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Analysis of Glycemic Indices and Loads of Food Prepared from Two Widely Consumed Nigerian Yam Tubers: *Dioscorea rotundata* and *Dioscorea alata*

Qrisstuberg Amua[1]*, Raphael A. Amokaha[2], Oga P. Abeni[3]

[1]Department of Chemistry, Federal University of Agriculture, Makurdi-Nigeria
[2]Department of Biochemistry, College of Health Sciences, Benue State University, Makurdi-Nigeria
[3]Department of Chemistry, Benue State University, Makurdi-Nigeria
*Author of correspondence: email: dr.qrisstuberg@gmail.com Phone: +2348167400007

Abstract Glycemic indices (GI) and glycemic loads (GL) of fried and boiled white yam, fried and boiled water yam were determined. The yam samples; white yam (*Dioscorea rotundata*) 'hembamkwase' variety and water yam (*Dioscorea alata*) 'shodan' variety were sampled from strategic selling points at Wurukum, Wadata and Modern markets in Makurdi Metropolis. The Samples were first analyzed for physiochemical and nutritional properties. From the result, 57 g of white yam contained 50 g of carbohydrate while 60 g of water yam contained 50 g of carbohydrate. Eight individuals of Benue State University were recruited and were divided into four groups, with two students in each group. A portion of fried white yam, boiled white yam; fried water yam and boiled water yam that contained 50 g of available carbohydrate were fed to the individuals with 500 mL of bottled table water. 50g of pure glucose dissolved in 500 mL of bottled table water (as control diet) was given to each individual of all the groups on the first day and the boiled and fried yam foods equivalent to 50g carbohydrate were given to each individual of the assigned groups on the next day. Blood samples were collected at various time-points i.e., at 0 (fasting), 15, 30, 45, 60, 75, 90, 105 and 120 minutes after ingestion of glucose and test foods. The results of the study indicated that these foods have high GI and GL values and hence should be used with precaution in the diet of patients with hyperglycemic complications.

Keywords *Glycemic indices, Glycemic load, Dioscorea rotundata, Dioscorea alata*

1. Introduction

One of the major aims of diabetes therapy is to normalize the blood glucose profile, including the fasting and postprandial blood glucose concentrations. It was not long ago that we believed starchy foods provoked much lower glycemic responses than did sugars, and thus sugars were restricted. In reality the picture is multifaceted. Many starchy foods elicit responses as high as a similar load of glucose. Glycemic index (GI) is a concept that ranks foods on the basis of their acute glycemic impact [1]. Potatoes have a high GI and legumes have a low GI. The underlying premise is that meals for individuals with diabetes should emphasize low GI foods, ie, foods that produce minimal fluctuations in blood glucose. At present, however, the GI approach has not been accepted as a useful tool in diabetes management by the majority of scientists. Monounsaturated fatty acids are much more fashionable despite lack of long-term studies in subjects with diabetes [2].

The concept of glycemic index was proposed by Jenkins and colleagues to characterize the rate of carbohydrate absorption after a meal and is defined as the area under the glucose response curve after consumption of 50g carbohydrate from a control food either glucose or white bread [3].

Diabetes mellitus, the most common form of diabetes caused by a deficiency in insulin action, which results in failure to metabolise sugars, is an inherited and acquired disorder that is characterized by increased levels of circulating blood glucose. This condition results from a total or a relative deficiency in insulin and/or insulin action with a consequent deranged metabolism [4]. Diabetes is one of the major health problems in the world, both in the developed and developing countries [5], of which Nigeria is sadly a part of. The prevalence of diabetes mellitus in Nigeria has increased from 2.2% as reported in national survey by Akinkugbe [6] to 5.0%, as stated by 2013 estimates of the International diabetes Federation (IDF) [7]. The United Nations (UN) recognizes diabetes as a chronic, debilitating and costly disease associated with severe complications [8]. Chronic diabetes could lead to blindness, renal failure, heart attack, and stroke [9]. more than 95% of cases of Diabetes in Nigeria are type-2 diabetes [10]. The diabetes Association of Nigeria (DAN) has in the past few years, harnessed local and international efforts on diabetes; leading a strong advocacy to the Federal Ministry of Health (FMOH) in Nigeria, to adopt international best practices to stem the tide of diabetes epidemic in Nigeria [11].

Nutrition plays a vital role in the management of this disease. The most popular approaches to treat hyperglycemic complications are drug and dietary therapy [12, 13]. Drug therapy is the most common but it's costly and has numerous unavoidable side effects [14]. The dietary therapy offers cost effectiveness, and is more feasible with little or no side effects. The diabetes' nutritional intake must be carefully monitored to minimize the load placed on the blood sugar regulating mechanism. Short-term treatment with 4g of white skin sweet potato extract per day improved the metabolic management in type 2 diabetic patients by decreasing insulin resistance without affecting body weight, glucose effectiveness, or insulin dynamics [15]. Thus, treatment of diabetes involves some form of dietary modification [16]. There is a better way to think about how carbohydrates act on our body. It is using what is called the Glycemic Index (GI). The GI is a measure of how fast a carbohydrate containing food affects the blood glucose level after ingestion [2, 16]. The Glycemic Load (GL) on the other hand, is the amount of carbohydrate present in a typical serving of a meal [17]. The concept of GI and GL was developed to decrease the quality and quantity of carbohydrate in food substances [18].

Glycemic Load (GL) refines the concept of GI to quantify the impact that a carbohydrate-containing meal, or a single food eaten in a "normal" portion has on blood sugar [19]. The effect of other carbohydrate-containing foods on blood sugar level can then be compared with the effect of glucose to ascertain the glycemic ranking of a particular food [20, 21].

The glycemic index can be applied only to foods where the test relies on subjects consuming an amount of food containing about 50g of available carbohydrate. But many foods contain less than 50g of available carbohydrate per typical serving. This makes GL more practically and easily applicable than GI [22].

