Original Research Article

Nutritional and Glycemic Indices of Different Rice Varieties From Ebonyi and Anambra States Nigeria

ABSTRACT

The Glycemic Indices and proximate composition of selected rice varieties commercially cultivated in Ebonyi State and Anambra State of Nigeria (IR-8, 1416, Faro 44 and 306) were evaluated. Forty five healthy Albino rats were caged in groups of five rats each to perform this study. Each group of rat were fed on a diet for a 14-day period to get them accustomed to it. The group of rats were later fasted for 18hours and tested for blood glucose at zero time before administering amount of test food containing an equivalent of 50g available carbohydrate in the Glucose (Standard), For consistency, each of the rice samples were ground into flour and administered to the rats together with water. Blood sugar was determine at 30,60,90 and 120 minutes by piercing the tip of the rat's tail with needle and One-Touch Ultra glucometer and test strip used. The result showed that 306 Achalla, 306 Afikpo had low glycemic index of 48 and 45 respectively. 1416 Ikwo and 1416 Igbariam had medium glycemic index of 51 and 68 respectively whereas IR-8 Ikwo, IR-8 Igbariam, Faro 44 Achalla and Faro 44 Akaeze had high glycemic index of 70, 78, 84, and 74. The proximate composition of the rice samples had a range of moisture (9.40- 11.10%); Ash (1.10-1.90%); Fat (1.25-2.00%); Crude fibre (0.90-1.40%); Protein (4.73-7.25%); and Carbohydrate (78.30-81.28%). From the results, 306 variety can be said to have a low glycemic index, 1416 a medium glycemic index whereas Faro 44 and IR-8 have high glycemic index, 306 variety could be recommended for the management of diabetics. The result of this study can help workers and experts involved in meal planning and can also go a long way to an effective utilization of our indigenous varieties thus adding value to the crop.

Keywords: Rice variety, Glycemic index, Proximate composition, Albino rat

Comment [D1]: rat group was

Comment [D2]: 14 days

Comment [D3]: Blood sugar was determined at 30,60,90 and 120 minutes by piercing the tip of the rat's tail with needle and One-Touch Ultra glucometer and test strip.

1. INTRODUCTION

Consumption of low glycemic index foods is suggested to be effective for the prevention and control of diabetes. The consumption of high glycemic foods may be implicated in the body's ability to engulf the blood stream with glucose and provoke the release of insulin. Excessive insulin has the ability to encourage the body to burn carbohydrate (CHO), which accumulates in our bodies. Glycemic index expresses the rise in blood glucose elucidated by a carbohydrate food as a percentage of the rise that will occur if an equal amount of carbohydrate from white bread or glucose was consumed [1]. Glycemic index GI is indeed a revolution to the diet of human and describes the ability of specific carbohydrate-rich foods to increase the concentration of glucose in the blood. GI is an indicator of the blood glucose raising potential of foods containing carbohydrate. The GI has been recommended to develop a guide for major carbohydrate food choices because it has been reported that a high GI diet may have adverse health consequences by increasing the risk for chronic diseases [2,3].

Comment [D4]: Consumption of low glycemic index foods is suggested to be effective for preventing and controlling diabetes.

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Rice is a seed of a monocotyledonous plant Oryza sativa. It is cultivated in swampy fields in many tropical countries where it is used as human food. It belongs to the grass family Graminae and tribe Oryzae characterized by one flowered spikelet with short glumes [4]. The centre of origin of rice is believed to be south-eastern Asia (Oryza sativa) and Africa (Oryza glaberrima) with some of the rice producing countries being China, India, Thailand, Indonesia, Japan, United States of America, Spain, Italy, Brazil before it

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spread to Africa. Although the original placental species of rice are native to south-East Asia and certain parts of Africa, centuries of trade and exportation have made it common place in many countries of the world [5]. Rice can be boiled and eaten with soup or stew, it could be pounded, crushed into rice-fufu (tuwo) and served with soup; processed into flour, starch, breakfast cereals and 'sake' a local alcoholic beverage. In Ebonyi state of Nigeria, rice is grown commercially in Ikwo, Akaeze and Izzi and in Anambra state it is grown in Igbariam, Omor and Igbasi. Indigenous rice retains a lot of its natural characteristics because they have not gone through a lot of chemical processing. It tends to be more nutritious than foreign rice. Factors like poor cultivation and postharvest practices; poor physical and cooking qualities; dirty appearance; presence of stones, shaft, husk etc. have contributed to underutilization of our indigenous rice [6].

