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An Exclusive Assessment on the Effect of Parboiling on Rice Paddy: A Review

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Abstract: *Rice is a staple food accepted as the most important cereals in the world. But before it is consumed, it will undergo different stages of processing to remove the hull, bran and germ from the rough rice kernel which is either parboiled or not. This paper review and analyzes the effects of parboiling on different varieties of rice from different countries. The results show a significant improvement from the new methods in used now. For all the varieties study/experiment conducted shows soaking and steaming affected the physico-chemical properties while steaming completely gelatinized the rice starch during parboiling process. Parboiling reduced the breakage, fat, protein and amylose content of the rice while cooking time, water uptake and thiamine content were increased. This paper suggested an improved method without wasting too much soaking time and temperature during the process. It can therefore be inferred that parboiling which has been the means of processing rice can be a way of improving vitamin content and milling properties of rice and should attract the interest of food technologist and food processing industries to keep on improving in order to produce good quality parboiled rice that meets consumer need and satisfaction.*

Key words: *Paddy, Oryza sativa japonica, Oryza sativa indica.*

1. INTRODUCTION:

Rice (Oryza Sativa) is one of the leading crops in the world. In 2010, the global rice production was 696 million tons. More than 90% of the world's rice is grown and consumed in Asia by 60% of the world's population on about 11% of the world cultivated land (FAO, 2010).

Rice, like barely and oat, is harvested as a covered grain, which is called rough rice (also referred to as paddy).Rough rice, consists of a white, starchy endosperms surrounded by tightly and having bran and germ within a hull. The hull surrounds, but is not bound to the grain and constitutes about 20-25% of the rough rice mass (Champagne,2004: Delcour and Hoseney, 2010).

Several investigation has shown that about 20% of the rice produced worldwide is parboiled, i.e. "partially boiled". This three step hydrothermal treatment involves; soaking, heating and drying of rice and is performed either on rough or on brown rice. Parboiling has a considerable impact on the texture and nutritional characteristics of cooked rice. In particular, cooked parboiled rice is firmer, less sticky and more nutritious than its cooked raw counterpart.It is also generally assumed that parboiling increase HRY.Parboiled rice has a darker color than raw rice and slightly different flavor (Bhattacharya, 2004; Delcour and Hoseney, 2010).

2. REVIEW OF PREVIOUS METHOD/TECHNOLOGY.

Raghavendra. (1970) ***effect of parboiling on some physicochemical properties of rice***: The experiment was conducted using seven varieties of rough rice and selection ranging from 2 to 27% of brown-rice amylose content was used to study the effect of parboiling on grain properties. They used samples of IR8,Acc.9800,Palawan,PI215936,Century Patna 231XSLO17,IR35-23-2,and IR253-16-1-2 rough rice which was obtained from the experimental farm in the institute(International Rice Research Institute,Los Banos,Laguna,Philippines).The experiment were conducted in a laboratory using different method to ascertain both the physical and chemical properties. The rice varied in age (storage time at 20^0c since harvesting) from 0.1 to 11 months at the time of parboiling while 2 to 3kg was soaked in water about 5^0c below the gelatinization temperature for 6 to 7 hours, drained, steamed for 14 minutes in an autoclave. They conducted the physical test on mean length and width of 20 kernels of rough, Brown, and milled rice were determined, while the hardness of brown rice was estimated from 10 Kernels using Kiya-type hardness tester (Vidal and Juliano, 1967).

Table II. Protein, Amylose, and Brown Rice Amylogram Data of Raw and Freshly Parboiled Rices of Seven Varieties and Selections

