Effect of Supplementation of Legume Fibre on Blood Glucose and Cholesterol in Selected Diabetics

BY

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Introduction

I. INTRODUCTION

"Health is man's natural condition, his birth right. It is the result of living in accordance with the natural laws pertaining to the body".

The world wide disorder, diabetes mellitus is recognised as a growing problem in developing countries due to the continuing advances in urbanisation and industrialisation.

The disease is very common in India, with the overall prevalence rate of 1.8 per cent amounting to less than 12 million diabetics in the country (Giri et al., 1987). According to Ahuja (1979) the prevalence of diabetes in South India is significantly higher in subjects whose income is above the mean and the prevalence is high among urban Indians.

Ramachandran (1986) reports that the prevalence was highest among Indians in 1975 and 1985. Diabetes is more prevalent in men than women. The ratio being 1.3:1.

Among U.S. population Non Insulin Dependent Diabetes mellitus is more prevalent in women than men. In Bangladesh male/female ratio is 7:1(Ibrahim, 1962).

Diabetes, the most common metabolic disease is responsible for most of the deaths occuring in India. It is a clinical syndrome characterized by Hyperglycemia, due to deficiency or diminished effectiveness in Insulin.

Diet plays an important role in all disease conditions. The diet should be well balanced with carbohydrate, protein, fat, minerals and vitamins. Inadequate calories, vitamins and proteins in the diet causes impairment of physical efficiency, impair s physical fitness and muscular weakness.

A well balanced diet should be modified according to the disease conditions. Modification may be made in the balance of nutrients such as high or low protein, carbohydrate, fat, minerals and vitamins(Sue Rod Williams, 1984).

Diet remains the cornerstone for diabetic patients especially non insulin dependent diabetics. The diets which are rich in fibre content seems to be very effective in reducing the blood sugar level as well as blood cholesterol level in diabetic patients.

According to Kritchevsky and Vahouny(1985) fibre is defined as "endogenous components of plant material in the diet which are resistant to digestive enzymes produced by man. They are predominantly non starch polysaccharides and lignin and may include, in addition associated substances".

Revellese et al,(1980) points out that plant fibres might have a therapeutic effect on glucose control and serum lipids in diabetic patients. The great part of these studies have been done with fibre added to meals, in form of guar gum, pectin, wheat bran and therefore the improvement in glucose control was ob tained. Indian diets like whole grain cereals, legumes, vegetables and fruits are rich sources of fibre. One of the

methods of incorporating fibre in the diet is through legumes.

Jenkins (1982) states that legumes are rich sources of soluble fibre. When it is incorporated in the diet the levels of both serum cholesterol and triglycerides have fallen. Decreases in serum triglycerides in diabetic patients on increased carbohydrate high fibre diets were also reported by Anderson and Ward (1978), and Albrink et al,(1979).

Glycemic Indexis based on the blood glucose response to the food in comparison with the response to an equivalent amount of glucose. Studies have indicated that the leguminous seeds produced lower blood glucose responses than cereal products and may be incorporated into therapeutic diets for diabetics(Jenkins et al., 1984).

Leguminous seeds have been shown to be potential benefit to diabetics either in a test meal situation or as part of a total diet plan. Legumes were confirmed as potential sources of slowly digested or sustained release carbohydrate for use in the diabetic diet. They are not only effective in diabetes but have a beneficial effect in lowering blood cholesterol level.

Studies have been done on the role of different types of foods in reducing the blood sugar level like Effect of fenugreek on blod glucose level, and Effect of bitter gourd in reducing the blood sugar level.

The glycemic Index of the many Indian foods are not known. Glycemic Index of foods in India is scarce especially in Tamil Nadu. Analysis of glycemic Index for the commonly consumed foods is very important in the development of therapeutic scienc:e.

In this line, the present study has been framed with the following specific objectives:

1. Study the glycemic response of diabetics supplemented with a legume fibre diet
2. Compare the glucose lowering effect of four different legumes commonly used in Indian dietaries.
3. Find out the effect of the legume fibre supplementation on the blood cholesteral level.

Review of Literature

II. REVIEW OF LITERATURE

The review of literature pertaining to the study on "**Effect of Supplementation of legume fibre on blood glucose and cholesterol in selected diabetics**' presented under the following headings:

A. Prevalence of Diabetes Mellitus

B. Management of Diabetes Mellitus

C. Complications in Diabetes

D. Glycemic Responses of Diabetic Patients to Various Foods.

A. PREVALENCE OF DIABETES MELLITUS

Diabetes mellitus is a heterogeneous primary disorder of carbohydrate metabolism with multiple etiologic factors that generally involve absolute or relative insulin deficiency of insulin resistance or both. All causes of diabetes ultimately lead to hyperglycemia, and glycosuria which are a hall mark of this disease syndrome(Olefsky, 1985).

Diabetes can be classified into two broad varieties. The individual totally or almost totally lacking insulin termed as 'Juvenile Onset' or 'Insulin Dependent' or 'Ketosis Prone' type of diabetic,since without insulin, death may occur in keto acidosis within a matter of days.

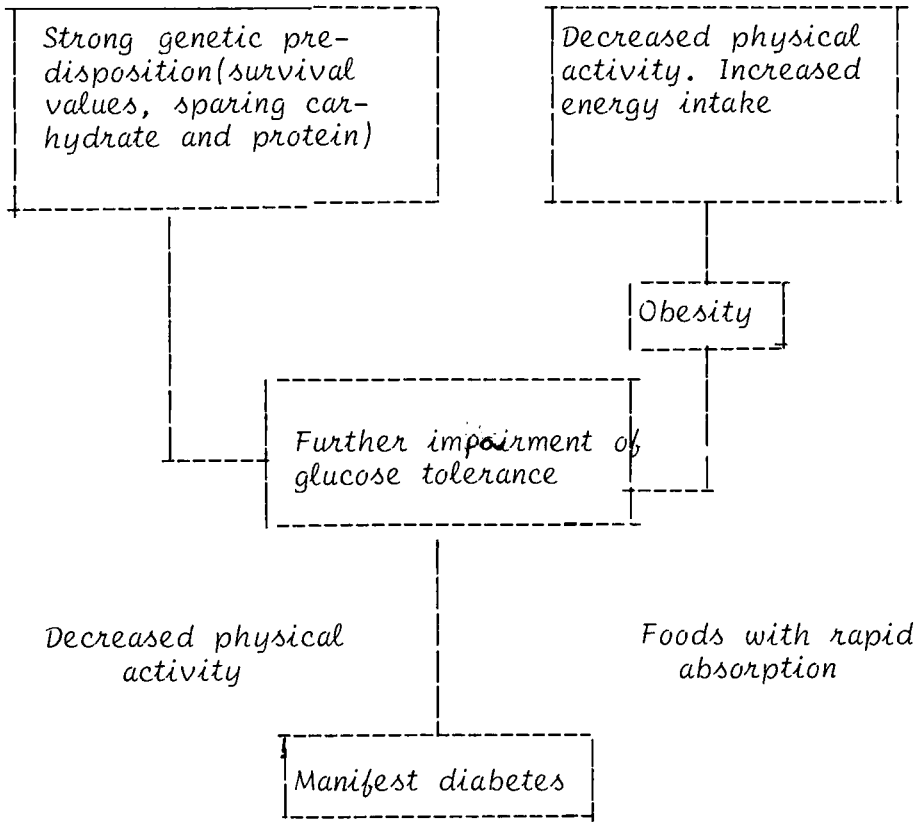
At the other end of the spectrum is the 'Stable' or 'Maturity Onset' or 'Non Insulin Dependent' individuals in whom there is relative deficiency of insulin(Alexander Marble *et al.*,1985).

NIDDM is associated with obesity in more than 80% patients, suggesting the possibility that this type of diabetes

may be due to disordered
mechanism of appetite regulation or energy expenditure. According to Hallfrisch(1987) the etiology of type II diabetes is heterogeneous.

Etiology

Cahill(1978), Bray (1979) and Keen and Jarrett(1979) explainthe development of maturity onset diabetes and putsforth the following causes:



Zawadzki and Ravussin(1988) suggests that the reduced thermic effect of glucose reported in obese NIDDM patients is primarily caused by an impairment of the glucose uptake and storage rates due to peripheral resistance.

According to Hoskins et al,(1989) the prevalence of diabetes mellitus is variable in the global population. The prevalence may be due toimproved nutritional state, urbanisation and increas ed life expectancy.

The disease is very common in India, with an overall prevalence rate of 1.8%(Giri et al., 1987). In South India the prevalence of diabetes is high among urban Indians. According to Mohan et al,(1989) obesity is an important risk factor in diabetes. Ramachandran et al,(1986) tells that only quarter of the diabetics are obese, but obesity is more common in women. The prevalence of Insulin dependent diabetes(IDDM) is believed to be low in Indians. Most of them are Non Insulin Dependent Diabetics.

Incidence

According to West (1978) the rate of juvenile diabetes in U.S. is roughly 7 times greater than in Japan. Viswanathan et al(1985) states that family history of diabetes was obtained in 40% of patients in USA and 60% in India. The incidence of diabetes has been reported to be much greater in some genetic subgroups than in the general U.S.population. These group include pima Indians(Knowler and Pettitt et al.,1987) mexican(Paisey et al., 1987) and mexican American(Rosenthal et al.,1987) puerto Ricans, Oklahoma Indians, Australians Aborigines and micronesians.

Snehalatha et al,(1981) found that patients in USA ate more fat and less carbohydrate compared to the patients in India. The diet of Indian patients are strikingly high in starch and fibre contents. The protein content of the diabe tic diet advocated

in India(Madras) is high due to the addition of vegetable protein. Mostly animal proteins are included in the western diet.

