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Comparative Evaluation of the Cooking Time, Nutritional and Sensory Properties of Meals Prepared with Whole, Semi-polished and Polished Rice Grains

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Abstract Encouraging the consumption of whole grains may be a feasible and easy measure to combat non-communicable diseases which are the major causes of death globally. This experimental study was therefore designed to compare the cooking time, nutritional and sensory properties of meals prepared with whole, semi-polished and polished rice grains with the view of encouraging the consumption of whole rice gains in place of the refined ones. White rice, curried rice and jollof rice were prepared with whole, semi-polished and polished rice grains using basic ingredients of standard recipes. Cooking time, nutritional and sensory evaluation were determined using appropriate standard procedures. Mean data were compared using Analysis of Variance at $p \leq 0.05$. For whole rice cooking time (minutes) for white, curried and jollof rice was: 30.33, 29.33 and 25.33; for semi-polished rice these was: 31.33, 32.00 and 38.00 while for polished rice it was: 32.33, 36.00 and 30.33 respectively. The proximate composition (% in DWB) of white rice prepared with whole, semi-polished and polished rice grains were as follows: Protein (9.80, 9.37, 8.70); Fat (4.19, 2.22, 0.78); Ash (3.20, 2.22, 2.01); Crude fibre (4.80, 1.95, 1.56) and Carbohydrate (78.01, 84.24, 86.95). White rice prepared with whole rice and semi-polished rice was significantly higher ($p \leq 0.05$) than polished rice in niacin and riboflavin but surprisingly, the meal from polished rice was highest in thiamine content. White rice, curried rice and jollof rice prepared with whole rice grains were comparable in flavour, texture, taste aroma and overall acceptability with those prepared with semi-polished and polished rice, however, there is need to improve on the colour and appearance as well as construction of rice milling machine that can dehusk only. The cooking time and sensory properties of whole rice dishes were comparable with that of the refined ones while the nutritive value was notably higher. Household and commercial preparation and consumption of whole rice dishes is hereby encouraged but the major militating factor, which is the unavailability of milling machine that can only dehusk, is a factor of utmost necessary concern.

Keywords: *whole rice, semi-polished rice, polished rice, properties*

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1. Introduction

Non communicable diseases are diseases that are not caused by infectious agents, that is, they are non-infectious. They are being referred to as chronic diseases because they progress slowly and the patient can suffer from it for a long period of time. They are the leading causes of death globally in the 21st century [1]. Examples of non communicable diseases include: diabetes; cardiovascular diseases, stroke, hypertension, cancers, chronic kidney diseases, osteoporosis, etc. Most of these diseases may be referred to as diseases of comfort or civilization diseases because there was an escalation in the prevalence of these diseases with the onset of sporadic technological advancement witnessed since early 21st century which encouraged civilization and physical inactivity [2]. Such non communicable diseases in this category include diet and lifestyle related diseases such as: cardiovascular diseases, obesity, hypertension, cancer, diabetes, osteoporosis and others.

For instance, in 2000, the global prevalence of hypertension in adult population was estimated to be 26.4% translating to 972 million people -333 million in economically developed countries and 639 million in economically developing countries and this was projected to increase to 1.56 billion by 2025 [3]. In 2010, 1.39 billion adults had hypertension globally [4] thus corroborating the increasing trend as projected by Kearney et al., [3]. In the same vein, 202 million adults were estimated to be living with peripheral artery disease

in 2010 [5] while in 2015 an estimate of 422.7 million people suffered from cardiovascular diseases [6]. The global prevalence of diabetes for all age groups was estimated to be 2.8% in 2000 which translates to 171 million people and this was projected to increase to 4.4% (366 million people) by 2030 [7]. Another study reported that people living with diabetes globally have reached 366 million in 2011 and this might increase to 552 million by 2030 [8] thus showing a greater rising trend than the projection of Wild et al., [7]. In their own estimation, Shaw et al, [9] reported the global prevalence of diabetes among adults to be 6.4% (285 million people) in 2010 and this was projected to increase to 7.7% (439 million) by 2030. All these clearly affirm the increasing trend of diabetes prevalence with time. Similarly, there was an estimate of 14.1 million cancer cases globally in 2012 and these new cases was projected to increase to 23.6 million new cases of cancer each year by 2030 [10]. Another study reported that a 5 year (2004-2008) global cancer prevalence was estimated to be 28.8 million in 2008 [11] whereas a total of 8.1 million new cases of cancer globally was estimated in 1990 [12]. Obesity which is a condition of excessive fat accumulation to the extent that health and well being are affected has also become a subject of concern to public health. Globally, the prevalence of overweight and obesity in men increased from 28.8% in 1980 to 36.9% in 2013 while in women it increased from 29.8% in 1980 to 38.0% in 2013 [13]. In the same vein, prevalence of overweight and obesity among children and adolescents (boys) in developing countries increased from 8.1% in 1980 to 12.9% in 2013 and 8.4% in 1980 to 13.4% in 2013 among girls. [13] Having established the continual increase in prevalence of these non communicable diseases globally, it is a laudable drive to explore the benefits of whole grain consumption in combating non communicable diseases.

