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Effect of processing method on the glycemic index of some carbohydrate staples (*Manihot esculanta, Ipomoea batata* and *Dioscorea rotundata*) in both normal and diabetic subjects

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ABSTRACT

The glycemic index (GI) provides a measure of how quickly blood sugar levels (i.e. levels of glucose in the blood) rise after eating a particular type of food. In this study, the glycemic index and glycemic load of certain root tuber foods (yam, potato, and cassava) in both diabetic and non-diabetic conditions were compared. Glucose with a glycemic index of 100 was used as reference. The comparative studies showed the glycemic indices for cassava flour (59.34±32.42 and 40.12±25.27) respectively for diabetic and healthy subjects was significantly higher (p<0.05) than that of yam flour (49.81±10.38 and 35.50±11.71) for diabetic and healthy subjects. The glycemic index for baked sweet potato (94.80±8.01) was significantly higher (p<0.05) than roasted (82.01±5.20), fried (76.01±7.10) and boiled (46.00±5.89), for the same root tuber.

Keywords: processing methods, carbohydrate staples, glycemic index

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INTRODUCTION

The glycaemic index (GI) is an important parameter of food quality which compares the hyperglycaemic effect of a tested meal with pure glucose (or of another defined standard food) [1, 2]. The GI is a measure of the food power to raise B-glucose concentration after a meal. Foods with carbohydrates that break down quickly during digestion and release glucose rapidly into the bloodstream tend to have a high GI; foods with carbohydrates that break down more slowly, releasing glucose more gradually into the bloodstream, tend to have a low GI. A lower glycemic index suggests slower rates of digestion and absorption of the foods' carbohydrates and may also indicate greater extraction from the liver and periphery of the products of carbohydrate digestion [1, 3, 4]. A lower glycemic response usually equates to a lower insulin demand but not always, and may improve long-term blood glucose control and blood lipids [5]. The insulin index is also useful for providing a direct measure of the insulin response to a food. The current validated methods use glucose as the reference food, giving it a glycemic index value of 100 by definition. This has the advantages of being universal and producing maximum GI values of approximately 100. White bread can also be used as a reference food, giving a different set of GI values (if white bread = 100, then glucose ≈ 140) [1, 2, 6, 7, 8]. For people whose staple carbohydrate source is white bread, this has the advantage of conveying directly whether replacement of the dietary staple with a different food would result in faster or slower blood glucose response. A low-GI food will release glucose more slowly and steadily, which leads to more suitable postprandial (after meal) blood glucose readings. A high-GI food causes a more rapid rise in blood glucose levels and is suitable for energy recovery after exercise or for a person experiencing hypoglycemia [9, 10, 11, 15]. The glycemic effect of foods depends on a number of factors such as the type of starch (amylose versus amylopectin), physical entrapment of the starch molecules within the food, fat and protein content of the food and organic acids or their salts in the meal [13,14].

Fruits and vegetables tend to have a low glycemic index. The glycemic index can be applied only to foods where the test relies on subjects consuming an amount of food containing 50 g of available carbohydrate. But many fruits and vegetables contain less than 50 g of available carbohydrate per typical serving. Carrots were originally and incorrectly reported as having a high GI [12, 16; 18] Alcoholic beverages have been reported to have low GI values, but it should be noted that beer has a moderate GI. Recent studies have shown that the consumption of an alcoholic drink prior to a meal reduces the GI of the meal by approximately 15% [19, 20]. Moderate alcohol consumption more than 12 hours prior to a test does not affect the GI.

Glycemic index charts often give only one value per food, but variations are possible due to variety, ripeness, cooking methods, processing, and the length of storage. Potatoes are a notable example, ranging from moderate to very high GI even within the same variety 10, 15, 21]. The glycemic response is different from one person to another, and even in the same person from day to day, depending on blood glucose levels, insulin resistance, and other factors [22]. Most of the values on the glycemic index do not show the impact on glucose levels after two hours. Some diabetics may have elevated levels after four hours [22, 23, 24]. Several lines of recent scientific evidence have shown that individuals who followed a low-GI diet over many years were at a significantly lower risk for developing both type 2 diabetes, coronary heart disease, and age-related macular degeneration than others [20, 23, 25]. High blood glucose levels or repeated glycemic "spikes" following a meal may promote these diseases by increasing systemic glycative stress, other oxidative stress to the vasculature, and also by the direct increase in insulin levels [24]. The number of grams of carbohydrate can have a bigger impact than glycemic index on blood sugar levels, depending on quantities [26].

Diabetes mellitus is a degenerative disease and if not properly managed will lead to a lot of complications. Dietary factors (fibers and glycemic load/index) may affect plasma adinopectin through modulation of blood glucose, because a diet rich in some types of fiber could lower glucose concentrations whereas a diet high in glycemic index may increase blood glucose [29, 30, 34]. This calls for dietary modification of the patient's diet to suit the disease condition. Glycemic index was conceived as a tool for the dietary management of type II diabetics. Sugars have been identified to cause a more rapid rise in blood sugar levels than complex carbohydrates [30. 31, 32].

