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Postprandial Blood Glucose Response: A Comparative Study of Two Nigerian Foods

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Abstract

This metabolic study determined the post-prandial effect of two Nigerian foods, *Detarium microcarpium*, DM (legume), *Gongronema latifolium*, GL (vegetable) on healthy non-diabetic adults. DM-based bread (DMB) contained 5g fibre and the control bread (CB) were fed to ten non-diabetics, five male and female subjects. Fifty grams of GL was processed and administered by wash-squeezed-drink (GLWSD) or chew-raw (GLCR) to eight non-diabetic subjects with a 50g glucose tolerance test as the control. These subjects fasted for 12 hours overnight, fasting blood was taken, experimental meals were fed. Post-prandial blood samples were taken at 30 minutes intervals for 2½ hours. Data was analyzed on the mean incremental blood glucose level using ANOVA to determine the effect of DMB and GL extract on the post-prandial glucose level. The result showed a statistically significant reduction ($P<0.05$) in the incremental blood glucose level at most post-prandial times. The peak reduction for GL occurred at 60 minutes compared to DM which was at 30, 90 and 120 minutes. The overall area under the glucose curve (AUC) was 62% for DMB, 18% and 13% for GLCR and GLWSD respectively. These two Nigerian foods could be useful adjuncts in the prevention and management of NIDDM.

Key words: Glucose, Healthy subjects, Nigerian foods.

Introduction

Diabetes is one of the non-communicable chronic disease (NCDs) that has emerged in the 21st century and is now seen as a global epidemic that poses a great public health challenge in sub-Saharan Africa (Thiam, Samba and Lwanga, 2006) In the year 2000, 7 million people were afflicted with diabetes in African regions which Nigeria is one. It is estimated that by the year 2030 this figure will double to 18 million people (WHO,2005). Globally it is estimated that a total of 190 million are afflicted with diabetes in 2004. This figure increased by 70% in 2005, to 325 million (Lefebvre, 2005). A more worrying fact is that 80% of people living with diabetes in Africa are undiagnosed. For every person known to have diabetes, there is at least one unidentified case, and death due to diabetes is expected to double over the next ten years (SCN, 2006).

The material resources for diabetic care are scarce, unaffordable, or unavailable in Nigeria, including essential supplies such as insulin, syringes and needles, oral hypoglycaemic drugs and equipment for monitoring blood glucose (Johnson, 1991). Dietary treatment for diabetes mellitus is even more important now than throughout the history of nutrition. The recommended diets for diabetics have changed over the years, from low to high carbohydrate diets with varying amounts of protein and fat, such as a diet high in complex carbohydrates and low in saturated fat (Wheeler, 2000).

The main thrust of dietary counseling in Nigeria has always been the avoidance of refined carbohydrate and greater consumption of legumes, fruits and vegetables. Studies have shown that there are a lot of unexploited, under-utilized Nigerian foods that have great potentials for diabetic management (Onyechi, Judd and Ellis, 1998). These foods are eaten less frequently by urban dwellers in Nigeria. Traditional food systems, play a significant role in maintaining the well-being and health of indigenous people (Okeke et al., 2009). These authors showed that different varieties of legumes, nuts, seeds, wild fruits and lesser known vegetables are in abundance and could be a health benefit in the prevention and management NCDs of which NIDDM is one (Okeke *et al*., 2009). Some of these foods are high in dietary fibre, high in non-starch polysaccharide (NSP), high in water soluble NSP (s-NSP), anti oxidants and have low glycemic index. These functional properties have been implicated with improved glycemic control (Groop, Aro and Stenman, 1993).