Variety/Selection	Treatment	Protein, %	Amylose, %	IBC, %	Gel. Temp., °C.	Gel. Time, min.	Temp. at Peak Visc., °C.	Viscosity, B.U.[a] Peak	Initial at 94° C.	After 20 min. at 94° C.	Cooled to 50° C.
R8	Raw (5.5)[c]	7.57	27.2	5.88	68.5	15	93	1010	1000	800	1570
	Soaked at 65° C.	7.78	27.5	5.83	67.5	16	94	1110	1110	980	1650
	Parboiled	7.45	27.4	6.12	71.5	23	94	350	120	350	530
R8[b]	Raw (0.5)[c]	10.2	28.9		63	15	88.5	950	885	790	1395
	Parboiled	10.0			82.5	18	94	705	400	695	1200
Acc. 9800	Raw (0.1)[c]	9.58	24.9	5.29	73.5	11	93	690	560	385	630
	Parboiled	9.44	23.4	5.43	79.5	17	94	330	225	325	605
Palawan	Raw (1.5)[c]	8.57	23.2	5.15	72	11	91	780	520	385	645
	Parboiled	8.20	22.9	5.05	76.5	13	94	600	540	535	960
PI 215936	Raw (1)[c]	9.61	18.8	3.26	66	17.5	93	420	410	230	380
	Parboiled	9.56	16.7	3.12	72	16	94	510	460	495	720
CP 231 × SLO 17	Raw (11)[c]	11.2	15.4	3.23	76.5	8.5	92	820	600	420	640
	Parboiled	11.1	14.6	3.10	78	8	93	850	700	525	765
CP 231 × SLO 17[b]	Raw (0.5)[c]	9.20	15.0		75	7	88	890	510	455	580
	Parboiled	9.06			75	10	94	940	935	680	950
IR35-23-2	Raw (1)[c]	12.8	7.5	2.40	75.5	8	90	950	520	435	630
	Parboiled	12.7	7.7	2.44	57	20	91	690	615	570	790
IR253-16-1-2	Raw (1)[c]	10.6	2.0	0.81	64	5.5	75.5	415	305	290	355
	Parboiled	10.6	2.0	1.02	32	33	84	410	375	340	415

[a] 11% paste. B.U. = Brabender units. [b] Additional samples. [c] Age of samples in months.

Table III. Amylose and Brown Rice Amylogram Data of Five Raw and Parboiled Rices after Storage for Eight Months

Variety/Selection	Treatment	Amylose, %	IBC, %	Gel. Temp., °C.	Gel. Time, min.	Temp. at Peak Visc., °C.	Viscosity, B.U.[a] Peak	Initial at 94° C.	After 20 min. at 94° C.	Cooled to 50° C.
Acc. 9800	Raw (8.1)[b]	21.4	4.09	82	5.5	93.5	960	820	620	790
	Parboiled	20.5	4.30	87	6.5	94	480	300	480	815
Palawan	Raw (9.5)[b]	20.5	4.22	73.5	10	92	955	860	580	660
	Parboiled	20.0	4.17	84	7	94	670	520	640	995
PI 215936	Raw (9)[b]		2.23	75	9	93	640	640	450	515
	Parboiled		3.06	79.5	20	94	460	240	450	720
IR35-23-2	Raw (9)[b]		2.38	76.5	7	90	1065	700	525	735
	Parboiled		2.03	85	11.5	94	550	420	560	725
IR253-16-1-2	Raw (9)[b]	3.3	0.39	66	4.5	75	660	550	520	490
	Parboiled	3.0	0.47	40.5	27	81	400	365	340	400

[a] 11% paste. B.U. = Brabender units. [b] Age of samples in months.

Another hardness test consisted of disintegrating 10 Kernels of brown rice in Wig-L-Bug amalgamator for 40 seconds for determining the percentage by weight that passed through an 80-mesh sieve. They used Little. (1958) to determine the Alkali test on whole milled rice, while the cooking time was determined by the method of Ranghino (1966) after the rice has being milled. Batcher (1956) method was used for the cooking test for just 10 minutes. Pre-soaking minimized the difference in cooking time between raw and parboiled samples. Selection of raw and parboiled samples were prepared and stained according to Del Rosario (1968) method, while the brown rice was analyze for crude protein (Nx5.95).parboiled and raw rough rice were stored for 8 months in a sealed bin at an ambient temperature and bimonthly samples were drawn, dehulled, milled and tested for amylograph and cooking time values

The results of the experiment show that many physical properties of rice kernel were altered by parboiling treatment while the 100 kernel weight of the rice did not change. Three varieties including the waxy IR253 selection, has essentially the same dimensions for both raw and parboiled. They agree that parboiling resulted in interesting changes in the amylograph curve of rice pastes. The changes in amylograph characteristics of the rice samples on parboiling may be partly ascribed to their difference in amylose content. They opined that aside from the loss of viability of rice, parboiling affected the physical more than the chemical properties of the grain. They recommended that various aspect of parboiling and aging requires further study to resolve conflicting results and to determine the cause or causes of the observed reduction in solubility of starch and protein.

