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IMPACT ASSESSMENT OF FIBER RICH SUPPLEMENT ON BLOOD GLUCOSE LEVEL OF DIABETICS

BY

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DISSERTATION

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CANDIDATE'S DECLARATION

I, hereby declare that the dissertation or part there of has not been previously submitted by me to any other University or Institute for a degree or diploma

Place: Parbhani

Date: 31/3 /2011

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This is to certify that **Miss SEEMA VIJAY MEDHE** has satisfactorily prosecuted her course of research for period not less than two semesters and that the dissertation entitled **"Impact Assessment of Fiber Rich Supplement on Blood Glucose Level of Diabetics"** submitted by her is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination.

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INTRODUCTION

CHAPTER I

INTRODUCTION

Diabetes mellitus places a very great burden on individuals, healthcare systems and societies in all countries. It is a chronic disease that has affected humankind through out the world. It affects persons of all ages and races. The disease reduces both a person's quality of life & life expectancy. In late decades it has emerged as a major health care problem in our country. India leads the world with largest number of subjects earning the dubitious distinction of being termed the "diabetes capital of the world" (Mohan *et al.*, 2007).

Diabetes mellitus is a chronic metabolic disorder that prevents the body to utilize glucose completely or partially. It is characterized by raised glucose concentrations in the blood and alterations in carbohydrate, protein and fat metabolism (Shrilakshmi, 2009). WHO diagnostic criteria for diabetes is – fasting plasma glucose 126mg/dl or 2–h plasma glucose 200mg/dl (WHO 1999). Type 2 diabetes is more prevalent in India. Prevalence of type 1 diabetes in India is also on the rise. According to the Diabetes Atlas published by the International Diabetes Federation (IDF) there were 40 million persons with diabetes in India in 2007 and this number is predicted to rise to almost 70 million people by 2025. It means then every fifth diabetic subject in the world would be an Indian (Joshi *et. al,* 2008).

Genetic predisposition combined with life style changes, associated with urbanization and globalization, contribute to this rapid rise of diabetes in India. Diabetes takes three major forms. Type 1 diabetes resulting from destruction of the beta cells in the pancreas, leading to absolute insulin deficiency. It usually occurs in children and young adults and requires insulin treatment. Type 2 diabetes, accounts for approximately 85 to 95 percent of all diagnosed cases and is usually characterized by insulin resistance. A third type of diabetes, gestational diabetes, is first recognized during pregnancy. Other rare types of

diabetes include those caused by genetic conditions (maturity-onset diabetes of youths), surgery, drug use, malnutrition, infections, and other illnesses (ICTPH, 2007).

Environmental factors include prenatal factors, obesity, physical inactivity, dietary and socioeconomic factors. Exposure to diabetes in uterus increases the risk of developing type 2 diabetes in early adulthood. Obesity and weight gain are the strongest and most consistent risk factors for diabetes and insulin resistance among different populations. A sedentary lifestyle and physical inactivity are associated with increased risks of developing diabetes. Increased affluence and westernization have been associated with an increase in the prevalence of diabetes in many indigenous populations and in developing countries.

People with diabetes play a central role in managing their disease. Thus, diabetes education is an integral part of diabetes care. The goal of diabetes education is to support the efforts of people with diabetes to understand the nature of their illness and its treatment; to identify emergency health problems at early, reversible stages; to adhere to self-care practices; and to make necessary changes in their diet and lifestyle (ICTPH, 2007).

Diet of diabetic person should have more amount of dietary fiber as it plays vital role in the health status of a diabetic person. Dietary fiber is the edible part of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Physical properties of dietary fiber are water holding capacity (WHC), cation binding capacity (CBC) and viscosity, whereas, physiochemical properties include hypoglycemic and hypolipidemic effects. Dietary fiber promote beneficial physiological effects including laxation and/or blood attenuation, (Hipsley, 1953).

Depending upon the solubility in water, dietary fiber is divided into two types as insoluble i.e. non viscous, slowly fermentable fiber, where as, other type is soluble dietary fiber which is viscous and fermentable. Total dietary fiber present in the food stuffs comprises both these fractions. The

insoluble dietary fibers are cellulose, lignin and some portion of hemicelluloses whereas, soluble dietary fiber fractions are pectin, gums, betaglucons, mucilage and major portion of hemicelluloses.

Dietary fiber and complex carbohydrates benefit Type 1 and Type 2 diabetes. Soluble dietary fiber such as pectin, gums, hemicelluloses increase intestinal transit time, delay gastric emptying, slow glucose absorption and lower serum cholesterol (Shrilaxmi, 2006). Insoluble dietary fiber reduces constipation and diverticulosis while soluble dietary fibers are effective in reducing incidences of cardiovascular diseases, noninsulin dependent diabetes mellitus and obesity. Soluble dietary fiber binds large quantity of water and becomes viscous in the stomach. There by it delays the secretions of gastrointestinal track which results into reduced digestion of food material and finally delaying the absorption of glucose. Due to delayed absorption of glucose, secretion of insulin by pancreas will also be delayed. Such condition result in activation of the receptors of the cells in target organs resulting in increased insulin sensitivity for glucose uptake by the cells. Hence, there will be reduction in the blood glucose level resulting in hypoglycemia.

Plant foods are the only sources of dietary fiber. Vegetables (particularly leafy), fruits, condiments, spices and unrefined whole grains are rich in fiber. Foods such as various gums viz. gum karaya, gum acacia, gaur gum, fenugreek seeds and supplements such as bran and psyllium are rich sources of dietary fiber. The suggested intake of total dietary fiber for diabetic person is 25 g / 1000 kcal energy (Raghuram *et al.*, 2006).

Many references support that the fiber supplement influences the glucose homeostasis and lower the risk of diabetes. Dietary fiber and type of carbohydrates have received particular interest due to their impact on postprandial glucose and insulin responses. There are several possible mechanisms that may explain the relationship between dietary fiber and glucose homeostasis.. Increased dietary fiber intake may reduce appetite and lower total energy intake, thus reducing the adiposity and improving insulin sensitivity.

Such supplements are available in the market. However, their prizes are not within the reach of common man. Therefore, keeping in mind the benefits of fiber supplement the present investigation was undertaken to develop a low cost fiber rich supplement from locally available foods. To study the benefits of developed supplement to diabetic patients, its impact was also assessed. The present investigation was planned with following objectives.

Objectives:

1) To develop a fiber rich supplement
2) To assess the nutritional quality of the developed supplement
3) To study the impact of developed fiber rich supplement on blood glucose content of selected diabetic patients.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Diabetes mellitus is the commonest metabolic abnormality in the world. The prevalence of diabetes is rapidly rising all over the globe at an alarming rate. The early identification of at risk individuals and appropriate intervention in the form of weight reduction, changes in dietary habits and increased physiological activity could greatly help to prevent, or at least delay, onset of diabetes and thus reduce the burden due to non communicable diseases in India. Short term studies with high fiber diet have been associated with reduction in post prandial glucose, serum cholesterol, triglyceride and insulin requirement in person with type 2 diabetes. Viscous fiber reduces post prandial increase in plasma glucose and insulin concentrations in normal diabetic subjects. Various studies conducted on these aspects at different places by various scientists are reviewed in this chapter under following subheadings

2.1. Diabetes : Prevalence, risk factors and complications

2.2. Glycaemic index

2.3. Role of fiber in diabetes mellitus

2.4. Role of fiber in other ailments

2.1. Diabetes : Prevalence, risk factors and complications

Robinson and Lawler (1972) defined diabetes as a genetically and clinically heterogenous group of disorders all of which show glucose intolerance. It is characterized by a partial or total lack of functioning insulin and alterations in carbohydrate, protein and fat metabolism.

To estimate the prevalence of diabetes and the number of people with diabetes who are =20 years of age of all countries of the world for three point in time, i.e. the year 1995, 2000 and 2025 and to calculate additional parameters, such as sex ratio, urban-rural ratio and the age structure of the diabetic population King *et al.* (1998) had carried out a research. Age specific diabetes prevalence estimates were applied to United Nations population

estimates and projections for the number of adults aged =20 years in all countries of the world. For developing countries urban and rural population were considered separately. Prevalence of diabetes in adults worldwide was estimated to be 4.0 % in 1995 and to rise to 5.4% by the year 2025. It is higher in developed than in developing countries. The number of adults with diabetes in the world will rise from 135 million in 1995 to 3300 million in the year 2025. The major part of this numerical increase will occur in developing countries. There will be 42 % increase from 51 to 72 million, in developed countries and a 170 % increase, from 84 to 228 million, in the developing countries. Thus, by the year 2025, >75 percent of people with diabetes will reside in developing countries as compared with 62 % in 1995. The countries with the largest number of people with diabetes are and will be in the year 2025, India, China and the US. In developing countries the majority of people with diabetes are in the age range of 45-64 years. In the developed countries the majority of the people with diabetes are aged =65 years. This pattern will be accentuated by the year 2025. There are more women than men with diabetes, especially in developed countries. In the future diabetes will be increasingly concentrated in urban areas.

To examine the relation between various sedentary behaviours, especially prolonged television (TV) watching and risk of obesity and type 2 diabetes in women Hu *et al.* (2003) had carried out a research. The study was conducted from 1992 to 1998 among women from 11 states. For obesity analysis 50,277 women and for diabetes analysis 68497 women were selected who were free from diagnosed cardiovascular disease, diabetes or cancer. All selected subjects completed questions on physical activity and sedentary behaviors at baseline. It was observed that, during 6 years of follow-up, 3757 (7.5%) of 50277 women who had a BMI of less than 30 in 1992 became obese (BMI - 30). Overall, 1515 new cases of type 2 diabetes were documented. Time spent watching TV was positively associated with risk of obesity and type 2 diabetes. In the multivariate analyses adjusting for age, smoking, exercise levels, dietary factors, and other covariates, each 2-h/d increment in

associated with a 23% increase in obesity and a 14% increase in risk of diabetes; each 2-h/d increment in sitting at work was associated with a 5% increase in obesity and a 7% increase in diabetes. In contrast, standing or walking around at home (2 h/d) was associated with a 9% reduction in obesity and a 12% reduction in diabetes. Each 1 hour per day of brisk walking was associated with a 24% reduction in obesity and a 34% reduction in diabetes. It was estimated that in cohort, 30% of new cases of obesity and 43% of new cases of diabetes could be prevented by adopting a relatively active lifestyle (-10 h/wk of TV watching and +30 min/d of brisk walking).

Wild *et al.* (2004) had carried out a research to estimate the prevalence of diabetes and the number of people of all age with diabetes for year 2000 and 2030. Data on diabetes prevalence by age and sex from a limited number of countries were extrapolated to all 191 World Health Organization members States and applied to United Nations population estimates for 2000 and 2030. Urban and rural population were considered separately for developing countries. From the findings of the study it was recorded that, the prevalence of diabetes for all age-groups worldwide was estimated to be 2.8% in 2000 and 4.4% in 2030. The total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030. The prevalence of diabetes is higher in men than women, but there are more women with diabetes than men. The urban population in developing countries is projected to double between 2000 and 2030. The most important demographic change to diabetes prevalence across the world appears to be the increase in the proportion of people >65 years of age.

Raghuram *et al.* (2006) classified diabetes as insulin dependent diabetes mellitus and non insulin dependent diabetes mellitus. IDDM affects children or adolescents. There is little or no production of insulin and as a result, such individuals require daily insulin injections. It is rapid in onset. The symptoms get severe, when insulin injections are discontinued. The diabetic develops a life-threatening metabolic complication referred to a ketoacidosis. NIDDM usually affects overweight or obese adult. The insulin production may be

usually affects overweight or obese adult. The insulin production may be normal or even high. However, the insulin produced is not as effective as normal insulin. The symptoms of disease are gradual in onset. In subjects with this type of diabetes, diet exercise or oral anti diabetic drugs may be enough to control the raised blood sugar.

Siddartha *et al.* (2010) had carried out a research to study an epidemiology of prevalence of type 2 diabetes among the adult residents in Ddakshina Kanada district. The study was carried out in and around Deralakatle, Manglore, Karnataka state, India. Venous blood sample (5ml each) was collected from the subjects in the morning after an overnight fast. Glucose concentration was determined. Detection of diabetes was done by estimating fasting and postprandial glucose as per WHO criteria. Detailed history was taken including their dietary habits and life style. Information regarding age, sex, religion, socio-economic status and duration of diabetes was also collected and pattern of distribution of diabetes in reference to these factors was assessed. It was observed that the prevalence of type 2 diabetes among the adult male was found to be 57% and that of female was 43%. In overweight male it was found to be 62 % whereas, that of overweight female was 53 % but it was found to be 38 % in adult obese male and 43 % in adult obese female. The prevalence of type 2 diabetes among the adult male of the age group of 35-44 years was found to be 13 %, for the age group of 45-54 years was found to be 32 %, for the age group of 55-64 years was found to be 38 % and for the age group of 65 years and above was found to be 117 %. It was found to be 31 % in the Hindu adults whereas, that of Christian and Muslim was 21 % and 43 % respectively. The prevalence of type 2 diabetes among the adult lower class was found to be 13% whereas, that of middleclass and higher class was 22% and 60% respectively. The prevalence of type 2 diabetes for the duration up to 5 years among the adult was found to be 58% whereas, that of adult patients up to the duration of 10 years, 15 years and above 15 years were 18%, 12% and 11% respectively.

2.2. Glycaemic index

Akanji *et al.* (1989) conducted a study on the dietary salt and the glycaemic response to meals of different fiber content. Ten healthy normal weight diabetic Nigerian persons were enrolled in the study. All were aged between 23.1 year ± 1.3 with body mass index (BMI) 19.9 ± 0.6, were consuming equal amounts of carbohydrates from glucose, boiled yam (low fiber content of 0.9 percent raw tuber weight) and boiled black eyed peas (fiber content of 1.8percent dry weight) with and without added table salt (4.25 g). The findings revealed that there was no significant difference in fasting, peak and 2-h plasma glucose concentrations and total and incremental areas under the 3-h glucose time curves in the subjects consuming each meal with and without added salt.

Glycaemic index of conventional carbohydrate meals was studied by Mani *et dl.* (1992). Thirty confirmed NIDDM patients were selected randomly from OPD of the diabetes clinic of the local general hospital. The glycaemc index and the triacylglycerol response were measured in selected subjects given 15 g portions of five different conventional Indian meals containing semolina cooked by two different methods or combination of semolina and pulse black gram dhal, green gram dal, and bengal gram dal. Oral glucose tolerance test was carried out for all the patients using 50 g glucose. It was noticed that there were no significant differences among meals in mean GI except for meals based on roasted semolina or semolina-black gram dal compared with the blood glucose response for a 50 g glucose load. Only meals based on steam cooked semolina and semolina-bengal gram dal elicited a significantly lower response at 1h post prandial, and only meals based on semolina-blackgram dal at 2h post prandial.

