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Glycaemic Index of Market Plantain in Healthy and Diabetic Subjects

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The glycaemic index (GI) and the glycaemic load (GL) of market green plantain was studied in Zaria, Nigeria. Ten volunteer diabetics and seven volunteer healthy subjects participated in the study. Fifty grammes of boiled plantain with stew and meat was served as the test meal while glucose (50grammes) was served as the reference food. The glycaemic index was calculated as the area under the blood glucose curve. The glycaemic indices in diabetic and healthy subjects were 68 and 69 respectively which are in the medium range. The glycaemic loads of this meal were 34 and 34.5 respectively which are high. Serving portions may have to be reduced to 30 grammes of carbohydrates to help lower the glycaemic load. The GI of plantain falls within the medium category in both diabetic and control subjects. Recommending plantain as one of the food to be consumed by the diabetics without caution on the quantity to be taken at a time may have an adverse effect on them.

Key Words: Glycaemic index, Plantain, Type-2 diabetes, Glycaemic load.

Musa, (bananas and plantain) a plant genus of extraordinary significance to human societies, produces the fourth most important food in the world today (after rice, wheat, and maize), (Wilson, 1987). *Musa* species grow in a wide range of environments and have varied human uses, ranging from the edible bananas and plantains of the tropics to cold-hardy fiber and ornamental plants (Marriot, 1980). They have been a staple of the human diet since the dawn of recorded history (Wilson, 1987). The plant is a source of food, beverages, fermentable sugars, medicines, flavorings, cooked foods, silage, fragrance, rope, cordage, garlands, shelter, clothing, smoking material, and numerous ceremonial and religious uses. These large, perennial herbs, 2–9 m (6.6–30 ft) in height, evolved in Southeast Asia, New Guinea, and the Indian sub-continent, developing in modern times secondary loci of genetic diversity in Africa, Latin America, and the Pacific (Wilson, 1987). Genetically *Musa* species are grouped according to “ploidy,” the number of chromosome sets they contain, and the relative proportion of *Musa acuminata* (A) and *Musa balbisiana* (B) in their genome. Most familiar, seedless, cultivated varieties (cultivars) of banana are triploid hybrids (AAA, AAB, ABB). Diploids (AA, AB, BB) and tetraploids (AAAA, AAAB, AABB, ABBB) are much rarer; the latter essentially being experimental hybrids. However, plantain (*Musa* spp. AAB group) cultivars as a whole are highly important staple fruit which provides one quarter of food energy required by people of west and central Africa

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(Wilson, 1987). The green mature fruits have a nutrient composition comparable to potatoes and are widely consumed as a cooked product (Marriot, 1980). The AAB plantains are predominantly in the humid lowlands of West and Central Africa but the humid forest zone of West and Central Africa is a secondary centre of plantain diversification. In Nigeria, plantain is grown mainly in the southern part of the country and the crop originally came to Africa form Asia (Simmonds, 1966). The distribution of *Musa* species are from the south or west to the northern part of the nation. They may be grown in the north, but generally fail to fruit due to the limitations of cool temperatures.

In most countries where plantains are a major staple, other crops such as cereals or tuber account for a larger share of calorie intake. In southwest Cameroon, per capita plantain consumption rates may be as high as 150 kg/per year (Fouré *et al.*, 1988). Although fruits are produced throughout the year, the major harvest comes in the dry season spanning the months of December through March (Nweke *et al.,* 1998). This vegetable-banana can be eaten and tastes different at every stage of development. The interior color of the fruit will remain creamy, yellowish or lightly pink. When the peel is green to yellow, the flavor of the flesh is bland and its texture is starchy. As the peel changes to brown or black, it has a sweeter flavor and more of a banana aroma, but still keeps a firm shape when cooked and still contained much starch (Vickery and Vickery, 1979). The plantain averages about 65% moisture content and the banana averages about 83% moisture content. Since hydrolysis, the process by which starches are converted to sugars, acts fastest in fruit of higher moisture content it converts starches to sugars faster in bananas than it does in plantains. Banana is ready to be eaten when the skin is yellow whereas a plantain is not ready to eaten (out of hand) until hydrolysis has progressed to the point where the skin is almost black. Fresh matured unripe plantain are unpalatable when raw but can be consumed boiled or fried into chips, or prepared into porridge, or sun-dried and milled into flour for stiff dough called 'amala'. As the plantains ripen some of the starch is converted to free sugar. Ripe peeled plantain can be eaten directly or sliced and fried in vegetable oil to produce chips called 'dodo'. In Nigeria there is a claim that unripe (green) plantain is beneficial to the diabetic and therefore this paper reports the glycaemic index of unripe plantain in the form most widely consumed (boiled) by the diabetic subjects.

