

Parboiling Of Paddy Rice, The Science And Perceptions Of It As Practiced In Northern Ghana

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Abstract: - Parboiling is a set of operations needed for the production of a gelatinized product. Scientifically it is a thermal treatment process done on rice and other cereals. Water and heat are two essential elements to transform the natural cereal into "parboiled" cereal. In rice, it is done to produce gelatinized or parboiled rice. Parboiling, if examined carefully has other scientific benefits beyond easy milling and reducing broken grains. Unfortunately, the technology has received little attention in terms of research as far as food processing or preservation is concerned. As part of an ongoing research to assess the extent to which parboiling affects the migration of vitamin B1, a preliminary survey was conducted between October, 2012 and December, 2012 in the three northern regions of Ghana to elucidate the scientific principles behind the practice and to what extent processors understand these principles. This work also aimed at highlighting the practice so as to encourage people to adapt indigenous technologies which may have more beneficial health effects. Eighty (80) processors in the three northern regions drawn by purposive sampling methods were interviewed using structured and semi structured questionnaires. The results showed that 100% of the people engaged in parboiling business are women with over 70% of them having no formal education and therefore are unaware of any effects of parboiling on nutritional elements. It became clear that parboiling increased the flavour and taste of the rice thus making it attractive to eat. However, the respondents only mentioned less broken grains, easy dehusking, ease of cooking, increase quantity, better prices, and parboiling being a norm as some of the reasons why they carry out rice parboiling. From the outcome of this survey it's recommended more studies be done on the subject to ascertain the nutritional impact of the practice. Also, the processors need to be trained on parboiling and nutrition to build their knowledge on the scientific advantages of the process to enable them improve their practices.

Index Terms: - Parboiling, Gelatinized, Paddy rice, Physical qualities, Northern regions

1 INTRODUCTION

Parboiling of paddy rice is carried out in the three Northern and Volta regions of Ghana. This indigenous technique is done to have easy milling as well as reduce breakages during milling. The processes involve soaking the paddy in hot water usually between 10 to 24 hours in order to saturate the paddy with moisture. The soaked paddy is then steam heated till they gelatinized. They are then dried and milled. Paddy rice parboiling process is an old practice done several years ago. More than 1000 years ago parboiling was done in simple clay pots to improve "shelf life" and resistance against insects (Joachim, 2011). The treatment is practiced in many parts of the world such as India, Bangladesh, Pakistan, Myanmar, Malaysia, Sri Lanka, Guinea, South Africa, Italy, Spain, Thailand, Switzerland, USA and France (Pillaiyar, 1981). West Africa and the Caribbean African diasporas are also accustomed to parboiling rice. Parboiled rice has cross culture relevance and is accepted by a number of tribes (Joachim, 2011). In India and Pakistan it's noted for its good storage properties and special taste. It is also appreciated in North America and Europe for easy cooking properties and low breakage during the milling process. African countries have adopted parboiled rice in their local recipes because of the good storage properties which reduces storage losses. In many African countries where rice production and consumption are assuming an increasing rate, parboiling is also practiced alongside production. In Nigeria parboiling of paddy rice is done in the Oyo, Denu and Goweri states using traditional techniques with manual equipments (Kaddus Miah et al., 2002). In the northern part of Ghana, especially in the Upper East region, not only rice that is parboiled but also millet, sorghum and shea nuts. Whatever the situation, parboiling is an important practice to the rural folks in the area of food preparations, processing or preservation. The process of parboiling is likely to drive nutrients, especially thiamine, from the bran to endosperm according to Tzia and Karathanos, (2011), hence parboiled white rice is 80% nutritionally similar to brown rice. The traditional parboiling process involves soaking rough rice overnight or longer in water at ambient temperature, followed by boiling or steaming

