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The Physico-Chemical Properties of *Detarium microcarpium* and Possible Effect in Modulating Postprandial Blood Glucose Response

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Abstract: Physico-chemical properties of *Detarium microcarpium* (DT), a legume, were investigated for possible use in diabetes. Metabolic study was conducted with 10 healthy subjects who came fasting overnight on two separate days. A control wheat bread (CB) and test meal of *detarium* bread (DTB) provided 6g soluble non-starch polysaccharide (s-NSP) and 75g of carbohydrate (CHO) were consumed. Venous blood sample was taken at fasting and postprandially for 2½ hours and analyzed for plasma glucose and insulin. The result of the physico-chemical properties showed that the s-NSP content of DT flour was high (59.7g/100g) and the insoluble NSP was (3.85g/100g). The sugar composition showed high proportions of Xylose, galactose and glucose and xyloglucan was the s-NSP fraction. The mean particle size, Water Binding Capacity (WBC) and intrinsic viscosity were 464.2 µm, 8.30 and 7.3±1dl/g, respectively. Analysis of variance showed that DTB meal had a significant reduction ($p<0.005$) on plasma glucose and insulin levels at most postprandial times. Area Under the Curve (AUC) for glucose and insulin were 62 and 43%, respectively. The result of the physico-chemical properties of DT lend credence to it's possible use in the prevention and management of Non-insulin Dependent Diabetes Mellitus (NIDDM).

Key word: *Detarium microcarpium*, physico-chemical properties, diabetes mellitus

INTRODUCTION

A lot of interest has been generated on the importance of leguminous plant foods in the management and treatment of chronic diseases like diabetes. The original interest in leguminous beans was simulated by the use of extracted Non-starch Polysaccharides (NSP) of guar gum and tragacanth (both galactomannans) from the legume of Indian Cluster bean, *cyamopsis tetragonoloba*, in the treatment of diabetes (Jenkins *et al*., 1980). These authors studied the digestibility and the effect on blood glucose of bread and leguminous seeds in healthy and diabetic patients. The results showed that carbohydrates in legumes are digested much more slowly, resulting in less rise in blood glucose in diabetic patients. Jenkins and co-workers noted that leguminous foods showed a lower Glycaemic Index (GI) which is measured by blood glucose levels at base line and 15-30mins interval for 2 hours after the consumption of food containing 50g available carbohydrate. The authors indicated that feeding legumes resulted in remarkable little rise in blood glucose level compared to other carbohydrate foods.

Jenkins *et al*. (1983) indicated that many factors in addition to fibre may be responsible for the effect of legumes. The authors pointed out that the glycaemic response may be predicted from the rate at which a food is digested *in vitro*. Food digestibility has been shown to be reduced by the presence of enzyme inhibitors lectins (Puzstai *et al*., 1979) and phytates (Cheryan, 1980) which are contained in beans. Cooked legumes are digested less rapidly than other carbohydrate foods. There is therefore growing evidence to suggest that high fibre foods such as legumes could be a useful addition to the diabetic diets. There are several properties of legume and some other carbohydrate foods that have been implicated in the decrease in the postprandial blood glucose level. These include particle size, Water Binding Capacity (WBC), water soluble NSP (s-NSP), viscosity and starch content.

Based on the above evidence this work was designed to study locally available, underutilized and unexploited legume that could be a useful adjunct in the diet of diabetics. *Detarium microcarpium* is an unexploited Nigerian leguminous food that is commonly used as condiment. *Detarium senegalense Gmelin* locally known as "ofor" plant belonging to the subdivision *Caesalpinoideae* (Balogun and Fatuga, 1989) and is considered to be synonymous with *Detarium microcarpium* Food and Agriculture Organization (FAO, 1988). *Detarium* is deep purple in colour and each pod produced by the plant contains one seed which is usually rounded, oval or flattened and about 40 mm in diameter (FAO, 1988). This leguminous plant grows predominantly in West Africa, Chad and Sudan. *Detarium* is sold in the South Eastern Nigeria as a condiment which is used in powdered form to thicken soups.

