European Journal of Social Sciences Studies
ISSN: 2501-8590
ISSN-L: 2501-8590
Available on-line at: www.oapub.org/soc

DOI: 10.46827/ejsss.v5i4.898 Volume 5 | Issue 4 | 2020

ASSESSMENT OF QUALITY OF PARBOILED JASMINE AND TOGO MARSHALL RICE GROWN IN THE HOHOE MUNICIPALITY OF VOLTA REGION, GHANA

Alexander Kafui Jarh[1i],
Samuel Yeboah Asiedu[2],
Joseph Oscar Azaglo[1],
Lavoe Robert[1]
[1]Akatsi College of Education,
Ghana
[2]Department of Horticulture KNUST,
Ghana

Abstract:
This study was conducted to determine the perception, acceptability and assessment of the effect of parboiling on physical, functional as well as cooking characteristics of Jasmine and Togo Marshall Rice Produced by farmers in the Hohoe Municipality of Volta Region, Ghana. A sample size of One hundred (100), comprising rice farmers and stakeholders who are into rice production were surveyed. The laboratory work carried out indicated that moisture content and broken grains reduced from 12.44% to 12.07% and 82% to 47% respectively as a result of parboiling. On the other hand, weight of 1000 grains, whole grains and head rice yield increased from 15.66%, 28%, 52.84% to 18%, 63% and 74.4%, respectively. Swelling power and solubility also increased from 0.58% and 15.46% to 0.64% and 20.21% respectively with parboiling. Water and oil absorption capacities also increased from 1.36% and 1.59% to 1.42% and 1.78% respectively through parboiling. Generally, Togo Marshall rice had superior physical qualities than Jasmine, however the functional qualities were similar in both varieties of rice. As far as physical properties were concern, Togo Marshall rice should be the variety of choice. It is recommended that parboiling should be incorporated into the processing techniques for farmers and processors in the production chain in the Hohoe Municipality to improve rice quality.

Keywords: laboratory, Marshal and Jasmine rice, physical properties, sensory, evaluation, parboiled

[i] Correspondence: email alexanderjarh8@gmail.com

1. Introduction

Rice (*Oryza sativa L.*) is the staple food for approximately two-thirds of the world's population (Wyann, 2008). The inability of producers to produce enough to meet the rising demand has resulted in huge sums spent on importation of rice in Ghana. In order to augment this, there is the need to increase production while postharvest losses are also reduced, especially, during storage. Over half of the world's supply and consumption is accounted for by India and China, with China producing 182 million tons, about 28.8% of global rice harvest, followed by India with 136.5 million tons, about 21.6%. In 2008, the production of rice stood at 685 million tons worldwide (Daniel, 2008).

Rice is one of the leading foods in the world and fourth most widely produced cereal in Ghana after maize, millet and sorghum and it is 10.8% of total cereal production (Obeng, 1994). WARDA (2007) reported that Ghana was below 25% self-sufficiency in rice production. This implies that Ghana still needs huge imports to supplement the difference in local demand (Manful *et al*, 1998).

Rice is an important economic crop in employment and income generation, household food security, and nutritional diversification and therefore helps in poverty reduction. Rice has become an important income-generating crop for women in the three Northern regions, as well as some parts of the Volta and Eastern regions of Ghana as they are involved in the production chain from cultivation to processing.

Despite the fact that local rice is said to be tastier than foreign and imported ones, many city dwellers prefer the imported rice even though the prices are higher than the local one. This situation is perceived to be due to the fact that imported rice is of higher quality. Imported white rice therefore dominates rice consumption in Ghana (Manful *et al*, 1998). It is estimated that about US $100 million is used to import rice annually to meet Ghana's rice requirement.

The demand for parboiled rice is increasing due to its nutritional value and health benefits. The protein content of rice is low, but research has shown that it is comparable to that of wheat, while its digestibility is high as compared to other cereals (Wan, 2006).

2. Problem Statement

In the Hohoe Municipality of the Volta region, milling recovery of rice is low coupled with breakage of grains. About half of the rice produced in this part of Ghana is broken during milling thereby reducing the market value, and negatively affecting livelihood. This could be attributed to the undulating rice fields thereby making it difficult to use machines in harvesting hence farmers depend on manual harvesting and these delays the paddy to over dry on the field.

In Hohoe municipality of the Volta Region, the local varieties commonly grown are Togo Marshall and Jasmine rice. They are mostly consumed as boiled rice in households. It has been reported by Adeyemi *et al*. (1986) that parboiling affects the physical, chemical and cooking qualities of rice, however, there is paucity of scientific information on the effect of parboiling on this varieties grown in the Hohoe Municipality.

2.1 Significance of the Study

This study is intended to determine the perception and acceptability of parboiling to stakeholders in the production of rice in Hohoe Municipality of Volta Region, Ghana and also to assess the effect of parboiling on Jasmine and Togo Marshall Rice, with respect to parameters such as physical, functional as well as cooking characteristics.

2.2 Limitations of the Study

The research work should have covered all rice producing communities in the Hohoe Municipality, but owing to financial constraints, it was limited to only two communities.

Another challenge was the language barrier between the researcher and the stakeholders involved, in terms of data collection. Most of the interviews were conducted in the local dialect and later transcribed into English with the original responses not altered.

2.3 Research Questions

1) To what extent will parboiling affect the physical and functional properties of Jasmine and Togo Marshall rice?
2) Will parboiling affect the eating quality of the Jasmine and Togo Marshall rice?

3. Materials and Methods

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

A survey on the demographic background of rice farmers, people involved in parboiling, milling recovery and cooking characteristics of parboiled rice was carried at two selected communities in the Hohoe Municipality of the Volta Region of Ghana. The Communities were Akpafu Odomi and Santrokofi. Hundred semi structured questionnaires aimed at collecting information on milling recovery as well as experience of parboilers, the parboiling process were administered.

3.1 Laboratory Work

3.1.1 Paddy Preparation

Togo Marshal and Jasmine paddy rice were harvested at 13% moisture content by the local farmers in the Hohoe Municipality of the Volta Region. Winnowing was done to remove all debris and weeds from the produce. The paddy was divided into two; one half was parboiled, dried and milled, with the other half processed by only drying and milling.

3.1.2 Soaking of Paddy

5 kg of paddy was thoroughly washed with clean water to get rid of chaff, stones, pebbles, sand and unfilled panicles. The paddy was soaked in approximately 10 litres of water and allowed to stand overnight.

3.1.3 Steaming

A basket was used to drain water off the paddy and the paddy put into another pot containing 3 litres of water and then, put on fire and covered with jute sack to steam for 5 minutes. Steaming was considered complete when panicles split open during the process.

3.1.4 Drying

The parboiled rice was dried on tarpaulin in the sun and frequently turned over with a rake for about 6 hours to bring the final moisture content to 13%. Samples were collected after drying into a room to cool for another three hours and stored in airtight polythene bags for moisture equilibration and hardness stabilization before milling as recommended by Kimura *et al*., (1995).

3.1.5 Milling

Milling was done with the Double Pass Whitener Machine, manufactured by the Hunan Towin Machinery Company Ltd. South Korea, with serial number CHP 150 and a capacity of 1500 tons/hour after which the rice was winnowed to separate the bran from grain.

