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A Controlled Comparison of the Effect of a High Fiber Diet on the Glycaemic and Lipid Profile of Nigerian Clinic Patients with Type 2 Diabetes

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Abstract: The prevalence of type 2 diabetes (T2DM) is increasing worldwide and a disproportionate burden of this increase is borne by developing economies. It is yet to be established whether dietary strategies and interventions which have been successful in the control of T2DM in Western nations will achieve the same effect in the African setting. We studied the effect of a formulated high caloric fibre diet on the glycemic and lipid profile of tablet treated type 2 Nigerian diabetics. We assigned 52 type 2 diabetics (26 men, 26 women) to either an intervention (35) or control group (17). Each subject in the intervention group consumed a diet providing at least 40g of fibre per day while subjects in the control group were fed a regular diet. The effect of both diets on glucose and lipid profile was then tested at 4 and 8 weeks. One way repeated measures analysis of variance for the follow up period showed a significant lowering of waist circumference $p = 0.002$, Fasting Blood Glucose, 2hr post prandial glucose, Total Cholesterol, Triglyceride, and LDL-C ($p = 0.000$ in all cases) by the third visit in the intervention group. At the end of the third visit, the mean FBG decreased by 4.9 ± 2.7mmol/l 95% CI -5.8 to -3.9 in the intervention group and by 3 ± 2.8mmol/l 95% CI -4.5 to -1.5 in the control group $p = 0.02$. 23 (65.7%) intervention group subjects had attained FBG levels = 7.0 mmol/l by the third visit. None of the control subjects had their FBG lowered below 7.0 mmol/l by the third visit. Plasma glucose concentration 2hr after meal, plasma TC, TG and LDL-C decreased significantly more in the intervention group than among those in the control group. By the second visit, all the patients in the control group had their Glibenclamide increased to10mg or their Chlorpropamide to between 375 and 500mg per day while 29 (82.9%) persons in the intervention group had their drugs increased in a similar fashion. By the third visit, 8(47.1%) control subjects had a further increase in the dose of their sulphonylurea while all but 2 (5.7%) patients in the subject group had achieved normoglycemia. Consumption of a high fibre diet provided mainly through soup thickeners and vegetables by newly diagnosed Type 2 diabetic patients being treated with oral hypoglycaemic agents resulted in early attainment of normoglycaemia and improved glycemic and lipid profile compared with a conventional diet. These findings underscore the need for our dietary guidelines to include specific recommendations on increased utilization of dietary fibre.

Key words: Dietary fibre, conventional diet, glucose, lipid profile

Introduction

The present global pandemic of type 2 diabetes (T2D) is accounted for by westernization of lifestyle, population growth, ageing and urbanization with consequent dietary change, sedentary lifestyle, and obesity (King and Dowd, 1990; Hamman, 1992; Manson *et al*., 1991). The past decade has also witnessed the emergence of T2D as a major health problem in Nigeria and other African populations, with T2D affecting about 2-7% of these populations (Anonymous, 1997; Amos *et al*., 1997; Rolfe *et al*., 1992).

Reports from health institutions in sub-Saharan Africa indicate that the complications of uncontrolled diabetes are becoming as important as communicable diseases as a cause of adult medical admissions and mortality (Kolawole and Ajayi, 2000; Abbas and Archibald, 2005). These complications include ischemic heart disease, nephropathy, neuropathy and limb amputation. The results of the Diabetes Control and Complications Trial (DCCT) and United Kingdom Prospective Diabetes Study (UKPDS) have however demonstrated a clear beneficial relationship between strict diabetes control and reduction in long-term complications of diabetes (Anonymous, 1993; 1998a).

Virtually all treatment strategies for diabetes include some form of dietary modification or another. Diet and exercise are thus regarded as the most important modalities in the therapy of diabetes and have been considered in its management for centuries. Because of the heterogeneity of the diabetic syndromes, the diabetic diet is tailored according to age, nutritional status, severity of the metabolic disorder, physical activity, education, social, cultural, and economic factors as well as the presence of any associated problems such as hyperlipidaemia, hypertension or renal disease (Jenkins *et al*., 1980).