There is a dearth of information in the literature on *detarium*, it was therefore important to study this food. The present investigation was designed to characterize

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this food and undertake the nutrient analysis and study the physico-chemical properties like particle size, WBC, viscosity, s-NSP. Knowledge of the physico-chemical properties will indicate it's nutritional properties that may have therapeutic role in influencing gut function and metabolism in the management and treatment of diabetes in Nigeria.

Furthermore, there has been a marked increase in the prevalence of diabetes in developing countries of the world of which Nigeria is one (SCN, 2006). In Nigeria the medical resources for diabetic care in most cases is scarce, unavailable or unaffordable. The worsening economic condition is disastrous with a disease like diabetes, where the underlying condition is incurable and the lifelong treatment and care is necessary. It has therefore become more imperative to study some potential food sources that are cheap and locally available that maybe effective in the prevention and treatment of diabetes mellitus.

MATERIALS AND METHODS

Processing method: The seed samples for this study were purchased at a local market in Nsukka, Enugu State, Nigeria and then transported to the United Kingdom for processing into flour. The processing included boiling the seeds for 45-60 min in water until the deep brown-purple seed coats (testae) peeled off easily when touched. The testae were then removed and the white cotyledon soaked in water for 60min. The cotyledons were washed three times with cold tap water which was changed each time and then soaked in water overnight to wash away some of the gummy material. The washed cotyledons were then sun-dried for 24 h and ground into fine powder to pass through a 1mm sieve, with a coffee grinder (Moulinex blender/mill). The flour was air dried at room temperature for 24 h until the powder did not form lumps when touched. The powder was yellowish-white in colour with a strong characteristic odour (Onyechi, 1995).

Physico-chemical method of analysis: Detarium flour was analyzed using standard methods. The moisture content was determined using Kirk and Sawyer (1991); ash, 104° for 16h; fat, Soxhlet method with light petroleum-diethyl ether extraction; protein, Kjeldahl method, Nx5.7. The starch content of the flour was analyzed by an enzymic method (Englyst *et al.*, 1992a). The Englyst method (Englyst *et al.* , 1992b) was used to determine total Non-starch Polysaccharide (NSP) and water insoluble fraction of the NSP; the water-soluble fraction of the NSP (s-NSP) was determined as the difference which involved acid hydrolysis of the NSP by gas chromatography to determine the neutral sugars. The uronic acid content was determined by sulfuric acid-dimethylphenol colorimetric assay.

The particle size distribution of *detarium* was determined by a standard laboratory sieve method (Lauer, 1996). The Water Binding Capacity (WBC) was determined by Quin and Paton method (1978). The molecular weight of *detarium* was estimated from measurement of intrinsic viscosity and molecular weight estimated by calculation of the Mark-Houwink equation.

Metabolic study: Ten adult healthy men and women between the ages of 21-39 years participated in the study. These subjects came in twice to the metabolic laboratory fasting overnight for 12 hours. Fasting venous blood samples were taken. The subjects were fed a control bread meal which was ordinary wheat bread and DTB meal with 164g DT flour within a week interval. The composition of the meal was two bread rolls weighing 100g, 38g apricot jam and sufficient water to make a total meal weight of 400g. The control meal supplied 50g CHO in the form of starch, the jam provided 25g of available CHO as sucrose, 1g s-NSP from wheat flour. The experimental meal supplied 50g CHO (starch), the jam supplied 25g CHO (sucrose) 6g of s-NSP as calculated from Englyst analysis of DT flour, plus additional 1g s-NSP from brown flour making a total of 6g s-NSP. The meals were consumed within 15 minutes. Postprandial blood glucose was taken at 30 minutes interval for 2½ hours. The blood glucose level was measured by glucose oxidase test method using Boehringer kit. Glucose concentration was determined after deproteinisation of the blood samples. Insulin level was determined using Boehringer Mannheim kit based on enzyme-immunological reaction for the quantitative determination of human insulin *in vitro*.

Statistical analysis: The difference between the effect of the two meals on the plasma glucose and insulin incremental levels were analyzed with repeated measures analysis of variance (ANOVA) using Statistical Analysis System, 1985. Significant difference between the control and the test bread were accepted at $p<0.05$. The study was approved by Kings College ethical committee.