2. Materials and Method

2.1 Materials: Na_2SO_4, $CuSO_4$, Selenium Oxide, Conc. H_2SO_4, Distilled water, 45 % NaOH, Boric acid solution (indicator), 0.01 M HCl, n-Hexane, 1.25 % H_2SO_4, 1.25 % NaOH

2.2 Methods

Sample Collection: White yam (*Dioscorea rotundata*) and water yam (*Dioscorea alata*) were collected from strategic selling points at wurukum, wadata and modern markets in Makurdi Metropolis. The sampled tubers were taken to the biological science department, Benue State University and were inspected and indentified by a botanist at the department. The varieties identified for each specie include: the 'hembamkwase' variety for the white yam species and the 'shodan' variety for the water yam species. Thereafter, a composite was then formed out of the sampled tubers [23-29].

Sample Preparation for Determination of Total Carbohydrate Contents: Part of the tuber crop samples was processed into a meal, for hydrogencemic-response analysis [2]. The rest of the sample was processed into flour for

proximate analysis for the determination of total carbohydrates content of the samples. This was done by washing the tuber samples with clean running tap water to remove sand and debris together with possible pesticide [2, 31], peeling with sterilized knife, slicing into very thin slices to facilitate the drying process. The chips were then air-dried in the laboratory until crispy. The dried tuber chips were then homogenized into fine powder with a manual hand-operated grinding machine and the powder was stored in sterilized dry glass bottle and properly corked for proximate analysis.

Proximate Composition Determination: The method employed in this analysis is that of association of official analytical chemists as described by Babalola (2016) with little modifications. The analysis was done in duplicate [30]

Moisture Content Determination: Empty crucible dishes were washed with distilled water, dried in an oven at a temperature of 105 ^{o}C for one hour and cooled in a desiccator [31]. 2g of the fresh samples were weighed, placed in a crucible and heated in an oven for 24 hours at 105 ^{o}C [32]. The dishes were then removed from the oven, cooled in a desiccator and then weighed. The percentage moisture content was calculated as follows;

$$\%\, moisture = \frac{weight\ loss}{sample\ \ weight} \times 100 \quad (1)$$

Determination of ash content: 2g of the powered sample was weighed into a clean dry crucible that was initially washed, dried in an oven and weighed. The crucible with its content was then transferred into a muffle furnace regulated between 400-600 ^{o}C for incineration for about 4 hours [33]. After this incineration, the crucible was then removed and cooled in a desiccator. After cooling, the crucible with the ash content was weighed. Ash content was calculated using the formula;

$$\%\, Ash = \frac{weight\ of\ ash}{weight\ of sample} \times 100 \quad (2)$$

Determination of crude protein: The crude protein was determined by Kjeldah method. 2 g of the powdered sample was weighed into a Kjeldah digestion flask and catalyst mixture of $NaSO_4$, $CuSO_4$ and Selenium oxide in the ratio 10:5:1 was added to each sample which was then followed by 10 mL of concentrated H_2SO_4 [34]. The contents in the flask were then heated in the Kjeldah digestion flask for 1 hour 30 minutes for digestion to be completed. After the digestion was completed, the flask was then cooled and the content diluted with 10 mL distilled water [34]. The diluted content was filtered into 100 mL volumetric flask and was made up to mark with distilled water and then distilled using micro Kjeldah distillation apparatus. The distillate was received into a flask containing 10 cm^3 boric acid solution as indicator, after the distillation was completed. The distillate was then titrated with 0.01 M HCl to the end point [34]. The percentage crude protein was then determined using the formula;

$$\%\, crude\ protein = \frac{TV \times C \times F \times V_1}{W \times V_2} \times 100 \times 6.25 \quad (3)$$

Where: TV is the titre value of the acid, C is the concentration of the acid used, V_1 is the volume of the distilled water used for diluting the digest, V_2 is the volume of aliquot used for titration, W is the weight of sample used, F is the protein multiplication factor 0.014

Determination of Crude Lipid: In the determination of crude fat, 2 g of the powdered sample each was weighed into a porous thimble, and mouth covered with cotton [35]. The thimble was then placed in an extraction chamber and suspended above a receiving flask containing n-hexane, after this, the flask was heated with a heating mantle for 4 hours and the oil was extracted. The flask containing the oil was then disconnected. The flask was then cooled in a desiccator and weighed. The percentage lipid content was calculated thus;

$$\%\, crude\ lipid = \frac{Weight of oil\ \ extracted}{weight of sample} \times 100 \quad (4)$$

Determination of Crude Fibre: 2 g of the powdered sample was weighed and poured into 500 ml round bottom flask that contains $100cm^3$ of 1.25% H_2SO_4. The mixture was then boiled for 30 minutes. The content was filtered, rinsed with hot water and the residue is scrapped back into the flask with a spatula. $100cm^3$ of 1.25% NaOH was added and was allowed to boil gently for 30 minutes [35]. The contents was then filtered and washed thoroughly with has distilled water. The content was then allowed to dry and the residue was scrapped into a weighed crucible

as was dried in an oven at a temperature of 105^oC for 30 minutes. After drying, the sample was cooled in sample then removed and finally cooled in the dedicator and weighed again [36]. The percentage crude fibre was calculated as;

$$\%\ crude\ fibre = \frac{weighed\ loss\ on\ inginition}{weight\ of\ sample} \times 100 \quad (5)$$

Carbohydrate Determination: The total amount of carbohydrate in the sample was calculated using the weight difference percentage [31]. This was carried out by subtracting the percentage sum of crude protein, crude fat, crude fibre and ash content of the sample from 1200% dry weight.

i.e.% carbohydrate = 100 – (% moisture + % ash + % crude protein + % crude fat + % crude fibre).