Hiromichi. (1983) ***effect of parboiling on texture and flavor components of cooked rice*****:** The experiment was conducted using samples of Nakateshinsembon variety of rice (oryza sativa L. Japonica) and Bluebonnet variety of rice (oryza sativa L.indica) harvested in Hiroshima prefecture, Japan, and that of Koshihikari variety of rice (oryza sativa L. japonica) harvested in Niigata prefecture, Japan, were used. An experiment process line was used for parboiling of these samples. The samples were soaked in water for 50^{0}c under atmospheric pressure for 170min and steamed at 115^{0}c under 0.5kg/cm^{2} for 15min.After the aerated at 45^{0}c for 7min until the moisture content had decrease to 29%,the steamed rice was dried in two steps; that is first at 50^{0}c for 10 hours to a 20% moisture content and second at 30^{0}c for 10 hours up to 15% moisture content, while the milling yield was 91-92% of the brown-rice samples for each samples using the test mill model TM05.other raw and parboiled brown-rice samples were milled with a satake two-in-one pass rice whitening and caking machine.

They discovered that the milled parboiled thus obtained had a pale amber and transparent appearance which indicated that it had been completely parboiled….while the milled rice samples were stored at 4^{0}c in polyethylene film bags. Other parameters consider were the physical measurement using the method of Tsugita (1983),extractability of protein by a modification of the percolation system described by Cagampang (1966), crude lipid was treated according to the method of Lee and Mattick(1964)to obtain the free fatty acid fraction. Fat by hydrolysis was extracted using Yasumatsu and Moritaka (1964) method using 20kg of milled flour rice with diethyl ether and petroleum ether successively for 30hours using a soxlet apparatus to obtained the unbound lipid fraction. Other parameters used include; Lipid Bound to Protein, Free Phenolic Acids, and Headspace Volatiles of cooked Rice, Steamed-Distilled Volatile concentrate of milled rice, GC and GC-MS Analysis. The results obtained by the their experiment shows that the milled parboiled brown-rice samples of Nakateshinsembon showed a significantly smaller expanded volume and water-uptake than the milled unparboiled rice.

While similar results have been reported by Raghavendra Rao and Juliano (1970) with the use of rough rice samples of indica rice. Cooked parboiled rice had a harder, more cohesive, and less sticky texture than cooked, unparboiled rice in the case of both Nakateshinsembon and Bluebonnet. Cooked parboiled and unparboiled Bluebonnet rice showed greater hardness and cohesiveness and less stickiness than in the case of Nakateshinsembon.

Also similar experiment was conducted by Okabe (1979) reported "texturogram" showing the relationship between the textural characteristics of cooked rice and acceptability, as judge by a trained panel of Japanese. According to Okabe (1979) cooked, unparboiled Nakateshinsembon rice was evaluated as being excellent for Japanese, and cooked parboiled Nakateshinsembon rice was slightly poor but acceptable, and further both cooked, parboiled and unparboiled Bluebonnet rice were evaluated as being unacceptable for Japanese, though the latter was preferable to the former. These objective evaluations indicate the acceptability of parboiled japonica rice and the unacceptability of parboiled indica rice for Japanese.

These results also agree with the actual sensory evaluation by members of the laboratory team for respective cooked rice.

Otegbayo. (2001) ***effect of parboiling on physico-chemical Qualities of Two Local rice Varieties in Nigeria*****:** The experiment was conducted using two varieties of local rice in paddy form. The samples were collected from local farmers at Okemesi Ekiti in Ekiti state of Nigeria (western Nigeria) The rice samples were the type of varieties consumed in Nigeria (Oryza glabarrima steud), but is known to the locals as Offanda (white variety) and Alaso-osun (Brown variety).The rice varieties were stored for 180 days after harvesting.25kg of each of the local varieties in paddy were divided while half was parboiled. Cleaned paddy were soaked in water at room temperature (below the gelatinization temperature of rice to minimize the splitting of the grains), to hydrate the grains in a steeping tank for 5-8hours.parboiling was done in the laboratory by the pressure parboiling method of Iengar (1980),in this method the paddy rice was not saturated with water but briefly exposed to steam under high pressure using autoclave to gelatinize the starch for 15minutes at 15 p.s.i.g. pressure(121^{0}c).the parboiled paddy rice was then tempered for 30min to cool and air-dried in a cabinet dryer at 45^{0}c for 8hours.both the raw and the parboiled rice samples were milled in a grantex mill.

