ABSTRACT

An alarming rise has been seen in the last decade in NCDs on a global level with obesity being one of the most pervasive and a major contributor to the global load of chronic disease and disability. India is the third most obese country in the world and in the universal hazard list of top 10 countries. Obesity may not be considered as a specific disease but it is certainly the mother of important degenerative diseases of adult life. Prevention and control of this problem is must, therefore, claim priority attention.

In the recent years, progress in understanding the mechanisms by which the gut microbiota interact with the host will provide new basis for putative role of nutraceuticals or dietary interventions in the management of obesity.

Fructooligosaccharide is often cited as being of particular interest with regard to its putative role in the management of obesity and metabolic disorders because it affects food intake, body weight, glucose homeostasis, plasma lipid profile, gut flora and LPS which are all associated risk factors for obesity, diabetes and cardiovascular diseases. A number of recent studies provide novel insight that might help establish a link between dietary non digestible carbohydrate that changes the composition of gut microbiota, obesity and insulin resistance. FOS is also gaining acceptance in large number of product and process development. The technological functionality of FOS as a fat and sugar replacer making some of the products low in calorie and fat can go a long way in providing healthy food choices to health conscious individuals. These properties of FOS proceed to study the feasibility of FOS incorporated food products, its health implications in obese population.

Thus, the present study was undertaken with 4 major objectives: 1) Development of FOS incorporated food products and studying their various organoleptic attributes and overall acceptability 2) Mapping the prevalence of obesity and hypertension in selected banks 3) Comparison between non-obese

and obese grade-I subjects in terms of anthropometry profile, medical history, family history of diseases, defecation profile, hunger and satiety, psychological depression status, dependency on habits, dietary intakes, biophysical profile, atherogenic profile, endotoxemia and gut microbiota (*LAB, bifidobacteria, bacteroides and clostridium*) and understand the correlations between various parameters and 4) Effect of fructooligosaccharide (FOS) supplementation on anthropometry, defecation, hunger and satiety, depression, dietary, lipemic parameters, LPS and gut microflora in obese grade-I adults.

The potential of incorporating fructooligosaccharide in the popular recipes of India and their sensory qualities were studied by the method of addition and substitution. Total of four products were selected on the basis of their cooking method namely deep frying, shallow frying, steaming and baking. Products that were added with fructooligosaccharide included *lilva kachori, vegetable parantha,* and *rawa idli* at various levels. In *chocolate cake* FOS was partially substituted with fat and sugar. All the products were studied for their sensory characteristics by numerical scoring test. Organoleptic evaluation done by 25 semi trained panel members.

The results of the phase I revealed that *Lilva kachori* was well accepted up to 5g of FOS addition without affecting sensory attributes. At higher levels of FOS incorporation, a significant gradual decrease in all the sensory attributes was exhibited, where color and appearance, texture and aftertaste were greatly affected. FOS can be incorporated to *vegetable paratha* upto 15g level without affecting the organoleptic qualities. *Rawa idli* was highly acceptable in terms of all the organoleptic attributes up to 20g of addition of FOS and *chocolate cake* was highly acceptable up to 30g of addition of FOS.

In phase II, a cross-sectional study design was used and a total of 595 bank employees irrespective of age and gender were screened for their anthropometric measurements, body fat percentage and blood pressure.

These subjects were classified under the various categories of BMI (non-obese and obese).

Results of this phase revealed that out of five hundred and ninety five subjects screened, 75.79% were males and 24.20% were females. The prevalence of obesity was observed to be 40.83% (BMI ≥25) and 19.29% for overweight (BMI 23–24.9). Approximately more than 54% of subjects were pre-hypertensive with more males (63.63%) than females (26.38%) and 24% of subjects had moderate hypertension.

In the phase III of the study, out of 595 subjects screened from above phase, 100 bank employees with normal BMI and 100 bank employees with obesity grade-I without any disorders were selected for phase III. Information regarding socio-economic profile, general habits, dietary intake, and physical activity pattern, personal medical and family history was collected using pretested semi structured questionnaire. Subjects were screened for various parameters in terms of anthropometric, dietary, biophysical, biochemical and microbial parameters. Physical activity pattern was measured using WHO-Global physical activity questionnaire-2. Dietary analysis was done using 24hr dietary recall and food frequency questionnaire. Baseline data on the subjects was carried out with respect to lipid parameters, and plasma LPS levels. Gut microbial counts levels were assessed in terms of *lactobacilli, bifidobacteria, clostridium* and *bacteriodes* from stool sample.

