CHAPTER 5

RESULTS AND DISCUSSION

The results of the present study entitled **"Acceptability trials of fructooligosaccharide (FOS) added food products"** are presented, discussed and interpreted in this chapter. These results are presented in to three main phases according to the objectives of the study.

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

PHASEIII- Anthropometric and metabolic responses of obese subjects to supplementation of FOS.

PHASE I

Sensory evaluation of FOS added popular Indian food products

A functional food is a food given an additional function (often one related to health-promotion or disease prevention) by adding new ingredients or more of existing ingredients. FOS has attracted special attention because of its prebiotic properties and also due to its sweet taste being very similar to that of sucrose (Yun 1996). It acts as functional food it promote the growth or activity of a limited number of bacterial species especially probiotics in the gut. They selectively nourish beneficial intestinal flora, stimulate their proliferation and reinforce their action and imparts beneficial health effects in humans (Ziemer and Gibson, 1998). Therefore, this phase of the research work was undertaken to study the acceptability trials of Fructooligosaccharide (FOS) added food products *viz.* **Buttermilk*, Lemon juice,* Milk, Tomato Soup*, Potato curry, Dal, Kadi, Kheer*** and ***Khichdi*** at varying levels of addition.

Effect of addition of food products *viz.* Buttermilk*, Lemon juice,* Milk*,* Tomato Soup*, Potato Curry, Dal, Kadi, Kheer* and *Khichdi* with varying levels of FOS

Nine food products for FOS addition selected and were buttermilk*, lemon juice,* milk*,* tomato soup*, potato curry, dal, kadi, kheer* and *khichdi* assessed for their physical and organoleptic properties. Since these food products are the most commonly consumed in Gujarat region, they were considered as a vehicle for FOS addition at five levels 2.5%, 4%, 5%, 6% and 7.5%.

The methodology to collect the above mentioned information is elaborated in Material and Methods chapter and results are presented in sections table 5.1.1 to table 5.1.9.

The results of this section are divided into following sections

- Assessment of organoleptic properties through numerical scoring and difference test for FOS added buttermilk.

- Assessment of organoleptic properties through numerical scoring and difference test for FOS added *lemon juice.*
- Assessment of organoleptic properties through numerical scoring and difference test for FOS added milk.
- Assessment of organoleptic properties through numerical scoring and difference test for FOS added tomato soup.
- Assessment of organoleptic properties through numerical scoring and difference test for FOS added *potato curry.*
- Assessment of organoleptic properties through numerical scoring and difference test for FOS added *dal.*
- Assessment of organoleptic properties through numerical scoring and difference test for FOS added *kadi.*
- Assessment of organoleptic properties through numerical scoring and difference test for FOS added *kheer.*
- Assessment of organoleptic properties through numerical scoring and difference test for FOS added *khichdi.*

5.1.1 Assessment of organoleptic properties through numerical scoring and difference test for FOS added buttermilk

The results of this section are presented in Table 5.1.1 (a) and 5.1.1 (b).

a) Assessment of organoleptic attributes of FOS added buttermilk through numerical scoring

The organoleptic scores of buttermilk added with FOS at varying levels are presented graphically in Figure 5.1.1 (a-e) and tabulated in Table 5.1.1 (a).

i) Color and Appearance: A non-significant increase in the scores of *butter* milk for color and appearance was reported up to 6% level of addition however a slight decrease in the scores was observed as the level of addition was further increased. With the increase in level of FOS addition, all samples exhibited an increase in whiteness.

ii) Taste and Mouthfeel: Non-significant increment in the taste and mouthfeel scores of buttermilk was found after addition of FOS up to 7.5%.

iii) After taste: Mean scores for after taste of buttermilk ranged from 6.67 (2.5% level of FOS addition) to 6.92 (7.5% level of FOS addition) as against 6.70 scored by the standard sample. Buttermilk was well accepted up to 7.5% of FOS addition.

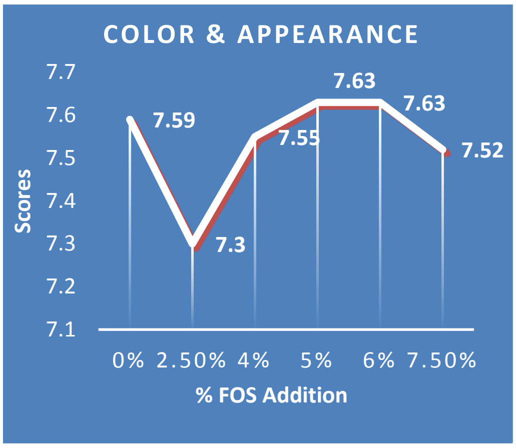
iv) Consistency: Non-significant increase in the consistency scores was reported in FOS added buttermilk at varying levels.