The application of the consumption of whole grains to prevent or treat these diseases of comfort or civilization diseases is not a novel practice. In fact, there occurred favourable alteration of biomarkers or risk factors of atherosclerotic cardiovascular diseases (ASCVD) due to the inclusion of whole grains in the diets. Consumption of 3 servings of whole grain daily was observed to prevent diabetes, obesity as well as reduce serum LDL-cholesterol, tryacylglycerol and blood pressure but increase serum HDL-cholesterol levels in humans [14]. Similarly, a daily consumption of 3 portions of whole grain meals was observed to reduce cardiovascular disease risk in middle-aged people vis blood pressure lowering mechanism [15] while the efficacy of whole grain consumption in lowering the risk of chronic diseases such as coronary artery diseases, diabetes, cancer as well as plays vital role in body weight management and gastrointestinal health has been observed and reported [16,17,18]. The components of whole grains that exert these beneficial effects include: dietary fibre, vitamins, minerals, antioxidants, phytosterols and other phytochemicals [14]. The bioactive components in whole grains that exert these beneficial effects are: phytosterols, tocols, beta-glucan, gamma-oryzanol, phytic acid, carotenoids, lignans, alkylresorcinols, flavonoids and phenolic acids [19,20]. In more recent studies the phenolic compounds and dietary fibre in whole grains moderated the glycemic profile of the meal for a healthier and more beneficial purpose thus improving the nutritional quality of the starch in the whole grain [21]. Childhood obesity was successfully prevented and managed with whole grain consumption [22]. The consumption of whole grain improved the postprandial glucose and insulin homeostasis compared to similar refined foods in healthy subjects, hence, whole grains consumption may prevent the incidence of diabetes [23]. All these studies have ascertained the beneficial effects of whole grains consumption, hence, all possible measures of inclusion of whole grains in human diets should be embraced.

Rice, which is the world's most important food crop and a primary source of food for more than half of the world's population [24] is commonly consumed in polished form. Harnessing the high global consumption level of rice is a potential in combating non communicable diseases globally if the rice is consumed in whole form rather than in polished form. Whole rice grain has the bran and germ intact and part of the endosperm. In semi polished rice some of the bran and germ is retained on the endosperm because these have not been completely shaven off in the rice milling process while polished rice is mainly the endosperm from which the bran and germ have been totally removed. Prolonged cooking time, shorter shelf life and unfavourable sensory attributes have been identified as the hurdles militating against the consumption of whole rice despite its healthier nutritional and functional constituents [25]. This study was therefore designed to compare the cooking time, nutritional and sensory properties of whole, semi polished and polished rice with a view of encouraging the consumption of whole rice in place of semi polished and polished rice.

2. Materials and Method

2.1. Collection of Rice Varieties

Harvested rice grains (Oryza sativa) with the paddy or husk not yet removed was purchased from farmers in Ekiti State, Nigeria. Semi-polished rice (Ofada-Oryza sativa) and polished rice (Caprice- Oryza sativa) were purchased from Bodija market in Ibadan, Nigeria. The rice from Ekiti state was parboiled and sun dried after which the dusk was removed using mortar and pestle while winnowing was done manually to separate the dusk. Other ingredients used were purchased from Bodija market.

2.2. Preparation of Rice Meals

Rice meals were prepared using methods described by Virmani, (26) with modification.

2.2.1. White Rice

This was prepared with the three types of rice grains, that is, whole; semi polished and polished rice grains. Three hundred grams of whole rice grains was boiled in 1.5litres of water. Similarly, 300g of polished rice was cooked with 1.5 litres of water while 300g of semi polished rice was cooked with 1.4 litres of water. The cooking times were recorded.