Traditionally, recommendations have included limitation of the intake of simple carbohydrates (monosaccharides and disaccharides) and increased caloric intake from complex carbohydrates (polysaccharides). However, among various simple and complex carbohydrates, the postprandial glycemic response varies considerably. When using the postprandial serum glucose response to white bread as a reference (100%) the glycemic index (Jenkins *et al*., 1983) to various carbohydrate foods is variable. One of the factors that affect the glycemic response to a meal is the fibre content of the meal. Dietary fibre is generally defined as the complex polysaccharides that are not digested by the small intestine and that lack caloric value. Dietary fibre thus has beneficial effects on glucose control and circulating lipid levels possibly through delayed gastric emptying, altered transit time in the small intestine, insulation of carbohydrates from digestive enzymes, and digestive enzyme inhibition (Jenkins *et al.*, 1983). High fibre diets have been advocated for and recommended in the treatment of diabetes (Miranda and Horwitz, 1978). Perhaps, with the exception of green leafy vegetables, fibre rich foods are predominantly high carbohydrate foods, for example cereals and legumes. Lack of palatability and possible effects on inducing mineral or vitamin deficiency because of bile acid interaction are some of the disadvantages of high dietary fibre.

While most studies on which present recommendations are based were conducted amongst Caucasian populations differing in prevailing socio-cultural and socio-economic conditions, it is known that cultural factors influence food consumption and acceptance/compliance with dietary advice (Fadupin and Keshinro, 2001) Many local food sources of fibre are available whose precise fibre content have not been previously determined. This study was therefore conducted to determine the impact of locally available high caloric fibre diets on glycemic control, plasma lipid profile and oral hypoglycaemic drug requirement in type 2 diabetic Nigerians and to assess the tolerability of such diets.

Materials and Methods

Design: This is an interventional longitudinal health system research. Subjects were recruited primarily from the Diabetes/Endocrinology clinic of the Obafemi Awolowo University Teaching Hospital Complex located at Ile-Ife and Ilesa, South Western Nigeria. Fifty-two consecutive newly diagnosed tablet-treated type 2 diabetics were recruited after obtaining their informed consent. Diabetes mellitus was defined as fasting plasma glucose = 7.0 mmol/l or a 2 hour post prandial plasma glucose = 11.1 mmol/l (American Diabetes Association, 2006).

Eligible patients were free of significant organ damage/dysfunction such as stroke, heart failure, chronic renal failure secondary to diabetic nephropathy, leg ulcers or gangrene. Insulin treated patients, poorly motivated patients, those living in distant areas where it was not easy to assess them or make them comply with regular clinic visits were also excluded from the study. Study participants were assigned to an intervention (35) or control group (17) by the physician (Principal Investigator) with the use of a randomization list not made available to laboratory personnel. Apart from the initial visit at recruitment (week 0), all study participants were also seen and evaluated at 4 weeks and 8 weeks post recruitment.

Subjects in the intervention and control groups were given general oral and written information about their diet at baseline and at subsequent visits but no specific individualized programme were offered to them. All patients were treated with oral hypoglycemic agents which were given free to ensure compliance. In addition, drug adherence was monitored at each visit by tablet counting. Drug dosages were adjusted according to a predetermined protocol at subsequent clinic visits.

Parameters measured: The following parameters were measured in all subjects at each visit; Body weight, height, body mass index, waist hip ratio, blood pressure and fasting plasma levels of glucose and lipid profile. Fasting plasma glucose, total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C) and triglycerides (TG) were measured with commercial kits. All measurements were done in our hospital's Chemical Pathology laboratory.

Diets: The composition of the diet is shown in Table 1. The content of total, soluble and insoluble dietary fiber as well as other food substances were estimated using the Official Methods of analysis of the Association of official Analytical Chemists (AOAC, 1975) The diet provided 60% of total caloric intake as complex carbohydrate, 20% as protein, 15% as polyunsaturated fat, 5% as saturated fat. A total of 40g fiber consumption per day was added for the intervention group. The total caloric content of each subject's diet was calculated and individualized depending on the patient's weight/body mass index and physical activity.