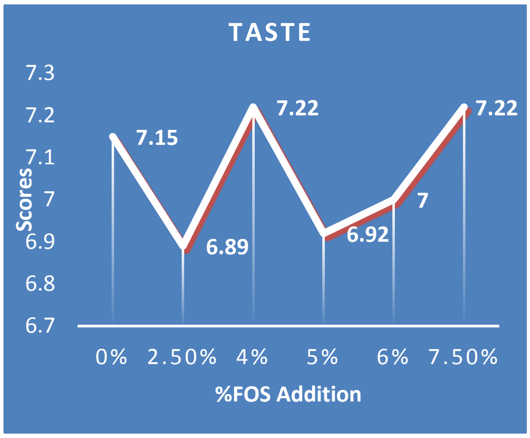
v) Overall acceptability: Overall buttermilk was acceptable up to 7.5% of FOS addition. After 6% of FOS addition, organoleptic scores of buttermilk increased from 6.81 to 7.15 (7.5% of addition), although it was not significant.

Table 5.1.1 (a): Mean values for organoleptic attributes of FOS added buttermilk

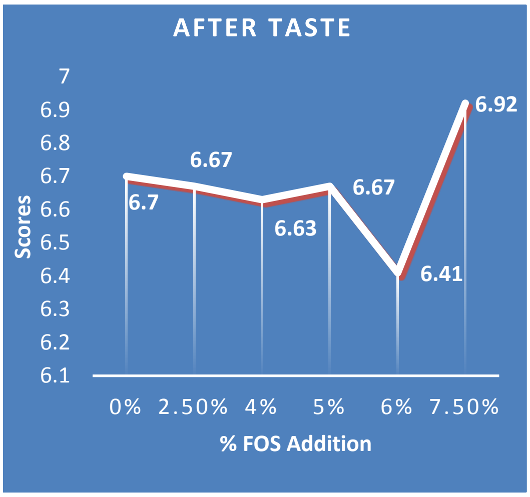
% FOS	BUTTER MILK				
	Color & appearance	Taste	After taste	Consistency	Overall acceptability
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
0%	7.59 ±1.50	7.15 ±1.85	6.70 ±1.99	7.55 ±1.71	6.85 ±1.91
2.5%	7.30 ±1.51	6.89 ±1.31	6.67 ±1.50	7.33 ±1.56	6.89 ±1.60
4%	7.55 ±1.34	7.22 ±1.25	6.63 ±1.76	7.40 ±1.55	7.07 ±1.52
5%	7.63 ±1.44	6.92 ±1.61	6.67 ±1.62	7.70 ±1.38	6.96 ±1.65
6%	7.63 ±1.47	7 ±1.39	6.41 ±1.69	7.59 ±1.57	6.81 ±1.64
7.5%	7.52 ±1.37	7.22 ±1.28	6.92 ±1.38	7.66 ±1.35	7.15 ±1.35
ANOVA	0.20 ^{NS}	0.27 ^{NS}	0.26 ^{NS}	0.24 ^{NS}	0.18 ^{NS}

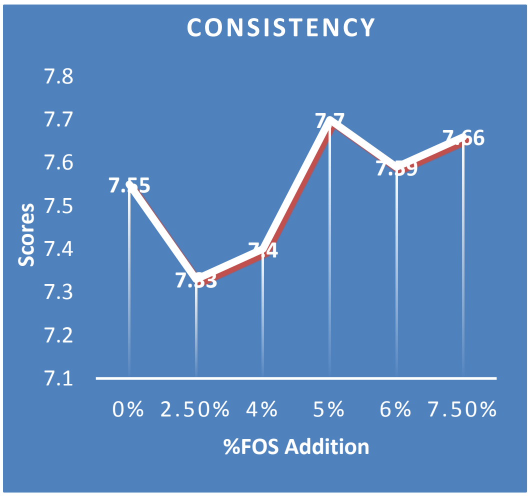
- *Mean value represent the average of 5 determinants in triplicates.*
- *NS- The difference between the mean values within the column is not significant.*
- *Maximum score for all the organoleptic attributes was 10.*



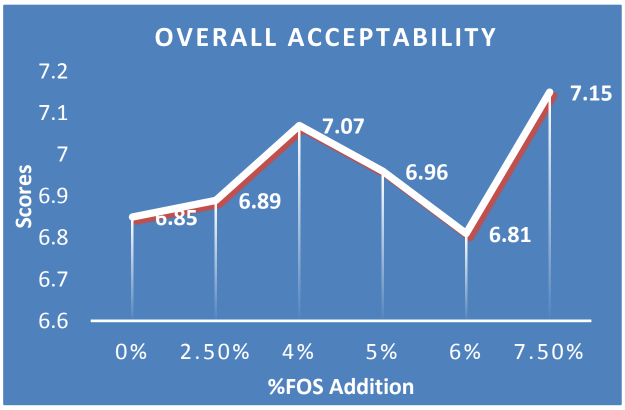


(a) **(b)**





(c) **(d)**



(e)

