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Comparative analysis of starch properties and proximate composition of some selected Nigerian rice varieties cultivated in Ebonyi State, Nigeria

Enenge, Chukwuma N and Oko, Augustine O

Department of Biotechnology, Ebonyi State University, PMB 053 Abakaliki, Nigeria

ABSTRACT

Unknown differences in starch properties and proximate composition of rice grains pose problem in choice making. The starch properties and proximate composition of 14 rice varieties were analyzed. Amylose content was determined spectrophotometrically. Significant differences (P< 0.05) were recorded in all traits studied among all the varieties. The highest composition of protein and fat (8.43±0.06%) and (1.73±0.03%) were both found in 'Eleco 20' and least in 'Maruwa' (5.43±0.04%) and FARO52 (0.36±0.03%) respectively. *306* has the highest content of carbohydrate (87.83±0.06%) and energy (383.81±0.30Kcal). Negative relationship existed between carbohydrate and every other proximate component of the rice grains. The highest and least values of gel consistency were recorded in 'Awafum'(48.67±2.02mm) and 'Maruwa'(34.33±0.6mm) respectively. FARO52 has highest (29.31±0.58%) and 'B12' least (20.18±1.05%) composition of amylose. 'Canada' and 'Eleco 20' have least alkali spread value of 3.00 while 'CP', FARO52 and B12 have the highest value of 7.00. Significant negative relationship exists between apparent amylose and amylopectin content. The result of this research is a strong guide to management of some metabolic disorders such as diabetes and nutrient deficiency diseases like kwashiorkor and marasmus while consuming rice grains, and will also help in checking appearance of rice grains after cooking following their gel type.

Keywords: Starch, proximate composition, rice varieties, and Nigeria

Highlights

- *306* has the highest composition of carbohydrate (87.83±0.06%) and energy (383.81±0.30Kcal) values.
- FARO52 has the highest composition of amylose (29.31±0.58%)
- Carbohydrate show negative correlation with all other proximate components.
- *CP*, FARO52 and *B12* have low gelatinization temperatures

INTRODUCTION

Rice is the seed of the monocot plants *Oryza sativa (* Asian rice) or *Oryza glaberrima* (African rice). As a cereal grain, it is the most widely consumed staple food for a large part of the world's human population [1]; [2]. Since a large portion of maize crops are grown for purposes other than human consumption, rice is the most important grain with regard to human nutrition and caloric intake, providing more than one fifth of the calories consumed worldwide by humans [3]. Rice cultivation is well suited to countries and regions with low labour costs and high rainfall, as it is labour-intensive to cultivate and requires ample water. However, rice can be grown practically anywhere, with the use of water- controlling terrace systems. Although its parent species are native to Asia and certain parts of Africa, centuries of trade and exportation have made it common place in many cultures worldwide [4]. High temperature during the grain-filling stage causes deleterious effects on the yield and quality of crop products. Temperature above certain growth-optimal temperatures impairs dry matter production, generally decreasing grain size in all major cereal crops such as rice (*Oryza sativa)*, wheat (*Triticum aestivum*), and maize (*Zea mays*). Such small grains result in not only decreased yield but also low milling quality. For japonica cultivars of rice, temperatures higher than 26°C render chalky grain appearance as well as reduction of grain weight. Severely chalky brown rice grains are inferior for polishing quality and palatability [5]. The chalky grains ripen under high temperature conditions result in lower yield after polishing and less sticky texture after cooking than translucent grains ripened under low temperature. Parboiling is a process developed for improving rice quality. It consists of soaking, steaming and drying of the raw rice. The major reasons for parboiling rice include higher milling yields, higher nutritional value and resistance to spoilage by insects and mold [6]. The parboiling process is applied to rice with a preliminary objective of hardening the kernel in order to maximize head rice yield in milling. Besides milling yield it was also the realization of the nutritional and health benefits of parboiled brown rice compared to raw rice that created the awareness and importance of parboiling among consumers. Traditionally, parboiling consists of steeping raw rice in water at room temperature followed by steaming or boiling at 100°C and sun-drying. Recently more sophisticated procedures such as dry-heat parboiling and pressure parboiling have been applied [7]. Rice is rich in carbohydrate and has a moderate amount of protein and fat, and also a source of vitamin B complex such as thiamin, riboflavin, niacin [8]. Starch is the main carbohydrate of rice in the form of amylose and amylopectin. The rice grain contains 12% water, 75% – 80% starch and only 7% protein with a full complement of amino acids [9]. The cooking and eating properties are determined by the amylose content and gelatinization temperature. The amylose content is significantly affected by the various storage intervals and treatments [10]. It is also affected by other factors such as rice cultivars, moisture content, proteins content, lipid, processing methods, prolamin, and pH [11]. Gelatinization temperature is inversely proportional to the alkali spreading value of rice starch. Rice texture is soft and sticky for varieties with low amylose content while rice varieties with high amylose content become stiff and fluffy on cooking [12]. When rice is cooked at 70.80°C, the uptake of water is strongly influenced by the gelatinization temperature. The lower the gelatinization temperature of the variety, the higher its water uptake and vice versa [13].

