GLYCEMIC INDICES OF DIFFERENT CASSAVA FOOD PRODUCTS

Ogbuji, C.A.[1] & David-Chukwu, N.P.[2]
Department of Food Science and Technology, Abia State Polytechnic, Aba[1].
Department of Hospitality Management Technology, Abia State Polytechnic, Aba[2].

ABSTRACT

This study investigated the proximate composition and glycemic indices of four different cassava food products. Four groups of volunteers were each fed with 167g of *abacha*, 162g of *tapioca*, 169g of *garri* and 205g of *fufu* diets and control volunteers were fed with 50g anhydrous glucose. The venous blood samples were drawn at 30mins intervals for 2 hours after fasting blood glucose test, which was determined, using glucose oxidase method. The blood levels after were determined and the areas under curve were calculated by trapezoid method. The glycemic indices for *fufu*, *garri* , *abacha* and *tapioca* were found to be 84, 92, 84 and78 respectively. The analysis of variance (F= 0.05) carried out showed that the method of preparation of the diets did not affect the glycemic indices of the food, there is also no significant differences ($p< 0.05$) in the glycemic indices of *fufu*, *abacha* , *garri*, and *tapioca* diets. The four cassava diets were within the high glycemic index range of above 70. From these results, it can be concluded that cassava food products are of high glycemic index.

Keywords: Fufu, abacha, garri, tapioca, glycemic index.

INTRODUCTION

Cassava (*Manihot esculenta Crantz*) is a major staple food in tropical countries. Nigeria is the world's largest producer of cassava with the potential for higher production. Cassava belongs to the family *Euphorbiaceae* and is a perennial woody shrub producing enlarged tuberous roots. The roots are the main storage organs and in some areas it is cultivated as perennial or annual plant with the storage roots being harvested during the first or second year (Ming and Aloys, 2006). Cassava contains anti-nutritional factors and toxins, it must be properly prepared before consumption, and improper preparation of cassava can leave enough residual cyanide to cause acute cyanide intoxication and goiters and may even cause a toxic or partial paralysis (Taiwo, 2006). Cassava is an important food crop in the tropics and a major carbohydrate staple consumed in various forms by humans. It contributes significantly to the nutrition and livelihood of about 800 million people and thousands of processors and traders around the world and forms a base for a wide variety of fermented foods in Africa, Asia, Brazil, India and America. In addition it serves as raw material in the manufacture of processed foods, animal feed and industrial products (Balagpalan, 2002, Aloys and Mings 2006, Taiwo 2006). Traditional cassava processing methods involves several unit operations including peeling, drying, milling, roasting, sieving, steaming, pounding and mixing in cold or hot water. Specific combinations of these processes lead to a myriad of different cassava products with acceptable taste to a wide range of consumers. Generally these steps are intended to reduce toxicity and improve palatability. In Nigeria the main food product of considerable domestic importance are *garri* (*eba*), flour and *fufu* (Taiwo, 2006). *Garri* is the most common food product processed from cassava in West Africa; production involves peeling, washing and grinding of the roots. The grated mash is put in jute sacks which are pressed using screw press and the dewatered mash is then sieved and fried. The average moisture content of *garri* ranged from 8 to 14% which makes it suitable for long term storage. It is usually eaten in the form of snacks by soaking in water or in the meal form

where it is reconstituted by stirring in hot water to form a dough (*eba*) which is eaten with soup (Udoro, 2012). *Fufu* is fermented cassava and is popular in Nigeria; it is prepared by soaking the tuber in water either with the peel or after peeling for 3 to 4 days. The tubers are then manually disintegrated by crushing, decanted and the mash spread on a flat surface. The mash is dried and milled to obtain the fermented flour. The flour is prepared by stirring in hot water to make smooth elastic dough which is eaten with vegetable soup (Taiwo, 2006). *Fufu* is a meal from soaked fermented cassava in Eastern Nigeria. The tubers are peeled, washed, cut into thick chunks and soaked in water for 4 to 5 days. During this period, the cassava tubers ferment and soften in water. A characteristic flavour of retted cassava meal is also produced. The retted tubers are disintegrated then passed through the sieve and allowed to settle for about 3 to 4 hours. The water is decanted while the sediment is packed into a cloth bag, tied, squeezed and subjected to a heavy pressure to expel excess water. The resulting meal is rolled into balls and cooked in boiling water for about 30 to 40 minutes. The cooked mass is pounded with a mortar and pestle to produce a paste (*fufu*) that can be eaten with soup, (Balagopalan, 2002).