Figure: 5.1.1 (a-e): Mean values for organoleptic attributes of buttermilk added with varying levels of FOS

b) Difference in the organoleptic attributes of FOS added buttermilk at varying levels in comparison with the standard buttermilk

As can be seen in Table 5.1.1 (b), a significant difference existed between 2.5 and 7.5% levels of FOS addition for consistency scores ($p<0.01$) there was a significant increase in the percent subjects from 26% to 56% who found buttermilk to be superior to the standard buttermilk. However, for attributes like color and appearance, taste, after taste and overall acceptability no significant difference existed in the scores in the buttermilk after FOS addition when compared to the standard buttermilk.

Table 5.1.1 (b): Percent subjects indicating the color and appearance, taste, after taste, consistency and overall acceptability of FOS added butter milk at varying levels in a difference test

Attributes	% FOS	BUTTER MILK Equal	Superior	Inferior	χ^2
Color & appearance	**2.5%**	22 (81)	4 (15)	1 (4)	6.17^{NS}
	4%	23 (85.2)	2 (7.4)	2 (7.4)	
	5%	23 (85.2)	4 (14.8)	0 (0)	
	6%	20 (74.1)	5 (18.5)	2 (7.4)	
	7.5%	18 (66.7)	7 (25.9)	2 (7.4)	
Taste	**2.5%**	16 (59.3)	9 (33.3)	2 (7.4)	9.72^{NS}
	4%	16 (59.3)	9 (33.3)	2 (7.4)	
	5%	12 (44.4)	10 (37)	5 (18.5)	
	6%	11 (40.7)	12 (44.4)	4 (14.8)	
	7.5%	7 (25.9)	14 (51.9)	6 (22.2)	
After taste	**2.5%**	19 (70.4)	7 (25.9)	1 (3.7)	12.74^{NS}
	4%	15 (55.6)	10 (37)	2 (7.4)	
	5%	13 (48.1)	12 (44.4)	2 (7.4)	
	6%	13 (48.1)	9 (33.3)	5(18.5)	
	7.5%	9 (33.3)	11 (40.7)	7 (25.9)	
consistency	**2.5%**	19 (70.4)	7 (25.9)	1 (3.7)	**17.06***
	4%	23 (85.2)	4 (14.8)	0 (0)	
	5%	17 (63)	8 (29.6)	2 (7.4)	
	6%	16 (59.3)	9 (33.3)	2 (7.4)	
	7.5%	9 (33.3)	15 (55.6)	3(11.1)	
Overall acceptability	**2.5%**	16 (59.3)	6 (22.2)	5 (18.5)	14.78^{NS}
	4%	19 (70.4)	5 (18.5)	3(11.1)	
	5%	16 (59.3)	6(22.2)	5(18.5)	
	6%	11 (40.7)	13 (48.1)	3 (11.1)	
	7.5%	8 (29.6)	13 (48.1)	6 (22.2)	

- *NS- not significant.*
- *Figure in parenthesis represent percent of subjects.*

5.1.2 Assessment of organoleptic properties through numerical scoring and difference test for FOS added *lemon juice*

The results of this section are presented in Table 5.1.2 (a) and 5.1.2 (b).

a) Organoleptic evaluation of *lemon juice*

The organoleptic scores of *lemon juice* added with FOS at varying levels are presented graphically in Figure 5.1.2 (a-e) and tabulated in Table 5.1.2 (a).

i) Color and Appearance: At all the levels of FOS incorporation, the color scores denoted that the addition of FOS at varying levels brought about no significant changes in the color and appearance of *lemon juice*. Though, a non-significant increase in the scores of *Lemon juice* for color and appearance was reported as the level of FOS addition increased from 4% till 7.5%

ii) Taste and Mouthfeel: Taste and mouthfeel scores of *lemon juice* added with FOS, ranged from 7.78 (standard) to 7.85(5% level of FOS addition) which further decrease at 6% level of FOS addition and increased as the level of addition increased to 7.5%. No significant differences in taste and mouthfeel scores were spotted amongst all the levels of FOS incorporated.

iii) After taste: Mean scores for after taste for *lemon juice* ranged from 7.67(2.5% level FOS addition) to 8 (7.5% level of FOS addition) as against 7.63 scored by the standard sample. There was no significant difference between all the samples of *lemon juice* within the levels of FOS enrichment. Slight reduction in the scores was reported at 6% level of FOS addition. At 7.5% level of FOS addition *Lemon juice* scored highest on numerical scoring for organoleptic attributes by the panel members for after taste.

iv) Consistency: Mean scores for consistency for *lemon juice* ranged from 7.70 (2.5% level FOS addition) to 8.11 (7.5% level of FOS addition) as against 7.78 scored by the standard sample. Non-significant increase in the consistency scores was reported in FOS added *lemon juice* at varying levels.

v) Overall acceptability: Overall *lemon juice* was acceptable up to 7.5% of FOS addition. After 6% of FOS addition, organoleptic scores of *lemon juice* decreased from 7.89 to 7.6, although it was not significant.

