World Journal of Pharmaceutical and Life Sciences
WJPLS
www.wjpls.org
SJIF Impact Factor: 4.223

FIBER RICH DIETS IN GLYCAEMIC MANAGEMENT OF HUMAN TYPE II DIABETES

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Article Received on 18/04/2017 **Article Revised on 07/05/2017** **Article Accepted on 28/05/2017**

ABSTRACT

Background: Considerable scientific studies prove that diet plays very important role in the management of Diabetes mellitus. Calories in the form of complex carbohydrate and fiber have multiple benefits in this disease. Fiber in the form of oats is effective element in management of Type II diabetes mellitus. **Objective:** This study is designed to evaluate the effects of fiber in glucose management of human Type II Diabetes Mellitus and to optimize the fiber amount. **Method:** Under this study three diets viz. control diet (no fiber), low fiber diet (5 gm fiber), high fiber diet (10 gm fiber) were given to Control group, Experimental group 1, Experimental group 2 respectively. Data were recorded after three months supplementation and statistically analyzed. **Result:** The major reduction in blood glucose level was worked by the test diet I and then a further minor reduction was done by test diet II. The statistical analysis showed clearly the level of fasting blood glucose as lowest in the case of test diet II, slightly higher in test diet I and highest in control diet. A similar behavior was observed in postprandial blood glucose levels. **Conclusion:** It is concluded that fiber is an influential component in the management of type II Diabetes mellitus.

KEYWORDS: Diabetes mellitus, Fiber, Glycaemic management, Oats.

INTRODUCTION

Diabetes mellitus is a common metabolic disorder resulting from defects in insulin action, insulin production, or both. Insulin, a hormone secreted by the pancreas, helps the body use and store glucose produced during the digestion of food. It is mainly characterized by hyperglycemia. Other symptoms are frequent urination, increased thirst, dehydration, weight loss, blurred vision, fatigue, occasionally coma, etc. Uncontrolled hyperglycemia over time damages the eyes, nerves, blood vessels, kidneys, and heart, causing organ dysfunction and failure. Family history, age, ethnicity, social group characteristics, behavior, life style, psychological and clinical factors are the risk factors of disease.

Diabetes mellitus is classified into four categories: type I, type II, gestational diabetes, and others.

In Type I Diabetes, specialized cells (β cells) in the pancreas are destroyed, leading to a deficiency in insulin production. It is frequently turned in to Type I. Type II Diabetes **i**s the most common form of diabetes mellitus, accounting for 90 to 95 percent of all diabetes cases worldwide.

Impaired glucose tolerance (IGT) and impaired fasting glucose (IFG) are two pre diabetic conditions associated with insulin resistance. In these conditions, the blood glucose concentration is above the normal range. Subjects with IGT and/or IFG are at substantially higher risk of developing diabetes and cardiovascular disease than those with normal glucose tolerance.[1]

Treatment for diabetes involves following a regimen of diet, exercise, self-monitoring of blood glucose, and taking medication or insulin injections. Diet plays very important role in the management of Diabetes mellitus. The number of calories needed to maintain weight depends upon person's age, sex, height, and weight and activity level. 45 - 65% of total daily calories should be provided by carbohydrates. The type and amount of carbohydrates both are important. Best choices are vegetables, fruits, beans, and whole grains. These foods are also high in Fiber. Carbohydrate intake can be monitored by diabetic person either through carbohydrate counting or meal planning exchange lists. 25 - 35% of daily calories should be provided by fats. Monounsaturated and omega-3 polyunsaturated fats are the best types. 12 - 20% of daily calories should be fulfilled by protein. Fish, soy, and poultry are better protein choices than red meat. Weight reduction is

advised if body mass index (BMI) is 25 - 29 (overweight) or higher (obese).[2]

Blood Sugar monitoring

Both, low blood sugar (hypoglycemia) and high blood sugar (hyperglycemia) are of concern for diabetic patients whether insulin is taken by them or not. It is important, therefore, to monitor blood glucose levels carefully.[3]

Table 1: Criteria of blood sugar given by American Diabetes Association.[3]

Diagnosis	Values
Diabetes	FPG126 mg/dl OGTT 200 mg/dl A1C > 6.5%
Impaired fasting glucose (Prediabetes)	OGTT 140 to199 mg/dl A1C 5.7% to 6.4%
	FPG 100 to125 mg/dl

FPG: Fasting plasma glucose
OGTT: Oral glucose tolerance test
A1C: Glycosylated hemoglobin test.