The results from the study shows that parboiling as a means of rice processing affects both the physical and the chemical properties of the grain, it improves milling and cooking qualities of the rice grains in a positive manner which has been found to influence consumers demand and acceptability. The increase in thiamine content of the parboiled rice can also serve as an effective means of improving the thiamine intake in people's diet thereby enhancing their nutritional status. They opined that parboiling which has been the means of processing rice in Nigeria can be a way of improving vitamin content and milling properties of rice and should attract the interest of food technologist and food processors to develop the rice industry because the two rice varieties used in the experiment shows high content of protein between 6.86-8.75%, this therefore means that the rice could be a major source of protein and diet for Nigerians if consumption is adequate.

Bhattacharya. (1966) ***effect of processing conditions on Quality of parboiled Rice*****:** The experiment was conducted using two varieties of rice in India popularly known to the locals as Bagara sanna(BS)and Ratna Chudi(RC) in semi parboiled paddy(rough rice).Only whole grains handpicked from the well mixed and cleaned samples were used for this experiment. The parameters obtained throughout the methods includes; coking quality of rice, cooking of rice in water and color of rice. However the results obtained shows that soaking above 60^{0}c affected the quality of rice, it shows that the greater the severity of heat treatment during soaking and steaming the lower the water uptake and the darker the color of rice. When it was soaked above 70^{0}c and above it will have a relatively effect on the color, while steaming above 60^{0}c will have effect on the processing conditions on quality.it was observed that beside nonenzymatic browning, the husk pigment and the bran also appeared to contribute to the color of parboiling rice. Parboiled rice specification was determined from the characteristics of its reflectance.

They opined that the cooking quality and color of rice were affected by the severity of heat-treatment during soaking and steaming. Quick cooling after parboiling may be the most important factor in industrial-scale operations. They discovered two factors which are the chief contributors to the quality of parboiled rice; the first being the discoloration during parboiling which is due to nonenzymatic browning of the maillard type inhibited by bisulfie, while the other factor is the husk pigment which also contribute by diffusing into the endosperm or by being absorbed on splitting of the grain during soaking.

Previous studies conducted were conducted on different varieties of rice. Roberts. (1954) studied the effect of certain conditions on the color, expanded volume, and soluble starch content of parboiled rice.Quarat (1962) observed certain dimensional changes in the grain after parboiling and alterations in its starch grannules.Kurien (1964) noted similar grain-dimension changes and studied the effect of steaming on the cooking of quality of the rice. A more comprehensive investigation covering wide processing conditions was desirable

3. REVIEW OF CURRENT METHOD/TECHNOLOGY

Graham. (2015) ***effect of soaking and steaming Regimes on the quality of Artisanal parboiled Rice*****:** The experiment was conducted using an improved high yielding aromatic upland variety of rice in Benin Republic. The sample used was grown in August-December 2012 planting season by the Africa Rice Center (Africa Rice) in Lokossa (Kinwedji) in Benin. The sample was dried to a moisture content of 13% before use. A CRCD of the experiment was set up using Statgraphics centurion XVII software(Standpoint Technologies inc;Warrenton VA)with two factors(K=2) namely IST(30-90^{0}c)and STM(5-20min).Fourteen treatment combination (table 1) were performed on the sample. The responses measured were water absorption during parboiling (WAP), milling (brown rice, total milled rice and head rice) recoveries, appearance (chalkiness and color), cooking properties (cooking time, water uptake, volume expansion, texture (hardness and stickiness) of food grains and pasting properties (PV, Tr, BD, FV and SB).

They agree that parboiling, a hydrothermal behavior has been identified as a key method used to improve the quality and effectiveness of locally produced rice. The process of parboiling seals internal fissures in the rice grain initiating in higher HRY during milling (Manful. 2009). Milled parboiled rice has also been reported to have lower glycemic indices, higher resistant starch content and higher contents of B vitamins than milled non-parboiled rice (Jenkins. (1988). Luh and Mickus (1991); Newton.(2011); Odenigbo.(2013). In addition to the improved milling and nutritional properties, parboiled rice has also been touted with a set of unique cooking, flavor and textural characteristics that are appealing to certain groups of consumers.