Predisposing Factors

Heredity is involved in the development of diabetes or its metabolic variations that lead to vascular complications. From the studies, it is now apparent that genetic factors are predominant in NIDDM.

Lee et al(1981) states that obesity is a major determinant in the etiology of NIDDM. He also noted that an inverse relationship between sugar intake and either obesity or diabetes. This inverse relationship between sugar intake and obesity as well as decreased glucose tolerance was confirmed by Keen et al(1979) in Britain.

Viral Factor

Several viruses, including mumps, rubella and coxsackie are being investigated. The frequency of any coxsackie viral antibody was significantly higher in young Ketosis Resistant Diabetics(YKRD) 80% and Young Ketosis Prone Diabetics(YKPD)65%(Singh et al., 1980).

Stress:

Infectious diseases such as influenza, pneumonia and scarlet fever, accidents or trauma or the physiological stress of pregnancy may precipitate symptoms of diabetes. Diseases of the liver, gall bladder, thyroid, pituitary, and pancreas are frequently associatedd with diabetes.

Trace Minerals

Diabetics excrete increased amounts of Zinc in their urine and that their plasma leucocyte and erythrocyte Zinc levels are

reduced. Another trace element possib ly involved in diabetes mellitus and glucose intolerance is chromium(Krause, 1984).

Shukla(1987) points out that in a diabetic person there is a marked alteration in the metabolism of lipids(fat) which on one hand causes down ward trend in the synthesis of fatty acids, while on the other hand the rate of Oxidation increases , thus the ability to dispose off the end products of fatty acids is reduced. This results in an accumulation of Ketones, due to which pH of the blood is lowered this leads to acidosis or ketosis which may lead to coma and death.

According to Shah (1983) in normal subjects glucose flows out of the pool exclusively into the peripheral tissues where it is metabolised to provide either energy or substances which take part in various synthetic processes. In diabetic patients a variable amount of glucose is lost from the pool into the urine, to an extent of 50-100 g per day or more.

In deed most of the Sugar in the human body is tied up in the glyco proteins. The glycoproteins are components of delicate membranes, all cells and the thicker structures upon which most cells rest. Glycoproteins also appear to be involved in the initial development of the disease by affecting the insulin producing pancreatic beta cells. Glycoproteins constitute a major metabolic path way of glucose utilization.

Spiro (1980) found that the kidney filter consists of a basement membrane to which cells are attached. In diabetes this basement membrane thickens considerably and filter loses its selectivity so that valuable proteins are lost in the urine.

B. MANAGEMENT OF DIABETES MELLITUS

Insulin administrations and commercial insulin preparations have been the corner stone of treatment of IDDM.

In IDDM there may be hyper insulinemia but the insulin is not effective because of aberrations or a decrease in the number of insulin receptor sites.

Oral Hypoglycemic Agents:

An antibacterial sulfonamide that was found to decrease blood glucose. Sulfonylureas may postpone the development of Impaired glucose tolerance(IGT) to manifest NIDDM. Newer sulfonylureas, such as glipizide and glyburide seem to be equally effective in reducing blood glucose levels(Arne Melander, 1987).

Effect of High Fibre Diet in Dieabetes Mellitus

Michalek (1987) defines dietary fibre, is the portion of the food that the human digestive system cannot digest. Humans do not have the enzymes necessary for breaking down the structural parts of plants such as skins, stems, seeds and pulp.

Fibre slows the digestion and absorption of fruit sugar(fructo se) and keeping the blood sugar level on an even in contrast to rapidly rising and quickly pulmmeting levels when concentrated sweets are eaten.

Fibre has most recently been defined as "endogenous components of plant material in the diet which are resistant to digestive enzymes produced by man. They are predominantly nonstarch polysaccharides and lignin and may include in addition associated substances"(Prosky, 1988).

According to Trowell (1974) dietary fibre has been defined physiologically as the sum of polysacharides and lignin not designed by the endogenous secretions of the human G.I. tract.

Dietary fibre is found only in plant products-fruits, vegetables, nuts and grains. The most concentrated sources of dietary fibres are whole grains, especially wheat bran. Because of their higher water content, fruits and vegetables provide less dietary fibre than the drier grains. Cooking of foods can cause browning reactions that increase the apparent fibre content of the food, since the browning products are analysed as lignin. Oatmeal is low in dietary fibre, but much of that fibre may be gums. Gums have been shoven to decrease serum cholesterol(Vahouny, 1982) and stabilize or reduce blood glucose(Anderson, 1982).

Legumes appear to be the champion of fibre sources.

How much fibre do we eat? Some approximations of desirable dietary fibre intakes have been presented and range from 25-50 gm dietary fibre per day according to Stephen(1981) and Mendeloff(1977).

Eastwood (1986) states that the total dietary fibre content of the diet is about as useful as stating the total vitamin content of the diet. Certain dietary fibre components have been found effective in the treatment of constipation, diverticular disease, diabetes and hyper cholesterolemia.

According to Simpson et al(1981) until recently the traditional diabetic diet contained 40% of total calories as carbohydrates. Recently Jenkins et al(1980) points out that High

fibre diets, comprising upto 75% of their total caloric intake as complex carbohydrate have allowed reduction or even withdrawal of insulin use in diabetics.

High Carbohydrate diet, low in Dietary Fibre showed no quantitative improvements in glycemic control. High carbohydrate High Fibre diets did show improvements in glycemic control(Arky et al., 1982). According to Bierman (1985) High carbohydrate, High fibre, low fat diet favourably influences the reduction of risk factors for the development of atherosclerosis.

Legumes contain High concentrations of water soluble components such as Pectin or guar gum and produces a favourable glucose and insulin response which significantly reduces serum cholesterol.

What ever the etiology of diabetes, any dietary factor which shows down the entry of glucose into the blood stream is likely to retard to reduce the expression of the disease. There is ample evidence that dietary fibre can play such a role(Royal College of Physicians, 1980).

Soluble fibres such as pectin, mucilage and guar are partly digested and absorb water in GI tract, forming a bulky gel. This gel slows the emptying time of the stomach contents, delaying the absorption of carbohydrate which aids in preventing the rapid influx of sugar into the blood Stream (Michalak, 1987).

Simpson et al(1981) confirmedin a well controlled study that a diet containing large amounts of legumes caused a modest reduction in fasting and post prandial glucose levels.

Rivellese et al (1981) clearly demonstrated that a normal carbohydrate, fibre rich diet improves metabolic control in diabetic patients.

Mainly soluble fibres will have a beneficial effect on post prandial plasma glucose and insulin levels(Eugenio et al., 1988).

The carbohydrate unrefined-which is to say it was both absorbable and Non absorbable carbohydrate(NAC). Non absorbable carbohydrate and the non carbohydrate lignin together constitute dietary fibre. Diets high in unrefined carbohydrate either do not lead to any deterioration or may actually improve carbohydrate control in Maturity Onset Diabetes(MOD).

Effect of Fibre on Insulin and Glucose Metabolism:

Ricardi et al(1984) demonstrated that fibre has effects which are independent of dietary carbohydrate. It must also be noted, that some evidence which suggests that fibre may be effective in reducing glucose and insulin levels when given in low carbohydrate diets.

Dietary fibres have been used successfully to treat diabetes with a reduction of the doses of insulin or hypoglycemic drugs(Wolever et al., 1978). The leguminous seeds are a rich source of dietary fibre in the form of galactomannans which are more viscous than the dietary fibre present in rice and wheat. Jenkins et al.(1978) had noted that guar gum a highly viscous substance reducing plasma glucose level.

A number of studies indicate that leguminous seeds(Grande et al.,1978) may lower the serum cholesterol in man and more recently legumes have attracted attention due to relatively flat blood glucose response they produce by comparison with their carbohydrate foods(Jenkins et al., 1982). Simpson et al(1981)

states that when diabetic patients were fed diets rich in leguminous seeds, in addition to improved glyceride levels were seen.

More recently studies by Anderson et al(1983) using high fibre diets aimed at improving diabetic control. According to Walther et al(1983) legumes also contain α-amylase inhibitors a proportion of which may survive cooking. It is possible that these are substances like them(Phytates) may also have an effect in reducing the rate of digestion and it is of interest that an anti amylase antisucrase which has been developed by pharmaceutical industry has been tested as a potential triglyceride lowering agent.

Potter et al.(1981) reported that the glucose responses in healthy were similar when either pito beans or all bran cereal was consumed. When single foods were consumed the glucose response was lower after consumption of legume seeds than of all bran cereal.

Jenkins et al.(1982) showed when Lentils were consumed at break fast there is low post lunch glucose response. Then Fleming et al.(1988) suggested that the low glucose responses observed after both breakfast and lunch reflected a lasting effect of legume seeds on attenuating post prandial glucose response.

According to Mohan et al.(1983) the High carbohydrate High Fibre diet helps in rapid as well as sustained control of hyper glycemia, helps to bring down hyper lipidemia and also aids to reduce the dose of anti diabetic drugs considerably.

Barbro Hagander (1988) concludes that the blood glucose levels were lower in NIDDM patients after the consumption of High fibre diet. The High fibre diet also resulted in lower levels of total cholesterol. The post prandial glucose responses to leguminous food and beet fibre meal are known to be flatter than for other low fibre meals. There is also decrease in the LDL cholesterol levels.

Abhimanyu et al(1988) conclude that the partial replacement of complex digestible carbohydrate with monounsaturated fatty acids in the diets of patients with NIDDM did not adversely affect plasmalipoproteins and may improve glycemic control. Diets with higher proportions of mono unsaturated fatty acids may be more palatable than low fat, high carbohydrate diets.

According to Mancini et al.(1980)normal carbohydrate, fibre rich diet gives better blood glucose control in diabetic than a traditional low carbohydrate(normal fibre) diet. Fibre reduces both total and LDL cholesterol and total and VLDL triglyceride in the blood without major changes in the other lipoprotein classes. Fibre has a hypotriglyceridemic effect.