3.1.6 Flour Production

The milled rice was pounded in a mortar with a pestle. The flour samples were sieved using a 0.5 mm mesh and stored in airtight containers in a refrigerator at 4°C until needed for analysis.

3.2 Determination of Physical Properties

3.2.1 Head Rice Yield

Approximately two weeks after drying, samples of parboiled and non-parboiled rice were milled. The head rice yield was calculated as percentage of milled grains with respect to the paddy rice (Bello *et al*., 2004)

3.2.2 Moisture Content

The standard oven method was used to determine the moisture content of rice. Three sets of 2 g samples were dried in hot air oven at 130°C for 16 hours (Mathews, 1962). Moisture content was expressed on a wet basis by subtracting the dry weight from the initial wet weight and the means calculated.

3.2.3 Percentage (Breakage and Whole grains)

Sorting out of broken and whole grains was done and percentage broken and whole grains calculated, and mean values determined in triplicates (IRRI, 2009).

3.2.4 Percentage Adulterants

Adulterants like stones, pebbles, weed seeds and unfilled panicles were sorted out in 10 g of sample, the percentage determined, and mean values calculated (IRRI, 2009).

3.2.5 Weight of 1000 grains

1000 whole grains were counted, and their weight determined.

3.3 Functional Properties

Swelling power and solubility; water and oil absorption capacity; gelation capacity; and bulk density are the functional properties studied.

3.3.1 Swelling Power and Solubility

This was done with the method described by Leach *et al*., (1959) with modification for small samples. 1 g of the flour sample was mixed with 10 ml distilled water in a centrifuge tube and heated at 80°C for 30 min. The set-up was continually shaken during the period of heating. The suspension was centrifuged at 1000 x g for 15 mins after heating. The weight of the decanted supernatant paste was taken. The supernatant was evaporated, and the dried residue weighed to determine the solubility. The swelling power was calculated as:

$$\frac{Weight\ of\ Paste}{Weight\ of\ dry\ flour}$$

3.3.2 Water and Oil Absorption Capacity

The method proposed by Sabularse *et al*., (1991) was used with modifications to determine both water and oil absorption for small samples. 20 ml distilled water or oil was mixed with 2 g of rice in a test tube covered with a piece of cotton plug. The text tube was placed in a thermostatically controlled water bath preheated to 97-99°C. The sample was cooled in water, excess water drained off, and the test tube placed upside down for one hour before weighing. Water absorption was calculated as increase in weight and expressed as gram of water per gram of rice.

3.3.3 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) (Okaka and Potter, 1979).

3.3.4 Gelation Capacity

Sample suspensions, 2-20% (w/v) were prepared in 5 ml distilled water as proposed by Coffman and Garcia (1977). The suspension tubes were heated in boiling water for one hour, followed by rapid cooling under cold running tap water. The tubes were further cooled for 2 hours at 7°C. The least gelation concentration (LGC) was determined as that concentration when the sample from the inverted tube did not fall off.

3.4 Rice Cooking and Cooked Rice Characteristics

3.4.1 Cooking time

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

3.4.2 Sensory Evaluation

Parboiled and non-parboiled samples of rice were cooked and served to 22 randomly chosen and semi-trained panelists. A scale of 1-7 was used, representing seven categories, where 1 = dislike extremely and 7 = like extremely. Aroma, colour, texture, stickiness, taste and acceptability were the sensory attributes measured.

3.5 Statistical Analysis

The Statistical Package for Social Sciences (SPSS) version 16.0 was used to analyze the data collected from farmers. Student edition of Statistix 9.0 was used to analyze the data collected from the laboratory and means were separated at 5% probability.

4. Results and Discussion

4.1 Rice Processing

4.1.1 Gender, Civil Status and Other Activities Performed by People Involved in Rice Cultivation and Processing

A survey conducted shows the gender balance among people involved in rice cultivation and processing interviewed during the survey. 75% of those involved in cultivation and processing were females with 25% being males.

This is an indication that rice processing, a post-harvest activity in the rice food chain is female dominated. Within many communities in Ghana, most men move to urban centres for non-existing white- collar jobs hence the women are left at the country side to go into subsistence farming and post-harvest activities like, threshing, drying, milling, storage and marketing. The preparation of milled rice for consumption, the transformation of milled rice to other usable products and the uses of broken rice, rice bran, rice hulls and husks, and rice straws provide additional income opportunities to women in the Hohoe municipality of the Volta region of Ghana. In a study examining women's role in the various stages of rice production in the Hohoe municipality of Ghana, it was established that women were predominantly engaged in seed sowing, fertilizer application, harvesting and milling (GIDA, 2006).

When asked of their marital status, 80% of the respondents indicated that they were married. 15% were divorced whiles 5% were single as shown in Figure 4.2. This implies that majority of them have family members to cater for. Hence, the women engaged in post-harvest activities to generate income for expenses on clothing, housing, education of their children and other social activities.

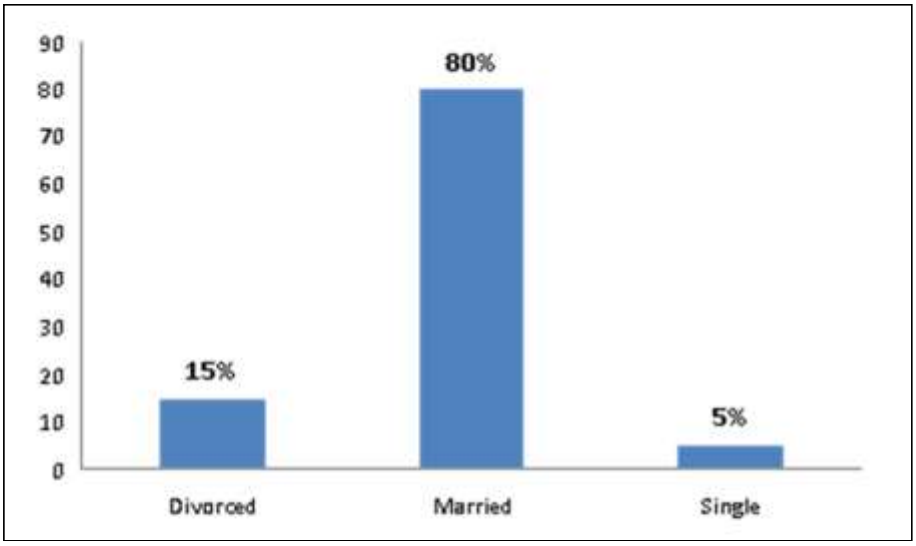

Figure 4.1: Marital Status of Respondents

4.1.3 Age Distribution of Respondents

The results showed that 49% of the respondents who were involved in the cultivation and processing were within the age bracket of 40 to 49 years, 20% in the range of 30 – 39, 17% between 50 – 59, 13 % between 20 – 29 years, and 5% between 60 – 69 years.

