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Comparative Study on The Glycemic Indices of Three Yam Cultivars (*Dioscorea rotundata, Dioscorea alata and Dioscorea dumentorum)* As Affected by Three Processing Methods

Okorie Chinasa[1], Obasi Nneoma Elechi[1*], Unamma Nnenna Cynthia[1] and Barber Lucretia Ifeoma[2]

[1]Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria

[2]Department of Food Science and Technology, Rivers State University, Port-Harcourt, Nigeria

***Corresponding author:** Obasi Nneoma Elechi, Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria, Tel: +234 8063893912, E-mail: nonyelucheya@yahoo.com

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Abstract

This study investigated the effect of different cooking methods on glycemic index (GI) of three yam cultivars commonly eaten in Nigeria namely: *Dioscorea rotundata, Dioscorea alata and Dioscorea dumentorum.* Yam tubers were processed by, frying, pounding and boiling, and then immediately consumed by twenty-seven normal healthy adults comprising of males and females. Capillary blood samples were taken at the fasting state and at different intervals of 15, 30, 45, 60, 90 and 120 minutes from the consumption of each meal. The blood samples were analysed for plasma glucose concentration and incremental areas under plasma glucose curves were calculated. The GI varied between 22.31 –72.78 for the yam cultivars studied. Samples prepared by boiling recorded *Dioscorea alata* as low GI (22.31) and *Dioscorea rotundata* as high GI (72.78). While those processed by frying and pounding, recorded a low GI (20.95 – 44.35) and *Dioscorea dumentorum* having the least GI value (20.95). The study indicates that the glycemic index of the three yam cultivars (*Dioscorea rotundata, Dioscorea alata and Dioscorea dumentorum)* varies significantly by their methods of preparation and variety differences. Consumption of boiled and pounded *Dioscorea alata* could minimize postprandial blood glucose spikes and therefore, may prove to be more efficacious in the management of type 2 diabetes mellitus.

Keywords: Yam Cultivars; Processing Methods; Glycaemic Index

Introduction

The glycemic index (GI) is a dietary measuring system that ranks carbohydrate containing food and relates the rate at which the blood sugar is increased after two hours of consuming the food to a reference food usually glucose [1]. Consumption of low glycemic index foods is suggested to be effective for the prevention and control of diabetes [2].

Glycemic index is expressed as percentages on an absolute scale. According to this system, carbohydrates containing foods are graded as either having low, intermediate and high glycemic index depending on the rate at which blood sugar level rises [3]. This in turn is related to the rate of digestion and absorption of sugars and starches available in that food [4]. The low GI foods are ≤ 55 % while Intermediate (medium) glycemic foods are those that are between 56 % and 69 % and high glycemic index ranges from 70 % and above on the glycemic scale.

New studies have shown that the regular consumption of diets containing high glycemic index foods increases the risk of type 2 diabetes mellitus [5] and coronary heart disease [6].

Type 2 Diabetes arises from interaction between genetic, environmental and behavioural risk factors [7]. Individuals living with type 2 Diabetes are more prone to various forms of both short and long-term complications, which usually lead to their premature death. In contrast, the inclusion of low glycemic index foods in diet without a change in the total amount of carbohydrate consumed may improve blood glucose control [8]; reduce serum triglycerols, Jenkins, *et al.* (*1981);* prolong endurance during physical activity and improve insulin sensitivity, [4].