The increased incidence of diabetes may be directly linked to the changes in dietary consumption patterns. Diabetes mellitus is one of the more common and serious chronic diseases across the world. The World Health Organization (WHO) estimates that more than 180 million people worldwide have diabetes. This number is likely to be more than double by 2030. WHO projects the diabetes death rates to increase by more than 50% in the next 10 years. Most notably diabetes deaths are projected to increase by over 80% in upper-middle income countries between 2006 and 2015 [7]. In Nigeria, Onyemelukwe [8] estimated that there are more than 6 million cases of diabetes mellitus. Most studies on diabetes suggested that the prevalence is less common amongst the Africans [9]. The 'slow-release' carbohydrate in African's traditional diets helped protect susceptible populations from developing this disease Onyemelukwe [8]. Several authors have discussed the benefits of consuming low glycemic index foods for diabetics but for most indigenous foods in Nigeria, the glycemic index is not yet defined

A sound knowledge and success of this work will lead to massive cultivation of the low glycemic index varieties (R8, Geshua, 306, Meruwa and FARO 44) thus providing food for individuals with special dietary needs. This will add value to the crops and enhance its effective utilization. It will also make Nigeria to harness her abundantly produced rice, making the low glycemic index varieties available to both local and international consumers hence boosting the gross domestic product while creating jobs for the masses. It is hoped that this study will form the basis for proper dietary prescription to diabetics who may not be able to afford western type of diet. Therefore, the present study has been designed to determine the blood glucose response after the consumption of simply boiled five varieties of indigenous rice varieties commercially grown in Ebonyi and Anambra states respectively.

2. MATERIALS AND METHODS

2.1 Source of raw materials

The animals used for this experiment were white albino rat obtained from the Department of Veterinary Medicine, University of Nigeria Nsukka, Enugu State. The rats were divided into eleven experimental groups of five rats each. The healthy rats weighed between 125 and 175 grams. Five varieties of rice

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Comment [D9]: It will also make Nigeria harness her abundantly produced rice, making the low glycemic index varieties available to both local and international consumers, boosting the

Comment [D10]: Hopefully, this study will form the basis for proper dietary prescription for diabetics who may not be able to afford western diet.

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namely R8, 306, Meruwa, Geshua and FARO 44 were purchased in the local rice mills located in Ikwo and Akaeze towns in Ebonyi state and Igbariam and Omor towns of Anambra State Nigeria. Glucose (control) was purchased at Umuahia-Ultra modern market, Ubani Ibeku. The rice samples were identified by a rice breeder at National Cereal Research Institute, Amakama-Umuahia.

Comment [D12]: A rice breeder identified the rice samples at National Cereal Research Institute, Amakama-Umuahia.

2.2 Preparation of raw materials

Each of the samples were cleaned and milled directly into rice flour using a hammer mill. All 10 samples (flour) will be made into a hot paste before feeding to animals. The paste will be made with water and rice flour in a ratio of 1:3 (w/w).

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2.3 Experimental design

The rats were grouped into 11 groups of 5. Group 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 were experimental groups and group 11 was glucose control. They were fed with the diet for seven days to get them accustomed to it, with a preliminary monitoring of the glycemic level. The rats was fasted for 18 hours after the seven-day period, and their fasting blood glucose determined with Ultra-one touch glucometer and test strips. The experimental and control groups were allowed access to diet for 60 minutes and then the diet withdrawn. Blood glucose level of all groups were monitored with glucometer at time intervals of 30 minutes, 60 minutes, 90 minutes and 120 minutes after diet withdrawal. Group 1 was fed with Geshua (Ebonyi), group 2 was fed with Geshua (Anambra), group 3 was fed with R8 (Ebonyi), group 4 was fed with R8 (Anambra), group 5 was fed with FARO 44 (Ebonyi), group 6 was fed with FARO 44 (Anambra), group 7 was fed with 306 (Ebonyi), group 8 was fed with 306 (Anambra), group 9 was fed with Meruwa (Ebonyi), group 10 was fed with Meruwa (Anambra) and group 11 was fed with 75 g of glucose.