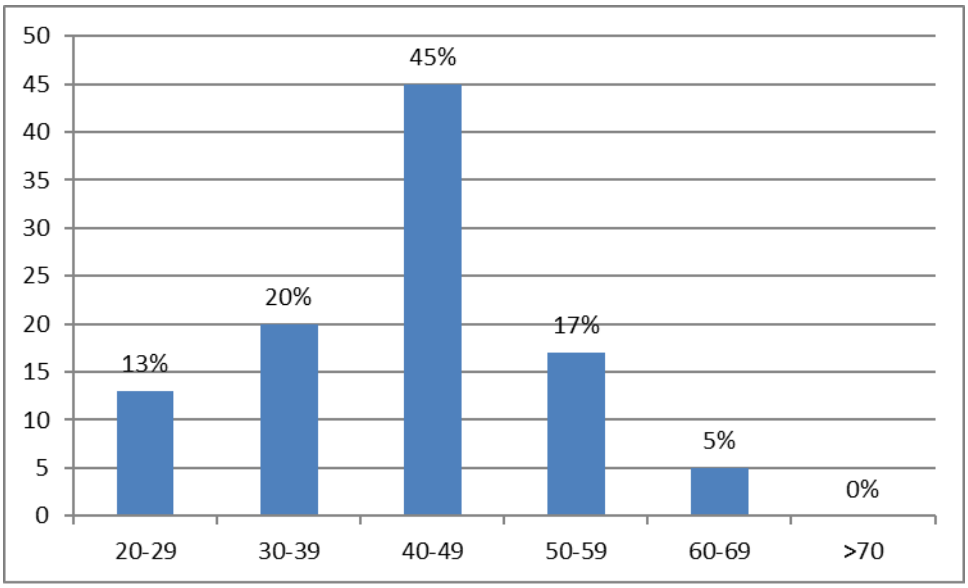

Figure 4.2: Age of Respondents

4.1.4 Level of Education

The result of the survey indicated that 20%, 27%, 40%, 3%, 5% and 5% had no formal education, only primary education, JHS / Middle School education, vocational / technical education, secondary / SHS and tertiary education, respectively.

The implication of the results is that it would be quite difficult for some of the respondents to find information to improve their trade. This is worrying and has serious repercussions on the quality of processed rice as processing itself is technical and needs to be controlled in order to obtain the needed qualities. It also accounted for the fact that 95% of the respondents were not into parboiling and only 5% parboiled occasionally. Roy *et al*., (2011) reported that over-parboiling for example, results in over-opening of the husk components followed by bulging out of the endosperm which initiates surface scouring during milling and the resultant ground particles being lost into the husk and bran. It is therefore important to provide training to those who are already processing to improve their skills in rice processing, so as to produce more quality rice and also employ the parboiling technique of rice processing, thereby raising their profit margin, which will in turn improve their standard of living.

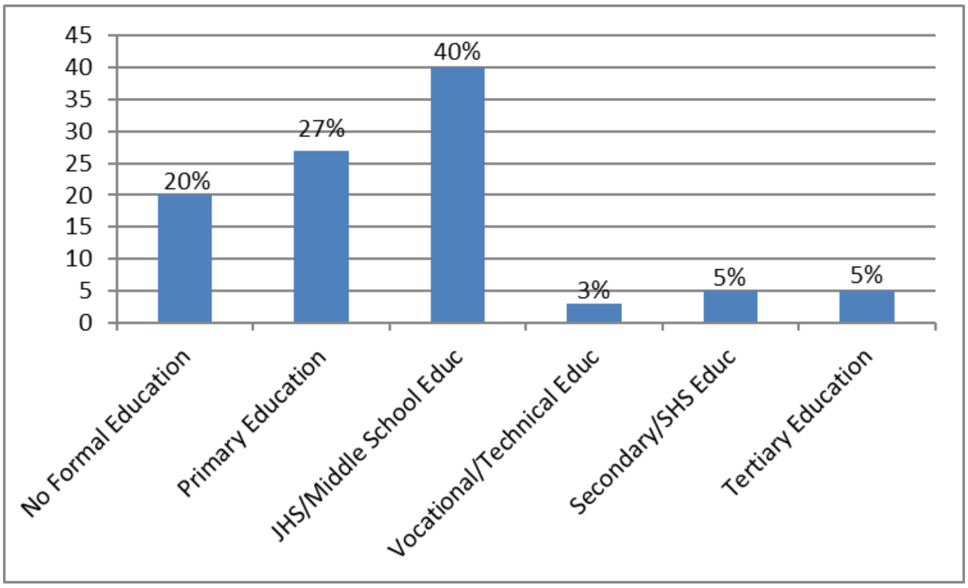

Figure 4.3: Level of Education

4.2 Milling Recovery of Parboiled and Non-parboiled Rice

As many as 78% of the respondents interviewed indicated a poor milling recovery of non-parboiled rice whiles 22% indicated a good milling recovery level. Only 6% of the respondents indicated that milling recovery of parboiled rice was very good whiles 94 % gave no response to the question because they were ignorant about the parboiling technique of rice processing as shown in Figure 4.6 and 4.7. Meanwhile, parboiling is used in the Northern Region to reduce breakages during milling and increase head rice yield. Parboiling process is applied to rice with a primary objective of hardening the kernel in order to maximize head rice yield is milling. This improvement is caused by stronger structure of rice starch as a result of gelatinization process (Soponronnarit *et al*., 2006). Saif *et al*., (2004) also reported that the increase in length, width and thickness due to parboiling, results in strengthening of kernel integrity and increase of milling recovery.