Yams (*Dioscorea spp*) are annual root tuber bearing plants with more than 600 species out of which six are socially and economically important in terms of food, cash and medicine [9]. Yam production has increased steadily in the last decade, from 18 million metric tonnes in 1990 to recent estimates of over 39 million (FAO, 2006). Several edible species which are common are white yam (*Dioscorea rotundata),* yellow yam (*Dioscorea esculentum),* three leaved yam (*Dioscorea dumentorum),* water yam (*Dioscorea alata*) and aerial yam (*Dioscorea bulbifera)* are the most important of those commonly consumed in Nigeria and West African countries [10,11]. Moreover, the glycemic indices of these yam species are not quite known. Okonkwo (1985) opined that the recommendation of water yam and some cocoyam varieties as tolerable energy sources to diabetics is worthy of further investigation. Thus, it is important to have the knowledge of the glycemic indices of these commonly consumed yam species processed in different ways that yams (*Dioscorea rotundata, Dioscorea alata and Dioscorea dumentorum)* are eaten as it will aid in evidenced meal planning and optimum food selection in West Africa and Nigeria in particular.

In Nigeria, there are no existing data on the glycemic index of various commonly consumed foods, which leaves several individuals at risk as they consume both low and high glycemic index foods without putting their health status into consideration.

According to experts, nutritional habits play an important role in increasing the burden of these chronic conditions. Therefore, modifying dietary habits could be beneficial in the prevention and management of these diseases. It has been suggested that the state of hyperglycaemia that is observed following food consumption under certain dietary regimes could be a risk factor for the development of various metabolic conditions especially in individuals with a poor glycemic control such as in diabetes mellitus and even healthy individuals. Under such circumstances, it would be important to be able to reduce the amplitude and duration of hyperglycemia. Hyperglycemia or high blood sugar is a medical condition in which there is an excess amount of glucose circulating in the blood plasma. This is generally a blood sugar level higher than 11.1 mmol/l (200 mg/dl) while Hypoglycemia, also known as low blood sugar, is when blood sugar declines to below normal levels. Some carbohydrate rich foods cause less post-ingestive hyperglycemia than others. Therefore, having the right kind of carbohydrate foods could actually be a potential strategy in the prevention and management of chronic metabolic disorder. Hence, the need to know the glycemic indices of the commonly consumed foods in Nigeria. This will aid healthy people and patients with various nutritional disorders to choose the class of food that will be beneficial to their health status.

There is lack of information about the glycemic index of foods consumed in many African communities and this has led to the poor health conditions and associated dietary related disorders. The Glycemic index has been identified as a vital tool to measure biological and health effects of meal. The management of dietary induced disorders have created fear of consuming certain foods by people suffering from metabolic diseases, yet little or no information exist on the glycemic index status of many commonly consumed foods. It is therefore extremely

important for this information to be available to all in order to maintain a healthy status.

The specific objectives of this research:

i. To process different yam cultivars (*Dioscorea rotundata, Dioscorea alata and Dioscorea dumentorum)* using different methods; boiling, frying and pounding.

ii. To determine the glycemic index of boiled, fried and pounded yam samples.

Materials and Methods

Source of raw materials

Some tubers of white yam (*Dioscorea rotundata),* water yam *(Dioscorea alata) and* three leaved yam (*Dioscorea dumentorum)* were purchased from Ubani Ibeku main market in Umuahia, Abia State. Allenbury Glucose D, product of Evan`s Medical Plc., Ogun state was purchased from a supermarket in Umuahia town. The test stripe, sterile blood lancet and glucometer produced by Roche diagnostic Indianapolis USA (Accu Check Active Diabeter Monitoring Kit) were purchased from Blessed pharmaceutical store in Umuahia town.

Sample preparation / Food preparation:

Boiled and pounded yams: The yam samples (5 kg) were boiled in 2L of water for 20 min. The water was drained, and the boiled yam was transferred into a wooden mortar and pounded to obtain a smooth consistency, then served plain to the subjects (see plates 1-3).

Fried yams: The yam samples were sliced into pieces approximately 2 mm thickness and submerged in a preheated vegetable oil at 160°C until golden yellow/brown colour developed. The fried yam slices were placed on a cellulose acetate paper (filter paper) to drain off the excess oil (see plates 4-6) and served plain to the subjects.