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2.4 Blood collection and determination of blood glucose level

The blood that was used for this work was collected by cutting the tip of the rat’s tail using a surgical blade. The blood glucose level was determined using Ultra-Touch glucometer and Ultra-Touch test strips. Glycemic Index was calculated by expressing the glycemic response area for the tested goods as a percentage of the mean response area of the glucose food taken by the animals. The following formula was applied:

$$\mathrm{GI} = \frac{Area\ under\ the\ curve\ for\ 75g\ carbohydrate}{Area\ under\ the\ curve\ for\ 75g\ carbohydrate\ from\ glucose} * \frac{100}{1}$$

The final glycemic index for each of test food and the glucose control was calculated as the mean for the respective average glycemic indices of the animals.

2.5 Determination of proximate composition

The method described by AOAC [10] was used to determine the moisture content, ash content, fat content, crude fibre, crude protein content and the carbohydrate content of the samples.

2.6 Data analysis

Data was expressed as mean ± error of means. Comparisons of the proximate analysis results and glycemic response of different varieties of rice with glycemic response of glucose was analyzed by Analysis of Variance (ANOVA) using MINITAB analytical package. Comparisons of glucose responses and glycemic index of different rice varieties was analyzed by Complete Randomized Design (CRD) using SAS analytical package.

3. RESULTS AND DISCUSSIONS

3.1 Blood glucose responses

From the Table 1, it was observed that the mean blood glucose responses ranged from 80.00- 146.00 mg/dl. Johnson-Delaney [11] stated that the value of blood glucose for healthy albino rats as 50-I25 mg/dl whereas Kohn and Clifford [12] stated it was between 85-132 mg/dl. In this way, the recent values obtained are within the limits proposed by other authors. It could be observed that fasting blood sugar of IR-8 Igbariam and IR-8 lkwo had highest value of 93.00 and 92.00 mg/dl respectively, among the samples whereas 1416 Igbariam and 1416 Ikwo recorded the lowest value of 80.00 and 83.00 mg/dl. At 30 minutes of post feeding, Glucose (standard) increased to the highest mean value of 140.00 followed by IR-8 Ikwo and IR-8 Igbariam with the value of 126.00 and 123.00 mg/dl respectively. Also, at 60 minutes of post feeding Glucose (standard) recorded the highest mean value of 130.00 mg/dl followed by Faro 44 Akaeze and Faro 44 Achalla which had 128.00 mg/dl and 124.00 mg/dl respectively. Furthermore, at 90 minutes Faro 44 Akaeze and Faro 44 Achalla had the highest value of 129.00 mg/d and 127 mg/dl respectively and was followed by Glucose (standard) which had a value of 124.00 mg/dl. More so, at 120 minutes, Faro 44 Akaeze and IR-8 Igbariam had the highest value of 128.00 mg/dl and 126.00 mg/dl respectively whereas Glucose (standard) had the lowest value of 108.00 mg/dl. These values were much higher than the values 22.31-72.78 mg/dl, 20.95 - 44.06 mg/dl and 33.52 - 44.35 mg/dl reported by Okorie *et al.* [13] for three yam cultivars (*Dioscorea Rotundata, Dioscorea Alata and Dioscorea Dumentorum*). The general trend observed in Figures 1 and 2 indicates that there was gradual increase in the blood glucose response recorded among the meal. This may be attributed to better amylose contents of the samples which may have affected the digestion of the rice samples. Again, internal carbohydrate transport is restricted to monosaccharide and as a result virtually all ingested carbohydrate can all be absorbed as monosaccharide. More so, the trend observed in Figures 1, 2 and 3 where tremendous increase was noticed in the blood Sugar may be attributed to sodium-glucose co-transportation mechanism where the diffusion energy of sodium ions pulls the glucose along with sodium ions from the

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Comment [D17]: The general trend observed in Figures 1 and 2 indicates a gradual increase in the blood glucose response recorded during the meal.

intestinal lumen of the rats into the intestinal epithelia cell across its lumen membrane where they are easily distributed in the bland stream.