Statistical analysis: Data were analyzed on computer using SPSS Software package and the Computer Programme for Epidemiologists (PEPI) version 3.01. Quantitative data were analyzed using simple proportions. Two sided t test was used to analyze the

Table 1: Sample menus of the intervention diet

Breakfast		
Boiled Yam	-	300g (i.e. 2 slices)
Fish stew		
Vegetable oil	-	2 table spoonful
Fresh tomatoes		
Red pepper		
Fish	-	80g
Vegetables		
Lunch		
Yam flour		-500g
or		
Cassava flour		-470g
Vegetable soup		
Vegetable oil		-2½ tablespoonfuls
Tomato		
Red pepper		
Onions		
Soup thickener		-2½ tablespoonfuls
Fresh vegetables		
Beef/Fish	-	100g
Fruit (pawpaw)	-	1 teacupful
Dinner		
Boiled rice	-	500g
Or		
Boiled beans	-	300g
Boiled plantain	-	250g
Stew		
Vegetable oil	-	2½ tablespoonfuls
Tomato		
Red pepper		
Onions		
Soup thickener	-	2½ tablespoonfuls
Fresh vegetables		
Beef/Fish	-	100g

differences between the intervention and control groups at baseline. The general linear model repeated measures analysis of variance was used to determine the effect of both diets during the follow up period. A two-tailed post hoc Tukey mean comparison test was also performed on the changes in study parameters. P values = 0.05 were regarded as statistically significant.

Results

Baseline: Fifty-two subjects completed the study, there were 35 subjects in the intervention group and 17 in the control group. The intervention group comprised 16 men and 19 women while the control group comprised 10 men and 7 women (Table 2). There were no differences in the mean age and duration of diabetes in both the intervention and control groups. Anthropometric indices (weight, body mass index, waist circumference, waist hip ratio), blood pressure, and lipid profile (plasma total cholesterol (TC), plasma triglyceride (TG), plasma high density lipoprotein cholesterol (HDL-C), plasma low density lipoprotein cholesterol (LDL-C) were also similar in both groups, p > 0.05 in all cases.

Follow up: One way repeated measures analysis of variance for the follow up period showed a significant lowering of waist circumference p = 0.002, FBG, 2hr post prandial glucose, TC, TG, and LDL-C (p = 0.000 in all cases) by the third visit in the intervention group (Table 3). Plasma HDL-C also increased significantly p = 0.000. Body mass index and waist hip ratio remained unchanged. In the control group, there was a demonstrable and significant lowering of mean BMI p = 0.01, though there was an initial rise at the second visit. Fasting blood glucose, 2hr post prandial glucose and plasma LDL-C all decreased significantly p = 0.002, 0.048 and 0.008 respectively. Mean plasma HDL-C, Waist circumference, WHR and plasma TC did not change significantly.
At the end of the third visit, the mean FBG decreased by 4.9 ± 2.7mmol/l 95% CI -5.8 to -3.9 in the intervention group and by 3 ± 2.8mmol/l 95% CI -4.5 to -1.5 in the control group p = 0.02 (Table 4). 23 (65.7%) intervention group subjects had attained FBG levels = 7.0 mmol/l by the third visit. None of the control subjects had their FBG lowered below 7.0 mmol/l by the third visit. Plasma glucose concentration 2hr after meal, plasma TC, TG and LDL-C decreased significantly more in the intervention group than among those in the control group. There was however a significantly greater increase in the intervention group than in the control group in the HDL-C concentration. Change in body weight, BMI, WC and WHR did not differ significantly between the two groups.

Medications and diet: All the participants were started on Sulphonyureas-Glibenclamide 5mg or Chlorpropamide 250mg once a day at the initial visit. Metformin, 500mg twice daily was added in those whose body mass index were greater than 25 kg/m^2. At the second visit, all the patients in the control group had their Glibenclamide increased to10mg or their Chlorpropamide to between 375 and 500mg per day while 29 (82.9%) persons in the intervention group had their drugs increased in a similar fashion. At the third visit, 8 (47.1%) control subjects had a further increase in the dose of their sulphonylurea while all but 2 (5.7%) patients in the subject group had achieved normoglycemia. All subjects in the intervention group tolerated their diets satisfactorily. None reported increased flatulence, diarrhea, constipation or vomiting.