Certain carbohydrate foods are digested rapidly releasing glucose into the blood stream where as some carbohydrate foods are digested slowly releasing glucose slowly into the blood stream (Jenkins *et al*., 1994). The numerical scale used to indicate how fast and how high a particular food can raise the blood glucose level is known as glycemic index. Glycemic index is rated on 1 to 100. Food which raises the blood glucose level quickly after meal is known as high glycemic index food and is assigned a value of 70 and above whereas food which releases glucose slowly into the blood stream is known as low glycemic index and has a value of 55 and below (Brand-Miller *et al*., 1996).

Health problems associated with high blood glucose such as obesity, metabolic syndrome, diabetes mellitus are due to high glycemic index foods. Therefore clinical trials have shown that low glycemic diets improve glycemic control in diabetes, increase insulin sensitivity; reduce food intake and body weight (Juntmen *et al*., 2003). Prospective studies suggest that low glycemic index diets may reduce the risk of diabetes, metabolic syndrome cardrovascular disease and possibly some type of cancer (Liu *et al*., 2000, Sulmeron *et al*; 1997). This study therefore is aimed at determining the glycemic indices *Fufu*, *Garri*, *Tapioca* and *Abacha* by the glucose oxidase reaction and the trapezoid methods.

MATERIAL AND METHODS

Fully matured cassava tubers were obtained from a farm at *Umuara Okpu Umuobo*, *Osisioma Ngwa* L.G.A, Abia State, Nigeria.

Sample Preparation

Table 1

SAMPLES FORM	PRE-PROCESING	PASTE PREPARATION
Garri	Cassava was pealed, washed, grated, the grated mash was put in jute sacks pressed using screw press and the devotered mash was then sieved and fried	*Garri* was reconstituted by stirring in hot water to form a dough which is eaten with soup.
Abacha	Cassava was peeled, washed, sliced and boiled for about 30 minutes and sun dried for 7 days.	Cassava was soaked in cold water.
Tapioca	Cassava was peeled, washed, boiled and cut into thin pieces and sun dried for 7 days.	Cassava was soaked in cold water.
Fufu	Cassava was peeled, washed, cut into thick chunks and soaked in water for 3 to 4 days.	Cassava meal was rolled into balls and cooked in boiling water for

	During this period, the cassava tubers ferment and soften releasing hydrogen cyanide into the soak water, the cassava was sieved in clean water and the starchy particles that pass through the sieve are allowed to settle for about 3 to 4 hours. The water was decanted while the sediment was packed into a cloth bag, tied, squeezed and subjected to a heavy pressure to expel excess water.	about 30 to 40 minutes. The cassava was pounded with a mortar and pestle to produce a paste that can be eaten with soup.

SOURCE: OKOH, 1998

Proximate Analysis
Determination of Moisture Content

3g of each sample were weighed out and were transferred into a weighed crucible and dried in an oven at 65^{o}c for 4 hours to obtain a constant weight. The samples were removed and placed in the desiccators to cool and weighed and the percentage moisture content was determined. (Skoog *et al*., 2009).

Determination of Ash Content

1g of each milled sample was weighed out and transferred into a weighed crucible and was transferred into a muffle furnace and ashed at 550^{0}C for 1 hour. The ashed sample was allowed to cool in a desiccators and weighed and the percentage ash content was determined (Nnedinso, 2007).

Determination of Fat Content

6g of each milled sample was weighed out and transferred into a soxhlet extractor. The extracting set up was made using N-Hexane as the extracting solvent and heated at 35^{o}c for 3 hours and the percentage crude fat was determined (Subbulakshim and Chitra, 1996).