2.2.2. Curried Rice

To minimize confounding variables only the basic ingredients of a standard recipe [26] were used. A measure of the three different types of rice (1.5 cups each) was boiled in 1.4 litres of water (whole rice), 1.45 litres of water (semi polished rice) and 1.25 litres of water (polished rice). One dessert spoonful of curry powder (Ducros, Nigeria) and 4 tablespoonful of soybean oil (Golden Penny, Nigeria) were added to each of the rice meal.

2.2.3. Jollof Rice

Only the basic ingredients of a standard recipe [26] were used to minimize confounding variables. The same measure (1.5 cups each) of the rice samples were boiled in 1.5 litres of water (for whole rice), 1.6 litres of water for semi polished rice and 1.4 litres of water for polished rice. Curry powder (0.5 dessert spoon), thyme (0.5 dessertspoon), soybean oil (4 table spoons), 4 tablespoons of tomato/bell pepper/onion paste) and 1 tablespoonful of tomato puree (Gino, Nigeria) were added to each rice meal.

2.3. Nutritional Composition

Proximate, thiamine, riboflavin and niacin content of the raw rice grains and white rice meal were determined.

2.4. Moisture Content Determination

This was determined using the air oven method [27]. A known weight of the sample (3g) was put in a washed, dried and cooled crucible and this was dried at 103°C until a constant weight was obtained. This was allowed to cool in a desiccator and the difference in weight was used to calculate the moisture content.

2.5. Protein Content Determination

The crude protein content was determined using the micro Kjeldahl method as described by Kirk and Sawyer, [27]. A tablet of Kjeldahl catalyst was added to a known weight of the sample (0.2077g) in a long necked Kjedahl flask. This was heated in a fume cupboard with 25cm^3 of concentrated H_2SO_4 until a clear solution was obtained. This was cooled, poured into a 10cm^3 volumetric flask and made up to mark with distilled water after which 10ml of this was measured into a distillation set. 5cm^3 of boric acid was pipette into a 100ml conical flask and placed at the receiving end of the distillation unit with the delivery tube completely dipped into the flask. 40% NaOH was used to liberate ammonia out of the digest into the boric acid under alkaline condition and this was titrated against 0.1N HCl until the first permanent colour change was observed. Blank sample was run through the procedure and the titre value was used to correct the titre value for the test samples. The protein content was calculated thus:

$$\%N = \frac{\left[\begin{array}{l} Molarity\ of\ HCl \\ x\left(sample\ titre - blank\ titre\right) \\ x0.014\ x\ DF\ x100 \end{array}\right]}{Weight\ of\ sample}$$

%N was converted to the percentage crude protein by multiplying by 6.25.
DF: Dilution Factor.

2.6. Crude Fat Content Determination

The fat content was determined using Soxhlets extraction method as described by Kirk and Sawyer, [27]. A known weight of the sample (2g) was put into a weighed filter paper and folded neatly. This was put inside a pre-weighed thimble (W_1). The thimble with the sample (W_2) was inserted into the soxhlets apparatus and extraction was carried out under reflux with petroleum ether (40°C – 60°C boiling range) or 6 hours. At the end of the extraction, the thimble was dried in the oven for about for about 30 minutes at 100°C to evaporate the solvent and thimble was cooled in a desiccator and later weighed (W_3). Crude fat content of the sample was calculated thus:

$$\%\ Fat = \frac{Loss\ in\ weight\ of\ sample\ x\ 100}{Original\ weight\ of\ the\ sample}$$

$$= \frac{W_2 - W_3}{W_2 - W_1} x100.$$

2.7. Ash Content Determination

The ash content denotes the total amount of minerals present in the products. This was determined using the method as described by Kirk and Sawyer, [27]. A known weight (1.5g) of finely ground sample was weighed into clean and dry previously weighed crucible with lid (W_1). The sample was ignited over a low flame to char the organic matter with lid removed. The crucible was then placed in muffle furnace at 600°C for 6 hours until it was turned to ash completely. This was then transferred directly to desiccators to cool and was later weighed (W_2).

