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EFFECT OF PREBIOTIC - GUAR GUM SUPPLEMENTATION AMONG DYSLIPIDEMIC PATIENTS WITH OR WITHOUT HYPERGLYCEMIA

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ABSTRACT

Coronary artery diseases (CAD) and diabetes are the major public health problems in India. Elevated serum low density lipoprotein cholesterol (LDLc), triglycerides and blood glucose are classical risk factors for CAD and its progression. Dietary errors such as habitually low fiber diets are associated with the higher incidence of CAD. This study was conducted to assess the effect of prebiotic (guar-gum) supplementation on the lipid profile and glucose levels. Guar-gum (15g/day) was supplemented in the habitual diets of 36 hypercholesterolemic patients with or without hyperglycemia for a period of four weeks. The study indicated a significant reduction in serum total cholesterol, LDLc and triglycerides; the mean drop being 36.5mg/dl, 30.4mg/dl and 7.4mg/dl respectively. Further, there was an increase in high density lipoprotein cholesterol (HDLc) level, the mean increase being 2.6mg/dl. These favourable changes were particularly significant among the high risk group. The mean reduction in fasting and post-prandial blood glucose levels was 25.5mg/dl and 47.5mg/dl respectively. Hence, supplementation with prebiotics such as guar-gum can help in the prevention, treatment and management of CAD and perhaps diabetes.

Keywords: Coronary Artery Disease, Dyslipidemia, Guar-Gum, Hypercholesterolemia, Hyperglycemia.

I. INTRODUCTION

In India, nearly 60 per cent of total deaths are due to non-communicable diseases; 29 per cent being due to cardiovascular diseases [1]. Several modifiable and non-modifiable risk factors have been identified for the increasing incidence of coronary artery diseases (CAD); dyslipidemia/hypercholesterolemia, hypertension and smoking being the three classical risk factors. Several studies have shown that the lipid composition of the atheroma correlates very closely with that of blood; the nature and level of blood lipids strongly influence the

deposition of atheromatus plaques [2]. Dietary errors particularly habitual consumption of diets low in fiber, high in saturated fat and cholesterol coupled with sedentary life styles are directly related to the occurrence of dyslipidemia/hypercholesterolemia and hypertension [3, 4, 5, 6].

Dietary fibers have been found to exert hypocholesterolemic effects through their prebiotic actions. *Prebiotics are non-digestible plant or animal components which selectively facilitate the growth of health promotive microorganisms - the probiotics, in the colon*. Guar-gum, obtained from the seeds of cluster bean is a viscous water soluble galactomannan, which gets fermented in the lower gastro-intestinal tract and hence exerts its hypocholesterolemic effect [7]. Guar-gum gets partially hydrolyzed during its extraction from the seeds and further when the food is subjected to cooking. The branched chain structure of guar-gum molecule lends itself to greater hydrogen bonding and, therefore, it has a considerable water binding capacity. Hydration of one part of the chain causes the other part to tear apart. This shearing action exposes new hydrogen bonding sites for water to occupy, as a result this hydrocolloid molecule gets encircled in a region of partially immobilized water molecules [8]. This property of guar-gum has been utilized for its use as a thickener and gelling agent in the food industry. Commercially available guar-gum powder contains 78 to 82 per cent galactomannan.

As a prebiotic, guar-gum exerts hypocholesterolemic effect through a number of mechanisms such as:

- adsorption to bile salts leading to their increased excretion via the fecal route. The enhanced excretion of bile salts diverts the serum cholesterol for increased synthesis of bile acids from cholesterol. This results in reduced availability of cholesterol for incorporation into lipoproteins to be released in venous circulation,
- reduced availability of bile salts in small intestine for micelle formation inhibits cholesterol absorption,
- being a gel-forming non-absorbable plant fiber, guar-gum may bind and partition some cholesterol which further reduces its intestinal absorption
- prebiotics such as guar-gum are utilized by the intestinal micro flora to produce short chain fatty acids (SCFAs) which in turn modify the activity of certain regulatory enzymes principally bile-salt-hydrolase enzyme, resulting in an improved lipid profile.
- Guar-gum also promotes the growth of microbes in the large intestine which results in binding and incorporating some cholesterol into the cellular membranes of various probiotics during their growth and multiplication [9, 10, 11, 12].