MATERIALS AND METHODS

Six healthy and 10 diabetics Type 2 volunteers took part in this study. The ethical committee of Ahmadu Bello University Teaching Hospital Shika, Zaria, Nigeria, approved the study and all subjects (patients and controls) consented to participate in the study. Each subject from the healthy and diabetic groups took glucose (reference food) and boiled plantain with stew and beef after an overnight fast. The type 2 diabetics were asked to stop their drugs one week before the commencement of the study and were tested trice with glucometer to monitor the blood glucose and to ensure compliance of not taking drugs before commencement of the research and all of the subjects were in good health.

Each volunteer took part in the experiment on two non-successively days. On the first day of the experiment, subjects took glucose (50 gm). The second day, they ingested boiled plantain (50 gm) with stew and beef. The food or glucose was consumed within 10-15min and 250 mls of water drunk with the meals. Two milliliters of venous blood samples were taken in the fasting state and at 30, 60, 90, 120 and 150 minutes after consumption of the food or glucose. The blood collected were allowed to clot, immediately centrifuged and analyzed for glucose using glucose oxidase method (Trinder, 1969).

Calculation of GI (Glycaemic index)

The glycaemic indices were calculated following the procedure of Wolever *et al.* (1991) using the incremental blood glucose area in relation to the corresponding area obtained when glucose was used as reference food. Each subject's individual GI for meal was calculated and the GI was calculated by expressing the glycaemic response area for the test foods as a percentage of the mean response area of the reference food taken by the same subjects (Wolever *et al.,* 1991; Wolever *et al.,* 1994) and the GI for each food was taken as the average of all 10 individual values for type 2 diabetics and average of all 7 individual values for control subjects.

Statistical analysis

Results were expressed as mean values plus or minus standard deviation. Paired Student t-test was used to compare the blood glucose responses between the glucose and meal in healthy and type 2 diabetics while unpaired student t-test was used to compare healthy and type 2 diabetic subjects. Significant level was $p \leq 0.05$.

RESULTS

The six healthy volunteer aged 55.4±6.9 years had mean body mass index (BMI) of 29.6±3.3 kg/m^2 while the 10 type-2 diabetics aged 48.8±9.2 years had mean BMI of 29.8±6.1 kg/m^2. There were no significant differences in both parameters. The two groups were over weight (BMI of ≥ 25 to 29.99 kg/m^{2}was used to define over weight). Overweight occurred in 4 (40%) of the Type-2 diabetic and 5 (71.4%) of control. The diabetics were more obese 4 (40%) compared to 2 (28.6%) in the control group. The mean duration since diagnosis of diabetes type-2 was 4 ± 2.44 years (range 2-10 years).

The mean blood glucose responses to both glucose and plantain in the two groups are shown in Table 1. Plantain meal produced

Table 1. Parameters of participant with glycaemic index and glycaemic load of plantain meals fed to diabetic and control subjects

	AGE(years)	BMI(Kg/m^2)	Duration	Glycaemicindex	Glycaemicload
Diabeticsubjects	48.80±2.91	29.79±1.92	4.00±0.77	69	34.5
Controlsubjects	55.29±2.62	29.55±1.24	N/A	68	34.0

Table 2. Blood glucose responses to glucose and plantain in diabetic and control subjects

	Diabetic		Healthy	
Time (Hour)	Glucose (mmol/L)*	Plantain (mmol/L)*	Glucose (mmol/L)*	Plantain (mmol/L)*
FBS	8.22±3.65	6.97±2.45#	4.36±0.43	3.17±0.46#
0.5	13.16±3.30	11.30±3.84	7.37±2.10	5.44±1.37#
1	16.61±3.07	12.96±4.71#	7.83±1.42	5.31±1.61#
1.5	16.97±5.04	10.72±4.05#	7.47±2.17	4.87±1.10#
2	15.77±5.15	10.64±4.49#	6.69±2.26	4.34±1.12#
2.5	14.17±4.57	8.92±2.74#	5.17±1.54	3.57±0.50#

*Means ± SD; #=Significant

Table 3. Incremental value of blood glucose concentration of diabetic and control subjects fed on glucose or plantain meal

	Diabetic		Healthy	
Time (Hour)	Glucose (mmol/L)*	Plantain (mmol/L)*	Glucose (mmol/L)*	Plantain (mmol/L)*
0.5	4.94±1.79	4.53±3.82	3.01±1.99	2.00±2.27
1	8.39±2.66	5.11±4.25#	3.47±1.33	2.14±1.57
1.5	8.75±3.25	3.61±3.40#	3.11±2.11	1.70±1.33
2	7.55±3.39	3.67±3.71#	2.33±2.21	1.19±1.32
2.5	5.95±3.52	2.05±1.43#	0.81±1.11	0.40±0.78

*Means's ± SD; #=Significant

significantly lower blood glucose at 60, 90, 120, and 150 minutes in diabetic group while it was lower at 30, 60, 90, 120, and 150 in the healthy subjects when compared to glucose drink. The incremental value in healthy group was not significant (Table 2) which means it has no effect on the blood glucose, but it was significantly lower at 60, 90, 120 and 150 minutes in the diabetics (Table 2). The peak of the meal was 4.99mmol/l which was reached in the diabetics subjects within 60 minutes while it was 2.21mmol/L which was reached at 30 minutes in the healthy subjects. The glycaemic index for the plantain meal in both healthy and diabetics subjects are 68 and 69 respectively. The glycaemic load of plantain meal was 34 and 34.5 respectively for the healthy and diabetic.

