ABSTRACT

Non-communicable diseases (NCDs) are the major cause of mortality worldwide. Among these NCDs, obesity is a global public health crisis that threatens the economies of all nations, particularly developing countries. Obesity is considered as cluster of non-communicable diseases called 'New World Syndrome'. Today, India leads at third position in the world with very high number of obese. Therefore, scientific community is involved in developing novel therapeutic measures to combat the rising epidemic of obesity and its complications.

The intestinal microbiota may be identified as an important target for improving health through reduced disease risk. Recent studies have highlighted the associations of gut microbiota in enhancing gut incretins like GLP-1 and reducing the hunger responses which may have an indirect effect in the improvement of these metabolic conditions. Scientists have postulated that to increase the number of beneficial bacteria in the gut is through the ingestion of prebiotics. These findings have led to development of prebiotic foods which might help in management of obesity.

A functional ingredient that has recently been recognized and received much attention in the scientific literature is Fructooligosaccharides (FOS). FOS are naturally occurring prebiotic dietary fiber which has a potential to exhibit beneficial health effect by stimulating the growth of *Bifidobacteria* and *lactobacillus* in the human colon and by suppression of putrefactive pathogens. This may lead to reduced food intake, body weight and fat mass along with reduction in endotoxemia. However, the extent of its feasibility and acceptability in routinely consumed Indian foods and its effect of endotoxemia and body weight gain in human obese subjects need to be studied. Hence the present study was undertaken with three main objectives: 1) Sensory evaluation of FOS added popular Indian food products. 2) Comparative analysis of obese and normal weight subjects for their anthropometric parameters, nutrient intake, gut microflora, GLP-1, LPS, hunger and satiety. 3) Anthropometric and metabolic responses of obese subjects to supplementation of FOS.

The possibilities of incorporating FOS in the popular Indian foods were studied by the method of addition. The products included *Buttermilk, Lemon* juice*, Milk, Soup, Potato curry, Dal, Kadi, Kheer* and *Khichdi* which were added with varying levels of FOS (2.5%, 4%, 5%, 6%, 7.5%) and studied for their organoleptic characteristics using ten point numerical scoring and difference test.

Results of this phase revealed that for all the nine products, FOS added recipes were well accepted up to 7.5% level of addition.Consistency of FOS added butter milk was reported to be superior as compared to the standard up to 7.5% level of addition. Color and appearance of tomato soup improved significantly when FOS was added up to 7.5% level of addition. For Kheer taste and mouthfeel improved significantly after addition of FOS at varying levels. Color and appearance, taste and overall acceptability of potato curry was significantly reported inferior as compared to the standard at 7.5% level of FOS addition. FOS can be added in all the food products studied. However, buttermilk, tomato soup and kheer remained the most acceptable products even at the higher (7.5%) level of FOS addition.

In phase II, comparative analysis between normal weight and obese was conducted for which 110 subjects (38 normal weight adults with BMI 18.5-22.9 kg/$m^2$and 72 were obese adults with BMI 25-30 kg/m^2 aged between 25-50 years) were screened and selected from Larsen and Toubro plant, Ranoli, Vadodara based on inclusion and exclusion criteria. Purposive sampling method was done to enroll subjects. Of these 110, 30 normal weight and 60 obese gave consent for their participation and intervention trial. Relevant medical history was obtained through patient's medical records, face to face interview and direct measurements were assessed for anthropometric measurements, physical activity levels, dietary profile, biochemical analysis like glucagon like peptide-1 (GLP-1), lipopolysaccharide (LPS) and enumeration fecal gut microflora in terms of *Lactic acid bacteria, Bifidobacteria* and Enteric pathogen.

Results of this phase of the study elicited that of the various NCD's studied the odds of occurrence of obesity with positive family history of obesity was statistically significant ($p<0.05$) in the obese subjects under study. Normal weight subjects had

high feeling of hunger for breakfast ($p<0.05$) and evening snacks ($p<0.001$) whereas obese subjects express significant higher feeling of hunger for lunch and dinner ($p<0.001$). Dietary data revealed significant higher intake of macro nutrients i.e. energy ($p<0.05$) and fat (0.001) were reported among obese as compared to normal weight subjects. This was also supported by food frequency data where obese subjects were reported to consume high fat snack ($p<0.01$), ice creams ($p<0.05$) and papad chutney more frequently ($p<0.05$) than normal weight subject.

Biochemical parameters revealed that obese subjects had higher plasma LPS ($p<0.001$) and lower plasma GLP-1 values ($p<0.05$) as compared to the normal weight subjects. Fecal sample analysis revealed that normal weight subjects had significantly better colonization of good bacteria i.e. *LAB*, *Bifidobacteria* ($p<0.05$) and lower Enteric pathogen count ($p<0.001$) as compared to obese subjects.

In phase III of the study, 60 obese subjects were asked to participate further in the study based on their willingness. The study design was double blind placebo control trial where the experimental group was given 12 g of FOS in powdered form to be consumed during meals for the duration of 60 days.

FOS supplementation to obese subjects resulted in significant reductions in body weight, WC, WHR and body fatby 1.06%, 1.66%, 2.13% and 4.23% respectively. The mean GLP-1 values increased by 17% and LPS levels significantly decreased ($p<0.05$) by 2.81%. Post supplementation the fecal log counts showed a significant change with an increase in *Lactic acid bacteria* (13.84%) and *Bifidobacteria* (10.30%) and a decrease in Enteric pathogen (20.24%).

Hence this phase of the study concludes that FOS is an attractive therapy for the management of obesity. As daily intake of 12 g FOS for period of >50 days resulted in reduction in the body weight, hunger, plasma LPS and plasma GLP-1 values along with improved colonization of beneficial gut microorganisms such as *LAB* and *Bifidobacteria*, indicating the potential of FOS for overall metabolic control in obese individual.