Discussion

Diet remains the cornerstone of diabetes management. The ideal diabetic diet should maintain a satisfactory body weight with euglycaemia and normolipidaemia and provide adequate energy and essential nutrients for normal body homeostasis (Anderson and Akanji, 1991). Fiber has been an important and effective addition to the diabetes diet since it was suggested by Trowell (1975) that diabetes may be a fiber deficient disorder. Such diets, in association with carbohydrate intake

Table 2: Baseline characteristics of study participants

	Intervention Group (n = 35)	Control Group (n = 17)	P value	95% CI of the difference
Age (years)	57.6 ± 6.3	58.2 ± 8.8	0.81	-4.4 to 5.6
Sex M/F	16/19	10/7	-	
Duration of DM (Months)	18.6 ± 16.6	22.4 ± 15.2	0.421	-36.7 to 42.3
Body Mass Index (BMI) Kg/m^2	23.8 ± 3.3	24.5 ± 3.4	0.972	-1.1 to 2.8
Waist circumference (cm)	88.7 ± 8.8	88.8 ± 11.5	0.972	-5.6 to 5.8
Waist Hip ratio (WHR)	0.89 ± 0.06	0.90 ± 0.06	0.575	-0.02 to 0.04
Systolic blood pressure (SBP) mmHg	136 ± 20	134 ±19	0.733	-9.7 to 13.7
Diastolic blood pressure (DBP) mmHg	83 ± 8	85 ± 10	0.44	-3.2 to 7.1
Fasting Plasma Glucose (FPG) mmol/l	10.9± 2.8	11.0 ± 2.9	0.905	-1.6 to 1.8
2 Hour post prandial glucose (2HPP) mmol/l	12.9 ±2.9	12.0 ± 2.1	0.26	-0.7 to 2.5
Total cholesterol (TC) mmol/l	4.8 ±1.1	4.5 ±1.2	0.375	-0.4 to 0.97
Triglyceride (TG) mmol/l	1.2 ± 0.4	1.1 ± 0.5	0.44	-0.15 to 0.35
High Density Lipoprotein Cholesterol (HDL-C) mmol/l	1.1± 0.6	1.4 ±1.1	0.208	-0.17 to 0.77
Low Density Lipoprotein Cholesterol (LDL-C) mmol/l	3.3 ±1.2	2.8 ±1.5	0.304	-0.4 to 1.2

Table 3: Comparisons of anthropometric and metabolic parameters during follow up in the intervention and control groups

Variables	Visit 1	Visit 2	Visit 3	Significance
Intervention Group n = 35				
BMI Kg/m^2	23.8±3.3	23.6±3.4	23.5±3.2	0.221
Waist Circumference (cm)	88.7±8.8	88.2±8.3	87.9±8.2	0.002*
WHR	0.89±0.06	0.9±0.06	0.89±0.06	0.51
Fasting blood glucose (mmol/l)	10.9±2.8	7.9±1.8	5.9±1.3	0.000*
2hr post prandial glucose (mmol/l)	12.9±2.9	9.7±1.9	7.3±1.6	0.000*
Total plasma cholesterol (mmo/l)	4.8±1.1	4.5±1.2	4.2±1.1	0.000*
Plasma Triglyceride (mmol/l)	1.2±0.4	0.9±0.2	0.9±0.2	0.000*
Plasma HDL cholesterol (mmol/l)	1.1±0.6	1.1±0.6	1.4±0.8	0.000*
Plasma LDL cholesterol (mmol/l)	3.2±1.2	3.2±1.6	2.4±0.9	0.000*
CONTROL GROUP n = 17				
BMI Kg/m2	25.9±3.4	26.1±4.2	25.6±3.4	0.015*
Waist Circumference (cm)	88.8±11.5	88.8±11.2	88.2±11.4	0.215
WHR	0.9±0.06	0.89±0.06	0.89±0.06	0.504
Fasting blood glucose (mmol/l)	11.0±2.9	9.1±2.1	8±2.3	0.002*
2hr post prandial glucose (mmol/l)	12±2.1	10.5±2.3	9.6±2.3	0.048*
Total plasma cholesterol (mmo/l)	4.5±1.2	4.4±1.4	4.3±1.5	0.5
Plasma Triglyceride (mmol/l)	1.1±0.5	1.1±0.4	1.1±0.3	0.8
Plasma HDL cholesterol (mmol/l)	1.4±1.1	1.2±0.8	1.4±1.5	0.001
Plasma LDL cholesterol (mmol/l)	2.8±1.5	2.4±1.6	2.4±1.6	0.008*