Sample Preparation for Hydroglycemic Response: Tubers of the selected species were processed by two different methods, to include boiling and frying [2]. Processing methods influencing changes in blood glucose levels after consuming processed tuber crops [2]. The boiling method was conducted by peeling, cutting into small pieces and boiling the tubers for about 30 minutes [2].

Fried yam sample were prepared by peeling the tubers. The tubers were cut into desired shape and deep fried for 5-8 minutes [2].

Blood sampling and analysis: Human subjects were used for the experiment. Blood samples were collected from each individual on each day at various time points by finger prick. The blood sample was taken after an overnight fast (o min or fasting blood), followed by second, third, fourth, fifth, sixth, seventh, Eighth and ninth blood sample at 15, 30, 45, 60, 75, 90, 105 and 120 minutes, respectively, after the ingestion of foods.

Ethical clearance was obtained from Benue State University Teaching Hospital (BSUTH) Makurdi.

Study population: The study was carried out on eight (8) non-diabetic and healthy volunteers within the age bracket of 18-55 years, with a Body Mass Index (BMI) of 18.5-25 kgm^{-2} and fasting blood glucose of (4-7) $mmoIL^{-1}$ (WHO standards). The volunteers comprised of six (6) males and two (2) females.

Exclusion criteria: Patients on any form of medication possible allergies to food, pregnancy or breastfeeding mothers were all excluded from this research work.

Experimental procedure: The GI value of the food samples were measured by feeding 8 (eight) healthy people (volunteers). The volunteers consumed a measured portion of the test and reference food substances that contained 50 grams of available carbohydrate, after which their blood glucose response was tested using a glucometer device (model: GB, Accu-Chek, Serial number: GB10052719), by finger prick at intervals of 15 munities from the time of ingestions through a time of two (2) hours.

The volunteers were divided into 4 groups comprising of 2 individuals per group. Each group fed on a particular test food but all the individuals were given 50 g of pure glucose dissolved in 500 mL of table water as control. A portion of each food was served to the volunteers contained 50 g of available carbohydrate. The volunteers took a period of fasting (about 10-12 hours) throughout the night before each day of the test. Blood glucose was measured in the next morning (fasting blood sample).

Test subject ‘A’ and ‘B’ fed on fried white yam

Test subject ‘C’ and ‘D’ fed on boiled white yam

Test subject ‘E’ and ‘F’ fed on fried white yam while test subjects ‘G’ and ‘H’ fed on boiled water yam.

After the volunteers had consumed these foods which contained 50 g of available carbohydrate, the blood glucose response of each individual following ingestion of the food samples were measured for the next 15, 30, 45, 60, 75, 90, 105 and 120 minutes after ingestion.

In another day, the same treatment was done by feeding the volunteers with pure glucose (as standard food, GL =100). The GI was then calculated by comparing the area under the curve of standard and tested foods.

Calculation of gycemic index: The GI was calculated by the method of Jenkins et al (1981). The values of blood glucose concentration were plotted against time for each person and for each food sample- the area under the 2 hours blood glucose response following ingestion of pure glucose (glucose IAUC) and for the test food eaten was then calculated. The mean IAUC values were then Calculated for each test food. Gycemic index value for the mean IAUC for the reference food (50 g of pure glucose) [37].

$$GI = \frac{IAUC\ for\ test\ food\ (Containing\ \ 50g\ for\ testfood\ )}{IAUC\ for\ refernce\ \ food\ (containing\ \ 50g\ glucose\ )} \times 100 \quad (6)$$

Blood glucose curves were constructed from blood glucose values for each individual at time 0,15,30,45,60,75,90,105 and 120 minutes after consumption of the reference food, and test food.

The incremental area under the curve (IAUC) was calculated for reference food (glucose) by the trapezoidal rule [38] in every individuals separately as the sum of the surface of trapezoids between the blood glucose curve and horizontal baseline going parallel to x-axis from the beginning of blood glucose curve at time o to the point at the time 120 minutes, to reflect the total rise in blood glucose concentration after eating the reference food (glucose) [6]. The incremental area under the curve (IAUC) for the test food for the same individuals is obtained similarly.

Calculation of glycemic load

GL refines the concept of GI to quantify the impact that a carbohydrate containing meal or on a single food eaten in a 'normal portion' has on blood sugar. The GL was calculated as the GI (%) multiplied by the grams of carbohydrate in the serving of food eaten. The GL for a meal would be the sum total of the GL of each food that is part of the meal. GL can be calculated by the formula:

$$GL = \frac{Net\ carbo\ hydrate\ \ in\ atypical\ \ serving}{100} \times GI \quad (7)$$

3. Results and Discussion

3.1 Result

Table 1: Proximate composition of the food samples

Parameter	White yam (%)	Water yam (%)
Moisture content	6.300+ 0.000	6.175+0.035
Ash content	2.850+0.071	5.375+0.177
Crude lipid	2.896+1.075	1.848+0.000
Crude fibre	0.150+0.141	0.150+0.000
Crude protein	1.058+0.258	3.063+0.000
Total carbohydrate in 2g sample	86.75+1.55	83.39+0.21
	1.74+0.03g	1.67+0.01g
Calculated portion of food	57g	60g
Containing 50g of available carbohydrate		

% carbohydrate = 100 – (moisture + % ash +% crude protein + % crude fat + % crude fibre).