the steeped rice at 100°C to gelatinize the starch. The grain expands until the hull's lemma and palea start to separate (Gariboldi, 1984). The parboiled rice is then cooled and sun-dried before storage or milling. The degree of starch gelatinization is responsible for many of the attributes of parboiled rice (Marshall et al., 1993). During the process of gelatinization, alpha-amylose molecules leach out of the micellar network and diffuse into the surrounding aqueous medium outside the granules (Hermansson and Svegmarm, 1996). The granules become fully hydrated, producing a maximum in the measured viscosity (Eliasson, 1986; Helbig et al., 2008). The starches in parboiled rice become gelatinized, and then retrograded after cooling. The parboiled rice kernels should be translucent when wholly gelatinized. Retrogradation is where amylose molecules re-associate with each other and form a tightly packed structure. This increases the formation of type 3-resistant starch which can act as a probiotic and benefit gut health in humans (Helbig et al., 2008). Marshall et al., (1993) reported that incomplete parboiling result in partial surface starch gelatinization. The dried kernels produced translucent outer layers and an opaque or white centre from the non-gelatinized starch (Kaddus Miah et al., 2002). Although the effectiveness of proper parboiling in improving the physical quality of milled rice is well known (Bhattacharya and Subba Rao, 1966a; Juliano et al., 1981; Marshall et al., 1993), this may not be so in the case of the rural poor processors who are into parboiling as a business to cater for themselves and their families.

2.0 MATERIALS AND METHODS

The study was carried out in the three northern regions of Ghana where rice parboiling is practiced most. Rice cultivation in this part of Ghana is being encouraged by several policies of the government aim at boosting local rice production and consumption. with support from NGOs and other organizations, parboiling of paddy rice has now become a commercial business activity where rural women are organized into groups and are supported with funds to undertake parboiling in commercial quantities. Parboiling is also carried out almost in every home that cultivates rice for

home consumption. Purposive sampling was used to get the study areas and the respondents as well.

The study districts were; Tamale Metropolis and Tolon-Kumbungu district in the Northern Region, Bolgatanga Municipal in the Upper East Region and Wa municipal in the Upper West Region. One processing group and fifteen households were selected in each district. Five processors were interviewed at each processing group and one processor at every household. Structured and semi-structured questionnaires were administered to respondents to get an overview on how parboiling process is done and the objectives of the practice. After which an observation was made on the parboiling activities and the steps recorded.

2.1 Statistical Analysis

The data collected was analysed using a descriptive statistic package (Statistical Package for Social Scientist or SPSS) and the results interpreted and presented on tables and charts.

3.0 Results and Discussions

The survey showed that parboiling business is a feminine dominated activity as all respondents (100%) were females (Table1).

Table 1: Sex of rice processors in the three northern regions.

Metro/Municipal/ District	Sex	
	Males	Female
Bolga Municipal	0 (0)	20 (25)
Tamale metro	0 (0)	20 (25)
Tolon Kumbungu	0 (0)	20 (25)
Wa Municipal	0 (0)	20 (25)
Total	0 (0)	80 (100)

Values in parenthesis are percentages

In the northern part of Ghana males tried to refrain from kitchen activities as much as possible as a norm. Since parboiling is a kitchen activity males are not directly involved in rice parboiling process. Females practice the processes as they learn how to cook from their mothers. Most of the respondents' therefore have over 20 years experience in parboiling. They therefore conduct this activity base on experience than on facts and guidelines. This can cause them to at times ignore certain steps that can have an effect on the final product. As a feminine dominated activity, it has not attracted much attention of the researchers who are predominantly males. This might account for parboiling not having guidelines developed to suit the northern local circumstances. It also became clear from the survey that formal education was very low among the respondents. About 71% of them had no formal education and about 16% attained primary or elementary education. (Table 2.)

Table 2: Educational status of respondents

District/ Metropolis	Educational status of respondents				
	No education	Primary / Elementary	JSS/JHS	SSS/SHS	Tertiary
Bolga-Municipal	12 (30)	4 (10)	2 (5)	1 (2.5)	1 (2.5)
Tamale Metropolis	14 (35)	3 (7.5)	1 (2.5)	1 (2.5)	1 (2.5)
Tolon-Kumbungu	16 (40)	2 (5)	1 (2.5)	1 (2.5)	0
Wa-Municipal	15 (37.5)	4 (10)	1 (2.5)	0	0
Total	57 (71.25)	13 (16.25)	5 (6.25)	3 (3.75)	2 (2.5)