As there was no significant difference witnessed in any of the organoleptic attributes, *lemon juice* was accepted by the panel judges at all the levels of FOS addition.

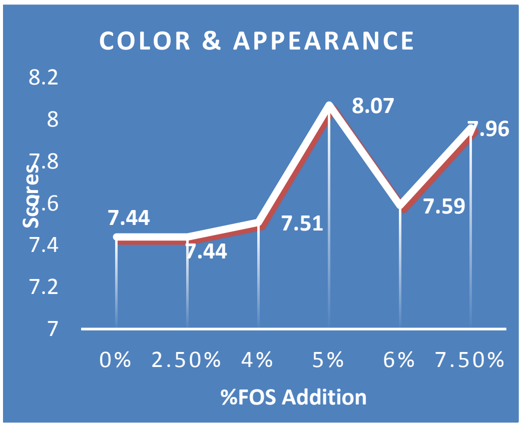
b) Difference in the organoleptic attributes of FOS added *lemon juice* at varying levels in comparison with the standard *lemon juice*

As demonstrated in Table5.1.2(b), chi square values depicts that, no significant difference was observed for all the organoleptic attributes of *lemon juice* in terms of color, taste, after taste, consistency and overall acceptability. *Lemon juice* was overall acceptable by almost 59% and 15% panel members as equal and superior respectively to the standard *lemon juice* at 7.5% FOS addition.

Table 5.1.2 (a): Mean values for organoleptic attributes of FOS added *Lemon juice*

% FOS	*LEMON JUICE*				
	Color & appearance	Taste	After taste	consistency	Overall acceptability
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
0%	7.44 ±1.52	7.78 ±1.05	7.63 ±1.24	7.78 ±1.28	7.70 ±1.35
2.5%	7.44 ±1.69	7.85 ±1.20	7.67 ±1.33	7.70 ±1.38	7.70 ±1.17
4%	7.51 ±1.60	7.89 ±1.05	7.74 ±1.13	7.96 ±1.12	7.74 ±1.13
5%	8.07 ±1.32	7.85 ±1.26	7.81 ±1.24	8.07 ±1.30	7.89 ±1.25
6%	7.59 ±1.67	7.63 ±1.42	7.52 ±1.40	8.11 ±1.31	7.67 ±1.39
7.5%	8.00 ±1.14	7.96 ±1.12	8 ±1.10	8.11 ±1.01	8.11 ±1.15
ANOVA	0.96^{NS}	0.24^{NS}	0.48^{NS}	0.55^{NS}	0.50^{NS}

- *Mean value represent the average of 5 determinants in triplicates.*
- *NS- The difference between the mean values within the column is not significant.*
- *Maximum score for all the organoleptic attributes was 10.*



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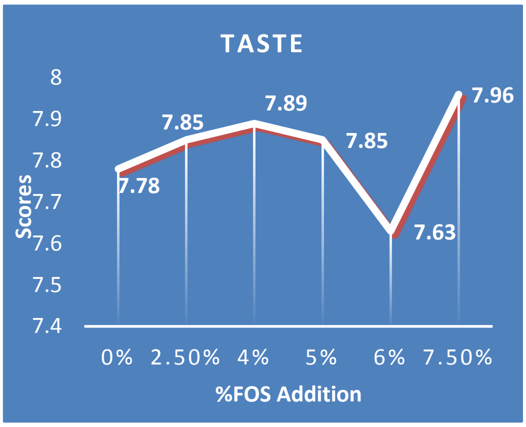

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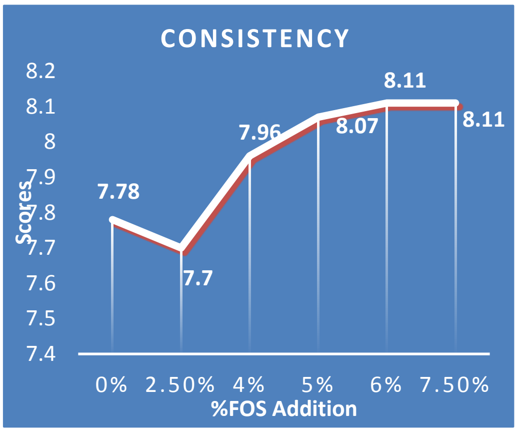

