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Proximate, malting characteristics and grain quality properties of some Nigerian rice of different varieties

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Abstract

The recent significant increase in rice production in Nigeria can lead to a surfeit of rice if rice paddy are not properly diversified into other products such as rice malt which can be used in production of syrup, beer, flavoured drinks and some baked goods. Therefore the objective of this research is to evaluate the grain and malting quality characteristics of ten (10) locally available rice varieties in Nigeria. Malting parameters measured were germinative energy (GE), germinative capacity (GC), malting loss, malt yield, degree of steeping and thousand corn weight. There were significant differences (p<0.05) among the rice varieties in most of the parameters assessed. Brown rice had higher scores of malting parameters (GE-98%, GC-97.96%, malt yield-87.81% and thousand corn weight-30.40g) compared to the other varieties. FARO 61 had the least GE (85.50%), GC (85.21%) and thousand corn weight (25g). Malted brown rice had the highest protein content (9.39%) compared to unmalted IWA 3 which had the least protein content (7.10%). FARO 52 had a highest carbohydrate content (84.84%) when compared to the least in unmalted brown rice (73.77%). The kilned sample had a significantly reduced moisture content than the original grain which caused a proportional increase in protein and carbohydrate content but with corresponding decrease in ash, fat and moisture content of rice flours.

Keywords: Rice, malting, grain quality, malted rice, unmalted rice.

Introduction

One of the most important cereal of the world is Rice. In most parts of Nigeria, rice (*Oryza sativa*) is produced locally and it is a major local staple. The governments in sub-Saharan Africa have been promoting the increase in the production of rice locally with the aim of achieving self-sufficiency in rice production. It is expected that with such a trend there could be need for industry to expand the uses of rice for a greater variety of products. One area that is recently gaining attention is the conversion of rice paddy to rice malt. The malting process involves steeping, followed by making cereal grains to germinate and then quickly kilned before shoot development. During malting, the germination process facilitates the production of hydrolytic enzymes which aids to transform the grains[1].

Rice malts can find wide and useful application in some food products such as syrups, beer, flavoured drinks, malted milkshakes and some baked goods. When rice malts are used for the production of syrups, it adds value to the quality of the syrup by influencing the syrup colour, aroma, sugar profile and other chemical properties of rice derivatives, which are usually desirable by the end users. They are especially good for manufacturers of beverages, confectionery and as an alternative ingredient to refined sugar for many processed foods. It is a sweetener that is rich in compounds categorized as sugars and other nutrients such as minerals and amino acids. As rice production increases in this region which might result to glut, it becomes imperative to find means of varying the range of rice products since most rice produced in this region are principally parboiled rice. One of the rice products is rice malt which can find usefulness in food industry as was earlier mentioned, thus the possibility of the use of rice paddy as raw material for malting is gaining significant attention in this region. This however, has made it important to evaluate the composition and malting qualities of some Nigerian rice of different varieties. A good understanding of this is important in guiding processors, researchers and investors on variety selection for optimized output and also enable end users to make guided selection for their intended food applications. Therefore, this work evaluates the proximate, malting characteristics and grain quality properties of some Nigerian rice of different varieties.

Materials and methods

Sample procurement: Ten (10) different varieties of locally available rice were obtained from competent breeders and the rice varieties were a blend of improved varieties, indigenous and native rice. Four (4) paddy rice varieties (FARO 44, FARO 52, FARO 57 and FARO 61) were purchased from Biotechnology Research and Development Centre of Ebonyi State University (EBSU), Abakiliki. The other six varieties of paddy rice (Brown rice, IWA 3, Nwangenya, R8, Dragon 12 and 306) were obtained from local seed growers and were identified by the Biotechnology Research and Development Centre of Ebonyi State University, Abakiliki, Nigeria.

The processing of samples and experiments were carried out using the facilities available at the laboratory of Department of Food Science and Technology, Federal University of Technology, Owerri and at International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria. Reagents & other chemicals used were of analytical grade.

Sample preparation: The rice paddy of different varieties were manually cleaned by sorting to remove extraneous materials and damaged seeds, followed by winnowing to remove dust.