Figures in parenthesis are percentages

It was clear that the literate population in Northern Ghana was low especially amongst women. It is therefore not surprising that majority of the respondents (71%) have not formal education. Eighteen (18) of them representing 22.5 % had basic education while 5 respondents representing 6.25 % had post basic education. This high number of illiteracy could have a negative effect on their activities and the final product as well. Also, the low number of literates' persons in the parboiling business might be explained to mean, the few literate women don't consider parboiling as a satisfactory job and therefore will not engage in it hence the low level of literates among the practitioners (Table 2). The respondents gave the advantages of parboiling to include; easy milling, better pricing, easy cooking etc. Eighty percent (80%) was attributed to easy milling as the main reason why they undertake parboiling. They said, parboiled rice does not break when milled or pounded and it takes less time to mill as compared to none parboil rice. Marketability was next (60%) as reason for parboiling. According to them, parboiled rice sell faster and therefore reap in more returns than straight milled rice, may be due to the less broken grains of parboiled rice when milled. However, straight milled rice looks whiter and thus attracts more consumers who look at appearance rather than nutrients availability. Also respondents said parboiled rice increased in quantity and therefore making returns on sales higher. Thus if you dehusk 10 kg of paddy raw, the quantity of grains you will get shall be less compared to the same 10 kg paddy parboiled before dehusking. About 27.5% and 12.5% were attributed to easy cooking and taste improvement respectively for being the reasons of parboiling. According to them, parboiled rice takes less time to cook, and the cooking is easier to the extent that even men can cook it. This agrees with Joachim (2011) who said, one advantage of parboiling to the consumer is, the less knowledgeable house wives (and men) in Northern Europe and North America can easily prepare good granular rice on the plate. None-parboil rice has lots of broken grains after milling and when cooked, the broken ones get over cooked and stacked together, whiles the

wholesome grains amongst them remain uncooked. Such rice will need special regulation of heat supply before the rice can cook well. This poses a serious challenge to inexperienced cooks. Few of them (10 %) mentioned that parboiling helps improve the hygiene of the rice. No respondent (0%) mentioned nutritional improvement as a reason for parboiling though when quizzed they agreed parboiled rice tastes better than non-parboiled rice (Figure 1). It therefore means issues of nutritional improvement particularly the soluble B vitamins are not taken into account by these processors when conducting parboiling practices.

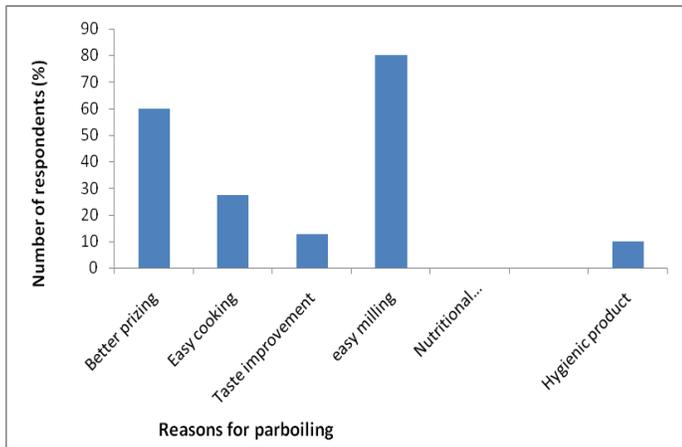


Figure 1: Reasons for parboiling paddy rice as reported by processors in northern Ghana.

3.1 Methods of parboiling paddy rice

The survey showed that the processes of parboiling have been categorized into three forms. These were the traditional methodology, improved methodology and modern methodology of which the first two are practiced in Ghana. The traditional methodology uses simple tools like earthen or metal cooking pots and a nearby stream or dam serves as source of water. The paddy is not cleaned before soaking and the intensity of heat supply was high. Also the volume of water used at soaking and steaming stage is the same. The modern parboiling method employs sophisticated tools like tanks, electric heaters, steam pipes etc and state of the art equipment to do the soaking, steaming and drying processes. The improved methodology is a combination in bits of the traditional and modern methods (Figure 2). In the improved methodology, pre-soaking activities such as washing, destoning, separation of immature seed etc. are carried out. Soaking is done in warm water not boiling water. Also, little water is used at the steaming stage as compared to the high volume of water used in traditional methodology that will usually cook the paddy at the end of process.