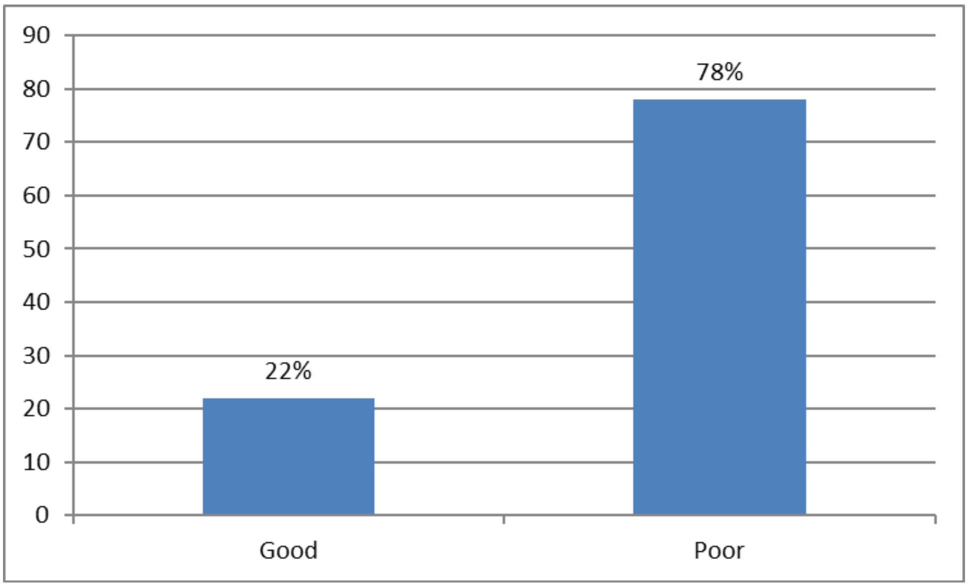

Figure 4.6: Milling Recovery of Non-Parboiling

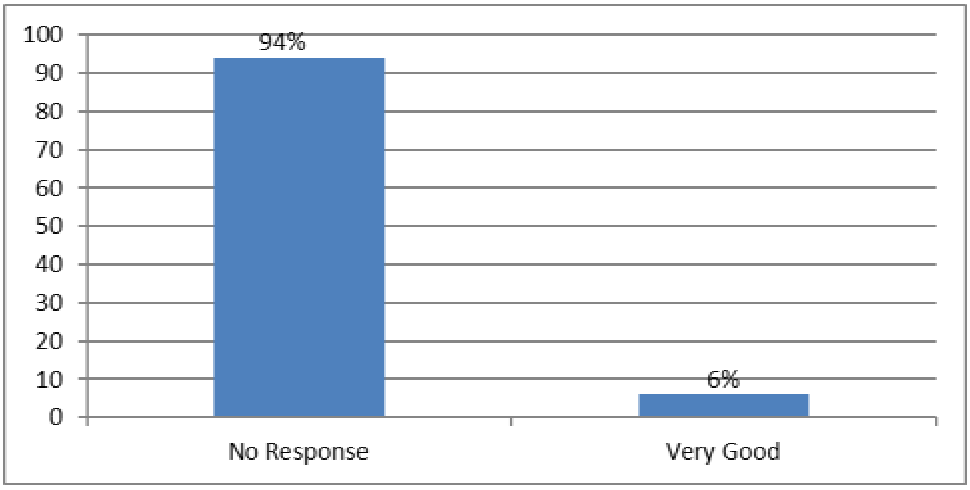

Figure 4.7 Milling Recovery of Parboiled Rice

4.3 Swelling of Parboiled and Non-parboiled Rice

During the survey rice consumers were asked to rate parboiled and non-parboiled rice in terms of their swelling ability and taste. In their responses as shown in Figures 4.8 and 4.9.

74% of the respondents said the swelling of non-parboiled rice was very good and 26% indicated that it was good. 84% of the people interviewed indicated that swelling of parboiled rice was good, with only 12% indicating that swelling was very good whiles 4% said it was poor. In general, consumers have the notion that non-parboiled rice swells better than parboiled rice hence 100% of the respondents either said swelling of non-parboiled rice was either very good or good.

Parboiling has obvious impact on the organoleptic properties of cooked rice. Kar *et al.*, (1999) reported that cooked parboiled rice is firmer than non-parboiled rice. De Datta (1986) also reported that parboiling gelatinizes the starch within the rice grains causing swelling and fusion within the kernel thereby increasing the moisture content.

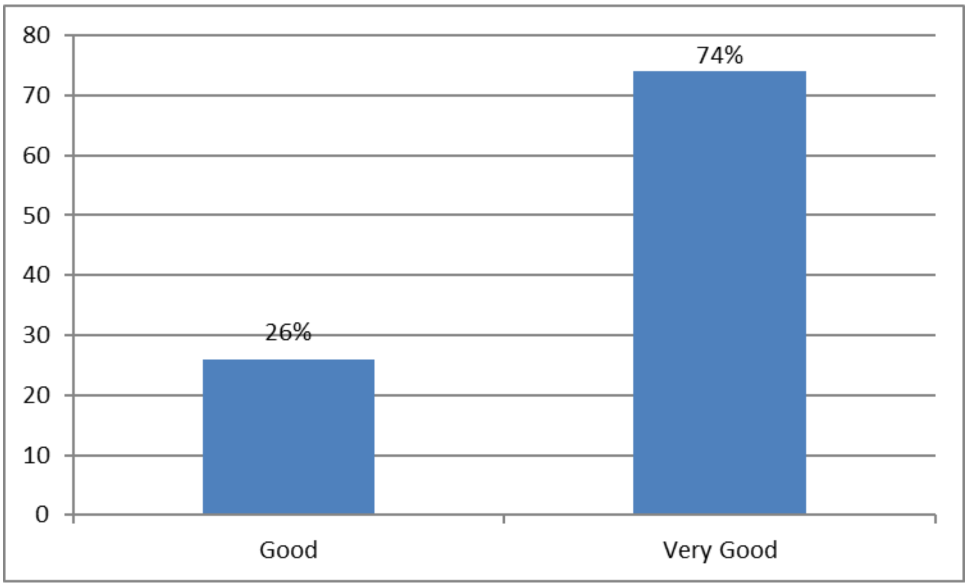

Figure 4.8: Swelling of Non-Parboiled Rice

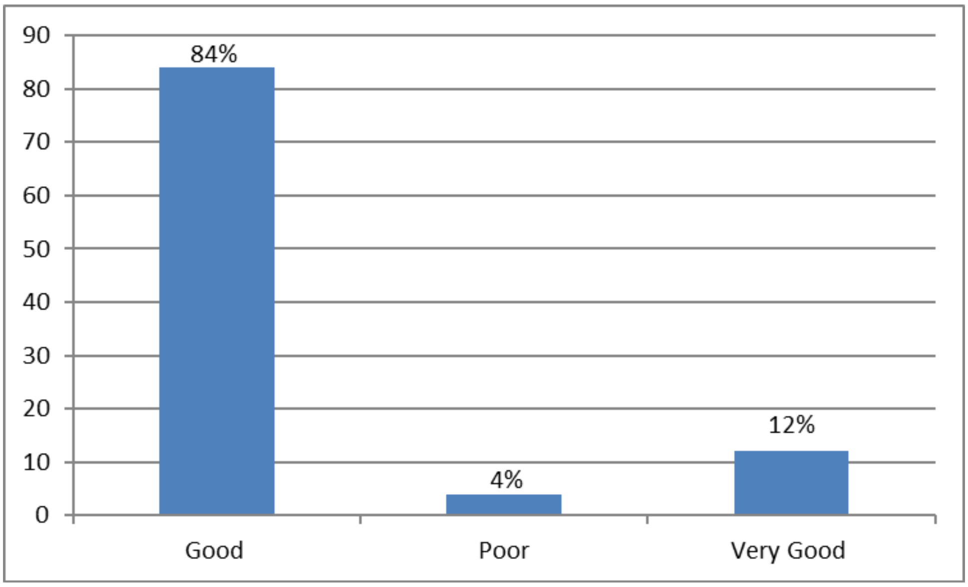

Figure 4.9: Swelling of Parboiled Rice

4.4 Rice Marketing

The survey showed that majority of the rice processors, that is 88%, sold their produce at the farm gate with only 12% sell their produce at the nearest markets. Transporting rice to the market involves additional cost; consumers therefore preferred farm gate sales to market sales to avoid glut as shown in Figure 5.