Leguminous foods, such as guar gum, contain s-NSP and when

incorporated into starchy foods and glucose drink, attenuate the postprandial rise in glucose and insulin concentration in healthy and diabetic subjects (Ellis, Dawoud and Morris, 1991) (Fairchild, Ellis, Luzio, Byrne and Mir, 1996). Animal studies have shown that the postprandial effects of s-NSP depend mainly on their ability to increase the viscosity of the digesta in the upper part of the gastrointestinal tract [Ellis, Rayment and Wang, 1996) The increase in intraluminal viscosity of digesta is the major factor in inhibiting the rate of digestion and absorption of available carbohydrate (Johansen, Bach Knudsen, Sandstrom and Skjoth, 1996). In Nigeria, DM locally known as 'offor' is used among the Ibos in the South Eastern Nigeria. Traditionally, DM is used as thickening agent in vegetable soups and it increases the viscosity of the soup when added as low moisture flour. Preliminary analysis of DM shows it contains significant amounts of NSP and the major fraction is s-NSP (Onyechi, Judd and Ellis, 2007)

Some indigenous vegetables that have also been identified as useful in the management of diabetes are *Solanum incanum* (anara) *Vernonia amygdalina* (onugbu), *Gongronema latifolium* (utazi), and *Occimum gratissimum* (nchanwu). These vegetables are bitter and are eaten by diabetic patients attending the University of Nigeria Teaching Hospital (UNTH) Ituku Ozalla, Nigeria. These diabetics believe that the vegetables would neutralize the 'too much sugar' in their system. However, Africa is still plagued with several diseases including those with reactive oxygen species (ROS) as their etiological factor. Cellular damage from ROS has been implicated in the etiology and pathophysiology of human diseases such as diabetes (Edosen and Ukpanab, 2003). The above mentioned vegetables act either by directly scavenging the reactive oxygen metabolites due to the presence of various antioxidant compounds or by increasing the synthesis of antioxidant molecules (Gupta, Mal and Haban, 2005).

Methodology

Area of study: This study was conducted in two parts. The Detarium microcarpium (DM) was carried out in University of London, London and Gongronema Latifolium (GL) study was at the University of Nigeria, Nsukka, Nigeria.

Purpose of the study: The main purpose of the study was to determine the blood glucose response of *Detarium microcarpium* and *Gongronema latifolium* of healthy non-diabetic subjects.

- to ascertain the efficacy of the plant foods in reducing of blood

glucose levels
- compare the incremental blood glucose responses postprandially on different time intervals
- to extrapolate their therapeutic efficacy in the prevention and management of non-insulin dependent diabetes mellitus (NIDDM).

***Detarium Microcarpium* study:**

Population for the study: Ten healthy non-diabetic subjects from King's College, London between the ages of 22 and 42 years participated in the study. Written information was given to each subject which included the nature and demand of the study and stated that any subject was free to withdraw if unable to continue for any reason. The consent forms were signed. The general practitioners of the participants were contacted to ascertain their health status with respect to the study. The protocol of the study was approved by the King's College London, Research and Ethical committee.

Preparation of *detarium microcarpium* bread (DMB)

Table 1: Food ingredients used in the preparation of CB and DMB rolls.

	Quantity of ingredients (g/1000g flour)	
Ingredients	**CB**	**DMB**
Brown flour	1000	850
Salt	18	18
Detarium flour	0	150*
Fat (hydrogenated)	7	7
Improver	100	100
Fresh yeast	25	25
Water	675	900

*Equivalent to 63g soluble fiber (Onyechi, 1995)

Table 1 shows the quantity of food ingredients used for the preparation of the *Detarium* bread and the control bread. The bread rolls were prepared using the Chorleywood bread process (Apling and Ellis, 1982). Ploughman's brown flour (Sovereign, Allied Mills, London) was the type of flour and flora brand (Unilever, UK) was the hydrogenated vegetable fat used. Each batch of the bread rolls contained variable amounts of water depending on the viscosity of the flour. *Detarium* flour was incorporated into the bread as a replacement for wheat flour. The weight of the dough was calculated such that a total of 50g CHO was contained in the two bread rolls. Each *detarium* bread roll contained 2.5g s-NSP. Two hours after baking,

the bread rolls were frozen in self-sealed freezer bags at -20°C until required for experimental use.

Analysis of the DMB

The proximate analysis of the test bread was done using standard assay methods of the Association of Analytical Chemist (AOAC, 1995) for moisture, fat (Soxhlet), protein (Kjeldal) fibre, available carbohydrate, and total energy (kcal/100g).