Fiber

Fiber or "roughage" as it is also known, is essentially a carbohydrate and is found solely in plants. It is found in the walls of the plant's cells and is the only part of the plant that cannot be digested by the human body.[4]

Types of Fiber

- Insoluble fiber
- Soluble fiber

Cellulose, hemicelluloses and lignin are some insoluble fibers. Stool is made soft and bulky by this kind of fibers, which is then easily passed through bowel and thus constipation is prevented. On the other hand gums and pectin are known as soluble fibers. They can be found in all fruits and vegetables. It is showed by the different studies that cholesterol level may be reduced with the help of soluble fiber in the blood. Digestion is also slowed down by soluble fiber and the sudden release of energy is delayed, especially from carbohydrates into the bloodstream. This means that blood sugar levels are more stable, which is good for people with diabetes.[5]

Table 2: Dietary fiber functions and benefits.[5]

Functions	Benefits
Increases food volume without increasing caloric content, providing satiety	May reduce appetite.
Attracts water and turns to gel during digestion, trapping carbohydrates and slowing absorption of glucose	Lowers variance in blood sugar levels.
Lowers total and LDL cholesterol	Reduces risk of heart disease.
Regulates blood sugar	May reduce onset risk or symptoms of metabolic syndrome and diabetes.
Speeds the passage of foods through the digestive tract	Facilitates regular defecation.
Balances intestinal pH and stimulates intestinal fermentation and production of short-chain fatty acids	May reduce risk of colorectal cancer.

Requirement of Fiber

According to current Canadian guidelines, at least 26 grams of fiber - ideally 26 to 35 grams should be consumed daily by healthy adults. At present average 4.5 to 11 grams only are taken by a Canadian in a day. Ideally 25 to 50 grams per day should be consumed by people with diabetes.[6]

Current recommendations from the United States National Academy of Sciences, Institute of Medicine, suggest that adults should consume 20–35 grams of dietary fiber per day, but the average American's daily intake of dietary fiber is only 12–18 grams.[5]

According to the British Nutrition Foundation it is advised that 18g fiber a day should be aimed by healthy adults.[5]

There have been no studies on evaluating the dietary fiber requirements in Indians. It was investigated by the data from diets of the Western part of the country that the dietary fiber content is about 30-40 gm/day. The intake was being increased with increasing level of energy intake, 39 g -47 g/d in young men. The fiber intake is lower in women (15-30 g/d) and is much less in tribal population (15-19 g/d). It was also showed by another report from North India that the average total fiber intake per day is about 52 g. More data needs to be generated in the Indian context to understand the phenomenon of health transition.[7]

Oats

Oats are a nutritional power food and have many health benefits including decreasing risk of the incidence of heart disease and diabetes. This grain is packed with vitamins and minerals such as silica and other trace elements to help the body build sturdy bones and muscles, maintain joint elasticity and much more. Oatmeal also contains a wide array of antioxidants and is a good source of protein, complex carbohydrates, fats and iron. It is mainly considered for high fiber source. Oats is rich in β-glucan soluble fiber.

Table 3: Amount of nutrients per serving of one cup (156.0 gm) of oats.[8]

Calories	607 Kcal
Total fat Saturated fat Poly unsaturated fat Mono saturated fat	10.8 gm 1.9 gm 4.0 gm 3.4 gm
Cholesterol	0 mg
Sodium	3 mg
Total Carbohydrate	103.4 gm
Dietary Fiber	16.5 gm
Protein	26.3 gm

Characteristics of Oats (8)

- Low in saturated fat
- No cholesterol
- Very low in sodium
- No sugar
- High in dietary fiber
- Very high in manganese
- High in magnesium
- High in phosphorus
- High in thiamin

SUBJECTS AND METHODS

In this study, the sample was selected from Type II Diabetic population of Diabetic camp, centre for translational research, Jiwaji University, Gwalior by probability random sampling method. The samples included male and female subjects in the age group of 35 to 65 years. For the purpose of study, subjects were divided into following three groups:

1. Control group (diabetic subjects without fiber diet)
2. Experimental group 1(diabetic subjects with low fiber diet 5 gm)
3. Experimental group 2 (diabetic subjects with high fiber diet 10 gm)
   Subjects were chosen randomly from various areas of greater Gwalior city.