Evaluation of rice samples: Determination of thousand corn weight: Hundred (100) grains of paddy rice were indiscriminately picked from the lot and were weighed. Each of measured kernel weight was multiplied by 10 to obtain the 1000 kernel weight and this experiment was done in triplicate[2].

Determination of germinative capacity and germinative energy: Rapid and complete germination are essential features of good malt. Germinative capacity and germinative energy were determined by the method described by Institute of Brewing (IOB)[3].

$$\text{Germinative Energy} = \frac{\text{Number of viable grains}}{\text{Total number of grains}} \times 100 \quad (1)$$

Germinative Capacity=% Germinative Energy- % Dormancy (2)

Degree of steeping: Kunze[4] was used to determine grain degree of steeping as shown in the formula below

$$\text{Degree of Steeping (\%)} = \frac{X}{Wi} \times 100 \quad (3)$$

$$\text{Where } X = \frac{Wi \times (D + Mc)}{Wf} \quad (4)$$

W_i = Mass of rice grain before steeping, W_f = Mass of rice grain after steeping, M_C = Moisture content of rice grain, D= W_f - W_i.

Malting of rice: The rice varieties were malted by adoption of barley malting protocols according to Kunze[4] with some modifications. Steeping of each rice sample was done at 20-25°C for 36 hours. The steep cycle involved alternating 12 hours wet-steep with 45 minutes air-rest period. At the end of steeping process, the rice grains were couched on jute bags previously sterilized with dry heat. Samples were germinated within a temperature range of 25°-30°C, and samples were removed after the second day of germination. Kilning was performed in a hot air oven at temperatures between 60-70°C for about 2-3 hours. Rice malt was continuously turned to aerate and achieve uniform controlled heat. Kilned samples were manually de-rooted by using hand to rub off the rootlets followed by winnowing to remove the dust.

Rice malt analysis: The following determinations were done on the rice malt of different varieties.

Malting Loss: The method of Adebowale *et al.*[1] was used to determine the malting loss of rice paddy after germination by weighing the rice grains before and after malting. The weight of 100 grains of rice was recorded before malting and the weight of the malted grains after the rootlets were removed by hand was also recorded. The Malting loss equation is expressed below in percentage dry matter.

$$\text{Malting Loss} = \frac{\text{Weight of unmalted grain} - \text{Weight of Malted grain}}{\text{Weight of unmalted grain}} \times 100 \quad (5)$$

Malt Yield: The method of Adebowale *et al.*[1] was used to determine the malting loss of rice paddy after germination by weighing the rice grains before and after malting. The weight of 100 grains of rice was recorded before malting and the weight of the malted grains after the rootlets were removed by hand was also recorded. The Malt yield equation is expressed below in percentage dry matter.

$$\text{Malt Yield} = \frac{\text{Weight of Malted grain}}{\text{Weight of unmalted grain}} \times 100 \quad (6)$$

Proximate Analysis of Malted rice flour and unmalted rice flour: The method of A.O.A.C.[5] was used for this determination of moisture content, fat, crude protein, crude fibre and ash determinations, while Carbohydrate was calculated by difference.

Results and discussion

Thousand Corn Weight: The mean values of the thousand (1,000) corn weight of the paddy grain varied from 25.00g to 30.97g. Significant differences ($p<0.05$) exists in the thousand corn weight amongst the rice varieties with Nwangbenya having the highest thousand corn weight of 30.97g while FARO 61 had the least thousand corn weight of 25.00g. The thousand corn weight of rice paddy grains measures varietal purity and it is also used in identification of variety[6]. The thousand corn weight however, provides knowledge about the seed size and density of grains[7]. The variation in the thousand corn weight of the paddy grains of different varieties was as a result of the differences in the individual weight of rice kernels which could be attributed to varietal effect such as variations in the grain moisture content, the type of soil where the rice was grown, fertilizer treatment, weather conditions and starch composition of the grain. Ayernor and Ocloo[8] reported that the starch content of grains plays a major role in grain kernel size. In other words, large grain kernel size could be as a result of its high starch content. According to literature, Vanangamudi *et al.*[9] grouped the rice hulled grains were grouped into the following categories based on their thousand corn weight as; below 15g, 15-18g, 18-21g, 21-24g, 24-27g, 27-30g, 30-33g, 33-36g, 36-39g and above 39g. IWA 3, FARO 61, FARO 57, FARO 52 and 306 are in the category of 24-27g, FARO 44 and Dragon 12 are in the category of 27-30g while Nwangbenya, R8 and Brown rice are in the category of 30-33g. From the results, Nwangbenya, R8 and Brown rice will have higher starch content and denser than the other rice varieties since they had higher thousand corn weight.