Table 2: Medical test result for each test subjects

Test Subject	**Sex**	**Age (years)**	**Height (m)**	**Weight (kg)**	**BMI (kgm^{-2})**	**Pulse rate (min^{-1})**	**Blood Pressure (mmHg)**	**Temp. (^oC)**
A	Male	23	1.78	52.80	16.66	61.00	120/80	36.20
B	Male	23	1.75	63.60	20.77	62.00	120/80	36.00
C	Female	19	1.65	56.80	20.86	61.00	100/70	35.80
D	Male	28	1.73	55.40	18.51	60.00	120/80	36.00
E	Male	30	1.58	59.30	23.75	57.00	120/809	35.00
F	Female	24	1.67	44.20	15.85	57.00	100/70	36.10
G	Male	21	1.79	60.00	18.73	61.00	110/70	36.00
H	Male	28	1.76	68.40	22.08	64.00	110/80	36.20

Table 3: Average medical test result for all test subjects

Medical parameters	Average values	Range
Sex	-	Males and females
Age	25+ 4 years	19-30 years
Height	1.71+ 0.07m	1.58-1.79 m
Weight	57.56 +6.79 kg	44.2-68.4 kg
Body mass index (BMI)	19.65+2.70 kg^{-2}	15.85-23.75 kgm^{-2}
Pulse rate	60.00+2 per minutes	57-64 times per min
Body temperature	35.9+0.4 ^oC	35.0-36.2 ^oC
Blood pressure (systolic)	113+9 mmHg	100-120 mmHg
Blood pressure (diastolic)	76+5 mmHg	70-80 mmHg
Fasting blood glucose level	4.9+1.8 $mmolL^{-1}$	4.1-6.0 $mmolL^{-1}$

Table 4: Values for postprandial blood glucose for test subject 'A'

Time (mins)	0	15	30	45	60	75	90	105	120
B-glucose conc. ($mmolL^{-1}$) After ingestion of pure glucose	4.4	5.1	6.6	5.8	6.1	6.8	6.7	6.6	6.4
B-glucose conc. ($mmolL^{-1}$) After ingestion of white yam	4.9	5.4	5.7	4.6	5.6	5.6	5.1	5.1	5.1

Table 5: Values for postprandial blood glucose curves of test subject 'B'

Time (mins)	0	15	30	45	60	75	90	105	120
B-glucose conc. ($mmolL^{-1}$) After ingestion of pure glucose	4.8	5.4	6.9	6.7	6.1	5.8	6.3	5.9	5.8
B-glucose conc. ($mmolL^{-1}$) After ingestion of white yam	5.2	5.2	6.7	5.9	5.1	5.2	4.9	5.1	5.1

Table 6: Plotted values for postprandial blood glucose curves of test subject 'C'

Time (mins)	0	15	30	45	60	75	90	105	120
B-glucose conc. ($mmolL^{-1}$) After ingestion of pure glucose	4.7	4.8	6.3	6.3	5.2	5.6	5.9	5.7	5.6
B-glucose conc. ($mmolL^{-1}$) After ingestion of boiled white yam	4.9	5.1	5.8	5.0	4.7	4.6	4.8	4.7	4.5

Table 7: Plotted values for postprandial blood glucose curves of test subject 'D'

Time (mins)	0	15	30	45	60	75	90	105	120
B-glucose conc. ($mmolL^{-1}$) After ingestion of pure glucose	4.7	5.7	7.6	7.7	8.1	7.7	6.0	4.7	3.9
B-glucose conc. ($mmolL^{-1}$) After ingestion of boiled white yam	4.9	5.4	6.8	5.7	4.8	4.7	4.8	4.9	5.1

Table 8: Plotted values for postprandial blood glucose curves of test subject 'E'

Time (mins)	0	15	30	45	60	75	90	105	120
B-glucose conc. ($mmolL^{-1}$) After ingestion of pure glucose	5.4	6.2	8.8	9.3	8.5	7.2	6.9	6.5	6.2
B-glucose conc. ($mmolL^{-1}$) After ingestion of fried water yam	6.0	5.7	5.6	5.8	6.1	5.9	5.8	5.6	5.5

Table 9: Plotted values for postprandial blood glucose curves of test subject 'F'

Time (mins)	0	15	30	45	60	75	90	105	120
B-glucose conc. ($mmolL^{-1}$) After ingestion of pure glucose	4.9	6.3	7.4	8.1	7.1	6.6	5.3	4.6	4.1
B-glucose conc. ($mmolL^{-1}$) After ingestion of fried water yam	5.0	4.9	5.6	6.2	6.2	4.9	5.0	5.1	5.1

Table 10: Plotted values for postprandial blood glucose curves of test subject 'G'

Time (mins)	**0**	**15**	**30**	**45**	**60**	**75**	**90**	**105**	**120**
B-glucose conc. ($mmolL^{-1}$) After ingestion of pure glucose	4.6	6.4	6.8	6.0	5.3	5.6	5.6	4.9	4.6
B-glucose conc. ($mmolL^{-1}$) After ingestion of boiled water yam	5.1	5.6	5.7	5.1	4.9	4.9	4.9	4.6	4.8

Table 11: Plotted values for postprandial blood glucose curves of test subject 'H'

Time (mins)	**0**	**15**	**30**	**45**	**60**	**75**	**90**	**105**	**120**
B-glucose conc. ($mmolL^{-1}$) After ingestion of pure glucose	4.3	5.0	5.6	6.4	5.2	4.8	3.7	4.2	4.3
B-glucose conc. ($mmolL^{-1}$) After ingestion of boiled water yam	4.1	4.4	4.6	5.2	4.6	4.7	4.2	3.9	4.2

Table 12: GI and GL values for tested foods

Food	**GI (glucose = 100)**	**Serving size (grams)**	**GL per serving**
Fried white yam	88	57	44
Boiled white yam	92	57	46
Fried water yam	82	60	41
Boiled water yam	85	60	43