In NIDDM current evidence, suggests that high fibre diets may offer some improvement in carbohydrate metabolism, lower total cholesterol and LDL cholesterol and have other beneficial effects. The present level of fibre intake is 15-30 g per day and it should be gradually increase to about 40 g per day(or 25 g per 1000 Kcal). Foods should be selected from a wide variety of choices to include both soluble and insoluble types of fibre(JADA NewsPrint).

Kris et al(1986) tells that relatively small amounts of legumes and beans in particular (100 to 150 g dry weight) can

be added to the diet without much dificulty and lower both plasma and TGL-s. Diets very high in both carbohydrate and fibre favourably affect fasting plasma triglycerides in hypertriglyceridemic individuals. According to Sharma (1984) legumes are rich sources of fibre in Indian diets. Pectin and gums form major components of legume fibre. When given in bengal gram lowered the cholesterol contents of serum liver.

Exercise:

Along with diet, drugs, education, exercise forms the fourth corner stones in the management of diabetes mellitus.

Benefits of Exercise:

Exercise leads to improvement in metabolic control.

Exercise facilitates reduction in the dosage of insulin and oral drugs.

Exercise helps in weight reduction.

Exercise leads to lowering of blood pressure which is commonly elevated in Diabetes.

Exercise helps in reducing blood levels of VLDL and LDL.

Exercise leads to improved physical fitness and stamina. Proper exercise is very useful and safe(Talwalker, 1988).

Education

"The American Hospital Association Bill of Rights" states that it is also the legal responsibility of the medical profession to the health care consumer to provide patient education as part of the total health care given(Krall, 1975).

Aims of Nutritional advice for Diabetics:

To maintain ideal body weight

To maintain or improve glucose tolerance

To maintain as near as practicable Euglycaemia.

To maintain normo lipidemia including cholesterol, triglycerides and HDL.

To allow ample physical activity(Flint, 1979).

C. COMPLICATIONS IN DIABETES MELLITUS

Acute Complications

Diabetic Keto Acidosis(DKA) is due to insulin deficiency. This occurs mostlyin Insulin Dependent Diabetes mellitus when there is insulin lack through either deliberate or unavoidable omission of prescribed insulin injections, an injection, surgical operation or other stress. Keto acidosis does not usually appear in maturity onset diabetics. The symptoms include thirst, dry mouth, flushed face, nausea, vomitting, abdominal pain,, cold and dry skin, characteristic acid breath(Keto acidosis), difficult breathing, head ache, dizziness, pain inback and legs.

Hypoglycemia

Insulin reactions occasionally experienced by diabetics result from the sudden decline of the percentage of glucose in the blood-hypoglycemia.

Signs and Symptoms

Sympathetic-faintness, weakness, pallor, tremulousness, nervousness, anxiety, irritability, hunger, palpitations, tachycarida and Diaphoresis.

Neuroglycopenic - Blurred vision, Diplopia, Lethargy, head ache, Inability to concentrate, loss of memory, confusion, paralysis seizures coma.

Chronic complications

Retinopathy

Retinopathy is a common and serious complication associated with Diabetes mellitus and increases with duration of the disease.

In USA more than 50% older onset diabetics have this complication. Prevalence rate in India is very low. Hypomegnesia is believed to be a risk factor for retinopathy(Raheja et al.,1988). A recent study shows that diet rich in pulses(lentils and dry legumes) and vegetables but limited in animal foods may have some protective action against the development of proliferative Diabetic Retinopathy(PDR).

Nephropathy

According to Bhupendra Gandhi(1988) Diabetic Nephropathy is the most important single disorder leading to renal failure in adults. Approximately 40% of IDDM and 0.25 to 1% of NIDDM patients progress to renal insufficiency and renal failure. There are 5 stages in Nephropathy.

Stage I - Hypertrophy and Hyper function of kidneys manifested by enlarged kidneys with increased glomerular filtration rate.

Stage II- Histopathology - No clinical signs and Symptoms, but renal lesion is present.

Stage III- This stage is found after 10 to 15 years of diabetes and characterized bymicro albuminuria along with hypertension.

Stage IV- Develops after 15-20 years of diabetes. There is overt prtoeinuria with hypertension. Glomerular filtration Rate is diminished for the first time.

Stage V- Develops after 20-25 years of diabetes and is characterised by end stage renal disease.

Neuropathy - Diabetic neuropathy is perhaps the most common disabling chronic complication of diabetes.

Degenerative vascular complications

The increased life span of the diabetic made possible by improved control of the disease. The vascular disease is of 2 types.

Atherosclerosis - It is not specific to diabetes, but it generally develops at an earlier age in diabetics and is the major cause of death in patients with maturity onset diabetes.

Microangiopathy - It has been stated that microangiopathy is seen clinical symptoms of diabetes and thus is independent of the hyperglycemia and metabolic changes of that disease.

According to Dandona et al (1981) blood vessels in diabetes may respond to anoxia and hypercapnia in such a way that compensatory falls in vascular resistance may not occur. Preston(1978) found that thepathogenesis of small vessel disease in diabetes is poorly understood. Diabetic microangiopathy is generally regarded as a pathological absnormality of the endothelial lining of small vessel.

Herman(1982) demonstrates that when diabetes develops serum uric acid level falls and continues to decrease with increasing duration of the disease. Uric acid excretion is enhanced by hyperglycemia. This enhancement is independent of diuresis. Obesity is associated with high serumuric acid and obesity precedes diabetes.

D. GLYCEMIC RESPONSES OF DIABETIC PATIENTS TO VARIOUS FOODS

The term 'Glycemic Index' has been applied to the degree of blood glucose response to the ingestion of specific carbohydrate foods in comparison with the response to a standard load, usuaully 50 g glucose or at times one slice of bread(Alexander Marble, 1985).

According to Gannon and Nuttall (1987) the purpose of these determinations is to systematically rank foods with respect to their quantitative effect on post meal glucose concentration.

Factors affecting starch digestibility and the glycemic response to leguminous seeds

Walton et al(1979) have shown that legumes produced decreased blood glucose responses compared with other High fibre foods. Legumes are an abundant sources of antinutriants. They contain enzyme inhibitors, lectins, saponins, phytates and tannins. Amylase inhibitors have been shown to survive cooking and inhibitors of bacterial origin reduce the rate of starch digestion and the glycemic response.

Jenkins et al(1984) present results indicate that white pea bean substitutioninto a test meal in place of bread reduced the glycemic response of NIDDM by more than 50%. However unlike the NIDDM results, no significant reduction was seen with IDDM patients.

Jenkins (1984) results demonstrate that the digestibility of a food is likely to be an important determinant of its glycemic response in diabetics. The increased carbohydrate intakes should be in the form of 'Complex' Carbohydrate high

fibre foods since diets high in fibre and high in carbohydrate have been shown both to reduce blood glucose excursions acutely and in the long term to improve many aspects of diabetic control. The dietary fibre guar was shown to reduce the acute glycemic response in normal subjects. In addition specific low glycemic index foods, ie. leguminous seeds have been shown to be of potential benefit to diabetics. Legumes were confirmed as potential sources of slowly digested or "Sustained release" Carbohydrate for use in the diabetic diet.

Low fibre diet containing such low glycemic foods as noodles(low fibre diet produced lower post prandial glucose and insulin responses. It appears that fibre is only one factor that may reduce the rate of digestion of a food and attenuate post prandial nutrient and endocrine responses with possible associated metabolic consequences. The alternations in the nature of the fibre eaten was reflected in the increased use of low glycemic Index foods such as oats, barley and legumes,which are rich in soluble fibre. Of interest was the reduction in urinary creatinine and urea outputs on the low glycemic index diet(Thompson, 1983).

According to Janel Kalmusky (1986) soluble and viscous fibres were most effective in reducing post prandial blood glucose and insulin levels. The soluble fibres eg: legumes and oat bran were also found to be the most consistently useful in the management of diabetes and hyperlipidemia. The fact that low glycemic index foods tend to be higher in fibre. The presence of the so called anti nutrients(lectins, saponins, phytates, tannins etc.) responsible for the low glycemic index of certain foods.

Upneja and Karmarker (1988) concludes that the fibres containing conjugated carbohydrates like galactomannans are more effective in their hypoglycemic response.

According to Behall (1988) plasma insulin response was significantly lower 30 and 60 minutes after the amylose meal than after amylopectin meal. Therefore the sustained plasma levels after the amylose meal with reduced insulin requirement suggest that amylose starch may be of potential benefit to carbohydrate-sensitive individuals or individuals with diabetes.

The small weight loss on the low glycemic index diet did not relate to lipid changes. Low glycemic index diets may be of use in the management of lipid abnormalities associated with hypertriglyceridemia.

Methodology

III. EXPERIMENTAL PROCEDURE

The experimental procedure followed in the present study on the **"Effect of Supplementation of Legume Fibre on Blood Glucose and Cholesterol Levels in Selected Diabetics"** is presented under the following headings:

A. Selection of the Legumes

B. Standardisation of Recipe

C. Selection of the Area

D. Selection of Subjects

E. Supplementation of Fibre Rich Diet

F. Evaluation Through Glycemic Response

G. Evaluation Through Blood Cholesterol Levels

A. Selection of the Legumes

The whole legumes are a rich source of dietary fibre in the diets and their effecti veness in controlling the blood glucose level, and lowering blood cholesterol level have been stressed by several nutritionists(Jenkins, 1984 and Anderson, 1984). Hence four legumes were selected for the present study as the source of fibre for supplementation. It was also ascertained that the legumes selected fulfilled the following characteristics:

1. The legumes were familiar to the subjects
2. They contained maximum amount of fibre
3. The legumes were capable of supplying minimum carbohydrate and protein of good quality, and
4. Easily digestible.

