CHAPTER 6

SUMMARY AND CONCLUSIONS

As the developing societies like India industrialize and urbanize, and with rising standards of living, weight gain and obesity are beginning to pose a growing threat to the health of the citizens. In the same period, we have seen the emergence of functional foods, a functional food is a food given an additional function (often one related to health-promotion or disease prevention). Fructooligosaccharide (FOS) is an upcoming functional food (prebiotic) with several health benefitting properties. FOS is a nondigestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon (Gibson and Roberfroid 1995). Gut microflora helps harvesting energy from the diet and increases lipogenesis. Environmental factor such as gut microflora may regulate energy storage, therefore the present study was undertaken to conduct **"Sensory evaluation of Fructooligosaccharide (FOS) added foods and study its impact on gut health and biochemical parameters in obese industrial employees of rural Vadodara".**

The results and the methods used for the study are summarized below under the following three phases-

Phase I: Sensory evaluation of FOS added popular Indian food products.

Phase II: Comparative analysis of obese and normal weight subjects of an industry for their anthropometric parameters, nutrient Intake, fecal gut microflora, GLP-1, LPS, hunger and satiety.

Phase III: Anthropometric and metabolic responses of obese to supplementation of FOS.

6.1 Phase I

This section of the study was conducted to assess the acceptability of FOS added food products *viz.* Buttermilk*, Lemon juice,* Milk*,* Soup*, Potato curry, Dal, Kadi, Kheer*

and *Khichdi* at varying level of FOS addition. FOS was added in the selected food products at 5 different levels i.e.2.5%, 4%, 5%, 6% and 7.5%. Twenty five semi trained panel judges evaluated these food products using ten point Numerical scoring test and Difference test.

Salient Findings of Phase I

6.1.1 Organoleptic properties of FOS added food products

- Overall acceptability of buttermilk was up to 7.5% of FOS addition. As the level of addition increased, after taste and consistency improved.
- *Lemon juice* added with FOS at varying levels were rated well within the acceptable limits. No significant difference was perceived in any of the organoleptic attributes of *lemon juice*. For all the organoleptic attributes, FOS added *lemon juice* was acceptable up to 7.5% level of addition according to Numerical scoring.
- No significant difference was perceived in any of the organoleptic attributes of milk. For all the organoleptic attributes, non-significant improvement was found after addition of FOS up to 7.5%.
- Soup added with FOS at varying levels was rated well within the acceptable limits. No significant difference in organoleptic attributes except for color and appearance. A non-significant improvement in color and appearance was found as the level of FOS addition increases from 2.5% to 7.5%. For all the organoleptic attributes, FOS added soup was acceptable up to 7.5% level of addition.
- A non-significant reduction in the organoleptic attributes of FOS added *Potato curry,* was observed.
- *Dal* added with FOS at varying levels was rated well within the acceptable limits. No significant difference in organoleptic attributes was observed amongst the various level of addition.
- Organoleptic attributes of FOS added *kadi* showed decrease in scores at the level beyond 4%.

- Except for consistency an improvement in all the organoleptic attributes of *kheer* was reported.
- Organoleptic attributes of FOS added *Khichdi* shows decrease in scores at the level beyond 2.5%.

6.1.2 Difference in the organoleptic attributes of FOS added test samples in comparison with the standard

- Organoleptic attributes FOS added buttermilk was rated equal to the standard except for consistency, which was rated superior to standard.
- No deviation was found, in the attributes of *lemon juice* and milk as compared to the standard.
- Color and appearance of the FOS added soup improved as the level of FOS addition increases, other attributes were rated equal to the standard.
- For *Potato curry* organoleptic attributes deteriorates after addition of FOS as compared to the standard.
- *Dal* added with varying level of FOS was rated equal for all the given attributes as compared to the standard.
- Percent of panel member increased who reported that as the level of FOS addition increased beyond 4% color, taste and mouthfeel and consistency of *kadi* becomes inferior as compared to the standard.
- FOS added *Kheer* was rated equal as compared to the standard for all the given organoleptic attributes, except for taste and mouthfeel which was rated superior as the level of FOS addition increase from 2.5% to 7.5%.
- The overall acceptability of *khichdi* was reported as equal and superior to the standard by almost 62% and 22% panel members respectively at 6% of FOS addition, further which overall acceptability, taste, after taste and consistency was scored as inferior to the standard by the panel members.