Hadole (1993) studied the glycaemic response of induced diabetic mice maintained on cereals and millet diets. Six groups of male Swiss mice (20 to 25 g) were maintained on the experimental diets. The mice in group I and II were fed synthetic diet and those in group III, IV, V and VI received respectively wheat, rice, jowar and bajra diets. After the 10 day acclimatisation to the

experimental diets, the mice in group II to VI were made diabetic. Group I mice were kept as normal control animals and group II mice served as diabetic control animals. Blood samples were collected from the mice in all the groups prior to induction of diabetes and subsequently on 10th, 20th and 30th days during post diabetic period for the analysis of blood glucose. From the findings of the study it was observed that the hyperglycemic response was more marked among the mice maintained on synthetic diet. The mice maintained on jowar diet showed lowest hyperglycemic response and diabetic mice maintained on wheat, rice and bajra showed similar effects like jowar.

Glycemic and lipemic response to various regional meals and South Indian snacks were studied by Mani *et al.* (1997). Thirty normal subjects were selected randomly who were free from any apparent complications. Enrolled subjects were within the age group of 18 to 24 years. They were further randomly subdivided into five groups comprising six subjects each. Each group was fed the test recipe. An oral glucose tolerance test was carried out for all the individuals using 75g glucose. Fasting and postprandial blood glucose was estimated. Plasma triglyceride response was determined (fasting and two hour postprandial). Within seven days, the subjects were given the test meal or snack containing 75g carbohydrate which was eaten in 8-10 minutes. Blood glucose and plasma triglyceride were estimated. Analysis was done on the blood samples by calculating the glycemic index of the foods. From the finding of the study it was documented that, South Indian snacks, *Bisbelle Bhat* and *Pongal* with *sambar* elicited the lowest glycemic response. Whereas current fast moving South-Indian snacks like *Dosai* with *Podi* and *Idli* with Chutney showed the highest glycemic response. Among regional meals, the South-Indian whole meal displayed the lowest GI as compared to the *Gujrathi* meal which showed the highst GI. The lipemic response was lowest showing a fall in triglyceride levels with the south-Indian whole meal (-6.3); whereas it was highest with the *Gujrathi meals* (+18.5), although the fat content of the recipes were similar (28.1g, 24.5g).

In the year 1999 Iyer *et al.* had carried out a study to assess the glycemic index of spirulina supplemented meals. Twenty four normal subjects in the age group of 20-25 years were selected for testing the glycaemic response of the recipies. The recipes tested were Punjabi meals with spirulina (R1), south Indian meals with spirulina (R2), *Gujarathi* meals with spirulina (R3) and West Bengali meal with spirulina (R4). Selected subjects ere supplemented with 2.5 g of spray dried spirulina powder. The subjects were fed equicarbohydrate meals providing 75 g of carbohydrates. On the first visit, an oral glucose tolerance test with 75 g of glucose was conducted for all the subjects. Serum glucose in fasting and post prandial, one and two hour was determined. On the subsequent visit (within 2 weeks) the subjects were given a test meal containing 75g carbohydrate which was consumed over an 8-10 minute interval. Blood glucose response and triglycerides were again monitored for the different groups, fed different meals. Blood glucose response curves for the glucose load and the test food were plotted and GI was calculated. The findings of the study revealed that the GI of Punjabi meal supplemented with 2.5g of spirulina was lowest (24.0 ± 16.64) whereas, the GI of Gujarathi meal supplemented with the same amount of spirulina was the highest (60.6 ± 21.89). GI of South Indian and West Bengali meal was 52.8 ± 21.18 and 58.0 ± 8.87 respectively. The least percentage rise from fasting to two hour post meal was found for Punjabi meal (3.3%). The remaining three test meals showed a rise in the range of 6.9-46 percent.

Torangatti and Naik (1999) reported the findings regarding the gycemic and lipemic response of composite foods in normal and NIDDM subjects. Eighteen type 2 diabetic adult subjects (16 males, 2 females) and 18 healthy adults, non diabetics (male 8, female 10) of Dharwad city and Haliyal town were selected for the study. Six composite foods which were commonly consumed in Karnataka viz. jowar roti + whole green gram bhaji, rice + red gram + dal curry, chapatti + cabbage bhaji, ragi balls + red gram + amaranthus curry, navani rice + curds + milk and bajara roti + brinjal bhaji were tested for glycemic and lipemic response in both normal and NIDDM subjects. Blood

glucose response after oral glucose tolerance test and the test meal were used to compute glycemic indices (GI). The results revealed a low glycemic index (55-65%) for all the six test meals. The GI of the millet based meal was the lowest, while the rice based meal recorded higher value in both the subjects, being higher in diabetic 60-65%) compared to normal (55-62%). The correlation between protein, fat and fiber content and GI of the test meals were found to be negative in both normals and diabetics. Besides, millet based test meals elicited the lowest triglyceride response and the rice based test meal higher, whereas the rest of the diets had intermediate responses.

Potdar (2002) conducted a research to assess glycaemic index of commonly consumed recipes of Indian diets in diabetic subjects. Twelve non-insulin dependent diabetic subjects and 15 commonly consumed recipes of cereals and pulses were selected for study. Majority of the selected diabetic subjects were 50 to 60 years of age. Each recipe was tasted on 6 subjects. A weighed amount of each food providing 25 g/ 50g carbohydrate was served to the selected diabetic subjects. Then blood glucose response values were recorded by using glucometer. Glycaemic index was calculated. The findings of the study inferred that among the cereal based recipes, lime rice showed significantly lowest glycaemic index (37.83 ± 2.08) while, *pohe* exhibited highest glycaemic index value (69.12 ± 11.89). Intermediate values of glycaemic index were recorded by *upma* and *paratha.* From the pulse recipes, *rajmah* had significantly lower glycaemic index (8.84 ± 0.38) while, *pithale* had the significantly highest glycaemic index (46.09 ± 9.90). The glycaemic index value of *chhole,* cow pea *usal,* peas *usal* and moth bean *usal* were 20.72 ± 3.91, 26.06 ± 2.00, 30.19 ± 4.80, 31.62 ± 24.00 respectively. The vegetable preparations, pumpkin *kheer* had the highest glycaemic index value of 12.98 ± 5.92. The remaining vegetable based preparations like cauliflower *subji,* raw sweet potato, potato *subji* recorded 15.45 ± 3.87, 19.67 ± 6.25 and 50.01 ± 1.20 glycaemic index values respectively.

2.3. Role of fiber in diabetes mellitus

Revellse *et al.* (1980) had carried out a study on effect of dietary fiber on blood control and serum lipoproteins in diabetic patients. To evaluate the effects of fiber rich diet on blood glucose and lipoprotein, eight diabetic patients, four on oral hypoglycemic drugs, were put on three different diets. For each consecutive 10-days period. Diet A had carbohydrate 53 % and fiber 16 g, diet B had carbohydrate 53 % and fiber 54 g, while diet C had carbohydrate 42 % and fiber 20 g. Findings of the study revealed that both the 2-h postprandial glucose and mean daily glucose level were significantly lower after diet B than after either of the two other diets. The similar effect was seen on total and LDL cholesterol levels. VLDL and triglyceride levels after diet B were significantly lower than those after diet A but most identical to those after diet C. HDL cholesterol concentration was not affected by dietary fiber but was significantly increased by the low carbohydrate diet.

Effect of test meal of varying dietary fiber content on plasma insulin and glucose response was determined by Potter *et al.* (1981). Eight healthy men of 22 to 45 years of age were enrolled in the study. Each meal provided 75 g of carbohydrates. The sources of dietary fiber were brown rice, pinto bean and all bran. All bran and pinto bean gave similar reduction in insulin level. The lowering effect of all bran (18 g) and pinto bean (16.2 g) on insulin response was attributed to the high fiber content of their sources.

Simpson (1981) suggested in his article high carbohydrate, fiber diet for diabetes that high amount of dietary fiber (85 g/day) in the form of leguminous vegetable, when fed to diabetics for six weeks significantly reduced blood sugar level and postprandial glycaemic response.

Kay (1982) had defined dietary fiber as plant-derived material that is resistant to digestion by human alimentary enzymes. Further it is reported that dietary fiber is of clinical significance in certain disorders of colonic function and in glucose and lipid metabolism. Certain types of fiber decrease the role of

the role of glucose absorption and adequate postprandial rises in blood glucose and insulin.

Heaton . ⁄ ⁄ (1983) in literature titled dietary fiber in perspective of human nutrition recorded that addition of gaur gum and pectin reduces plasma glucose and insulin response. The important physiological effect of dietary fiber is 'Slow in fast out'.

Ray *et al.* (1983) reported the findings regarding the long term effects of dietary fiber on glucose tolerance and gastric emptying in NIDDM. Experimental period was two months. Dietary fiber used for supplementation was 20 g gaur gum and 10 g of wheat bran per day. Addition of fiber significantly reduced urinary excretion of glucose from 30.81 ± 6.0 g to 8.3 ± 2.0 g (24 hour) and fasting plasma glucose concentration from 301 ± 24 mg to 184 ± 15 mg/day. Hence, they indicated that long term fiber supplementation was responsible for improvement of postprandial glucose curve in diabetics.

A study on effect of high fiber breakfast on glucose metabolism in NIDDM was carried out by Parson (1984). Carbohydrate content of breakfast was 50 g. The test breakfast differed primarily in fiber content. Standard breakfast contained 3 g bran where as the test breakfast was enriched with fruit and bran or bran to 18 g. They found that high fiber breakfast reduced plasma glucose level ($P < 0.05$) over 800 minutes when compared with control breakfast.

Anderson *et al.* in 1987 summarized number of studies that used adequate controls were two weeks or longer in metabolic ward or six week or longer in ambulatory populations, had minimum eight subjects, and an increase of 20 g/day of fiber from foods or 8 g/day from supplements. Of the eight studies of supplemented diet reviewed, and the 11 studies of high fiber diet reviewed, 17 studies, reported decreased fasting blood glucose levels ranging from 6 to 39 %, 13 of which were statistically significant.

A study on effect of bran of different cereals, hulls of different pulses and fenugreek seeds on blood glucose response in normal and diabetic subjects was carried out by Deshpande (1987). Results of the study indicated that there

was no significant effect of brans in lowering blood glucose of normal subjects where as in diabetics green gram hull and Bengal gram hull showed a significant effect in lowering blood glucose response. The fenugreek seeds showed significant blood glucose reducing response in the diabetics, while in normals the effects was non significant.

Mani and Mani (1987) had investigated the effect of wheat bran supplementation on blood sugar, glycosylated protein and serum lipid in NIDDM subjects. Wheat bran supplementation (11gm/day) was carried out for a period of two months in 30 maturity onset diabetics. The efficacy of bran supplementation was monitored by measuring the fasting and 2 h post prandial blood sugar levels. Glycosylated serum protein levels, glycosylated albumin levels and serum lipid and lipoprotein cholesterol levels were analyzed. The result indicated a transient reduction in fasting and 2 h postprandial blood sugar levels after one month bran therapy. No appreciable changes in the serum glycosylated protein levels, glycosylated albumin levels, serum lipids and lipoprotein cholesterol levels were observed during the period of supplementation.

Geeta and Eswaran (1990) estimated the hypoglycemic effects of millet incorporated breakfast items in selected non insulin dependent diabetic patients. A total of 30 non insulin dependent diabetic patients were selected and divided into 4 experimental groups receiving one millet of each group. Four millet namely ragi, maize, jowar and samai were incorporated into the diet of the subjects. The findings revealed that fiber rich millet when incorporated into the breakfast items reduce the blood glucose levels. The millet ragi brought the highest reduction followed by samai.

Murthy and Easwaran (1990) reported the findings regarding the hypoglycemic effect of fenugreek on blood glucose levels in selected diabetic patients. The study was conducted on 6 normal subjects and 5 NIDDM patients. Eye tone reflectance meter was used to assess blood glucose of subjects. From the results of the study it was observed that the fenugreek lowered the blood glucose in both normal and diabetic subjects. This indicated

that common condiments had hypoglycemic property and can be beneficially used by diabetic patients.

Sharma *et al.* (1990) studied the effects of fenugreek seeds on blood glucose and serum lipids in type 1 diabetes patients. Ten insulin dependent diabetes patients were selected and defatted, debittered fenugreek seeds (100g) powder was supplied them by incorporating in chapattis. Supplement was given in two equal doses. The results of the study indicated that the mean fasting blood glucose levels after fenugreek diet consumption were significantly reduced from 15.1 ± 2.4 to 10.9 ± 2.75 mmol/L. the fenugreek diet also reduced the 24 hour urinary excretion of sugar to the extent of 54 percent from 363 ± 71 to 167 ± 61 mmol/L. It was also observed that serum total cholesterol, LDL, VLDL and triglyceride levels were significantly reduce after the consumption of fenugreek diet as compared to controlled diet. The study concluded that 100 g fenugreek per day has beneficial effects in diabetic patients.

The effect of consumption of powdered fenugreek seed on blood sugar and HbA_{1c} levels in patients with type 2 diabetes mellitus was analyzed by Zargar *et al.* (1992). Forty-two patients who attended the outpatient clinic were chosen for the study based upon certain definite criteria. They were then divided into 3 groups comprised 14 patients who were fed 10 g of powdered fenugreek seeds per day. Group II comprised 14 patients who were not fed any powder but were continued on the diet and drug regimen already prescribed. Patients were assessed for 6-week fortnight. The results inferred that the blood sugar levels in group II showed a significant drop in fasting sugar levels (175 ± 74.2 to 108.5 ± 31.4, postprandial = 18.7 ± 56.6), but the decrease was insignificant in Group I and II. The difference in HbA_{1C} levels was statistically insignificant.

Wolever and Jenkins (1993) reported the findings regarding the effects of dietary fiber and foods on carbohydrate metabolism. The results of the study showed that gaur gum, adequately mixed into a food, reduced the postprandial blood glucose response by 44 %, pectin reduced it by 29 %, pysellium by 29 %,

other gelling fibers (gum tragacanth, methyl cellulose, locust bean gum, agar, konjac mannan) by 23 %, wheat bran by 27 %. Other non gelling fibers besides wheat bran, that were studied reduced postprandial blood glucose response by 17 %.

Dietary fiber as it is edible parts of plant or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary fiber includes polysaccharides, oligosaccharides, lignin and associated plan substances. Dietary fiber promote beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation (AACC, 2001).

