academicJournals

Vol. 14(50), pp. 3295-3302, 16 December, 2015
DOI: 10.5897/AJB2015.14638
Article Number: CFAFFC456609
ISSN 1684-5315

http://www.academicjournals.org/AJB

African Journal of Biotechnology

Full Length Research Paper

Blood glucose response of normoglycemic adults fed breakfast porridges made from *Zea mays* supplemented with *Afzelia africana*, *Detarium microcarpum* or *Sphenostylis stenocarpa*

Uchenna Agatha Onyechi*, Vivienne NkirukaIbeanu and Nkechinyere Gift Ugwumba

Department of Home Science, Nutrition and Dietetics, University of Nigeria, Nsukka, Nigeria.

Received 11 April, 2015; Accepted 5 November, 2015

Effect of high fibre leguminous products in breakfast porridges, made from *Afzelia Africana* (AA), *Detarium microcarpum* (DM), *Sphenostylis stenocarpa* (SS) and *Zea mays* on blood glucose level of humans was investigated in this study. The food items were processed into flour using African (Nigerian) traditional processing methods. The flours were combined in a ratio of 4:1, *Z. mays-A. africana* (CAA), *Z. mays-D. microcarpum* (CDM), and *Z. mays-S. stenocarpa* (CSS). Each composite was mixed with water and cooked for 10 min to produce porridge. The test porridges provided 50 g available carbohydrate (10 g from a legume and 40 g from *Z. mays*). The porridges were consumed on separate days by 18 subjects after an overnight fast. Seven days interval was allowed between the consumption of each, test porridge. Fasting and postprandial blood glucose levels were taken at 30 min interval for 2 h after the consumption of each, test porridge. The results of the mean absolute glucose levels at 60 min showed that CAA and CDM lowered blood glucose level significantly (P<0.05). At 90 min, CDM and CSS elicited more effect (P<0.05) compared to CAA. Mean incremental blood glucose demonstrated that CAA and CDM lowered (P<0.05) blood glucose at 30, 60, and 90 min and CSS at 120 min. Area under the curve (AUC) for CAA and CDM were lower. The three legumes had effects on the postprandial glucose levels; however, CAA and CDM were more efficacious. The sensory evaluation showed that CAA was more acceptable than CSS and CDM, but the general acceptability rating was high for all the porridges.

Key words: Blood glucose, postprandial, *Afzelia africana, Detarium microcarpum, Sphenostylis stenocarpa*.

INTRODUCTION

The prevalence of non-insulin dependent diabetes mellitus (NIDDM) has escalated in the world (Venn and Mann, 2004). Eighty percent of deaths caused by diabetes occur in low and middle income countries like

*Corresponding author. E-mail: uche.onyechi@gmail.com. Tel: +2348066794814.

Nigeria (WHO, 2014; Guariguata et al., 2014). In many parts of sub-Saharan Africa, notably among urban dwellers, there has been a marked increase in the prevalence of type 2 diabetes (Thiam et al., 2006; Rawal et al., 2012). Studies showed that this type of diabetes which used to be characterized as the developed world 'disease of affluence' has become a global epidemic that pose a great public health challenge in sub-Saharan Africa. The rapid change in this disease pattern is due to shifts in the eating habit (nutrition transition) and decreased physical activity and the adoption of westernized life style due to economic development and market globalization (World Health Organization/Food and Agriculture Organization [WHO/FAO], 2003; Rawal et al., 2012). The prevalence of diabetes in West Africa ranges from 2 to 3.5% and figures are expected to double in the next 25 years (International Diabetes Federation, 2006). More worrying trend is that 80% the people living with diabetes are undiagnosed and deaths due to this disease are expected to double in the next 10 years (Thiam et al., 2006). World Health Organization estimated in 2000 that 171 million people worldwide suffer from diabetes and this is projected to increase to 366 million by 2030. The current global prevalence is estimated at 9% among adults aged 18+ (WHO, 2012; Guariguata et al., 2014), and the report of Ramanchandran et al. (2004) had inferred that the greatest increase in the prevalence rate will come from the developing countries of the world. These authors postulated 42% increase in the developed countries and 170% in the developing ones. The projection for the developing countries is attributed to nutrition transition and sedentary life style which are associated with urbanization (WHO/FAO, 2003). Type 2 diabetes is the most common accounting for 90% of all cases of diabetes in Nigeria (Familoni et al., 2011). The national prevalence for over 40 years is 6.8% (Abubakaria and Bhapalb, 2008) but it is 0.9 to 15% in some parts of the country (Okeoghene et al., 2008). Over the past three decades therefore, the number of people with diabetes has more than doubled globally, making it one of the most important public health challenges to all nations (Chen et al., 2012).

In Nigeria, the use of drug therapy of insulin and hypoglycemic drugs is expensive, lacks compliance (inefficient administration of drugs and/or lack of adherence to prescribed dosage specification and instruction) and poses long-term use complications (Okeke et al., 2009). Many Nigerian diabetics use traditional herbal medicine in the management and treatment of diabetes. This could be due to the perceived effectiveness of the active ingredients in them, their minimal side effects and low cost (Okeke et al., 2009). Evidence has however, shown that consumption of food high in dietary fibre improves intestinal motility as well as aid the treatment and prevention of diet related chronic diseases, like diabetes (Ramanchandran et al., 2004, 2012). Venn and Mann (2004) reported that diets high in unrefined cereal grains and legumes are beneficial to diabetics and thus help to reduce mortality rate from the disease (Jacobs et al., 2000). The reason why foods high in dietary fibre are suitable for diabetics is because of the low glycemic index and minimal content of rapidly digestible starch (Venn and Mann, 2004; Fujii et al., 2013). There is however, low consumption of these foods (Adams and Engstrom, 2000).