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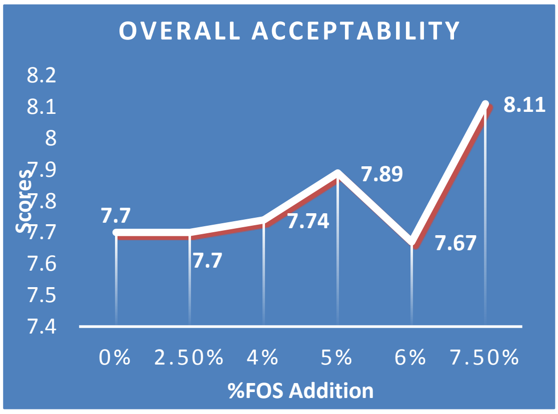

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Figure: 5.1.2 (a-e): Mean values for organoleptic attributes of *lemon juice* added with varying levels of FOS

Table 5.1.2 (b): Percent subjects indicating the color and appearance, taste, after taste, consistency and overall acceptability of FOS added *Lemon juice* at varying levels in a difference test

Products	% FOS	*LEMON JUICE* Equal	Superior	Inferior	χ^2
Color & appearance	2.5%	19 (70.4)	5 (18.5)	3 (11.1)	7.81 NS
	4%	18 (66.7)	6 (22.2)	3 (11.1)	
	5%	17 (63)	9 (33.3)	1 (3.7)	
	6%	19 (70.4)	7 (25.9)	1 (3.7)	
	7.5%	19 (70.4)	3 (11.1)	5 (18.5)	
Taste	2.5%	17 (63)	7 (25.9)	3 (11.1)	9.90 NS
	4%	17 (63)	8 (29.6)	2 (7.4)	
	5%	20 (74.1)	7 (25.9)	0 (0)	
	6%	15 (55.6)	5 (18.5)	7 (25.9)	
	7.5%	17 (63)	6 (22.2)	4(14.8)	
After taste	2.5%	20 (74.1)	5 (18.5)	2 (7.4)	3.28 NS
	4%	21 (77.8)	4 (14.8)	2 (7.4)	
	5%	18 (66.7)	7 (25.9)	2 (7.4)	
	6%	17 (63)	8 (29.6)	2 (7.4)	
	7.5%	20 (74.1)	4 (14.8)	3 (11.1)	
consistency	2.5%	22 (81.5)	4 (14.8)	1 (3.7)	4.52 NS
	4%	22 (81.5)	3 (11.1)	2 (7.4)	
	5%	21(77.8)	5 (18.5)	1 (3.7)	
	6%	19 (70.4)	6 (22.2)	2 (7.4)	
	7.5%	17 (63)	8 (29.6)	2(7.4)	
Overall acceptability	2.5%	17 (63)	6 (22.2)	4 (14.8)	4.90 NS
	4%	16 (59.3)	4 (14.8)	7 (25.9)	
	5%	14 (51.9)	9 (33.3)	4(14.8)	
	6%	16 (59.3)	6 (22.2)	5 (18.5)	
	7.5%	16 (59.3)	4 (14.8)	7 (25.9)	

- *NS- not significant.*
- *Figure in parenthesis represent percent of subjects.*

5.1.3 Assessment of organoleptic properties through numerical scoring and difference test for FOS added milk

The results of this section are presented in Table 5.1.3 (a) and 5.1.3 (b).

a) Organoleptic evaluation of milk

The organoleptic scores of milk added with FOS at varying levels are presented graphically in Figure 5.1.3 (a-e) and tabulated in Table 5.1.3(a).

i) Color and appearance: At all the levels of FOS addition, the scores denoted that the addition of FOS at varying levels brought no significant difference in the color and appearance of milk. Mean scores ranged between 7.67 (std. milk) to 8.11 (7.5% level of FOS addition).

ii) Taste and Mouthfeel: Taste and mouthfeel scores of milk added with FOS, ranged from 7.33 (standard) to 7.18(4% level of FOS addition) which further increase at 6% (7.59) to 7.5% (8.18) level of FOS addition No significant differences in taste and mouthfeel scores were spotted amongst all the levels of FOS incorporated .

iii) After taste: Mean scores for after taste for milk *gradually* increase from 7.37(2.5% level FOS addition) to 7.96 (7.5% level of FOS addition) as against 7.30 scored by the standard sample. There was no significant difference between all the samples of milk within the levels of FOS enrichment. At 7.5% level of FOS added milk scored highest on organoleptic scale amongst varying level in the amount of FOS addition as perceived by the panel members for after taste.

iv) Consistency: Mean scores for consistency for milk ranged from 7.85 (2.5% level FOS addition) to 8.07 (7.5% level of FOS addition) as against 7.63 scored by the standard sample. Non-significant increase in the consistency scores was reported in FOS added milk at varying levels.

v) Overall acceptability: Overall milk was acceptable up to 7.5% of FOS addition. There was no significant difference witnessed in any of the organoleptic attributes, however *FOS* added milk scored higher as level of addition increase from 2.5% to 7.5% by the panel judges.