In the year 2002 Chandalia *et al.* at Dallas carried out a research on beneficial effects of high dietary fiber intake in patients with type 2 diabetes mellitus. In a randomized, crossover study, 13 patients with type 2 diabetes mellitus were assigned to follow two diets, each for six weeks. A diet containing moderate amounts of fiber (total 24-8g soluble and 16g insoluble) (American Dietetic Association Diet), and high fiber diet (total 50g - 25g soluble and 25g insoluble). Both the diets were prepared in research kitchen and had the same macronutrient and energy content. Findings of the study showed that the mean plasma glucose was lower when patient completed the high fiber diet than with the ADA diet. Daily plasma glucose concentration were 10 percent lower with the high-fiber diet than with the ADA diet, and plasma insulin concentrations were 12 percent lower. Glycosylated hemoglobin values were slightly lower after the high-fiber diet. As compared with ADA diet, the high-fiber resulted in a lower fasting plasma total cholesterol concentrations by 6.7 percent, a lower plasma triglyceride concentration by 10.2 percent, and lower plasma VLDL concentration by 12.5 percent. The fasting LDL cholesterol concentration was 6.3 percent lower with the high fiber diet. There were no significant differences between the two diets in terms of the fasting plasma HDL cholesterol concentration. As compared with the ADA diet, high-fiber diet decreased gastrointestinal absorption of cholesterol by 10

percent and increased fecal acidic sterol excretion by 41 percent, but did not significantly affect the excretion of neutral sterol.

Schulze *et al.,* (2004) studied the glyceamic index, glyceamic load and dietary fiber intake and incidence of type 2 diabetes in younger and middle-aged women. There were 91,249 female nurses assigned for study who were 24-44 year of age at the starting of the study. Dietary intake of participants was assessed by semi quantitative food frequency questionnaire. The women were followed for 8 years for the development of type 2 diabetes. During 8 y of follow up 741 new cases of type 2 diabetes were documented. Among the study population of 91,249 women, higher glycaemic index was related to higher carbohydrate intake, higher glycaemic load, higher trans fatty acid intake, lower alcohol intake, lower total fiber intake, lower magnesium and caffeine intakes, lower physical activity. Participants with diets relatively high in glyceamic load and cereal fiber were less likely to smoke, reported less frequently a family history of diabetes and a history of hypertension, and were average leaner and more physically active. Glyceamic load and cereal fiber intake were positively related to carbohydrate and total fiber intakes and inversely related to saturated fat, monounsaturated fat, trans fat, alcohol and caffeine intakes, whereas cereal fiber intake was positively related to magnesium intake. Increasing glyceamic index was strongly associated with a progressively higher risk of type 2 diabetes. A significant inverse association between total dietary fiber intake and risk of diabetes was observed. It was observed that, high intake of cereal and fruit fiber were associated with a lower risk of diabetes.

Qi *et al.,* (2006) had conducted a study to examine the association of dietary fibers and glyceamic load with plasma adiponectin in diabetic women. He had also investigated the modification effects of obesity. A cross-sectional analysis in 902 women with type 2 diabetes was conducted. Dietary information was obtained by food frequency questionnaires. It was observed that intakes of cereal fiber and fruit fiber were significantly associated with an increasing trend of plasma adiponectin concentrations. Adiponectin

concentrations were 24 percent higher in the highest compared with the lowest quintile of cereal fiber. Dietary glyceamic load and glyceamic index were significantly associated with lower plasma adiponectin concentrations. The present differences in adiponectin concentrations between the highest and the lowest quintiles of dietary glyceamic load and glyceamic index were 17 and 18 percent. The association between dietary factors and plasma adiponectin were consistent across lean (BMI <25), overweight (BMI< 30) and obese (BMI=30).

Weickert *et al.*, (2006) had reported the findings that cereal fiber improves whole body insulin sensitivity in overweight and obese women. A randomized, controlled, single-blind, cross-over study was performed, and 17 overweight or obese subjects with normal glucose metabolism were analyzed. After consumption of nine macronutrient- matched portions of fiber enriched bread (white bread enriched with 31.2 g insoluble fiber/day) or control (white bread) over a time period of 72 h, whole body insulin sensitivity was assessed by euglycemic-hyperinsulinemic clamp. Energy intake was individually adjusted by providing standardized liquid meals. Hydrogen breath tests were performed to control for dietary adherence. The findings revealed that whole-body glucose disposal was improved after fiber consumption. Thirteen subjects had increased hydrogen breath test concentrations after fiber consumption. It was concluded that the increased insoluble dietary fiber intake for 3 days significantly improved whole-body insulin sensitivity. The findings also suggested a potent mechanism linking cereal fiber intake and reduced risk of type 2 diabetes.

Dietary fiber intake, dietary glyceamic load and the risk for gestational diabetes mellitus (GDM) was studied by Zang *et al.*, in the year 2006. A sample of 13,110 eligible women was selected. GDM was self reported and validated by medical record review in a subsample. It was documented that 758 incident GDM cases were recorded during 8 years of follow-up. It was observed that, the total dietary fiber, cereal and fruit fiber were strongly associated with GDM risk. Each 10 g/day increment in total fiber intake was

associated with 26 percent reduction in risk; each 5g/day increment in cereal fiber or fruit fiber was associated with a 23 percent or 26 percent reduction, respectively. Dietary glyceamic load was positively related to GDM risk. The combination of high glyceamic load and low cereal fiber diet was associated with 2.15 fold increased risk compared with the reciprocal diet. From the above study it was concluded that, in pregnancy diet might be associated with GDM risk. In particular, diet with low fiber and high glyceamic load was associated with an increased risk.

Barclay *et al.*, (2007) had conducted a study on glyceamic index, dietary fiber, and risk of type 2 diabetes in a cohort of older Australians, 1,833 participants were selected. Type 2 diabetes was self reported and validated by medical record. The findings of this study revealed that, during 10 years of follow-up, 138 incident cases of type 2 diabetes were identified among 1,833 participants. It was documented that, vegetable fiber had a significant inverse association with risk of type 2 diabetes. After stratifying by age, a significant negative association between vegetable fiber and risk of incident diabetes was found in the age and sex-adjusted model, but not after multivariate adjustment, in individuals aged <70 years at baseline. No association were found for those aged > 70 years at baseline (26 percent of the cohort). For all ages combined, there were positive trends of association between GI and risk of diabetes, but none reached statistical significance. In the age-stratified and multivariate analyses, a significant positive association between GI and incident diabetes was found for individual aged < 70 years at baseline, but no association was found for those aged >70 years.

Natale *et al.*, (2009) conducted a research to study the effects of a plant based high-carbohydrate / high fiber diet versus high-monounsaturated fat / low-carbohydrates diet on postprandial lipids in type 2 diabetics patients. According to randomized crossover design, 18 type 2 diabetic patients aged 59±5 years, BMI 27±3 kg/m^2 satisfactory blood glucose control on diet or diet plus metformin followed a diet relatively rich in carbohydrates (52 percent total energy), rich in fiber (28g/1000kcal), and with a low glycaemic index (58

percent) (high-carbohydrate/high fiber diet) or a diet relatively low in carbohydrate (45 percent) and rich in monounsaturated fat (23 percent) (low-carbohydrate/high-monounsaturated fat diet) for 4 weeks. Thereafter, they shifted to the other diet for 4 more weeks. At the end of each period, plasma glucose, insulin, lipids, and lipoprotein fractions were determined on blood samples taken at fasting and over 6 h after a test meal hawing a similar composition as the corresponding diet. In addition to a significant decrease in postprandial plasma glucose, insulin responses, and glyceamic variability, the high carbohydrate / high fiber diet also significantly improved the primary end point, since it reduced the postprandial incremental areas under the curve (IAUCS) of triglyceride - rich lipoproteins.

In the year 2009, Wanammetee *et al.* had conducted a study on association between dietary fiber and inflammation, hepatic function, and risk of type 2 diabetes in older men. Three thousand four hundred twenty eight non diabetic men aged 60-79 years were selected as participants. They were followed up for 7 years, during which 162 incident cases of type 2 diabetes were recorded. The findings of the study revealed that, low total dietary fiber (lowest quintile < 20g/day) was associated with increased risk of diabetes after adjustment for total calorie intake and potential confounders. This increased risk was seen separately for both low cereal and low vegetable fiber intake. Dietary fiber was inversely associated with inflammatory markers (c-reactive protein, interleukin-6) and with tissue plasminogen activator and a- glutamyl transferase. From this study it was concluded that dietary fiber is associated with reduced diabetes risk, which may be partly explained by inflammatory markers and hepatic fat deposition.

2.4. Role of fiber in other ailments

Hypocholesterolmic effects of a dietary fiber supplement was assessed by Hunninghake *et al.,* (1994). The cholesterol lowering effects of a fiber supplement were evaluated in patients with mild to moderate hypercholesterolemia. After a 9 week diet stabilization period patients were randomly assigned to treatment with 10 or 20 g / d of the fiber supplements or

with a matching placebo. The findings of the study showed that, among patients who completed the 15 week treatment period, total cholesterol, LDL cholesterol, and the ratio of LDL to HDL (LDL / HDL) were significantly reduced for the 10 and 20 g/d groups compared with the placebo group. In the placebo group and 10 and 20g/d groups the percent changes in total cholesterol were 0.4 percent, 5.8 percent and 4.9 percent in LDL cholesterol were 0.4 percent, 8.1 percent and 7.3 percent and in LDL/HDL were 1.0 percent, 5.6 percent and 8.7 percent respectively. The fiber supplement had no significantly effects on HDL cholesterol or triglycerides. The changes in lipoprotein concentrations could not be attributed to changes in diet or body weight because there were no significant changes in these variables during the 15 wk. treatment period.

Jenkins *et al.*, (1999) had tested the effect of wheat bran particle size on laxation and colonic fermentation. Two studies, each with three phases, were undertaken in healthy subjects in a randomized crossover design. In one study (metabolic, n = 23) subjects took three diets containing either an additional 19 g/d dietary fiber with mean particle size (MPS) 50 μm or 758 μm in bread or a control low fiber bread. In the other study where the supplement was provided as a breakfast cereal (ad libitum, n = 24) the respective wheat bran mps were 692 μm and 1158 μm and the control was low fiber. Fecal collection were obtained during the last week of each diet. In the metabolic study, fecal short chain fatty acids were measured and 12 hours breath gas collection obtained. It was observed that in both studies, wheat bran supplement significantly increased fecal bulk compared to the control with no significant difference between bran of different particle size and no differences in fecal water content. However, higher fecal butyrate concentrations, butyrate output and breath CH_4 levels were seen on the low MPS wheat bran compared to the other two treatment, suggesting increased bacterial fermentation.

Knopp et al. (1999) had investigated the long term blood cholesterol lowering effects of a dietary fiber supplement. Subjects were randomly assigned to receive 20 g/d of the fiber supplement (n=87) or matching placebo

(n=82) for 15 weeks and then received the fiber supplement for 36 weeks. The mean decreases during the 15 week period for LDL cholesterol, total cholesterol and LDL-C/HDL-C ratio were greater in the fiber group. The mean changes from pretreatment values in LDL-C, TC and LDL-C / HDL-C ratio for subjects in the fiber group were 0.51 mmol/L (12.1 percent) 0.53 mmol/L (8.5 percent) and 0.30 (9.4 percent) respectively. The corresponding changes in the placebo group were 0.05 mmol/L (1.3 percent), 0.05 mmol/L (0.8 percent) and 0.05 (1.5 percent) respectively. The fiber supplement had no significant effects on HDL cholesterol (HDL-C) triglyceride, iron, ferritin or vitamin A or E levels. Similar effects were seen over the subsequent 36-week non comparative part of the study.

Vuskan *et al.* (1999) had carried out an investigation to study the effect on laxation and serum lipid metabolism of novel source of wheat fiber and protein produced by the amylolytic digestion of starch from wheat. Twenty four healthy subjects were selected (12 men and 12 female). All subjects were of age 21-60 yrs. The test supplement and the positive control, American Association of Cereal Chemist wheat bran supplement, both provided the same amount of fiber (21 g/d) and the negative control supplement provided 1-7 g fiber/d. The findings of the study indicated that, the test supplement and the positive control supplement increased fecal bulk similarly (239-5±19 and 216.7±19 g/d respectively) and significantly more than did the negative control supplement (165.6 + 16 g/d). Compared with the negative and positive control supplements, the week 2 value of the test supplement for the ratio of total to HDL cholesterol was significantly reduced.

Gallaher *et al.* (2002) conducted a study titled a glucomannan and chitosan fiber supplement decreases plasma cholesterol and increases cholesterol excretion in overweight normocholesterolemic humans. Twenty one overweight normocholesterolemic subjects (11 males and 10 females) were fed 2.4 g / day supplement containing equal amount of chitosan (aminopolysaccharide found in the exoskeleton of arthropods and certain fungi) and glucomannan. Prior to taking the supplement (initial period) and after 28

days (final period) blood was drawn for measurement of serum lipids and a three day fecal sample collected for determination of fat, neutral sterol and bile acid excretion. Subjects maintained their normal dietary and activity patterns during the study. Calorie intake and intake of fat and dietary fiber (excluding the supplement) did not differ between the initial and final periods. Serum total, HDL and LDL cholesterol concentrations were significantly lower in the final period compared to the initial period. Serum triglycerol concentration did not change between periods. There was a trend towards greater fecal excretion of neutral sterols and bile acids in the final period. However, fecal fat excretion did not differ between periods.

An investigation was carried out by Liu *et al.* (2002) to examine the hypothesis that higher intake of dietary fiber is inversely related to the risk of cardiovascular disease (CVD) and myocardial infarction (MI) in a large prospective cohort of women. A semi-quantitative food frequency questionnaire was used to assess dietary fiber intake among 39,876 female health professionals with no previous history of CVD or cancer. Women were frequently followed for an average of six years. For incidence of nonfatal MI, stroke percutaneous tran-sluminal coronary angioplasty, coronary artery bypass graft or death due to CVD confirmed by medical record or death certificates. During 6 yrs 570 incident cases of CVD were documented, including 177 M1s. A significant inverse association was observed between dietary fiber intake and CVD risk. Comparing the highest quintile of fiber intake (median: 26.3g/day) with the lowest quintile (median:12.5g/day) the relative risk (RR) were 0.65 for total CVD and 0.46 for MI. Inverse relations were observed between both soluble and insoluble fiber and risk of CVD and MI, and among those who had never smoked and those with body mass index <25.

Mozaffarian *et al.,* (2003) had conducted a research to study the relation between cereal, fruit and vegetable fiber intake and the risk of cardiovascular disease in elderly individuals. This study was conducted from 1989 to june 2000. Population based, multicenter study among 3588 men and women aged 65 years or older and free of known CVD at baseline in 1989-1990. Usual

dietary fiber consumption was assessed at baseline (mean participant age, 72 years) using food frequency questionnaire. During 8.6 years mean follow-up, there were 811 incident CVD events were observed. Fruit, vegetable fiber and cereal fiber consumption was inversely associated with incident CVD with 21% lower risk in the highest quintile of intake, compared with the lowest quintile. In similar analyses, neither fruit fiber intake nor vegetable fiber intake were associated with incident CVD. When CVD events were separately evaluated, higher cereal fiber intake was associated with lower risk of total stroke and ischemic stroke and a trend toward lower risk of ischemic heart disease death. In a post hoc analysis, dark breads such as wheat, rye or pumpernickel were associated with a lower risk of incident CVD rather than cereal fiber from other sources.