Administration of the test bread

The test meal consisted of two small bread rolls, 38g apricot jam (Robinson's) and sufficient water to make a total meal weight of 400g. The available carbohydrate portion of the meal was 75g. The DMB and CB each supplied 50g CHO mostly in the form of starch. The jam provided 25g of available carbohydrate mostly as sucrose. The two DM bread rolls provided 5g of s-NSP as calculated from Englyst analysis of the foods plus additional s-NSP from the brown flour.

The subjects visited the metabolic kitchen of the Department of Nutrition and Dietetics, King's College London once a week for two weeks. The subjects ate the CB and DMB in random order. Only one type of bread meal was eaten at each visit. A fasting venous blood sample of 10ml was taken from each subject. The test meal was served and eaten within a 15 minutes period. Postprandial blood samples of 10ml were taken at 30, 60, 90, 120, 150 minutes from the commencement of the meal.

Glucose Analysis

The glucose increments (changes relative to fasting values) were determined at 30, 60, 90, 120, and 150 minutes after the subjects had consumed DMB and CB rolls. The blood glucose was measured by standard glucose oxidase method Werner, Rey and Wielinger (1970] using Boehringer Mannhein kit (Boehringer Mannheim House, Bell Lane, Lewes BN7 1LG). The frozen deproteinized plasma was allowed to thaw and mixed in a rotamixer for 2 minutes. Plasma (100 ul) was mixed with 5 ml reagent which contains buffer, enzymes and chromogen. The sample was mixed in a rotamixer and incubated in a water bath at 20-25°C for 40 minutes avoiding direct exposure to sunlight. The absorbance of the sample and the standard were measured against a blank in a spectrophotometer at 610 nm.

Data analysis

The difference between the effects of the CB and DMB meals on the blood glucose was analysed by repeated measures of analysis of variance, ANOVA (SAS, 1985). Total area under the curve was calculated (AUC; trapezoid rule). Comparison

between the effects of the test meals on the postprandial levels was made. Significance difference between the control and the test meals was accepted at $p<0.05$.

***Gongronema latifolium* study:**

Study population

Eight non-diabetic subjects between the ages of 22 and 40years were selected. The subjects were recruited after the details of the study were explained and consent obtained. The study was approved by University of Nigeria Teaching Hospital (UNTH) ethical committee.

Preparation and processing of Gongronema latifolium vegetable

Gongronema latifolium vegetable was plucked from a farm at the senior quarters of University of Nigeria Nsukka. The vegetables were de-stalked, sorted and then washed in tap water. Fifty g of GL was processed according to the method used by the diabetic patients. This involve squeezing the vegetables with two hands until the juice is produced, the vegetables were mashed and sieved to extract all the juice. The "chew raw" involved eating the vegetables raw after they were washed.

Proximate analysis of the vegetable extracts

Gongronema leaf (100g) was analyzed using the standard assay methods of the Association of official Analytical Chemist for moisture, ash, fat (Soxhlet) protein (Kjeldal) AOAC, 1995) and carbohydrate (Englyst, Kingman and Cummings,1992) (Food Technology Department, International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria). The sample was fresh and analysis was carried out within 24h of procurement.

Administration of test meal

The test meals were given on separate days with a one-week interval. On the first day of the experiment, the subject came in after an overnight fasting (10-12h). Using an Accu-chek Active glucometer, the fasting blood glucose (FBG) was taken. A glucose tolerance test with 50g of glucose was performed on each subject to serve as a control for the test meal. The blood glucose concentrations of the subjects were determined at 30, 60, 90, and 120 minutes postprandial. On the second experimental day, subjects came in fasting, FBG was taken and the test meal GLWSD was served to the subjects. Postprandial blood samples were taken at the same time interval. On the last day of the experiment, 50g of the vegetable sample GLCR was given to the subjects.

The same experimental procedure was carried out.

Data analysis

Difference between the effects of the test vegetables on the blood glucose incremental values were analyzed by

repeated measures of analysis ANOVA (SPSS Version 11). The effects on the postprandial blood glucose level were compared. Significant difference was accepted at $p<0.05$.