The four legumes thus selected were:

1. Bengal gram
2. Dry peas
3. Green gram

and 4. Horse gram

B. **Standardisation of the recipe**

Sundal was selected as the method of incorporation of legumes in the diet of diabetics because:

1. This was a traditional preparation of Tamil Nadu
2. All the four legumes lend themselves for this preparation.

and 3. Preparation and distribution to the subjects was easy.

Using a panel of 10 students from II M.Sc. class as judges, the preparation of sundal was standardised and the standard recipes thus finalised are given in Appendix I.

For further discussions the four standardised recipes are referred as test diets D-1, D-2, D-3and D-4 as given below.

D-1 Bengal gram sundal

D-2 Dry peas sundal

D-3 Green gram sundal

D-4 Horse gram sundal

The four recipes thus standardised and used for supplementation are presented in Plate 1. The total nutrient composition of 50g of the four fibre supplements finalised are presented in Table 1.

THE STANDARDISED SUNDAL PREPARATIONS

OF THE FOUR SELECTED LEGUMES

PLATE - 1

TABLE I

NUTRIENT COMPOSITION* OF THE FOUR TEST DIETS(Amount 50 g)

Diet	Legumes	Carbohydrate g	Protein g	Fat g	Fibre g
D-1	Bengal gram	30.5	9.0	2.7	2.0
D-2	Dry peas	28.6	9.8	0.5	2.2
D-3	Green gram	28.3	12.0	0.6	2.0
D-4	Horse gram	28.6	11.0	0.2	2.6

*Nutritive value of Indian Foods(ICMR, 1984).

C. **Selection of the Area**

The Arulvel Clinical Laboratory in Tirupattur town in North Arcot district was selected for the study because, there were adequate number of diabetic patients available, the authorities of the clinic were very much co-operative and helpful.

D. **Selection of the Subjects**

All the diabetic patients attending the Arulvel Clinic in Tirupattur town were observed and twenty Non-Insulin Dependent Diabetics(Type II) were selected for the study.

The subjects selected consisted of 12 males and 8 females, all of them doing moderate work, and were between 30 to 55 years of age. The duration of their diabetes range from 2 to 10 years. These twenty diabetics were divided into four groups of five subjects each for receiving the four leguminous fibre supplement. Each group had three males and 2 females, thus making the distribution of sex uniform in the four experimental groups.

Another group of five normal subjects comparable in age and sex were selected for comparison. Thus, finally five groups were formed. The four groups of diabetic patients constituted the experimental group for receiving the supplement and one group of normal subjects were kept as control group. The control group was not given any supplement.

A food weighment survey was conducted on all the selected subjects to examine the food and nutrient intake of the subjects, and ensure that there is no drastic variation among the subjects selected.

E. **Supplementation of Fibre-Rich Diet**

All the twentysubjects in the experimental group and the five subjects in the control group were requested to report in the clinic, and the purpose of the study and role of the subjects in the conduct of the study were explained with the help of the doctor. The subjects assured of their co-operation and help for the study..

The fibre supplementation was started after the initial blood glucose analysis. The suplementation was continued for a period of ten days. The supplement provided 29 g of carbohydrate on an average. Hence an equivalent amount of carbohydrate was calculated in the normal breakfast of the subjects and it was reduced from their breakfast during supplementation period.

The four experimental groups of subjects received the four different supplements for a period of ten days. But the control group of normal subjects were not given any supplement. At the end of ten days supplementation, the blood glucose response was again evaluated on all the diabetics.

F. Evaluation Through Glycemic Response

Glycemic response is a useful tool in the evaluation of diets for diabetics. Hence in the present study the glycemic response was calculated before and after the supplementation of the legume fibre.

The fasting blood glucose and the post prandial glucose levels after one hour and two hours of taking the normal breakfast without the supplement(130 g carbohydrate) were estimated for all the subjects. On the final day of the suppplementation again the glycemic response at fasting, one hour after breakfast and two hours after break fast were estimated. Since the control group of subjects did not receive any supplement glycemic response was calculated only once.

The glucose estimations were done using the glucose oxidatioon method gi ven by Dische et al(1955).

The procedure followed is presented in Appendix II.

The percentage glycemic response was calculated using the following formula,

The percentage glycemic Index at first hour =

$$= \frac{\text{Fasting blood glucose - blood glucose in 1 hr}}{\text{fasting blood glucose}} \times 100$$

The percentage glycemic Index at Second hour =

$$\frac{\text{Fasting blood glucose - blood glucose 2 hrs.}}{\text{fasting blood glucose}} \times 100$$

The values thus obtained were analysed statistically and the results examined.

G. Evaluation Through Blood Cholesterol Levels

As the non insulin dependent diabetics are always at risk for the increase in blood cholesterol level(Vinik, 1988), it was also considered of interest to study the ability of the legume fibre in controlling the blood cholesterol level. Hence the blood cholesterol levels were also assessed before and after the legume fibre supplementation. For the estimation of blood cholesterol the method (one step method of Wybenga and Pileggi[Wybenga et al.,1970]) was followed. The procedure used for the estimation of cholesterol is given in Appendix III.

The results obtained were statistically analysed and discussed.

Results and Discussion

IV. RESULTS AND DISCUSSION

The results obtained in the present study on "**Effect of Supplementation of Legume Fibre on Blood Glucose and Cholesterol Levels in Selected Diabetics**" has been statistically analysed and discussed under the following headings:

A. Food and Nutrient Consumption Pattern of the Normal and Diabetic Subjects

B. Effect of Legume Fibre Supplementation on Glycemic Response After One Hour

C. Effect of Legume Fibre Supplementation on Glycemic Response After Two Hours

and D. Efficacy of the Supplements in Lowering Blood Cholesterol Levels in Diabetics.

A. Food Consumption Pattern of the Normal and Diabetic Subjects

The food consumption pattern of the selected subjects were analysed and are presentedin Table II. The individual food consumption values are presented in Appendix IV.

TABLE II

FOOD CONSUMPTION PATTERN OF THE SELECTED SUBJECTS

Group	Cereals	Pulses	Green leafy vegetables	Roots and tubers	Other vege-tables	Fruits	Milk	Flesh Foods	Fats and oils	Sugar and jaggery
D-1	293	115	100	48	105	..	260	95	26	..
D-2	284	111	95	32	120	..	240	150	35	..
D-3	351	157	150	30	89	..	267	..	27	..
D-4	255	123	10	25	101	..	267	150	18	..
Control	376	93	143	87	86	46	440	..	53	33

Table II shows that the diabetic patients consume less cereal than the normal subjects. But the pulse consumption of the diabetics were more than the normal subjects. Except one group(D4) all the other three groups(D-1,D-2 and D-3) consumed more green leafy andother vegetables. All the four groups of the diabetics have restricted the consumption of roots and tubers. Milk, fats and oils consumption were also low in the case of diabetics. The diabetics did not ta ke any preformed sugar or jaggery. The above results show that all the diabetics were diet conscious and also that they have already received advise on the type of food to be included in their diet.

Table III presents the nutrient intake of the selected diabetic and the normal subjects. The individual values of nutrient consumption are presented in Appendix V.

TABLE III

THE NUTRIENT INTAKE OF THE SELECTED DIABETIC AND NORMAL SUBJECTS

Group	Energy (K.cal)	Carbohydrate g.	Protein g.	Fat g.	Fibre g.	Calcium mg.	Iron mg.	Carotene µg.	Vitamin A I.U.	Thiamine mg.	Riboflavin mg.	Niacin mg.	Vitamin C mg.
D_1	2108	334.0	68.2	55.7	11.1	960	36.4	2023	448	1.48	1.28	15.4	18
D_2	2256	363.9	69.3	56.4	14.5	1022	40.6	2610	479	1.51	1.18	13.6	30
D_3	2427	423.8	74.9	46.3	13.8	959	36.8	1780	358	1.95	1.44	16.9	33
D_4	1907	329.4	62.6	34.3	13.2	826	30.5	287	474	1.41	1.03	12.9	15
Control	3131	476.6	92.0	99.5	14.3	1309	51.9	5588	677	1.52	1.21	17.9	47
RDA*	**2800**		**55**			**400 to 500**	**24**	**3000**	**750**	**1.4**	**1.7**	**19**	**40**

*Recommended Dietary Allowances - ICMR(1984).

From Table III it is evident that the calorie consumption of all the diabetics were less than the RDA, whereas the normal subjects consume more than the RDA. The protein intake of all the subjects were more and the fat consumption was very much less. Though studies reveal an average fibre intake of about 22 g (Bingham, 1985) by Indians the subjects included in the present study consumed only about 11.1 to 14.5 (D-1 and D-2) grams of fibre. The intake was found to be adequate with regard to calcium, iron, Vitamin A and other B-complex vitamins. But the vitamin C intake was found to be inadequate in all the diabetic subjects. But the normal subjects consumed adequate amount of vitamin C. This may be due to the fact that the diabetics consumed less fruits.

Thus the food and nutrient consumption pattern revealed that the intakes were adequate, except fibre, vitamin C and energy. As energy reduction is recommended during diabetes especially in NIDDM, the subjects had reduced their energy intake. But regarding the fibre intake, (Vinik and Jenkins, 1988) have indicated that on an average indians consume about 25 g of fibre.

B. Effect of Legume Fibre Supplementation on the Glycemic Response After one Hour

Table IV presents the mean percentage glycemic response after one hour before and after supplementation. The individual values are presented in Appendix VI.