Materials and Methods

Plant materials

Fourteen rice varieties sourced from different parts of Nigeria: *Aiwa8*, *Awafum*, *B12*, *Canada*, *Cp*, *Dangot*, *Eleco20*, FARO52, *Maruwa*, *Mass*, NERICA7, *Short Caro*, *Ton2* and *306* were grown under the same normal agronomic practices in the Faculty of Sciences, Ebonyi State University, Abakaliki. All analyses were carried out at the National Cereal Research Institute, Badeggi, Niger State, Nigeria.

Sample preparation

The rice grains were harvested at maturity and threshed. The grains were parboiled and sun-dried. The paddy were dehusked using laboratory Dehusker, THU 35B (Satake Engineering Company Ltd, Tokyo) and then prepared for analyses.

Gelatinization Temperature

The Gelatinization temperature of different varieties was obtained by alkali spreading test [14]. The degree of spreading of whole milled rice grain in alkali solution at room temperature was recorded on a 7-point numerical scale of 1 to 7 [15]. Test was conducted three times for each rice variety; 6 whole milled grains were placed in a petridish containing 15 ml of 1.7% potassium hydroxide Solution. The grains were kept separate from each other and incubated at room temperature for 23 hours. A low ASV corresponds to a high gelatinization temperature (GT), high ASV indicates a low GT. The values were read following the GT score table [14].

Determination of Amylose and Amylopectin Content

A simplified procedure of [16] was used for amylose content analysis. The rice samples were ground into powder with Cyclone Sample Mill, 310-019, UDY Corporation, Fort Collins Colorado, USA. 100mg of the rice flour was mixed with 1ml of ethanol solution and 9ml of IN sodium hydroxide. The mixture was heated in boiling water until there was gelatinization of the starch. After one hour of cooling, water was added and content stirred. Amylose standard varieties were included as controls. 5ml of the starch solution was measured and 1ml of IN acetic acid, 2ml iodine solution was added and volume made up with distilled water. Mixture was then stirred and read at 620nm with a spectrophotometer (Model AA-6650, Shimadzu Co., Japan). Amylopectin content is equal to 100-amylose content.

Determination of Gel consistency (GC)

100mg of rice flour prepared from grains of different varieties was put in test tube and 0.2ml of ethanol containing 0.25% thymol blue and 2.0ml of 2.8g of KOH in 250ml of distilled water were added and mixed thoroughly. They were then kept in boiling water bath for 8 minutes, and allowed to cool for 5 minutes. It was mixed and kept in ice bath for 20minutes. The test tubes were then removed and laid on graph paper for one hour and measurements were made using the graph paper. The degrees of flow were recorded as the consistency of gels of different varieties [17].

Proximate Analysis

The nutritional compositions of the samples were determined as follows.

Determination of Crude Protein Content

This was determined by Micro Kjeldahl method. 100mg of the sample was mixed with kjeldahl catalyst comprising, copper sulphate: Potassium sulphate: Selenium in the ratio 10:50:1. The mixture was digested with 10ml concentrated sulphuric acid. The digested sample was subjected to distillation in the Kjeldatherm distillation machine and the released ammonia was captured in a solution of 4% boric acid. This was then titrated with

0.INHCl. The nitrogen content that resulted was converted into crude protein by multiplying by a conversion factor of 5.95 [18].