Schatzkin *et al.* (2008) had carried out a study to determine the relationship between intake of dietary fiber/whole grains and the incidence of small intestinal cancer. In this study data collected from 293,703 men and 198,618 women in the National Institute of Health-AARP diet and Health study was analyzed. Multivariate Cox proportional hazards models were used to estimate relative risk (RR) and 2-sided 95 percent confidence intervals for quintiles of dietary fiber and whole grain intake. Through 2003, 165 individuals developed small intestinal cancers. Dietary fiber/whole grain intake was generally associated with a lower risk of small intestinal cancer. The multivariate RRs were 0.79 for total dietary fiber, 0.51 for fiber from grains, and 0.59 for whole grain foods. Intake of fiber from grains and whole grain foods was inversely associated with small intestinal cancer incidence; the RR values were consistent with those from the same dietary factors for large bowel cancer in this cohort.

Streppel *et al.* (2008) had conducted a research to study recent and long-term dietary fiber intake in relation to coronary heart disease and all-cause mortality. One thousand three hundred and seventy three middle-aged men selected as the subjects to investigate the effects of recent and long term dietary fiber intake on mortality. The follow-up period was 40 years. Information on

habitual food consumption was collected by using the cross-check dietary history method. It was reported that during 40 y of follow-up, 1130 of the 1373 men participants died. A total of 348 men died of CHD. Every additional 10 g of recent dietary fiber intake per day reduced coronary heart disease mortality by 17 percent and all-cause mortality by 9 percent. The strength of the association between long-term dietary fiber intake and all cause mortality decreased from age 50 yrs until age 80 yrs. It was observed that clear associations for different types of dietary fiber. A higher recent dietary fiber intake was associated with a lower risk of both coronary heart disease and all-cause mortality. For long term intake the strength of the association between dietary fiber and all-cause mortality decreased with increasing age.

Theuwissen and Mensink in the year 2008 had studied the relation between water-soluble dietary fibers and cardiovascular disease. It is estimated that for each additional gram of water-soluble fiber in the diet serum total and LDL cholesterol concentrations decrease by 0.028 mmol/L and 0.029 mmol/L respectively. Despite large differences in molecular structure no major differences existed between the different types of water-soluble fiber, suggesting a common underlying mechanism. As a result hepatic conversion of cholesterol into bile acids increases, which will ultimately lead to increased LDL uptake by the liver.

Barclay (2009) had conducted a study titled dietary fiber may help to prevent body weight, waist circumference gain. This study consisted of 89,432 European participants, aged 20 to 78 years, without cancer, CVD, and diabetes at baseline. Validated, country specific, food frequency questionnaires were used to obtain dietary information. Average duration of follow-up was 6.5 years. The results indicated that, there was an inverse association of total fiber intake with subsequent change in weight and in waist circumference. For each 10 g/day increase in total fiber intake, the pooled estimate was 39 g/year for weight change and 0.08 cm / year for waist circumference change. For each

10 g /day increase in fiber intake from cereals, there was a weight change of -77 g /year and change in waist circumference of - 0.10 cm / year. Fruit and vegetable fiber was not associated with weight change. However, the association of fruit and vegetable fiber intake with change in waist circumference was similar to that seen for intake of total dietary fiber and cereal fiber.

MATERIAL AND METHODS

CHAPTER III

MATERIALS AND METHODS

The present study was designed to determine the impact of fiber rich supplement on blood glucose content of selected diabetic patients. The investigation was carried out in two phases. During phase I a fiber rich supplement was developed and analyzed for its nutrient content. During phase II impact of fiber rich supplement was assessed on diabetic patients.

3.1. Phase I – Development of fiber rich supplement

For development of fiber rich supplement different variations of the product were prepared and their acceptability was evaluated. The highly accepted variation among all variations was analyzed for nutrient composition. The below given steps were adopted for development.

3.1.1. Selection and procurement of fiber rich foods

By referring the 'Nutritive Value Book' published by National Institute of Nutrition (Gopalan *et al.*, 2004) and other literature the fiber rich foods viz. gum acacia, wheat bran, aniseed, coriander seed, cumin seed and omum were selected for supplement development. The listed good quality foods were procured from local market. The ingredients were cleaned to remove dust or dirt if any.

3.1.2. Preparation of powders of ingredients

The cleaned gum acacia, wheat bran, aniseed, coriander seed, cumin seed and omum were used in powdered form. The ingredients were roasted and were ground to make powder. Prepared powders of the different ingredients were stored in air tight containers.

3.1.3. Preparation of fiber rich supplement

Different variations of fiber rich supplement were prepared by using powders of selected foods. Sixteen combinations of the selected ingredients were tried and were given for the taste to a group of people. Based on the opinions of majority of the people,three variations were finalized (Annexure I).

P1 - Preparation of fiber rich supplement

3.1.4. Organoleptic assessment

The acceptability of the developed supplement variations under study was assessed by conducting sensory evaluation.

3.1.4.1. Selection of panel members

The sensory threshold test was carried out on 20 persons in view of selecting them as panel members for sensory evaluation. Different concentrations of solutions viz. citric acid, sugar and salt were prepared as described by Ranganna (1979). Twenty members were requested to evaluate solutions for strength of different tastes. Considering the accuracy in evaluation of taste, 15 panel members were selected out of 20 to act as judges for sensory evaluation of developed products.

3.1.4.2. Sensory evaluation of selected recipes

Different variations of selected developed products were evaluated by conducting sensory evaluation by selected panel members. All the selected panel members were requested to evaluate the recipes by using 9 point Hedonic rating test (Shrilakxmi, 2004) for ranking the responses. The judges were requested to score the products for different sensory characters namely color, texture, flavor, taste, appearance and overall acceptability. The range of score varied between1 to 9. The judges were requested to evaluate the products with the help of given score card (Annexure I

3.1.5. Final selection of variation

Among the three variations of the product prepared and evaluated by sensory evaluation, one variation was selected for further research. The basis for final selection of the variation was maximum mean score of acceptability of that variation.

3.1.6. Nutrient analysis

The best accepted fiber rich supplement was biochemically analyzed for assessing its nutrient content. The proximate composition (moisture, protein, fat, carbohydrates, total fiber and total minerals), trace elements (iron and zinc), total dietary fiber, soluble fiber and insoluble dietary fiber were estimated. The proximate composition was estimated as per procedure

P2 - Fiber rich supplement

prescribed by A.O.A.C. (1975). The carbohydrate content was calculated by subtraction method. The trace elements were estimated by atomic absorption spectrophotometer (Perkin R. Enaler model - 3110). Total dietary fiber, soluble fiber and insoluble dietary fiber were estimated at NIN, Hyderabad.

3.1.7. Estimation of glycaemic index

The glycaemic index of the selected supplement was estimated by selecting six healthy subjects. Fasting blood glucose of the selected subjects was estimated early in the morning with empty stomach. An amount of 25 g pure glucose was given by mixing it in water immediately. Postprandial blood glucose was estimated after 30 minutes of ingestion of glucose and at the interval of every 30 minutes up to 120 minutes. On next day an equiamount of fiber rich supplement (118.5 g supplying 25 g carbohydrate) was given after estimating fasting blood glucose. Postprandial blood glucose was estimated in the same way as it was estimated for pure glucose. The graph was plotted with the data and glycaemic index of the supplement was calculated (Jenkins *et al.*, 1981).

3.2. Phase II – Intervention programme

In the phase II an intervention was conducted to study the effect of fiber rich supplement on the blood glucose content of diabetics.

3.2.1. Selection of subjects

A local eminent physician was contacted to whom the persons suffering with diabetes mellitus were visiting for treatment and follow-up regularly. After discussion with the physician regarding the fiber rich supplement and intervention programme a one day camp was organized for diabetic patients. Twenty seven patients attended the camp. For the awareness of the participants informative talks of the nutritionists were arranged. The topics covered were what is diabetes, role of diet in management of diabetes, role of dietary fiber in controlling diabetes, importance of fiber supplementation, preference for high fiber food items and importance of lifestyle and exercise.

The fiber rich supplement selected for intervention programme was shown and was served for taste to all the participants. After attending the camp

17 diabetic patients were ready to participate in the intervention programme. To maintain the homogeneity in the patients 13 non insulin dependent diabetic patients were selected for supplementation. Subjects free from added risk factors like hypertension, thyroid, kidney disease, smoking, alcoholism and chewing tobacco were selected. There were two dropouts because of concomitant family problems. Hence, the final number of the subjects was 11 which comprised of 5 male and 6 females. They were enrolled after giving consent to participate in the intervention programme. All the selected subjects were supplied with a folder on diabetes mellitus in local language.

3.2.2. Data collection

Each subject was examined clinically by General Physician to confirm that there are no additional existing risk factors. Baseline information pertaining to age, sex, socioeconomic background etc. was collected. The anthropometric measurements weight and height were recorded and BMI was calculated. Recent pathological reports of blood glucose levels of the selected subjects were examined to confirm history of diabetes mellitus. Before starting the intervention programme initial fasting and postprandial blood glucose levels were assessed by using Glucometer (Smart care mini make).

The selected subjects were interviewed to collect the information regarding food consumption pattern (AnnexureIII). Twenty-four hour recall method was used to evaluate food and nutrient intake. The amount of the food consumed in cooked form was converted into raw food ingredients and the nutritive value of the raw foods was determined to find out the nutrient intake of the subject per day. Nutrient intake of the studied diabetic patients was calculated and compared with the suggested nutrient requirements (Shrilakxmi, 2011) to check the sufficiency or deficiency.

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3.2.3. Supplementation

Daily 40 gram of developed fiber rich supplement was given to subjects divided in two equal amounts. Supplement was given immediately after breakfast (20 g) and lunch (20 g) by adding it in water. Their daily diet was not altered throughout the study period except for the inclusion of fiber rich

P3 - Consumption of the supplement by subject

supplement. The period of intervention was 60 days. The purpose of giving the supplement immediately after the meal was to fetch the benefit of the property of fiber that it delays the emptying of stomach and helps for slow releasing of glucose in the blood.

3.2.4. Estimation of blood glucose

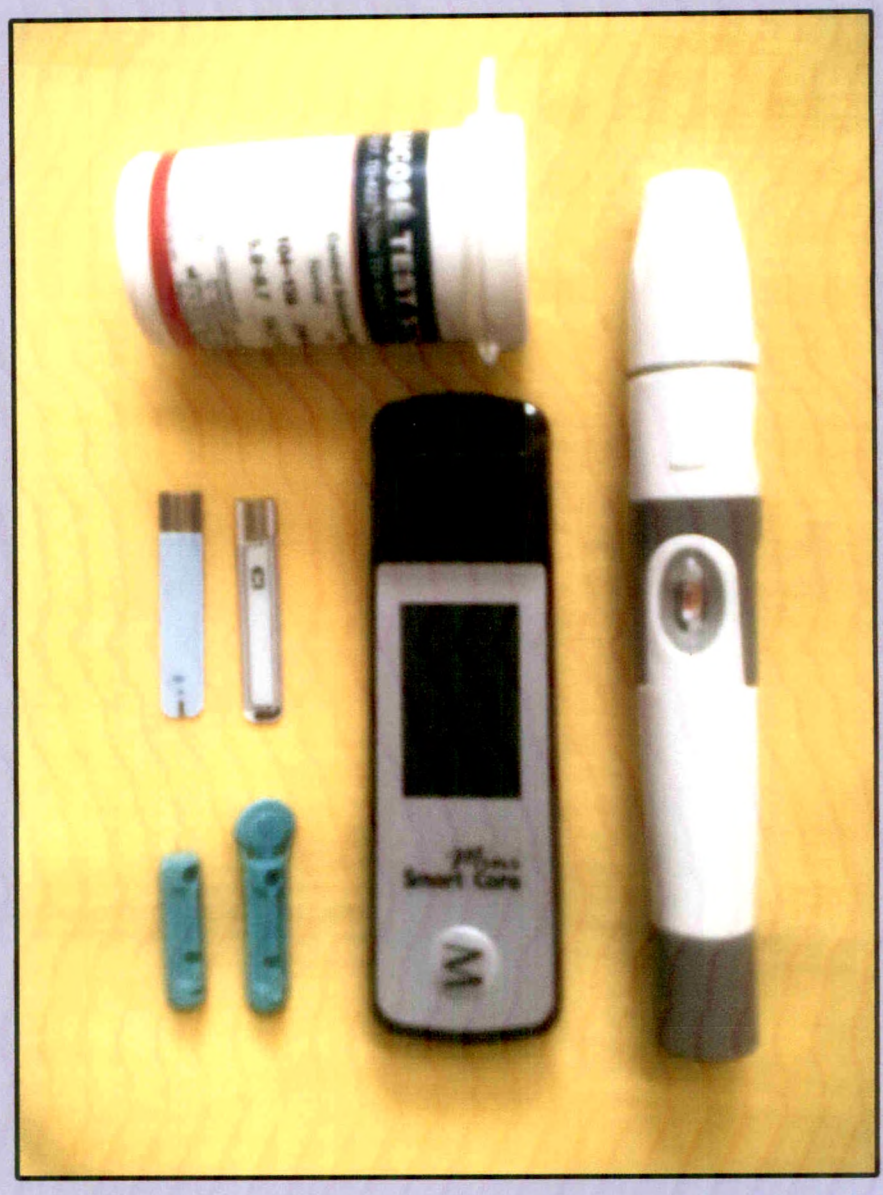
The blood glucose level of the selected subjects was estimated one day prior to the supplementation, and at the interval of 15 days till the end of the supplementation. The fasting blood glucose was estimated early in the morning before ingestion of any food material and postprandial blood level was estimated 2 hours after lunch.

3.2.5. Physiological symptoms

The data on physiological symptoms experienced by selected subjects was gathered by asking them about the frequency of symptoms such as polydypsia, polyphagia, polyuria and nocturia in 24 hours. The frequency of the symptoms was noted before and after completion of supplementation. Apart from this the data on frequency of constipation and the opinion of the subjects regarding the fiber rich supplement and intervention programme was also collected.

3.3. Statistical analysis

The data was compiled and analyzed statistically for interpretation of results. The means and percentages were calculated to express the nutrient intake and sensory evaluation scores. The nutrient intake of the subjects was compared with requirements by calculating 't' values. The data on organoleptic evaluation and blood glucose response was analyzed by applying analysis of variance and the 'F' values were calculated to find out the difference in the blood glucose level initially and at the end of the supplementation (Panse and Sukhatme, 1985).



P4 - Glucometer

P5 - Measurement of blood glucose

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

Diabetes mellitus is a complex metabolic disorder which is associated with deleterious health effects if not managed properly. Indians are predisposed to diabetes due to Asian Indian Phenotype. Diabetes should be managed well because several physiological, physical and biochemical changes occur due to high blood sugar level and when these changes become permanent in the body, they develop into serious diabetic complications. A viable approach for management of diabetic complications could be dietary sources with therapeutic role. It is revealed from the documented literature that the dietary fiber plays an important role in controlling the blood sugar levels. It is difficult to achieve a high dietary intake of fiber especially soluble fiber from daily diet. Therefore in the present study an attempt was made to develop a fiber rich supplement and to study its impact on the glycaemic control of type 2 diabetics by undertaking an intervention. The results of the investigation are presented in this chapter.