In the South Eastern part of Nigeria, there are many plant foods that are high in dietary fibre which are consumed more in the rural areas. According to Famuyiwa (1985), some of such foods are leguminous seeds of *Afzelia africana* (Counter wood tree), *Detarium microcarpum* (Tallow tree) and *Sphenostylis stenocarpa* (African yam bean) which are under-utilized in Nigerian cuisines. *A. africana* is known as counter wood tree in English, 'akparata' in the Southeast Nigeria among the Ibos. It belongs to the family Leguminosea and sub-family Caesalpinaceae. The plants are largely cultivated in the savannah, fringing forest and the drier parts of the forest regions of Africa (Ikhajiagbe et al., 2009). The seeds are black, smooth, ellipsoid or oblong and shiny. The seeds of *A. africana* are very hard and woody, nearly black and bursting violently to discharge the seeds (Hutchinson and Dalziel, 1931) having waxy orange cup-like structure at the base. The seeds are edible and have high medicinal values (Okeke and Obizoba, 1986). They are used in Nigeria generally as soup thickening ingredient (Onyechi, 1995). *D. microcarpum* is a leguminous plant that grows predominantly in West Africa (Chad and Sudan). It belongs to the subdivision Caesalpinoideae (FAO, 1988). *D. microcarpum* is known as Tallow tree in English and 'ofor' among the Ibos in Nigeria. Each pod contains one seed which is round, oval or flat and about 40 mm in diameter. *S. stenocarpa* is known as African yam bean in English language and 'Ijiriji' to Ibos in Nigeria. It is a leguminous crop of the family of Leguminosea grown in tropical regions of Africa, particularly, in Cameroon, Côte d'Ivoire, Volta region of Ghana, Nigeria and Togo (Okeke and Obizoba, 1986). The seeds are rounded or truncated with considerable variation in size and colour, varying from creamy-white or brownish yellow to dark brown (Kouyate and Van Damme, 2006). The pods are long and up to 50 cm (Okorie and Amachi, 2003).

These legumes have been shown to be high in dietary fibre as 37.4, 70, and 19.12 g per 100 g dry matter for *A. africana*, *D. microcarpum*, and *S. stenocarpa*, respectively (Ene-Obong and Carnovale, 1992) and soluble non-starch polysaccharide (SNSP), as 29.3 and 59.8 g per 100 g dry powder, for *A. africana* and *D. microcarpum*, respectively (Onyechi, 1995). These food items are used mainly in rural areas as condiments and traditional soup thickeners. Traditional soups are now less frequently consumed by urban dwellers due to nutrition transition and constraint of time for their preparation. The main

Table 1. Quantity of flour and available carbohydrate (CHO) composition of the test porridges.

Test porridge	Food stuff (g)							
	Z. mays		***A. Africana***		***D. microcarpum***		***S. senocarpa***	
	Quantity of flour	**Available CHO**	**Quantity of flour**	**Available CHO**	**Quantity of flour**	**Available CHO**	**Quantity of flour**	**Available CHO**
CAA	114	40	38	10	-	-	-	-
CDM	114	40	-	-	55	10	-	-
CSS	114	40	-	-	-	-	37	10

CAA: *Z. mays* and *A. Africana* porridge; CDM: *Z. mays* and *D. microcarpum* porridge; CSS: *Z. mays* and *S. stenocarpa* porridge.

purpose of this work was to formulate low glycemic breakfast porridges for urban diabetics using *A. african*a, *D. microcarpum* and *S. stenocarpa*. It is hypothesized that the breakfast porridges will be suitable for the busy life style of urban dwellers. The effect of these foods on the postprandial blood glucose level of healthy subjects and the sensory attributes of the test porridges were determined. The result of this study would help to diversify the use of these plant foods in the diet of urban diabetics by commercial production of ready-to-use flour for making breakfast porridges and the flour might be introduced in baked products.

MATERIALS AND METHODS

Background and processing of plant foods

A. africana, *D. microcarpum*, and *S. stenocarpa* and *Zea mays* seeds were purchased from local market known as Ogege in Nsukka town, Enugu State in the South Eastern part of Nigeria. The seeds of these foods were hand-picked and cleaned to remove dirt and they were all processed using Nigerian traditional processing method used by the Ibo tribe in the South Eastern part of Nigeria. *A. africana* seeds were roasted in aluminum stainless steel pan for 20 min at 120°C before dehulling (manually with a laboratory hammer to crack open the seed endocarp). The dehulled seeds were fermented for 48 h with water changed every 8 h, sundried for 7 days and milled into fine flour with a coffee Moulinex grinder.