Determination of Moisture

5g of the rice flour was weighed into a porclain dish. The dish was placed in an oven maintained at 105^{o}C and dried for 2 hours [19]. The dish was then cooled in a desiccator and weighed. The moisture content of the flour was calculated as follows.

$$\text{Percentage moisture} = \frac{\text{Loss in weight x100}}{\text{Initial weight of the flour}}$$

Determination of Total Ash

The dried flour used in moisture determination was ignited on a blue flame of a burner till the smokes were given off. The porclain dish was kept in a muffle furnace maintained at 550^{o}C for 1 hour before it was cooled in a desiccator and weighed. The ash content was then calculated as follows.

$$\text{Percentage ash} = \frac{\text{Weight of ash x 100}}{\text{Weight of sample}}$$

Determination of Crude Fat

This was determined using the Soxhlet extractor. 2g of dried rice flour was transferred into the extraction thimble and placed in the extractor so that it was within its siphon height. Extraction flask was then connected to the extractor. Sufficient petroleum ether was poured into the extractor to the siphon and the flask was filled to half. The extractor that was fixed to the condenser was heated for 3 hours. The fat present in the sample is extracted by the solvent that fall drop wise into the thimble. When the level of the solvent reached the siphon height, the ether flowed down into the flask taking along the extracted fat. The solvent in the flask was then evaporated and the one left in the flask was dried in oven maintained at 100^{o}C to obtain a constant weight. The amount of fat was obtained by multiplying the increase in weight of flask by hundred and dividing by 2 [18].

Determination of Crude Fibre

The fat-free residue obtained from fat determination was transferred into one-liter conical flask. A boiling dilute sulphuric acid was poured into the flask and boiled for 30 minutes and the liquid level maintained by connecting the flask to a reflux condenser. The flask was rotated frequently and any particle by the side removed. After 30 minutes, the flask was removed and the content was filtered through 5 layers of fine linen and washed with boiling water. The process was repeated with NaOH. The residue obtained was transferred to Gooch Crucible and dried to constant weight at 105^{o}C in the oven. The crucible and content was ignited in muffle furnace at 600^{o}C and was later cooled in a desiccator and weighed. The weight of the ash was subtracted from the weight of the residue dried at 105^{o}C to obtain the weight of the crude fibre.

Determination of Total Carbohydrate

This was obtained by anthrone method as described by [20]. 50mg of rice flour was digested with INHCl for 12 hours at room temperature and neutralized with sodium carbonate. The filtrate was mixed with anthrone reagent and left for 8 minutes in boiling water bath. The absorbance was read with spectrophotometer at 630nm (Systronics 119) using D-glucose as standard.

Calculation of Total Energy (Kcal)

Gross energy was calculated using the formula reported by [21].

Gross energy (KJ per 100 dry matter) = (crude protein x 16.7) + (Crude Lipidx37.7) + (Crude carbohydrate x16.7). The value in Kilojoules (KJ) was converted to kilocalories (Kcal) by dividing each value by 4.184.

Result of Starch Property Analysis

Table 1 shows starch properties of different rice varieties. The highest length of gel (48.67±2.02mm) was recorded in 'Awafum' and least (34.33±0.67mm) in 'Maruwa'. FARO 52 has highest composition of amylose (29.31±0.58%) while least composition (20.18±1.05%) was found in 'B12'. The amylopectin content of the grains were in the range of 70.69±5.58% in FARO 52 to 79.82±1.05% in 'B12'. FARO 52, 'CP' and 'B12' have alkali spread values of 7 while 'Eleco 20' and 'Canada' have values of 3. Figure 1 shows the spreading of the grains in 1.7% KOH solution.