Germinative Capacity and Germinative Energy: The Brown rice had the highest germinative energy (98.00%) and germinative capacity (97.96%) which were significantly different ($p<0.05$) from the other rice varieties except for Nwangbenya and R8. It showed this pattern for both the germinative energy and germinative capacity. Also, FARO 61 had a significantly ($p<0.05$) least germinative energy and germinative capacity which was different from other varieties except for FARO 57. This pattern was also consistent for both parameters. There was no significant difference ($p>0.05$) between Dragon 12, FARO 44, 306 and FARO 52; FARO 57 and FARO 61 in both their germinative capacity and energy. Germination is the significant beginning of malting. Germinative energy and germinative capacity were conducted for the rice grains to ensure favourable germination of the grains during malting[1]. From the results, it was observed that the rice variety with higher thousand corn weight, in other words larger kernel size had higher germinative properties compared to other varieties. This observable difference could be that these varieties (Brown rice, Nwangbenya and R8) contain proportionately less husk and therefore higher starch content than the varieties with lower thousand corn weight as a result of varietal difference. This was also in agreement with the work of Nnamchi[10] on grains. Satisfactory germinative properties which is acceptable for malting were recorded by all the rice grains since they recorded over 85% germination. Almost identical results have earlier been recorded by Ameko *et al.*[11] and it was recorded that germinative capacities of malted maize ranged from 85% to 97%. All the cultivars exhibited over 85% germination capacities which showed that the grains were alive; and also evidence that suggests that when the grains are germinated under optimum conditions, low dormancy level will be exhibited[12].

Degree of steeping: The degree of steeping of the rice grains varied from 45.02% to 55.53% with FARO 52 having the highest degree of steeping of 55.53% followed by Dragon 12 (53.30%) while Brown rice had the least degree of steeping of 45.02%. There were significant differences ($p<0.05$) between the rice varieties in their degree of steeping. Degree of steeping is simply the water content or amount of water absorbed by the steeped grain. The degree of steeping is of importance for the germination process since enzyme formation, growth and metabolic transformations are decisively influenced by it[4]. The variations in the degree of steeping between the rice varieties could be due to the moisture content of the paddy rice, kernel size (thousand corn weight), rice variety and rice harvest year, since the steeping duration and temperature were constant in this research work for the entire rice varieties. According to Kunze[4], small kernels take up much more water than larger kernels; and grains from inland regions swell and germinate more quickly than grains from maritime regions. However, the results showed that the rice varieties with high degree of steeping had higher malt yield thus lower malting loss probably because these varieties had low metabolic processes, growth and enzyme formation during germination within the 2 days germination period. From this, it can be seen that a high water uptake does not necessarily mean a rapid and homogenous moistening of the endosperm, because the distribution of the water absorbed can vary considerably[4].