Glycemic index of *detarium* bread meal was calculated from AUC values using 100 as the reference standard for the control. The reduction in the insulin level (AUC) for 0-150min after the consumption of DTB was also calculated.

RESULTS

Table 1 showed the nutrient content of *detarium*. All the results were expressed in g/kg flour of dry weight. The result showed that the dietary fibre content of *detarium* was high (55.5g/100g) while the starch content was low (0.4g/100g).

Table 2 showed the NSP content of *detarium* in both wet and dry form. The result showed that *detarium* had high level s-NSP (59.7g/100g) and very little insoluble NSP (3.85g/100g).

The result in Table 3 showed that the sugar composition of the s-NSP of *detarium* showed a high proportion of xylose, galactose and glucose. There were traces of rhamnose, fructose and arabinose. Small amount of uronic acids were also found mainly in the s-NSP fraction, indicating the presence of small amount of pectic substances.

Table 4 showed the mean particle size of *detarium* to be 464.2 µm which was considered to be large particle size. The water binding capacity of *detarium* was high (8.30) and the intrinsic viscosity of 7.3±1dl/g which is indicative that is of high molecular weight polymer.

Table 5 showed that the AUC was significantly reduced ($p<0.0005$) for *detarium* bread compared to the control. The AUC for insulin was also significantly reduced $p = 0.0005$.

Figure 1 shows incremental blood glucose levels calculated relative to the fasting values. The result showed a significant ($p<0.05$) reduction in the incremental blood glucose after the consumption of DTB at 90, 120 and 150 minutes compared to the CB.

Figure 2 showed that DTB had a significant lowering effect ($p<0.05$) in the plasma insulin levels at 90 and 120 minutes postprandially compared to the CB.

DISCUSSION

The result of the food constituents of DT showed that it contains high level of moisture 6.4g/100g dry weight, it also contain high level of fat 5.9g/100g and the protein content was also high 12.1g/100g and 55.5g/100g of fibre. *Detarium* seem to contain nutrients that may benefit diabetic subjects and people with other chronic diseases considering the high fibre content. Recommendations have been made in the treatment and prevention of chronic diseases like diabetes, hypertension and cardiovascular disease, for increase in the consumption of food that are high in fibre (SCN, 2006). This is indicative of the important role of diet and nutrition as determinants of chronic disease. In most Sub-Saharan Africa, there is a shift in the consumption

Table 1: Nutrient content of *Detarium microcarpium* flour (g/100g)

Nutrients	Parameters g/100g
Moisture	6.4
Fat	5.9
Protein	12.1
Ash	1.9
Total Carbohydrate (CHO)	73.8
Available CHO	18.3
Starch content	0.4
Dietary fibre (by difference)	55.5

Table 2: Soluble, insoluble and total NSP content of *Detarium microcarpium* (g/100g) of wet and dry food sample

Type of NSP	Wet flour	Dry flour
Soluble NSP	55.9	59.8
Insoluble NSP	3.7	4.0
Total NSP	59.7	63.8

Table 4: Physical properties (Particle size, water binding capacity and viscosity) of *Detarium microcarpium*

Particle size	Water binding capacity	Intrinsic viscosity
464.2 µm	8.30	8.9±1dl/g

Table 5: Area under curves for postprandial plasma glucose and insulin concentrations 0-150min) in healthy subjects consuming control bread (CB) and detarium bread (DTB).sem N=10

Bread meal	Glucose(mmol/min) mean se	Insulin(Mu/lmin) mean se
CB	100 21	3003 423
DTB	73 9	1723 307

Mean values were significantly different from the control

Table 5: Incremental plasma glucose levels (mmol/L) of healthy subjects fed control bread (CB) and *detarium* bread (DTB). Results are mean±sem (n = 10)

	Plasma glucose levels	
Time (min)	CB	DTB
30	1.3±0.18	0.64±0.11
60	1.62±0.16	0.94±0.12
90	1.61^a±0.15	0.58^a±0.08
120	0.31^a±0.25	0.13^a±0.07
150	0.94^a±0.16	0.12^a±0.06

