



Abstract



ABSTRACT

Non-communicable diseases (NCDs) have seized the globe with its growing prevalence and severity. Among these NCDs, type 2 diabetes is a global public health crisis that threatens the economies of all nations, particularly developing countries. Today, India leads at second position with very high number of diabetics worldwide. Diabetes is characterized by group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The chronic hyperglycemia of diabetes is associated with long-term damage, dysfunction, and failure of various organs. Therefore, scientific community is involved in developing novel therapeutic measures to stem the rising epidemic of diabetes and its complications.

Important role of beneficial gut microflora is an emerging field of research in management of these chronic metabolic disorders. 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 maintenance of overall health and well-being.

A functional ingredient that has received much attention in the scientific literature is Fructooligosaccharides (FOS). FOS are naturally occurring prebiotic dietary fiber with potentially technological, functional, nutritional and health benefitting properties. It has shown to exhibit beneficial health effect by stimulating the growth of *bifidobacteria* and *lactobacillus* in the human colon, by suppression of putrefactive pathogens which may lead to improvement of various metabolic activities in the host and may respond to improved immune system, serum cholesterol levels, blood glucose levels, insulin response, digestibility and many others. These salutary properties of FOS proceed to study

the feasibility of FOS incorporated food products, effect of processing on its retention and its health implications in type 2 diabetes.

Thus, the present study was undertaken with 3 major objectives: 1) Development of FOS incorporated food products and studying their various organoleptic attributes, overall acceptability and the recovery of FOS during processing of these products using HPLC technique. 2) Collection of baseline data of type 2 diabetic subjects attending health clinic of M.S. University of Baroda in terms of anthropometry, dietary, biophysical, glycemic, lipemic, GLP-1 and gut microbiota (*LAB*, *bifidobacteria* and enteric pathogen) and understanding the correlations between various parameters. And, 3) Effect of Fructooligosaccharide (FOS) supplementation on Glycemic, Lipemic parameters, Gut incretin (GLP-1) and Gut Microflora in type 2 diabetic adults.

The possibilities of incorporating FOS in the popular Indian foods were studied by the method of substitution. The products included *chapati*, *thepla*, *dhokla*, and *patra* which were incorporated with various levels of FOS and studied for their physical and organoleptic characteristics using ten point numerical scoring and difference test. HPLC technique was used to study the recovery of FOS in the food processing through different processing methods.

The results of the phase I revealed that FOS incorporated *thepla*, *dhokla* and *patra* were the most acceptable products at all the three levels of substitution. Whereas, *chapatis* were slightly less accepted at higher levels of substitution. Recovery of FOS revealed maximum recovery in *chapati* and *thepla* that underwent roasting and shallow frying and lower recovery in *dhokla* and *patra* which underwent steaming.

In phase II, a cross-sectional study design was used and 120 known type 2 diabetic subjects were enrolled from the Health clinic of The Maharaja Sayajirao University, Baroda Gujarat. Relevant data was obtained through patient medical records, face to face interview and direct measurements. Biophysical parameter like blood pressure, biochemical parameters like glycemic parameters, lipemic parameters and gut incretin (GLP-1) and microbial parameters in terms of *Lactobacillus*, *Bifidobacteria* and enteric pathogen were examined from the stool samples of the subjects.

Results of this phase of the study elicited that 88% subjects had family history of diabetes with 56% subjects having diabetes for more than 15 years. Prevalence of secondary complications among diabetic subjects was also high such as hypertension (71%), dyslipidemia, stroke, CVD (25%) neuropathy, nephropathy and retinopathy (11%). Most subjects led a sedentary lifestyle with low to moderate physical activity (90%). About 20.8% and 61% subjects were overweight and obese respectively. Mean fasting serum blood glucose and post prandial blood glucose was 143 mg/dl and 219 mg/dl respectively. Mean glycated hemoglobin and glucagon like peptide-1 (GLP-1) was 9.0% and 0.3 pmol/L respectively. Around 28.3% and 13.4% had borderline and poor control on total cholesterol levels and 15.9% subjects had triglycerides >200 mg/dl. Subjects consumed a diet which was high in fat (85 g/d) and low in dietary fiber (12 g/d). The mean log values in terms of CFU/g of stool sample for *Lactobacillus*, *Bifidobacteria* and Enteric pathogen were 6.34, 6.34 and 4.47 respectively. Pearson's correlation values revealed a strong correlation between glycemic, lipemic, dietary and gut microbial parameters.

In phase III of the study, 65 diabetic subjects were asked to participate further in the study based on their willingness. The experimental group was given 10

grams of FOS in powdered form to be consumed during meals for the duration of 8 weeks.

FOS supplementation to diabetic subjects resulted in significant reductions in FBS, PP2BS and HbA_{1c} by 24%, 21% and 9%. The mean GLP-1 values increased by 52%. Lipemic parameters also showed significant reductions in TC (10%), TG (5.4%), LDL (6.8%), TC/HDL (10.4%), LDL/HDL (7.6%) and non-HDL (13%). The intake of dietary fiber of the supplemented group increased by 84% due to their FOS intake.

Post supplementation the fecal log counts showed a significant change with an increase in *Lactic acid bacteria* (9.3%) and *bifidobacteria* (10.9%) and a decrease in Enteric pathogen (4.8%). The gut *Lactobacillus* of the subjects after intervention was negatively associated with FBS, HbA_{1c} ($p < 0.001$) and VLDL-C ($p < 0.05$). *Bifidobacteria* showed a significant inverse correlation with DBP, PP2, HbA_{1c} ($p < 0.01$). *Enteric pathogen* was positively associated with DBP, PP2 ($p < 0.001$), SBP, FBS and HbA_{1c} ($p < 0.05$) and inversely associated with GLP-1. Linear multiple regression analysis revealed that maximum reduction in FBS, PP2BS and HbA_{1c} was affected most by *Bifidobacteria*.

Hence this phase of the study concludes that a daily supplementation of 10 grams of FOS for 8 weeks to the Type 2 diabetics on OHA improved glycemic control, lipemic control, GLP-1 and colonization of beneficial gut microbiota in terms of *LAB* and *bifidobacteria*.