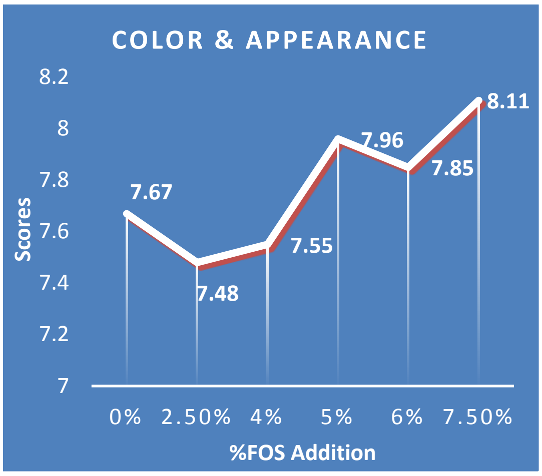
b) Difference in the organoleptic attributes of FOS added milk at varying levels in comparison with the standard milk

As demonstrated in Table 5.1.3 (b), chi square values depicts that, no significant difference was observed for all the organoleptic attributes of milk in terms of color, taste, after taste, consistency and overall acceptability. Milk was found to be equal as standard for color and appearance, taste, after taste and consistency by majority of the panel members at 7.5% level of FOS addition, the overall acceptability of milk was reported as equal and superior by almost 74% and 22% panel members respectively to the standard at 7.5% FOS addition.

Table 5.1.3 (a): Mean values for organoleptic attributes of FOS added milk

% FOS	MILK				
	Color & appearance	Taste	After taste	consistency	Overall acceptability
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
0%	7.67 ±1.21	7.33 ±1.39	7.30 ±1.75	7.63 ±1.39	7.48 ±1.52
2.5%	7.48 ±1.22	7.26 ±1.23	7.37 ±1.47	7.85 ±1.23	7.52 ±1.42
4%	7.55 ±1.01	7.18 ±1.30	7.37 ±1.60	7.37 ±1.33	7.52 ±1.45
5%	7.96 ±0.94	7.59 ±1.36	7.41 ±1.57	7.89 ±1.19	7.70 ±1.35
6%	7.85 ±1.26	7.63 ±1.30	7.67 ±1.49	8 ±1.07	7.78 ±1.28
7.5%	8.11 ±1.31	8.18 ±1.39	7.96 ±1.43	8.07 ±1.41	8.11 ±1.55
ANOVA	1.90^{NS}	2.05^{NS}	0.72^{NS}	1.12^{NS}	0.75^{NS}

- *Mean value represent the average of 5 determinants in triplicates.*
- *NS- The difference between the mean values within the column is not significant.*
- *Maximum score for all the organoleptic attributes was 10.*



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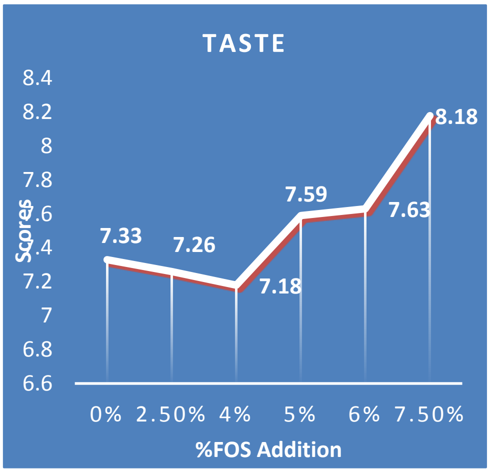

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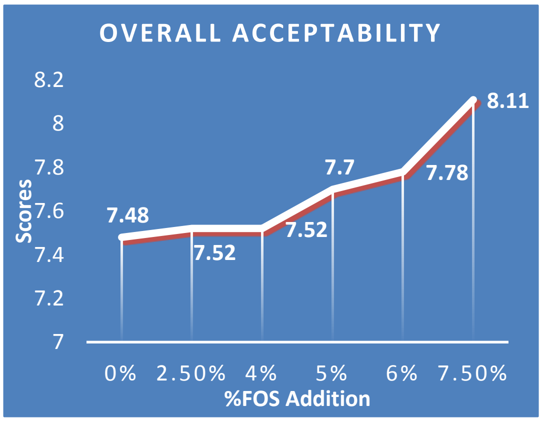