D. microcarpum seeds were boiled for 25 min to remove the seed coat easily when touched. The white seeds were soaked in water for 60 min and washed three times with cold water. They were then fermented overnight. The fermented seeds were sundried for 7 days, ground into fine powder (to pass through a 1 mm screen) with a coffee grinder (Moulinex blender), air-dried at room temperature for 24 h, so that the powder would not be lumpy to touch. The powder was yellowish-white in colour with a strong aroma (Onyechi, 1995).

S. stenocarpa seeds were roasted in a stainless steel pan for 10 min at 90°C. The seeds were allowed to cool before milling into fine flour with a coffee Moulinex grinder. *Z. mays* (corn) seeds were cleaned and washed to remove dirt and sundried. The seeds were milled into fine flour using coffee Moulinex grinder.

Formulation and production of the test porridges

The three breakfast porridges contained 50 g available carbohydrate (CHO) each, per serving. *Z. mays* contributed 40 g of the available CHO while the legumes (*A. africana, D. microcarpum* and *S. stenocarpa*) each contributed 10 g of the available CHO per serving. The quantities of the food stuff (flour) used in formulation of the porridges were 114 g of *Z. mays*, 38 g of *A. africana*, 55 g of *D. microparum* and 37 g of *S. senocarpa*, as shown in Table 1. The CAA porridge was made from a mixture of 114 g *Z. mays* and 38 g of *A. africana* flours, *Z. mays-D. microcarpum* (CDM) porridge from 114 g corn and 55 g *D. microcarpum* flours and the *Z. mays-S. stenocarpa* (CSS) porridge from 114 g corn and 37 g *S. stenocarpa* flours, respectively. To produce the porridges, 600 ml of water was added to *Z. mays-A. africana* (CAA) flour, 680 ml to CDM and 530 ml to CSS and each was cooked (stirred continuously) for 10 min to yield 650 g of CAA, 720 g of CDM and 549 g of CSS porridges.

Sensory evaluation of test porridges

Twenty adults from the Department of Home Science, Nutrition and Dietetics, University of Nigeria Nsukka, Nigeria, were recruited to evaluate the sensory attributes (colour, textures and taste) and overall acceptability and preference for the test porridges. The three porridge samples were coded as CAA (*Z. mays* and *A. africana* flours), CDM (*Z. mays* and *D. microparum* flours) and CSS (*Z. mays* and *S. senocarpa* flours). The panelists consumed the test meal independently and in silence to avoid influencing one another. A hedonic scoring form was developed as the instrument for the sensory evaluation of the breakfast porridges. A nine point-hedonic scale was developed as the instrument scoring form/sheet, 9 represented liked extremely, 8 liked very much, 7 liked moderately, 6 liked slightly, 5 neither liked nor disliked, 4 disliked slightly, 3 disliked moderately, 2 disliked very much and 1 disliked extremely. The purpose of the study and the assessment procedures were fully explained to the assessors.

Characteristics and feeding trial of subjects

Eighteen healthy adults (4 females and 14 males) 23 to 33 years old were recruited from student population at University of Nigeria Nsukka, Enugu State, Nigeria. The mean age of the subjects was 28 years. All the subjects were within the normal range (18.5 to 24.9 kg/m^2) of body mass index (BMI) with a mean BMI of 21 kg/m^2. The study was approved by the University of Nigeria Ethical Committee. The nature of the study was explained to the subjects and consent forms were signed and obtained before the commencement of the study. The feeding trial was carried out in the Diet Therapy Laboratory of the Department of Home Science Nutrition and Dietetics, University of Nigeria, Nsukka. The subjects fasted over night for 12 h and visited the metabolic unit on three separate occasions to consume one of the test porridges on each

Table 2. Nutrient composition of test porridges per 100 g dry matter.

Breakfast porridge	Protein (%)	Fat (%)	Ash (%)	Dietary fibre (%)	Total carbohydrate (%)
CAA	11.94^{b}	4.98^{a}	1.94^{b}	14.49^{b}	66.65^{b}
CDM	10.82^{a}	5.50^{b}	1.66^{a}	16.81^{c}	65.21^{a}
CSS	12.68^{c}	4.67^{a}	1.98^{b}	9.97^{a}	70.70^{c}

Means on the same vertical column with different superscripts are significantly ($p<0.05$) different. CAA: *Z. mays* and *A. Africana* porridge; CDM: *Z.mays* and *D. microcarpum* porridge; CSS: *Z. mays* and *S. stenocarpa* porridge.

Table 3. Sensory attributes of the porridges.

Test porridge	Colour	Taste	Texture	General acceptability
CAA	7.44^{a}	5.20^{a}	**6.32^{a}**	5.80^{a}
CDM	4.36^{b}	4.92^{b}	5.44^{a}	3.96^{b}
CSS	4.36^{b}	4.40^{b}	5.24^{a}	4.60^{b}

Means on the same vertical column with different superscripts are significantly ($p<0.05$) different. CAA: *Z. mays* and *A. Africana* porridge; CDM: *Z. mays* and *D. microcarpum* porridge; CSS: *Z. mays* and *S. stenocarpa* porridge.

of the three visits to the department. The test days were separated by 7 days to minimize any carry-over effect. The subjects were supervised to ensure the porridges were consumed within 15 min of service without interruption. These subjects also served as their own controls for the feeding study.