Malting Loss and Malt Yield: The highest malt yield was recorded for FARO 57 (94.96%) which also had the least malting loss (5.04%). It is possible that leaching and other causes of malting were diminished in FARO 57 as a genetic characteristic. The least malt yield was for Brown rice (87.81%) which also recorded a very high malting loss (12.19%) second to R8 (12.55%). The high germinative energy and germinative capacity for Brown rice and R8 might have influenced the high malting losses for both varieties. There were significant differences ($p<0.05$) between the malting loss of the malts amongst the rice varieties. Also, significant differences ($p<0.05$) exists between the malt yield of the malts amongst the rice varieties. Malting loss is the material lost as percent dry weight in converting the rice paddy grain into rice malt. Suhasini and Malleshi[13] stated that malting loss is a measure of metabolic activity associated with grain germination and separation of grain's rootlets and acrospire during its development, which increases as germination duration increases. Similarly, malting losses were also reported by Hammond[14]. The malt yield and malting loss of rice grains in this work could be as a result of some physicochemical changes that occurred during the malting. Furthermore, the decrease in malt yield observed for Brown rice, Nwangbenya and R8 could be due to higher physiological activities during germination and moisture loss after kilning. It is important to note that the grains physiological activities increased during germination probably as a result of the enzymatic activities leading to the effective use of food reserves in the endosperm for growth and energy[15]. Also, the combined action of steeping process as well as germination might in part have contributed to the decrease in malt yield for the aforementioned varieties as a result of loss of minerals and other grain soluble extracts through leaching. In addition, decrease in malt yield with an increase in malting loss of these varieties (Brown rice, Nwangbenya and R8) indicated that these rice varieties exhibited faster germination more than the other varieties; and this could be attributed to various agronomic practice. According to Kunze[4], grains from inland regions swell and germinate more quickly than grains from maritime regions[4]. The observable low malt yield and high malting loss could also attributed to the starch breakdown in the germinated rice paddy grains. This is in agreement with the work done by other researchers[8] who reported that large grain kernel size could be as a result of its high starch content, thus higher thousand (1,000) corn weight. The result showed that the rice varieties with higher thousand corn weight had higher malting loses and lower malt yield compared to other varieties. The main goal of a maltster is to obtain the desired modification in a grain for a particular type of malt while reducing to a minimum the loss in weight consequent on the activity of the embryo[16].

Table-1: Malting Characteristics and Grain Quality Properties of Rice Varieties.

Rice Variety	Thousand Corn Weight (g)	Germinative Energy (%)	Germinative Capacity (%)	Malt Yield (%)	Malting Loss (%)	Degree of Steeping (%)
306 Variety	26.47^{e}±0.02	93.50^{b}±0.03	93.37^{b}±0.02	94.72^{b}±0.00	5.28^{h}±0.03	48.64^{h}±0.03
Brown Rice	30.40^{b}±0.08	98.00^{a}±0.04	97.96^{a}±0.03	87.81^{i}±0.01	12.19^{b}±0.01	45.02^{i}±0.03
Dragon 12	29.53^{c}±0.19	95.00^{b}±0.01	94.90^{b}±0.03	94.67^{b}±0.04	5.33^{g}±0.03	53.30^{b}±0.03
FARO 44	27.27^{d}±0.07	94.00^{b}±0.01	93.88^{b}±0.02	89.34^{g}±0.00	10.66^{c}±0.03	53.10^{c}±0.07
FARO 52	26.00^{f}±0.16	94.00^{b}±0.01	93.88^{b}±0.02	92.49^{c}±0.01	7.51^{f}±0.01	55.53^{a}±0.04
FARO 57	25.57^{g}±0.07	87.00^{d}±0.01	86.74^{d}±0.03	94.96^{a}±0.03	5.04^{i}±0.00	51.08^{d}±0.03
FARO 61	25.00^{h}±0.05	85.50^{d}±0.03	85.21^{d}±0.04	90.67^{e}±0.03	9.33^{d}±0.04	50.75^{e}±0.03
IWA 3	26.27^{e}±0.10	92.00^{c}±0.04	91.84^{c}±0.05	92.22^{d}±0.03	7.78^{e}±0.03	49.59^{f}±0.01
Nwangbenya	30.97^{a}±0.04	97.00^{a}±0.01	96.94^{a}±0.02	88.97^{h}±0.03	11.03^{c}±0.00	49.12^{g} ±0.03
R8 Variety	30.33^{b}±0.02	96.50^{a}±0.03	96.45^{a}±0.03	87.45^{f}±0.03	12.55^{a}±0.00	46.85^{i}±0.03
LSD	0.22	1.53	1.53	0.06	0.05	0.08

Values are the means of duplicate determinations. Means with different superscript (a,b..) along a column for each treatment differs significantly (P<0.05).

Table-2a: Mean Values of Proximate Composition of Unmalted and Malted Rice Flour.