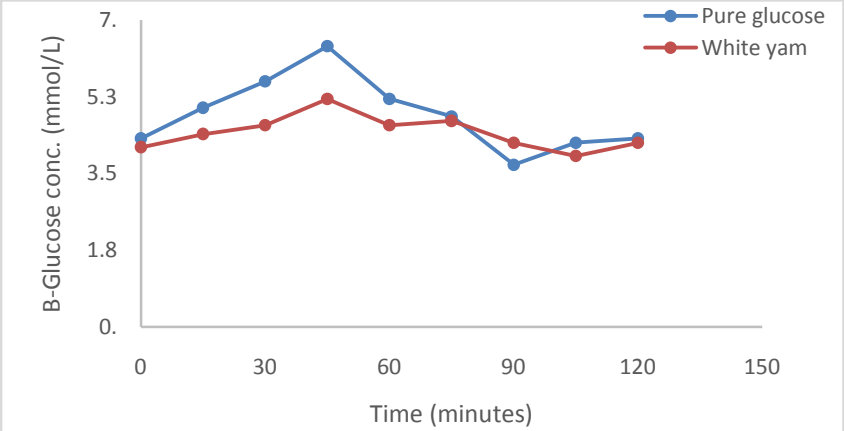

Figure 1: Graph of postprandial blood glucose for test subject 'A'

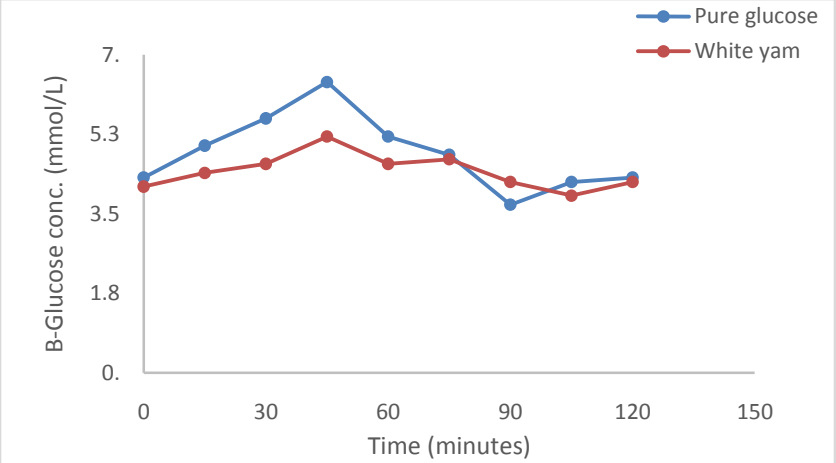

Figure 2: Graph of postprandial blood glucose for test subject 'B'

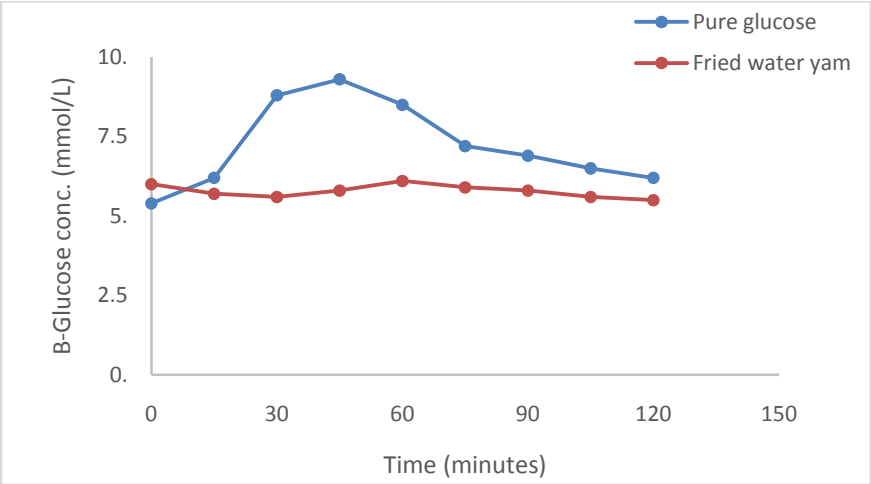

Figure 3: Graph of postprandial blood glucose for test subject 'C'

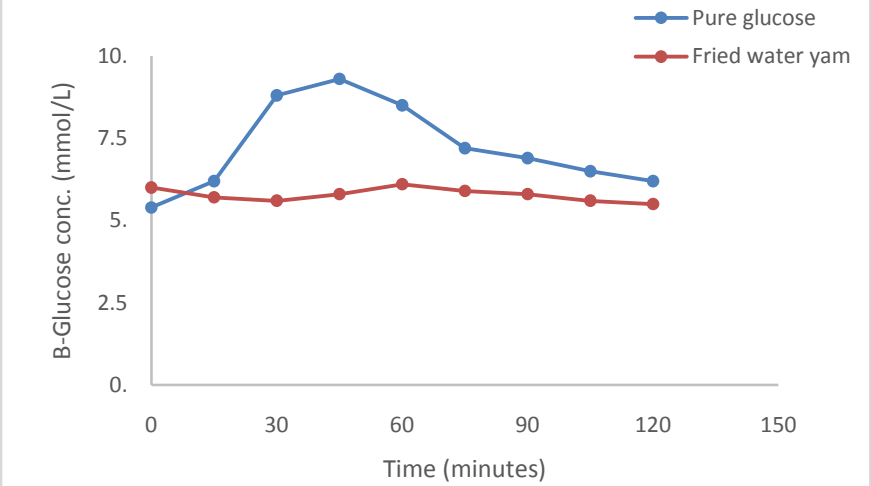

Figure 4: Graph of postprandial blood glucose for test subject 'D'

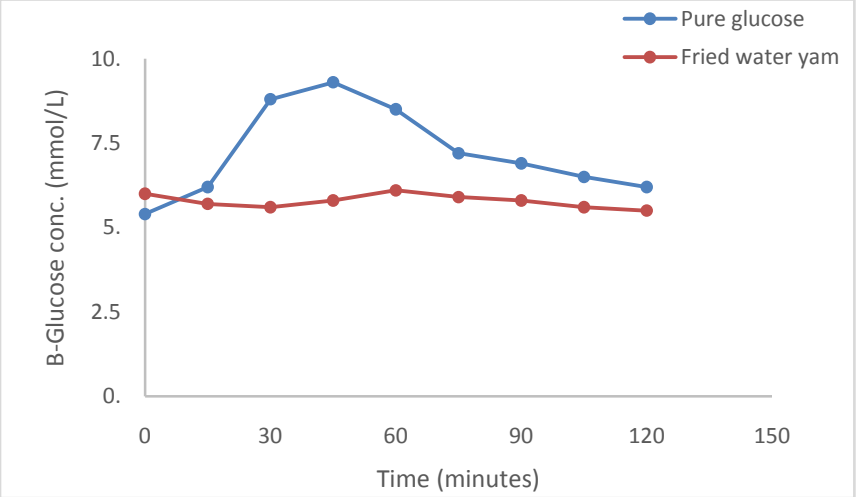

Figure 5: Graph of postprandial blood glucose for test subject 'E'