Determination of Crude Fiber Content

6g of defatted sample was digested with 200ml of 12.5% H_2SO_2 solution under reflux for 45 minutes boiling , the digest was allowed to cool and then filtered with buckner funnel equipped with muslin cloth. The residue was washed thrice with hot water, scooped into a conical flask and digested with 200ml of 12.5% NaOH solution under reflux for 45 minutes boiling. The digest was cooled, filtered and washed thrice with distilled water. The residue was drained and scooped into a previously dried and weighed crucible and then put into the oven to dry at 105^{o}c to a constant mass. The dish with its content was reweighed after drying and then placed in the muffle furnace to ash at temperature of 550^{o}c for 3 hours. The sample was cooled in a desiccators and weighed to determine the fibre content. The percentage fibre content was calculated (Nnedinso, 2007).

Determination of Protein Content

The milled sample of 0.7g was weighed into a kjeldahl digestion flask. 1g of $CuSO_4$ and 2g Na_2SO_4 and 10ml of concentrated H_2SO_4 were added to the sample. It was digested by locating under a fume cupboard until a clear solution was obtained. The digested solution was transferred into a 100ml volumetric flask and made p to mark with distilled water. 10ml of the digest was measured out and mixed with equal volume of 45% NaOH solution in

Kjeldahl distillation flask. The mixture was distilled into 10ml boric acid solution containing mixed indicator (methyl red and bromo cressol green) and was titrated with 0.02 NH_2SO_4. A blank experiment was also set involving digestion of all the materials except the sample. The distillation was also carried out on the blank. The titre value of the blank was subtracted from that of the sample and the difference obtained was used to calculate the crude protein.

Determination of Carbohydrate

The carbohydrate was determined by arithmetic difference of other analysis results using the formula (AOAC, 1990).

Methodology For Blood Glocose Determination

Twenty (20) healthy subjects aged 16-29 years were selected from students of Abia State Polytechnic Aba, and recruited for the study and were grouped into five. In this analysis only non diabetic volunteers were eligible to participate in the study, smokers, overweight and obese individual were excluded from participating in the study. Emphases were placed on volunteers who were healthy with an active life style without any diagnosed disease and not on prescribed medication. The study was carried out using standard glycemic index testing protocol. The reference food used was 50g anhydrous glucose with a glycemic index assumed to be 100. They were given informed consent form to sign for permission to use their blood in the analysis.

Determination of Blood Glucose Response

The fifth group made up of four volunteers was fed with 50g of anhydrous glucose each to serve as control. Their blood samples were also drawn at 30 minutes, 60 minutes, 90 minutes and 120 minutes intervals for 2 hours after feeding. Each of the drawn blood samples was applied to the side of the strip which was curved to fit the shape of the finger. This does not only make it easy for the small drop of blood to be drawn into the strip but also to avoid any blood contaminating the meter. At the end, the results were gradually displayed after 26 seconds.

Calibration of One Touch Glucometer

The one touch glucometer was calibrated each time a new batch of strip was used. This was performed with each vial of test strips. The strip was inserted at the back of the meter and the code number was displayed which is the same as shown on each test strip of the batch.

Determination of Area Under Curve (Auc)

The area under curve was determined using trapezoid method of different time intervals (David; 2002). A plot of concentration against time was used for the calculation, AUC, = $Conc_2$+ $Conc_1$ 2x (t_2-t_1).

Determination of Glycemic Index

The sum of area under curve for each sample, *Fufu*, *Garri*, *Abacha* and *Tapioca* menu was divided by the sum of area under curve for standard glucose and multiplied by 100. The value obtained is the glycemic index and the formula is given below:

Glycemic index (GI) = %AUC of test food/AUC of standard glucose *100 (Brouns *et al*., 2005).

Statistical Analysis

The results obtained were analysed with a replicate of five samples on each treatment using one way analysis of variance (ANOVA) at F = 0.05 and student t-test at P = 0.05 to determine the level of significance of the treated samples (Ogbenna; 2005).