4.1 Development of the fiber rich supplement

A fiber rich supplement was formulated with three variations and was evaluated organoleptically for acceptance by a panel of judges. Sensory scores allotted by the panel members for three different variations of fiber rich supplement are given in Table 1and Fig 1. Variation A obtained more sensory scores than the variation B and variation C. It is very clear from the data that there was no significant difference between A, B and C variations for color, texture, flavor, taste and appearance, however, there was significant difference with respect to overall acceptability. Though there was non-significant difference, variation A secured numerically more scores for color, texture, flavor and taste (7.46, 7.46, 7.66, 7.13) than variation B (7.20, 7.20, 7.5 and 6.66) and variation C (7.20, 7.13, 7.40 and 6.73) respectively. As variation A

Table 1: Sensory scores of developed fiber rich supplement

Variation	Color	Texture	Flavor	Taste	Appearance	Overall acceptability	Total
A	7.46	7.46	7.66	7.13	7.06	7.93	44.70
B	7.20	7.20	7.53	6.66	7.33	6.80	42.72
C	7.20	7.13	7.40	6.73	7.13	7.26	42.85
F value	NS	NS	NS	NS	NS	11.19**	
SE±	-	-	-	-	-	0.17	
CD	-	-	-	-	-	0.47	

NS- Non significant * Significant at 5 percent ** Significant at 1 percent

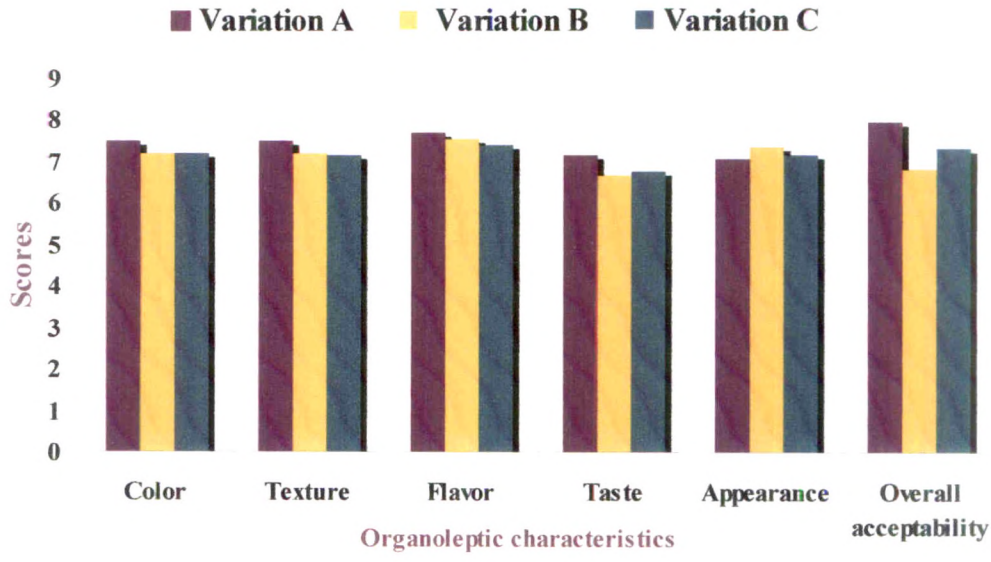


Fig.1. Sensory scores of different variations of fiber rich supplement

scored highest (44.70) in total scores among all three variations it was selected for further research.

The data regarding the nutrient content of selected fiber rich supplement is presented in Table 2. It can be noticed from the findings that the selected variation was containing high amount of total dietary fiber (58.65g/100g) followed by carbohydrate (20.70g). Moisture content of fiber rich supplement was very low (2.52%). The values for protein and fat content were 6.53 percent and 5.02 percent respectively. Total minerals were 6.2 percent. Soluble fiber was 38 g and insoluble fiber was 20-65 g. Iron and zinc content were 0.28 mg and 0.09 mg respectively. The calculated values of calcium, thiamin, carotene, riboflavin, niacin and vitamin C were 507 mg, 0.18 mg, 121.36 μg, 0.44 mg, 0.79 mg and 3.2 mg respectively. The cost of the developed supplement was Rs. 24.44 / 100 g which is far below the commercially available supplements.

The glycaemic index of fiber rich supplement was calculated and is presented in Table 3 and Fig 2. It is evident from the data that, before giving pure glucose and test food (fiber rich supplement) the blood glucose content of all the subjects was less. After the consumption of glucose and test food there was an increase in blood glucose content up to 30 minutes in all the subjects. There after there was decline in the blood glucose content till 120 minutes. The initial values of blood glucose level of selected normal healthy subjects ranged between 80-115mg/dl. After glucose intake, it raised to peak at 30 minutes in five subjects and after 60 minutes in one subject. After the ingestion of fiber rich supplement the glucose content of the blood raised to maximum at 30 minutes in four subjects and after 60 minutes in remaining two subjects. At the end of the experiment (after 120 minutes) the blood glucose came down for all the subjects. The data regarding area under curve indicated that the values were more for glucose (1245 to 3375) than that of fiber rich supplement (450 to 1586). The calculation of glycaemic index values indicated that it ranged between 24.14 to 50 with a mean value of 38.14. The observed effect of the developed supplement may be due to the slow glucose releasing role of the fiber present in the supplement.

Table 2: Nutritional composition of selected fiber rich supplement (per 100g)

Nutrient	Amount
Moisture (g)	2.52
Protein (g)	6.53
Fat (g)	5.02
Fiber (g)	58.65
Carbohydrate (g)	20.70
Iron (mg)	0.28
*Calcium (mg)	507
*Carotene (µg)	121.36
*Thiamin (mg)	0.18
*Riboflavin (mg)	0.44
*Niacin (mg)	0.79
*Vitamin C (mg)	1.1
Cost (Rs.)	24.44

*** - calculated values**

Table 3: Glycaemic index of selected fiber rich supplement

Subject	Food	0 min	30 min	60 min	90 min	120 min	AUC	GI
1	Glucose	90	124	126	109	97	2696	24.47
	F.R.S	100	117	97	100	67	660	
2	Glucose	106	142	120	106	101	1863	24.14
	F.R.S	90	125	98	100	95	450	
3	Glucose	80	135	125	100	79	3375	47
	F.R.S	95	120	98	112	80	1586	
4	Glucose	95	132	122	100	98	2865	40.18
	F.R.S	90	122	100	110	82	1151	
5	Glucose	115	135	120	125	97	1245	43.07
	F.R.S	100	98	112	109	96	536	
6	Glucose	86	132	125	107	85	3105	50
	F.R.S	90	110	122	98	70	1552	
							Mean GI	**38.14**

FRS -Fiber Rich Supplement AUC - Area Under Curve

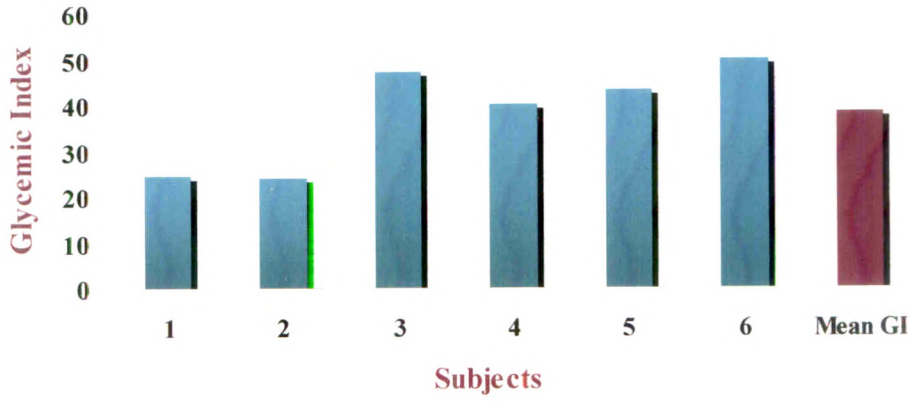


Fig.2. Glycemic Index of fiber rich supplement by different subjects

From the findings of the experiment it can be concluded that the developed fiber rich supplement was having low glycaemic index which would be beneficial for diabetic patients for slow release of glucose from the intestines into blood due to the soluble fiber present in it. The study conducted by Mani *et al.* (1997) revealed that the diet containing higher amount of soluble fiber had lowest glycaemic index. Torengatti and Naik (1999) also observed that, as the fiber content of test meals increased, the glycaemic index values were decreased.

4.2 Intervention programme

Data regarding the baseline information of selected diabetic subjects is given in Table 4. There were 11 subjects who enrolled in the study. Out of which six subjects were male and remaining five were female. The mean age of selected female subjects was 48.6 years and it was 58.9 years for male subjects. The female subjects had low mean body weight (53.9kg) as compared to male subjects (60.67kg). The average height of the male subjects was 162.3 cm while, it was 155.7 cm of female diabetics. Both the male and female subjects were having normal BMI. Female patients' mean BMI was 22.03. The average BMI of male subjects was 22.46. The mean duration of disease of subjects was 4 years for female subjects and 4.2 years for male subjects. No one among selected diabetics was consuming any oral hypoglycemic drug.

The average food intake of selected subjects is given in Table 5. It can be noticed from the table that the cereals, pulses, green leafy vegetables, other vegetables, fruits, roots and tubers, milk and milk products and nuts and oil seeds were consumed in the amounts of 221 g, 76 g, 67 g, 60 g, 60 g, 43 g, 165 g and 5 g respectively by female subjects. The consumption of respective foods was 262 g, 61 g, 85 g, 55 g, 75 g, 38 g, 154 g and 6 g by the male subjects. The data regarding the food intake of patients indicated that the consumption of protective foods (fruits and vegetables) was less by the subjects.

Table 4: Baseline characteristics of the selected diabetic subjects (n=11)

Parameters	Female (mean)	Male (mean)
No. of patients	5	6
Age (years)	48.6	58.9
Duration of diabetes (years)	4	4.2
Body weight (kg)	53.9	60.67
Height (cm)	155.7	162.3
BMI	22.03	22.46
Oral hypoglycemic drug	No	No

Table 5 : Mean food intake of selected subjects (g)

Nutrient	Female (n=5)	Male (n=6)
Cereals	221	262
Pulses	76	61
Green leafy vegetables	67	85
Other vegetables	60	55
Fruits	60	75
Roots and tubers	43	38
Milk and milk products	165	154
Nuts and oilseeds	5	6

The average per day nutrient intake and requirement of female diabetic subjects is presented in Table 6. The mean intake of energy by selected female subjects was 1587 kcal, protein 58.32 g, fat 40.52 g, carbohydrates 251.95 g, iron 14.55 mg, calcium 837.38 mg, carotene 1535.33 μg, thiamin 1.39 mg, riboflavin 0.92 mg, niacin 11.83 mg, vitamin C 48.82 mg, total dietary fiber 30.14 g while, the requirements for above nutrients were 1571kcal, protein 58.91g, fat 26.18 g, carbohydrate 274.93 g, iron 30 mg, calcium 400 mg, carotene 2400 μg, thiamin 0.9 mg, riboflavin 1.10 mg, niacin 12 mg, vitamin C 40 mg, total dietary fiber 39.37g. The data revealed that there was no significant difference in intake of energy, protein, carbohydrates, niacin and vitamin C indicating that the values were at par. There was significant difference in mean intake and requirements of the remaining nutrients. The intake of fat and calcium was significantly higher than the requirements. Significantly higher consumption of fat may because of the use of oil or fat for almost all cooked preparations. The intake of iron, carotene, thiamin and riboflavin were significantly less than the requirements. It can be concluded from results that there was significantly less intake of minerals and vitamins by the diabetic female subjects. It may be attributed to the restriction for consumption of fruits and less quantity of vegetables.

Mean nutrients intake and requirements of male diabetic subjects are presented in Table 7. The mean intake of energy by selected male subjects was 1729 kcal, protein 59.23 g, fat 40.74 g, carbohydrates 283.82 g, iron 18.05 mg, calcium 624 mg, carotene 1299 μg, thiamin 1.44 mg, riboflavin 0.95 mg, niacin 12.88 mg, vitamin C 55.77 mg, total dietary fiber 33.40 g. The requirements for above nutrients were 1815 kcal, protein 68.06 g, fat 30.25 g, carbohydrate 317 g, iron 28 g, calcium 400 g, carotene 2400 μg, thiamin 1.20 mg, riboflavin 1.40 mg, niacin 40 mg, vitamin C 40 mg and total dietary fiber 45.37g. The statistical analysis of the data indicated that there is significant difference in the intake and requirements of all the studied nutrients except for energy where the difference was non-significant. The fat and calcium intake of the subjects was significantly higher than the requirements

Table 6: Nutrient intake by selected female diabetic patients (n=5)

Nutrient	Intake	RDA Requirement	't' value
Energy (kcal)	1587	1571	NS
Protein (g)	58.32	58.91	NS
Fat (g)	40.52	26.18	3.422**
CHO (g)	251	274	NS
Iron (mg)	14.55	30.00	14.92**
Calcium (mg)	837	400	3.258*
Carotene (μg)	1535	2400	5.816**
Thiamin (mg)	1.39	0.90	8.016**
Riboflavin (mg)	0.92	1.10	6.315**
Niacin (mg)	11.83	12.00	NS
Vitamin C(mg)	48.82	40.00	NS
TDF (gm)	30.14	39.38	3.345*

NS- Non significant * Significant at 5 percent ** Significant at 1 percent

Table 7: Nutrient intake by selected male diabetic patients (n=6)

Nutrient	Intake	RDA Requirement	't' Value
Energy (kcal)	1729	1815	NS
Protein (g)	59.23	68.06	2.307*
Fat (g)	40.74	30.25	2.845*
CHO (g)	283	317	3.23**
Iron (mg)	18.04	28.00	5.952**
Calcium (mg)	624	400	5.498**
Carotene (µg)	1299	2400	12.291**
Thiamin (mg)	1.44	1.20	2.644*
Riboflavin (mg)	0.95	1.40	10.534**
Niacin (mg)	12.88	16.00	4.61**
Vitamin C(mg)	55.77	40.00	3.392**
TDF (gm)	33.40	45.37	5.105**

NS- Non significant * Significant at 5 percent ** Significant at 1 percent

while the intake of other nutrients was significantly less than the requirement. The observed non-significant different in energy may be because of higher fat intake. The significantly less intake of vitamins and minerals may be because of the less consumption of fruits and vegetables by the subjects.