6.2 PHASE II

The study involved 90 subjects out of which 30 were normal weight adults (BMI 18.5-22.9 kg/m^2) and 60 were known obese adults aged between 25-50 years, from Larsen and Toubro plant, Ranoli, Vadodara. Purposive sampling method was done to

enroll subjects. Relevant data was obtained through patient medical records, face to face interview and direct measurements like anthropometric measurements, biophysical determination, biochemical analysis like fasting glucagon like peptide-1 (GLP-1), lipopolysaccharide (LPS) and fecal gut microflora in terms of *Lactic acid bacteria, Bifidobacteria* and Enteric pathogen.

Salient Findings of Phase II

6.2.1 Baseline information of normal weight and obese subjects

- Socio demographic data of normal weight and obese subjects revealed that all subjects were males, majority of them were Hindus (97% and95% respectively) with 100% literacy level. More than 50% of population from both the categories belonged to the nuclear families.
- Strong significant association between family history of obesity and higher BMI of obese subjects, whereas family history of hypertension, DM and CVD were not associated with obesity.
- Personal habits of normal weight and obese subjects showed that tobacco chewing was found significantly higher among obese subjects (32%) as compared to normal weight subjects (7%).

6.2.2 Satiety index of normal weight and obese subjects

- Normal weight subjects had high hunger scores for breakfast and evening snacks whereas obese subjects express significant higher feeling of hunger for lunch and dinner. Many obese subjects skipped breakfast.
- No significant difference between obese and normal weight subject for the feeling of satiety was observed.

6.2.3 Dietary profile of normal weight and obese subjects

- Significant higher intake of macro nutrients i.e. energy, fat, carbohydrate among obese subjects as compared to normal weight subjects.
- Normal weight subjects were reported to consume significantly higher protein as compared to obese subjects.

- Obese subjects were reported to consume high fat snack, ice creams and papad chutney more frequently than normal weight subject.
- Higher consumptions of Green Leafy Vegetables, fruits, nuts and oilseeds among normal weight subjects as compared to obese subjects.
- High fat food such as ice creams snack and high sodium foods such as pickle and papad were consumed more frequently among obese subjects as compared to normal weight subjects.
- The overall frequency of obese subject eating out was significantly higher than normal weight subjects.

6.2.4 Physical activity profile of normal weight and obese subjects

- No significant difference between normal weight and obese subjects in terms of physical activity was determined.

6.2.5 Biochemical profile of normal weight and obese subjects

- Significant difference between LPS and GLP-1 levels were reported among obese and normal weight subjects.
- Obese subjects were detected with higher LPS and lower GLP-1 values as compared to the normal weight subjects.

6.2.6 Gut microflora in fecal samples of normal weight and obese subjects

- Normal weight subjects were reported to have significantly better colonization of good bacteria i.e. *LAB*, *Bifidobacteria* and lower Enteric pathogen count as compared to obese subjects.

6.2.7 Anthropometric, biochemical, microbial profile of the obese subjects based on family history of obesity

- Family history of obesity was positively associated with the higher BMI of the obese subjects.

6.2.8 Biochemical, microbial profile of the obese subjects based on BMI (<27 and >27 kg/m^2) of obesity subjects

- Higher BMI was positively associated with higher LPS levels, higher Enteric pathogen count, high intake of energy (kcal), CHO (g), lower GLP-1, lower colonization of *LAB* and *Bifidobacteria* count.

6.2.9 Anthropometric, biochemical, microbial profile of the obese subjects based on personal habits

- High intake of alcohol was positively associated with lower level of GLP-1, *bifodobacteria*, and higher level of LPS and Enteric pathogen count.
- Cigarette smoking is correlated with higher establishment of Enteric pathogen count.
- High intake of aerated beverages was positively correlated with higher body weight, BMI, LPS levels and lower GLP-1 levels.