$$\%\ Ash = \frac{W2 - W1}{Weight\ of\ sample} x100.$$

2.8. Crude Fibre Determination

The crude fibre was determined using the method as described by Kirk and Sawyer, [27]. Two hundred millilitres (200ml) of freshly prepared 1.25% H_2SO_4 was added to a known weight (3g) of the residue obtained from fat extraction and this was boiled for 30 minutes and then filtered after which the residue was washed until it was free from acid. The residue was transferred quantitatively into a digestion flask and 1.25% NaOH was added after which this was boiled for 30 minutes. This was followed by filtration and the residue was then washed with methylated spirit and then petroleum ether to be free of alkali. This was then allowed to drain and the residue was transferred to a silica dish (previously ignited at 600°C and cooled). The dish and its content were dried to constant weight at 105°C. The organic matter of the residue was burnt by igniting for 30 minutes in a muffle furnace at 600°C). The residue was cooled and weighed while the loss on ignition was reported as crude fibre.

2.9. Carbohydrate Content Determination

This was calculated by difference of all other nutrients from 100 [27].

2.10. Thiamine, Riboflavin and Niacin Determination

These B vitamins content were determined using the method as described Kirk and Sawyer, [27].

2.11. Thiamine Determination

Method as described by Kirk and Sawyer [27] was used Fifty millilitres (50ml) of 50% methanol and 50ml 0f 17% sodium carbonate was added to 1g of the sample in order to extract the vitamin. This was then filtered after which Folins-Denis reagent was added. This was allowed to cool until a bluish colour was developed and absorbance was read in a spectrophotometer at 415nm. A standard curve was prepared using the data obtained with Tannic acid in place of the sample and the values for the sample were extrapolated from this curve.

2.12. Riboflavin Determination

The method as described by Kirk and Sawyer [27] was used. To 0.5g of the sample 30ml of Dichloroethane and 30ml of 30% HCl were added. This was followed by the addition of 50ml of ammonium hydroxide solution after which filtration was carried out and later the absorbance was read at 415nm. A standard curve was constructed using the data obtained from the use of standard Riboflavin in place of the sample and the curve was used to extrapolate the values for the samples.

2.13. Niacin Determination

Method as described by Kirk and Sawyer [27] was used. Niacin was extracted by autoclaving the sample (1g) with 0.75g calcium hydroxide and 20ml deionised water at 121°C for 30 minutes. The mixture was diluted with 30 ml of water, mixed thoroughly and allowed to cool after which it was centrifuged at 0°C and 2500 rpm for 15 minutes. A 15ml sample of the supernatant was adjusted to pH 7 with aqueous oxalic acid. The resulting suspension was centrifuged at 2500 rpm for 10 minutes to precipitate the calcium oxalate and the absorbance was measured at 650nm. A standard curve was constructed using the absorbance readings obtained from the reference niacin solutions in place of the sample and this was used to extrapolate the niacin content of the samples.

2.14. Sensory Evaluation

The cooked rice meals were subjected to sensory evaluation with a total of 20 trained taste panellists using a 9 point hedonic scale with 1 denoting ‘dislike extremely’ and 9 denoting ‘like extremely’. The following sensory properties were evaluated: colour, appearance, flavour, texture, taste, aroma and overall acceptability [28].

2.15. Statistical Analyses

Data were analyzed using Statistical Package for Social Science. Mean data were compared using Duncan Multiple Range Test at $p \leq 0.05$ [29].

3. Result

The cooking time for the rice dishes was expressed in Table 1.

For each of the meal the cooking time is still less than 40 minutes (Table 1). The proximate composition of the rice grains in raw form is expressed in Table 2.

Raw whole rice was significantly higher in protein, fat, ash and crude fibre than semi polished and polished rice grains (Table 2) while the cooked forms of the rice followed similar trend (Table 3).

Table 1. Cooking time (minutes) for rice meals using whole, semi-polished and polished rice

Rice meals	Whole rice	Semi polished rice	Polished rice
	Cooking time	Cooking time	Cooking time
White rice	30.33a±0.21	31.33a±0.07	32.33a±0.05
Curried rice	29.33c±0.02	32.00b±0.17	36.00a±0.12
Jollof rice	25.33c±0.13	38.00a±0.07	30.33b±0.05

Mean data with same alphabet in same row are not significantly different ($p \leq 0.05$).