An extra of specific methods exist for producing parboiled rice, however, the central processes remain the same and comprise soaking paddy rice in water for a number of hours until kernels are fully hydrated, draining the water, steaming the rice, drying and milling. Although the exact processes of most commercial parboiling units in developed countries are commercial secrets (Bhattacharya.1985), it is generally known that paddy is soaked at a constant temperature between 60 and 65^{0}c up to 3 hours and pressure steamed for up to 20 min (Manful. 2009). The equipment and procedures used for parboiling in industrial plants have been standardized to give consistently high- quality parboiled rice.

In many sub-Saharan African (SSA) countries, artisanal methods of parboiling using diverse rudimentary equipment and procedures are the mainstays. In artisanal parboiling, all operations are carried out under atmospheric pressure. The paddy is soaked in water with initial temperatures ranging from ambient to over 90^{0}c and allowed to cool for up to 16 hours until the grains are fully hydrated before steaming. Steaming techniques employed in artisanal parboiling include the use of steel drums with a false bottom on which the paddy is directly steamed or the paddy is put in a jute bag before being placed on sticks in the steaming container (Behrens and Heinemann (2007); Fofana. (2011)). The importance of proper pre-processing steps such as paddy cleaning is being addressed while several new parboiling vessels and stoves are also being developed and tested (Houssou and Amonsou (2004); Houssou (2005); Ndindeng. (2015). Variations in parboiling processes have been noted to produce rice with different characteristics Oli. (2014).

The experimental results show that Artisanal parboiling can be successfully applied to improve the quality of rice particularly the milling recoveries and appearance especially if the quality of the starting paddy is poor. However, treatment combinations (IST and STM) ought to be carefully chosen in order to achieve the desired effect. Varying parboiling treatments alter other physico- chemical properties of rice such as cooking properties, cooked rice texture, pasting properties and nutritional com- position of rice. This could be exploited to produce rice with cooking properties and texture that meet demands of target consumers. Given the effects on pasting properties, parboiling could also be optimized to alter the functional properties of rice in food formulations. Artisanal parboiled rice with good HRY and uniform translucent appearance can be produced when soaked at initial temperatures beyond 80^{0}C, cooled to ambient temperature and steamed for 15–20 min. TABLE

1. Treatment Combinations Generated From Response Surface Central Rotatable Composite Design.

Treatment	IST		STM	
	Coded unit	Uncoded unit(^{0}C)	Coded unit	Uncoded unit(min)
1	0	60.0	0	12.5
2	-1	30.6	-1	5.0
3	+1	90.0	-1	5.0
4	0	60.0	0	12.5
5	-1	30.0	+1	20.0
6	+1	90.0	+1	20.0
7	0	60.0	0	12.5

8	0	60.0	0	12.5
9	0	60.0	+1.414	23.1
10	-1.414	17.6	0	12.5
11	0	60.0	0	12.5
12	+1.414	100.0	0	12.5
13	0	60.0	-1.414	1.9
14	0	60.0	0	12.5

Chijioke. (2015) ***effect of steaming on physical and Thermal properties of parboiled Rice*****:** The experiment was conducted using Samples of five improved rice paddy varieties (FARO 44, FARO 52, FARO 60, FARO 61) used in this study were harvested in December, 2012 by the Breeding Unit of Rice Research Program, National Cereal Research Institute (NCRI) Badeggi Niger State, Nigeria and one local variety (Bisalayi) also harvested in the same period was obtained from Crop Improvement Unit of Kano State Agriculture and Rural Development Agency (KNARDA). They were packed in nylon jute bags and transported in February, 2013 to Bioresource Engineering Department, McGill University of Montreal, Canada and stored at room temperature. Prior to experiments, the unparboiled paddy samples were taken out, thoroughly cleaned and flawed grains removed. The moisture contents of the samples were determined by the fixed air-oven method drying at 120^{o}C for 24 h in duplicates and found to be 0.0713 + 0.0023 g/g d.b. Their experiment include; studying the effect of steaming time on physical properties(translucency, hardness, lightness, and color intensity)of parboiled rice, evaluation effect on steaming time on thermal properties(degree of gelatinization)of parboiled rice varieties and determine the optimum steaming condition required to obtained optimum quality of parboiled rice. The main purpose of this process is to pre-gelatinize the starch granules, transforming the crystalline structure of the starch into an amorphous one.