Rice Variety	Moisture (%)		Protein (%)		Fat (%)	
	Unmalted	Malted	Unmalted	Malted	Unmalted	Malted
306 Variety	*9.45^{d}±0.03	7.00^{b}±0.03	8.22^{bc}±0.04	8.30^{c}±0.02	*3.35^{i}±0.03	1.47^{c}±0.01
Brown Rice	*10.95^{a}±0.03	7.46^{a}±0.03	8.91^{a}±0.05	*9.39^{a}±0.08	*4.90^{e}±0.01	1.90^{b}±0.01
Dragon 12	*10.50^{b}±0.01	5.97^{e}±0.03	8.32^{b}±0.10	*8.57^{b}±0.05	*5.37^{b}±0.01	0.99^{d}±0.00
FARO 44	*9.50^{c}±0.03	7.46^{a}±0.03	6.75^{f}±0.06	*7.88^{d}±0.04	*4.95^{d}±0.01	0.98^{d}±0.01
FAR0 52	*9.00^{e}±0.01	4.98^{g}±0.01	7.43^{d}±0.10	*7.71^{e}±0.10	*5.42^{a}±0.03	0.99^{d}±0.00
FARO 57	*8.96^{f}±0.03	7.50^{a}±0.01	8.08^{c}±0.05	*8.56^{b}±0.05	*5.31^{c}±0.01	1.94^{a}±0.01
FARO 61	*8.46^{g}±0.00	6.47^{d}±0.03	6.88^{f}±0.08	*8.17^{c}±0.11	*2.90^{j}±0.01	0.98^{d}±0.01
IWA 3	*10.50^{b}±0.03	6.47^{d}±0.03	7.10^{e}±0.03	*7.75^{d}±0.08	*3.79^{g}±0.01	0.97^{d}±0.01
NWANGBENYA	*8.96^{f}±0.03	6.97^{c}±0.01	6.18^{g}±0.06	*6.99^{f}±0.08	*4.50^{f}±0.01	1.48^{c}±0.01
R8	*8.50^{g}±0.01	5.47^{f}±0.03	7.37^{d}±0.09	*8.57^{b}±0.05	*3.48^{h}±0.01	0.97^{d}±0.01
LSD	0.05	0.06	0.16	0.16	0.04	0.03

Table-2b: Mean Values of Proximate Composition of Unmalted and Malted Rice Flour.

Rice Variety	Crude Fibre (%)		Ash (%)		Carbohydrate (%)	
	Unmalted	Malted	Unmalted	Malted	Unmalted	Malted
306 Variety	0.50^{a}±0.00	0.50^{a}±0.00	1.48^{b}±0.01	1.48^{b}±0.01	77.00^{bc}±0.01	*81.25^{cd}±0.03
Brown Rice	0.50^{a}±0.00	0.50^{a}±0.00	0.97^{c}±0.03	0.97^{d}±0.03	73.77^{d}±0.02	*79.78^{d}±0.01
Dragon 12	0.50^{a}±0.00	0.50^{a}±0.00	1.46^{b}±0.01	1.46^{bc}±0.01	73.85^{d}±0.03	*82.51^{bc}±0.02
FARO 44	0.50^{a}±0.00	0.50^{a}±0.00	1.95^{a}±0.03	1.94^{a}±0.01	76.35^{bc}±0.01	*81.24^{cd}±0.03
FAR0 52	0.50^{a}±0.00	0.50^{a}±0.00	0.98^{c}±0.01	0.98^{d}±0.01	76.67^{bc}±0.03	*84.84^{a}±0.03
FARO 57	0.50^{a}±0.00	0.50^{a}±0.00	0.99^{c}±0.01	0.98^{d}±0.01	76.16^{c}±0.02	*80.52^{d}±0.01
FARO 61	0.50^{a}±0.00	0.50^{a}±0.00	*0.98^{c}±0.01	0.96^{d}±0.01	80.28^{a}±0.03	*82.92^{bc}±0.03
IWA 3	0.50^{a}±0.00	0.50^{a}±0.00	0.49^{d}±0.01	0.49^{e}±0.00	77.62^{b}±0.01	*83.82^{ab}±0.02
NWANGBENYA	0.50^{a}±0.00	0.50^{a}±0.00	*1.46^{b}±0.01	1.44^{c}±0.01	78.40^{ab}±0.02	*82.62^{bc}±0.03
R8	0.50^{a}±0.00	0.50^{a}±0.00	0.98^{c}±0.00	0.98^{d}±0.00	79.17^{a}±0.03	*83.51^{ab}±0.01
LSD	NS	NS	0.12	0.03	2.15	2.18