MATERIALS AND METHODS

Ninety subjects were randomly selected for this work. Forty five were diabetic while forty five were normal subjects. Measured portions of test foods containing 50 g of carbohydrates were eaten each by five diabetic and non-diabetic volunteers after an overnight fast; the same approach was used after an afternoon fast. Fingerprick blood samples were investigated at one hour after the meal. Each volunteer measured his/her B-glucose concentrations by means of a glucometer Optium. At the end of the one-week test period the B-glucose values were transferred from the memory of the glucometer into a PC for further analysis. The averages of the respective B-glucose concentrations after the meal were used to draw a B-glucose response curve for the period. For the purpose of statistical evaluation, the incremental area under the curve (IAUC) was calculated for each meal in the volunteers separately. The IAUCS for the standard reference food (i.e. 50 g of pure glucose) was obtained similarly to the mean from the first three independent IAUCS1, IAUCS2, IAUCS3 in the same volunteer. In each volunteer, the GI was calculated by dividing the IAUC for the tested food by the IAUCS for the standard food and multiplying by 100.

The GI for each tested food was calculated as the mean from the respective average GI's of the volunteers, wit the variability of GI for each tested food assessed according to standard deviation of the mean.

RESULTS AND DISCUSION

The glycemic indices of common Nigerian carbohydrate staples in both diabetic and non-diabetic subjects are presented in table 1 above. The glycemic indices of Cassava flour for diabetic (59.34±32.42) and non-diabetic (40.12±25.27) were significantly lower ($p < 0.05$) than those of Cassava eba (82.25±0.05) for diabetic and (69.42±0.87) for non-dibetic subjects. Those of Cassava starch were (98.60±2.68) for diabetic and (70.54±6.12) for non-diabetic subjects, and were significantly higher than those of Cassava flour (p<-0.05), while the increase is not significant compared to Cassava eba (p>0.05). This agrees with the reports of [8, 9 and 11], but slightly contradicts that of [15], which said the difference in glycemic index of differently processed cassava products are not significant. Sweet potato was prepared as baked, roasted, fried and boiled. The result showed that those of baked sweet potato for diabetic (94.81±8.72) and (83.76±7.01) for non-diabetic were significantly higher (p<0.05) than those of boiled sweet potato; which were (46.51±5.71) for diabetic and (32.47±7.53) for non-diabetic subjects. The processing methods produced sweet potato products that yielded low, medium and high glycemic indices. This makes potato a more suitable food for different metabolic and health conditions, as the glycemic index can be manipulated to suite a particular condition. The glycemic index for yam flour (49.81±10.39) for diabetic and (35.50±11.74) for non-diabetic subjects were significantly lower (p<0.05) than those of yam processed as amala, which was (84.35±2.68) for diabetic and (71.47±5.93) for non-diabetic subjects.

Table 1: Glycemic indices of differently processed common Nigerian carbohydrate staples

Food type	Diabetics	Non-diabetics
Cassava flour	59.34±32.42	40.12±25.27
Cassava eba	82.25±0.05	69.42±0.87
Cassava starch	98.60±2.68	70.54±6.12
Baked sweet potato	94.81±8.72	83.76±7.01
Roasted sweet potato	82.54±5.93	70.84±0.01
Fried sweet potato	76.79±7.81	61.53±9.03
Boiled sweet potato	46.51±5.71	32.47±7.53
Yam flour	49.81±10.39	35.50±11.74
Yam amala	84.35±2.68	71.47±5.93

The concept of the glycaemic index of foods has been developed in the course of the last thirty years without having reached its final version [35, 36]. Recent studies indicate that the risks of diseases such as type 2 diabetes and coronary heart disease are strongly related to the GI of the overall diet. In 1999, the World Health Organisation (WHO) and Food and Agriculture Organisation (FAO) recommended that people in industrialised countries base their diets on low-GI foods in order to prevent the most common diseases, such as coronary heart disease, diabetes and obesity [5, 7, 9, 10, 14, 15, 17, 23]. Some foods on the world market already show their GI rating on the nutrition information panel. Terms such as complex carbohydrates and sugars, which commonly appear on food labels, are now recognised as having little nutritional or physiological significance. The WHO/FAO recommend that these terms be replaced with the total carbohydrate content of the food and its GI value. 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). The results from this research has shown that processing method can affect the glycemic index of a food source. Hence, the method that yields the lowest glycemic index can be adapted in processing foods required in the management of diabetes, while the one with the highest glycemic index could be adapted in the management of hypoglycaemic and other related conditions.

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