* statistically significant

sometimes as high as 75% of total calories have allowed withdrawal of insulin therapy (Kiehm *et al.,* 1976). Some studies have also demonstrated clearly beneficial effects of fiber supplementation in lowering total cholesterol, LDL-C, (Anderson *et al.,* 2000; Davidson *et al.,* 1996) and increasing HDL-C (Rodriguez-Moran *et al.*, 1998). Despite its well documented beneficial effects, the dietary intake of fiber remains low among people living in Western countries (Anonymous, 1998b) In Nigeria, fiber is readily available in our staples and other local food sources yet it is not routinely included in the diet prescription for type 2 diabetes (Fadupin and Keshinro, 2001; Naidu, 2000). We therefore investigated the effect of the consumption of a diet enriched with fiber on glycemic control and lipid profile in our type 2 diabetics.

We found a significant reduction in the BMI (intervention group) and waist circumference (control group) over the 8 weeks of follow up. The change in all anthropometric indices studied over time were however comparable in both groups. Very few well controlled studies have determined the effect of increased fiber consumption on weight and other indices of body fatness and the results from these studies have been inconsistent (O'Dea *et al.*, 1989; Ziai *et al.*, 2005. Thompson *et al.*, 2005) did not find any significant difference in the change in weight of outpatient type 2 diabetics who were fed a high fiber diet (psyllium) when compared with placebo. O'Dea *et al.* (1989) had also observed "unexplained weight loss" during the high fiber diet phase of a crossover study. The sequence of the high fiber and low fiber diets were however not randomly assigned. The initial increase in the mean BMI by the second visit in our control group was not observed in the intervention group. This is perhaps a consequence of improved glycaemia, a similar effect in the intervention group having been

Table 4: Changes in selected clinical and metabolic variables from baseline to the last visit in the intervention and control groups

Variable	Intervention Group n = 35 Mean ± SD	95% CI	Control Group n = 17 Mean ± SD	95% CI	P value
Weight (Kg)	-0.3± 2.1	-1.9 to 0.2	-0.35± 2.3	-1.6 to 0.87	0.938
BMI Kg/m2	-0.3± 0.9	-0.6 to 0.06	-0.32 ± 0.6	-0.6 to -0.02	0.934
Waist Circumference (cm)	-0.8± 1.3	-1.2 to -0.3	-0.62 ± 1.4	-1.3 to 0.1	0.829
WHR	.001± .03	-.009 to .01	.005 ± .03	-.02 to .007	0.654
Fasting blood glucose (mmol/l)	-4.9± 2.7	-5.8 to -3.9	-3 ± 2.8	-4.5 to -1.5	0.023*
2hr post prandial glucose (mmol/l)	-5.6± 2.9	-6.6 to -4.6	-2.3 ± 3.5	-4.1 to -0.5	0.001*
Total plasma cholesterol (mmo/l)	-0.6± 0.5	-0.8 to -0.4	-0.16 ± 0.8	-0.5 to 0.2	0.019*
Plasma Triglyceride (mmol/l)	-0.3± 0.3	-0.4 to -0.2	-0.01 ± 0.4	-0.2 to 0.19	0.005*
Plasma HDL cholesterol (mmol/l)	0.4± 0.4	0.2 to 0.5	1.1 ± 2.3	-0.1 to 2.2	0.000*
Plasma LDL cholesterol (mmol/l)	-0.8± 0.7	-1.1 to -0.6	-0.4 ± 0.5	-0.7 to -0.1	0.04*

*p values statistically significant

mitigated by the high fiber diet. Mechanisms suggested for how dietary fiber aids in weight management include promoting satiation, decreasing absorption of macronutrients, and altering secretion of gut hormones (Slavin, 2005).