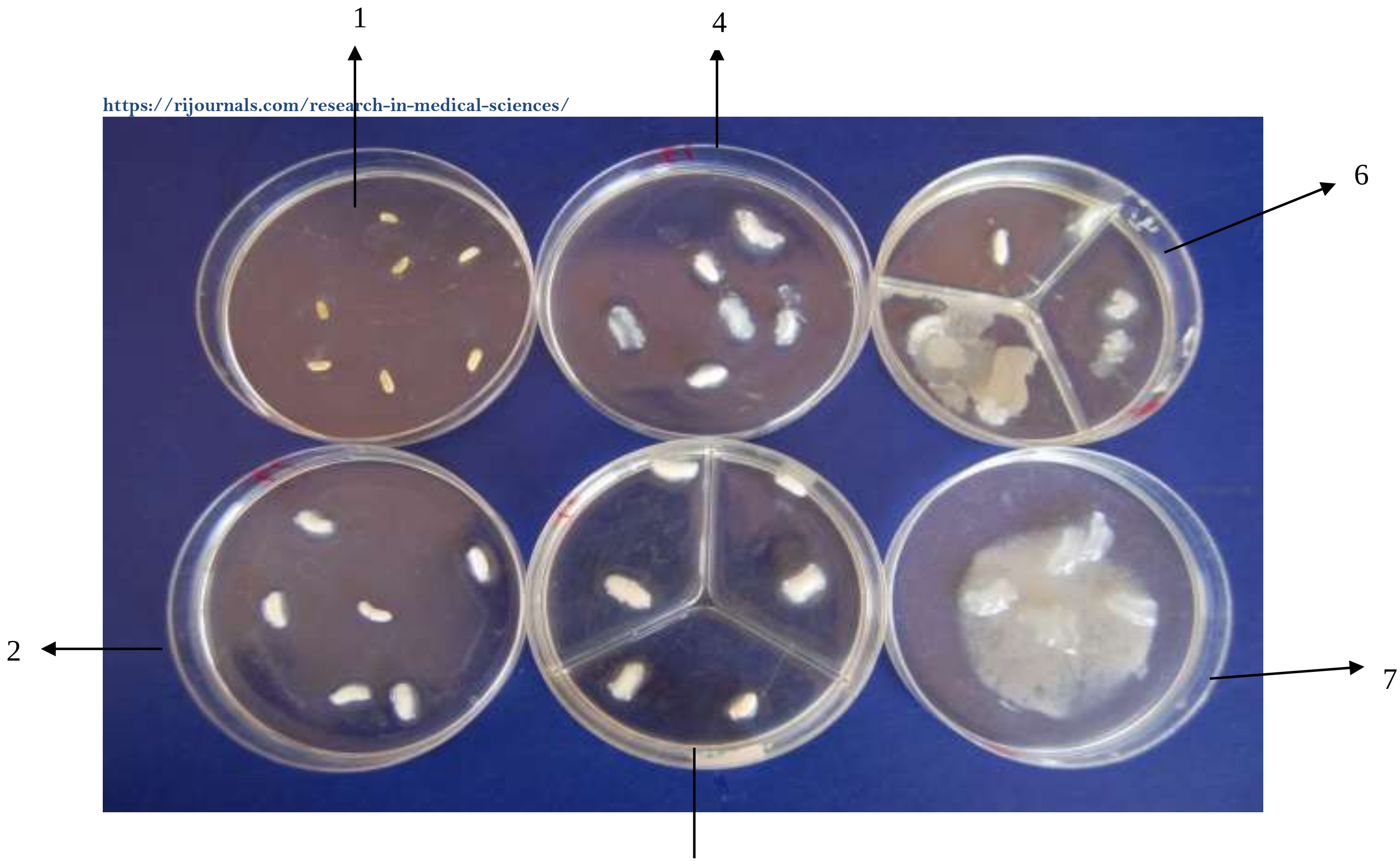

Figure 1: Alkali spread value Scores of Rice Grains

Table 1: Mean Values of Starch Properties of Rice Grains

VARIETY	GC	AAC	APC	ASV	GT
Maruwa	34.33±0.67^{ab}	24.35±2.26^{b}	75.65±2.26^{b}	5.00±1.00^{ab}	Intermediate
Aiwa8	47.33±4.04^{a}	27.83±0.93^{a}	72.17±0.93^{c}	5.00±1.00^{ab}	Intermediate
Awafum	48.67±2.20^{a}	22.44±0.85^{bc}	77.56±0.85^{a}	5.00±2.00^{ab}	Intermediate
Canada	41.67±1.13^{b}	24.86±1.13^{b}	75.14±1.13^{b}	3.00±0.00^{b}	High
Mass	43.33±11.37^{a}	23.84±1.13^{b}	74.16±2.78^{b}	4.00±2.00^{ab}	Intermediate
Ton2	43.67±0.58^{a}	28.55±0.31^{a}	71.45±0.31^{c}	5.00±0.00^{ab}	Intermediate
306	43.33±1.53^{a}	22.09±1.08^{a}	77.91±1.08^{a}	5.00±0.00^{ab}	Intermediate
Cp	38.00±6.08^{ab}	24.34±0.99^{b}	75.66±0.99^{b}	7.00±1.00^{a}	Low
FARO52	35.33±11.50^{ab}	29.31±0.58^{a}	70.69±5.58^{c}	7.00±0.00^{a}	Low
Dangot	39.67±4.51^{a}	21.92±2.67^{ab}	78.08±2.67^{a}	6.00±1.00^{a}	Intermediate
NERICA7	44.67±0.58^{a}	24.52±0.09^{b}	75.48±\0.09^{b}	4.67±1.15^{ab}	Intermediate
Short Caro	37.00±4.36^{ab}	22.19±0.05^{bc}	77.81±1.05^{a}	4.00±0.00^{ab}	Intermediate
Eleco20	37.33±5.77^{ab}	20.78±2.55^{bc}	79.22±2.55^{a}	3.00±0.00^{b}	High
B12	40.00±7.00^{a}	20.18±1.05^{bc}	79.82±1.05^{a}	7.00±0.00^{a}	Low
Grand Average	41.02±6.33	24.09±2.99	75.77±3.07	5.05±1.55	Intermediate

*Values are mean ± standard deviation
*Means with the same letters the column are not significantly different at $p \leq 0.05$