Size and Classification of Sample

100 diabetic subjects were randomly chosen irrespective of sex, age (35-65), occupation, income, religion etc. Out of these, 50 were assigned as control group and other 50 as Experimental group 1. The same 50 subjects, assigned as Experimental group 1, were then assigned as Experimental group 2 (after three months of intervention).

A self made interview schedule was applied to collect the information from the subjects. This schedule was prepared considering all the possible aspects related to study. Blood sugar level was estimated by a glucometer. A glucometer is a medical tool that determines the amount of glucose in the blood. There are many different types of glucometers available in market. Accu check glucometer was used in study for determination of blood sugar level.

Formulation of Different Test Diets

In order to carry out the study in a systematic manner, it was planned to formulate three test diets. First of which would contain no fiber, the second would have low fiber while the third one would have high fiber.

(a) Formulation of Control Diet

Firstly rice flakes and bengal gram were roasted separately. Bengal gram was dehusked and then rice flakes and bengal gram were mixed. After that measured amount of oil was taken, heated up to desired temperature and then spices were added into oil. This oil was mixed into mixture of bengal gram and rice flakes. At last salt was added to this in required amount. All the ingredients were mixed properly. Three different diets were prepared as per table.

Table 4: Amount of ingredients for formulation of control diet.

Ingredients	P1	P2	P3
Rice flakes (gm)	40	50	60
Bengal gram(gm)	30	20	10
Oil (ml)	5	5	5

P1, P2, P3, etc. denote various diet preparations with different amounts of ingredients.

The amounts of ingredients for formulation of control diet were taken as per the above table. No fiber source was used. The ingredients were processed as per the formulation procedure mentioned earlier.

(b) Formulation of Test diet I

Firstly rice flakes and oats were roasted separately. Rice flakes and oats were mixed. After that measured amount of oil was taken, heated up to desired temperature and then spices were added into oil. This oil was mixed into mixture of oats and rice flakes. At last salt was added to this in required amount. All the ingredients were mixed properly. Here also three different diets were also prepared as per the ingredients.

Table 5: Amount of ingredients for formulation of Test diet 1.

Ingredients	P4	P5	P6
Oats (gms)	25	50	-
Wheat bran (gms)	6	-	15
Rice flakes (gms)	40	20	50
Oil (ml)	3	3	3

The amounts of ingredients for formulation of Test diet 1 were taken as per the above table. Oats and wheat bran were used here as a fiber source. The ingredients were processed as per the procedure mentioned earlier.

(C) Formulation of Test diet II

Firstly Oats and coriander seeds were roasted separately. The coriander seeds were crushed and then oats and coriander seeds were mixed together. After that measured amount of oil was taken, heated up to desired

temperature and then spices were added into oil. This oil was mixed into mixture of oats and coriander seeds. At last salt was added to this in required amount. All the ingredients were mixed properly.

Table 6: Amount of ingredients for formulation of Test diet II.

Ingredients	P7	P8	P9
Oats (gms)	35	-	70
Rice flakes (gms)	25	50	
Wheat bran (gms)	10	20	-
Coriander seeds (gms)	5	5	5
Oil (ml)	1	1	1

The amounts of ingredients for formulation of Test diet II were taken as per the above table. Oats and wheat bran were used here as a fiber source. The ingredients were processed as per the procedure mentioned earlier.

On the basis of the sensory evaluation scores P1 (Control diet), P5 (Test diet I), P9 (Test diet II) were decided for Control group, Experimental group 1and Experimental group 2 respectively.

Statistical Analysis

Percentage method was used for making simple comparison. For drawing significant conclusion, ANCOVA (software by SPSS 13.0) is a suitable analytical method, which was applied here.