RESULT AND DISCUSSION

The glycemic index values obtained from feeding a total of twelve volunteers with the four different cassava food products shown a mean of 85 and their individual glycemic indices are 92.4, 84.1, 84.9 and 78.7 respectively. The statistical data obtained from the four samples using student t-test (P= 0.05 d.f = 4) with one way analysis of variance (ANOVA) show a significant difference between *garri* and glucose, *abacha* and glucose, *fufu* and glucose and *Tapioca* and glucose. All the four cassava based food samples are within the high glycemic index range.

Table 2: PROXIMATE ANALYSIS OF FOUR DIFFERENT CASSAVA FOOD PRODUCTS:

CASSAVA FOOD PRODUCT	MOISTURE %	ASH%	CRUDE LIPID%	CRUDE FIBRE%	CRUDE PROTEIN %	CARBOHY-DRATE %	GLYCEMIC INDEX
ABACHA	7.20±0.95	0.30±0.00	0.20±0.06	0.43±1.53	0.65±0.25	91.22±1.95	84.88
TAPIOCA	8.00±1.00	0.27±0.58	0.2±0.00	0.39±2.08	1.53±0.20	89.61±3.38	78.67
GARRI	11.10±1.01	0.33±0.58	1.30±1.50	0.37±2.08	2.03±0.20	84.88±3.38	92.36
FUFU	15.90±4.04	0.43±0.58	0.30±0.00	0.26±1.09	2.27±0.34	80.84±1.25	84.06

Values are means of triplicate readings ± SEM

The glycemic indices of different preparation *Fufu, Abacha, Garri* and *Tapioca* menu were compared with glucose with the glycemic index of 100 and *Abacha, Fufu, Garri* and *Tapioca* were found to be high with glycemic indices of 84.88, 84.06, 92.36 and 78.67.

The result from the glycemic indices showed a significant difference between *Abacha, Fufu, Garri* and *Tapioca* with respect to their menu. However, the glycemic indices of *Abacha, Garri, Tapioca* and *Fufu* showed a significant change at ($p < 0.05$). This supports the contribution made by Taiwo, (2006) that *Abacha, Fufu, Garri* and *Tapioca* contain starch molecules that are easily digestible and are regarded as the most important domestic food products. The glycemic index of *garri* is 92.36 and the average moisture content of it ranges from 8 to 14%. The glycemic index of *fufu* is 84.06 and it is a meal made from soaked fermented cassava and the tubers are peeled, washed and soaked in water for 4 to 5 days to ferment and soften releasing hydrogen cyanide (HCN) (Balangopalan, 2002), these results

may vary in cultivar growing location and preparation method. The results suggest that the processing method, especially boiling may affect the glycemic index of the food. During the boiling process, wet heat is used to cause free sugar to leach into the liquid medium, then more leaching of glucose monomers occurs during amylase amylopectin degradation. However, the loss of the readily digestible sugar to leaching had no direct implication on the amount of carbohydrate used to calculate the glycemic index, testing was calculated on the final cooked product.

However, the degree of starch conversion may differ across cultivars (Walter *et al*., 1975). The different carbohydrate contents of the foods may explain the differences in glycemic index and it was found that similar levels of carbohydrate content do not have similar glycemic index. Therefore, carbohydrate has stronger resistance to digestive enzymes and its digestion and absorption in the intestine is slow and incomplete. Under this kind of condition, low blood glucose is seen. However the glycemic index results obtained are within the same range. Analysis of area under curve among the *Fufu*, *Abacha*, *Tapioca* and *Garri* show that peak of blood glucose response are 7.83mm01/L, 7.86mm01/L, and 8.63 mm01/L at ½ hour where as standard glucose exhibit more blood glucose response at 1 hour. This suggest that *Abacha*, *Fufu*, *Tapioca* and *Garri* release glucose slowly into the blood stream and blood glucose response for standard glucose is rapid.