Previous studies shows that starch gelatinization imparts additional hardness to the rice grains and allows them to withstand harsher milling (Rao & Juliano, 1970; Bhattacharya, 1985; Islam, 2002) It is reported that parboiled rice also has better organoleptic properties, retains more nutrients and cooks better than non-parboiled rice (Rao & Juliano,(1970); Sareepuang .(2008); Lamberts.(2008). In generally, parboiling process consists of three stages namely: soaking of paddy to saturation moisture content (SMC), steam heat treatment of the soaked paddy to partially gelatinize the rice starch, thereby eliminating white portions and cementing crack developed in rice during harvesting and/or threshing and finally drying the steamed product to moisture content adequate for milling. Parboiling brings about modifications in rice during which vitamins and minerals are transferred from the aleurone and germ into the starchy endosperm. These transformations are accompanied by reduction in white portion, and give milled rice more translucent appearance (Juliano and Bechtel, 1985). A common problem with parboiling, especially by employing high temperature and pressure and longer processing time, is darkening of the grain (Bhattacharya, 1995). Also, steaming operation, which bring about the gelatinization of starch, requires a lot of energy to produce steam for the process, it is therefore necessary to establish optimum processing conditions required to obtain better qualities of the finished product while saving energy and time. Marshall. (1993) studied the relationship between percentage of gelatinization and head yield (the primary parameter used to quantify rice milling quality given by the ratio of weight of rice grains that are three-quarters intact to the total weight of milled parboiled rice) of parboiled rice (Cooper and Siebenmorgen, 2005).

They reported that maximum head rice yield could be achieved when the rice starch is 40% gelatinized during parboiling of paddy and that extensive parboiling or extensive starch gelatinization is not required to obtain maximum head rice yields.

The results obtained from the different processes including the grain kernel translucency which was determined by adopting the method of Marshall. (1993) with slight modification. The hardness of 25 unfissured whole brown rice kernels was measured using a compression method (Introns 4502, Canton MA, USA). The average bio-yield point value (Mohsenin, 1980) of the 25 measurements was expressed as the hardness in newton's (N). Brown rice kernels were put on the base plate and the bio-yield point value measured in flat position (Islam. 2001). A 500 N load cell, a probe of 3.84 mm diameter and 5 mm/min compression rate were used. The probe was set to travel a distance of 2.25mm into the sample. For the lightness value a spectrophotometer (CM – 3500d, Minolta Co., Ltd., Japan) was used to measure the lightness and saturation of the color intensity value of the whole kernel milled rice utilizing the L*a*b* uniform color space procedure. The thermal (gelatinization) properties were determined with a Differential Scanning Calorimeter (DSC Q100, TA instruments, Wilmington, DE USA). Heat flow and temperature calibrations of the DSC were performed using pure indium with heat of fusion and a melting temperature of 28.41 J/g and 156.66^{o}C respectively.

The instrument was coupled with refrigerated cooling system. Nitrogen was used as a purge gas at a flow rate of 50 ml/min. Raw and parboiled rice were de-husked using an electric compact rice de- husker (TR 200, Kett Electric Laboratory, Tokyo) and polished using a test polisher (Pearlest, Kett Electric Laboratory, Tokyo). Rice flour was then prepared by grinding samples of the polished rice using a coffee grinder (SUMEET Multi Grind, India) and passed through 0.075 mm sieve (Fisher brand test sieve, Fisher scientific co., USA). This ratio accounts for more than 60% moisture, corresponding to the moisture content required for rice gelatinization and to obtain a single endotherm during DSC experiment (Billiaderis.1986). The pans were hermetically sealed with TA sample crimping device. The sealed samples were stored at room temperature for one hour to stabilize before thermal scanning. The pans were placed in the sample cells of the DSC while an empty pan was sealed and placed in the reference cell of the DSC. The data of the effect of dependent variables (steaming time and variety) on the dependent variables (percentage of translucency, hardness, lightness, gelatinization temperature and gelatinization enthalpy) were statistically analyzed using SAS software (version 9.2), and where there was significant effect, means were separated using the Duncan's multiple range test ($P<0.05$) The findings from this study show that steaming time significantly affects physical and thermal properties of parboiled rice.