It is well established that different carbohydrate foods elicit a wide spectrum of plasma glucose responses when consumed without other foods [14]. Therefore, replacing the consumption of high GI rice such as Faro 44 and 1R-8 with 306 and 1416 varieties may improve glycemic control and among persons treated with insulin may reduce hypoglycemic episodes. A few years ago, Geoffrey *et al.* [15] found that lower glycemic index diets reduce both fasting blood glucose and glycated proteins independently of variance in available and unavailable carbohydrate intakes. This may also go a long way to aid in diabetic management. Generally, differences in blood glucose responses in human subjects and animals for different foods and among the same group of food may be related to various factors such as chemical composition or the components of the food, components and the nature of the carbohydrates, dietary fiber, method of food processing and presence of any substances which act as inhibitors of enzymatic digestion [16,17].

Table 1. Blood glucose response, Incremental Area Under Curve (IAUC) and Glycemic Index for selected rice varieties (meal) fed to healthy albino rats

Samples	**Blood Glucose Response, mg/dl**	**IAUC (mg/dl/min)**	**Glycemic Index**
	Time (minutes)		

	0 fasting	30	60	90	120		
IR-8 Ikwo	90.00^{b}	126.00^{d}	120.00^{e}	118.50^{e}	114.00^{f}	3180.00^{g}	70.00^{d}
IR-8 Igbariam	93.00^{a}	123.00^{e}	129.00^{b}	128.00^{b}	126.00^{b}	3525.00^{e}	78.00^{c}
306 Achalla	85.00^{c}	97.00^{h}	104.00^{g}	110.00^{g}	116.00^{e}	2145.00^{j}	48.00^{h}
306 Afikpo	84.00^{d}	95.0^{i}	103.00^{h}	84.05^{i}	112.00^{g}	2040.00^{k}	45.00^{h}
Faro 44 Achalla	86.00^{d}	116.00^{f}	124.00^{b}	127.00^{b}	122.00^{c}	3810.00^{f}	84.00^{d}
Faro 44 Akaeze	92.00^{ab}	112.00^{b}	128.00^{c}	129.00^{a}	128.00^{a}	3330.00^{f}	74.00^{d}
1416 Igbariam	80.00^{h}	101.00^{g}	107.00^{f}	116.00^{f}	118.00^{d}	3072.00^{h}	68.00^{e}
1416 Ikwo	83.00^{f}	98.00^{h}	105.00^{g}	109.00^{h}	111.00^{g}	2307.00^{i}	51.00^{f}
Glucose standard 1	84.00^{e}	142.00^{a}	130.00^{b}	124.00^{d}	108.00^{h}	4680.00^{a}	100.00^{a}
Glucose standard 2	89.00^{b}	146.00^{a}	135.00^{a}	126.00^{c}	106.00^{i}	4455.00^{b}	100.00^{a}
Glucose standard 3	82.00^{g}	132.00^{c}	125.00^{e}	122.00^{e}	110.00^{gh}	4410.00^{c}	100.00^{a}
LSD	1.17	1.18	1.18	0.59	2.35	3.00	1.17

The mean values are average of five albino rats that consumed each die. Mean values in each column with the same superscript are not significantly different ($p<0.05$) from each other

3.2 Glycemic Index

Many studies have shown that the classification of rice as low or high GI food may depend on the amylose content of the commercial varieties [18]. In general, most of the rice contains about 20% of amylose and 80% of amylopectin [19]. Rice with high amylose fraction of about 28% have been shown to produce a lower blood glucose and insulin response [19]. The present findings tend to confirm these results. The amylose content of the rice samples (306 Achalla and 306 Igbariam) were 26.20 and 27.50% respectively and they could be categorized as having low GI values and was observed to produce lower blood glucose responses. The glycemic index characterization of the varieties of rice grain showed that they had low, medium and high glycemic index. The significant difference observed in the GI of these foods suggests that GI may influence the blood sugar. These results may be affected by processing methods as milling and drying employed but however is subject to further investigation. Rice is generally known to have a high glycemic index compared to other starchy foods. There is an inverse relationship between glycemic index and amylose content; hence the lower the amylose content, the higher the glycemic index scale and vice versa [20].

Comment [D18]: Generally, most rice contains about 20% of amylose and 80% of amylopectin [19].