Our study showed that consumption of a high fiber diet for 8 weeks resulted in a greater change (lowering) in blood glucose than a control (conventional) diet without concomitant hypoglycaemia. In addition, more subjects in the intervention group attained normoglycaemia even though both groups demonstrated significant plasma glucose lowering by the end of the study. While many studies have shown improved glycaemia with high fiber diets, (Ziai *et al.,* 2005; Thompson *et al*., 2005; Slavin, 2005) these diets are not uniformly effective in all individuals, though most patients derive at least some benefit (Anderson and Akanji, 1991) The efficacy of dietary fibre differs according to their dietary sources (fruits, legumes or cereals), and also according to their specific chemical structure which is responsible for their physical properties (i.e. gel forming capacity) or their fermentation capacity in the lower part of the gut (Delzenne and Cani, 2005). The fermentability of dietary fibre is important in that it exerts specific effects on satiety and glycemia through the release of gut peptides such as glucagon-like peptide^{-1}. While the bulk of the fibre content of both diets in our study were cereal or legume based, the intervention diet included vegetable soups enhanced with local food thickners, “Ofor” (afzedia africana) and “Ukpor” (mucuna sloanei) which accounted for the extra and high fibre in this diet. These are nuts which when ground provide high concentrations of fermentable soluble fibre.

Expectedly, the high fibre diet significantly reduced plasma total cholesterol concentrations and other lipid parameters except HDL-C. The diet also induced a greater change in mean lipid parameters compared with the control group. The cholesterol reducing effects of soluble fibre is well established (Anderson and Akanji, 1991; Ziai *et al.*, 2005; Chandalia *et al.,* 2000) The hypolipidemic effects of dietary fibre are mediated by the actions of soluble fibre in binding bile acids, thereby increasing their faecal excretion and interrupting the enterohepatic circulation of bile salts (Anderson and Akanji, 1991) The fermentative end products of fibre-acetate, propionate, and butyrate also play a role in this process (Delzenne and Cani, 2005) In contrast to previous reports, we found significantly greater increase in mean HDL-C in the control group than intervention group in our study. One possible reason for this finding is that the intervention group had a much lower, (though insignificant) HDL-C at baseline.

Our study has also demonstrated that it is possible to achieve a high intake of dietary soluble fibre with minimal or no adverse effects by consuming locally available unfortified food. These fibre sources are cheap, palatable, free of untoward effects and readily adaptable. In a resource poor setting as ours where cost considerations are of paramount importance, the oral hypoglycaemic sparing effect of such diets are an added benefit. The long term benefit of improved glycemic control as well, can not be overemphasized.

Conclusions: We found that the consumption of a high fibre diet provided mainly through soup thickeners and vegetables by newly diagnosed Type 2 diabetic patients being treated with oral hypoglycaemic agents resulted in early attainment of normoglycaemia and improved glycemic and lipid profile compared with a conventional diet. These findings underscore the need for our dietary guidelines to include specific recommendations on increased utilization of dietary fibre.

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References

Abbas, Z.G. and L.K. Archibald, 2005. Epidemiology of the diabetic foot in Africa. Med. Sci. Monit., 11: RA 262-70.

American Diabetes Association, 2006. Diagnosis and Classification of Diabetes Mellitus (Position Statement). Diabetes Care 2006, Suppl. 1: S43-S48.

Amos, A.F., D.J. McCarty and P. Zimmet, 1997. The rising global burden of diabetes and its complications: estimates and projections to the year 2010. Diabet. Med., 14: S1-S8.

Anderson, J.W., M.H. Davidson and L. Blonde, 2000. Long term cholesterol lowering effects of psyllium as an adjunct to diet therapy in the treatment of hypercholesterolemia. Am. J. Clin. Nutr., 71 :1433-38.

Anderson, J.W. and A.O. Akanji, 1991. Dietary fiber – An overview. Diabetes Care, 14: 1126-31.

Anonymous, 1997. The Expert committee on Non Communicable Disease. Final Report of a National Survey. Federal Ministry of Health, Lagos: 1997.

Anonymous, 1998a. National Health and Nutrition Examination Survey III, 1988-94. NCHS CD-ROM series 11. no 2A. ASCII version. Hyattsville, Md.: National center for health Statistics.

Anonymous, 1998b. The UKPDS study group: Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDSS 33). Lancet, 352: 837-853.

Anonymous, 1993. The Diabetes Control and Complications Trial Research Group: The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. N. Engl. J. Med., 329: 977-986.

Association of Official Analytical Chemists (AOAC), 1975. Official Methods of Analysis of the Association of Official Analytical Chemists. Washington DC.

Chandalia, M., A. Garg, D. Lutjohann, K. von Bergman, S.M. Grundy and L. Brinkley, 2000. Beneficial effects of high dietary fibre intake in patients with type 2 diabetes mellitus. N. Engl. J. Med., 342: 1392-8.