CONCLUSION

The statistical analysis obtained show that the four cassava food products belong to high glycemic index foods.

Although, low glycemic foods have been associated with certain low risk factors in metabolism and high of glycemic foods are associated with high risk factors in carbohydrate metabolism and cardiovascular disorders (Keys *et al*., 1986), it is therefore important to understand the glycemic effect of foods based on their compositions and processing methods as this will enhance the understanding of their roles in the management of carbohydrate metabolic disorders and to find out the best preparation method that produces a low glycemic index.

The result of this study suggests that cassava food products are of high glycemic index.

REFERENCES

Aloys, N. and Ming, Z.H.(2006). Traditional cassava food in Burundi; Food Reviews International, 22; 1-27.

AOAC (1990). Official methods of Analysis (15th Ed), Association of Official Analytical Chemists, Washington DC, USA.

Balagopalan, C. (2002). Cassava utilization in food, feed and industry. In: Cassava: Biology production and utilization R.J. Hillocks, J.M. Tresh and A.C. Belloti (eds). CIAT. Colombia, Pp. 301-318.

Brand-Miller, J., Foster Powell, K. and and Colagiuri ,S.(1996). The Glycemic Index Factor: The Glycemic Index solution. The Scientific answer to weight reduction, peak sports performance and blood sugar control. Hodder & Stoughton, 10-16 South street, Rydalmere ,NSW, 2116

Brouns, F., Bjorck, I., Frayn, K. N., Gibbs A.L, Lang V, Slama G, Wolever T.M.(2005). Glycemic Index Methodology, Nutr. Res. Rev.18(1): 145-171.

David, B. (2002). AUC calculation using Trapezoid Rule (david @ www.boomer.org.)

Jenkins, D.J. Jenkins, A.I., Wolever, T. M., Vuksan, V., Venket, R. A., Thompson, I.U. and Jasse, R. G. (1994). Low Glycemic index carbohydrate and physiological effect of altered food frequency. Am. J. Clin. Nutr. 59: 706 -709.

Keys A, Menotti A, Karvonen M.J, Aravanis C, Blackburn H, Buzina R, Djordjevic B S, Dontas A.S, Fidanza F, Key M. H. et al.,(1986). The diet and 15-year death rate in the seven countries study. Am. J.Epidemiol .124(6): 903-15.

Luis,S., Willett, W.C. and Stampfer, M.J., Hu, F.B, Franz M., Sampson L, Hennekens, C.H, Manson, J.E. (2000). A Prospective study of dietary glycemic load, carbohydrate intake and risk of coronary heart disease in U.S. women. Am. J. Clin. Nutr. 71(6): 445-61.

Nnedinso, N.K. (2007). Chemical composition of some indigenous vegetables Jatropha aconitifolia and Colocasia esculenta and the effect of their extracts on zinc, iron and vit. A metabolism in rats, Home SC., Nutr., and Dietetics 23-26.

Okoh, P.N., (1998). Cereal grains in Nutritional Quality of Plant foods (Eds). In A.U. Osagie and O.U. Eka, Post- Harvest Research unit, University of Benin, Pp 32-52.

Skoog, E.A., West, D.W., Holler, F.J, and Crouch, R.C. (2009). Fundamentals of analytical chemistry, lengage learning. New Delhi; 314-449.

Subbulakshim, G., Chitra, L.C. (1996). Method for determining nutrients in foods. A critical appraisal, J. Food Science Technology, 33: 267-284.

Salmeron , J. A. and Ascherio, A., Rimm ,E.B. et al.,(1997). Dietary fibre glycemic load and risk of NIDDM in men. Diabetes care, Vol. 20 (4): 545-550.

Taiwo, K.A. (2006). Utilization potentials of cassava in Nigeria: The domestic and industrial products. Food Reviews international 22 (1):29-42.

Walter, W.W., Purcell, A.E., Nelson, A.M. (1975). Effects of Amylolytic enzymes on "moistness" and carbohydrate changes of baked sweet potatoes cultivars, J. Food Science, 40:793-6.