In view of the above known mechanisms, it appears that prebiotics can be used as an alternative therapy to improve lipid profile and hence facilitate the prevention, treatment and management of CAD. However, studies related to fiber supplements, have often indicated controversial results. While some studies have shown significant positive effects [13, 14, 15, 16, 17] other have brought forth no significant improvement in lipid profile [18, 19]. Thus, studies need to be carried out regarding the type and amount of dietary fiber supplements (prebiotic) that may prove to be beneficial in the treatment and prevention of CAD and diabetes, particularly under Indian situations and with the existing dietary habits. Therefore, in this study, the effect of guar-gum supplementation was assessed keeping the following objectives in mind:

- To understand the prognosis of hypercholesterolemia and hyperglycemia among enrolled patients
- To identify the etiological factors related to these conditions among the subjects
- To study the dietary pattern of patients suffering from dyslipidemia/hypercholesterolemia with or without hyperglycemia – before, during and after guar-gum supplementation

- To study the blood lipid profile, glucose and other parameters of the subjects, both before and after supplementation
- To assess the impact of guar-gum supplementation among hypercholesterolemics with or without hyperglycemia

II. METHODOLOGY

The subjects for the study - both males and females (N=36), were enrolled from the Out-Door Patient Department of a multi-specialty Government hospital of Delhi, keeping the inclusion/exclusion criteria in mind.

Patient inclusion criteria were:

- Informed written consent to participate in the study
- Dyslipidemia with or without hyperglycemia (non-genetic)
- Stable medical condition with no impending status of surgery
- No significant change anticipated in dietary habits and lifestyle practices during the 4 week supplementation period

Patient exclusion criteria were:

- Informed written consent not available
- Normocholesterolemics with other forms of heart diseases
- Change anticipated in medication or impending surgery
- Significant changes expected in dietary habits and lifestyle practices during the period of supplementation.

The enrolled patients were divided into three groups:

Group A (n=29): high risk hypercholesterolemic patients (blood cholesterol $\geq$240mg/dl)

Group B (n=3): borderline hypercholesterolemic patients (blood cholesterol 200 to <240mg/dl)

Group C (n=4): high risk hypercholesterolemic patients (blood cholesterol $\geq$240mg/dl) with hyperglycemia (fasting blood glucose $\geq$100mg/dl)

Eleven patients were considered as drop outs because either they had not consumed guar-gum regularly or there had been significant changes in their diets/lifestyle during the study period.

2.1 Tools and Techniques: Data relating to the personal profile, dietary habits/ intake, anthropometric measurements and clinical parameters of the patients were gathered by using appropriate tools and techniques which included:

2.1.1 Questionnaires: Questionnaires were developed, designed and pre-tested to gather the necessary data. Questionnaire on general information helped to gather data regarding age, gender, education, occupation, income and family profile. It also helped to collect information relating to the activity pattern (distance walked/stairs climbed in a day) and the extent of physical exercise undertaken by the patients. Another questionnaire was framed to gather information on dietary habits especially relating to the quality and quantity of fat, quantity/frequency of consuming dietary fiber rich foods as well as habits relating to smoking and alcohol consumption. Questionnaire on Clinical Profile helped to understand the past/ present signs/symptoms as well as treatment (drugs, diet, exercise) undertaken by the patient.

2.1.2 Performa for diet recall-record: During the study, the diet related data were gathered by three approaches i.e. 24hr recall, dietary record and food frequency. At enrollment, dietary data were gathered by 1

day 24 hr. dietary recall coupled with 2 days dietary record. The same was repeated at the mid-term i.e. 1 day 24 hr. dietary recall method and two day 2 days dietary record. At the end of supplementation period, dietary data were gathered only by 1 day 24 hr. dietary recall method. In addition, Food Frequency Questionnaire was developed to identify the usual dietary habits of the enrolled patients.

2.1.3 Case Files: Case files of the patients were studied in detail to understand the prognosis of the disease and to know about the present health status of the patients. This helped to find out whether, after the medical treatment, over the years, the disease had progressed or regressed. Reports of the physical and biochemical examination helped to find out the severity and extent of the disease.

2.1.4 Anthropometric Measurements and Clinical Parameters: Weight and height were measured in duplicate to assess the Body Mass Index (BMI). The data on BMI were further classified into obese (positive risk factor)/ non-obese (negative risk factor) as per the classification given by the World Health Organization for Asians, 2004 [20]. Data on blood pressure were categorized as per the classification given by the Seventh Joint National Committee on the Prevention, Detection, Evaluation and Treatment of High Blood Pressure, 2004 [21]. Data on blood parameters included fasting lipid profile viz. total cholesterol, very low density lipoprotein cholesterol (VLDLc), low density lipoprotein cholesterol (LDLc), high density lipoprotein cholesterol (HDLc) and triglycerides as well as fasting and post prandial blood glucose levels were gathered. The data on lipid levels were used to categorize patients as per the National Cholesterol Education Programme (NCEP) Expert Panel on the Detection, Evaluation and Treatment of High Blood Cholesterol in Adults, Adult Treatment Panel III, 2001 [22].