The impact of fiber rich supplement on the fasting blood glucose content of the selected diabetic subjects is presented in Table 8 and Fig 3. The initial fasting blood glucose of the subjects ranged between 120 to 178 mg/dl. There was subsequent reduction in the fasting blood glucose of all the subjects as the period of fiber rich supplement intake increased from beginning of the experiment to 60 days with few exceptions. The statistical analysis of the data indicated that there was significant reduction in the fasting blood glucose levels from the within two months after starting the consumption of fiber rich supplement. There was 30 to 70 mg/dl reduction in the blood glucose content due to continuous consumption of fiber rich supplement. The fasting blood glucose content was reduced to 88 to 140 mg/dl at the end of the supplementation. The developed fiber rich supplement had very high fiber content (58.65%) and very low glyceamic index. Hence, it might have exerted the positive effect on the blood glucose content of the diabetic subjects.

The data regarding the impact of developed supplement on the post meal blood sugar level of selected subjects is depicted in Table 9 and Fig 4. The blood glucose values of the diabetic patients indicated that the initial postprandial blood glucose levels of the patients were very high which ranged from 190 to 295 mg/dl. As the patients started taking fiber rich supplement, the blood glucose values of the subjects started declining after 15 days. The reduction in blood glucose level was continued there after till the end of the experiment i.e. up to 60 days. After 60 days period the blood glucose of the patients ranged between 143 to 234 mg/dl, which indicated that there was reduction in the blood glucose content by 24 to 73 mg/dl. The statistical analysis of the data indicated that the reduction in the postprandial blood glucose of the patient was highly significant.

Table 8: Effect of fiber rich supplement on fasting blood glucose levels of selected diabetic subjects (mg / dl)

Subjects	Initial	15 days	30 days	45 days	60 days
1	134	121	132	107	92
2	178	168	156	156	140
3	177	135	128	124	121
4	130	127	128	122	111
5	120	118	105	90	88
6	141	132	131	124	95
7	173	186	168	142	140
8	141	115	120	121	119
9	177	168	163	128	122
10	178	198	183	148	139
11	142	130	123	120	112
Mean	**153.73**	**145.27**	**139.73**	**125.64**	**116.27**
F value-3.90**		**SE ± 7.49**		**CD-20.74**	

NS- Non significant *Significant at 5 percent **Significant at 1 percent

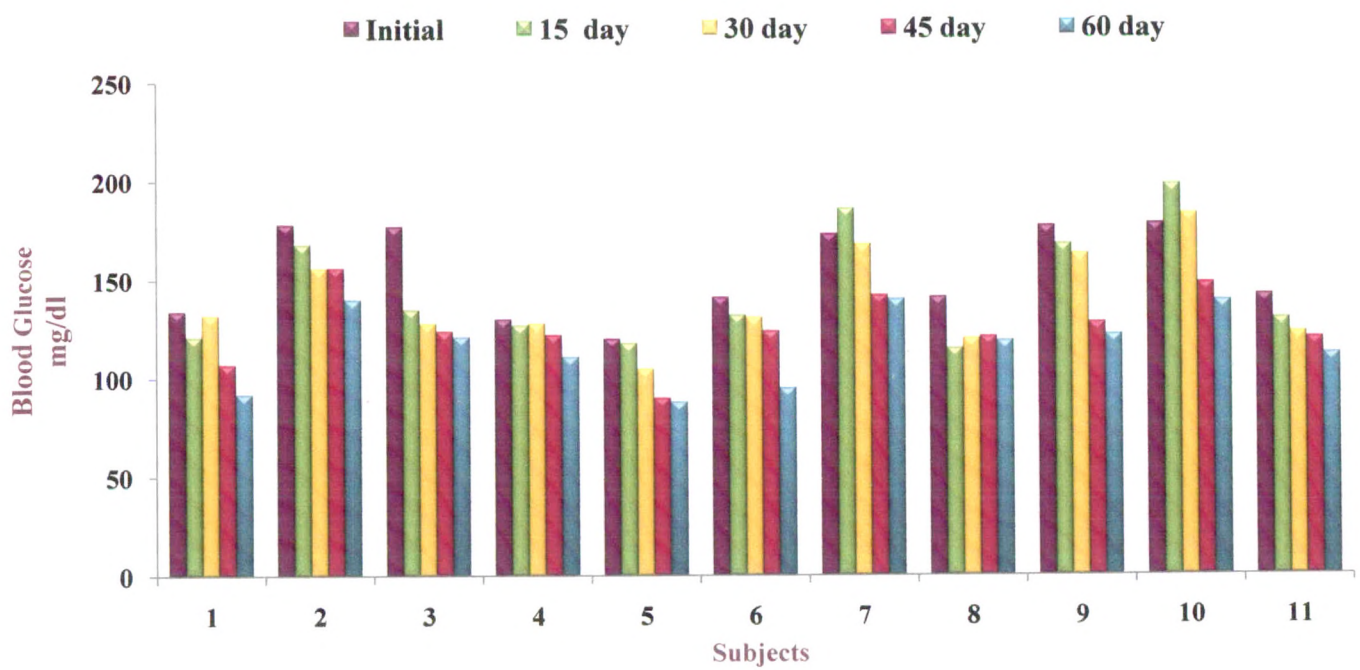


Fig.3. Effect of fiber rich supplement on fasting blood glucose levels of selected subjects

Table 9: Effect of fiber rich supplement on postprandial blood glucose levels of selected diabetic subjects (mg / dl)

Subjects	Initial	15 days	30 days	45 days	60 days
1	199	188	174	152	144
2	274	264	244	230	229
3	258	243	249	236	234
4	295	280	257	246	231
5	256	241	273	210	183
6	190	192	177	155	143
7	293	278	268	232	230
8	190	168	176	165	160
9	235	274	224	203	188
10	249	274	232	217	208
11	223	228	209	210	195
Mean	**242**	**239.09**	**225.73**	**205.09**	**195**
F value-2.80*		**SE±12.05**		**CD-33.35**	

NS- Non significant *Significant at 5 percent **Significant at 1 percent

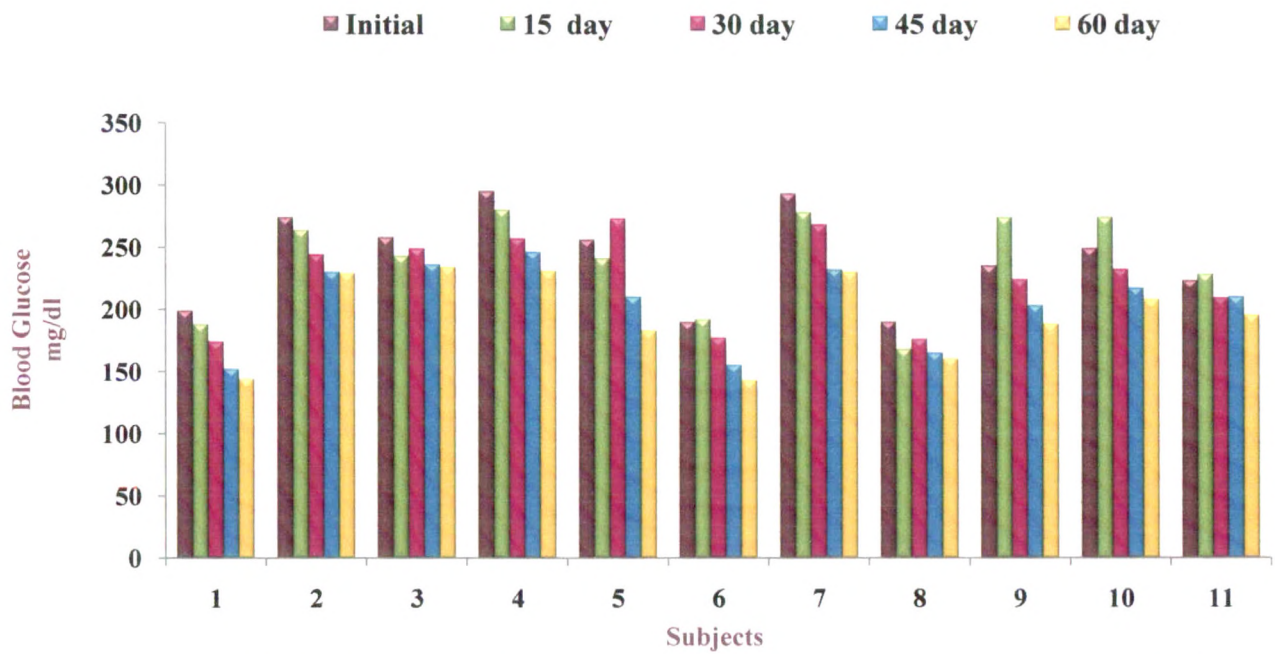


Fig.4. Effect of fiber rich supplement on postprandial blood glucose levels of selected subjects

The data regarding the fiber rich supplement on fasting blood glucose response of female subjects is given in Table 10 and Fig 5. It can be observed that the blood glucose content of female diabetics before starting the intervention was 120 to 177 mg/dl. The fiber rich supplementation therapy was found to be effective in transient reduction in fasting blood sugar level of all the female subjects. The 60 days intervention proved to be beneficial in reducing the fasting blood glucose minimum by 19 mg/dl and maximum by 56 mg/dl. The statistical comparison in the mean initial and final blood glucose values of female subjects showed that the reduction was non significant. It might be due to the fact that there was more difference in the blood glucose levels of individual subjects.

Postprandial blood glucose response of female subjects (Table 11 and Fig 6) indicated that there was appreciable decrease in the postprandial blood glucose content after implementing the two months supplementation to the diabetic females. The initial postprandial blood glucose values of the female subjects ranged between 190 to 295 mg/dl. After implementation of the fiber rich supplementation the blood glucose started sliding down till two months, which reached to an average decrease of 54 mg / dl blood glucose. The critical scrutiny of the data indicated that slight increase (from 255 to 273 mg/dl) in postprandial blood glucose level was noticed at the period of 30 days of supplementation in case of subject number three. The statistical analysis of the data indicated that there was non significant difference in the initial and final postprandial blood glucose values.

Fasting blood glucose response to fiber rich supplement by selected male subjects is presented in Table 12 and Fig 7. The initial fasting blood glucose of the diabetics ranged between 134 to 178 mg/dl with an average value of 158 mg/dl. It was noticed from the data that there was reduction in the fasting blood glucose values of all the male diabetics after receiving supplementation which reached finally to a range of 92 to 140 mg/dl with a mean decrease up to 120 mg/dl. The critical scrutiny of the data showed that one month supplementation of fiber rich supplement did not exert any

Table 10: Effect of fiber rich supplement on fasting blood glucose levels of female diabetic subjects (mg / dl)

Subjects	Initial	15 days	30 days	45 days	60 days
1	177	135	128	124	121
2	130	127	128	122	111
3	120	118	105	90	88
4	141	132	131	124	95
5	173	186	163	142	140
Mean	**148.20**	**139.60**	**132.00**	**120.40**	**111.00**
F value-NS					

NS- Non significant

Table 11: Effect of fiber rich supplement on postprandial blood glucose levels of female diabetic subjects (mg / dl)

Subjects	Initial	15 days	30 days	45 days	60 days
1	258	243	249	236	234
2	295	280	257	246	231
3	256	241	273	210	183
4	190	192	177	155	143
5	293	278	268	232	230
Mean	**258.4**	**246.8**	**244.8**	**215.8**	**204.2**
F value-NS					

NS- Non significant

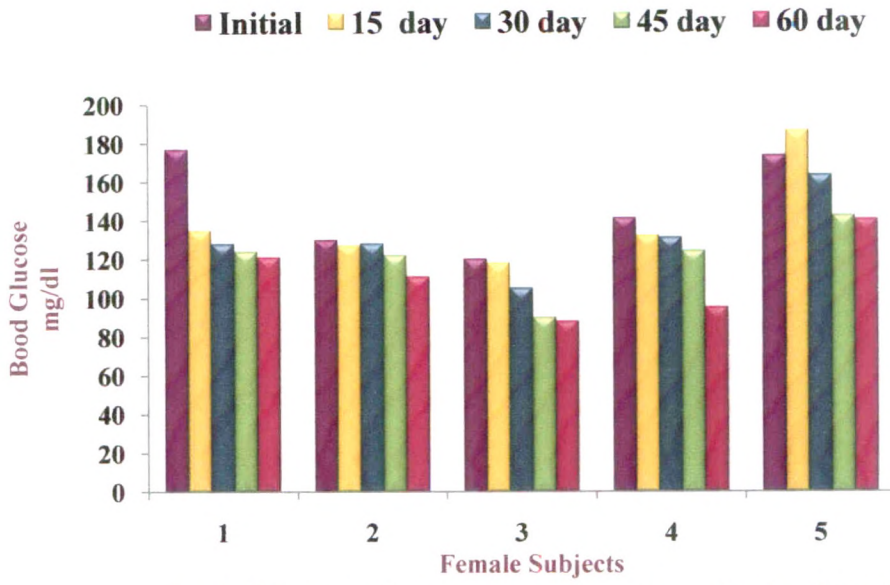


Fig.5. Effect of fiber rich supplement on fasting blood glucose levels of female diabetic subjects

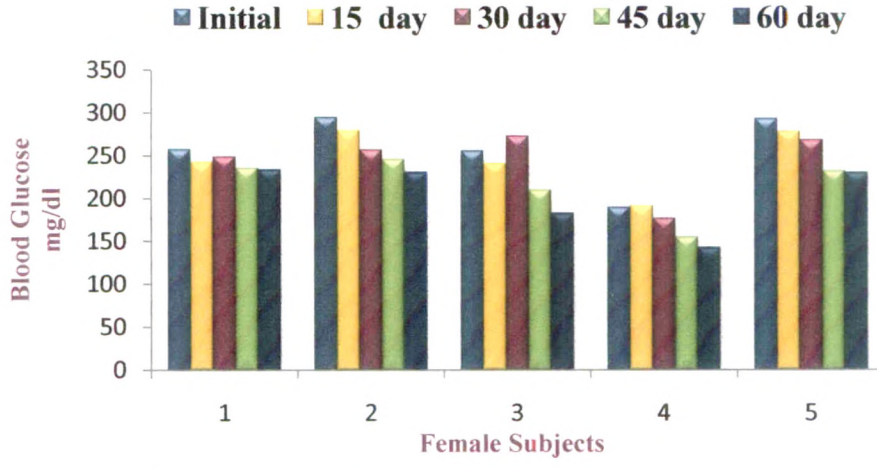


Fig.6. Effect of fiber rich supplement on postprandial blood glucose levels of female diabetic subjects

Table 12: Effect of fiber rich supplement on fasting blood glucose levels of male diabetic subjects (mg / dl)

Subjects	Initial	15 days	30 days	45 days	60 days
1	134	121	132	107	92
2	178	168	156	156	140
3	141	115	120	121	119
4	177	168	163	128	122
5	178	198	183	148	139
6	142	130	123	120	112
Mean	**158.33**	**150**	**146.17**	**130**	**120.67**
F value – NS					

NS- Non significant

Table 13: Effect of fiber rich supplement on postprandial blood glucose levels of male diabetic subjects (mg / dl)

Subjects	Initial	15 days	30 days	45 days	60 days
1	199	188	174	152	144
2	274	264	244	230	229
3	190	168	176	165	160
4	235	274	224	203	188
5	249	274	232	217	208
6	223	228	209	210	195
Mean	**228.33**	**232.67**	**209.83**	**196.17**	**187.33**
F value-NS					