Comment [D19]: These results may be affected by methods such as milling and drying but are subject to further investigation.

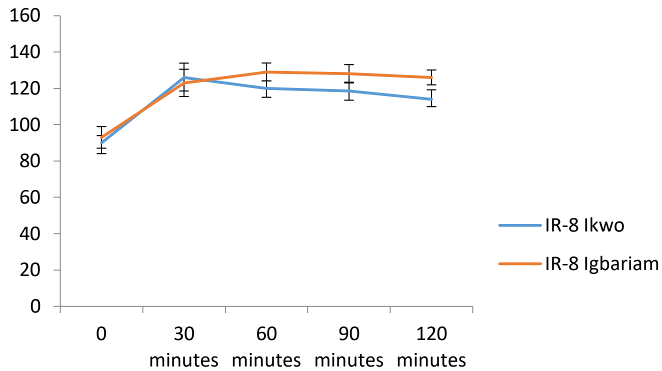

Fig. 1. Graph of glycemic responses after feeding on IR-8

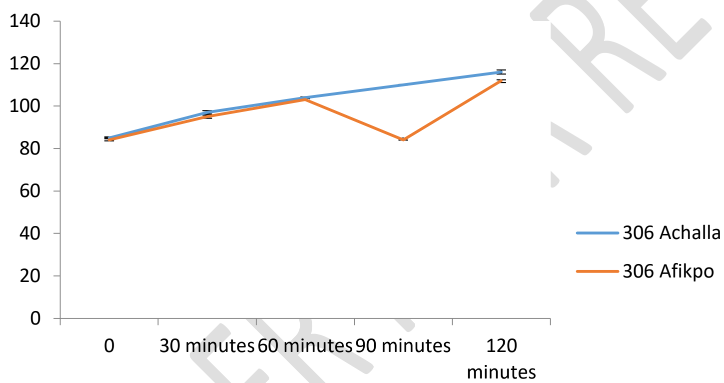

Fig. 2. Graph of glycemic responses after feeding on 306

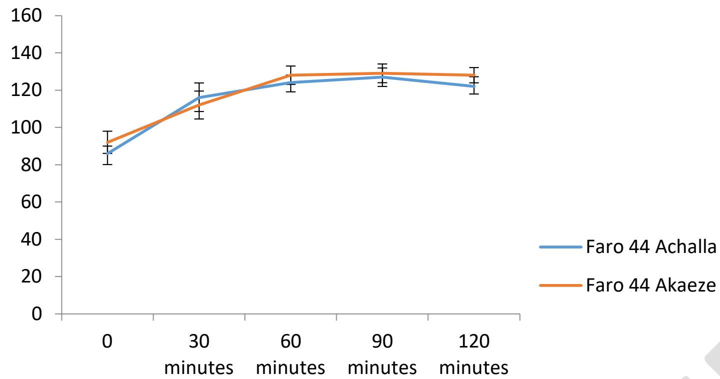

Fig. 3. Graph of glycemic responses after feeding on Faro 44

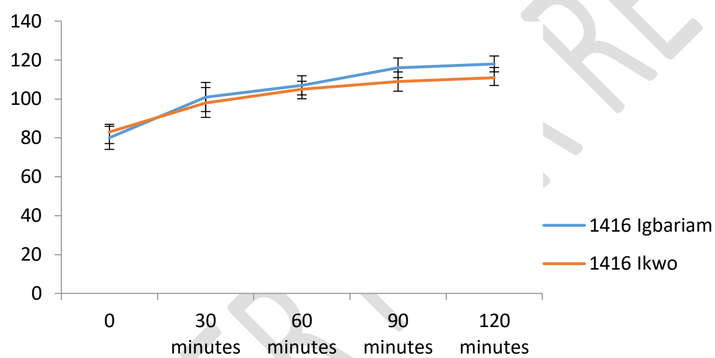

Fig. 4. Graph of glycemic responses after feeding on 1416

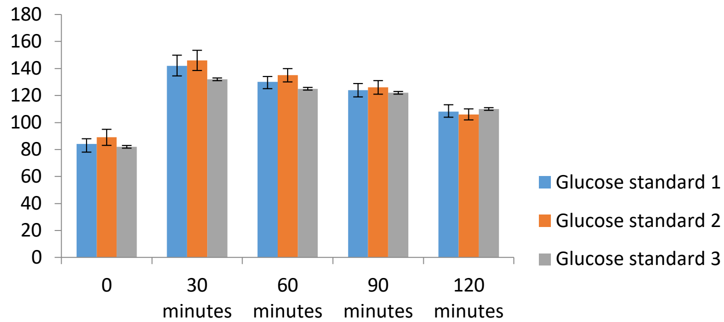

Fig. 5. Graph of glycemic responses after feeding on glucose (standard)