TABLE IV

THE MEAN PERCENTAGE GLYCEMIC RESPONSE AT ONE HOUR

(Before and After Supplementation

Group	Before Supplementation	After Supplementation	't' value
	Glycemic Response at one hour	Glycemic Response at one hour	
D_1	66.8 ± 18.9	65.0 ± 19.2	0.23
D_2	59.2 ± 35.1	35.4 ± 10.6	0.67
D_3	65.8 ± 18.8	21.2 ± 6.6	4.9**
D_4	48.6 ± 15.3	34.4 ± 29.3	0.67
Control	45.4 ± 14.5		

**Significant at one per cent level.

It was observed that the glycemic response after one hour was much higher than the values obtained for normal subjects. But three groups had registered lesser values(D-3 = 21.2; D-4 = 34.4 and D-2= 35.4) after the supplementation period, which shows that the fibre supplementation had aided in decreasing the glucose level.

When the four groups of diabetic subjects were compared, it was seen(Table IV) that group D-3(Green gram) had registered lowest value followed by horse gram, dry peas and Bengal gram. Only in the green gram group the difference in values before and after supplementation was significant at one per cent level. The difference was not significant in the other three groups.

C. **Effect of Legume Fibre Supplementation on Glycemic Response AfterTwo Hours.**

Table V presents the mean percentage glycemic responses after two hours before and after supplementation. Appendix VII presents the individual values.

TABLE V

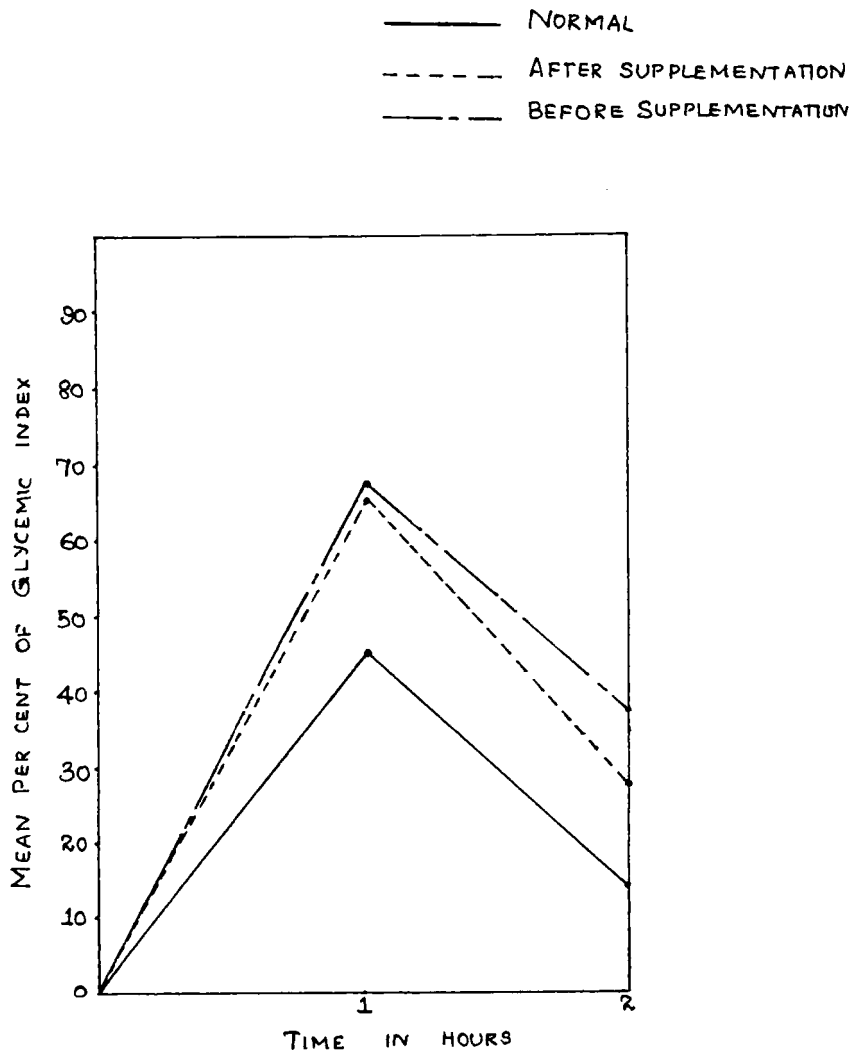
THE MEAN PERCENTAGE GLYCEMIC RESPONSE AFTER TWO HOURS

(Before and After Supplementation)

Group	Before Supplementation	After Supplementation	't' value
	Glycemic Response at Two hours	Glycemic Response at Two hours	
D1	37.6 ± 22.2	28.2 ± 13.0	1.54
D2	31.8 ± 17.2	12.0 ± 5.8	1.79
D3	48.6 ± 21.3	5.8 ± 6.4	3.08*
D4	48.6 ± 15.3	11.2 ± 17.4	0.7
Control	6.2 ± 8.3		

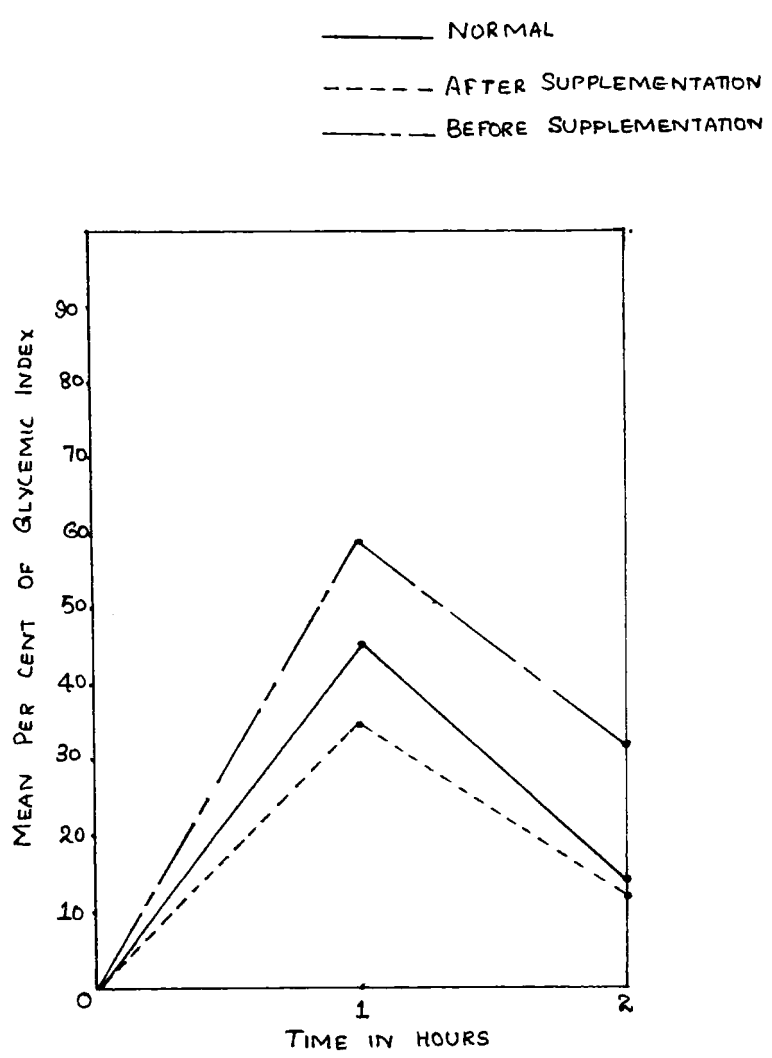
*Significant at one per cent level.

From Table V, it is evident that the glycemic response after two hours was also higher than the normal subjects before supplementation. But after supplementation the two hours glycemic response decreased very much. The glycemic response of the D-3 group supplemented with green gram had registered a value (5.8) lower than that registered by the control group(6.2). A slightly higher value wasregistered by the group fed horse gram(11.2) and the group fed dry peas(12.0). Only the Bengal gram fed group had registered a very high value of 28.2. Figure 1 to 4 shows



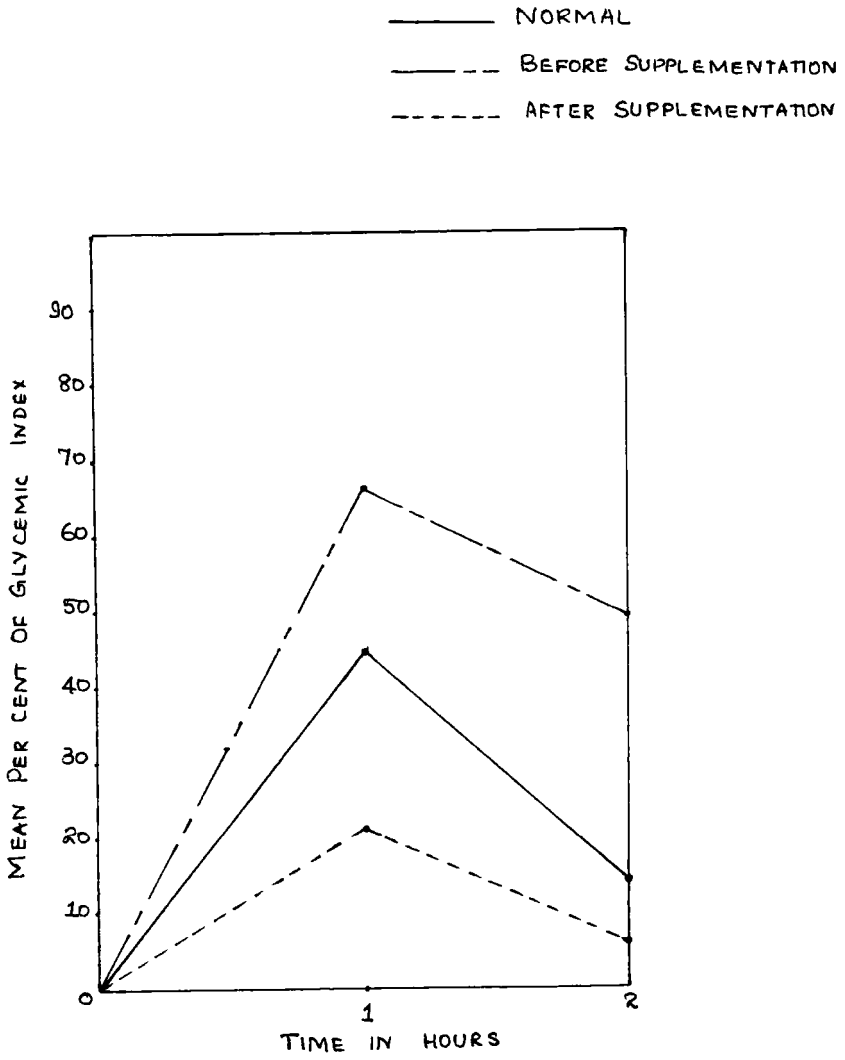
GLYCEMIC RESPONSE BEFORE AND AFTER SUPPLEMENTATION OF BENGAL GRAM (D-1)