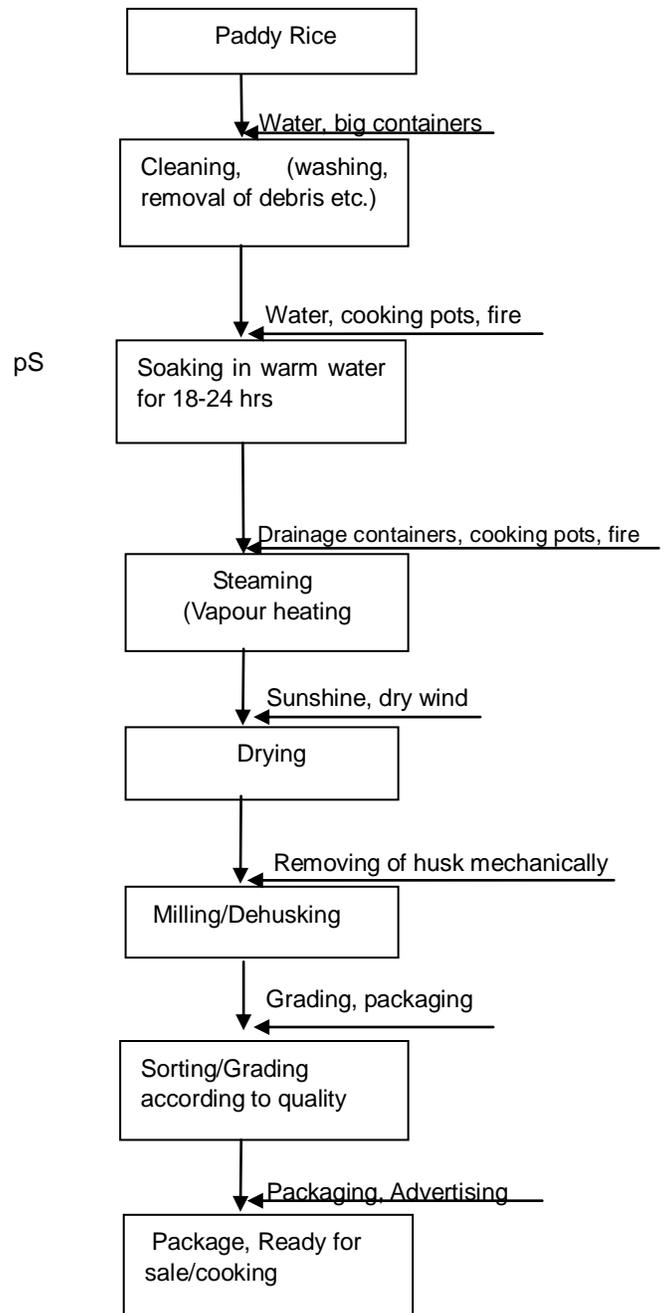


Figure 2 a. Steps of improved method of parboiling paddy rice.

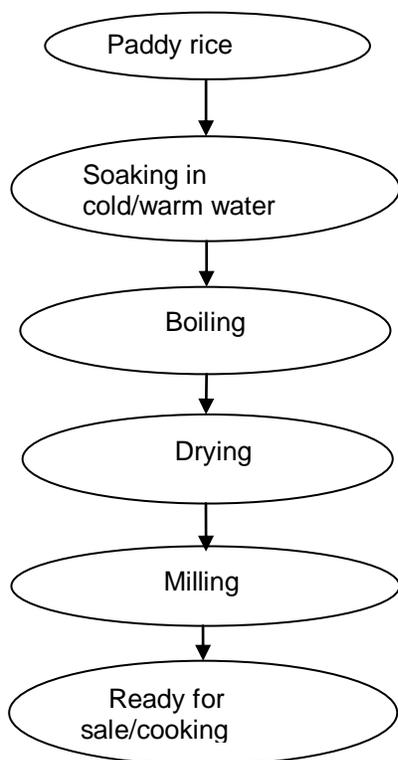


Figure 2 b. Steps in Traditional methods of parboiling paddy rice.

3.2 Procedures and processes of parboiling paddy rice

The observed unit operations involved in paddy rice parboiling processes includes;

3.2.1 Sieving: This is done if there are broken grains in the paddy. A wire netting is used to sieve to separate the broken kernels so that they will not get cooked and stick the content together during parboiling. Thick viscous liquid arising from cooked broken-kernels usually stack the paddy together and hampers effective speedy drying. This could lead to fungal growth and spoilage of the rice if care is not taken.

3.2.2 Washing, Floatation and Sedimentation: The paddy is submerged in water and stirred vigorously for the soil and other dirt to dissolve out. The lighter debris float while the heavier materials settle at the bottom. The floating debris (dead insect parts, weeds, unfilled seeds etc) are skimmed off while the paddy rice is scooped out leaving heavier materials (sand, stones, pieces of metals etc.) at the bottom and poured away. Washing is done twice or thrice depending on the extent of dirt in rice. Scientifically, the washing removes dirt, debris and fungal toxin found in the rice.

3.2.3 Boiling: The washed paddy is then submerged in water on a pot and partially boiled to a warm temperature of 35 to 40°C. This enhances uptake of water by the paddy, and also deactivates certain enzymes activities. Some microbes and their cellular products could be killed or inactivated at this temperature.