Results of this phase revealed that, there were more males (162) than females (38) in both the categories with majority of subjects being Hindu. Age was positively correlated with anthropometric parameters and blood pressure. Prevalence of abdominal obesity was significantly high ($p<0.000$) in obese subjects. Obese were 1.88 times at a higher risk of developing hypertension. Subjects with severe family history of co-morbidities were at 5.13 times higher risk of developing obesity [RR-5.13; CI (2.69-9.77)] and anthropometric parameters, percent body fat and diastolic BP was positively associated with family history of diseases. 26% of obese and 16% of non-obese had

constipation and overall defecation status was negatively associated with BMI, WC and percent body fat. Significant association was seen between BMI and intake of alcohol (χ^2-10.53**), cigarette smoking (χ^2-4.04*), intake of tea (χ^2-20.38***), and intake of coffee (χ^2-6.78**). Total MUFA intake was positively correlated with WC. The intensity of hunger pattern was same in both the groups. The non-obese subjects consumed less quantity of food and had early satiety compared to obese individuals. The mean cholesterol of the subjects was within the normal range. Both the groups were at risk as the TC/HDL ratio was higher than 4. Age was positively associated with TC, STG and VLDL. TC, LDL, TC/HDL and LDL/HDL ratio was negatively associated with lactic acid bacteria and positively associated with *bacteriodes.* The LPS was found to be significantly high by 8.52 pg/ml in obese subjects as compared to non-obese subjects. Age and family history of diseases was positively correlated with LPS. Hunger scores were negatively correlated with LPS. The gut of the non-obese subjects was colonized more with the friendly bacteria and the gut of the obese subjects was colonized with higher counts of *bacteroides* and *clostridium* which are potential pathogens. Satiety scores were negatively correlated with *bifidobacteria* and *clostridium. Lactic acid bacteria* were negatively correlated with fat intake. LPS was negatively associated with *LAB* and *clostridium*. Factors that contributed to obesity ranked in the order of contribution were intake of fat (β=0.452) followed by intake of energy (β=0.344), *LAB* (β=0.312), *Bacteroides* (β=0.257), intake of sodium (β=0.243) and intake of tea (β=0.231) were found to be the significant contributors.

Phase IV of the study was designed to evaluate the impact of FOS supplementation on obese (grade-I) young adults of urban Vadodara. For achieving the desired objectives, a total of 116 obese subjects were enrolled and randomly divided in two groups i.e. experimental and placebo groups which received FOS (20 g) and dextrose (20 g) respectively for 90 days and examined the effect of daily intake of FOS on anthropometry profile, blood pressure, defecation profile, hunger and satiety, psychological depression, dietary intakes, lipemic parameters, plasma LPS levels and gut microbiota

(*LAB, bifidobacteria, bacteroides and clostridium*). Post intervention the sample size remained as 51 in experimental group and 32 in placebo group, after considering the dropouts due to various reasons.

Results revealed that supplementation with FOS significantly reduced weight (1.44%) and BMI (1.32%) in experiment group subjects post intervention. A significant reduction was also seen in waist circumference by 2.18%, WHR by 2.15% and percent body fat by 2.92% after intervention. Systolic blood pressure values significantly ($p<0.001$) reduced by 1.79%, where diastolic blood pressure values also reduced non-significantly in experimental group subjects after intervention. Defecation profile significantly improved after intervention in experimental group subjects. Degree of constipation reduced significantly ($p<0.001$) from moderate to absence of constipation after intervention in experimental group subjects. A significant reduction was seen in the appetite by 12.83% and 15.12% during lunch and dinner time respectively in experimental group subjects after intervention. A significant improvement was seen in achieving early satiety during most of the meal times. Significant reduction was seen in mean dietary intakes of energy (7.50%), CHO (3.06%), protein (8.39%), and fat (10.42%) in experimental group subjects with increase in soluble fiber (327.93%) and total dietary fiber (92.30%) intake. Atherogenic profile significantly improved in experimental group after intervention. LPS levels reduced non-significantly (4.03%) in experimental group post intervention. FOS as a successful prebiotic in significantly colonizing the gut with the friendly bacteria like *Bifidobacterium* and *Lactobacillus* and a significant reduction was observed in the counts of *Bacteroides* and non significant reduction in *Clostridium* counts.

Hence, the present study concluded, that FOS is able to counteract several metabolic alterations linked to obesity including blood pressure, defecation profile, hunger and satiety, psychological depression, dietary intakes of macronutrients, lipemic parameters, and gut microbiota (LAB, bifidobacteria, bacteroides and clostridium) in obese grade-I adults.