Key: GC =gel consistency, AAC= apparent amylase content, APC= amylopectin content, ASV= alkali spread value, GT=gelatinization temperature

Table 2: Correlation between Starch Properties

	GC	AAC	APC	ASV
GC	1			
AAC	0.159	1		
APC	-0.102	-0.954**	1	
ASV	-0.170	0.129	-0.093	1

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)
Key: GC = gel consistency, AAC = apparent amylose content, APC = amylopectin content, ASV = alkali spread value.

Result of Proximate Analysis

FARO52 has the highest moisture content (8.51±0.02%) while '306' with 3.73±0.04% has the least moisture content. Table 3 shows significant variation in fat content of the varieties with 'Eleco 20' having the highest value (1.73±0.03%), followed by 'B12' (1.52±0.06%) while FARO52 is the least with (0.36±0.03%). 'Eleco 20' has the highest crude protein (8.43±0.06%) while least percentage was found in 'Maruwa' (5. 43±0.04%). The highest fibre content (1.71±0.03) was found in FARO52 and 'Mass' with least amount in '306' (0.89±0.08%). Ash is most abundant in 'Canada' (1.28±0.03%) with the least value (0.24±0.04%) in '306'. The highest composition of carbohydrate (87.83±0.06%) was obtained in *306* with the least composition in FARO52 (80.83±0.05%). '306' has the highest energy content (383.81$\pm 0.30 kcal$) and the least (357.92±0.08) was found in FARO 52. Correlation between pairs of the proximate components is presented in table 4.