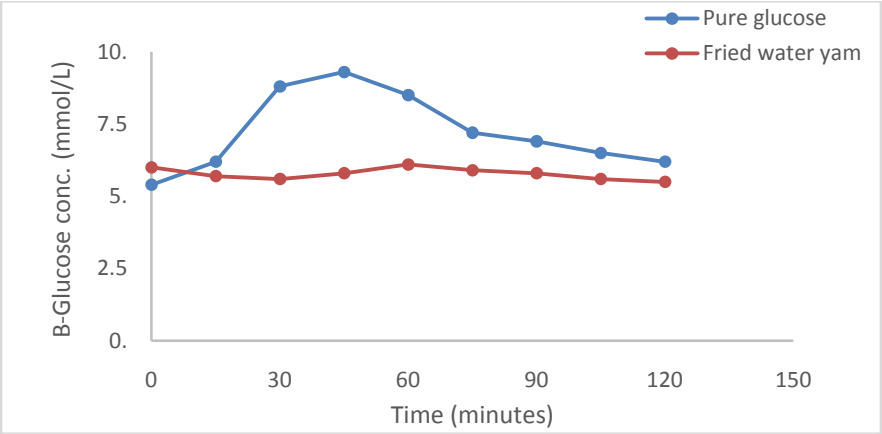

Figure 6: Graph of postprandial blood glucose for test subject 'F'

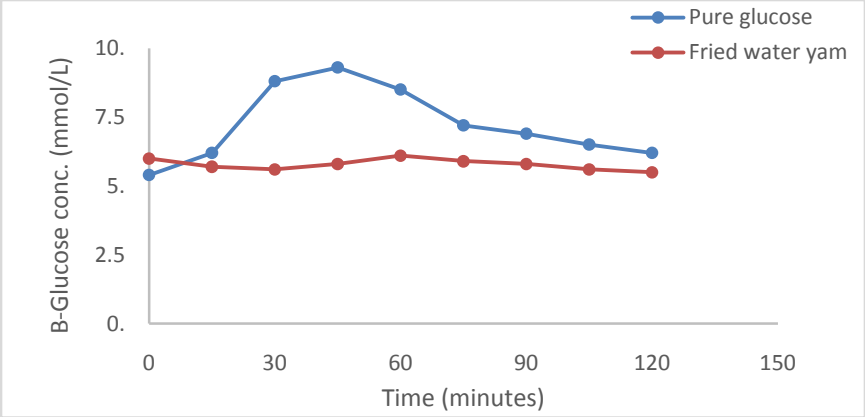

Figure 7: Graph of postprandial blood glucose for test subject 'G'

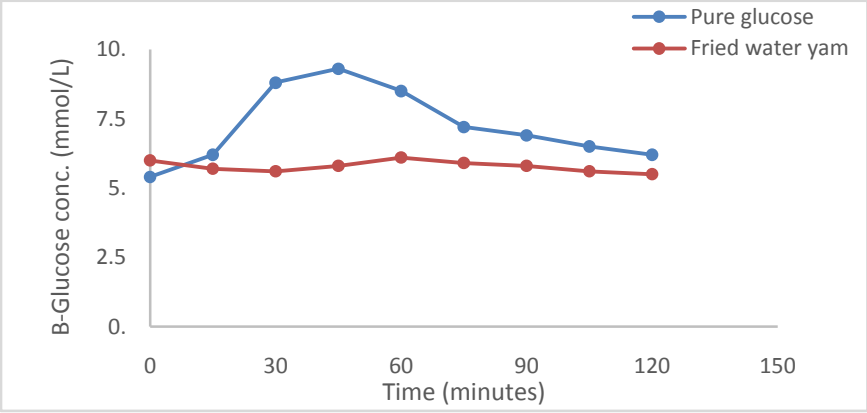

Figure 8: Graph of postprandial blood glucose for test subject 'H'

3.2 Discussion

Eight volunteers were successfully recruited for the exercise. The average age of the participants was 25 years. Their average body mass index (BMI) was within the normal acceptable range of 18.5 – 25.0 kgm^{-2} the observed fasting blood glucose concentrations fell within the normal range (4.0 – 7.0 $mmol^{-1}$). All of these show the medical fitness and health status of the test subjects and therefore qualify them for the test. The foods were first tested for their

carbohydrate quantity through proximate analysis. The analysis was carried out on the raw samples in order to investigate the effect of food processing method on the GI of the foods. As expected, the fried versions of the food showed relatively lower GI and GL than the boiled versions of the meals. This may be due to the presence of higher amount of fat (cooking oil) added during its preparation [2, 3, 5-9]. Fat and protein reportedly show negative association with GI [37] on the virtue of their ability to delay gastric emptying and affect insulin secretion. The second reason for increased GI in the boiled samples as compared to their fried versions may be due to the gelatinization of starch during boiling. This high starch gelatinization has certainly inhibited the action of macronutrients (fats, fiber, protein), thus leading to the increased GI of the boiled meals. The gelatinization makes the starch quickly and easily digestible. Thus, digestion becomes more rapid, leading to a higher GI value [38].