FIGURE - 1



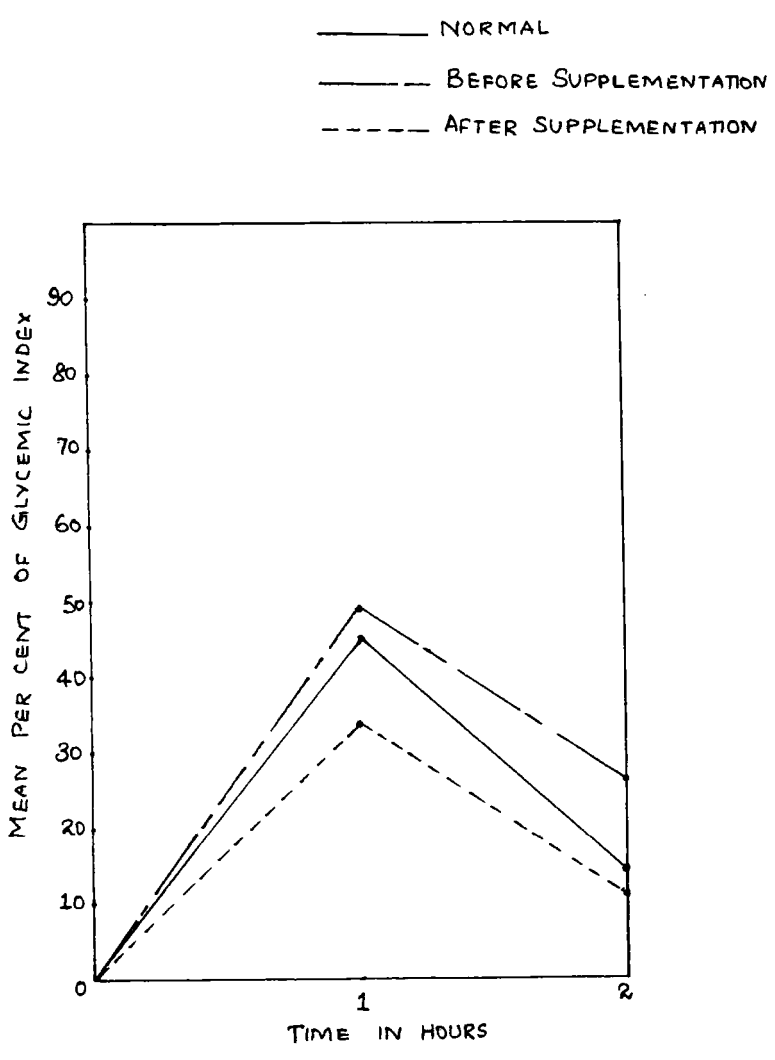
GLYCEMIC RESPONSE BEFORE AND AFTER SUPPLEMENTATION OF DRY PEAS (D-2)

FIGURE - 2.



GLYCEMIC RESPONSE BEFORE AND AFTER SUPPLEMENTATION OF GREENGRAM (D-3)

FIGURE -3



GLYCEMIC RESPONSE BEFORE AND AFTER SUPPLEMENTATION OF HORSE GRAM (D-4)

FIGURE - 4.

pictori ally the glycemic response before and after supplementation.

When the glycemic response before and after supplementation were statistically analysed it was shown that after supplementation the value registered by the green gram fed group was significantly lower. The values of other groups were not statistically significant.

D. Efficacy of the Supplements in Lowering Blood Cholesterol Levels in Diabetics

The mean blood cholesterol levels of the four groups of the diabetic subjects before and after supplementation and the mean valueobtained for the normal subjects are presented in Table VI. The individual cholesterol values registered before and after supplementation are presented in Appendix VIII.

TABLE VI

THE MEAN BLOOD CHOLESTEROL LEVELS OF THE SELECTED SUBJECTS

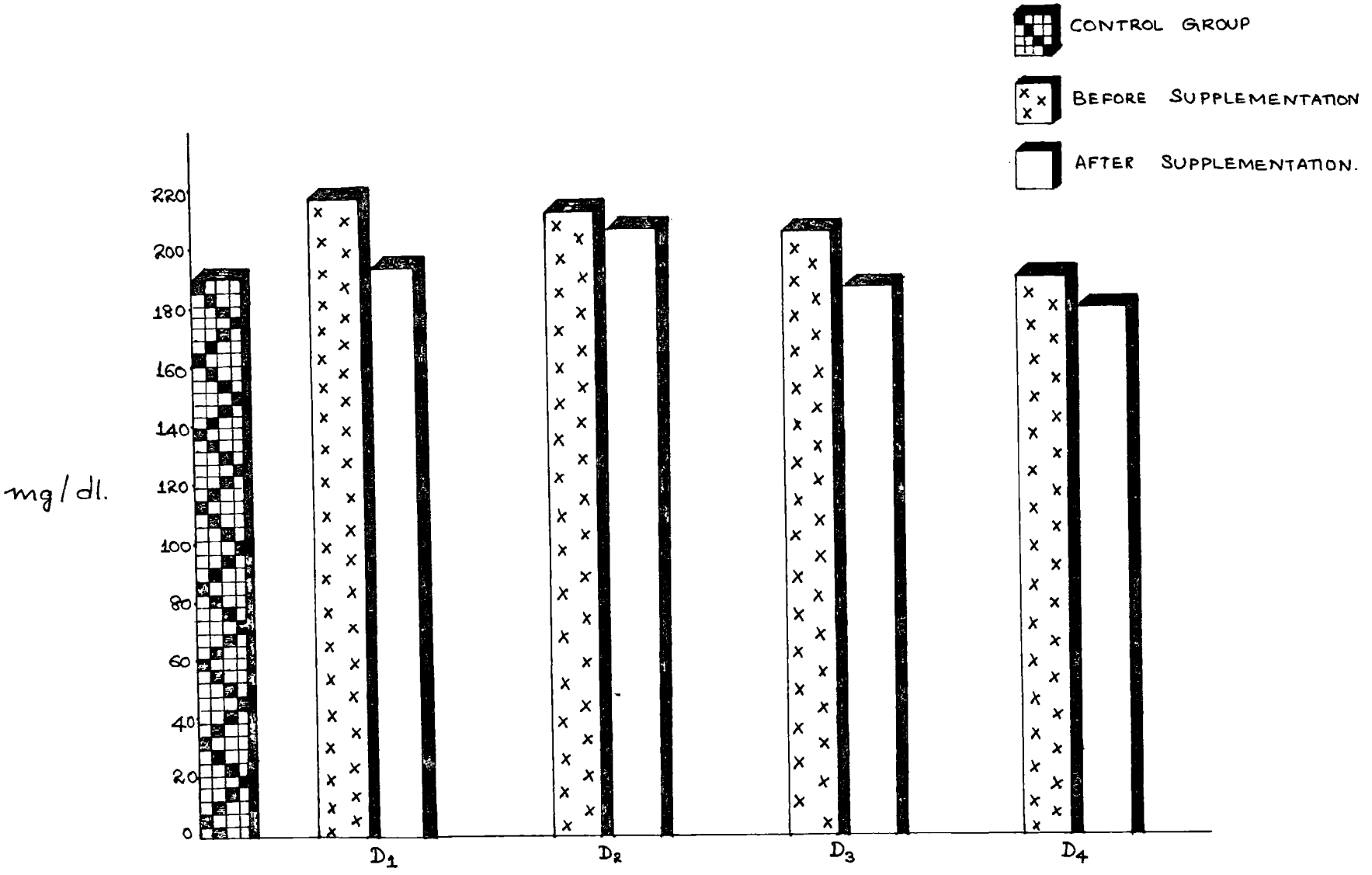
Group	Blood Cholesterol values(mg/100 ml)		't' value
	Before supplementation	After supplementation	
D1	217 ± 14	194 ± 19.5	2.15*
D2	211 ± 34.6	207 ± 31.2	1.63
D3	206 ± 10.19	187 ± 11.66	2.54*
D4	190 ± 12.6	180 ± 14.14	3.16*
Control	185 ± 22.36		
Normal value(Varley,1980)	140 - 250 mg		

*Significant at five per cent level.

Table VI shows that the mean blood cholesterol values were slightly higher than that of the value registered by the normal subjects. But at the same time all the values were within the normal range. But after supplementation even these values had decreased for all the groups. The decrease was significant at one per cent level in the case of all the groups except the group supplemented with dry peas. Figure 5 depicts the blood cholesterol levels before and after supplementation.

These results show that the legume fibres are effective in lowering blood cholesterol level also.

The study has confirmed the fact that the legumes which are a good source of fibres if included in the diet can well help in controlling the blood glucose level. Among the four legumes selected, green gram has shown better ability in lowering blood glucose level and also significantly lowered the blood cholesterol level. In general the legumes which are good sou rces of fibres can be used in the therapeutic diet for non-insulin dependent diabetics and hyper cholesterolemic patients. It is recommended that further studies on large number of diabetics may be conducted which may help in further disclosing the therapeutic values of plant fibres.