RESULTS AND DISCUSSION

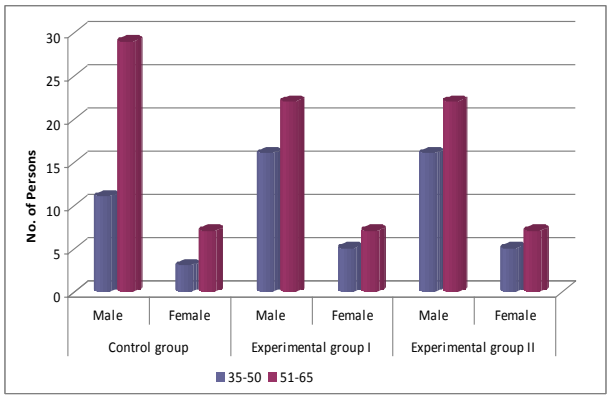
Some observations during the study have been tabulated below, and for quick and better understanding data have also been represented by bar diagrams.

Table 7: Distribution of subjects belonging to chosen three groups.

Groups	Value Label	Number of subjects
Control group	No fiber	50
Experimental group 1	5 gm fiber (Test diet I)	50
Experimental group 2	10gm fiber (Test diet II)	50

Table 8: Distribution of subjects according to age and Sex.

S. No.	Age group	Control group				Experimental group 1				Experimental group 2			
		Male	Female	Total	%	Male	Female	Total	%	Male	Female	Total	%
1	35-50	11	3	14	28	16	5	21	42	16	5	21	42
2	51-65	29	7	36	72	22	7	29	58	22	7	29	58

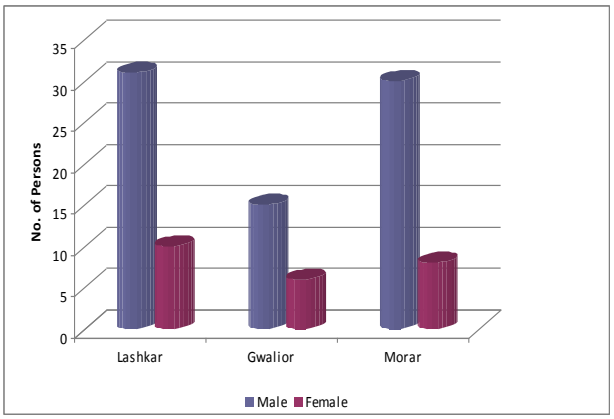


Graph 1: Distribution of subjects according to age and Sex.

Above table shows the distribution of subjects according to age and sex. 50 subjects each were included in three groups viz. control group, Experimental group 1 and Experimental group 2. In age group of 35-50yrs 28% subjects were in control group and 42% subjects were in Experimental group 1 and 2, respectively whereas in age group of 51-65 years 72% were in control group and 58% were in Experimental group 1 and 2 respectively.

Table 9: Demographic profile of the respondents.

S. No.	Study Area	Distribution of subjects according to sex		
		Male	Female	Total
1	Lashkar	31	10	41
2	Gwalior	15	6	21
3	Morar	30	8	38
Total		76	24	100



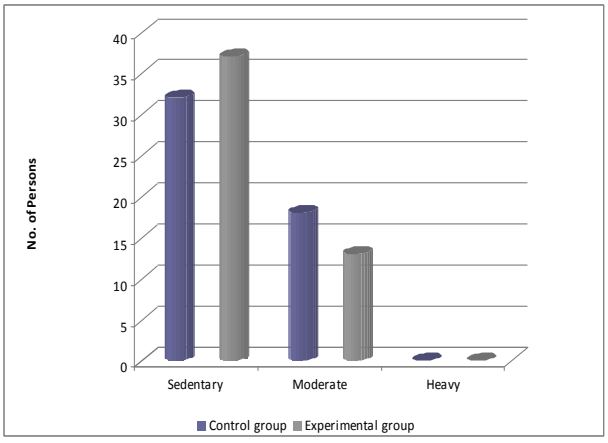
Graph 2: Demographic profile of respondents.

Above table and graph shows the demographic profile of subjects (control and Experimental group 1, 2) under

study. The study group comprised of 100 subjects. As the study area was greater Gwalior which is composed of three regions viz. Gwalior, Lashkar, Morar, among the total 100 subjects 31 male and 10 female from lashkar, 15 male and 6 female from Gwalior and 30 male and 8 female were randomly chosen from Morar for the purpose of study.