Values in rows with the same superscript are significantly different at $p<0.05$

Table 6: Incremental plasma insulin levels (mU/l) of healthy subjects fed control bread (CB) and *detarium* bread (DTB). Results are means±sem (n = 10)

	Plasma insulin level	
Time (min)	CB	DTB
30	22.16±3.55	10.84±2.47
60	24.16±2.69	17.46±3.97
90	36.71^a±5.76	24.92^a±4.44
120	14.99^a±4.25	5.28^a±1.41
150	4.34±2.01	1.47±0.47

Values in rows with the same superscript are significantly different from each other at $p<0.05$

Table 3: Non-cellulosic polysaccharide composition of *Detarium microcarpium* (g/100g) Non-cellulosic polysaccharide

Detarium sample NSPs	Arabinose	Xylose	Mannose	Galactose	Glucose	Uronic acid
Soluble NSP	2.3	18.0	0.3	10.0	26.7	2.5
Insoluble NSP	0.5	0.5	0.1	0.3	T	0.3
Total NSP	2.8	18.5	0.4	10.3	26.7	2.8

Rhamnose, Fructose and Arabinose all have trace levels

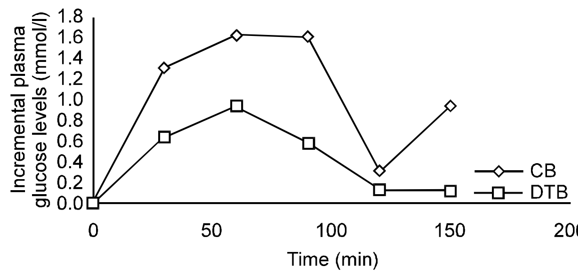

Fig. 1: Incremental plasma glucose levels (mmol/l) of healthy subjects fed Control Bread (CB) and Detarium Bread (DTB). Results are means sem (n = 10)

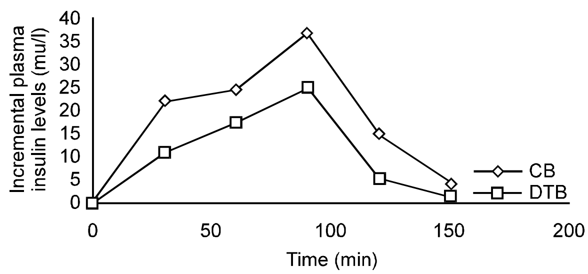

Fig. 2: Incremental plasma insulin levels (mU/l) of healthy subjects fed Control Bread (CB) and Detarium Bread (DTB). Results are means sem (n = 10)

of the traditional African diet that is high in fibre and an increase in the consumption of food high in fat and animal products. This shift in diet, the adoption of a westernized lifestyle and market globalization has resulted in a rapid change in disease pattern (SCN, 2006). *Detarium* contains starch even though in small amount 0.4g/100g. The nature of the starch in DT is not known, however it has been shown that starch content of food affect the GI of food. This may indicate that DT could be useful in the lowering postprandial glucose level in subjects with diabetes.

Particle size: *Detarium* flour had a coarse mean particle size of 464 µm. It is possible that the DT flour with coarse consistency may give a lower postprandial glycemic response. Studies have shown that particle size or texture of food plays an important role in glycemic response or blood glucose level. Milling and grinding grain foods breaks the cell walls and there is quicker access of amylase to the starch in flours than in whole grain (O'Dea *et al*., 1980). Foods of coarse consistency produced lower glycemic responses (Heaton *et al*., 1988). The coarse nature of *Detarium* may have contributed to the postprandial decrease in the blood sugar.

Water Binding Capacity (WBC): Water binding capacity is the maximum amount of water that can be taken up per unit weight of dry food material in the presence of excess water. That is the ability of fibre to hold water under specific conditions (Deher, 1987). *Detarium* flour had a WBC of 8.30. Studies have shown that fibre with high WBC like DT, prolong gastric emptying and subsequently lower postprandial blood glucose level. This property of DT flour makes this legume a useful food that may have helped in modulating postprandial glucose level of subjects.