Boiled yams: Freshly harvested yam was peeled and approximately 5 kg portion was cut into (10 mm length) and was boiled in 2L of water for 20 min. The water was drained (see plates 7-9) and was served plain to the subjects.

Determination of glycemic index

Glycemic index values were determined using a standard protocol by [12]. Twenty-seven normal healthy adults comprising of males and females participated in the glycemic index test in line with the method used by Brand-Miller, *et al.* (2003b) [13]. The volunteers were of average age of 25years and basal metabolic index of 21.5kg/m. Ethical permit was obtained from Federal Medical Centre Umuahia, Abia State. The objectives and benefits of the study were explained to the subjects and they were requested to sign an informed consent form to affirm their willingness to participate in the study.

All subjects for the investigation fasted overnight. Their blood samples were collected through finger prick using a sterile lancet. Each blood sample was placed on a test strip which was inserted into a calibrated glucometer (Accu-Check Active Diabeter Monitoring Kit) which gave direct readings after 45sec based on glucose oxidase assay method. The determination of glucose level of the standard food was monitored at intervals of 0 min (fasting level), 15 min, 30 min, 45 min, 60 min, 90 min and

Plate 1: *Dioscorea dumentorum*

Plate 2: *Dioscorea rotundata*

Plate3: *Dioscorea alata*

Plate 4: *Dioscorea dumentorum*

Plate 5: *Dioscorea rotundata*

Plate 3: *Dioscorea alata*

Plate 7: *Dioscorea dumentorum*

Plate 8: *Dioscorea rotundata*

Plate 9: *Dioscorea alata*

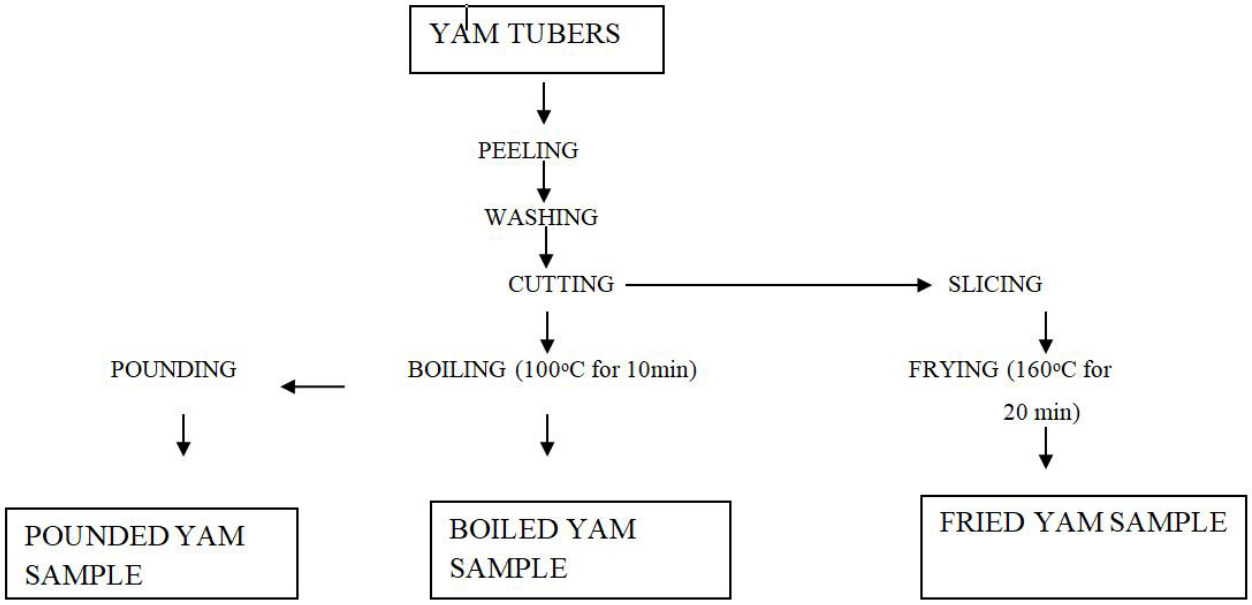

Figure 1: Flow chart for production of the yam samples

120 min after consumption of glucose mixed in 250ml of water. Then the subjects were fed with 50g available carbohydrate portion of the reference test food on a separate morning and their blood glucose level monitored at intervals of 0 min (fasting level), 15 min, 30 min, 45 min, 60 min, 90 min and 120 min.