Table 10: Distribution of subjects according to activity.

S. No.	Activity	Control group		Experimental group	
		No.	%	No.	%
1	Sedentary	32	64	37	74
2	Moderate	18	36	13	26
3	Heavy	0	0	0	0
	Total	50	100	50	100

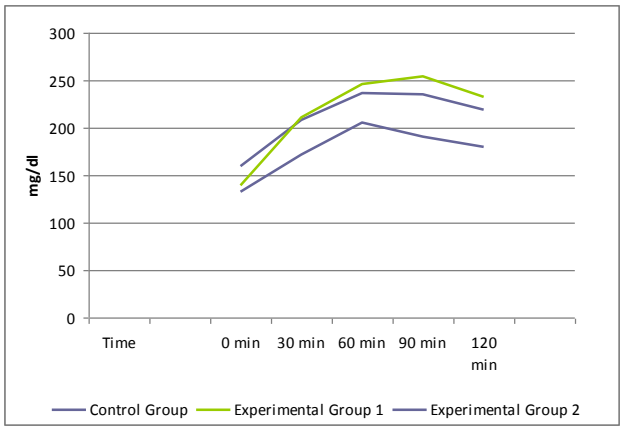


Graph 3: Distribution of subjects according to activity.

As is evident in the above table majority of the subjects under study were sedentary active (control group 64% experimental group 74%). Remaining patients had moderate active. None of them undertook heavy activity.

Table 11: Blood glucose area in different subjects (at beginning of intervention).

Time	At beginning of intervention		
	Control group	Experimental Group 1	Experimental Group 2
0 min	159	138.9	133
30 min	208	210.6	171
60 min	237	246.4	205
90 min	235	253.5	190
120 min	219	232	180

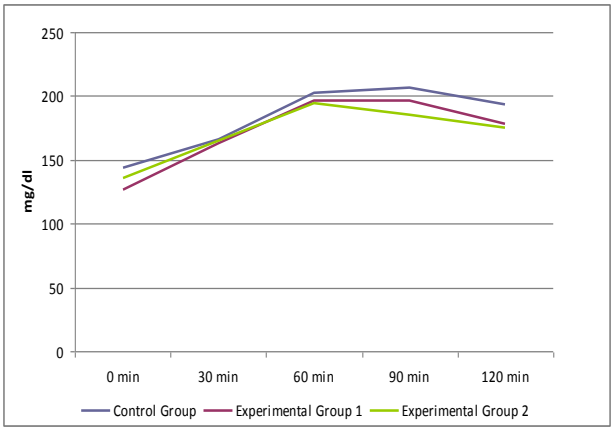


Graph 4: Blood glucose area in different subjects (at beginning of intervention).

It can be seen that in the beginning itself there is a clear distinction between the blood sugar level of subjects taking control diet, test diet I and test diet II, the last one being the lowest.

Table 12: Blood glucose area in different subjects (3 months after intervention).

Time	3 months after intervention		
	Control group	Experimental Group 1	Experimental Group 2
0 min	144	127	136
30 min	166	163	165
60 min	202	196	194
90 min	206	196	185
120 min	193	178	175



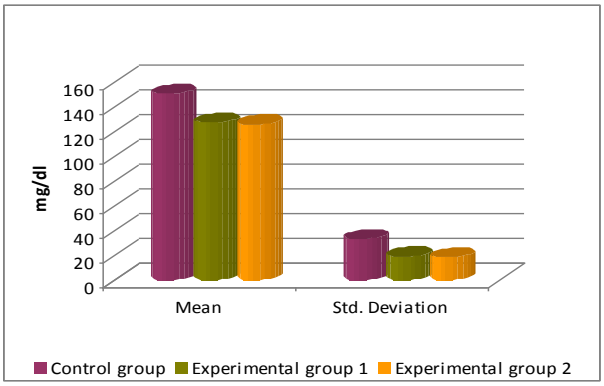
Graph 5: Blood glucose area in different subjects (3 months after intervention).

After 3 months of intervention the blood glucose level in all the three cases has come down. However, the effect seems to be more dramatic in control diet and test diet I, where the blood glucose level (after 120 min) has come down by about 20%, whereas in test diet II it came down by less than 5%. Though, overall the blood glucose level was lowest in the case of test diet II.