Soluble NSP/ Viscosity: The total NSP content of DT was 59.7g/100g and the water s-NSP content was 55.9g/100g. The sugar composition of the s-NSP fraction indicated a high proportion of glucose, xylose and galactose. Analysis of *detarium* flour showed that s-NSP fraction of detarium flour consist mainly of xyloglucan. An analysis of detarium xylogucan showed that it has an intrinsic viscosity of 7.3±1dl/g indicating that it is a high molecular weight polymer (Wang *et al*., 1997). This explains why it has the capacity to generate high viscosity in aqueous solution. The xyloglucan fraction seems to be the main component of detarium flour responsible for it's viscosity. The xyloglucan in *detarium* is similar to the main polymer found in tamarind gum, a seed extract of the plant Tamarindus indica L. (Reid, 1985). Studies have shown that tamarind xyloglucan and guar galactomannan are responsible for the viscosity enhancing effect when added in water and liquid foods hence increasing the viscosity of the digesta as well as reducing the rate of emptying from the stomach. It is therefore possible that *detarium* xyloglucan may have the same effect as that of tamarind xyloglucan. An important determinant of the biological activity of these polymers 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 and possibly the extent of digestion and absorption of available carbohydrate (Ellis *et al*., 1996).

Jenkins *et al*. (1978) showed a positive correlation between mean peak rise in blood glucose and gum viscosity with a wide variety of viscous NSPs. The authors indicated that the action of these viscous agents may be two fold which includes delay of gastric emptying and delay of glucose absorption from the small bowel lumen. These gelling agents entrap glucose and slowly release it for absorption. Recent evidence has shown that in addition to increasing the viscosity of the digesta, these s-NSPs may act as a physical barrier to amylase-starch interaction in the lumen of the small intestine (Brennan *et al*., 1996). This effect can be helpful in controlling blood glucose concentration.

The glycemic index of detarium bread meal, the AUC reduction was 62%. Significant reduction in the postprandial rise in plasma insulin after consumption of

DTM compared to the CB. The reduction in the insulin (AUC for 0-150min) after the detarium bread was 43%. These values were substantially lower than the glycemic indices of guar containing foods seen in studies where subjects consumed s-NSP at doses much higher than what was used in the current study (Morgan *et al.*, 1990; Ellis *et al.*, 1991).

Metabolic study: The result of the study showed that the addition of DT to wheat flour resulted in significant lower post-prandial plasma glucose and insulin levels in the subjects compared to a simple wheat bread. Jenkins *et al.* (1981) made edible product from guar gum in the form of crisp bread, Apling and Ellis (1982) produced guar bread. All clinical trials have shown that wheat bread containing guar gum improves carbohydrate tolerance in healthy and diabetic patients. The physicochemical properties were attributed to this positive effect. These authors suggested that s-NSP should be intimately mixed well with the food, just as in the production of DTB, to obtain the desirable effect.

Conclusion: *Detarium* could be a useful adjunct in the prevention and management of non-insulin dependent diabetes mellitus in Nigeria and other parts of Africa where the prevalence of diabetes is a serious health problem.

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REFERENCES

Apling, E.C. and P.R. Ellis, 1982. Guar bread: concept to application. Chem. Ind., 23: 950-954.

Balogun, A.M. and B.L. Futaga, 1989. Chemical composition of some unexploited leguminous seeds in Nigeria. J. Agric. Food Chem., 34: 189-192.

Brennan, C.S., D.F. Blake, P.R. Ellis and J.D. Schofield, 1996. Effect of guar galactomannan on wheat bread microstructure and the *in vitro* and *in vivo* digestibility of starch in bread. J. Cereal Sci., 24: 151-160.

Cheryan, M., 1980. Phytic acid interaction in food systems. CRC critical reviews. Food Sci. Nutr., 13: 115-120.

Deher, M.L., 1987. Handbook of dietary fibre. In Fennema, O.R., G.W. Sanderson, P. Walstra, M. Karel, S.R. Tannenboum and J.R. Whitaker, (Eds.)., New York, Marcel Dekker Iinc.

Ellis, P.R., F.M. Dawoud and E.R. Morris, 1991. Blood glucose, plasma insulin and sensory responses to guar-containing wheat breads: effects of molecular weight and particle size of guar gum. Brit. J. Nutr., 66: 363-379.