DISCUSSION

Obesity occurred more commonly in this study, and they were predominantly females in both groups. This is similar to the findings of Akintewe and Adetuyibi (1986) that obesity occurred more commonly among female patients in diabetic Nigerians.

Plantain had a lowering effect on the blood glucose of diabetics' subjects than the control group. The lowering effect could be as a result of the quantity of plantain consumed, since they usually consumed more plantain than the amount used for the research. The slow digestion of unripe plantain starch is probably related to properties of the starch granule (e.g. amylose: amylopectin ratio) and its physical association with the plant cell wall (fiber), which could contribute to reducing total starch gelatinization.

The glycaemic index for the plantain meal in both healthy and diabetic subjects are 68 and 69 respectively, which showed that boiled plantain which has to be transported may have been undergoing ripening and as such have medium glycaemic index. It was also observed by Bahado-Singh *et al.* (2006) that changes in the physiologic state of the food, from green to ripe, influences GI. In their study it was reported that boiled ripe plantain had a higher GI value of 66 (SE 2) when compared to boiled green plantain with a GI value of 39 (SE 4). When processed by frying, ripe plantain resulted in a significantly higher GI than green plantain of 90 (SE 6) and 40 (SE 3), respectively. This resulted from an increased conversion of complex polysaccharides to free sugars during the ripening process. The green plantain used in their study was freshly harvested. Whereas the one that was used in this study was transported from the south to the north which may have taken three to five days before it reached the consumer.

The unripe plantains were processed within the skin, this may not allowed much of water absorption and concentrating free sugars within the food. Degradation of starches could further increases the total sugar content resulting in increase GI values. Different factors can influence blood glucose response. These include the physical form of the food, degree and type of processing, e.g., cooking method and time, amount of heat or moisture used (Pi-sunyer, 2002), type of starch (that is, amylose versus amylopectin), and Co- ingestion of protein (Manders *et al.,* 2005) and fat (Collier *et al.,* 1984) with test foods. It has been shown that plantain pulp tissue contained starch and amylose and work on potato has shown that when more starch and amylose is present it is associated with firmer tissue (Jarvi *et al.,* 1992; McComber *et al.,* 1994). Linehan and Hugges (1969) suggested that amylose chains might act as cement by formation of hydrogen bonds with polysaccharides of the cell walls. Studies by Qi, Moore and Orchard (2000) showed that on cooking plantain, the starch content remained constant, and so medium glycaemic index is not surprising.

Cooking of the plantain meals allowed the starch granules to swell, gelatinize and increase the availability to amylase digestion and thereby increased starch digestibility (Bahado-sigh *et al.,* 2006). Chewing would have reduced particle size and increased the surface area of exposure and facilitate salivary amylase digestion of carbohydrate (Omoregie and Osagie, 2008). The glycaemic load of plantain of this meal was 34 and 35 respectively for healthy and diabetic which is very high. Portion sizes vary markedly from country to country and between people in the same country. The serving portion of the meal will give the glycaemic load to be 19. The serving portion of this meal was so small compared to the amount being consumed by the diabetics in their homes. Higher glycaemic load is associated with increase risk of coronary heart disease (Liu *et al.,* 2000).

The higher the GL, the greater the expected elevation in blood glucose and in the insulinogenic effect of the food. The long-term consumption of a diet with a relatively high GL (adjusted for total energy) is associated with an increased risk of type 2 diabetes and coronary heart disease (Liu *et al.*, 2000).

Therefore it is necessary to be careful when counseling diabetics to specify the quantity and not only the type of food. There is need to find the glycaemic index of the fresh green plantain in the diabetics and control. Also the various ripening stages must be associated with how long it is kept instead of the colour of plantain to denote the ripening. The stage of ripening was usually based on peel colour as outlined by Brunzell (1971). The maturation stage or ripeness of a food may also be an important determinant of GI. As a fruit ripens, the starch gradually turns to sugars (Englyst and Cummings, 1986). The findings of the present study can provide useful guidance for health workers involved in meal planning for diabetics and diabetes education programmes, especially in Nigeria.

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