Table 3: Mean Values of Proximate Compositions of Rice Grains

Varieties	Moisture (%)	Fat (%)	Crude protein (%)	Crude fibre (%)	Ash (%)	CHO (%)	Energy value (kcal)
Maruwa	6.07±0.07^{a}	1.01±0.07^{b}	5.43±0.04^{e}	1.08±0.03^{e}	0.61±0.04^{c}	85.73±0.17^{b}	373.90±0.33^{d}
Aiwa 8	5.43±0.18^{ab}	1.03±0.12^{b}	6.45±0.03^{d}	1.47±0.02^{c}	0.98±0.05^{a}	84.74±0,16^{b}	372.68±0.40^{d}
Awafum	6.56±0.02^{a}	1.29±0.03^{b}	5.62±0.04^{e}	1.68±0.04^{ab}	0.51±0.02^{e}	84.32±0.05^{b}	371.57±0.29^{f}
Canada	3.95±0.15^{b}	0.64±0.02^{d}	8.17±0.04^{b}	1.36±0.02^{c}	1.28±0.03a	84.48±0.35^{b}	377.23±0.63^{b}
Mass	5.07±0.03^{ab}	0.56±0.05^{e}	5.45±0.03e	1.71±0.03^{a}	0-57±0.55^{d}	86.93±0.07^{a}	374.47±0.18^{c}
Ton 2	6.41±0.09^{a}	0.74±0. 17^{c}	8.19±0.01^{a}	1.34±0.01^{d}	0.60±0.02^{d}	82.73±0. 14^{c}	369.87±0.59^{c}
306	3.73±0.04^{c}	0.61±0.07^{e}	6.69±0.06^{c}	0.89±0.08^{f}	0,24±0 .04^{f}	87.83±0.06^{a}	383.81±0.30^{a}
Cp	5.12±0.06^{ab}	0.84±0.05^{c}	5.71±0.07e	1.03±0.02^{f}	0.46±0.03^{f}	86.77±0.05^{a}	377.88±0.13^{a}
FARO 52	8.51±0.02^{ab}	0.36±0.03^{e}	7.81±0.02^{c}	1.71±0.03^{a}	0.75±0.03^{b}	80.83±0.05°	357.92±0.08^{c}
Dangot	4.64±0.02^{a}	0.75±0.09^{c}	6.21±0.10^{e}	1.00±0.07^{f}	0.67±0.02^{b}	86.61±0.22^{a}	378.19±0.02^{a}
NERICA7	7.29±0.02^{a}	0.54±0.04^{e}	6.68±0.07^{c}	1.28±0.03^{d}	0.71±0.02^{b}	83.50±0.06^{c}	365.62±0.38^{E}
Short Caro	6.18±0.03^{a}	1.00±0.03^{c}	7.18±0.03^{c}	1.61±0.21^{b}	0.53±0.02^{d}	83.43±0.28^{c}	371.62±0.72^{f}
Eleco 20	6.32±0.02^{a}	1.73±0.03^{a}	8.43±0.06^{a}	1.26±0.05^{d}	0.88±0.04^{b}	81.33±0,03^{c}	375.14±0.69^{c}
B12	5.19±0.02^{ab}	1.52±0.06a	7.32±0.01^{c}	1.22±0.02^{d}	0.72±0.02^{b}	84.01±0.02^{c}	379.03±0.34^{a}
Grand Average	5.75±1.26	0.90±0.39	6.81±1.04	1.33±0.27	0.68±0.27	84.52±2.05	373.49±6.19

*Values are mean ± standard deviation
*means with the same letter down the column are not significantly different at p ≤ 0.05

Table 4: Correlation between Proximate Components

	Moisture	Fat	Crude protein	Crude fibre	Ash	CHO	Energy Value (Kcal)
Moisture	1						
Fat	-0.27	1					
Crude protein	0.71	0.115	1				
Crude fibre	0.514**	-0.065	0.089	1			
Ash	0.000	0.102	0.4488	0.177	1		
CHO	-0.762**	-0.241	-0.717**	-0.485**	-0.380*	1	
Energy Value (Kcal)	-0.922**	0.317*	-.203	-0.636**	-0.156	0.708**	1

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)
Key: CHO = carbohydrate.

DISCUSSION

Starch properties

Significant difference was recorded in amylose, amylopectin and gelatinization temperature across the 14 varieties. Gel consistency was found to be in the range of 48.7mm to 34.3mm with 'Awafum' having the highest value and 'Maruwa', the least gel length. Highest amylose content was recorded for FARO52 and ranged from 29.3% to 20.2%. 'B12' showed highest amount of amylopectin followed by 'Eleco20' and is in the range of 79.8% to 70.7%. Alkali spread value (ASV) which measures the gelatinization temperature, has its highest value recoded for 'B12' and is least in 'Canada'. ASV ranged from 7 to 3 with average value of 5.05±1.55. Rice is classified based on gel length as soft (61 to 100mm), medium (41 to 60mm) and hard (27 to 40mm) according to [22]. All the varieties analyzed are of medium and hard gels as they have length ranging from 48.7mm to 34.3mm with average length of 41.02±6.33mm. 'Maruwa', FARO52, 'CP', 'Dangot', 'Short caro', 'Eleco20' and 'B12' with hard gels will cook dry. High protein content was reported to be associated with harder gel consistency and that hard gel consistency implies longer cooking time and more water [22]. [23], reported that most consumers prefer soft gel consistency to hard gel consistency. Hard gel is also associated with high amylose content. The result on amylose is in agreement with the report of [24] that had a range of 23.1% to 29%. [15], noted that many of the cooking and eating characteristics of rice are influenced by the ratio of amylose to amylopectin in the rice grain. Rice variety with high content of amylose show high volume expansion during cooking and appear dry, less tender and hard on cooling [25]. All the varieties analyzed fall within intermediate (20-25%) and high (>25%) amylose. This means that all the varieties may cook dry, less tender and become hard as they cool. Varieties with high amylose content like FARO52, Ton2 and 'Aiwa8' will be best for diabetic patients. This is due to the fact that amylose is less digestible than amylopectin, thus its description as digestion resistant form of starch. The varieties ranged from high to low gelatinization temperatures (GT), with mean value falling within intermediate gelatinization temperature. This refers to the temperature range at which starch granules begin to swell irreversibly in hot water. Rice with high GT becomes excessively soft when overcooked, elongates less and requires more water than those with intermediate or low GT [26]. Low GT ranges from 55°C to 69°C, intermediate is from 70-74°C, while high GT is 75°C and above [27], there was insignificant negative correlation between amylopectin and gel consistency. Significant negative correlation exists between amylopectin and apparent amylose content.