Results

***Detarium microcarpium* study:**

Table 2: Proximate Composition (g/100) of raw bread dough

	Quantity of nutrients in (g)	
Nutrients	**CB**	**DMB**
Moisture	39.1	46.1
Protein	7.8	6.8
Fat	0.4	0.8
Fibre	4.2	4.2
Available CHO	68.6	60.9
Total energy Kcal/100)	309.6	276.3

Weight of the raw dough used to provide 50g carbohydrate was 160g (DTB).

Table 2 shows the proximate composition of the Detarium and control bread. The DMB had more moisture, less available carbohydrate and total energy. However the fibre content of the two types of bread was the same.

Effect of DMB and CB on plasma glucose levels

The results showed that fasting blood glucose levels were within normal range for non-diabetic subjects. The pooled mean of the fasting blood glucose level for the subjects was 4.30mmol/L. The post-prandial rise in blood glucose levels was expressed as incremental blood glucose levels relative to the fasting values and calculated. The mean incremental blood glucose levels were shown in Figure 1. Analysis of the data using ANOVA showed a significant bread meal effect (Wilks' Lambda 11.1; df 6 and 18; ($p=0.0049$) and a significant time effect at ($p=0.0129$). Comparison of the mean incremental blood glucose rise showed a significant reduction ($p<0.05$) on the incremental blood glucose levels with the consumption of DMB compared to the CB. When the difference between the bread meals was analyzed at each time interval, the result showed that there was a significant difference ($p<0.05$) for DMB meal at 90, 120 and 150 minutes when compared with the CB.

Gongronema latifolium **study:**

Table 3: The Proximate composition (100g) of fresh GL wet weight

	Quantity of nutrients in (%)
Nutrients	**GL leaf**
Moisture	55.4
Protein	18.1
Fat	5.5
Fibre	4.1
Ash	3.3
Carbohydrate	16.6

Table 3 shows the proximate composition of GL 100g wet weight. The moisture content was 55% and fibre was 4.1%

The results of the blood glucose test and the post-prandial blood glucose levels following the administration of the vegetables using wash-squeeze-drink and the chew-raw methods are shown in Fig 1. Both results showed that GL lowered the blood glucose levels and the peak reduction occurred at 60minutes with the two methods of administration. The Area-under the curve (AUC) showed GL caused a 13% reduction with the GLWSD method and 18% reduction with GLCR method. The GLWSD method had statistically significant reduction effect ($p<0.05$) on the postprandial blood glucose level.

Comparison of the effect of DMB meal and GLWSD and GLCR method on postprandial blood glucose profile

The result showed that both DM and GL have comparable amounts of fibre i.e., 4.2g and 4.1g respectively. Both experimental treatments had a statistically significant reduction ($p<0.05$) on the plasma glucose levels at most postprandial times. However, DMB showed glucose reduction in all time intervals but reduction was more at 90, 120 and 150 minutes postprandially. GL extract showed a reduction at all time intervals but the peak reduction was at 60minutes. The AUC was 62% for DMB, 18% for GLCR and 13% for GLWSD. When the DMB, GLWSD and GLCR were compared to the CB, DMB showed a significant reduction ($p<0.05$) at all the post-prandial times, while GL extract showed a marked reduction at 30, 60 and 90mins as shown in Fig 1.