Results And Discussions

The GI values of commonly eaten Caribbean, carbohydrate-rich, root and tuber crops were determined in the present study using a standard protocol (Wolever et al. 1991, 2003) [12] The GI values of commonly eaten Caribbean, carbohydrate-rich,

root and tuber crops were determined in the present study using a standard protocol [12].

The results of the yam cultivars showed a significance differences ($p<0.05$) in glycemic index (Table 1). When processed by boiling, *Dioscorea dumentorum* was found to have an intermediate GI (56.53) while *Dioscorea alata* had a low GI of (22.31) and *Dioscorea rotundata* had a high GI of (72.78). The fried yam varieties were found to have a low GI but differed significantly ($p<0.05$) from each other. There was also a significant difference in the pounded samples with *Dioscorea alata having* the least GI (33.30). Food processed by frying had the lowest GI at the processing method main effect and *Dioscorea alata* had the least GI at the variety main effect. Highest glycemic index value was seen in boiled *Dioscorea rotundata* (72.78) and fried *Dioscorea dumentorum* had the least glycemic index (20.95). The present results suggest that the different processing methods used (boiling, pounding and frying) could have influenced the GI of a particular food. The low glycemic index recorded in fried *Dioscorea dumentorum* could be attributed to the high fibre content recorded in this study (2.63%) as soluble fiber is reported to thicken the mixture of food in the digestive tract, which in turn slows down enzymatic activity and thereby slows down rate and digestion which results in lower glycemic index [14]. During the boiling process, wet heat is used causing free sugars to leach into the liquid medium. Further leaching of glucose monomers occurs during amylose–amylopectin degradation. The different carbohydrate contents of the foods may also explain the differences in GI. It was found that foods with similar levels of carbohydrate content do not necessarily have similar GI. This may be due to the difference in varieties and fibre content. The range of GI between the yam varieties could be beneficial to health as [15] reported that if the consumption of staples with high GI is reduced and the consumption of those with intermediate and low GI values increased.

This is particularly important since epidemiologic studies have shown a positive association between dietary GI and the risk of type 2 diabetes [5]. Similarly, increased consumption of low GI diet has been found to have a protective effect on the development of Cardiovascular Diseases [16] as well as cancer [17]. Also, low GI diets have been associated with higher HDL-cholesterol concentrations and decreased risks of developing diabetes and Cardiovascular Disease [18]. Boiled *Dioscorea alata* had lower GI values when compared to fried and pounded, boiling is believed to induce gelatinization thereby disrupting the amylose-amylopectin structure, thus making it more readily accessible by digestive enzymes. At the same time retrograded amylase is indigestible due to the presence of stronger hydrogen bonding in comparison with retrograded amylopectin. The lower glycemic indices observed on frying for *Dioscorea dumentorum* and *Dioscorea rotundata* could be attributed to the increased fat content resulting in slow movement of the food from the stomach to the duodenum, consequently this could lead to delay in gastric emptying and a lower glycemic response [19]. Adding fats to diet is reported to slow down carbohydrate digestion and absorption, thus lowering GI [13]. This principle was supported by Fernandes, *et al.* (2005) [20] who reported similar GI values for French fries from *Solanum spp.* In addition, invitro studies by Garc´ıa-Alonso and Go˜ ni. (2000) [24] revealed that the formation of amylose-lipid complex during the frying process increases the amount of resistance starch (RS), thereby decreasing the rate of hydrolysis of the amylose-amylopectin starch structure resulting in a lowered glycemic response [21]. Additionally, studies by Leeman, *et al.* (2008) reported that amylose is prone to react with lipids to form amylose-lipid complexes thus reducing the rate of amylolysis and resulting in lower glycemic responses and GI values. Furthermore, intravarietal variations could be related to differences in the starch physicochemical properties and maturity index of the different varieties used.