NS- Non significant

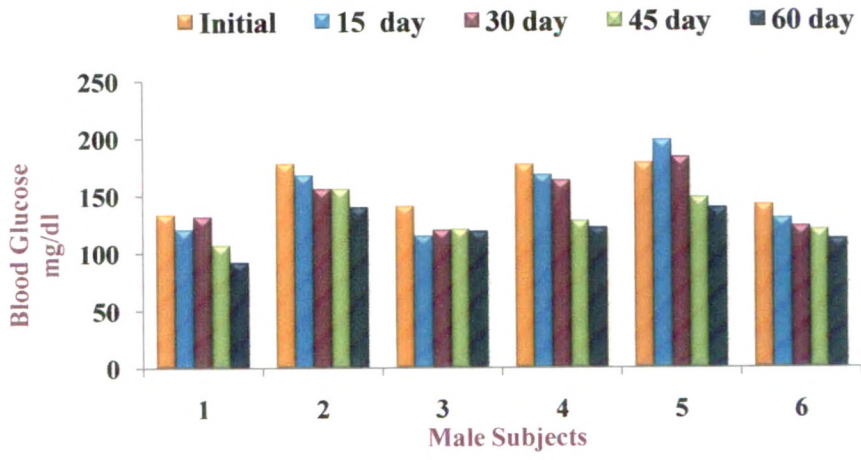


Fig.7. Effect of fiber rich supplement on fasting blood glucose level of male diabetic subjects

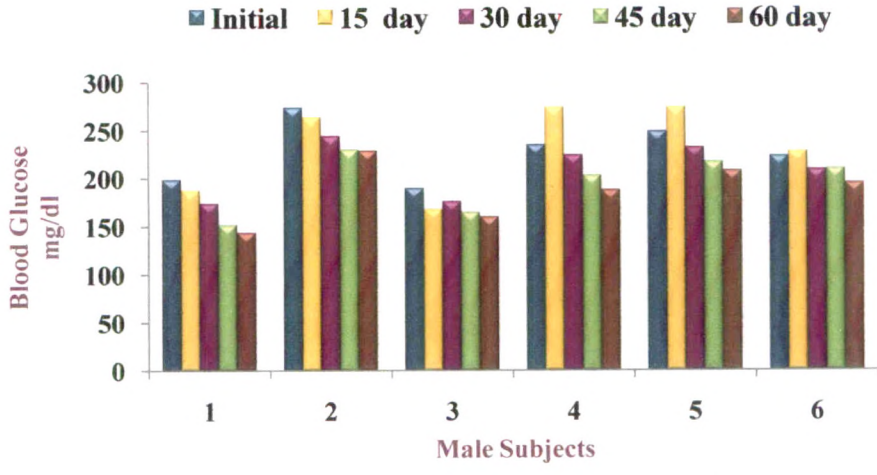


Fig.8. Effect of fiber rich supplement on blood glucose level of male diabetic subject

reduction in blood glucose level of subject number five. Rather it was increased but there after it started reducing which reached to 139 mg/dl at the end of experiment. The statistical analysis of the blood glucose values indicated that the reduction in blood glucose level of the male diabetics was non significant in case of all the selected subjects.

The results presented in Table 13 and Fig 8 revealed the effect of fiber rich supplementation on postprandial blood glucose levels of selected male subjects. At the beginning of the experiment the postprandial blood glucose ranged between 190 to 274 mg/dl. The final postprandial blood glucose levels ranged from 144 to 229 mg/dl in the experimental male subjects with a mean value of 228 mg/dl and 187 mg/dl at the beginning and at the end of experimentation respectively. The impact of fiber rich supplement was positive on the postprandial blood glucose content which resulted in reducing the postprandial blood glucose content of the male patients on an average by 41 mg/dl. The subject wise decrease in postprandial blood glucose level of male subjects ranged between 28 to 55 mg/dl after two months intervention. The decrease in the postprandial blood glucose levels of the experimental group of male subjects was found to be non significant. It can be observed from the data that there was not a similar decreasing trend in the values of postprandial blood glucose of male subject number 4, 5 and 6. Rather even after supplementation the increase in the postprandial blood glucose was noticed at the completion of first fortnight. However, the postprandial blood glucose started sliding down there after which was continued up to the last observation.

The scrutiny of data presented in the Table 8 and 9 indicated that statistically significant reduction in fasting and postprandial blood glucose levels of the diabetic patients was noticed after the fiber supplementation. The sexwise interpretation of the data indicated that there was positive trend of association between the fiber rich supplement and the decreased blood glucose levels, but it did not reach the statistical significance. The observed effect of the supplement may be attributed to the role of fiber in making the intestinal content viscous, thereby delaying the release of glucose in the blood. Apart

from this the developed supplement exhibited lower glycaemic index (Table 3), thus having a beneficial effects on blood glucose level. Hence, it can be concluded from the findings that the developed fiber rich supplement has therapeutic value and is effective contrivance in fighting the most common degenerative metabolic disorder – diabetes mellitus.

The study conducted by Wolever and Jenkins (1990) revealed that gaur gum, adequately mixed into a food, reduced the postprandial glucose responses by 44%. When used in the dietary treatment of diabetes, gaur gum has been reported to reduce insulin requirement and urinary glucose excretion. In the studies conducted by Mani and Mani (1987) and Haripriya and Premakumari (2010) wheat bran supplementation to diabetic patients was undertaken to evaluate its effect on blood glucose levels. The findings of their studies revealed that there was reduction in fasting and postprandial glucose levels after supplementation.

The data with respect to physiological symptoms of selected diabetics is presented in Table 14. The mean frequency of the polydipsia, polyphagia, polyuria and nocturia were 7.5, 4, 6.19 and 3.08 respectively before starting the supplementation. The respective frequencies after supplementation were 6.49, 3, 4.61 and 2.85 for above referred symptoms. It can be inffered that occurrence of the symptoms in the initial phase of the experiment was more frequent than that of the final phase. Haripriya and Pramakumari (2010) studied the changes in physiological symptoms of diabetic subjects. They observed that polyuria, polydipsia, polyphagia, nocturia and constipation were most commonly occurring symptoms in diabetics. The bran supplementation for six months to patients helped in drastic reduction in the physiological symptoms.
Apart from the physiological symptoms the data with respect to opinions of the patients regarding the supplement and intervention programme were collected which revealed that the flatulence was experienced by two subjects in the beginning two-three days, afterwards it was subsided. Stomach heaviness and hardness was reduced after supplementation. Six out of eleven patients

Table 14 : Effect of supplementation on physiological symptoms of selected subjects (n =11)

Symptoms	Initial frequency	Final frequency
Polydypsia	7.35	6.49
Polyphagia	4.0	3.0
Polyurea	6.19	4.61
Nocturea	3.08	2.85

expressed that they were revealed of the constipation in the first fortnight of supplementation programme. One subject told that he had tremour in legs while standing which disappeared after supplementation. All the subjects expressed that they were feeling fresh. The observations may be due to the fact that the supplementation was beneficial in reducing the blood glucose level of subjects and hence, was beneficial in reducing the frequency of physiological symptoms. Almost all the selected subjects expressed that they desired to continue the supplementation even after completion of the study. This might be due to the positive effect of supplement in reducing the blood glucose and physiological symptoms.

SUMMARY & CONCLUSION

CHAPTER-V

SUMMARY AND CONCLUSION

Diabetes mellitus is metabolic disorder in which the glucose uptake by the cells will be impaired resulting in hyperglycemia. Its prevalence is increasing day by day with a very high rate. A rapid rise in the prevalence of diabetes especially in urban as well as semi urban areas of the countries is witnessed in past decade. Even the age of onset had slided down capturing younger age groups. Being a metabolic disorder, diabetes impairs individual's health in general and the energy metabolism inparticular resulting in hypertriglycridemia, ketonemia, hyperaminoacidemia. Such clinical changes have delitorious health effects.

Dietary fiber contains unique blend of bioactive components which include resistant starches, vitamins, minerals, phytochemicals and antioxidants. Clinical studies demonstrate that intake of dietary fiber is inversely related to many health complications including diabetes. Hence, increasing its level in the diet would be beneficial to human health. As the dietary fiber brings about changes in intestinal viscosity, nutrient absorption and rate of passage it helps in slow release of glucose resulting in controlling hyperglycemia. Therefore, the present investigation was undertaken to develop a fiber rich supplement and evaluate its impact on type 2 diabetic subjects.

The study was conducted in two phases, in phase I the fiber rich supplement was developed and in phase II its impact on blood glucose levels of type 2 diabetic patients was assessed.

In phase I by using locally available foods a fiber rich supplement was prepared in three variations A, B and C. The prepared supplements were organoleptically evaluated by 15 semi trained judges. The variation A scored highest sensory score among three variations (44.7) hence, it was selected for supplementation. It was biochemically analyzed for nutrient content and

especially for total dietary, soluble and insoluble dietary fiber content. The glyceamic index of developed fiber rich supplement was calculated.

In phase II for selection of subjects a one day camp for diabetic patients was organized. Diabetics willing to participate in intervention were selected for supplementation. The final number of selected subjects was 11 comprising 5 female and 6 male patients. Their baseline information was collected. By 24-hr recall method diet survey was conducted to elicit food and nutrient intake. They were interviewed for collecting the information regarding physiological symptoms. The data collected was compiled, analyzed statistically and tabulated for interpretation of results. Twenty grams of fiber rich supplement was administered for a period of 60 days to all the selected subjects.

The fasting and postprandial blood glucose was measured initially one day prior to starting the supplementation and with an intermitant interval of 15 days till the end of the supplementation. The findings of the study revealed that selected subjects were 48.6 year (female) and 58.3 year (male) old. The average weight of female subject was 53.9 kg and of male subject was 60.67 kg. The mean height of female and male subject was 153.7 cm and 162.3 cm respectively. According to the BMI classification, all the selected subjects were normal. The mean duration of disease was four years.

The diet survey revealed that the consumption of protective food (fruits and vegetables) was less which may be due to the dietary restriction. The nutrient intake by the subjects inferred that the mean intake of energy was 1587 kcal, protein 58.32 g, fat 40.52 g, carbohydrates 251.95 g, iron 14.55 mg, calcium 837.38 mg, carotene 1535.33 μg, thiamin 1.39 mg, riboflavin 0.92 mg, niacin 11.83 mg, vitamin C 48.82 mg, total dietary fiber 30.14 g respectively by female subjects. However, intake of energy was 1729 kcal, protein 59.23 g, fat 40.74 g, carbohydrates 283.82 g, iron 18.05 mg, calcium 624.73 mg, carotene 972.65 μg, thiamin 1.44 mg, riboflavin 0.95 mg, niacin 12.88 mg, vitamin C 55.77 mg and total dietary fiber 33.40 g by male subjects. The statistical comparison of nutrient intake with requirements of female subjects indicated that there was no significant difference in energy, protein,

carbohydrate, niacin, vitamin C and total dietary fiber. While, iron , carotene, thiamin, riboflavin intake was significantly less than requirements. The fat and calcium were taken significantly more than the requirement. The data regarding the nutrient intake of male subjects illustrated that significant difference was noticed in all the nutrients except energy. Like female subjects the fat and calcium intake was significantly more in male subjects, while other nutrient intake was significantly less than requirement.

The fasting blood glucose of selected subjects ranged between 120 to 178 mg/dl with an average blood glucose of 153.73 mg/dl which is indicative of presence of hyperglycemia. After intake of the fiber rich supplement by the subjects the blood glucose content started reducing after one month which continued till the end of supplementation. At the end of the experiment the reduction in the blood glucose content was significant, which dropped down to 88 to 140 mg/dl. The average reduction in the fasting blood glucose level was 37.46 mg/dl. The mean postprandial blood glucose value of selected diabetic patients before starting of supplementation was 233.27 mg/dl. It was significantly reduce after supplementation (186.91 mg/dl). The maximum initial postprandial glucose level was 295 mg/dl. After intervention the maximum blood glucose content was 229 mg/dl.

The mean initial blood glucose content of female subjects was 148.20 mg/dl with a range of 120 to 177 mg/dl. Due to the 60 days supplementation, the fasting blood glucose was reduced to 88 to 125 mg/dl with a mean value of 108 mg/dl at the end of the experiment.

The postprandial plasma blood glucose values of female subjects ranged between 190 to 295 mg/dl in the beginning of the experiment. Two months supplementation was beneficial two bring down the blood values up to a range of 143 to 234 mg/dl with an average reduction of 54 mg/dl.

The blood glucose values of the male subjects indicated that the initial fasting blood glucose ranged between 134 to 178 mg/dl with an average of 158.33 mg/dl. Which is very high than the normal value (120 mg / dl). After receiving the supplementation for two months blood glucose values reduced to

a range of 92 to 140 mg / dl with a mean decrease up to 120.67 mg/dl. The statistical difference of initial and final blood glucose values was not significant. The postprandial blood glucose values of selected male subject initially were 190 to 274 mg/dl. The final postprandial blood glucose level ranged from 144 to 229 mg / dl. The mean initial postprandial blood glucose was 228.33 mg/dl which was reduced to 187 mg/dl due to supplementation. The reduction in the physiological symptoms polydypsia, polyphagia, polyurea, nocturia and constipation was noticed after supplementation.

From the investigation it can be concluded that

- Fiber rich supplement having therapeutic value can be developed by locally available foods.
- The developed supplement was very rich in total and soluble dietary fiber.
- It had very low glycaemic index.
- The two months intervention with fiber rich supplementation was beneficial in reducing the fasting and postprandial blood glucose levels of diabetic subjects.
- Fiber rich supplement is beneficial in reducing the physiological symptoms.

LITERATURE CITED

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A.O.A.C. (1975). Association of official Agricultural Chemists. Official Methods of Analysis. 12th Edn. Wasshington D.C. pp. 100-101.

AACC Report (2001). The Definition of Dietary Fiber. Cereal Food World, Vol. 46, No.3.

Akanji, O.A., Davies A.M.C., Ezenwaka, C., Abbiyesuku, A.F., Osotimehin, O.B. (1989). Dietary salt and the glyceamic response to meals of different fiber content. Euro.J.Clin.Nutri. (43) : 699-703.

Anderson J.W., Gustafson N.J., Bryant C.A. and Tietyn-Clark J. (1987). Dietary fiber and diabetes: a comprehensive review and practical application. J. Am. Diet. Assoc. 87(9): 1189-1197.

Barclay Alan W., Paul Mitchell, Victoria M. Flood, Jennie C. Brand-Miller and Elena Rochtchina (2007). Glecemic index, dietary fiber and risk of type 2 diabetes in cohort of older Australians. Diabetes Care, Vol 30., No.11.

Barclay Laurie (2009). Dietary fiber may help prevent body weight, waist circumference gain. Am.J.Clin.Nutr.