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Figure: 5.1.3 (a-e): Mean values for organoleptic attributes of milk added with varying levels of FOS

Table 5.1.3 (b): Percent subjects indicating the color and appearance, taste, after taste, consistency and overall acceptability of FOS added milk at varying levels in a difference test

Products	% FOS	MILK Equal	Superior	Inferior	χ^2
Color & appearance	2.5%	20 (74.1)	7 (25.9)	0 (0)	9.02 [NS]
	4%	20 (74.1)	7 (25.9)	0 (0)	
	5%	21 (77.8)	6 (22.2)	0(0)	
	6%	19 (70.4)	7 (25.9)	1(3.7)	
	7.5%	23(85.2)	2 (7.4)	2 (7.4)	
Taste	2.5%	18 (66.7)	8 (29.6)	1 (3.7)	12.73 [NS]
	4%	21 (77.8)	6 (22.2)	0 (0)	
	5%	18 (66.7)	4 (14.8)	5 (18.5)	
	6%	18 (66.7)	7 (25.9)	2 (7.4)	
	7.5%	21 (77.8)	6 (22.2)	0 (0)	
After taste	2.5%	19 (70.4)	5 (18.5)	3 (11.1)	6.11 [NS]
	4%	23 (85.2)	4 (14.8)	0 (0)	
	5%	20 (74.1)	5 (18.5)	2 (7.4)	
	6%	18 (66.7)	7 (25.9)	2 (7.4)	
	7.5%	23 (85.2)	3 (11.1)	1 (3.7)	
consistency	2.5%	22 (81.5)	5 (18.5)	0 (0)	4.69 [NS]
	4%	20 (74.1)	7 (25.9)	0 (0)	
	5%	20 (74.1)	6 (22.2)	1 (3.7)	
	6%	20 (74.1)	5 (18.5)	2 (7.4)	
	7.5%	22 (81.5)	4 (14.8)	1(3.7)	
Overall acceptability	2.5%	18 (66.7)	8 (29.6)	1 (3.7)	5.08 [NS]
	4%	16 (59.3)	11 (40.7)	0 (0)	
	5%	19 (70.4)	6 (22.2)	2 (7.4)	
	6%	18 (66.7)	7 (25.9)	2 (7.4)	
	7.5%	20 (74.1)	6 (22.2)	1 (3.7)	

- *NS- not significant.*
- *Figure in parenthesis represent percent of subjects.*

5.1.4 Assessment of organoleptic properties through numerical scoring and difference test for FOS added tomato soup

The results of this section are presented in Table 5.1.4 (a) and 5.1.4 (b).

a) Organoleptic evaluation of tomato soup

The organoleptic scores of tomato soup added with FOS at varying levels are presented graphically in Figure 5.1 4 (a-e) and tabulated in Table 5.1.4 (a).

i) Color and Appearance: The color and appearance scores of tomato soup increase as the level of FOS addition increased up to 5 % after that scores continued to remain stable with increasing levels of FOS addition (Figure 4 a). There was a no significant difference in the color and appearance scores even at 7.5% level of addition.

ii) Taste and Mouthfeel: Mean scores for taste and mouthfeel for tomato soup ranged from 7.22 (2.5% level FOS addition) to 7.48 (7.5% level of FOS addition) as against 7.33 scored by the standard sample. Non-significant increase in the taste scores was reported in FOS added tomato soup with the increasing levels.

iii) After taste: Mean scores for after taste of tomato soup ranged from 7.07 (2.5% level of FOS addition) to 7.33 (7.5% level of FOS addition) as against 7.30 scored by the standard sample. Tomato soup was well accepted up to 6% (7.59) of FOS addition and further decreased at 7.5% (7.33).

iv) Consistency: Mean scores for consistency for tomato soup ranged from 7.89 (2.5% level FOS addition) to 7.70 (7.5% level of FOS addition) as against 7.78 scored by the standard sample. An increased in the scores was reported at 2.5% of FOS addition; however a non-significant decrease in the consistency scores was reported with further increase in the FOS levels.

viii) Overall acceptability: Tomato soup was found to be acceptable up to 6% level of FOS addition; however scores reduced with the further increase in the level of FOS addition, although it was not significant.