6.2.10 Anthropometric, biochemical, microbial profile of the obese subjects based on eating pattern

- Total dietary fiber intake found to be negatively associated with weight, BMI, Enteric pathogen count and LPS and positively correlated with GLP-1, *Bifidobacteria*.
- Obese with higher consumption of insoluble fibre had lower BMI, *LPS*, Enteric pathogen and higher GLP 1 levels along with better colonization of *Bifidobacteria.*
- Soluble fiber had among obese subjects shown better GLP-1, *Bifidobacteria* count and less LPS, Enteric pathogen.
- Frequent consumption of outside food have been associated with lower *LAB* count.

6.2.11 Anthropometric, biochemical, microbial profile of the obese subjects based on gut microflora colonization

- Higher *Bifidobacteria* count was found significantly associated to higher *LAB* count.
- Higher colonization of *LAB* among obese subjects was significantly correlated to lower LPS levels, Enteric pathogen count and higher *Bifidobacteria* count.
- Obese subjects with higher Enteric pathogen count have lower GLP-1 values, *LAB*, *Bifidobacteria* count and higher levels of LPS.

6.2.12 Anthropometric, biochemical, microbial profile of the obese subjects based on GLP-1 and LPS levels

- GLP-1 negatively associated with weight, BMI, LPS levels, Enteric pathogens, feeling of hunger and positively associated with *LAB*, *Bifidobacteria* count, intake of dietary fiber (total, insoluble, soluble, crude) .
- Higher LPS values was found to be associated with higher BMI, lower GLP-1 levels, higher Enteric pathogen and higher feeling of hunger .

6.3 PHASE III

Obese subjects (n=60) who satisfied the inclusive criteria of the study were randomly divided in to placebo control (n = 30) and experimental group (n = 30) with the help of randomized tables and were given 12 g FOS/dextrose for 8 weeks and examined for the effect of FOS intake daily on clinic-biochemical as in terms of anthropometric parameters, GLP-1, LPS and fecal gut microflora in terms of *lactic acid bacteria, Bifidobacteria* and Enteric pathogen of the obese adults.

6.3.1 Anthropometric, Biophysical and dietary profile of the obese subjects after supplementation trial

- Anthropometric parameters revealed that there was a significant reduction in body weight, BMI, WC, WHR after FOS supplementation for 60 days.

- More reduction in anthropometric parameters was observed in the obese subjects with BMI≥ 27 kg/m^2 and with good compliance of FOS supplementation.

6.3.2 Satiety index of obese subjects after supplementation trial

- Hunger scores showed that FOS supplemented group felt less hunger duing the lunch hours as compared to the other group. No difference was determined in the satiety scores.
- Better control on hunger for dinner was reported among obese group with BMI≥ 27 kg/m^2 as compared to the other where BMI was 25-27kg/m^2.
- Obese subjects with weight reduction showed better control on hunger as compared to the group with no weight reduction.

6.3.3 Dietary profile of obese subjects after supplementation trial

- The dietary profile data showed that there was reduction in the energy, protein, CHO and fat by 8%, 6%, 8%, 7% among the obese subjects after FOS supplementation.
- Significant reduction in the intake of calories was found in experimental group with weight reduction and good compliance of FOS intervention.

6.3.4 Plasma GLP-1 and LPS values of obese subjects *after FOS supplementation*

- GLP-1 values increased by 17% and LPS values significantly decreased by 2.81% after FOS supplementation.

6.3.5 Gut microflora counts in fecal samples of the obese subjects after FOS supplementation

- The fecal log count of the *Lactic acid bacteria*, and *Bifidobacteria* showed a significant increase of 14% and 10% respectively. Significant reduction by 20% in the fecal log count of Enteric pathogen in the obese subjects after FOS supplementation.

- Higher increment in the fecal log count of *LAB* and *Bifidobacteria*, reduction in Enteric pathogen was reported in obese subjects with weight reduction and good compliance of FOS intervention.

6.3.6 Gastrointestinal profile of the obese subjects after FOS supplementation

- Reduction in the complain of GI problems was reported in the FOS supplementation group.