Blood sampling

On arrival on the test days, subjects rested for 10 min before the experiment began to enable the blood volume to stabilize. It was ascertained that the subjects had nothing to eat for 12 h. Cotton wool was used to apply methylated spirit on the finger tips, usually the thumb. Blood lancet was used to prick the fingers; a drop of blood was applied on the circular portion on the test strip. This was displayed on the screen and the result given after 45 s from the Glucometer. Fasting blood was taken and subsequently postprandial blood glucose were measured every 30 min for 2 h. Blood glucose level was measured using one touch basic Glucometer with a measuring range of 0 to 600 mg/dl (0 to 33.3 mmol/L).

Statistical analysis

Statistical Package for Social Sciences (SPSS) was used for the analysis of the data. Analysis of variance (ANOVA) was used for means separation and comparison. The mean incremental blood glucose levels relative to the fasting values were calculated and determined at 30, 60, 90 and 120 min. Duncan's Multiple New Range Test (DNMRT) was used as a post-hoc test to further ascertain the result. Significance was accepted at $P < 0.05$. The area under the glucose curve was calculated using the trapezoid rule which is one of the formulas for numerical integration.

RESULTS

In Table 2, the nutrient composition of the breakfast porridges were presented on dry matter basis. The percent protein of the breakfast porridges ranged from 10.82 to 12.68%. CSS contained significant ($p<0.05$) higher percentage dietary protein (12.68%) than CAA (11.94%) and CDM (10.82%). The fat content of the breakfast porridges differed and ranged from 4.67 to 5.50%. CDM contained significantly ($p<0.05$) higher fat content (5.05%) as compared to CAA (4.98%) and CSS (4.67%). The ash content of the porridges differed; CSS had the highest value (1.98%) compared to CAA (1.94%) and CDM (1.94%). The dietary fibre content of the breakfast porridges ranged from 9.97 to 16.81%. CDM contained significantly ($p<0.05$) higher dietary fibre (16.81%) as compared to CAA (14.49%) and CSS (9.97%). The CSS porridge contained significantly higher ($p<0.05$) total carbohydrate (70.70%) as compared to CAA (66.65%) and CDM (65.21%).

Table 3 shows the sensory evaluation of the test porridges. The colour of the products varied and ranged from 4.36 to 7.44. The colour of CAA was preferred (7.44) as compared to CDM and CSS that scored 4.36 each. CAA had significantly ($p<0.05$) better colour than CDM and CSS. The breakfast porridges produced from *A. Africana* had higher value (5.20) for taste and was significantly ($p<0.05$) different from *D. microcapum* and *S. stenocarpa*. The texture of the porridges ranged from 5.24 to 6.32. CAA had the highest score (6.32) and was preferred to CDM (5.44) and CSS (5.24). However, there was no significant ($p<0.05$) difference in the texture of the three breakfast porridges. The general acceptability of CAA was higher (5.80) than that of CDM and CSS which had values of 3.96 and 4.60, respectively and significantly ($p<0.05$) different from CDM and CSS. The CAA porridge was significantly ($p<0.05$) more acceptable

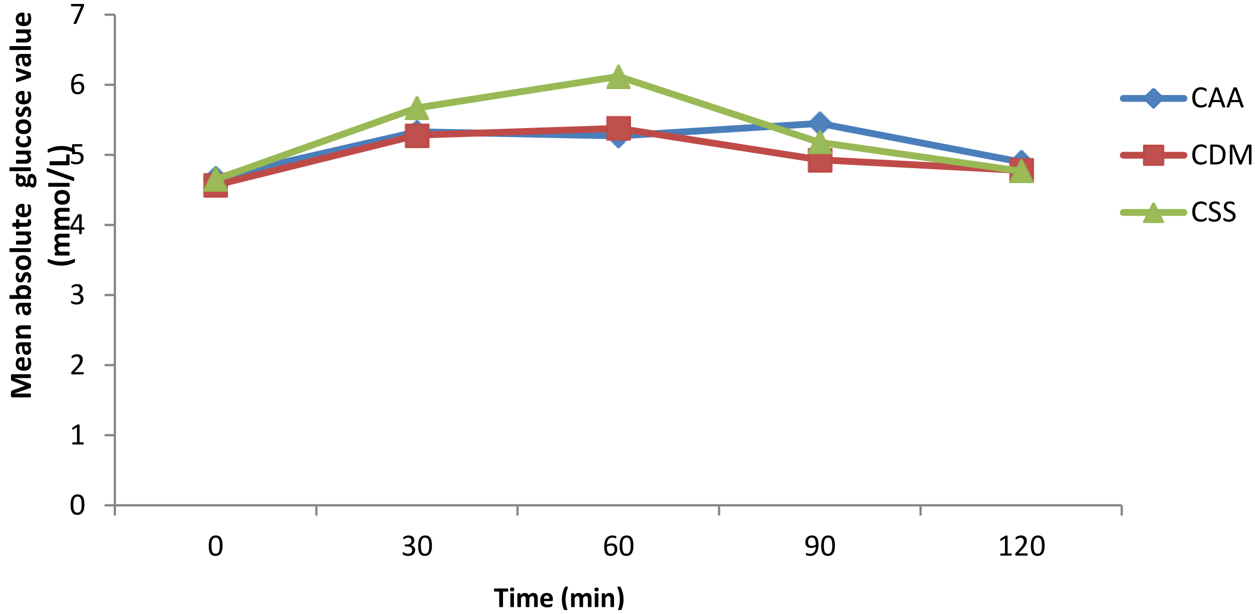

Figure 1. Mean absolute blood glucose values (mmol/L) of healthy subjects fed breakfast porridges. CAA: *Z. mays* and *A. Africana* porridge; CDM: *Z. mays* and *D. microcarpum* porridge; CSS: *Z. mays* and *S. stenocarpa* porridge.

in all the attributes than the CDM and the CSS porridges.