3.2.4 Soaking: The paddy rice is left to stay in the warm water overnight (10-24 hours) for the paddy to imbibe water and become moisture saturated. The scientific principles here are enzymes activation. A conducive environment is created after content is cooled down for enzymes and pigments transformation. Toxins are diluted and microbial pathogens may be inactivated or removed at such high moisture level. The saturated grains expand and fill the hull's lemma making it lose in the process.

3.2.5 Steaming: The soaked paddy is then steamed in a pot with little water lining the pot. The high moisture content in the grain is used to gelatinize the starch during the steaming process. The steam is made to reach all sections of the pot by covering with jute sacks and polythene sheets. The covering prevents the steam from escaping easily thereby creating a partial pressure over the content that aid in inward movement of molecules in each gelatinous kernel. When paddy begins to crack open their husks and there is steam vapour arising all over pot it is an indication that steaming is enough. The heat also evaporates extra moisture in the grain leaving concentrated nutrients in the kernel. The high temperature up to 80°C is able to inactivate or kill some microorganisms and degrade toxins and other poisonous substances present in the rice. Physico-chemical reaction processes e.g gelatinization, starch retrograding, pigment transformations, enzymes deactivations etc. are all facilitated by the pressurized steaming process. This brings about improved flavor, colour-change and cooking characteristics of the rice.

3.2.6 Drying: The steamed paddy is spread out quickly at an airy place to dry. Excessive sunshine is avoided otherwise non-uniform drying of kernel which results in breakage during milling. Other scientific advantages of the drying processes could be; i) the art of drying evaporate the moisture and this concentrates solutes in the kernel ii) drying will also stop microbial pathogens from developing on steamed paddy. iii) it compresses the gelatinous amylose starch together in a compact mass and delocalizes it from the husk making de-husking (milling) easier.

3.2.7 Milling: The dried paddy is milled using a milling machine or, at the local level is pounded using mortar and pestle to separate the kernels from the husk. This process also has the ability to remove pathogens and other dirt's that stick to the hulls.

3.2.8 Winnowing: Winnowing is done either mechanically or manually. Where milling is done manually using mortar and pestle to pound the paddy rice, the rice is winnowed to separate the husks and foreign materials away. Winnowing help to remove dirt, dead insects, and other impurities still present in the rice.

3.2.9 Sorting/Grading: Commercial parboiling groups go further to do handpicking of discolored rice and foreign materials before sorting in to grades (grade 1, 2 and 3) as, very few, few and many broken grains respectively).

3.3 Category of processors and type of methodology

Majority of the respondents (65 %) practice the traditional method of parboiling while only 35% uses the improved procedure (Table 3). It was also observed that individual

processors who parboil for home consumption or for sale were the people who practiced the traditional methodology most (Table 3). These individual processors explained that the improved methodology was laborious and wastes more water than the traditional methodology. However, the low educational level among them might have influenced their choice of the traditional methodology, since they cannot easily conceive the advantages of the improved methodology as against it challenges. In the case of grouped processors who are usually organized by NGOs, they observed these pre-soaking treatments seriously.

Table 3: Category of processors and type of methodology used.

Category of Respondent	Methodology	
	Traditional Method	Improved Method
Organised group processors	0 (0%)	20 (25%)
Individual processors (self consumption)	28 (35%)	0 (0%)
Individual processors (Commercial)	24 (30%)	8 (10%)
Total	52 (65%)	28 (35%)

Figures in parenthesis are percentages

Traditional way of parboiling means pre-treatments processes like washing, floatation, separation of immature seeds, destoning, sieving etc are not done to the paddy before soaking. There were some variations in the traditional methodology as practiced in the various districts. For instance, individual processors in Bolga Municipality soak their paddy in warm water and the paddy was left in the warm water overnight. But in Tamale metropolis, the paddy boiled in hot water till it was about to cook. Also, at the steaming stage processors in Bolga Municipality will use little water, just enough to line the surface of the steaming container while those in Tamale will use more water that was enough to further cook the paddy. The improved methodology which was an improvement of traditional procedure was uniformly practiced among grouped processors in all the studied areas. Also, processing groups do undertake post milling practices like separating discoloured grains, sorting into grades and packaging before sales. According to respondents, the procedures in the improved methodology started in Bolgatanga in the Upper East region and spread to other regions where organized groups adopted it. Thus this improved methodology or procedure is termed Bolga – Bolga procedure (Bolga-methodology).