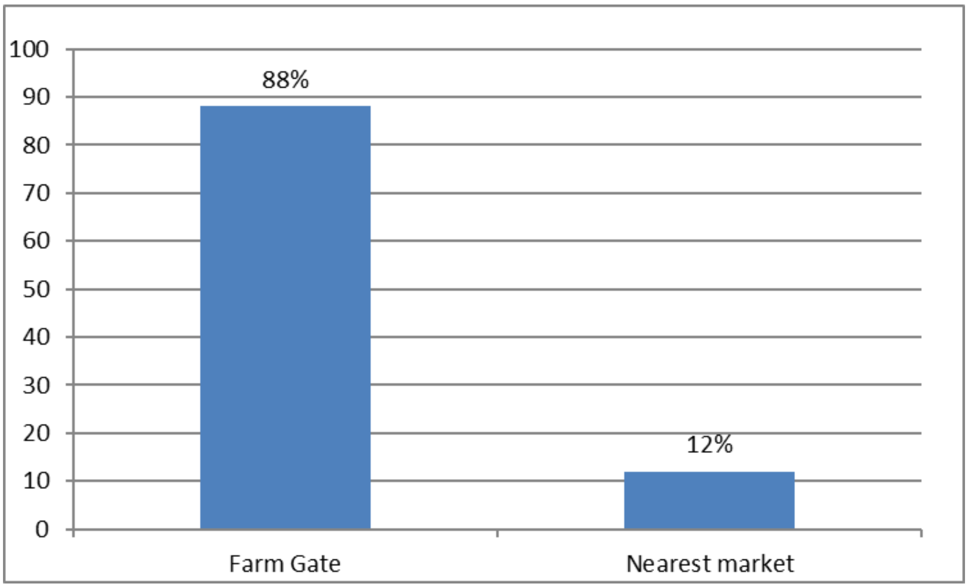

Figure 5: Rice marketing (Sales Point)

4.5 Physical Properties of Parboiled Jasmine and Togo Marshall Rice

Table 4.1 shows that there was no significant difference between the moisture content of parboiled Jasmine (12.01) and parboiled Togo Marshall Rice (12.06). There was significant difference between parboiled Jasmine (18.00) and parboiled Togo Marshall (18.33) with respect to 1000-grain weight.

There was a significant increase ($P<0.05$) in whole grains of parboiled Togo Marshall (65%) than in parboiled Jasmine rice (53%), whilst there were more broken grains in parboiled Jasmine (47%) than in parboiled Togo Marshall (35%).

There was significant difference ($P\leq0.05$) between parboiled Togo Marshall (75.80) and parboiled Jasmine rice (74.40) in terms of head rice yield percentage.

Table 4.2: Physical properties of Parboiled Jasmine and Togo Marshall Rice

Parameter	Variety			
	Jasmine	**Togo Marshall**	**LSD**	**CV**
Moisture Content	12.07	12.06	0.095	0.21
Weight of 1000 grains	18.00	18.33	0.043	0.06
Whole grains (%)	53.00	65.00	0.049	0.01
Broken grains (%)	47.00	35.00	3.759	2.44
Head Rice Yield (%)	74.40	75.80	1.085	0.38

4.6 Physical Properties of Non-parboiled Jasmine and Togo Marshall rice

With exception of Head rice yield, all the other parameters showed no significant difference ($p\leq0.05$) when raw Jasmine rice and Togo Marshall rice were compared statistically as indicated in Table 4.2. The moisture content of raw Jasmine was 12.44 and raw Togo Marshall was 12.45. The weight of 1000 grains of non-parboiled Jasmine was 15.66 whiles non-parboiled Togo Marshall was 15.67. Whole grain percentage for raw Jasmine was 18.0 whilst raw Togo Marshall was 18.20. Broken grain numbers were very high in the two raw rice; Jasmine was 82% whiles Togo Marshall rice was 81.8%. There was significant difference ($p \leq 0.05$) in the head rice yield of non-parboiled Jasmine rice (51.24) as compared to non-parboiled Togo Marshall value (52.84).

Table 4.2: Physical Properties of non-parboiled Jasmine and Togo Marshall Rice

	Variety			
Parameter	**Jasmine**	**Togo Marshall**	**LSD**	**CV**
Moisture Content	12.44	12.45	0.078	0.17
Weight of 1000 grains	15.66	15.6	0.031	0.05
Whole grains (%)	18.00	18.20	0.031	0.02
Broken grains (%)	82.00	81.80	2.671	0.87
Head Rice Yield (%)	51.24	51.84	0.041	0.02

4.7 Functional Properties of Parboiled and Non-Parboiled Jasmine and Togo Marshall Rice

Table 4.3 indicates that there was no significant difference ($p \leq 0.05$) in all the parameters measured in functional properties of parboiled Jasmine and parboiled Togo Marshall. This implies that irrespective of the variety, parboiling as a post-harvest technique for processing rice could improve the swelling power, solubility, water and oil absorption capacity, bulk density, least gelation capacity and the cooking time to an appreciable level.

Table 4.3: Functional Properties of Parboiled Jasmine and Togo Marshall Rice

	Variety			
Parameter	**Jasmine**	**Togo Marshall**	**LSD**	**CV**
Swelling Power	0.64	0.64	0.022	0.90
Solubility (%)	20.21	20.2	0.031	0.04
Water Absorb. Cap. (%)	1.42	1.42	0.078	1.46
Oil Absorb. Cap. (%)	1.78	1.79	0.038	0.56
Bulk Density (%)	0.80	0.78	0.031	1.03
Least Gelation cap (%)	32.35	32.36	0.043	0.04
Cooking Time (Mins)	29.93	29.92	0.057	0.05

Table 4.4: Functional Properties of Non- Parboiled Jasmine and Togo Marshall Rice

	Variety			
Parameter	**Jasmine**	**Togo Marshall**	**LSD**	**CV**
Swelling Power	0.58	0.63	0.049	2.13
Solubility (%)	15.46	15.45	0.031	0.05
Water Absorb. Cap. (%)	1.36	1.37	0.031	0.60
Oil Absorb. Cap. (%)	1.59	1.60	0.015	0.26
Bulk Density (%)	0.84	0.85	0.031	0.96
Least Gelation cap (%)	32.82	32.83	0.031	0.02
Cooking Time (Mins)	25.15	25.15	0.043	0.02

4.7.1 Swelling Power

Swelling is the initial stage in the changes in hydration related properties. There was no significant difference ($p \leq 0.05$) between the swelling power of parboiled Jasmine (0.64) and Togo Marshall (0.64) as shown in Table 4.3.

Non-parboiled Togo Marshall (0.63) recorded a significant difference ($p \leq 0.05$) as against non-parboiled Jasmine (0.58), but there was no significant difference in their solubility. Jasmine recorded (15.46) whiles Togo Marshall was (15.45) as shown in Table 4.4.

The first stage in the initiation changes in hydration related properties in swelling. The swelling power of parboiled Jasmine rice (0.64) was significantly higher ($p \leq 0.05$) than the non-parboiled (0.58). Parboiled Togo Marshall (0.64) was also significantly higher than the non-parboiled (0.63).

Swelling power has been related to the associative binding within starch granules hence the strength and character of the micellar network is related to the amylose content of the starch. The lower the content of the amylose, the higher the swelling power. The moisture content of the parboiled rice was significantly lower than the non-parboiled and this could account for the higher swelling power of the parboiled than the non-parboiled (Table 4.4). The degree of starch gelatinization is responsible for many of the attributes of parboiled rice (Marshall *et al.*, 1993). During the gelatinization process, molecules of amylose leach out of the micellar network and diffuse into the surrounding aqueous medium outside the granules (Hermansson and Svegmark, 1996). This could have resulted in increased solubility of parboiled Jasmine (20.21%) against the non-parboiled (15.46%).

The trend remained the same with parboiled Togo Marshall (20.2%) which was significantly higher than the non-parboiled (15.45%). Swelling power is an important property for noodle production since the parboiled rice had higher swelling power, it could be a better ingredient for noodle production than the non-parboiled rice.

4.7.2 Solubility

There was no significant difference between the two parboiled varieties ($p \leq 0.05$) Jasmine recorded 20.21 whiles Togo Marshall 20.20.

