oryza sativa L.*) is the staple food for nearly two-thirds of the World's population [33]. It is reported that the World's stocks of stored rice grain have been falling relative to each year's use, because the consumption has surpassed the production [23]. China and India account for over half of the world's supply of rice and consumption, with China producing 182 million tons (28.8%) of global rice harvest, closely followed by India with 136.5 million tons (21.6%) of global harvest. The production of rice worldwide stands at 685 million tons as at 2008 [4].

Rice is one of the leading foods in the world and fourth most widely produced cereal in Ghana after maize; sorghum and millet, contributing about 10.8% of total cereal production [18]. According to [32] Ghana was below 25% self-sufficiency in rice production. This means that Ghana still require huge imports to supplement the difference in local demand [11].

Rice as an economic crop is important in household food security, nutritional diversification, income generation and employment; hence it helps in poverty alleviation. The crop has become an important income generating commodity for women in the three northern regions of Ghana as they are involved throughout the production chain from planting to processing.

Even though local rice is said to taste better, many urban dwellers prefer imported rice despite its high price. The situation has been attributed to the fact that imported rice is perceived to be of higher quality. Imported white rice dominates rice consumption in Ghana [11]. It is estimated that the country spends about US$100 million annually to import the rice needed to meet more than half of Ghana's rice requirement.

The introduction of "eat Ghana rice" has brought about the sensitization of farmers the need to adopt new ways of processing paddy locally to the level of quality of foreign rice. This will lead to the release of pure breed, stone-less, foreign material free and correctly milled grains of rice in the country. The adoption of these local ways of processing rice has increased the consumption of local rice to 239400 tons of milled rice a year in Ghana [18].

Modern parboiling is said to increase the quantity and quality of rice because it reduces the number of broken grains at milling, thereby obtaining higher milling yield. It also creates physical and chemical changes in the grain that makes it more nutritious and easier to sell and cook. The parboiled produce exhibit several advantages over non-parboiled product such as the strengthening of kernel integrity, increased milling recovery, prevention of the loss of nutrients during milling and improved shelf life as well as prevention of the proliferation of fungus and insects [2].

Parboiling of rice is a processing technique that involves three stages of; soaking paddy overnight, followed by a short period of steaming to complete gelatinization of the starch and drying. These processes require more energy and longer time [29] and has some serious draw backs such as foul odour due to microbial fermentation during the prolonged soaking and also loss of dry matter [3]

Demands for parboiled rice are increasing because of its nutritional value and the health claims associated with it. The protein content of rice is low but studies have shown that it is comparable to that of wheat, while its digestibility is high compared to other cereals [30]

1.   Materials and Methods

2.1 Experimental Procedure

The experiment was done in two phases: A survey and a laboratory work.

A survey on the demographic background of people involved in parboiling, milling recovery/cooking characteristics of parboiled rice as well as the economics of parboiling   was conducted at some selected communities in the Tamale Metropolis of the Northern Region of Ghana. The communities were Nyohini; Dungu; Malshagu; Lamashegu; Kumbuyili and Chogu. Fifty semi structured questionnaires aimed at collecting socio-economic data, information on milling out-turn as well as parboilers experience with parboiling; the parboiling process and the economics of parboiling were issued by well trained enumerators from the Northern School of Business in the Northern Region. Other important information collected included respondents' suggestion for the improvement of parboiling in the region.

2.2 Preparation of Paddy

Local Degan rice in paddy form was collected from local farmers in the Northern Region of Ghana. The paddy was winnowed to get rid of debris and cut weeds during harvest. It was then divided into two halves, one half was processed by Parboiling, drying and milling, the other half was processed by drying and milling only. The average initial moisture content of paddy was 13±2%. Before conducting the experiment, paddy rice packed in a 5 kg polyethylene bag were stored in a refrigerator at 10°C.

2.3 Parboiling Process

2.3.1 Soaking Condition

The paddy was washed thoroughly about three times using clean water in every instance to get rid of chaff, stones, sand and unfilled panicles. It was then put into bigger pots and saturated with water. Three buckets of water to half bag of paddy was used. Fire was set under it and allowed to boil till bubbles appeared. The bubbling meant the soaking process is complete. The fire was extinguished and the paddy scooped into an empty pot of the same size covered and allowed stand overnight.

2.3.2 Steaming Condition

The second step of the parboiling process is steaming to improve rice moisture to 30–35% [9; 2] and heat treatment also irreversibly gelatinizes the starch. The next morning after soaking a basket was used to drain the water off and the paddy was put into another pot with little water on fire and covered with jute sack for steaming to complete the gelatinization process. The steaming is complete when the paddy panicles split open during the process

2.3.4 Drying Condition

The steamed rice was then dried on tarpaulin in the sun (34±1ºC, 58±5 %RH) and turned over frequently depending on the intensity of the sun with a rake for six hours, resulting in the final moisture content of 13±2%. After drying, samples were collected into the room to cool for another three hours and later stored in airtight polyethylene bags for moisture equilibration and hardness stabilization before milling as prescribed by [9] This reduces breakages at milling

2.3.5 Milling

Milling was done with the Engleberg milling machine after which the rice was winnowed to separate the bran from the rice.