Table 13: Table showing the descriptive statistics like Mean, Standard deviation of post scores of FASTING BLOOD GLUCOSE (mg/dl) under three conditions viz. group provided with no fiber; 5 gm fiber in the breakfast and 10 gm fiber in the breakfast.

Group	Mean	Std. Deviation	N
Control group	149.92	33.087	50
Experimental group 1	126.72	19.033	50
Experimental group 2	125.38	18.431	50
	134.01	26.807	150

1. N: Number of people
2. Std. Deviation: Standard Deviation



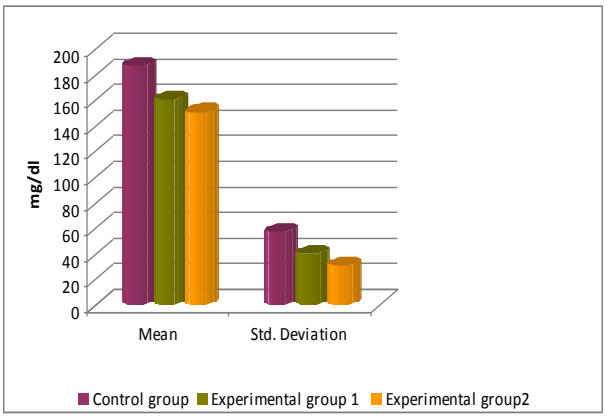
Graph 6: Showing the descriptive statistics like Mean, Standard deviation of post scores of FASTING BLOOD GLUCOSE (mg/dl) under three conditions viz. group provided with no fiber; 5 gm fiber in the breakfast and 10 gm fiber in the breakfast.

Table 14: Summary of one way ANCOVA of post scores of FASTING BLOOD GLUCOSE under three conditions viz. group provided with no fiber; 5 gm fiber in the breakfast and 10 gm fiber in the breakfast.

Source	Type III Sum of Squares	Df	Mean Square	F	Remark
Group	7834.519	2	3917.259	**10.344**	**< 0.05**
Error	55290.707	146	378.703		
Total	2800743.000	150			
Corrected Total	107074.993	149			

1. ANCOVA: Analysis of covariance, 2. Df: Degree of freedom, 3. F: Variance ratio, 4. P: Probability.

From the above table, it is evident that the F value for group being 10.344 is significant with df= 2/146. It indicates that the adjusted mean scores of fasting blood glucose levels under three conditions viz group provided with no fiber; 5 gm fiber in the breakfast and 10 gm fiber in the breakfast, considering the baseline of fasting blood glucose levels as covariate, differ significantly. Thus the null hypothesis, "There is no significant difference in the adjusted mean scores of fasting blood glucose levels when the subjects are not given fiber; when they are treated with test diet I (5gm fiber in the breakfast) and when they are treated with test diet II (10 gm fiber in the breakfast)" is rejected. This evidently proves that oatmeal which is rich in fiber plays a vital role in deciding the fasting blood glucose levels of the diabetics. It is now obvious with the adjusted means delivered by ANCOVA that Test diet II proved to have lower fasting levels than the test diet I and test diet I proved to have lower fasting levels than the control group where no fiber was provided.



Graph 7: showing the descriptive statistics like Mean, Standard deviation of post scores of POST PRANDIAL BLOOD GLUCOSE (mg/dl) under three conditions viz. group provided with no fiber; 5 gm fiber in the breakfast and 10 gm fiber in the breakfast.

Table 15: showing the descriptive statistics like Mean, Standard deviation of post scores of POST PRANDIAL BLOOD GLUCOSE (mg/dl) under three conditions viz. group provided with no fiber; 5 gm fiber in the breakfast and 10gm fiber in the breakfast.

Group	Mean	Std. Deviation	N
Control group	186.28	57.163	50
Experimental group 1	160.36	40.090	50
Experimental group 2	150.53	30.499	50
	165.72	46.238	150

Table 16: Summary of one way ANCOVA of post scores of POST PRANDIAL BLOOD GLUCOSE under three conditions viz. group provided with no fiber; 5 gm fiber in the breakfast and 10 gm fiber in the breakfast.