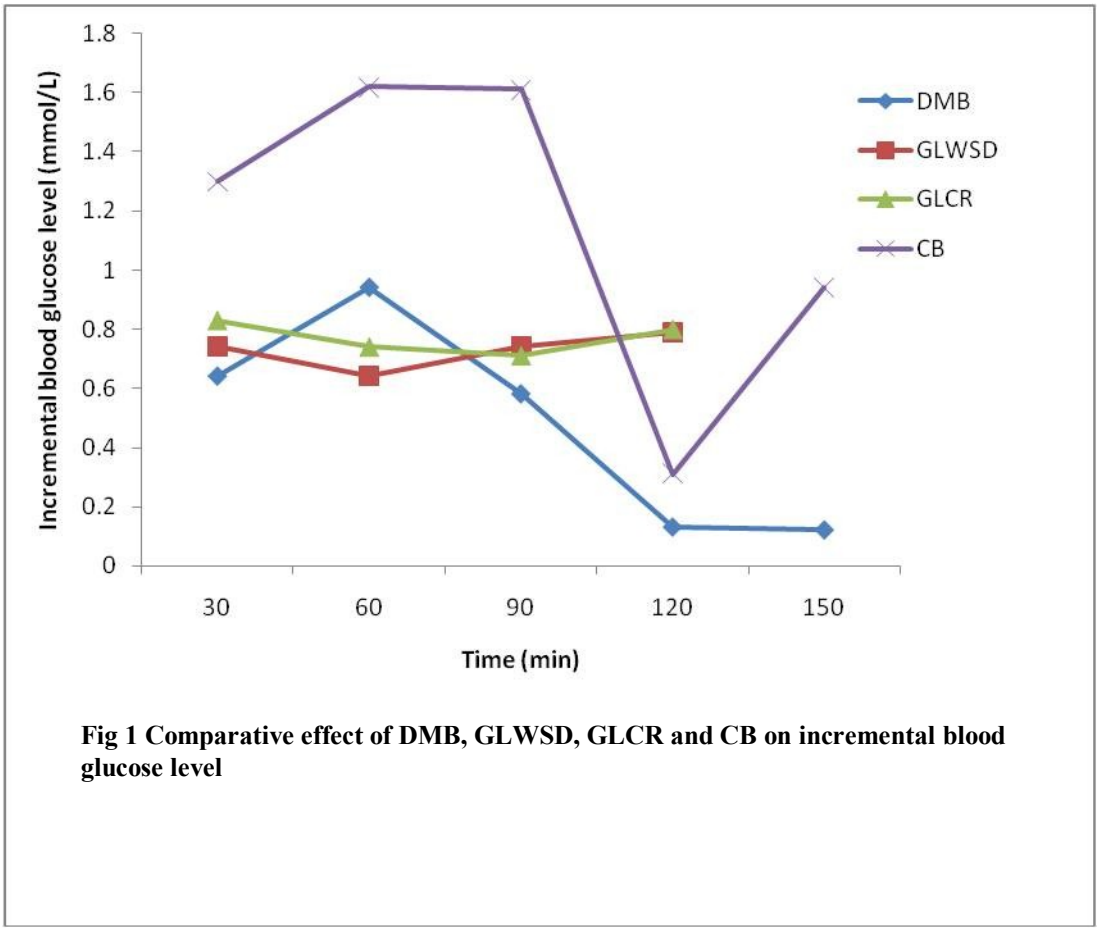

Fig 1 Comparative effect of DMB, GLWSD, GLCR and CB on incremental blood glucose level

Key: DMB = *Detarium microcarpium* bread;
GLWSD= *Gongronema latifolium* wash squeeze drink;
GLCR= *Gongronema latifolium* chew raw;
CB= Control bread

Discussion

***Detarium microcarpium* study:**

The result of this study showed that when healthy subjects were fed bread meals containing 75g CHO and 5g s-NSP from DM flour, there was a significant effect ($p<0.05$) compared to the low fibre CB on the postprandial glucose levels. When the incremental plasma glucose level of DMB was compared to the CB, a significant lowering effect occurred after the consumption of DMB ($p<0.05$) at 90, 120 and 150 minutes

post-prandially. The DMB proved to be significantly effective in lowering plasma glucose.

The mechanism of action for DM may be similar to that of guar gum. Both DM and guar gum are legumes and contain s-NSP, they have similar rheological properties and DM has a molecular weight similar to medium-grade guar gum (Onyechi, 1995). These mechanisms of action may include (1) a viscosity effect (2) reduction of insulin response (3) slow absorption and (4) gastric emptying/small intestinal absorption. A positive correlation between the peak rise of blood glucose and 2-hour post-prandial glucose level with the viscosity of four viscous NSP, guar, tragacanth, pectin and methyl cellulose was seen in healthy subjects (Jenkins, et al., 1978a). Fibre-enriched meals produced a marked flattening to postprandial glycaemia (Jenkins et al., 1976). There was overall flattening of the endocrine response induced by viscous NSP in wkshich gastric inhibitory polypeptide (GIP) response was flattened after guar supplementation (Morgan, Goulder, Tsiolakis, Marks and Alberti). Depressed postprandial glycaemic response with s-NSP was due to slow absorption rather than malabsorption (Jenkins et al., 1978b). Delayed mouth-to-caecum transit times are associated with ingestion of the viscous NSP and viscosity (Jenkins, et al., 1980). Delayed gastric emptying may be of great importance in flattening post-prandial glycaemia. Viscous NSP slows gastrointestinal flow and the rate of nutrient absorption resulting in flatter post-prandial levels of glucose, metabolites and hormones (Jenkins et al., 1980).