Chandalia Manisha, Garg Abhimanyu, Lutjohann Dieter, Bergmann Kalus Von, Grundy Scott M. and Brinkely Linda J. (2000). Beneficial effects of high dietary fiber intake in patients with type 2 diabetes mellitus. N.Engl.J.Med.342:1392-8.

Deshpande, K.B. (1987). A study on the effect of bran's of different cereals, hulls of different pulses and fenugreek seeds on blood glucose response in normal and diabetic subject. Thesis (M.Sc.), MAU., Parbhani.

Gallaher Daniel D, Gallaher Cynthia M., Mahrt Gregory J., Carr Timothy P., Hollingshead Carolyn H., Hesslink Robert and Wise Jhon (2002). A Glucomannan and Chitosan Fiber Supplement Decrease Plasm Cholesterol and Increases Cholesterol Excretion

in Overweight Normocholesterolemic Humans. Jr. Am. Clg. Nutr. Vol.21, No.5, 428-433.

Geeta, C. and Easwaran, P.P. (1990). Hypoglycemic effect of millet incorporated breakfast items on selected non-insulin dependent diabetic patients. The Ind. J., Jutr. Dieter. (27) : 316-320.

Gopalan C., Rama Sastri B.V. and Balsubramanian S.C. (2004). Nutritive Value of Indian Foods. Printed by National Institute of Nutrition, ICMR, Hydrabad.

Hadole, M.V. (1993). Glycaemic response of induced diabetic mice maintained on cereals and millet diets. Thesis (M.Sc.), MAU. Pabhani.

Heaton, K.W. (1983). Dietary fiber in perspective. Human nutrion. Clin Nutri. 37:108.

Hipsley E.H. (1953). Dietary "fiber" and pregnancy toxemia. British Medical Journal 2:420-422.

Hunninghake D.B., Miller V.T., LaRosa J.C., Kinosian B., Brown V., Howard W.J., DiSerio F.J., and 0 'Connor R.R. (1994). Hypocholesterolemic effects of a dietary fiber supplement. Am. J. Clin . Nutr. 59: 1050-4.

Iyer Uma, Deshmukh Shilpa and Mani Uliyar (1999).Glycemic Index of Spriulina Supplemented Meals. Int. J. Diab. Dev. Countries, Vol. 19.

Jenkins D.J.A., Wolever T.M.S., Taylor R. H., Barker H., Fielden H., Baldwi J.M., Bowling A.C., Newman H. C., Jenkins A.L. and Goff D. V. (1981). Glycemic index of foods: a physiological basis for carbohydrate exchange. Am. J. Clin. Nutr. 34: 362-366.

Jenkins David J.A., Kendall Cyril W.C., Vuksan Valdimir, Augustin Livia S.A., Li Yu-Min, Lee Brenda, Mehling Christine C., Parker Tina, Faulkner Dorothea, Seyler Hilda, Vidgen Edward and Fulgoni Victor (1999). The effects of wheat bran particle size on laxation

and colonic fermentation. Journal of the American College of Nutrition,Vol 18, No.4,339-345.

Joshi S.R., Das A.K., Vijay V.J. and Mohan V. (2008). Challenges in diabetes care in India : Sheer Numbers, Lack of Awareness and Inadequate Control. © JAPI. Vol. 56.

Kay, R. M. Dietary fiber. 1. Lipid Res. 1982. 23 221-242.

King H., Aubert R. E., Herman W.H. (1998).Global Burden of Diabetes, 1995–2025 Prevalence, numerical estimates, and projections. Diabetes Care 21 :1414–1431.

Knopp R.H., Superko H.R., Davidson M., Insull W., Dujovne C.A., Kwiterovich P.O., Zavoral J.H., Garham K., O'Connor R.R. and Edelman D.A. (1999). Long-term blood cholesterol-lowering effects of dietary fiber supplement. Am.J.Clin.Nutr.17(1):18-23.

Liu Simin, Buring Julie E., Sesso Howar D., Rimm Eric B., Willett Walter C.and Manson JoANN E. (2002). Aprospective study of dietary fiber intake and risk of cardiovascular disease among women. J.Am.Coll.Cardiol.39:49-56.

Mani Indirani and Mani Uliyar V. (1987). Effect of wheat bran supplementation on blood sugar, glycosylated protein and serum lipids in NIDDM subjects. Plant Foods for Human Nutrition 37:161-168.

Mani U. V., Pradhan S. N., Mehta N. C., Thakur D. M., Iyer U. and Mani I. (1992). Glycaemic index of conventional carbohydrate meals. British Journal of Nutrition. 68, 445-450.

Mani U.V., Mani I.U., Iyer U.M., Prakash B., Manivannan T., Campbell S. and Chandalia S. (1997). Glycemic and Lipemic Response to Various Regional Meals and South Indian Snacks. Int. J. Diab. Dev. Countries, Vol. 17.

Mohan V., Sandeep S., Deepa R., Shah B.and Varghese C. (2007). Epidemiology of type 2 diabetes: Indian scenario. Indian J. Med. Res. (125) pp. 217-230.

Mozaffarian Dariush, Kumanyika Shiriki K., Lemaitre Rozenn N., Olson Jean L., Burke Gregory L., Siscovick David S. (2003). Cereal, fruit and vegetable fiber intake and the risk of cardiovascular disease in elderly individuals. JAMA, Vol 289, No.13.

Murthy, R. and Easwaran, P.P. (1990). Hypoglycaemic effect of fenugreek on blood glucose levels in selected non-insulin dependent diabetic parients. The Ind. J. Nutr. Dietet. (27) : 265-267.

Natale Claudia DE, Giuseppina Costabile, Giovanni Annuzzi, Ornella Ciano, Lutgarda Bozzetto, Riccardi Gabriele, Raffaella Mazzarella and Rivellese Angla A. (2009). Effects of a plant based high-carbohydrate/high-fiber diet versus high monounsaturated fat/low-carbohydrate diet onpostprandial lipids in type 2 diabetic patients. Diabetic Care, Vol 32, No.12.

Panse , V.G. and Sukhatme, P.V. (1985). Statistical methods for agricultural workers. ICAR publication, New-Delhi 58-60, 97-110.

Parson, S.R. (1984). Effect of high fiber breakfast on glucose metabolism in NIDDM. Am.J.Clin Nutri. 40:60.

Potdar R. M. (2002). Assessment of glyceamic index of commonly consumed recipes of Indian diets in diabetic subjects. Thesis (M.Sc.),MAU, Parbhani.

Potter, J.G., Coffman, K.P., Reid, R.L., Krall, J.M. and Albrink, M.J. (1981). Effect of test meals of varying dietary fiber content on plasma insulin and glucose response. Am.J.Clin Nutri. 34:328.

Qi Lu, Manson Joann E., Meigs James B., Mantzoros Christos, Liu Simin and Hu Frank B. (2006). Dietary fiber and glyceamic load, obesity and plasma adiponectin levels in women with type 2 diabetes. Diabetes Care, Vol 29., No.7.

Raghuram, T.C., Prsricha, S., Sharma, R.D. (2006). Diet and Diabetes, NIN.

Ray, K.T., Mansell, K.M., Knight, L.C., Malmud, L.S., Owen, O.E. and Boden, G. (1983). Long term effects of dietary fiber on glucose tolerance and gastric emptying in NIDDM. Am.J.Clin.Nutri. 37:376.

Revellse A. , Giacco A., Genovese S., Riccardi G., Pacioni D., Mattioli P.L. and Mancini M. (1980). Effects of dietary fiber on glucose control and serum lipoproteins in diabetic patients. The Lancet, Vol 316, Issue 8192:447-450.

Robinson, C.H. and Lawler, M.R. (1972). Normal and therapeutic nutrition. 15th Ed. Macmillian Publishing Co., Inc. New York. Collier Macmillian Publisher, London : 495.

Schulze M. B., Liu S., Rimm E.B., Manson J. E., Willett W.C. and Hu F. B. (2004).Glycemic index, glycemic load, and dietary fiber intake and incidence of type 2 diabetes in younger and middle-aged women. Am. J. Clin. Nutr. 80:348 –56.

Sharma, R.D. and Raghuram C.T. and Sudhakar rao, N. (1990). Effect of fenugreek seeds on blood and serum lipids in type 1 diabetics. Euro. J. Clin. Nutr (44) : 313-306.

Shrilaxmi, B. (2004). Food Science third edition New Age International Publishers. Pp:294.

Siddartha, Pooja Mohan Rao, Suchetha Kumari N, Sampath Kumar, Madhu L.N. (2010). An epidemiology of prevalence of Type 2 Diabetes among the adult residents in Dakshina Kannada district. RJPBCS Vol. 1(3) Page No. 586

Simpson, H.C.R. (1981). High carbohydrate, fiber diet for diabetes. Proc. Nutri. Soci. 40:219.

Srilakshmi B. (2009). Dietetics. 5th Edn. New Age International (P) Limited, Publishers, New-Delhi.

Streppel Martinette T., Ocke Marga C, Boshuizen Hendriek C, Kok Frans J and Kromhout Dann (2008). Dietary fiber intake in relation to coronary heart disease and all-cause mortality over 40y. Am. J. Clin.Nutr., 88:1119-25.

Torangatti G. and Naik R.K. (1999).Glycemic and Lipemic Response of Composite Foods in Normal and NIDDM Subjects. Int. J. Diab. Dev. Countries., Vol. 19.

Vuksan Valdimir, Jenkins David JA, Vidgen Edward, Ransom Thomas PP, Ng Mary K, Culhane Carol T and O'Connor Donald (1999). A novel source of wheat fiber and protein: effects on fecal bulk and serum lipids. Am.J.Clin.Nutr.69:226-30.

Wannamethee S.Goya, Thomas Mary C., Whincup Petter H. and Sattar Naveed (2009). Association between dietary fiber and inflammation , hepatic function and risk of type 2 diabetes in older men. Diabetes Care, Vol 32, No.10.

Weickert Martin O., Viehoff Hannan, Mohlig Matthias, Koebnick Corinna, Schofl Christof, Khol Angela, Arafat Angela, Spranger Joachim, Otto Barbel and Andeas F.H. Pfeiffer (2006). Cereal fiber improves whole-body insulin sensitivity in overweight and obese women. Diabetes Care,Vol 29, No.4.

WHO (1999). Definition, Diagnosis and Classification of Diabetes Mellitus and its Complications. Report of a WHO Consultation. Part 1: Diagnosis and Classification of Diabetes Mellitus. Geneva: WHO Department of Non-communicable Disease Surveillance, 1-59. http://www.who.int.

Wild S., Bchir Mb, Roglic G., Green A., Sicree R., King H. (2004).Global Prevalence of Diabetes. Diabetes Care 27:1047–1053.

Wolever T.M.S. and Jenkins D.J.A. (1993). Effect of dietary fiber and foods on carbohydrate metabolism. In CRC Handbook of dietary Fiber in Human Nutrition, 2nd Edition.Ed.Gene A. Spiller,pp 111-152.

Wu Huyun, Dwyer Kathleen M., Fan Zhihong, Shirocore Anne, Fan Jing and Dwyer James H. (2003). Dietary fiber and progression of atherosclerosis: the Los Angeles atherosclerosis study. Am.J.Clin.Nutr.78:1085-91.

Zang Culing, Solomon Caren G., Liu Simin and Hu Frank B. (2006). Dietary fiber intake, dietary glecemic load and the risk of gestational diabetes mellitus. Diabetes Care, Vol 29, No.10.

Zargar A.H., Nehru A., Laway B.A., Dar F.A. (1992). Effect of consumption of powdered fenugreek seeds on blood sugar and Hb A/c. levels in patients with type 2 diabetes mellitus., Intl.J.Diab.Dev.Countries., (12) : 49-51.

ANNEXURE

ANNEXURE-I

Composition of different variations of fiber rich supplement

Sr. No.	Variation No.	Ingredients (g)							
		Wheat bran	Gum acacia	Anissed	Coriander seed	Cumin seed	omum	Cardamom	Skimmed milk powder
1	1	20	20	25	10	10	2.5	2.5	10
2	2	25	25	10	10	5	2.5	1.5	22
3	3	20	25	25	10	10	1.5	2.5	5
4	4	20	25	15	5	2.5	2.5	5	25
5	5	20	20	10	15	10	2.5	2.5	20
6	6	25	20	20	5	5	2.5	2.5	20
7	7	20	20	10	10	15	2.5	2.5	20
8	8	20	20	10	15	15	2.5	2.5	15
9	9	20	20	20	15	10	2.5	2.5	10
10	10	25	25	20	5	5	2.5	2.5	15
11	11	25	25	25	0	0	2.5	2.5	20
12	12	20	20	20	0	10	5	5	20
13	13	20	20	20	10	0	5	5	20
14	14	20	20	20	10	5	0	5	20
15	15	20	20	15	15	15	2.5	2.5	10
16	16	25	25	25	0	0	0	5	20

ANNEXURE II

Sensory evaluation score card

Recipe : _____ Date :

Name : _____ Sign :

Variation	Color	Texture	Flavor	Taste	Overall acceptability
A					
B					
C					

9 - Like extremely

8 - Like very much

7 - Like moderately

6 - Like slightly

5 - Neither like nor dislike

4 - Dislike slightly

3 - Dislike moderately

2 - Dislike very much

1 - Dislike extremely

ANNEXURE III

Personal interview schedule to study the food consumption pattern and anthropometric measurements of the selected diabetic subjects

A. General Information

1. Name :
2. Address :
3. Age :

Age of detection of diabetes mellitus :_____ years

4. Sex :

B. Anthropometric measurements

1. Weight : _____ kg
2. Height : _____cm
3. BMI : _____

C. Family History

Disease	Father's side	Mother's side	If yes relation with sufferer
Diabetes			
Blood pressure			
Heart attack			
Kidney problems			
Any other			

D. Dietary Pattern

Food Habits :

1. Vegetarian ☐ Yes ☐ No
2. Non- vegetarian ☐ Yes ☐ No

If yes, what is the frequency of consumption of non-vegetable foods?

3. Meal pattern : How many meals do you take per day

   2 meals per day ☐

   3 meals per day ☐

   4 meals per day ☐

4. What is your meal pattern?

   Break fast

   Brunch

   Lunch

   Dinner

   Late night

5. Do you take tea/coffee daily ? ☐ Yes ☐ No

   If yes, how many cups do you take ? Mention below

6. Dose it contains sugar ? ☐ Yes ☐ No

   If yes, how much 1 tsp/ 2 tsp / more than 2 tsp (tick any one)

7. Do you use artificial sweeteners ? ☐ Yes ☐ No

8. What food stuffs do you avoid ? Enlist below

E. Symptoms experienced

1. Nocturia ☐
2. Polyuria ☐
3. Polyphagia ☐
4. Polydypsia ☐
5. Weight loss ☐
6. Easy tiredness ☐
7. Eye problem ☐
8. Feet problem ☐
9. Slow healing of cuts and wounds ☐
10. Any other ☐

F. How often do you go for a medical checkup?