3.2 Proximate composition of the rice varieties

The result of the proximate composition of the selected rice varieties from Ebonyi and Anambra states of Nigeria respectively is shown in Table 2. The proximate composition evaluated were significantly different ($p<0.05$) among the rice samples. On the average, the results were comparable with the values reported by Oko and Ugwu [21]; Olembo *et al.* [22]. The moisture content levels of the rice samples were comparatively low (9.40 — 11.10%) with IR-8 Igbariam recording the lowest value of 9.40% and 1416 Ikwo recording the highest value of 11.10%. This value is comparable to the value of 10.97% obtained by Adepoju *et al.* [23] for raw Ofada rice and 11.36% for raw Abakaliki rice. This result indicates the ability of the rice samples to possess a stable shelf-life when properly processed, packaged and stored. It also indicates that the rice samples evaluated have an increased energy value.

The values for percentage crude protein content are in the range of 4.73 to 7.25%. This range conforms with the value of 7.19% for raw Abakaliki rice obtained by Adepoju *et al.* [23]. However, it is below the value of 8.28% obtained for raw Ofada rice by Adepoju *et al.* [23]. The slight difference may be attributed to prolonged parboiling which the rice samples may have been subjected to and it tends to lower the protein content of rice and some other environmental and edaphic factors. However, the range is comparable with the range obtained by Ibukun [24]. The lowest crude protein content was recorded by Faro 44 Akaeze which had 4.73% and the highest protein content was recorded by 306 Achalla.

The crude fibre content of the varieties of rice analyzed ranged from 0.90%- 1.40%. Faro 44 Akaeze and IR-8 Igbariam had the highest value whereas 1416 Igbariam had the lowest value. Although this range is a bit lower than the range (1.93-4.3%) obtained by Edeogu *et al.* [25] but like the mean value obtained by Sotelo *et al.* [26]. This may be attributed to degree of milling operations that was done on the rice samples.

Comment [D20]: The lowest crude protein content was recorded by Faro 44 Akaeze which had 4.73% and 306 Achalla recorded the highest protein content.

Comment [D21]: The crude fibre content of the rice varieties ranged from 0.90% to 1.40%.

Comment [D22]: This may be attributed to the degree of milling operations done on the rice samples.

The percentage fat content of the rice is in the range of 1.25% to 2.00%. The results of this study agree with earlier results reported by Juliano [27] who also gave the fat range 0.9 to 1.97% in different milling fractions. However, this range is lower than the range of 0.5-3.0% obtained by Oko *et al.* [21] for rice varieties grown in Ebonyi State of Nigeria. This difference may be attributed to the degree of milling. Milling of rice removes the outer layer of the grain where most of the fats are concentrated [28]. Since fat is more on the bran layer and the more this layer is removed during milling the less the fat content of the milled rice [29]. Higher fat content may expose the grains to spoilage during storage due to oxidation.

Comment [D23]: Milling rice removes the grain's outer layer where most of the fats are concentrated [28].

The ash content of the varieties ranges from 1.00 to 1.90%. 306 Afikpo had the highest ash content whereas 1416 Igbariam had the lowest. High ash content of a food sample holistically gives an idea of the mineral elements imbedded in the food sample [30].

Carbohydrate content of the rice samples ranged from 78.30-81.28%. Faro 44 Akaeze had the highest value whereas 1416 Ikwo and 1416 Igbariam had the lowest values. This result is comparable to the values range of 51.53-86.03% obtained by Oko *et al.* [21] for rice grown in Ebonyi State in Nigeria. Carbohydrate is one of the human body's two main source of energy, the second being fat. Unlike, other cereals the carbohydrate in rice is mainly in the form of starch- a complex polysaccharide, and like other cereals the starch occur in granules in the endosperm.