Figure 1 shows the mean absolute blood glucose values (mmol/L) of healthy human subjects fed the test porridges. The mean fasting blood glucose levels of the subjects on the 3 test days were 4.67, 4.57 and 4.65 mmol/L for CAA, CDM and CSS, respectively. There was no significant ($p<0.05$) difference in the postprandial blood glucose level at 30 min after the consumption of the porridges. The CAA and the CDM porridges significantly ($p<0.05$) lowered the postprandial blood glucose of the subjects when compared with CSS at 60 min. At 90min, CDM and CSS significantly ($p<0.05$) reduced the postprandial blood glucose of the subjects more than CAA porridge. At 120 min, there was no statistical ($p<0.05$) difference on the blood glucose levels of the subjects. Figure 2 shows the mean incremental blood glucose response (mmol/L) of healthy subjects fed breakfast porridges containing *A. africana*, *D. microcarpum* and *S. stenocarpa* blended with corn. The mean incremental glucose levels at 30 and 60 min showed that the CAA and CDM porridges significantly ($p<0.05$) lowered the blood glucose levels as compared to the CSS porridge. At 90 min, CDM significantly lowered the blood glucose levels of the subjects while the effect of the CSS was more at 120 min. The three breakfast porridges were significantly ($p<0.05$) different from one another at 120 min. This means that *A. africana* and *D. microcarpum* elicited more effect on the blood glucose responses of the subjects at most intervals than *S. stenocarpa*.

DISCUSSION

The result of the sensory evaluation in Table 3 shows that porridge made from *A. africana* flour was significantly more accepted in all the organoleptic attributes than the other legumes, *D. microcarpum* and *S. stenocarpa*. All the porridges were however, rated high in general acceptability, indicating that the porridges could be accepted by the urban diabetics and there might be increase in the consumption of the base ingredients in the urban areas. Evidence has shown that food high in dietary fibre when incorporated into starchy foods or glucose drink attenuate the postprandial rise in blood glucose and insulin concentration in healthy and diabetic subjects (Fairchild et al., 1996; O'Shea et al., 2012). Animal studies have shown that the postprandial effects of dietary fibre depend mainly on their capacity to increase the viscosity of the digesta in the upper part of the gastrointestinal tract (Johansen et al., 1996; Scazzina et al., 2013). Increase in intraluminal viscosity of the digesta is a major factor in inhibiting the rate of digestion of available carbohydrate (Ellis et al., 1996; Brownlee, 2011). The result in Table 2 shows that these breakfast porridges were high in dietary fibre. The *A. africana* CAA, CDM and CSS contained high level of dietary fibre of 14.49, 16.81 and 9.97%/100 g dry matter, respectively. The result of this study as shown in Figure 1 indicates that there was apparent reduction in the postprandial rise in blood glucose concentration after the consumption of all the three breakfast porridges. However, *A. africana*