Proximate Composition of Unmalted and Malted Rice Flour: The mean values of the proximate composition of unmalted and malted rice flour are presented on Table-2a&b.

Moisture Content: The moisture content of the unmalted rice flour samples varied from 8.46 to 10.95% while that of malted rice flour sample varied from 4.98 to 7.50% for the different rice varieties respectively. Brown rice and FARO 61 had the highest and least moisture content of 10.95% and 8.46% respectively for unmalted rice flour while FARO 57 and FARO 52 had the highest and least moisture content of 7.50% and 4.98% respectively for malted rice flour. There were significant differences ($p<0.05$) between the rice varieties in their moisture content. The variations in the moisture content of these unmalted rice flours could be attributed to differences in environmental conditions such as climatic, soil, processing conditions and the duration of storage of the paddy grains after harvest[17]. Malted rice flour samples and unmalted rice flours were significantly different ($p<0.05$) in moisture level amongst the rice varieties. The decrease in amount of moisture in malted rice flours was obviously due to the kilning of the germinated grains in an oven in order to stop germination process which in turn reduces the moisture content of the germinated grains as the drying process progresses[18,19]. Moisture content is an indication of grain quality and also gives information on milled grains consistency. Low grain moisture content is obtained when temperature of drying is high and also when duration of drying is prolonged for medium drying temperature. According to Ayernor and Ocloo[8], malt to be stored for a long period should be dried to a slightly lower moisture level. At the moisture level obtained in this research work, the malts can be stored as shelf stable product for a reasonable duration since moisture content of 4.98 to 7.50% is still regarded as low to invite pest infestations[20]. On the other hand, investigations have shown that low moisture content foods are desirable probably because of its reduced microbial activity[21]. Foods with low moisture content tend to have longer shelf life[22], while foods with high moisture content encourage microbial growth; hence, food spoilage[23,24].

Protein Content: The protein content of the unmalted rice flour samples varied from 6.18 to 8.91% while that of malted rice flour samples varied from 6.99 to 9.39% for the different rice varieties respectively. Brown rice and Nwangbenya had the highest and least protein content of 8.91% and 6.18% respectively for unmalted rice flour while Brown rice and Nwangbenya had the highest and least protein content of 9.39% and 6.99% respectively for malted rice flour. The protein content of the malted rice flour samples was significantly higher ($p<0.05$) than that of unmalted rice flour samples amongst the varieties. The increase in protein content of the malted rice flour when compared to unmalted rice flour could be attributed to the early development response of the grain during steeping where the embryo had to signal the gibberellic acid to resume production of amino acids to complement what the embryo needs for development. During germination, some of the enzymes which are high molecular weight proteins are produced[4] and therefore as a percentage of the entire rice kernel, the protein content and related compounds appear to increase.

The above statement confirms the report of Guido and Moreira[16] which reported that the early stages of germination involves production of many hydrolytic enzymes (which are proteins) by the scutellum, followed by enzymatic breakdown of cell walls of the crushed cell layer, proteins and starch granules of the endosperm. However, the increase in protein content was due to increase in nitrogenous compounds[4] but eventually reaches its peak in the first two days of germination and tends to decrease afterwards as these nitrogenous compounds are used to build up new tissues for rootlet development. This observation is in agreement with other scientific researches that germination as a processing operation improved the nutritional quality of the food products, especially in terms of its protein content[25]. The result obtained in this study for protein content was also in conformity with the work of Fasasi[26] who reported a significant increase in the protein content of malted millet as compared to unmalted millet. The higher protein content of malted rice flour could be as a result of proteolytic activities of enzymes during germination, which increased bioavailability of amino acids.