4.7.3 Water and Oil Absorption

The water and oil absorption capacity describes water and oil association ability under limited water and oil supply. The water and oil absorption of parboiled Jasmine and Togo Marshall were dependent on each other. There was no significant difference between parboiled Jasmine (1.42) and parboiled Togo Marshall (1.42) in terms of water absorption. The oil absorption also followed the same trend with no significant difference ($p \leq 0.05$) between Jasmine (1.78) and Togo Marshall (1.79) values (Table 4.3 and 4.4) The water association ability under limited water supply is termed as water absorption capacity. The water and oil absorption of parboiled Jasmine (1.42) and (1.78) were significantly higher than that of the non-parboiled (1.36) and (1.59) as shown in Table 4.3. Mustapha

(1979) in his research into the functional qualities of rice stated that parboiled rice has higher water absorption which could be attributed to the steaming pressure during parboiling which may also affect starch gelatinization. This significant difference ($p \leq 0.05$) between parboiled and non-parboiled Jasmine rice could be as a result of gelatinization of starch resulting in exposure of sub-units of hydrophilic protein in rice, and therefore higher moisture absorption (Narayana and Narasinga Rao, 1984). Higher water absorption of the parboiled rice implies that it would perform as a better ingredient for infant food than the non-parboiled. The higher oil absorption capacity of the parboiled could perhaps be as a result of exposure of lipophilic and non-polar amino acids (Kinsella, 1976).

Parboiled rice could therefore be useful for carrying flavour – enhancing oils than the non-parboiled hence could be used in the production of sausages and cakes. The water and oil absorption of parboiled Togo Marshall (1.43) and (1.79) were higher in value than the non-parboiled (1.37) and (1.60).

4.7.4 Bulk Density

There was no significant difference ($p \leq 0.05$) between the bulk densities of parboiled Jasmine (0.80) and parboiled Togo Marshall (0.78) as indicated in Table 4.3.

There were also no significant differences between the water and oil absorption capacities of the two non-parboiled varieties. The water absorption of Jasmine was 1.36 and that of Togo Marshall was 1.37 whiles the oil absorption of non-parboiled Jasmine was 1.59 that of Togo Marshall was 1.60 as shown in Table 4.4 above.

Bulk density is a measure of heaviness of a flour sample. The non-parboiled Togo Marshall and Jasmine had higher densities (0.85) and (0.84) as compared to the parboiled (0.78) and (0.80); respectively. The higher bulk density of the non-parboiled rice could be attributed to the higher moisture content as compared to the parboiled as shown in Table 4.4.

4.7.5 Gel Formation

Gelling capacity of parboiled Jasmine and parboiled Togo Marshall rice in water at different protein levels is shown in Table 4.3. There was no significant difference $p \leq 0.05$) between the gel formation capacity of parboiled Jasmine (32.35) and parboiled Togo Marshall (32.36) using student t-test.

Gel formation capacity of parboiled and non-parboiled Togo Marshall rice in water at different protein concentration is shown in Table 4.3 and 4.4. The least gelation concentration increased significantly ($p \leq 0.05$) from 32.36 in the non-parboiled to 32.82 in the parboiled. Parboiled and non-parboiled Jasmine had similar results, (32.35) to (32.82) respectively. Gelation is the swelling of starch granules upon heating. The low gelation concentration of non-parboiled rice could be as a result of the higher level of total available carbohydrate that can be found in the parboiled rice.

The gel formation capacity is attributed to denaturing, aggregation and thermal degradation of starch. Schmidt (2010) indicated that a high protein concentration is usually required for the gelation of globular proteins. According to Walkenstrom and Hermansson (1996), protein gel structure becomes increasingly fine and continuous with the gel possessing an improved capacity to retain moisture.

The parboiled rice had the least gelation capacity, hence, may not be a good gelling agent when compared to the non-parboiled.

4.7.6 Cooking Time

There was no significant difference ($p \leq 0.05$) between the cooking times of both parboiled Jasmine (29.93) and parboiled Togo Marshall (29.92) as shown in Table 4.3.

As shown in Table 4.4, there was also, no significant difference ($p<0.05$) between the cooking time of non-parboiled Jasmine and non-parboiled Togo Marshall.

The cooking time of the parboiled Jasmine (29.93) was significantly higher than the non-parboiled (25.15). Similarly, parboiled Togo Marshall had higher value (29.92) compared to the non-parboiled (25.15). This result was similar to what Saeed *et al*., (2011) reported in milled super Basmati rice.

Cooking time depends not only on parboiling process, but also on rice variety and time of storage (Hogan, 1963). It is a generally observed that cooked parboiled rice is harder and less sticky than raw cooked rice (Islam *et al*., 2002).

Hardness value is generally influenced by parboiling condition such as starch gelatinization and amylose content. The most important physical property of parboiled rice among all the properties is hardness. Harder kernels usually require longer time to cook under the same conditions. It is clear that parboiled rice would require a higher cooking time and more energy, which would be an economic disadvantage.

Similar studies were carried out in the northern part of Ghana by Issah who reported that, the moisture content of the raw Degan rice was 9.33% and the parboiled was 10.33%. Comparing this to the results of the present study in which parboiled rice had an average percentage moisture of 12.06%, and non-parboiled 12.44%, these were higher than that obtained in the study from northern Ghana. This difference in moisture could be attributed to the dry atmospheric conditions in the north.

Rice is parboiled with the aim 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 ($p \leq 0.05$) the head rice yields by 1.48 folds from 51.25% to 75.8%, which was similar to the study carried out in northern Ghana by Issah in 2011 in which the head rice yield also increased by 1.4 folds, from 52.84% to 74.4%.

Swelling power recorded in the studies conducted in the north was far more than the record obtained in the south. Parboiled rice recorded 5.06% as against 0.64% for Jasmine and Togo Marshall in the south whilst the non-parboiled recorded 5.36% in the North against 0.58% for Jasmine and 0.63 for Togo Marshall in the south.

Solubility was higher in the South for both parboiled (20.21%) and non-parboiled Jasmine (15.46%) and parboiled Togo Marshall (20.20%) and non-parboiled Togo Marshall (15.45%) as against 3.0% parboiled and 3.0% non-parboiled in the North. The high Swelling power observed in the North could be as a result of the low moisture content of the rice as a result of dryer conditions, as compared to moderate weather conditions of the South coupled with varietal differences.

The water absorption capacity of the rice studied in the North was higher (1.50%) for parboiled and (1.38%) for non-parboiled as compared to (1.42%) in parboiled Jasmine and (1.36%) in non-parboiled Jasmine, and parboiled Togo Marshall (1.43%) and non-parboiled Togo Marshall (1.37%)

The 1000-grain weight of parboiled Togo Marshall (18.33 g) was significantly higher ($p \leq 0.05$) than the non-parboiled one (15.67 g). Likewise, 1000-grain parboiled Jasmine rice also weighed higher (18.00 g) than the non-parboiled (15.66 g). The study is similar to the one carried out by Issah in 2011 in the North which recorded (18.13 g) for parboiled rice and (15.60 g) for non-parboiled rice.

This revealed that irrespective of where parboiling is carried out, it has an added advantage over the non-parboiled rice.

5. Conclusion

This study has shown the need to parboil rice in the Hohoe Municipality of the Volta Region. Parboiling was able to improve the physical properties, such as head rice yield, whole grain, water absorption as well as least gelation capacity of Jasmine and Togo Marshall Rice. The high percentage of contaminants in rice in Hohoe Municipality gives some indications that people involved in the postharvest handling of rice have some important role to play ensuring that a quality, foreign material free rice product are made available to consumers.