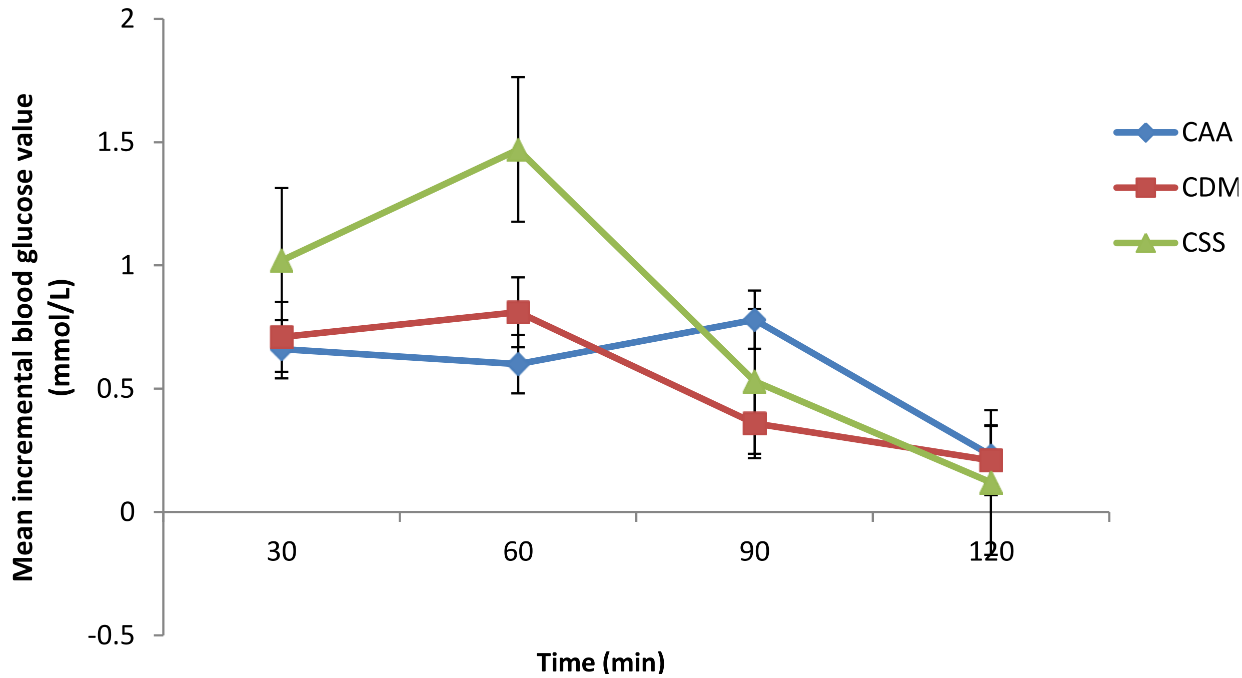

Figure 2. Mean incremental blood glucose values (mmol/L) of healthy subjects fed breakfast porridges. n=6. CAA: *Z. mays* and *A. Africana* porridge; CDM: *Z. mays* and *D. microcarpum* porridge; CSS: *Z. mays* and *S. stenocarpa* porridge.

and *D. microcarpum* revealed a significantly lower ($p<0.05$) postprandial incremental blood glucose at 30 and 60 min intervals when compared with *S. stenocarpa*. The American Diabetic Association (ADA, 2004) indicated that the glycemic response to food is influenced by the processing or preparation, fibre content, other foods included in the meal and individual tolerances. The reduction in the postprandial blood glucose level of the study subjects could be attributed to the fibre contents, especially the water soluble non-starch polysaccharide (SNSP) of the legumes (Kaczmarczyk et al., 2012). The American Diabetes Association (2012) recommended 8 g of SNSP to control the blood sugar. Previous studies have also shown that 5 g of SNSP (which was equivalent to 9 and 18 g of *D. microcarpum* and *A. africana* flours, respectively) decreased postprandial blood glucose in both healthy and diabetic subjects (Onyechi et al., 1995). Studies have shown that the major determinant of the biological activity of SNSP is their capacity to generate viscosity in the lumen of the stomach and small intestine. This is considered to be of primary importance in reducing the rate of digestion and absorption of available carbohydrate (Ellis et al., 1996; Dhingra et al., 2012; Jenkins et al., 2012). Ingestion of viscous fibre has been shown to slow transit time, delay glucose absorption, lower blood glucose concentrations, and affect hormonal response, especially insulin to the absorbed nutrient (Jie et al., 2000). *D. microcarpum* and *A. africana* contain significant amounts of SNSP (55.9 g/100 g and 27.4 g/100 g wet flour, respectively). Similarly, Ene-Obong and Carnvoale (1992) reported that the SNSP content of *D. microcarpum* and *A. Africana* were 50.0 and 24.9% per 100 g dry matter, respectively. This property of *D. microcarpum* and *A. Africana* could be the major reason for the postprandial reduction of blood glucose of the subjects fed the porridges that contained them.

There is dearth of information on the SNSP content of *S. stenocarpa*. However, Ene-bong and Carnovale (1992) reported that *S. stenocarpa* has 19.12% of dietary fibre. This is also less than that found in *D. microcarpum* (70.2%) per 100 g dry matter and in *A. africana* (37.4%). Fibre contents of these test porridges may explain the differences in some of their responses (Post et al., 2012). Protein has been shown to stimulate insulin secretion (Fajans et al., 1966). This is in line with the result of this study as the porridge containing *S. stenocarpa* with higher protein content (Table 3) may have caused reduction in glucose response. The carbohydrate digestibility of the foods measured in terms of changes in the blood glucose over a period of time indicated that porridges with *S. stenocarpa* digested rapidly when compared with that of *D. microcarpum* and *A. africana* as shown in Figure 2. It has also been shown that the addition of protein and fat to a carbohydrate load produces flattening of the glucose response curve (ADA, 2004; Ley et al., 2014). However, the differences in protein and fat contents in the test porridges were very minimal and may unlikely have played a significant role in reducing the postprandial blood glucose levels of the subjects.

The method of processing of the breakfast porridges studied may have contributed to the reduction of the postprandial blood glucose levels. Consumption of cooked or boiled starch affects serum glucose level and insulin responses, possibly by increasing viscosity or by splitting starch granules and thereby increasing the availability of the starch to the enzyme amylase (Collings et al., 1981). In this study, various food processing methods, such as fermenting and roasting (*A. africana*), boiling (*D. microcarpum*), and roasting alone (*S. stenocarpa*) were employed and may have affected the glucose responses of the subjects. It was possible that the method of preparation might have also affected the viscosity, fibre and protein contents of the different porridges, thereby affecting the blood glucose responses of the subjects (Dhingra et al., 2011). Stadler et al. (2004) indicated that non-enzymic browning (Mallard reaction) occurs when protein and carbohydrate exist together in the same food and this might play a role. The ability of some Mallard products and fibre to absorb substances depends in part on gastrointestinal acidity and alkalinity (pH) as well as particle size, food processing and fermentation ability (Eastwood and Passmore, 1984). Mallard products result from food processing and consist of enzyme-resistant linkages between the amino groups (NH_2) of amino acids, especially –(OO) of reducing sugars (Gropper et al., 2005). Figure 2 shows significant reduction in the incremental blood glucose response for *A. africana* and *D. microcarpum* at 30 and 60 min. However, at 90 min only, *D. microcarpum* showed a significant reduction. At 120 min, there was lower incremental glucose level when the subjects consumed *S. stenocarpa* porridge. This is indicative that at longer period *S. stenocarpa* bioactive potentials to reduce blood glucose was at best relative to the other products.