Table 2. The proximate composition of selected rice varieties

Samples (%)	Moisture	Ash	Fat	Fibre	Protein	Carbohydrate
IR-8 Igbariam	9.70^{c}	1.45^{b}	2.00^{a}	1.40^{a}	7.00^{ab}	78.45^{de}
IR-8 Ikwo	9.40^{c}	1.10^{c}	1.80^{b}	1.10^{bc}	6.30^{bc}	80.30^{b}
306 Achalla	10.40^{b}	1.50^{b}	1.45^{d}	1.10^{b}e	7.25^{a}	78.30'
306 Afikpo	9.70^{c}	1.90^{a}	1.60^{c}	1.20ab	6.65^{abc}	78.95^{cd}
Faro 44 Achalla	10.70^{b}	1.10^{c}	1.25^{e}	1.00^{k}	6.48^{bc}	79.48^{c}
Faro 44 Akaeze	9.80^{c}	1.50^{b}	1.25'	1.40a	4.73^{d}	81.28^{a}
1416 Igbariam	10.40^{b}	1.00^{c}	1.80^{b}	0.90^{c}	6.48^{bc}	79.43^{c}
1416 Ikwo	11.10a	1.80a	1.80^{b}	1.00^{bc}	6.00^{c}	79.10^{c}
LSD	0.35	0.18	0.09	0.17	0.58	0.52

Mean values in each column with the same superscript are not significantly different ($p<0.05$) from each other.

4. CONCLUSIONS

The present stud has provided reliable data on glycemic index, nutritional, functional and phytochemical properties of selected rice varieties commercially cultivated in Ebonyi and Anambra States of Nigeria. IR-8 (70 and 78 respectively) and FARO 44 (84 and 74 respectively) have high glycemic index diet and its diet could be desired by individual who engage in strenuous activities like athletes. The 306 variety have low glycemic index(48 and 45) respectively and could have benefit in the prevention and management of metabolic and nutritional diseases whereas 1416 (68 and 51 respectively) have a medium glycemic index. The consumption of 306 variety could be also lower postprandial blood glucose spikes depending on the glycemic load. The result of proximate composition were comparable with the findings of some researchers who investigated indigenous rice varieties in Nigeria.

Comment [D24]: benefit

REFERENCES

1. Brand-Miller J, Hayne S, Petocz P, Colagiuri S. Low-glycemic index diets in the management of diabetes: a meta-analysis of randomized controlled trials. Diabetes care. 2003;26(8):2261-7. https://doi.org/10.2337/diacare.26.8.2261
2. Augustin LS, Franceschi S, Jenkins DJA, Kendall CWO, La Vecchia C. Glycemic index in chronic disease: a review. Eur. J. N" utr. 2002;56:1049-1071.
3. Ludwig DS. The glycemic index: physiological mechanisms relating to obesity, diabetes, and cardiovascular disease. /AMA. 2002;287:2414-2423.
4. lhekoronye AI, Ngoddy PO. Tropical Root Tuber Crops. In: Integrated Food Science and Technology for the Tropics and, The Macmillan Press Ltd. London. 1985;Pp. 253.
5. IRRI. International Rice Research Institute Rice Genetics III. Proceedings of the Third International Rice Genetics Symposium. Page 1;1996
6. Uzuegbu JO, Eke OS. Basic Food technology; Principles and Practice. Osprey Publications Centre. Owerri. 2000;Pp. 10 -2.
7. WHO. World Health Organization (WHO) report on prevention of blindness from Diabetes Miletus. Geneva, Switzerland. 9-11th November 2005;Pp. 7-8.
8. Onyemelukwe GC. Newsletter on the propose diabetes mellitus center, Abuja, Nigeria; 1993
9. Rajkiran W, Nusrath U, Sujatta K. Role of sesamumalatum L. on nephropathy in diabetic rats. African Journal of Pharmacy and Pharmacology, 2011;3(5)171-180.
10. AOAC. Official Methods of Analysis.Association of Official analytical Chemists Washington D. C. 2001;Pp235-237.
11. Johnson-Delaney C. Exotic Animal Companion Medicine. Handbook of Veterinarians, Zoological Education Network; 1996
12. Kohn DF, Clifford CB. Biology and disease of rats in J.G Fox, L.C Anderson, F.M Lowe et al., eds. Laboratory Animal Medicine, 2nd edition. New York: Academic Press, 2002;121-167.
13. Okorie C, Obasi NE, Unamma NC, Barber LI. Comparative Study on The Glycemic Indices of Three Yam Cultivars (Dioscorea Rotundata, Dioscorea Alata and Dioscorea Dumentorum) As Affected by Three Processing Methods. Journal of Advances in Agronomy and Crop Science. 2021;1: 102.
14. Thomas MS, Wolever Claudia B. Source and amount of carbohydrate affect postprandial glucose and insulin in normal subjects. Journal of Human and Clinical Nutrition.1996; https://academic.oup.com/jn/article/126/11/2798/4724672
15. Geoffrey L, Taylor R, Hulshof T, Howlett J. Glycemic response and health — a systematic review and meta-analysis: relations between dietary glycemic properties and health outcomes. American Journal of Clinical Nutrition 2008;87: 258S-268S.