Yam Variety	**Processing method**			**Variety main effect**
	Boiled	Fried	Pounded	
Dioscorea dumentorum	$56.53^{ab}\pm14.6$	$20.95^{c}\pm4.34$	$44.35^{abc}\pm1.51$	$40.61^{ab}\pm18.31$
Dioscorea alata	$22.31^{bc}\pm4.68$	$44.06^{abc}\pm5.49$	$33.52^{bc}\pm19.27$	$33.30^{b}\pm13.95$
Dioscorea rotundata	$72.78^{a}\pm40.56$	$40.81^{abc}\pm19.66$	$42.39^{abc}\pm5.47$	$51.99^{a}\pm27.55$
Processing method main effect	$50.54^{a}\pm31.09$	$35.27^{a}\pm15.04$	$40.09^{a}\pm12.59$	

Values are mean ± standard deviation of replicate determination: n = 9 for processing method main effect, n = 9 for yam variety main effect and n = 3 for the processing method * yam variety interaction. Means in the same Processing method main effect row, Variety main effect column and the interaction cells bearing different superscripts are significantly ($p<0.05$) different.

The health benefits of a low GI diet are supported by a number of semi-long-term and long-term studies which suggest that diets characterized by low Gl starchy foods improve factors related to glucose and lipid metabolism in humans (Brand-Miller, 1994) [23]. In diabetics, low-GI diet can improve glucose tolerance [22,25]]. In hyperlipidemic patients, low GI diets can substantially lower the levels of total serum cholesterol and serum triacylglyceride. However, the mechanisms are still unclear. Ingestion of a slow release carbohydrate food produces an attenuated glucose response, so the resulting hormone responses and effects are less dramatic.

Conclusion

The fried samples recorded a low GI compared to other cooking methods while boiled *Dioscorea rotundata* showed a high GI. Boiled *Dioscorea alata* and fried *Dioscorea dumentorum* recorded a low GI which makes them suitable for a good menu plan for individuals with type 2 diabetes and health-conscious individuals as they could minimize the risk of postprandial blood glucose spikes, thereby reducing diabetic and cardiovascular disease and thus may prove to be more efficacious in the management of type 2 diabetes mellitus. The results suggest that health conscious individuals and persons with diabetes should avoid the consumption of boiled *Dioscorea rotundata*. Similarly, the identification of cooking methods with lower glycemic responses could be beneficial in the management and prevention of other chronic diseases.

Yam is a major staple food in Nigeria, and consuming yam varieties with low GI is recommended for overall GI. The yam products produced variable glycemic responses depending on cultivars, processing method, and starch structure. It is important to identify the best processing that will elicit low GI. Food processing plays an important role in the control of the GI. The findings of the present study could be recommended for use by health care professionals, nutritionists and in diabetes education in order to help diabetic individuals and health conscious individuals plan their diets so as to reduce the incidence of postprandial spikes in blood glucose levels. However, a healthy lifestyle and daily activities should be encouraged.

References

1. Wolever TMS (1993) Glycemic tolerance and the glycemic index In: Macrea, R., Roinson, R.K and Sadler, M.J (Eds), Encyclopaedia of Food Science, Food Technology and Nutrition. Academic press, London: 2214-20.

2. Little D (2003) Non-pharmacological management of diabetes: the role of diet and exercise. Geriatrics and Aging. 6: 27-9.

3. Mendosa I (2000) The glycemic index.

4. Frost G, Leeds A, Trew G, Margara R, Domhorst A (1998) Insulin sensitivity in women at risk of coronary heart disease and effect of a low glycemic index diet. Metabolism 47: 1245-51.