Table 2. Proximate composition of raw whole, semi polished and polished rice grains (DWB)

Samples	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)
WR	10.47a±0.43	1.95a± 0.28	3.04a±0.26	2.18a±0.21	82.36a±0.44
SPR	9.77b±0.21	1.77b± 0.45	2.79b±0.43	1.63b±0.17	84.04b±0.67
PR	9.27c± 0.18	1.36c±0.44	2.45c±0.12	1.44c±0.45	85.48c±0.26

Mean data with same alphabet in a column are not significantly different ($p \leq 0.05$)
WR: Whole Rice
SPR: Semi Polished Rice
PR: Polished Rice.

Table 3. Proximate composition of boiled white whole, semi polished and polished rice (DWB)

Samples	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)
WR	9.80a±0.47	2.32a±0.72	3.20a±0.12	2.14a±0.28	82.54a±0.49
SPR	9.37ab±0.56	1.56b±0.34	2.22b±0.49	1.95b±0.18	84.90b±1.27
PR	8.70b±0.45	0.78c±0.37	2.01bc±0.23	0.78c±0.44	87.73c±1.89

Mean data with same alphabet in a column are not significantly different (p≤0.05)
WR: Whole Rice
SPR: Semi Polished Rice
PR: Polished Rice.

Table 4. Thiamine, Riboflavin and Niacin content of raw and boiled whole, semi polished and polished rice (mg/100g-DWB)

Samples	Raw			Boiled		
	Thiamine	Riboflavin	Niacin	Thiamine	Riboflavin	Niacin
WR	0.58a±0.12	0.09a±0.02	5.01a±0.12	0.10a±0.15	0.65a±0.15	4.30a±0.15
SPR	0.35b±0.10	0.07ab±0.01	3.56b±0.17	0.07b±0.02	0.56b±0.12	3.34b±0.45
PR	0.24c±0.09	0.04b±0.02	1.63c±0.19	0.04c±0.01	0.43c±0.15	1.49c±0.87

Mean data with same alphabet in a column are not significantly different (p≤0.05)
WR: Whole Rice
SPR: Semi Polished Rice
PR: Polished Rice.

Table 5. Sensory scores of white whole, semi polished and polished rice

Samples	Colour	Appearance	Flavour	Texture	Taste	Aroma	OA
WWR	4.90c±0.10	5.20c±0.10	6.47b±0.09	6.73a±0.07	6.40a±0.10	6.40a±0.11	6.90a±0.10
SPWR	6.10b±0.10	6.73a±0.06	6.40b±0.10	6.10b±0.10	6.45a±0.04	6.20b±0.16	6.83b±0.06
PWR	6.47a±0.06	6.40b±0.10	6.63a±0.04	6.77a±0.12	6.33ab±0.05	6.90c±0.44	6.33c±0.06

Mean data with same alphabet in a column are not significantly different (p≤0.05)
WWR: Whole White Rice
SPWR: Semi Polished White Rice
PWR: Polished White Rice
OA: Overall Acceptability.

Table 6. Sensory scores of curried whole, semi polished and polished rice

Samples	Colour	Appearance	Flavour	Texture	Taste	Aroma	OA
WCR	5.13c±0.06	5.43c±0.06	6.83b±0.06	6.17c±0.12	6.83ab±0.06	6.40b±0.10	6.27b±0.12
SPCR	6.83b±0.15	7.40b±0.10	6.73bc±0.03	6.93b±0.06	6.30b±0.20	6.50b±0.16	6.57b±0.42
PCR	7.83a±0.06	7.77a±0.07	7.03a±0.45	7.10a±0.40	6.90a±0.40	7.13a±0.15	7.40a±0.10

Mean data with same alphabet in a column are not significantly different (p≤0.05)
WCR: Whole Curried Rice
SPCR:Semi Polished Curried Rice
PCR: Polished Curried Rice
OA: Overall Acceptability.

Table 7. Sensory scores of jollof whole, semi polished and polished rice

Samples	Colour	Appearance	Flavour	Texture	Taste	Aroma	OA
WJR	6.80b±0.10	5.73c±0.04	6.67c±0.06	6.73a±0.06	6.50a±0.10	6.90ab±0.12	6.90b±0.34
SPJR	6.80b±0.15	6.77b±0.08	6.93a±0.06	6.71a±0.06	6.10ab±0.43	6.33b±0.15	6.50c±0.71
PJR	6.83a±0.06	6.83a±0.06	6.83b±0.05	6.67a±0.06	6.40a±0.24	7.03a±0.17	7.13a±0.15

Mean data with same alphabet in a column are not significantly different (p≤0.05)
WJR: Whole Jollof Rice
SPJR:Semi Polished Jollof Rice
PJR:Polished Jollof Rice
OA: Overall Acceptability.