In conclusion, the result of this study shows that the test porridges had the potential to lower the postprandial blood glucose level of healthy non-diabetic subjects. These foods are cheap, easily available and commonly used in rural Nigeria. They could be of great benefit if incorporated into Nigeria cuisine as breakfast meal for the urban dwellers where the prevalence of diabetes is currently a serious health problem.

Abbreviations

AA, *Afzelia africana*; **DM,** *Detarium microcarpum*; **SS,** *Sphenostylis stenocarpa*; **CAA,** *Zea mays-Afzelia africana*; **CDM,** *Zea mays-Detarium microcarpum*; **CSS,** *Zea mays-Sphenostylis stenocarpa*; **NIDDM,** non-insulin dependent diabetes mellitus; **SNSP,** soluble non-starch polysaccharide; **BMI,** body mass index, **ADA,** American diabetic association.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

Abubakaria AR, Bhapalb RS (2008). Systematic review on the prevalence of diabetes, overweight/obesity and physical inactivity in Ghanaians and Nigerians. Pub. Health 122:173-182.

Adams JF, Engstrom A (2000). Helping consumers achieve recommended intakes of whole grain foods. J. Am. Coll. Nutr. 19:339s-344s.

ADA (American Diabetic Association) (2004). Nutrition principles and recommendations in diabetes. Diabet. Care 27:S36-S46.

Brownlee IA (2011).The physiological roles of dietary fibre. Food Hydrocoll. 25(2):238-250.

Chen L, Magliano JM, Zimmet PZ (2012). The worldwide epidemiology of type 2 diabetes mellitus – present and future perspectives. Nat. Rev. Endo. 8:228-238.

Collings P, Williams C, Macdonald I (1981). Effect of cooking on serum glucose and insulin responses to starch. Br. Med J. 282:1032.

Dhingra D, Micheal M, Rajput H, Patil RT (2012). Dietary fibre in foods: a review. J. Food Sci. Technol. 49(3):255-266.

Eastwood M, Passmore R (1984). A new look at dietary fibre. Nutr. Today 19:6-11.

Ellis PR, Rayment P, Wang Q (1996). A physico-chemical perspective of plant polysaccharides in relation to glucose absorption, insulin secretion and the entero-insular axis. Proc. Nutr. Soc. 55:881-889.

Ene-Obong HN, Carnovale E (1992). Nigeria soup condiments: traditional processing and potential as dietary fibre sources. Food Chem. 43:169-175.

Fairchild RM, Ellis PR, Byrne AJ, Luzio SD, Mir MA (1996) A new breakfast cereal containing guar gum reduces postprandial plasma glucose and insulin concentration in normal-weight human subjects. Br. J. Nutr. 76:63-73.

Fajans SS, Floyd JC, Knopf RF, Conn JW (1966). Recent programme. Horm. Res. 23:617.

Familoni OB, Olatunde O,Ralmi TH (2011). The relationship between QT interval and cardiac autonomic neuropathy in Nigeria patients type 2 diabetes mellitus. Nig. Med. Prac. 53:48-51.

Famuyiwa OO (1985). A review of the dietary fiber hypothesis and its relation to diabetes mellitus in Nigeria. Nig. J. Nutr. Sci. 6(2):61-69.

FAO (1988). Traditional food plants: In a source book for promoting the exploitation and consumption of plants in arid, semi-arid and sub-humid lands of Eastern Africa. FAO Nutr. 42:593.

Fujii H, Iwase M, Ohkum T, Ogata-Kaizu S, Ide H, Kikuchi Y, Idewald Y, Joudal T, Hira Kawa Y, Uchida K, Sasaki S, Nakamura U, Kitazono T (2013). Impact of dietary fiber intake on glycemic control, cardiovascular risk factor and chronic disease in Japanese patients with type 2 diabetes mellitus: the Fukuoka diabetes registry. Nutr. J. 12:159.

Gropper SS, Smith JL, Groff JL (2005). Advance nutrition and human metabolism. (4thed.). U.S.A: Peter Marshall. P 115.

Guariguata L, Whiting DR, Hambleton I, Beagley J, Linnenkamp U, Shaw J. (2014). Global estimatesof diabetes prevalence for 2013 and projections for 2035. Diabet. Res. Clin. Prac. 103(27):137-149.

Hutchinson J, Dalziel JM (1931). Flora of West Tropical Africa. In: The British West Africa colonies. Royal Botanic Gardens, Kew, London: The Herbariuml pp. 338-351.

Ikhajiagbe B, Mgbeze GC, Erhenhi HA (2009). Growth and yield responses of *Sphenostylissternocarpa* (Hochest ex A. Rich), harms to phosphate enrichment of soil. Afr. J. Biotechnol. 8(8):641-643.