2.3.6 Flour Production

The milled rice was ground into flour using pistle and motar. The flour samples were passed through a 0.5 mm mesh size sieve and stored in airtight containers in a refrigerator at 4°C until needed for analysis.

2.4 Determination of Physicochemical Properties

2.4.1 Head Rice Yield

Approximately two weeks after drying, samples of non-parboiled and parboiled rice were milled using the Engleberg milling machine. The head rice yield was calculated as percentage of milled grains with respect to the paddy rice [1]

2.4.2 Moisture Content

The moisture content of rice was determined by the standard oven method. Three 2g samples were dried in hot air oven at 130ºC for 16 h [11] Moisture content was expressed on a wet basis by subtracting the dry weight from the initial wet weight and calculating the mean values

2.3.3 Percentage (Breakage and Whole Grains)

Percentage of breakages and whole grains was determined after milling by sorting out the breakages in 10 g of

sample by simple calculation in triplicates and calculating the mean values [8].

2.3.4 Percentage Adulterants

Percentage adulterants were determined by sorting out adulterants in 10 g of sample by simple calculation in triplicates and calculating the mean values [8].

2.3.5 Weight of 1000 grains

This was done by counting 1000 whole grains and calculating their weight in triplicates

2.3.6 Functional Properties

The following functional properties were studied; swelling power and solubility; water and oil absorption capacity; gelation capacity; bulk density.

2.3.7 Swelling Power and Solubility

One gram of the flour sample was mixed with 10 ml distilled water in a centrifuge tube and heated at 80 °C for 30 min. This was continually shaken during the heating period. After heating, the suspension was centrifuged at $1000 \times g$ for 15 min. The supernatant was decanted and the weight of paste taken. The supernatant was evaporated and the dried residue weighed to determine the solubility. The swelling power was calculated as: Swelling power = weight of the paste / weight of dry flour.

2.3.8 Water and Oil Absorption Capacity

The method proposed by [24] was used with modifications to determine both water and oil absorption for small quantities. Two gram of rice was mixed with either 20 ml distilled water or oil in a test tube covered with a piece of cotton plug. The test tube was then placed in a thermostatically controlled water bath preheated to 97-99° C for cooking the rice. This was then followed by cooling in water, draining of excess water, and the test tube placed upside down for 1 h and then weighed. Water absorption was calculated as increase in weight, and expressed as gram of water per gram of rice.

2.3.9 Bulk Density

A 50 g flour sample was put into a 100 ml measuring cylinder and filled to a constant volume. The bulk density (g/cm^3) was calculated as weight of flour (g) divided by flour volume (cm^3), [19].

2.3.10 Gelation Capacity

Sample suspensions 2 – 20 % (w/v) were prepared in 5 ml-distilled water. The tubes containing these suspensions were heated in boiling water for 1 hour followed by rapid cooling under cold running tap water. The tubes were then further cooled for 2 hour at 7 °C. The least gelation concentration (LGC) was determined as that

concentration when the sample from the inverted tube did not fall off.

2.4 Rice cooking and cooked rice Characteristics

2.4.1 Cooking time

Three lots of ten grams of rice sample was mixed with 70 ml distilled water in 100ml beaker and cooked at 97-99°C in cooker (Toshiba, Model RC-18R). After 10 min of cooking, ten grains were randomly removed and pressed between two glass plates. The number of translucent kernels were counted and recorded. Sampling was done at every 2 min interval and rice grains were analyzed until the end of the cooking cycle.

2.4.2 Sensory Evaluation

Rice samples were cooked and served to 22 discriminatory and semi-trained panellists. A scale of 1-7 was used, representing seven categories, where 1= dislike extremely and 7 like extremely. Sensory attributes of cooked parboiled rice that were subjected to evaluation were aroma, colour, texture, stickiness, taste and overall acceptability

2.4.3 Statistical Analysis

The Statistical Package for Social Sciences (SPSS) version 17 was used to analyze the responses on farmers' perception of postharvest losses. Analysis of variance (ANOVA) was performed on experiment data collected using GENSTAT Discovery Edition 3 and separation of treatment means was done using the LSD at 5% level of significance.

3. Results and Discussion

3.1 Sensory Analysis

Table 1: Sensory evaluation of cooked parboiled and non-parboiled rice (n=22)

Parameter	Parboiled	Non-parboiled
Aroma	$4.31\pm0.30_A$	$3.56\pm0.35_B$
Colour	$3.67\pm0.23_B$	$4.26\pm0.20_A$
Texture	$3.54\pm0.14_A$	$3.35\pm0.02_A$

Stickiness	$4.23\pm0.29_A$	$3.48\pm0.14_B$
Taste	$4.31\pm0.24_A$	$3.39\pm0.17_B$
Overall acceptability	$4.80\pm0.07_A$	$3.98\pm0.25_B$

Means of triplicates $\pm$ SD followed by different letters within a row is significantly different ($p < 0.05$).