Fat Content: The unmalted rice flours recorded 2.90 to 5.42% fat for the different rice varieties while that of malted rice flour samples varied from 0.97 to 1.94% for the different rice varieties. FARO 52 and FARO 61 had the highest and least fat content of 5.42% and 2.90% respectively for unmalted rice flour while FARO 57 and IWA 3 had the highest and least fat content of 1.94% and 0.97% respectively for malted rice flour. The fat content of the malted rice flour samples were significantly lower ($p<0.05$) than that of the unmalted rice flour samples. The lower fat content in the malted rice flour samples might be as a result of increased actions of lipolytic enzymes during germination[27], which hydrolyses fats to fatty acids and glycerol. The simpler products can be used for synthesis of carbohydrate and protein or as a source of energy for the developing embryo[28]. A reduction in fat content of malted foxtail millet, malted chicken pea and malted wheat as compared to the unmalted samples since fat provides twice as much energy as carbohydrates during germination was also reported by Laxmi *et al*[29].

Crude Fibre: The mean values of the crude fibre content for both unmalted and malted rice flour samples for the different rice varieties was 0.50%. The results showed that there was no significant difference ($p>0.05$) found in both unmalted and malted rice flour samples. This result is in agreement with the work of Banusha and Vasantharuba[30] who reported that there was no significant difference ($p>0.05$) in the crude fibre content of finger millet ungerminated and those germinated for 12 hours, 24 hours and 36 hours.

Ash Content: The mean values of the ash content of unmalted rice flour samples varied from 0.49 to 1.95% while that of malted rice flour samples varied from 0.49 to 1.94%. FARO 44 recorded the highest asch content of 1.95% while IWA 3 recorded the least ash content of 0.49% for unmalted rice flour. However, FARO 44 recorded the highest ash content of 1.94% while IWA 3 recorded the least ash content of 0.49% for malted rice flour. The results showed that there were no significant differences ($p>0.05$) in ash content for both unmalted and malted rice flour for the different rice varieties. There was no variation in the ash content of malted samples compared to the unmalted samples except for FARO 44, FARO 57, FARO 61 and Nwangbenya that showed slight decrease in ash content. This is in agreement with the report of Banusha and Vasantharuba[30] between germinated and ungerminated finger millet having insignificant ash content. The amount of ash in a product is an indication of its mineral constituent.

Carbohydrate Content: The mean values of the carbohydrate content of unmalted rice flour samples varied from 73.77 to 80.28% while that of malted rice flour samples varied from 79.78 to 84.84%. FARO 61 and Brown rice had the highest and least carbohydrate content of 80.28% and 73.77% respectively for unmalted rice flour while FARO 52 and Brown rice had the highest and least carbohydrate content of 84.84% and 79.78% respectively for malted rice flour. There were significant differences ($p<0.05$) in the carbohydrate content amongst the rice varieties. From the results, the carbohydrate content of the malted rice flour were significantly higher ($p<0.05$) than that of unmalted rice flour. However, it is expected that the mean values of carbohydrate content of malted rice flours be lower than that of unmalted rice flour because during malting, the rice seed passed through different metabolic processes such as modification of starchy endosperm thus causing an increase in quantity of grain enzymes present and also partial degradation of reserve substances in the starchy endosperm[8,31] but that is not the case in this experiment. The higher mean values of malted rice flour samples could be as a result of proportionate decrease of other constituents in the malted grain thereby causing an increase in the carbohydrate content of malted grains. This is in consonance with the findings of Morris *et al*.[32] which reported that moisture removal in most cases causes concentration of nutrients to increase thereby can making some nutrients more available.

Conclusion

The locally available Nigerian rice varieties exhibited satisfactory capacity to be used as malted grain particularly Brown rice, Nwangbenya and R8. Grains with larger kernel size have better malting properties than small kernel size grains, but tend to have higher malting loss. Generally, all the rice varieties exhibited desirable grain quality characteristics. Malting reduces ash, fat and moisture content of rice flours with a corresponding increase in protein and carbohydrate.

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