2.1.5 Palatability trials: Guar gum is used as an additive in small amounts in the food industry. Yoon SJ et al (2008) have also suggested some uses of partially hydrolyzed guar-gum at the time of food processing [23]. However, no suggestions have been given so far regarding the incorporation of guar-gum in daily Indian diets. Hence, as an innovative approach, before undertaking the supplementation trial, palatability trials were conducted to find out the most suitable ways of incorporating guar-gum in the daily diets, which could then be proposed to the subjects. Thus, guar-gum was added to various dishes commonly consumed in North India, both, during and after cooking (at the time of serving) and their palatability was evaluated. In dishes like curries (kidney beans, horse gram, pea-potato, bottle gourd), pulses (whole urad, dehusked moong), vegetable preparations (brinjal-potato), rice and tomato soup since the addition of guar-gum after cooking resulted in a gritty taste, this soluble fiber was added during cooking. Similarly, in case of cold coffee and milk, trials were carried out by adding guar-gum at the time of preparation. In the case of chappati, guar-gum powder was used as a filling in the already prepared dough or it was added to the flour while preparing the dough for chappatis. In curds, guar-gum was added both with/without adding water.

2.2 Data Collection: During the four week supplementation study data were gathered during the pre-supplementation, mid-term supplementation and post-supplementation phases. In the pre-supplementation phase, data were gathered on general profile, physical activity, dietary habits and dietary intake (24 hour recall method) using pretested questionnaires and performa. Weight and height were measured in duplicate to ensure accuracy. Resting blood pressure was recorded for each patient. Fasting blood samples were analyzed for lipid profile and glucose levels. Performa were given to the patients to record their dietary intake for next two days. After gathering all the necessary data, 14 packets (each containing 15g +1mg) of guar-gum were given to every

patient. As per the results of palatability trials, various methods of incorporating guar-gum were suggested to the patients. The subjects were advised to consume one packet of guar-gum a day and that the contents of each packet need to be divided into approximately three equal portions for incorporating into three main meals viz. breakfast, lunch and dinner. During the mid-supplementation phase i.e. two weeks after the supplementation, the mode of incorporating guar-gum in the meals and the problems faced by the subjects during the previous two weeks were discussed. The completed performa of two day dietary record were collected back and one day dietary data were gathered by 24 hour recall method. Once again dietary record performas were given to the patients so that they could enter their dietary intake for subsequent two days. 14 packets (each containing 15 grams $\pm$1mg) of guar-gum were given to each patient. During the Post-Supplementation Phase i.e., when the patient had consumed 15grams of guar-gum daily for 4 weeks, the regularity of consumption of guar-gum and the problems, if any faced by the subjects were discussed. To ascertain regular consumption of guar-gum given to the patients, each patient was requested to bring back any unused packet. Once again at the end of the study period, one day dietary data were gathered by 24 hour recall method. Data on weight, serum lipid profile (fasting) and blood glucose (fasting and post-prandial) levels were recorded. Once the study period was over, the patients were given nutrition counselling with special emphasis on the benefits of dietary fiber and the ways of incorporating dietary fiber in daily diets.

Throughout the supplementation period, regular telephonic contacts were made to keep a record on the regularity of guar-gum intake and motivate the patients to adhere to the daily intake of the fiber supplement. The data were analyzed both quantitatively and qualitatively. The dietary intake data were translated into the amount of raw ingredients and the nutrient intake was computed using the Nutritive Value of Indian Foods as given by Indian Council of Medical Research, 1999 [24]. In addition to energy, protein, carbohydrates, total fat, visible fat, crude fiber and dietary fiber were computed. Data were statistically analyzed and paired t-test ($p=0.05$) was applied to find out whether the changes in serum lipid profile and blood glucose levels was significant or not.

III. RESULTS AND DISCUSSION

3.1 General Information: The subjects under study were aged between 30 to 76 years; 28 (77.6%) being between 51-70 years of age. Majority of the patients were from nuclear families. In most cases, the food was planned and prepared by the wives or themselves (in case of female patients) and in only 10 (27.7%) cases, it was prepared by other family members. This information helped in identifying the family members who took care of the patient's meals and thus were given dietary counselling along with the patient regarding the most effective methods of incorporating guar-gum in his/her meals.