Source	Type III Sum of Squares	df	Mean Square	F	p value
Group	24922.194	2	12461.097	**9.729**	**p < 0.05**
Error	187008.705	146	1280.882		
Total	4438184.250	150			
Corrected Total	318550.768	149			

From the above table, it is evident that the F value for group being 9.729 is significant with df= 2/146. It indicates that the adjusted mean scores of postprandial blood glucose levels under three conditions viz group provided with no fiber; 5 gm fiber in the breakfast and 10 gm fiber in the breakfast, considering the baseline of fasting blood glucose levels as covariate, differ significantly. Thus the null hypothesis, stated, "There is no significant difference in the adjusted mean scores of postprandial blood glucose levels when the subjects are not given fiber; when they are treated with test diet I (5gm fiber in the breakfast) and when they are treated with test diet II (10 gm fiber in the breakfast)" is rejected. This evidently proves that oatmeal which is rich in fiber plays a vital role in deciding the postprandial blood glucose levels of the diabetics.

It is now obvious with the adjusted means delivered by ANCOVA that test diet II proved to have lower postprandial blood glucose levels than the test diet I and test diet I proved to have lower postprandial blood glucose levels than the control group where no fiber was provided. Hence it is again proved that oatmeal of 5gm or 10 gm everyday in the breakfast has an effective combat with diabetes mellitus because of its anti diabetic properties (tendency to reduce fasting and postprandial sugar levels).

CONCLUSION

This study was designed to assess the therapeutic importance of dietary fiber in the management of diabetes mellitus. It is already established that fiber plays important role in regulation of blood sugar level. Through this study an attempt has been made to optimize the amount of fiber that should be incorporated in one's diet.

The diabetic subjects were provided with test diets comprising of different quantities of fiber or no fiber at all. After the continuous consumption of test diets by all three groups (one control and two experimental) it was concluded that fiber is a very influential component in the glucose management of Type II Diabetes mellitus. Remarkable changes were seen in the patients who were given fiber supplemented test diet in comparison to those who consumed control diet (no fiber). Minor differences could be observed in two test diets viz. one with 5 gm fiber and the other with 10 gm fiber, indicating thereby that too much of fiber does not lead to remarkable relief in the disease.

The effect in blood sugar level was found to be more in control diet and test diet I rather than test diet II. This could be due to the fact that the same patients who were given test diet I, were also given the test diet II. The major reduction in blood glucose level was worked by the test diet I and then a further minor reduction was done by test diet II. The statistical analysis showed clearly the level of fasting blood glucose as lowest in the case of test diet II, slightly higher in test diet I and highest in control diet. As similar behavior was observed in postprandial blood glucose levels so this clearly indicates positive impact of fiber on blood glucose level.

Apart from fiber rich diets, even the control diet (no fiber) showed positive changes in some characteristics, showing that there are some factors other than the fiber content of the diet, which can also provide relief to the diabetic subjects. This could be the consequence of counseling, physical activities, awareness towards life style and kind of carbohydrate consumed by the subjects. Overall it is proved that fiber is effective component in the management of Type II Diabetic mellitus.

ACKNOWLEDGEMENT

It gives me great pleasure in acknowledging the support and help of Professor G B K S Prasad, School of Studies in Biochemistry, Jiwaji University, Gwalior. A well equipped lab, expert comments and friendly environment facilitated my practical work.

My work was also partly undertaken at Centre for Food Technology, Jiwaji University, Gwalior. I am thankful to the coordinator, Centre for Food technology, Jiwaji University, Gwalior for providing necessary laboratory facility to carry out the experimental work.

COI CERTIFICATE

Certified that author Shweta Choudhary has not any conflict of interest regarding the relation of manuscript with any of the companies, patents or any other organization.

AUTHORS' CONTRIBUTION CERTIFICATE

It is certified that all the parts/sections of the manuscript has been only contributed by the author and that the work undertaken with human subjects was in accordance with norms of the ethical committee of the institution. No funding from any source.

Abbreviation list
ANCOVA: Analysis of covariance
A1C: Glycosylated hemoglobin
Df: Degree of freedom
F: Variance ratio
FPG: Fasting plasma glucose
OGTT: Oral glucose tolerance test
P: Probability
Std. Deviation: Standard deviation.

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