It is possible that the positive physiological effect of DM in modulating postprandial glucose could be attributed to the above mentioned mechanisms. Like guar gum, *Detarium microcarpium* has similar physiological properties and had the same effect on rats (Bell, Onyechi, Judd, Ellis and Ross-Murphy, 1993). This suggests this indigenous food could be a useful adjunct to the management of diabetes mellitus in Nigeria and DMB may provide a variety to the diet of the diabetics who reside in urban areas.

***Gongronema latifolia* study:**

The post-prandial time points after the administration of GL extract show that it has a hypoglycemic effect. The nutrient composition showed that GL contains fibre just like DM. Indigenous African plant foods are rich in non-starch polysaccharides (NSP) and have the potential to modulate postprandial blood glucose and insulin concentrations in humans. Fibre-rich meals produced a marked flattening

of post-prandial glycaemia.

In rat studies, there were other mechanisms for the hypoglycemic effect of GL. Unlike the mechanism of *Detarium microcarpium*, *Gongronema latifolium* acts by the activation of hepatic hexokinase and glucose -6- phosphate dehydrogenase (G6PDH) and inhibition of glucokinsae in the liver (Manach, Scalbert, Morand, Rosemary and Jimenez, 2004). This is suggestive that GL leaves could have exhibited anti-diabetic action due to its antioxidant properties. GL leaves harvested from South Eastern Nigeria significantly reduced the activity of superoxide dismutase, the level of glutathione peroxidase and glucose -6- phosphate and lipid peroxidation (Ugochukwu and Babaddy, 1938). This finding again supports the claim that GL could have hypoglycemic effects because of it's antioxidant properties. Edible plants with identified antioxidant properties have protective effects on diabetes. Stems, roots and leaves of plants contain flavonoids and phenolic compounds which are antioxidants that protect biosystems against damaging effects of free radicals and may be medicinal. The medicinal properties of GL may be attributed to the same active ingredients *Gonioanthelma* and *Gonolobus* (Manarch, Scalbert, Morand, Rosemary and Jimenez, 2004).

Conclusion

The result showed a significant lowering effect on post-prandial glucose levels of healthy non-diabetic subjects fed DMB meal and GL extract. The findings indicated that both *Detarium* and *Gongronema* contain fibre that reduced postprandial blood glucose levels. The type of fibre GL contains is not known but *Detarium* contains viscous s-NSP which is a property that may have caused reduction in post-prandial glucose. However, GL contains the active ingredients *Gonioanthelma* and *Gonolobus,* which have been linked to the prevention and management of NCDS including NIDDM (Manach, Scalbert, Morand, Rosemary and Jimenez, 2004). oduce *Detarium microcarpium,* a leguminous seed *Gongronema latifolium,* a leafy vegetable could be useful adjuncts in the prevention and management of NIDDM.

Recommendations

There is sufficient evidence from this study to substantiate the efficacy and importance of these two indigenous plant foods. Therefore it is recommended that

- Dissemination of information on the potential of these two plants to reduce blood glucose levels should be made available through workshops and seminars

- Government should through agricultural extension programmes encourage farmers to cultivate these plant foods
- Nutrition education programmes should be carried out in diabetic clinics, clinical settings and healthcare centers about the potentials of these plant foods
- Families, diabetics and non-diabetics should be encouraged to incorporate these foods in their daily diets
- *Detarium* bread recipe should be standardized to help bakeries, diabetic patients living in the urban area to be able produce this bread as an alternative to the traditional method of incorporation of *Detarium* in soup.

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