The improved rice varieties used in this study show better hardness than the local variety which might be due to the difference in the structural arrangement of starch granules among rice varieties in addition to varying extent of bonding between gelatinized starch and ruptured protein bodies. Hardness of rice was found to increase with steaming duration and ranged from 59.45 – 113.65 N, 79.39 – 158.17 N, 77.24 – 136.70 N, 73.59 – 136.65 N, and 73.14 – 126.20 N for Bisalayi, FARO 61, FARO 60, FARO 52 and FARO 44, respectively.

The optimum grain hardness was achieved at 20 min of steaming for Bisalayi and FARO 44 while for FARO 61, FARO 60 and FARO 52 it was attained at 15 min. Bisalayi (local variety) was found to be more discolored more than the FARO (improved) varieties. Lightness value decreased with increase in steaming period with values of 78.34 – 58.98 , 71.27 – 58.67 , 73.85 – 59.06 , 70.21 – 57.00 and 69.75 – 58.67 for Bisalayi, FARO 61, FARO 60, FARO 52 and FARO 44 respectively, corresponding to 0 – 20 min of steaming. The varietal difference in color change observed as observed could be due to a more rapid nonenzymatic browning of the Maillard reaction in the Bisalayi than in the FARO varieties in addition to genetic make-up among cultivars. Steaming completely gelatinized rice starch in samples, thus, there was no residual enthalpy of gelatinization after steaming of paddy.

Table 1: Gelatinization properties of non-parboiled paddy rice from Nigeria

Parameters	variety				
	Bisalayi	FARO 61	FARO 60	FARO 52	FARO 44
T_o °C	72.78±0.38[a]	73.90±0.18[a]	73.16±0.08[a]	64.24±0.16[b]	64.37±0.82[b]
T_P, °C	76.61±0.16[a]	77.03±0.08[a]	76.07±0.06[a]	68.79±0.28[b]	75.26±0.47[b]
T_c, °C	83.78±1.03[a]	82.55±0.85[a]	80.98±0.08[a]	77.70±10.0[b]	75.26±0.47[b]
ΔH, J/g	5.76±1.49[a]	3.62±0.65[ab]	3.15±0.37[b]	1.55±0.74[b]	2.35±0.08[b]

Means with the same superscript along the lines are not significantly different at $P < 0.05$ To, Tp, and Tc is onset, peak and conclusion gelatinization temperatures, respectively; ΔH is the gelatinization enthalpy

They opined that steaming time significantly affected both physical and thermal properties of the selected varieties of parboiled rice from Nigeria. The improved rice varieties used in this study show better hardness than the local variety which might be due to the difference in the structural arrangement of starch granules among rice varieties in addition to varying extent of bonding between gelatinized starch and ruptured protein bodies. Hardness of rice was found to increase with steaming duration and ranged from 59.45 – 113.65 N, 79.39 – 158.17 N, 77.24 – 136.70 N, 73.59 – 136.65 N, and 73.14 – 126.20 N for Bisalayi, FARO 61, FARO 60, FARO 52 and FARO 44, respectively. The optimum grain hardness was achieved at 20 min of steaming for Bisalayi and FARO 44 while for FARO 61, FARO 60 and FARO 52 it was attained at 15 min Bisalayi (local variety) was found to be more discolored more than the FARO (improved) varieties. Lightness value decreased with increase in steaming period. Steaming completely gelatinized rice starch in samples, thus, there was no residual enthalpy of gelatinization after steaming of paddy.

4. PROPOSAL/SUGGESTION

Because of the inconsistence in the results of different method carried out on different rice varieties in many countries. Parboiling still remained and still in used in improving milling quality of rice. Several Authors and researches agreed on their findings that parboiling has significant effect on the physical as well as the chemical properties of rice. The main findings of this review paper detect that difference in soaking temperature and steaming time is responsible for giving out conflicting results. This review paper agreed with the latest research conducted by Ebrahim et al(2015)whose research work provide the most suitable soaking temperature of 65^0c and 4 min steaming time which gave the highest value of head rice yield, lightness and rupture force. This treatment was found to provide the most desirable quality of parboiled rice. The paper also suggested that future Research/studies should focus and pay more attention to the difference in soaking temperature and steaming time to improve the quality of rice.

5. CONCLUSION

It is evident that Parboiling still remained the alternative process of improving the quality of rice by increasing its vitamin content, amylose content, and thiamine content. The physical properties are more affected by parboiling than the chemical properties. However it is very important for researchers and food processing industries to look deep into the issues suggested by this paper.

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