The results of the sensory assessment showed that the aroma, stickiness and taste of cooked parboiled Degan rice were significantly better preferred to the unparboiled. Whereas parboiled rice scored 4.31, 4.23 and 4.31 respectively for aroma, stickiness and taste the unparboiled rice scored 3.56, 3.48 and 3.39. On the other hand the colour of the unparboiled was perceived to be more acceptable than the unparboiled. The colour of the parboiled was darker than the unparboiled. Panel preferred the lighter colours of unparboiled rice. The degree of colour change has been reported to be influenced by soaking temperature, heating duration, and heating and drying temperature [2]. Colour change during parboiling of rice has been attributed to non-enzymatic browning of the Maillard type.The texture of both parboiled and raw Degan rice was perceived to be similar (3.67-4.26).

3.2 Physico-chemical Properties

Table 2: Effect of parboiling on the physico-chemical properties of rice

Parameters	Parboiled	Non-parboiled
Head Rice Yield (%)	$74.40\pm0.46_A$	$52.84\pm0.19_B$
Moisture Content (%)	$10.83\pm1.04_A$	$9.33\pm0.29_A$
Whole Grains (%)	$74.47\pm4.70_A$	$27.77\pm0.92_B$
Adulterants (%)	$2.25\pm0.25_A$	$0.67\pm0.08_B$
Weight of 1000 Grains	$18.13\pm0.64_A$	$15.60\pm0.44_B$

Means of triplicates $\pm$ SD followed by different letters within a row is significantly different ($p < 0.05$)

Table 2 shows the results of data on the physico-chemical properties of both parboiled and raw rice samples. Whereas the moisture content of the raw rice was 9.33%, that of parboiled was 10.33%. Moisture content of the raw rice differed significantly ($p < 0.05$) from the parboiled. According to (5) parboiling gelatinises starch within the rice grains, causing swelling and fusion within the kernel and increasing moisture content. Moisture

content of rice is known to affect its milling characteristics

The moisture content of the parboiled rice probably contributed to the milling yield (74%) observed in this study. The 1000 grain weight of the parboiled rice (18.13g) was significantly higher (P<0.05) than the raw (15.60g). The observed increase could be attributable to absorbed moisture during parboiling (Table 1).

Rice is parboiled with the objective of hardening the kernel in order to maximize head rice yield in milling. Soaking and steaming processes during parboiling has great influence on milling recovery of parboiled rice. Parboiling significantly increased (p < 0.05) the head rice yields by 1.4 times from 52.84% to 74.40%. Parboiling is known to toughen grain and reduce the amount of breakage during milling [2] During parboiling gelatinization of starch makes grains stronger and tougher improving milling qualities (27). This therefore could account for the higher percentage result in the whole grains, which also increased significantly (p < 0.05) by 2.7 times from 27.77% in the raw to 74.47% in the parboiled.

It was observed that the parboiled rice had significantly higher levels of adulterants (2.25%) which were 3.3 times higher than the raw (0.67%). The higher levels of adulterants in the parboiled rice could be attributed to poor handling practices during drying. It was observed that the farmers dried their parboiled rice on poor concrete floors and therefore during the collection of the dried parboiled rice they picked up stones in the process. This observation explains why the respondents in the survey reported that parboiled rice has many stones.

3.3 Rice cooking and cooked rice characteristics

3.3.1 Cooking time

The cooking time of the parboiled Degan rice (13.16 minutes) was significantly higher (P<0.05) than the raw (11.70 minutes) as indicated in Table 4.4.

Table 3: Effect of parboiling on the cooking time of rice

Parameter	Parboiled	Non-parboiled
Cooking time (minutes)	$13.16 \pm 0.06_A$	$11.70 \pm 0.52_B$

Means of triplicates ± SD followed by different letters within a row is significantly different (p < 0.05).

The cooking time of the parboiled Degan rice (13.16 minutes) was significantly higher (P<0.05) than the raw (11.70 minutes) as indicated in Table 3. Cooking time depends not only on parboiling process, but also on rice variety and storage time. It is generally understood that cooked parboiled rice is harder and less sticky than raw cooked rice (Islam *et al.,* 2001). Hardness value is greatly affected by parboiling condition such as starch gelatinization and amylose content. Hardness is the most important physical property of parboiled rice among all the physical properties. Generally, harder rice requires longer time to cook under the same conditions. The higher cooking time for parboiled rice is indicative that it would require more energy and time for cooking

which present economic disadvantage.

4. Conclusion

This study has shown that there is a high preference for parboiled rice in the Northern Region. Parboiling was able to significantly improve the physical properties as well as head grain yield, whole grain water absorption and least gelation concentration of Degan rice. The high percentage of stones in parboiled rice in the Northern Region of Ghana gives some indications that people involved in rice parboiling have some part to play in ensuring that a pure, foreign material-free rice product is sold to consumers. Appropriate postharvest handling practices should be adopted to ensure superior quality free from adulterants.

The cost benefit analysis of parboiled rice in the Northern Region of Ghana also showed that if parboiling is done well it can help improve the financial well being of farmers.

The number of years the farmers have got in parboiling also indicates that they have experience in parboiling hence a quality product (rice) can be produced. It was also realised that most of the farmers are in their productive ages, this means that they can contribute greatly to the working force of the country.

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