BLOOD CHOLESTEROL LEVEL BEFORE AND AFTER SUPPLEMENTATION.

FIGURE - 5

Summary and Conclusion

V. SUMMARY AND CONCLUSION

The present study on the "**Effect of Supplementation of Legume Fibre on Blood Glucose and Cholesterol Levels in Selected Diabetics**" aimed at evaluating the glycemic response of a legume fibre diet in a diabetic patients; to compare the efficacy of the four selected legumes in lowering bloc d glucose level in diabetics and to find out the effect of legume fibre supplementation on the blood cholesterol content of the blood.

Four legumes namely Bengal gram, dry peas, green gram and horse gram were selected as the source of fibre for supplementation in the diet of the diabetics. Sundal which is a South Indian preparation was selected as the method of preparation because four legumes lent themselves for this preparation. The recipe was standardised in the laboratory before supplementation.

Twenty non-insulin dependent diabetics attending a private hospital in Tirupattur were selected for the study. They were grouped into four groups of five diabetics each. A comparable group of five normal adults of the same age range served as the control for comparison.

The initial glucose tolerance and blood cholesterol levels of all the subjects were assessed before starting the supplementation. The food consumption pattern of the subjects were also assessed through a weighment survey.

The four legume preparations were served to the diabetics with their breakfast. The supplementation was continued for a period of ten days. The legumes were supplemented only for diabetics. On the tenth day of supplementation, again the blood glucose

tolerance and the blood cholesterol levels were analysed. The results thus obtained were statistically analysed and discussed. The results revealed the following:

1. From the food consumption pattern it was evident that the diabetic patients had restricted the consumption of cereals, roots and tubers, fats and oils and sugar and jaggery. They also consumed adequate amount of green leafy vegetables

2. The calorie consumption of all the diabetics were very much less than the RDA. The protein content of their diet was more, and fat and fibre contents of the diet were very much less. The fibre content of the diets of the diabetics and the normal controls were almost the same. The diabetics diets were deficient in Vitamin C content.

3. When the glycemic response after one hour was calculated, it was much higher than the values obtained for the normal subjects, before supplementation. But after supplementation the values had decreased showing the beneficial effect of the fibre diet. The group which was fed the green gram sundal had registered lowest value followed by horse gram, dry peas and Bengal gram.

4. The glycemic response after two hours also showed a similar trend ie. the values were very much higher before supplementation whereas, after fibre supplementation the glucose response was much lower. Here also the green gram fed group had registered a very low value equal to that of the normal subjects. This was followed by horse gram

dry peas and Bengal gram. The difference in the value registered by the green gram group before and after supplementation was also significant statistically.

5. The blood cholesterol values also decreased very much after the supplementation period. The difference in the values were significant at five per cent level for all the three groups except the group fed dry peas.

These results reveal the fact that the legume fibres can be effectively used in lowering blood glucose levels in diabetics. The whole legumes should be given an impor tant part in the diabetic diet. Among the various legumes green gram was found to be more effective in lowering blood glucose. These legume fibres have the dual benefit of lowering the blood cholesterol levels also. Further studies can be conducted on other fibrous foods to find out their therapeutic effects.

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Appendix

APPENDIX - I

STANDARDISED SUNDAL RECIPES

Bengal Gram Sundal

INGREDIENTS

i)	Bengal gram	50 g
	Big Onions	5 g
	Coriander leaves	5 g
	Green chillies	5 g
	Curry leaves	5 g

METHOD

1. The 50 g Bengal gram was soaked overnight.
2. The soaked ones were cooked by pressure cooking method.
3. With the Bengal gram onions and green chillies were added and pressure cooked.
4. Fat was not used for frying.
5. The cooked gram was sprinkled with coriander leaves, curry leaves and salt.

ii) Dry peas sundal

INGREDIENTS

Dry peas	50 g
Big onions	5 g
Coriander leaves	5 g
Green chillies	5 g
Curry leaves	5 g

METHOD

1. The 50 g dry peas was soaked overnight.
2. With the dry peas onions and green chillies were added and pressure cooked.
3. Fat was not used

4. The cooked peas was sprinkled with co riander and curry leaves and salt.

iii) **Green gram sundal**

INGREDIENTS

Green gram	50 g
Big onions	5 g
Green chillies	5 g
Coriander leaves	5 g
Curry leaves	5 g

METHOD

1. The green gram was not soaked overnight. It was just cooked by pressure cooking method. With the green gram, onion and green chillies were also cooked.

2. For the fat was not used for seasoning.

3. The cooked sundal was sprinkled with coriander leaves, curry leavesand salt.

iv) **Horse gram sundal**

INGREDIENTS

Horse gram	50 g
Big onions	5 g
Green chillies	5 g
Coriander leaves	5 g
Curry leaves	5 g

METHOD

1. The horse gram was also not soaked for overnight.

2. The 50 g Horse gram was pressure cooked for about 15 minutes, with onions and green chillies.

3. Then it is sprinkled with coriander leaves, curry leaves and salt. Fat was not used.

APPENDIX - II

ESTIMATION OF BLOOD GLUCOSE LEVEL - GLUCOSE OXIDATION METHOD

(Dische et al, 1955)

PRINCIPLE:

Glucose, on boiling with alkaline copper solution, reduces copper from cupric to cuprous state(cuprous oxide). The cuprous oxide so formed reduces phosphomolybdic acid to blue coloured molybdenum blue, which is measured colorimetrically. The intensity of blue colour is proportional to the amount of glucose. This reaction can be represented as:

i) Cu^{++} + Glucose $\xrightarrow{OH^-}$ Cu^{+}

ii) Cu^{+} + phosphomolybdic acid --- Cu^{++} + Molybdenum blue (blue colour)

REAGENTS: (Supplied in the Kit)

Reagent 1 :	Suphuric Acid, 2/3 N.
Reagent 2 :	Sodium Tungstate, 10%, W/v
Reagent 3 :	Alkaline Copper Reagent.
Reagent 4 :	Phosphomolybdate Reagent.
Reagent 5 :	Saturated Benzoic Acid solution.
Reagent 6 :	Stock Glucose Standard, 1% W/v.

PREPARATION OF WORKING SOLUTIONS

Working Standard : Dilute 1.0 ml of Reagent 6 (Stock Glucose Standard) upto 50 ml with Reagent 5.

All the reagents are ready for use.

PROCEDURE:

For spectrophotometer and colorimeter.

Step A. Deproteinisation of test sample: In a test tube.

Distilled water	: 2.6 ml
Blood	: 0.4 ml
Reagent 1: H_2SO_4, 2/3N	: 0.5 ml
Reagent 2: Sodium Tungstate 10% W/v	: 0.5 ml

Mix well and allow to stand at room temperature for 10 minutes and centrifuge or filter through Whatman No.1 filter paper.

Step B. Colour Development: In Folin-Wu tubes.

	Standard	Test(T)
Supernatant/Filtrate(from Step A) ..		1.0 ml
Working standard	1.0 ml	..
Reagent 3: Alkaline Copper Reagent	1.0 ml	1.0 ml
	Mix well and keep them in a boiling water bath for 10 minutes and cool them under running tap water.	
Reagent 4: Phosphomolybdate Reagent	1.0 ml	1.0 ml

Mix well and dilute the contents of each tube upto the 25 ml mark with distilled water. Mix by inversion and measure the O.D of Standard(S) and Test(T) against distilled water at 620 nm on Spectrometer or using Red filter on Colorimeter.

CALCULATIONS:

$$\text{Blood sugar in mg/100 ml} = \frac{\text{O.D. test}}{\text{O.D. Std.}} \times 200$$

NORMAL VALUES:

Fasting level	: 80 - 120 mg/100 ml.
Average Renal Threshold	: 180 mg/100 ml.

APPENDIX - III

ESTIMATION OF CHOLESTEROL (Wybenga, 1970)

CLINICAL SIGNIFICANCE:

High values may be found in diabetes mellitus, Hypothyroidism, obstructive jaundice, nephrotic syndrome, biliary cirrhosis, atherosclerosis etc. Low values may be found in hyperthyroidism, malnutrition, gaucher's disease and acute hepatitis.

PRINCIPLE:

Cholesterol reacts with hot solution of Ferric Perchlorate, Ethyl Acetate and Sulphuric acid(Cholesterol Reagent) and gives a lavender coloured complex, which is measured colorimetrically.

SAMPLE:

Serum/plasma (0.05 ml is required).

REAGENTS(Supplied in the Kit).

Reagent 1 :	Cholesterol Reagent.
Reagent 2 :	Working cholesterol Standard, 200 mg%
Reagent 3 :	Normal saline

PROCEDURE:

For Calorimeter/Spectrophotometer:

	Blank(B)	Standard(S)	Test(T)
Reagent 1:Cholesterol Reagent	5.0 ml	5.0 ml	5.0 ml
Reagent 2: Working Cholesterol Standard, 200 mg%	..	0.05 ml	..
Serum/plasma	..	..	0.05 ml

Mix well and keep the tubes immediately in the boiling water bath exactly for 90 seconds(1½ minutes). Cool them immediately under running tap water. Measure the O.D. of Standard(S) and Test(T) against

Blank(B)_ on a colorimeter with a yellow green filter or on a Spectrophotometer at 560 nm.

CALCULATIONS:

$$\text{Serum/plasma cholesterol in mg/100 ml} = \frac{\text{O.D. test}}{\text{O.D.Std.}} \times 200$$

Normal Values:

Normal value vary with diet and age.

Adults	: 130 - 250 mg/100 ml serum/plasma
Children	: Lower values are found.