3.4 Scientific principles (reasons) behind parboiling.

Apart from the above reasons, processors could not give other scientific benefits of parboiling. Even nutritional improvement, a common idea as far as food processing is concern was not mentioned because they cannot get the synergy between parboiling and nutrition let alone movement of water soluble vitamins in rice. This could be traced to the low level of formal education of processors hence their inability to figure out the scientific principles and advantages behind parboiling like

inactivation or killing of microbes, and dilution of possible poisons. Since it takes academic knowledge at a certain level to comprehend nutritional characteristics of food, especially vitamins, the low level of formal education among the processors, would surely have an effect on nutritional issues on their product. Though not mentioned, nutritional improvement, especially vitamin B1 (thiamine) enrichment might be one of the important advantages of parboiling process. In 2001, Otegbayo et al studied the effect of parboiling on physico-chemical qualities of two local rice varieties in Nigeria. According to Ibukun, (2008) their results indicated that parboiling reduced the breakages, fat, protein and amylose content of the rice while the water uptake and thiamine contents were increased. Also the pre-treatments given to the rice before the parboiling process help remove factors that could antagonized the nutritional qualities of the rice. Firstly, washing paddy rice in water removes dirt, microbes and their toxins in the rice. The long hours of soaking in warm water do not only facilitate water absorption but also further reduces the substances like aflatoxins that are in the rice during storage (old stock). This is because the absorption of water to a saturation point would dilute and reduces the concentration of toxic substances in the rice. The soaking might also cause certain enzymes or pigments transformation and their movement inwards to the endosperm. The steaming to a temperature of 80°C supplies heat enough to kill pathogens still found in the rice. The activity of pressurized steaming enabled vitamins notably thiamine to move inward onto the endosperm. It further deactivates enzymes and make available substances like vitamins that otherwise could have been inaccessible. The transformation and concentration of enzymes and pigments could be the reason why parboiled products such as millet, groundnuts, rice etc tastes better than non-parboiled ones. In rice parboiling the important nutritional and physiological change is the active movement of soluble molecules. Much of the rice nutrients are concentrated at the embryo (the germ) and during the steaming process, the partial pressure created by covering directs solutes movement inwards onto the endosperm through the aleurone layer that surrounds the endosperm. Other advantages are easy milling of parboiled paddy rice because the amylose starches retrograde and stack together in a compact manner that pulls away from the husk when dried. This makes the kernel becomes somewhat delocalised and now moves freely inside the husk. This makes it easier for husk to be removed when milled or pounded on mortar and pestle. Since the point of attachment between the husk and the endosperm is also loosened, the husks can easily get removed without breaking off the germ. Non-parboil rice has its husk intimately attached to the embryo where all the nutrients are concentrated. Forceful removal of the husk will usually breaking away the germ with the husk, thereby losing all the vital nutrients including thiamine. And such rice will certainly not taste the same as rice that retains its germ or embryo after parboiling. Thus the process of parboiling inadvertently cures nutrient deficient-diseases or has the ability to supply certain nutrients that otherwise could have lost to consumers. A number of NGOs and some government agencies have begun training women to improve their parboiling activities. Their efforts all along has been on how to improve head rice yield (HRY) and eliminate stones in the rice in order to get good market but not the nutritional aspect.

4.0 Conclusion and Recommendations

Parboiling of paddy rice is an important processing technique that has many advantages. This indigenous technology was able to curtail all unwanted processes, both latent and ongoing (germination, proliferation of molds or spores, eggs, grubs, pupas, adult insects etc), are completely inactivated or eliminated. Apart from the physical and economic advantages such as better storage, insect resistance, easy milling, better prizing etc, there are also nutritional benefits like enrichment of water soluble vitamins at the endosperm. Majority of the processors are women, with little or no education. They carried out the practice without understanding the scientific principles or advantages that underscores those activities. They are unaware of the important health benefits that their practices bring to the public. There is the need to further investigate the effect of the unit operations involved in the parboiling processes so as to improve on them in terms of minimizing cost as well as improving quality. The processors and other actors in the rice value chain need to be trained on parboiling and nutritional relationship to build their capacities. This will enable them appreciate the importance of their activities. If they are sensitized and their capacities built they could improve their practices to be more beneficial health wise. This shall also enable them get good market as they can explain to the understanding of consumers the benefits of their products over imported rice.

5.0 References

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