3.2 Physical Activity: Majority of the patients were engaged in office jobs or were retired and hence were leading a sedentary life-style. Most of these patients also did not undertake any regular walking activity or the walking was confined to less than one kilometer per day. Twenty nine subjects 80.5 per cent (n=29) did not climb stairs at all as they were confined to the ground floor both for their residence and office. Further, 91.6 per cent (n=33) subjects did not undertake any kind of regular physical activity or exercise. All this information indicates that most of the patients belonged to the sedentary activity category, which could be one of the reasons for their suffering from dyslipidemia and/or impaired glucose tolerance.

3.3 Dietary Habits: Data indicated that 63.9 per cent were eggetarians or non-vegetarians. Among the non-vegetarian food items, chicken was most frequently consumed followed by egg, meat and fish. Consumption of vegetables and fruits especially with edible peels indicated that nearly 50 per cent were habitually taking a low fiber diet. All were using refined vegetable oils as a substitute to animal fat but none was found to be taking canola or olive oil. This could have adversely affected the n-3/n-6 ratio. Studies have indicated that poor intake of n-3 fatty acids increases the risk of sudden death usually arising from cardiac arrhythmia [25, 26, 27]. Smoking appeared to be a major risk factor for CAD, as fourteen (38.8 per cent) patients were the current and an equal number had been the past smokers. Seven of these subjects were heavy and three, in addition to cigarette smoking consumed tobacco in other forms also. Smoking is a classical risk factor for CHD; the incidence being usually two to three times higher in smokers and therefore public awareness regarding the harmful aspects of smoking needs to be created so that this modifiable risk factor can be averted.

3.4 Clinical Profile: Among the enrolled patients, 63.8 per cent had a positive family history. Dyslipidemia/hypercholesterolemia had been diagnosed in 58.4 per cent (n=20) patients more than five years back; 16.5 per cent (n=6) had been suffering from more than 10 years. Thus, most of the subjects were old cases of CHD and the disease was well established. Case files indicated that high risk hypercholesterolemics (Group A) were having a higher incidence of angina and myocardial infarction than the borderline hypercholesterolemics. Among the enrolled subjects, LDLc levels may be directly related to the higher incidence and severity of angina and/or myocardial infarction. Obesity and hypertension were not the major risk factors in the patients under study (TABLE 1).

Table 1: Duration of Hyperglycemia/Hypercholesterolemia and Family History

Group	N	Disease	Number of years since detected					Family History	
			<1yr	1<5yr	5<10yr	10<20yr	>20yr	Positive	Negative
A	29	HC	1 (3.4%)	11 (37.9%)	11 (37.9%)	5 (17.2%)	1 (3.4%)	18 (62.1%)	11 (37.9%)
B	3	HC	-	1 (33.3%)	2 (66.6%)	-	-	2 (66.6%)	1 (33.3%)
C	4	HC HG	- -	3 (75%) 2 (50%)	1 (25%) 2 (50%)	- -	- -	3 (75%)	1 (25%)
Total	36	HC HG	1 (2.7%) -	15 (41.6%) 2 (5.5%)	14 (38.8%) 2 (5.5%)	5 (13.8%) -	1 (2.7%) -	23 (63.8%)	13 (36.1%)

*HC: Hypercholesterolemia, HG: Hyperglycemia

3.5 Dietary Intake: Data gathered from the Recall-Record method during the three phases of supplementation indicated that there was not much of a variation in the energy and nutrient intake during the study. The total dietary intake data (gathered by recall-record and food frequency methods) indicated that 52.7 per cent patients had higher energy intake than recommended levels. Since there was not much variation in the energy intake

during the three phases, it can be said that guar-gum supplementation did not have any anorexic effect on these patients. Howarth et al (2003), have also reported that fermentable fiber does not alter the appetite [28]. In the diets of 63.8 per cent subjects more than 20 per cent of the dietary energy was contributed by fats.

At enrollment, the dietary fiber intake ranged between 4.95g to 26.96g per day. The diets were extremely deficient in dietary fiber. According to the results obtained from the Nutrient Adequacy Ratio (computed on the basis of 40g dietary fiber per day), in majority of subjects (72.2 per cent) the dietary fiber intake from food prior to supplementation was less than half the amount proposed by ICMR (2010). During the period of guar-gum supplementation the dietary fiber intake reached somewhat near the proposed levels; the dietary fiber intake being $\geq$40g per day only in case of five patients. The mean intake of energy, protein, carbohydrate, total fat, crude fiber and dietary fiber of the patients during the three phases of study are given in TABLE 2.