In the same vein whole rice contained the highest quantity of thiamine, riboflavin and niacin both in raw and cooked forms (Table 4).

Whole white rice was comparable with semi polished and polished white rice in acceptability of the flavour, texture, taste, aroma and overall acceptability except in colour and appearance (Table 5). The sensory scores of the curried forms of the rice grains (Table 6) showed similar trend as can be seen in Table 5,

The sensory score of whole jollof rice in texture parameter did not differ significantly from those of the semi polished and polished rice (Table 7). Even though the scores for other sensory parameters were significantly different, these were still comparable and within the acceptable range except for appearance of whole jollof rice (Table 7).

4. Discussion

There existed no significant difference in the cooking time of white rice using whole, semi polished and polished rice (Table 1) showing that there exists no disparity in the time used in cooking whole white rice and the milled forms of rice grains, hence, the issue of longer cooking time being a hurdle militating against the consumption of whole rice dishes may not be of concern if the same variety of rice used in this study (Oryza sativa) is used. However, the cooking time of boiled rice observed in this study differed from the report of Singh *et al.,* [30] who observed a minimum cooking time of between 13.3 to 24 minutes of 23 Indian rice cultivars. This disparity may be as a result of different rice cultivars used because even though the rice used in this study was an Asian variety it was cultivated in Nigeria. A more recent study reported a cooking time of whole rice grain which is in close proximity with that observed in this study. Thirumdas *et al.,* [31] observed the cooking time of brown rice to be 29.1 minutes before cold pasma treatment and this was in close proximity with the cooking time of whole white rice observed in this study which was 30.33 minutes. This may be as a result of similarity in rice variety and cooking procedures used. Whole curried and jollof rice cooked faster than the related semi polished and polished forms (Table 1) showing that cooking time will not pose a problem in the event of promoting and encouraging whole rice consumption.

It is evident from Table 2 and Table 3 that polished rice, the form in which rice is commonly consumed (both in raw and cooked forms), was least nutritious while whole rice was most nutritious, hence, consumption of whole rice grain is a laudable drive which should be embraced towards improvement of public health nutrition. This may be as a result of the fact that the germ and bran which contains most of the protein, minerals, vitamins and fibre have not been removed in the whole rice grain while some of these have been removed in semi polished rice and all have been removed in polished rice. The higher nutritional value of whole rice compared with polished rice was also reported by Samaranayake *et al.,* [32] who observed that the proximate composition of whole Basmati type rice was 10.76% crude protein, 1.57% total ash, 2.57% crude fat, 3.21% total dietary fibre and 85.09% total carbohydrate while at 100% polished rate (that of polished rice) it contained 8.76% crude protein, 0.67% total ash, 1.22% crude fat,0.37% total dietary fibre and 88.35% total carbohydrate. These corroborate the result of this study that whole rice is more nutritious than polished rice.

In the same vein thiamine, riboflavin and niacin content of rice in whole form was higher than semi polished and polished rice in both raw and cooked forms (Table 4). This also confirms that whole rice contains more of these vitamins than semi polished and polished rice because the bran and germ which contain most of these vitamins have been removed in polished rice.

Table 5, Table 6 and Table 7 show the sensory scores of white, curried and jollof rice prepared using whole, semi polished and polished rice. The sensory scores for the whole rice dishes or meals were in close proximity with those of semi polished and polished rice for flavour, texture, taste, aroma and overall acceptability except for colour and appearance for whole white rice (Table 5) and whole curried rice (Table 6) which were below the acceptance range. This shows that whole rice dishes were as acceptable as semi polished and polished rice in all sensory parameters except in colour and appearance which may be improved upon during the rice parboiling process commonly carried out before husk removal.

5. Conclusion

Whole rice is more nutritious than semi polished and polished rice and is comparable to the other two in cooking time and sensory properties, hence, consumption of whole rice should be encouraged. However, the colour and appearance of whole rice meals ned to be improved upon and there is need for the construction of milling machine that can only dehusk rice without removing the bran and germ.

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