APPENDIX IV

FOOD INTAKE

Group	Cereals	Pulses	Leafy Vegetable	Roots & Tubers	Other Vegetables	Fruits	Milk	Flesh foods	Oil and fat	Sugar and Jaggery
Group D_1										
A	300	125	..	..	150	..	100	..	25	..
B	330	115	100	..	60	..	400	..	25	..
C	370	235	..	..	..	..	100	..	15	..
D	270	50	..	35	..	..	300	45	20	..
E	195	50	..	60	..	..	400	150	45	..
Total	1465	575	100	95	210	...	1300	190	130	..
Mean	293	115	100	48	105	..	260	95	26	..
Group D_2										
A	250	120	..	15	145	..	400	..	25	..
B	350	150	150	30	130	..	300	..	50	..
C	330	185	115	45	80	..	400	..	35	..
D	250	50	..	40	125	..	..	..	25	..
E	240	50	20	30	..	..	100	150	40	..
Total	1420	555	285	160	480	..	1200	150	175	..
Mean	284	111	95	32	120	..	240	150	35	..

Group	Cereals	Pulses	Leafy Vegetable	Roots & Tubers	Other Vegetables	Fruits	Milk	Flesh foods	Oil and fat	Sugar and jaggary
Group D_3										
A	285	145	100	35	75	..	100	..	30	..
B	400	135	200	20	50	..	300	..	40	..
C	300	200	..	45	..	..	..	..	15	..
D	470	255	..	20	140	..	400	..	20	..
E	300	50	..	..	90	..	..	..	30	..
Total	1755	785	300	120	355	..	800	..	135	..
Mean	351	157	150	30	89	..	267	..	27	..
Group D_4										
A	275	105	..	25	125	..	..	..	15	..
B	240	110	..	30	120	..	..	..	15	..
C	130	90	..	..	60	..	200	..	15	..
D	350	155	10	20	..	..	300	150	35	..
E	280	155	..	..	100	..	300	..	10	..
Total	1275	615	10	75	405	..	800	150	90	..
Mean	255	123	10	25	101	..	267	150	18	..
Control										
A	390	30	70	110	80	40	500	..	45	30
B	285	120	100	50	60	45	400	..	40	30
C	450	65	200	100	80	55	400	..	70	..
D	390	95	200	35	70	50	500	..	80	60
E	365	155	..	140	140	40	400	..	30	10
Total	1880	465	570	435	430	230	2200	..	265	130
Mean	375	93	143	87	86	46	440	..	53	33

	Energy (Kcal)	Carbohydrate (g)	Protein (g)	Fat (g)	Fibre (g)	Calcium (mg)	Iron (mg)	Carotene (µg)	Vitamin A I.U.	Thiamin E (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin C (mg)
Group IV D_4													
a	1598	347.4	48	21.1	22.6	1284	37.8	393	..	1.65	0.79	6.12	155
b	1502	291.4	42.5	17.0	8.6	360	23.7	300	..	1.05	0.4	12.21	34
c	1273	212.4	40.6	28.9	8.6	768	20.2	205	522	0.83	0.91	6.95	16
d	2887	424.3	107.7	51	16.2	901	35.7	317	378	1.55	1.93	17.8	44
e	2276	371.5	74.5	53.5	10.3	819	35.1	218	522	1.98	1.13	21.6	58
Total	9536	1647	313.3	171.5	66.3	4132	152.5	1433	1422	7.06	5.16	64.6	307
Average	1907	329.4	62.6	34.3	13.2	826.4	30.5	286.6	474	1.41	1.03	12.9	61
Control													
a	2439	395.1	56.5	67.8	6.6	864	24.8	647	696	1.17	0.86	13.9	133
b	2593	410.4	106.4	72.9	11.1	1020	56.2	7354	522	1.37	1.02	15.9	200
c	4297	588.1	96.4	171.1	31.3	2095	66.3	14434	348	1.32	1.12	18.8	481
d	3467	494.2	82.1	126.5	11.7	1429	69.19	4973	1296	2	1.85	20.4	87
e	2860	495.6	118.8	59.6	11.2	1137	43.5	534	522	1.77	1.24	20.5	49
Total	15656	2383.4	460.2	497.9	71.9	6545	259.9	27942	3384	7.63	6.08	89.5	950
Average	31312	476.68	92.04	99.58	14.38	1309	51.9	5588.4	676.8	1.52	1.21	17.9	190
RDA	2800 (Moderate)		55			0.4-0.5 (g)	24	3000	750	1.4	1.7	19	40

APPENDIX V

NUTRIENT INTAKE

Group	Energy (kcal)	Carbohydrate (g)	Protein (g)	Fat (g)	Fibre (g)	Calcium (mg)	Iron (mg)	Carotene (µg)	Vitamin A I.U.	Thiamine B (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin C (mg)
Group I D_1													
a	2059	382.2	52.98	36.3	13.0	490	32.9	400	174	1.26	0.81	17.5	46
b	2391	373.4	71.35	68.1	9.6	1258	59.1	7772	522	1.62	1.71	20.1	179
c	2387	424.5	81.5	40.4	17.6	1323	41.5	339	174	2.11	1.11	13.7	23
d	1618	259.5	47.0	43.3	7.6	887	22.9	930	684	1.33	1.23	12.0	63
e	2087	230.7	88.6	90.7	7.7	840	25.6	674	684	1.1	1.54	13.9	40
Total	10542	1670.3	341.43	278.8	55.5	4798	182	10115	2238	7.42	6.4	77.2	351
Average	2108	334.0	68.2	55.76	11.1	960	36.4	2023	447.6	1.48	1.28	15.4	70
Group II D_2													
a	2027	333.4	63.2	47.3	12.4	911	3312	379	696	1.35	1.17	14.15	108
b	2793	446.2	87.5	71.4	13.6	1688	64.6	9116	348	1.45	1.52	16.9	178
c	2744	455.4	83.8	62.5	14.5	1025	46.0	1571	696	1.85	1.53	19.2	191
d	1723	327.0	36.2	29.13	22.9	1120	36.3	332	..	1.39	0.85	6.1	56
e	1995	257.5	75.9	72.0	9.3	367	23.4	1655	174	1.53	0.84	12.1	71
Total	11282	1819.5	346.6	282.3	72.7	5111	3482.3	13053	1914	7.57	5.91	68.4	604
Average	2256	363.9	69.3	56.4	14.5	1022	696.4	2610	478.5	1.51	1.18	13.69	120
Group III D_3													
a	2190	376.2	71.61	44.3	10.8	1159	40.3	7143	174	1.57	1.57	16.94	240
b	2936	465.6	79.4	83.0	14.2	913.5	36.9	629	348	2.54	1.37	21.7	295
c	1940	365.8	68.9	21.9	17.6	1304	36.6	398	..	2.12	1.0	9.13	6
d	3290	599.1	106.9	46.1	12.2	1054	48.8	386	552	2.18	2.44	25.3	59
e	1778	312.4	48	36.3	14.3	362	31.8	344	..	1.34	0.86	11.7	50
Total	12134	2119.1	374.8	231.6	69.1	4792.5	194.4	8900	1074	9.75	7.24	84.7	650
Average	2427	423.8	74.9	46.3	13.8	958.5	38.8	1780	358	1.95	1.44	16.9	130

APPENDIX VI

A. GLYCEMIC RESPONSE AFTER ONE HOUR BEFORE SUPPLEMENTATION

Groups	Individuals	Glycemic Response
D_1	A	41
	B	99
	C	59
	D	64
	E	71
D_2	A	35
	B	125
	C	45
	D	27
	E	64
D_3	A	79
	B	88
	C	53
	D	36
	E	73
D_4	A	25
	B	45
	C	45
	D	72
	E	56
Control	A	44
	B	66
	C	27
	D	33
	E	57

B. GLYCEMIC RESPONSE AFTER ONE HOUR AFTER SUPPLEMENTATION:

Groups	Individuals	Glycemic Response
D_1	A	65
	B	95
	C	34
	D	65
	E	66
D_2	A	18
	B	33
	C	48
	D	33
	E	45
D_3	A	18
	B	32
	C	13
	D	25
	E	18
D_4	A	13
	B	14
	C	44
	D	88
	E	13

APPENDIX VII

A. GLYCEMIC RESPONSE AFTER TWO HOURS BEFORE SUPPLEMENTATION:

Groups	Individuals	Glycemic Response
D_1	A	22
	B	79
	C	15
	D	36
	E	36
D_2	A	44
	B	57
	C	24
	D	7
	E	27
D_3	A	30
	B	57
	C	35
	D	87
	E	34
D_4	A	15
	B	28
	C	13
	D	36
	E	37
Control	A	0
	B	38
	C	0
	D	10
	E	21

B. GLYCEMIC RESPONSE AFTER TWO HOURS AFTER SUPPLEMENTATION:

Groups	Individuals	Glycemic Response
D_1	A	29
	B	48
	C	7
	D	27
	E	30
D_2	A	6
	B	7
	C	9
	D	20
	E	18
D_3	A	15
	B	24
	C	- 21
	D	12
	E	- 1
D_4	A	- 6
	B	- 6
	C	11
	D	64
	E	- 7

APPENDIX VIII

BLOOD CHOLESTEROL LEVEL BEFORE AND AFTER SUPPLEMENTATION:

Groups	Individuals	Before Supplementation mgs %	After Supplementation mgs %
D_1	A	200	190
	B	210	200
	C	225	160
	D	210	200
	E	240	220
D_2	A	200	200
	B	200	200
	C	210	200
	D	275	265
	E	170	170
D_3	A	190	190
	B	210	205
	C	220	190
	D	210	170
	E	200	180
D_4	A	190	170
	B	190	180
	C	190	190
	D	170 170	160
	E	210	200
Control	A	160	-
	B	185	-
	C	210	-
	D	210	-
	E	160	-