5. Salmeron J, Ascherio A, Rimm EB, Colditz GA, Spiegelman D, et al. (1997) Dietary fiber, glycemic load, and risk of NIDDM in men. Diabetes Care 20: 545–50,

6. Ford ES, Liu S (2001) Glycemic index and serum high-density lipoprotein cholesterol concentration among US adults. Archives Internal Med 161: 572-6.

7. Chen L, Magliano DJ, Zimmet PZ (2011) The worldwide epidemiology of type 2 diabetes mellitus: present and future perspectives. Nature reviews endocrinology, 12: 47-76.

8. Brand-Miller J, Pang E, Bramall L (1992) Rice: a high or low glycemic index food Amer J Clin Nutri 56: 1034-6.

9. IITA (2009) ITTA Annual report, International Institute of Tropical Agriculture, Ibadan, Nigeria.

10. Okonkwo SNC (1985) The botany of yam plant and its exploitation in enhanced productivity of the crop, In: Osuji, G.O. (Ed), Advances in yam research, biochemical society of Nigeria, Ibadan: 1-29.

11. Ihekoronye AI, Ngoddy PO (1985) Tropical Roots and Tuber Crops, In: Integrated food science and technology for the tropics. Macmillan, London: 266-82.

12. Wolever TMS, Jenkins DJA, Jenkins AL, Josse RG (1991) The Glycaemic index: methodology and clinical implications. Ame J Clin Nutri 54: 846–54.

13. Brand- Miller JC (2003) Glycemic load and chronic disease. Nutrition Reviews 61: 49-55.

14. Brand-Miller J, Wolever TMS, Foster-Powell, K, Colagiuri S (2003) The new glucose revolution. 2nd ed. New York: Marlowe & Company.

15. Ramdath DD, Isaacs RLC, Teelucksingh S, Wolever TMS (2004) Glycaemic index of selected staples commonly eaten in the Caribbean and the effects of boiling crushing. British J Nutri 91: 971-7.

16. Ludwig DS, Pereira MA, Kroenke CH, Hilner JE, Van-Horn L, Slattery ML, Jacobs DR (1999) Dietary fiber, weight gain, and cardiovascular disease risk factors in young adults. JAMA 282: 1539-46.

17. Higginbotham S, Zhang Z, Lee I, Cook NR, Giovannucci E, Buring JE, et al. (2004) Dietary glycemic load and risk of colorectal cancer in the women's health study. J National Cancer Institute 96: 229-33.

18. Jenkins DJA, Kendall CWC, Augustin LSA, Franceschi S, Hamidi M, et al. (2002) Glycemic index: overview of implications in health and disease. Ame J Clin Nutri 76: 266S-73S.

19. Cunningham KM, Read NW (1989) The effect of incorporating fat into different components of a meal on gastric emptying and postprandial blood glucose and insulin responses. British Journal of Nutrition 61: 285–90.

20. Fernandes G, Velangi A, Wolever TMS (2005) Glycemic index of potatoes commonly consumed in North America, J American Dietetic Association 105: 557–62.

21. Leeman M, Ostman E, Bj¨ orck, I (2008) Glycaemic and satiating properties of potato products. European J Clin Nutri 62: 87–95.

22. Brand JC, Nicholson PL, Thorburn AW, Truswell AS (1985) Food processing and the glycemic index. Ame J Clin Nutri 42: 1192–6.

23. Brand-Miller JC (1994) The importance of glycemic index in diabetes. Ame J Clin Nutri 59: 747–52.

24. Garcia-Alonso A, Goni I (2000) Effect of processing on potato starch: in vitro availability and glycaemic index. DieNahrung 44: 19–22,

25. FAO (1997) Report on the inter-center review of root and tuber crops research in the CGIAR. Rome: Food and Agriculture Organization.