International Diabetes Federation (2006) Diabetes Atlas. https://www.idf.org/sites/default/files/Diabetes-Atlas-3rd-edition.pdf

Jacobs DR, Pereira MA, Meyer KA, Kushi, LH (2000). Fibre from whole grains, but not refined grains is inversely associated with all-cause mortality in older women: the Iowa women's health study. J. Am. Coll. Nutr. 19:326S-330S.

Jenkins DJA, Kenedall CWC, Augustin LSA, Mitchell S, Sahye-Pudaruth S, Mejia SB, Chiavaroll L, Mirrahimi A, Ireland C, Bashyam B, Vidgen E, de Souza RJ, Sievenpiper JL, Coveney J, Letter LA, Josse RG (2012). Effect of legumes as part of a low glycemic index diet on glycemic control and cardiovascular risk factors in type 2 diabetes mellitus: a randomized controlled trial. Arch. Int. Med. 172(21):1653-1660.

Jie Z, Bang-yao L, Ming-jie X, Hai-Wei L, Zu-Kang Z, Ting-Song W, Craig S (2000). Studies on the effects of polydextrose intake on physiological functions of Chinese people. Am. J. Clin. Nutr. 72:1503-1509.

Johansen HN, Bach Knudsen KE, Sandstrom B, Skjoth F (1996). Effect of varying content of soluble dietary fibre from wheat flour and oat milling fractions on gastric emptying in pigs. Br. J. Nutr. 75:339-351.

Kaczmarczyk M, Miller MJ, Freund GS (2012). The health benefits of dietary fibre: Beyond the usual suspects of type 2 diabetes mellitus, cardiovascular disease and colon cancer. Metabol. 61(8):1058-1068.

Kouyate AM, Van Damme P (2006). Detariummicrocarpum, medicinal plants In: Schmelzer GH, Gurib-Fakimeds. Wageningen, Netherlands.

Ley SH, Hamdy O, Mohan V, Hu FB (2014). Prevention and management of type 2 diabetes: Dietary components and nutritional strategies. Lancet 383(9933):1999-2007.

Okeke EC, Okolie VU, Ehiemere OI,Ezenduka OP (2009). Investigation of the effect of Solanum on Postprandial blood glucose concentration of normoglycemic Nigerians. Pak. J. Nutr. 8(10):1631-1635.

Okeke EC, Obizoba IC (1986).The nutritive value of all vegetable protein diets based on legumes, cereal and tuber in weaning rats. Qual. Plant Foods. Hum. Nutr. 8(10):1631-1635.

Okeoghene AO, Chinenye S, Onyekwere A, Fasanmade O (2008). Prognostic indices of diabetes mortality. Ethn. Dis. 17:721-725.

Okorie SU, Amachi EC (2003). Effect of roasting on the proximate composition and functional properties of selected tropical legumes. Global J. Pure Appl. Sci. 9(2):177-182.

Onyechi UA (1995). Potential role of indigenous Nigerian food in the treatment of non-insulin dependent diabetes mellitus, PhD thesis, University of London.

O'Shea N, Arendt EK, Gallagher E (2012). Dietary fibre and phytochemical chacteristics of fruits andvegetables by-products and their recent applications as novel ingredients in food products aovel ingredients in food products and their recent applications as novel ingredients in food products.Innov. Food Emerg. Technol. 16:1-10.

Post RE, Mainous AG, King DE, Simpson KN (2012). Dietary fibrefor the treatment of type 2 diabetes mellitus: Meta–Analysis. J. Am. Board Fam. Med. 25(1):16-23.

Ramanchandran A, Sehalatha C, Zimmet P, King H, Taylor LR, Baikau B, Thomas K (2004). Global prevalence of diabetes. Diabet. Care. 27(9):1047-1053.

Ramanchandran A, Snehalatha C, Samith A, Nanditha A (2012). Trends in Prevalence of diabetes in Asian countries. World Diabet. 3(6):110-117.

Rawal LB, Tapp RJ, Willam ED, Chan C, Yasin B, Oldenburg B (2012). Prevention of Type2 diabetes and it's complications in developing countries: A review. Int. J. Behav. Med. 19(2):121-133.

Scazzina F, Siebenhendi S, Pellegrin N (2013). The effect of dietary fibre on reducing glycemic index of bread. Brit. J. Nutr. 109(7):1163-1174.

Stadler RH, Robert F, Riediker S, Varga N, Davidek T, Devaud S, Goldmann T, Hau J, Blank I (2004) In-depth mechanistic study on the formation of Maillard reaction. J Agric. Food Chem. 52:5550-5558.

Thiam I, Samba K, Lwanga D (2006). Diet related chronic disease in West Africa region. Stand. Comm. Nutr. 33:6-10.

Venn BJ, Mann JI (2004). Cereal grains, legumes and diabetes. Eur. J. Clin. Nutr. 58:1443-1461.

WHO (2000) Preventing and managing the global epidemic: A report of a WHO consultation on obesity. WHO, Geneva, 2000.

WHO/FAO (2003). Diet, Nutrition and the prevention of chronic disease. Report of a joint WHO/FAO expert consultation, Geneva 28 January – 1 February 2002. WHO technical report series 916 WHO, Geneva 2000.

WHO (2012). Global status report on non-communicable diseases, WHO, Geneva 2014.

WHO (2014). Global health estimates: Deaths by cause, age, sex and country 2002-20012, WHO, Geneva.