The concept of classification of foods according to their blood glucose response is emerging as one of the effective strategies to control the complications of hyperglycemia. People in industrialized countries base their diets on low GI and GL foods in order to prevent the most common diseases such as coronary heart disease, diabetes and obesity [39]. According to GI, foods may be divided into three groups: foods with low GI (GI = 55 or less), foods with medium GI (GI = 56-69) and foods with high GI (GI = 70 or more) [40].

The results of the present study presented in table 12 show the GI values of fried white yam, boiled white yam, fried water yam and boiled water yam as 88, 92, 82 and 85 respectively. Maximum value of 92 was recorded for boiled white yam while minimum GI (82) was recorded for fried water yam. All of these foods have a high GI value (i.e, GI = 70 or more).

The GI values of fried white yam, boiled white yam, fried water yam and boiled water yam were 44, 46, 41 and 43 respectively. The maximum value of 46 for boiled white yam with minimum glycemic load of 41 for fried water yam. These data indicate that all the tuber foods investigated in the current study have high GI and GL. The GI is influenced by; the type of food (including particle size, presence of intact grains, texture, and viscosity), the degree of food processing and cooking, the presence of fructose or lactose (both have a low GI, the ratio of amylopectin and amylase in starch (amylase has a slower rate of digestion) and starch-protein or starch-fat interactions [41].

4. Conclusion

This study has provided GI and GL values for four common staple carbohydrate rich foods in Makurdi. The fried white yam, boiled white yam, fried water yam and boiled water yam all have high GI and GL values and are therefore hyperglycemic foods. These foods are not advised for diabetic patients. Healthy people can consume these foods in moderate quantities. These findings suggest the importance of informing diabetes patients on diets following the GI concept to choose carbohydrate foods, so as to reduce the risks. Findings of the present study may serve as useful guidance for dietitians who are involved in meal planning for diabetes patients. They can be used to achieve healthy eating and to establish a plan for chronic disease risk reduction programs in this locality.

References

[1]. Sardesai, V. M. (2003). *Introduction to Clinical Nutrition*. Marcel Dekker Inc. New York p. 339-354.

[2]. Astawan, M. and Windowati, S. (2011), Evaluation of Nutrition and Glycemic Index of Sweet Potatoes and its Appropriate Processing to Hypoglycemic Foods. *Indonesian Journal of Agricultural Science 12 (1)*: 40-46.

[3]. Akinkugbe, O. O. (Ed). (1997). Non-Communicable Diseases in Nigeria: National Survey (Final Report) on Hypertension, Coronary Heart Disease, Diabetes Mellitus, Haemoglobinopathies, G6PD Deficiency and Ameamia, *National Expert Committee on Non-Communicable Disease Lagos, Nigeria Federal Ministry of Health and Social Service.*

[4]. IDF Diabetes Alas, 6th Edition International Diabetes Federation, 2013 Available at: http://www.idf.org/diabetesalas.

[5]. Oputa, R. N. and Chinenye, S. (2015) Diabetes in Nigeria –a Translational Medicine Approach, *African Journal of Diabetes Medicine 23 (i)p. 7-10*

[6]. Faruku T., Alam K., lifkhar, A., Niamatullahi, Saleem, K., Imran, K., Muhammad. Z Muhammed, Z., Kalsoon, Q., Mahpara S and Ziaud Din. (2013). Determination of Glycemic Indices and Glycemic Load of Various Types of Cereal Foods *ARPN Journal of Agricultural and Biological Science* 8(6): 493-497.

[7]. Ludvik, B., Waldhausl., W Prager. R., Kautzky Willer, A and Pacini G (2003) Mode of action of Ipomoea batatas (Caiapo) in Type 2 Diabetic Patients *Metabolism* 52(7):875-880

[8]. Ebbeling, C.B and Ludwig D.S (2001). Treating Obesity in Youth: should Dietary Glycemic Load be a Consideration. *AdvPediatr* 48 pg 179-21A

[9]. Khan A, Bryden N.A polansky, M.M and Anderson R.A (1990). Potentiating factor and chromium content of Selected Foods and Spices Bio. Trace Element Res. 24:183-188.

[10]. Ferri, F.F. 2004. Diabetes mellitu in: Ferri F.F. Practical guide to the care of the medical Patient St. Louis, MO: Mosby, in 6: 247-268.

[11]. Jenkins D.J., Wolever T.M Taylor R, H., Barker H., Fielden H., Baldwin. J.M bowling A.C newman H.C Jenkins A.L and Goff D.V (1981) Glycemic index of foods: A physiological basis for carbohydrate exchange *Am J. Clin Nutr.* 34(3): 362-366.

[12]. Brand J.C., Nicholson, P.L Thorburn, A.W and Truswel, A.S (1985). Food processing and the glycemic index *American Journal of Clinical Nutrition* 42(6): 1192-1196.

[13]. Rudolf, C., Josef, B., Martina, R., Jana, Z., Blanka, D., Ludmila, C., Pavel, S., Svatava, D., Vilim, S. (2004). Determination of the glycemic index of selected foods (white breat and cereal bars) in healthy persons. *Biomedical Papers*. 148(1): 17-25.

[14]. Bruns, W., Wagner, D.a dn Taubert, F.P (1989), Glycemic index and obesity. *America Journal of Clinical Nutrition* 76:2815-2855.

[15]. Gannon, MC Nutall F.Q. Krezowski, P.A., Billington CJ, Parker, S (1986). The serum insulin and plasma glucose responses to milk and fruit products in type-2 (non-inslin-depend) diabetic patients. *Diabetologia* 39: 784-791

[16]. Jenkins, A.L., Jenkins, D.J., Zdravkovitz, U., Wurch, P., Vuksan, V (2002) depression of gylcemic index by high levels of beta-glucan fiber in two functional foods tested in type 2 diabetes. *Eur. J. Clin Nutr*. 56: 622-628.