Appreciable and appropriate postharvest handling practices should be employed to ensure superior quality, free of foreign materials. It was also realized that most of the farmers are in their reproductive ages, which implies that they can contribute greatly to the work force of the economy. It also came to light that parboiled Togo Marshall had more and higher parameters as compared to parboiled Jasmine rice.

5.1 Recommendations

Improved postharvest handling methods should be adopted by both farmers, and processors to ensure superior quality devoid of foreign materials. Parboiling of grains should be integrated into the processing technique for the farmers and processors. The cultivation of more Togo Marshall Rice should be encouraged in the Hohoe Municipality.

Handling of paddy in the production chain should be done with proper care so as to avoid contamination. Good farming practices like threshing on tarpaulins, cemented floors as well as weeding should be employed by farmers, in order to produce clean products of parboiled rice for consumers.

References

Abbey, B. W. & Ibeh, G. O. (1988). Functional properties of raw and heat processed cowpea flour. Journal of Food Science 53:1775-1777.

Adeyemi, I. A., Fagade, S. O., & Ayotade, A. K. (1986). Some physicochemical and cooking qualities of Nigeria rice varieties. Nigeria Food Journal. 4 (1): 26-33.

Ali, S. Z. & Bhattacharya, K. R. (1991). Hydration and amalyse solubility behaviour of parboiled rice. Lebenson, WISS Technol.5:207-12

Araullo, E. V. & de Padua, D. B. (eds) (1976): Rice post-harvest technology, IDRC Ottawa, Canada.

Bello, M., R. & Tolaba M. P. (2004). Quality Characteristics of Milled and Cooked Rice Affected by Hydrothermal Treatment. Food Journal England 72: 124-133.

Bhattacharya, K. R. (1985). Improved Parboiling Technology for Better Product Quality; India Food Industry: Mysore, India; pp.23-26

Bienvenito, O. & Juliano, P. A. (1996). Food Review International-vol.12, issue 1996, pp, 76-103.

Chang S. M. Chang, Y. C. (1988). Retrogradation of rice starches with various amylase contents. Proceedings of the National Science Council 12, 247-251.

Chang, S. M. & Liu, L. C. (1991). Retrogradation of rice starches studied by differential scanning calorimetry and influence of sugars NaCl and lipids. J. Food sci.56:564

Coffman, C. W. L. & Gracia, V. C. (1977). Functional properties and amino acid of a protein isolate from mung bean flour. Journal of Food Technology 12:473-484

Danekar, G. G. (2010). Parboiled rice. Available online at http://partner.m3conenct.de/-v/Ghana/modules/viewfile.phd (accessed on 27th July, 2011)

Daniel, Workman (2008). Top rice producing countries at world rice production. Available online at http://www.suit101.com/contenttop-rice-producing-countries (accessed on 15th June, 2011).

De Datta, S. K., Chang, T. T., & Yoshida, S. (1986). Drought Tolerance in upland rice. Pp.101-116 in P.C. Gupta and J. C. O. O'Toole, Upland rice: a global perspective, International Rice Research Institute, Los Baŋos, Philippines.

Dogbe, W. (1996). Characterisation of the inland valleys of Northern Ghana. U.P. Savanna Agricultural Research Institute (SARI), Tamale, Ghana.

Dorinder, H. (2009). A Taste of African Rice. Available online at; http://www.africanrice.org/warda/guide.asp (Accessed on 2nd May, 2010).

FAO -Food & Agricultural Organization (2001). Rice in the World. In Report of the Fifth External Programme and Management Review of the International Plant Genetic Resources Institute (IPGRI); FAO: Rome, Italy, Available online at: http://www.fao.org/wairdocs/tac/x5801e08/x5801e08.htm (accessed on 11th December, 2010).

FAOSTAT (2011). Food & Agricultural Organization Statistical Database. Available online at: www.fao.org/faostat/ (accessed on 15th August,2011)

Felix, S. H. (2009): Growing and processing top quality rice will get you top money. African rice centre (WRADA): Available online at; http://www.africanrice.org/warda/guide.asp (accessed on 1st October, 2010).

GIDA-Ghana Irrigation Authority (2006). Annual report.

Haroon, A. S. (2009). Pakistan rice-25% broken regular milled.

Hermansson, A. M. & Svegmark, K. (1996). Development in the understanding of starch functionality. Trends Food Science and Technology, 7,345-353.

Hermansson, A. M., & Walkenström, P. (1996): fine stranded mixed gel whey proteins and gelatine. Food hydrocolloids, 10 (1), 51 62

Hogan, J. T. (1963). Rice research at of Southern laboratory. Rice J. 66(7)38

Ibrahim, A. S. (1984). An economic analysis of rice response to fertilizer application in the Tamale district of Northern Region of Ghana, Msc. Thesis, University of Ibadan, Nigeria.

Indiamart, S. (2010). Available online at www.indiamart.com (accessed on 20th December, 2010)

International Rice Research Institute, IRRI (2003): Main Milling Practice; International Rice Research Institute (IRRI): Manila, Philippines. Available online at: http://www.knowledgebank.irri.org/trorice/Main Milling Practices.htm (accessed on 12 November,2010).

Islam, M. R., Roy, P., Shimizu, N. and Kimura, T. (2002). effect of processing condition on physical properties of parboiled rice. Food science and Technology Research, 8 (2): 106 -112

Issah, M. H. (2011). The effect of parboiling on Degan rice grown in the Northern Region of Ghana.

Juliano, B. O. (1985). Cooking and eating qualities of parboiled rice. Rice Chemistry and Technology. Dept of cereals chemistry, IRRI, Los Banos, Laguna, Philippines.

Kar, N., Jain, R. K. & Srivastaya, P. P. (1999). Changes in physicochemical properties of parboiled rice. Available at; www.cigrjournal.org/index.php/Ejounral/article/view/1221/1078

Kimura, T.; Shimuzu, N.; Shimohara, T.; Warashina, J. Trials of quality evaluation for parboiled and other rice by means of the near infrared spectroscopy and the rapid visco analyzer. J. Soc. Agric. Struc. Jpn. 1995, 25, 175-181

Kinsella, J. E. (1976). Functional properties of protein foods. Crit.Rev. Sci. Nutrition 1: 219-229

Lancon, & Erentein (2002). Rice production and consumption in West Africa. Available online at: http://www.unep.ch/etu/etp/events/agriculture/warda.pdf (accessed on 12th November, 2010).

Leach, H. W., McCowen, L. D. Schoch, T. J. (1959). Structure of the starch granules. In: Swelling and solubility patterns of various starches. Cereal Chem. 36: 534-544

Manat, M., Pimjan, P. & Jittra, S. (2011). Functional properties of rice bran and its application in bread. Dept of Agro industry Faculty of Agriculture, Uban Ratchathani University Warinchamrap,34190 Thailand

Manful, J., Langyintuo, A., Hammond, & Coote, C. (1998). An Assessment of Rice Post-Harvest System, Study produced for the DFID project 'Improving the competitiveness and marketability of locally-produced rice in Ghana'

Marshall, W. E., Wardsworth, J. I., Verma, L.R., & Velupillai, L. (1993). Determining the degree of gelatinization in parboiled rice: Comparison of a subjective and objective method. Cereal Chemistry, 70(2):226-230.