Ellis, P.R., P. Rayment and Q. Wang, 1996. A physico-chemical perspective of plant polysaccharides in relation to glucose absorption, insulin secretion and the entero-insular axis. Procc Nutr. Soc., 55: 881-898.

Englyst, H.N., M.E. Quigley, G.J. Hudson and J.H. Cumming, 1992a. Determination of dietary fibre as non-starch polysaccharide by gas liquid chromatography. Analyst, 177: 1707-1714.

Englyst, H.N., S.M. Kingman and J.H. Cummings, 1992b. Classification and measurement of nutritionally important starch fractions. Eur. J. Clin. Nutr., 46: S23-S50.

FAO, 1988. Traditional food plants A source book for promoting the exploitation and consumption of plant foods in Arid semi-Arid and semi-humid lands of Eastern Africa, pp: 234-245. Rome: FAO.

Heaton, K.W., S.N. Marcus, P.M. Emmett and D.H. Bolton, 1988. Particle size of wheat, maize, oat test meals. Effect on plasma glucose and insulin responses and rate of starch digestion *in vitro*. Am. J. Clin. Nutr., 47: 675-682.

Jenkins, D.J.A., T.M.S. Wolever, R.H. Taylor, H. Ghafari, A.L. Jenkins, H. Baker and M.J.A. Jenkins, 1980. Rate of digestion of foods and postprandial glycaemia in normal and diabetic subjects. Br. Med. J., 281: 14-27.

Jenkins, D.J.A., A.C. Bowling, H.C. Newman, A.L. Henkins, D.V. Goff and J.M. Baldwin, 1981. Glycemic index of foods: A physiological basis for carbohydrate exchange. Am. J. Clin. Nutr. , 34: 362-366.

Jenkins, D.J.A., A.L. Jenkins, G.S. Wang and R. Josse, 1983. Glycemic response to wheat: reduced response to pasta but no effect with fibre. Diabetic Care, 6: 155-159.

Jenkins, D.J.A., T.M.S. Wolever, A.R. Leeds, A.M. Gassull, P. Haisman, J. Dilawari, D.V. Goff, G.L. Metz and K.G.M.M. Alberti, 1978. Dietary fibre, analogues and glucose tolerance: importance of viscosity. Br. Med. J., 279: 1392-1394.

Kirk, R.S. and R. Sawyer, 1991. Pearson's chemical analysis of foods, 9th ed. Edinburgh: churchhill Livingstone.

Lauer, O., 1996. Grain size measurement on commercial powders. Ausberg, Alpine AG, Ausberg.

Morgan, L.M., J.A. Tredger, J. Wright and V. Marks, 1990. The effect of soluble and insoluble-fibre supplementation on post-prandial glucose tolerance, insulin and gastric inhibitory polypeptide secretion in healthy subjects. Br. J. Nutr., 64: 103-110.

O'Dea, K., P. Nestel and L. Analoff, 1980. Physical factors influencing postprandial glucose and insulin responses to starch. Am. J. Clin. Nutr., 33: 760-765.

Onyechi, U.A., 1995. Potential role of indigenous Nigerian foods in the treatment of non-insulin dependent diabetes mellitus. PhD Thesis, University of London, UK.

Puzstai, A., E.M.U. Clarke and T.P. King, 1979. The nutritional toxicity of *Phaseolus vularis* lectin. Proce. Nutr. Soc., 38: 115-120.

Quin, J.R. and D. Paton, 1978. A practical measurement of water hydration capacity of protein materials. Cerl. Chem., 56: 38.

Reid, J.S.G., 1985. Cell wall storage carbohydrate in seeds. Biochemistry of seed ‘gums’ and ‘hemicelluloses.’ Adv. Botan. Res., 11: 125-155.

Standing Committee in Nutrition, 2006. Diet related chronic disease and double burden of malnutrition in West Africa. No 33. United Nations.

Wang, Q., P.R. Ellis, S.B. Ross-Murphy and W. Burchard, 1997. Solution charactertistics and of xyloglucan extracted from *Detarium senegalense Gmelin*. Carbo. Poly., 33: 114-124.