Proximate composition

There are significant differences in the proximate composition of the different varieties. Moisture content is in the range of 8.51% to 3.73% with FARO52 having the highest value while '306' has the least value. Fat content ranged from 1.73% in 'Eleco20' to 0.36% in FARO52. 'Eleco20' has highest amount of crude protein (8.43%) while 'Maruwa' has the least amount (1.08%). Fibre content ranges from 1.71% in FARO52 to 0.89% in '306'. Highest amount of ash was found in 'Canada' with least in '306'. Highest carbohydrate content and energy, 87.83±0.06% and 383.81±0.30kcal respectively were both recorded for '306' while least amount of both was found in FARO52. The result of [3] on proximate composition of rice grains is similar to ours in this work. Their result showed 8.16% as highest value of protein, 0.90% of ash and carbohydrate content of more than 70%. The nutritional quality of rice depends on the protein content and rice is the poor source of protein content among cereals [18].

The amino acid composition of rice protein should be of greater importance. Rice protein is known to have unique composition of essential amino acids [21]. Considering the higher content of protein in 'Eleco20', it is expected to be best for children who require higher amount of protein. 'Canada', 'Ton2', FARO52 and 'B12' are also richer in protein than the other rice varieties. On the other hand, '306' with highest content of carbohydrate and energy will be suitable for those adults who engage in energy consuming activities. However such high carbohydrate varieties cannot be recommended for diabetic patients. 'Aiwa8', 'Canada', 'FARO52', 'Eleco20' and 'B12' have higher percentage of ash. The amount of ash in food sample shows the overall range of minerals in the sample. There is higher ash content of the varieties reported in this work than values available in other literatures. However, the values are comparable with that reported by [22] in their analysis of Morogoro rice cultivars. The higher values in this result may have been caused by the mineral content of the soil where these varieties were grown and the water supply to the rice farm. High content of ash affects the sensory quality of the rice especially colour and taste [4]. 'Awafum', 'Mass', FARO52 and 'Shortcaro' with higher fibre content are best for diabetic patients. This is because high fibre content lowers digestibility. Fibre also reduces incidence of constipation and also helps in lowering the cholesterol level, which is implicated in diabetic complications. The protein content of these varieties varying from those of other literatures may have been influenced by factors such as environment, stress like diseases, temperatures, salinity and alkalinity. Total nitrogen in the soil and minerals like chlorine that tend to increase grain protein may have also contributed to this [22]. Differences in the fat content of all the varieties may be accounted for by the removal of part of the bran during milling. This is because fat is concentrated in the aulerone layer of rice kernel. Plant fat is preferred to animal fat considering its composition of unsaturated fatty acids and high level of high density lipoprotein (HDL), the good cholesterol. 'Eleco 20' has the highest amount of crude fat and should be the variety of choice in terms of fat composition. Table 4 shows that moisture has significant negative correlation with carbohydrate and energy at $P \leq 0.01$. This explains the lower carbohydrate content of FARO52 with highest moisture content. Negative relationship also exists between carbohydrate and every other proximate component of rice. Fat show significant correlation with energy only, while energy values has strong negative relationship with moisture and crude fibre. This shows that increase in moisture and fibre lowers the energy value of the grains through reduction in the amount of the component such as carbohydrate, protein and fat.

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