Mathews, J. (1962). The accuracy of measurement of brown changes in moisture content of cereal by typical oven methods. Journal Agricultural Engineering Research, 7(3): p185-191.

Mobil, J., & Okran, V. K. (1985). Trends in the production and consumption of rice in Ghana, p.11. Accra, Ghana.

Morton, J. (1987). Breadfruit: Fruits of Warm Climates, Jr. Dowling, CF. (Ed.). Greensborough, US: Media Incorporated, pp: 50-63.

Mustapha, F. O. (1979). The effect of parboiling on some physico-chemical properties of some local rice varieties. B.Sc. Thesis, University of Ife, pg.22-27

Narayana, K. & Narasinga Rao M. S. J. (1984): Functional Properties of raw and heat processed bean flour. J. Food Sci. 47: 1534-1538.

Nikuni, Z. (1978). Studies on starch granules. Starch/staeke 30: 105-111

Norman, J. C. & Otoo, E. (2002). Rice development strategies for food security in Africa. In proc. 20th Session of the international Rice Commission, Bangkok, Thailand, July 2002.

Nwanekezi, E. C., Alawuba, O. C. G. & Owuamamam, C. I. (1994). Functional properties of raw and heat processed African yam bean (Sphenostilis stenocarpa) and bambara groundnut (Vocandzela subterranean) flours. J. Food Sci. and Tech. 31: 179-201.

Obeng, H. (1994). Soils suitable for large-scale rice cultivation in Ghana. Paper presented at the International Seminar, Towards Rice –Sufficiency in Ghana, 6-7 June 1994, Akosombo, Ghana.

Okaka, J. C. & Porter, N. (1979). Physicochemical and functional properties of cowpea powders processed to reduce beany flavor. J. Food Sci. 44:1235-1240.

Oshodi, A. A. (1992). Proximate composition, nutritionally valuable minerals and functional properties of Adenopus breviflorus benth seed flour and protein concentrate. Food Chemistry. 45: 79-83.

Oteng J. W. (1994). Research strategies for improved rice production in Ghana. Paper presented at the international Seminar, Towards Rice Self-Sufficiency in Ghana, 6-7 June 1994, Akosombo, Ghana.

Otoo, E. & Asuboateng, S. (1996). Survey and reconnaissance characterization of rice environment in southern Ghana, Crop Research Institute, Kumasi, Ghana.

Pillaiyar, P. (1996). Rice: postproduction manual, Wiley Eastern, New Delhi.

Roy P., Orikasa T.; Okadome H.; Nakamura N. & Shiina T. (2011). Processing Conditions, Rice Properties, Health and Environmental. International Journal of Environmental Research and Public Health.

Roy, P. (2003). Improvement OF Energy Requirement in traditional parboiling process. PhD Thesis, University of Tsukuba, Ibaraki, Japan.

Roy P.; Shiina, T. (2010). Global Environment, Biofuel: Sustainable Food production and distribution. In Global Environmental Policies: Impact, Management and Effects; Riccardo,C., Monte, G., (Eds.o; Nova Science publishers: New York, USA;pp.29-58

Roy P.; Shimizu, N.; Kimura, T. (2004). Effect of temperature distribution on the quality of parboiled rice produced by parboiling process. Food Sci. Technol. Res., 10,254-260.

Saeed, F., Imran, P., Faqir, M. A. Hafiz A., Rasul, S. and Muhammad, F. (2011). Effect of parboiling on physico-chemical & cooking attributes of different rice cultivars.

Saif, S. M. H., Suter, D. A. & Lan, Y. (2004). Effects of processing conditions and Environmental Exposure on the tensile properties of parboiled Rice Biosystems Engineering, 89(3): 321-330

Subularse, V. C., Liuzzo., J. A., Rao, R. M. & Gardner, R. M. (1991). Cooking quality brown rice as influenced by gamma irradiation, Variety and storage. Journal Food Science, vol. 56: 96-98.

Schmidt, H. (2010). USA Rice Federation. African Buyer Conference. Nigeria. Available at; www.africanbuyerconference.com/USARicehartwig.pdf (accessed on 28th December, 2010).

Seini, A. W. (2002). Agricultural Growth and Competitiveness under policy Reforms in Ghana. Technical publication No. 61. Institute of Statistical, Social and Economic Research, University of Ghana, Legon.

Shilpa, A. (1996). Nitrogen response behaviour of four rice varieties under wetland culture. Thai Journal of Agricultural Science 30: 195 202

Shitanda, D.; Nishiyama, Y. & Koide, S. (2001). Performance analysis of an impeller husker considering the physical and mechanical properties of paddy rice. J. Agric. Eng. Res. 79, 195-203. Soil Science Society, Bunso, Ghana.

Soponronnarit, S., Nathakaranakule, A., Jirajindalert, A., & Taechapairoj, C. (2006) Parboiling brown rice using superheated steam fluidization technique. Journal of Food Engineering, 75: 423-432.

SRID, MoFA, Report January, (2011).

Tomlins, K. I., Manful, J., Iarweh, P. & Hammond, L. (2002) (in press) Customer acceptability of local and imported parboiled and raw rice in Ghana. Food Quality and Preference.

Tung Chien, J., Chih-Chia, C. & Jon-Wen, L. (1998). Studies on the rehydration rates and swelling power of microwave-popped rice journal of the Chinese Agricultural Chemical Society. 35(4) 365-375

USDA (2009): world rice production. Available online at; http//worldwide-rice-production.html (accessed on 11th September, 2010).

Velupillai, L., Verma L. R., & Tsang Mui Chang, M. (1989): Process for parboiling rice. United States Patent No. 4,810,511.

Vivian, M. F. (1999). Department of food and nutrition province. University Shalu, Taichung 43301. Taiwan 2 Institute of Chemistry, Academia Sinica Nankang, Taipei 11529, Taiwan.

Wan, X. Y. , wan, J. M., Jiang, J. K., Wang, H.Q., Zhai, et al (2006): QTL analysis for rice grain length and fine mapping of an identified QTL with stable and major effects. Thoer. Appl. Genet. 112 1258 1270.

Wang, M., Hettiarachchy, N. S., Qi, M., Burks, W. & Siebenmorgen, T. (1999). Preparation and functional properties of Rice Bran protein Isolate (RBPI) J. Agric food chemistry, 47, pp411-416.

WARDA (2005). Annual Report. Available online at: www.warda.org/warda1/main/publications.htm (accessed on 20th February, 2011).

WARDA (2007): Overview of Recent Development of Sub-Saharan Africa Rice Sector. African Rice Trends, Cotounou, Benin, p.10.

Wynn, T. (2008). Rice Farming: How the Economic Crisis Affects the Rice Industry. A reported presented at the rice producers forum, USRPA, Houston, TX, USA. Int. J. Environ Res. Public Health 2011, 8 12. Available online at; http://www.ricefarming.com/home/2009_JanProducersForum.htm (accessed on 7th May, 2010).

Yang, C. C., Lai, H. M. & Lii, C.Y. (1987). The pasting behavior of some rice starches and flours in different media. Food sci. 14:212.

Zenith, C. (2009). Expert in milling machines at www.zenithcruser.com (accessed on the 19 of September, 2011).