[17]. Jenkins, D.J., Kendall, C.W., Augustin L.S., Franceschi, S., Hamidi, M., Marchie, A., Jenkins, A.L Axelsen, M. (2002). Glycemic index: overview of implications of health and disease. *Am. J. Clin Nutr*. 76: 2665-2673.

[18]. Liu S., Willett, W.C (2002). Dietary Glycemic load and atherothromobotic risk. *Curr. Atheroscler Rep.* 4: 45-61.

[19]. Ludwig, D.S (2002). The glycemic index: physiological mechanism relating to obesity, siabetes, and cardiovascular disease. *JAMA* 287: 2414-2423

[20]. Raben A (2002), should obese patients be counseled to follow a low-glycaemic index diet? No. *Obesity Review* 3: 245-256

[21]. Spraul, M., Chantelau, E., Schonbach, A.M., Berger, M. (1988). Glycemic effects of beer in IDDM patients. *Diabetes Care* 11: 659-661.

[22]. Bahado-Singh, P. S., Wheatley, A. O., Ahmad, M. H., Morrison, E. S. A., & Asemota, H. N. (2006). Food processing methods influence the glycaemic indices of some commonly eaten West Indian carbohydrate-rich foods. *British journal of nutrition*, *96*(3), 476-481.

[23]. Quansah, J. K., Saalia, F. K., Abbey, L. D., & Annor, G. A. (2010). Performance of yam as an alternative to frozen potato French fries.

[24]. Lawal, O. O., Agiang, M. A., & Eteng, M. U. (2012). Proximate and anti-nutrient composition of white Guinea yam (*Dioscorea rotundata*) diets consumed in Ibarapa, South West region of Nigeria. *J. Nat. Prod. Plant Res*, *2*(2), 256-260.

[25]. Kouassi, N. K., Tiahou, G. G., Abodo, J. R. F., Camara-Cisse, M., & Amani, G. N. (2009). Influence of the variety and cooking method on glycemic index of Yam. *Pakistan Journal of Nutrition*, *8*(7), 993-999.

[26]. Nishimune, T., Yakushiji, T., Sumimoto, T., Taguchi, S., Konishi, Y., Nakahara, S., ... & Kunita, N. (1991). Glycemic response and fiber content of some foods. *The American journal of clinical nutrition*, *54*(2), 414-419.

[27]. Bahado-Singh, P. S., Riley, C. K., Wheatley, A. O., & Lowe, H. I. (2011). Relationship between processing method and the glycemic indices of ten sweet potato (Ipomoea batatas) cultivars commonly consumed in Jamaica. *Journal of nutrition and metabolism*, *2011*.

[28]. Allen, J., D Corbitt, A., P Maloney, K., S Butt, M., & Truong, V. D. (2012). Glycemic index of sweet potato as affected by cooking methods. *The Open Nutrition Journal*, *6*(1).

[29]. Lin, M. H. A., Wu, M. C., Lu, S., & Lin, J. (2010). Glycemic index, glycemic load and insulinemic index of Chinese starchy foods. *World Journal of Gastroenterology: WJG*, *16*(39), 4973.

[30]. Omoregie, E. S., & Osagie, A. U. (2008). Glycemic indices and glycemic load of some Nigerian foods. *Pakistan Journal of Nutrition*, *7*(5), 710-716.

[31]. Anyakudo, M. M. C. (2014). Effects of food processing methods on diets proximate nutrient composition and glycemic profile in male type 2 diabetic subjects. *British Journal of Applied Science & Technology*, *4*(27), 3995.

[32]. Oboh, H., Osagie, A., & Omotosho, A. (2010). Glycemic response of some boiled legumes commonly eaten in Nigeria. *Diabetologia Croatica*, *39*(4), 113-138.

[33]. Okafor, G. I., & Usman, G. O. (2014). Production and Evaluation of Breakfast Cereals from Blends of A frican Yam Bean (S phenostylis stenocarpa), Maize (Z ea mays) and Defatted Coconut (C ocus nucifera). *Journal of food processing and preservation*, *38*(3), 1037-1043.

[34]. Levis, S. P., McGowan, C. A., & McAuliffe, F. M. (2011). Methodology for adding and amending glycaemic index values to a nutrition analysis package. *British journal of nutrition*, *105*(8), 1117-1132.

[35]. Adedayo, B. C., Ademiluyi, A. O., Oboh, G., & Akindahunsi, A. A. (2012). Interaction of aqueous extracts of two varieties of Yam tubers (Dioscorea spp) on some key enzymes linked to type 2 Diabetes in vitro. *International journal of food science & technology*, *47*(4), 703-709.

[36]. Iwe, M. O., Onyeukwu, U., & Agiriga, A. N. (2016). Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour. *Cogent Food & Agriculture*, *2*(1), 1142409.

[37]. Eke-Ejiofor, J. (2015). Physico-chemical and pasting properties of starches from cassava, sweet potato and three leaf yam and their application in salad cream production. *International Journal of Biotechnology and Food Science*, *3*(2), 23-30.

[38]. Ahmed, F., & Urooj, A. (2008). In vitro starch digestibility characteristics of Dioscorea alata tuber. *World Journal of Dairy & Food Sciences*, *3*(2), 29-33.

[39]. Inocent, G., Adelaide, D. M., Gisele, E. L., Solange, M. O. R., Richard, E. A., & Elie, F. (2011). Impact of three cooking methods (steaming, roasting on charcoal, and frying) on the β-carotene and vitamin C contents of plantain and sweet potato. *Am. J. Food Technol*, *6*, 994-1001.

[40]. Akinoso, R., & Abiodun, O. A. (2016). Yam: technological interventions. *Tropical roots and Tubers: Production, Processing and technology*, 558-90.

[41]. Liljeberg, H., & Björck, I. (2000). Effects of a low-glycaemic index spaghetti meal on glucose tolerance and lipaemia at a subsequent meal in healthy subjects. *European Journal of Clinical Nutrition*, *54*(1), 24.