Davidson, M.H., L.D. Dugan and J.H. Burns, 1996. A psyllium-enriched cereal for the treatment of hypercholesterolemia in children: a controlled, double blind, cross-over study. Am. J. Clin. Nutr., 63: 96-102.

Delzenne, N.M. and P.D. Cani, 2005. A place for dietary fibre in the management of the metabolic syndrome. Curr. Opin. Clin. Nutr. Metab. Care, 8: 636-40.

Fadupin, G.T. and O.O. Keshinro, 2001. Factors influencing dietary compliance and glycaemic control in adult diabetic patients in Nigeria. Diabet. Int., 11: 59-61.

Hamman, R.F., 1992. Genetic and environmental determinants of non-insulin dependent diabetes mellitus (NIDDM). Diabetes Metab. Rev., 8: 287-338.

Jenkins, D.A., T.M.S. Wolever, S. Bacon, R. Nineham, R. Lees, R. Rowden, M. Love and T.D.R. Hockaday, 1980. Diabetic diets: high carbohydrate combined with high fibre. Am. J. Clin. Nutr., 33: 1729-33.

Jenkins, D.A., T.M.S. Wolever, A.L. Jenkins, M.J. Thorne, R. Lee, J. Kalminsky, R. Reichert and G.S. Wong, 1983. The glycaemic index of foods tested in diabetic patients: a new basis for carbohydrate exchange favouring the use of legumes. Diabetologia, 24: 257-64.

Kiehm, T.G., J.W. Anderson and K. Ward, 1976. Beneficial effects of a high carbohydrate, high fiber diet in hyperglycaemic men. Am. J. Clin. Nutr., 29: 895-99.

King, H. and J.E. Dowd, 1990. Primary prevention of type 2 (non-insulin-dependent) diabetes mellitus. Diabetologia, 33: 3-8.

Kolawole, B.A. and A.A. Ajayi, 2000. Prognostic indices for intrahospital mortality in Nigerian diabetic NIDDM patients. Role of gender and hypertension. J Diabet. Complications, 14: 84-9.

Manson, J.E., E.B. Rimm and M.J. Stampfer, 1991. Physical activity and incidence of non-insulin-dependent diabetes mellitus in women. Lancet, 338: 774-8.

Miranda, P.M. and D.L. Horwitz, 1978. High fibre diets in the treatment of diabetes mellitus. Ann. Int. Med., 82: 482-86.

Naidu, R., 2000. Dietary management of diabetes in Africa. Diabet. Int., 10: 5-8.

O'Dea, K., K. Traianedes, P. Ireland, M. Niall, J. Sadler, J. Hopper and M. De Luise, 1989. The effects of diet differing in fat, carbohydrate, and fiber on carbohydrate and lipid metabolism in type 2 diabetes. J. Am. Diet. Assoc., 89: 1076-86.

Rodriguez-Moran, M., F. Guerrero-Romero, and G. Lazcano-Burciaga, 1998. Lipd and glucose lowering efficacy of plantago psyllium in type 2 diabetes. J. Diabet. Complications, 12: 273-78.

Rolfe, M., C.M. Tanga, R.W. Walker, E. Bassey and M. George, 1992. Diabetes mellitus in the Gambia, West Africa. Diabet. Med., 9: 484-88.

Slavin, J.L., 2005. Dietary fibre and body weight. Nutr., 21: 411-8.

Thompson, W.G., N. Rostad Holdman, D.J. Janzow, J.M. Slezak, K.L. Morris and M.B. Zemel, 2005. Effect of energy-reduced diets high in dairy products and fibre on weight loss in obese adults. Obes. Res., 13: 1344-53.

Trowell, H.C., 1975. Dietary fiber hypothesis of the etiology of diabetes mellitus. Diabetes, 24: 762-65.

Ziai, S.A., B. Larijani, S. Akhoondzadeh, H. Fakhrzadeh, A. Dastpak, F. Bandarian, A. Rezai, H.N. Badi and T. Emami, 2005. Psyllium decreased serum glucose and glycosylated hemoglobin significantly in diabetic outpatients. J. Ethnopharmacol., 102: 202-7.