Table 2: Average nutrient intake of patients during each phase of supplementation

Group	Phase of Supplementation	Energy (Kcal)	Protein (g)	Carbohydrates (g)	Total Fat (g)	Crude Fiber (g)	Dietary Fiber (g)
A (n=29)	Pre (3days)	2160	73.8	321.0	60.6	15.78	16.35
	Mid (3 days)	1984	63.8	297.6	53.35	15.27	33.20+15*
	Post (1 day)**	2275	70.9	350.0	58.88	10.0	16.57+15*
B (n=3)	Pre (3days)	2209	65.2	331.6	63.98	11.30	17.27
	Mid (3days)	2279	66.1	349.7	69.98	11.95	21.82+15*
	Post (1 day)	2408	73.7	356.9	69.98	14.1	14.10+15*
C (n=4)	Pre (3days)	1989	63.0	300.4	53.36	8.86	15.32
	Mid (3days)	2068	67.3	312.5	53.52	11.23	16.23+15*
	Post (1day)	2270	74.0	331.3	62.56	12.09	18.99+15*

*15g of dietary fiber is from guar-gum ** Data not available for 11 patients (drop outs)

3.6 Clinical Parameters: Serum lipid profile and blood glucose levels, registered a significant drop. The data relating to changes in the blood lipids and glucose levels are given in TABLE 3. The mean drop in total cholesterol was 42.8mg/dl in Group A (42.8mg/dl) and 37.3mg/dl in Group C but not in Group B. In group B, two patients had registered a mean decrease in total cholesterol by 15.5mg/dl while in case of third patient there was an increase by 37mg/dl indicating that perhaps there was no effect of guar-gum supplementation in this individual. However, the sample in group B was too small to make any generalization.

Similar results were observed in case of LDLc with a maximum drop (39.22mg/dl) in high risk hypercholesterolemics followed by the patients in the high risk hypercholesterolemia category who were also suffering from hyperglycemia (15.0mg/dl). The decrement was not significant in borderline cases (Group B). Although there was a decrease in the VLDL fraction on an average by about 7.44mg/dl, the change was not significant in all the groups as indicated by paired t-test (p=0.05).

The mean pre-supplementation HDLc levels were 44.0mg/dl which increased to 46.6mg/dl in the post supplementation phase, registering an increase of about 2.6mg/dl. The average increase in the HDLc was 4.3mg/dl, 0.7mg/dl and 3.7mg/dl in Group A, B and C respectively. Hence, the HDL fraction, registered a marked increase in Group A followed by a significant increase in group B. However, in group C, no definite reason can be given for the decrease in HDLc. Perhaps it could possibly be due to hyperglycemia in addition to

hypercholesterolemia among these patients. The results of paired t-test indicated a significant increase in HDLc in the total sample (n=25).

There was a significant decrease in the LDL/HDL ratio for the total sample and group A. However, in group B and C, the mean LDL/HDL ratio remained nearly the same. LDL/HDL ratio is a direct indicator of the patients LDLc and HDLc levels in the blood. High LDL/HDL ratio is a risk factor for future cardiac events.

Table 3: Data on lipid profile and blood glucose levels – before and after supplementation – Group wise