16. Darabi A, Taleban FA, Esmaili M, Valaii N. Glycemic index of split peas, rice (binam), kidney beans, grean peas, "Lavash" bread and broad bean kernels in NIDDM subjects. Acta Medica Iranica 2000;38: 79-83.
17. Thannoun AM, Al-Kubati AMM Blood glucose response and Glycemic Index of some dried legumes in normal human subjects. Mesopotamia J. of Agric. 2005;33: 19-28.
18. Luliano BO, Goddard MS. Cause of varietal difference in insulin and glucose responses to ingested rice. Plant Foods Hum. Nutr., 1986;36: 35-41.
19. Brand-Miller J, Pang E, BrainaH L. Rice: a high or low glycemic index food? American Journal of Clinical Nutrition 1992;56:1034-1036.
20. Hu EA, Pan A, Malik V, Sun Q. White rice consumption and risk of type 2 diabetes: Meta-analysis and systematic review. British Medical Journal, 2012;344.
21. Oko AO, Ubi BE, Efisue AA, Dambaba, N. A Comparative study on local and Newly introduced rice varieties grown in Ebonyi State of Nigeria based on selected Agronomic Characteristics. International Journal of Agriculture and Forestry. 2012;2:(2)16-23.
22. Olembo N, M'mboyi F, Oyugi K. Success Stories in Crop Improvement in Africa: The Case of Rice in Sub-Saharan Africa; African Biotechnology Stakeholders Forum (ABSF), Nairobi, Kenya. 2010;Pp.1-29.
23. Adekpoju OT, Akinleye O, Ajayi K. Comparative study of Nutrients in Imported and Local Rice (Oryza sativa) Varieties. British Journal of Applied Science and Technology 2016;*16 (2): 1-9*
24. lbukun EO. Effect of prolonged parboiling duration on proximate composition of rice. Scientific Research and Essay 2008;3(7)323-325.
25. Edeogu CO, Ezeonu FC, Okaka ANC, Ekuma CE,bElom SO. Proximate Compositions of Staple Food Crops in Ebonyi State, South Eastern Nigeria. International Journal of Biotechnology. Biochem., 2007;1: 1-8.
26. Sotelo A, Saisa V, Montolvo I, Hernandez M, Hernandez, L. Chemical composition of different fractions of 12 Mexican varieties of rice obtained during milling. Cereal Chem., 1990;67(2):209-212.
27. Juliano BO. Factors affecting Nutritional Properties of Rice Protein. Trans. National Academy of Science and Technology (Philippines) 1985;7:205-216.
28. Frei M, Becker K. Studies on the in vitro starch Digestibility and the Glycemic Index of six different indigenous rice cultivars from the Philippines. Food chem.., 2003;83:395-402.
29. Okaka JC. Handling, Storage and Processing of Plant Foods. OCJ Publishers Enugu. 2005;Pp.3-5
30. Dipti SS, Bari MN, Kabir KA. Grain Quality Characteristics of some Beruin Rice Varieties of Bangladesh. *Pakistan Journal of Nutrition* 2003;2(4)242 - 245.