Variable	Pre-Supplementation	Post-Supplementation	Difference and t-test value
Group A (n=18)			
Total Cholesterol (mg/dl)	280.9±12.57 (241-448)	238±13.64 (177-421)	-42.8 (15.2%); 5.22*
LDL Cholesterol (mg/dl)	175.3±12.95 (128-338)	136.1±9.45 (89-233)	-39.2 (22.36%); 4.35*
VLDL Cholesterol (mg/dl)	60.8±5.61 (56-64)	54.1±1.64 (40-65)	-6.7 (0.11%); 1.33
HDL Cholesterol (mg/dl)	44.1±1.24 (38-59)	48.4±1.36 (39-61)	+4.3 (9.75%); -3.5*
LDL/HDL Ratio	4.0±0.34 (2.1-8.6)	2.8±0.20 (1.5-5.1)	-1.2 (30.0%); 4.85*
Triglycerides (mg/dl)	197±18.65 (103-417)	168±14.30 (94-370)	-26.7 (13.71%); 2.82*
Group B (n=03)			
Total Cholesterol (mg/dl)	230.6±2.84 (225-234)	232.6±14.6 (218-262)	-2.0 (0.86%)
LDL Cholesterol (mg/dl)	132.0±6.80 (123-164)	134±13.01 (120-160)	-2.0 (1.51%)
VLDL Cholesterol (mg/dl)	53.6±4.33 (46-61)	52.6±2.67 (50-58)	-1.0 (1.86%)
HDL Cholesterol (mg/dl)	45.3±5.04 (42-47)	46.8±1.15 (44-48)	+0.7 (1.54%)
LDL/HDL Ratio	2.9±0.28 (2.4-3.3)	2.9±0.35 (2.5-3.6)	-
Triglycerides (mg/dl)	192.0±31.04 (130-226)	128.0±30.89 (72-182)	-64.0 (33.3%)
Group C (n=04)			
Total Cholesterol (mg/dl)	261.0±8.26 (248-284)	223±12.23 (199-249)	-37.3 (14.29%)
LDL Cholesterol (mg/dl)	150.0±5.40 (136-162)	135.0±6.17 (123-150)	-15.0 (10.0%)
VLDL Cholesterol (mg/dl)	65.0±10.51 (46-95)	49.7±6.00 (37-60)	-15.3 (23.5%)
HDL Cholesterol (mg/dl)	42.7±1.79 (41-43)	39.0±0.40 (38-40)	-3.7 (8.66%)
LDL/HDL Ratio	3.4±0.18 (3.1-3.8)	3.4±0.5 (3.1-3.5)	0.0 (-)
Triglycerides (mg/dl)	221.7±44.16 (115-307)	207.2±54.65 (115-332)	-14.5 (6.54%)
Blood Glucose (F, mg/dl)	119.56±6.51 (108-136)	94.0±3.02 (86-100)	-25.5 (21.3%)
Blood Glucose (PP, mg/dl)	155.2±10.39 (125-172)	107.7±6.30 (92-122)	-47.5 (30.6%)

*Statistically significant (p=0.05).

The mean drop in fasting serum triglycerides was 29.3mg/dl (n=25). The decrease in triglycerides was most marked in group B (64mg/dl) followed by group A (28.0mg/dl) and group C (13.8mg/dl). The beneficial effects

of guar-gum could be more pronounced among patients suffering from both, hypercholesterolemia as well as hyperglycemia but due to small sample size no conclusions can be derived.

There was a significant decline in the fasting (25.5mg/dl) as well as post-prandial (47.5mg/dl) blood glucose levels of patients suffering from hypercholesterolemia as well as hyperglycemia (group C). Although the sample size in this category is too small, yet these results indicate a definite trend in the reduction of blood glucose levels among hyperglycemic patients, when their diets are supplemented with dietary fiber.

Consequent to guar-gum supplementation (based on serum lipid profile and blood glucose levels), within 4 weeks, a number of high-risk category patients shifted to the borderline-risk category. According to the National Cholesterol Education Programme Report (2001), every 1mg increase in HDLc level reduces CHD risk by 3 per cent and every 1mg decrease in LDLc reduces the risk of CHD by 1 per cent [22]. It can therefore be concluded that guar-gum supplementation can help reduce the risk of CHD/its progression considerably.

IV. CONCLUSION

Guar-gum supplementation does have significant effects in lowering the serum total cholesterol, LDLc, VLDLc, triglycerides and blood glucose levels in hypercholesterolemic patients with or without hyperglycemia. In addition, supplementation with this prebiotic also helped in raising the HDLc levels, an attribute which plays an important role in reducing the risk of CAD. The effect is more marked in high risk hypercholesterolemic patients than in borderline cases except for triglyceride levels, where the effect was more marked among borderline than in high-risk cases. However, since the sample size was small, particularly in case of borderline hypercholesterolemics as well as in case of patients suffering from hypercholesterolemia along with hyperglycemia, further work for a longer period covering a larger sample is needed to substantiate these findings. Among the etiological factors, dietary errors particularly intake of high energy, and/or high amount of fats with low n-3/n-6 ratio, as well as low dietary fiber coupled with cigarette smoking appear to be of greater relevance. Therefore, dietary counselling especially relating to the inclusion of foods rich in dietary fiber and public awareness regarding harmful effects of smoking of not only the patients, but also of the common people (non/passive smokers) appear to be the need of the hour. Further, the concept of Medical Nutrition Therapy needs to be strengthened wherein nutrition interventions in the form of counselling and/or dietary supplementation/modifications must become an inherent part of the treatment process for all out-door and in-door patients.

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