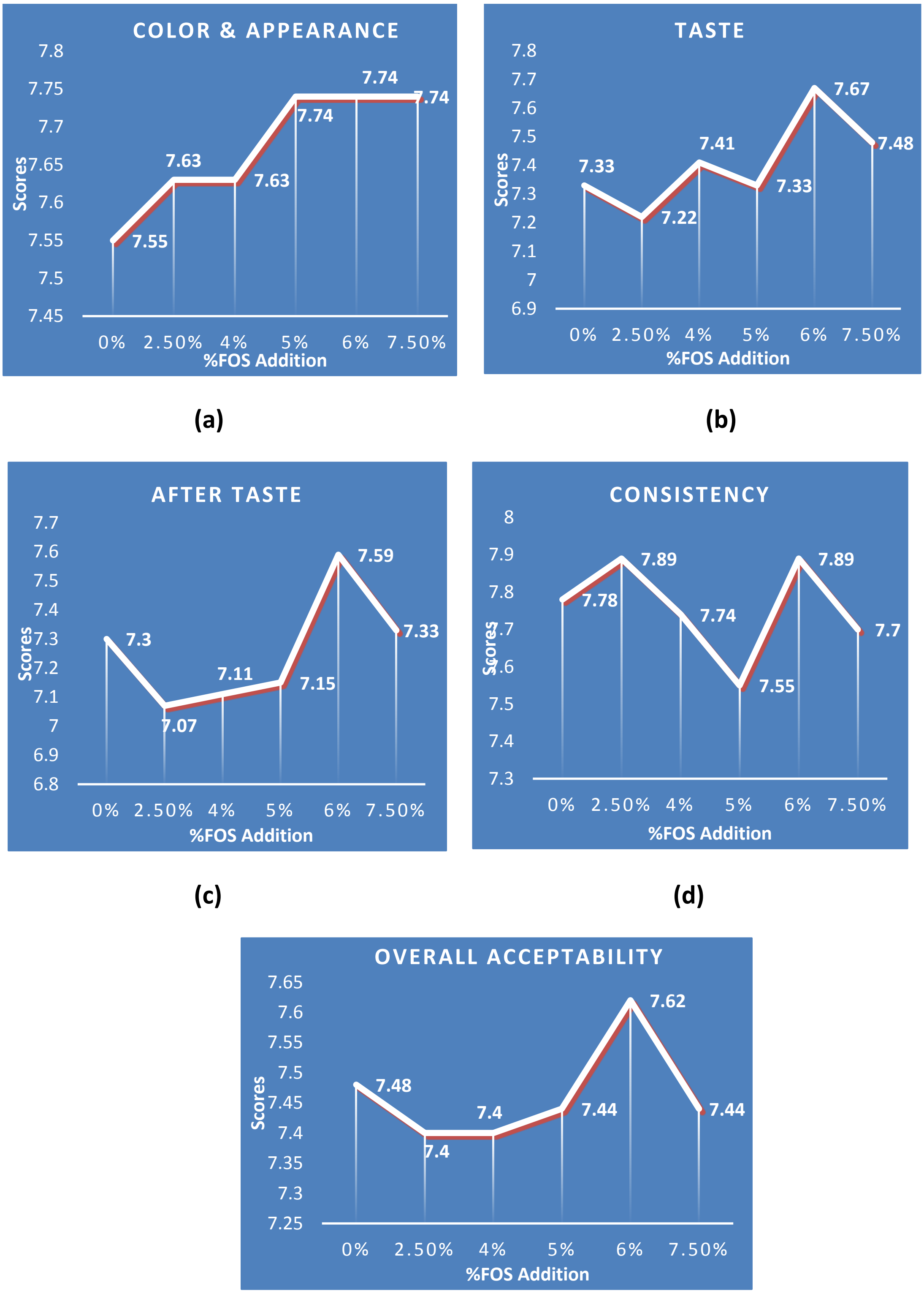
b) Difference in the organoleptic attributes of FOS added tomato soup at varying levels in comparison with the standard tomato soup

As can be seen in Table 5.1.4 (b), a significant difference existed between 2.5 and 7.5% levels of FOS addition for color and appearance scores ($p<0.01$) there was a significant increase in the percent subjects from 15% to 37% who found tomato soup to be superior with the increase in the percent addition of FOS from 2.5% to 7.5%. However, for attributes like taste, after taste, consistency and overall acceptability no significant difference existed in FOS added tomato soup as compared to the standard tomato soup.

Table 5.1.4 (a): Mean values for organoleptic attributes of FOS added tomato soup

% FOS	TOMATO SOUP				
	Color & appearance	Taste	After taste	consistency	Overall acceptability
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
0%	7.55 ±1.53	7.33 ±2.07	7.30 ±2.05	7.78 ±1.42	7.48 ±1.94
2.5%	7.63 ±1.64	7.22 ±2.17	7.07 ±2.18	7.89 ±1.55	7.40 ±2.00
4%	7.63 ±1.76	7.41 ±1.71	7.11 ±1.87	7.74 ±1.70	7.40 ±1.97
5%	7.74 ±1.35	7.33 ±1.69	7.15 ±2.09	7.55 ±1.78	7.44 ±1.78
6%	7.74 ±1.32	7.67 ±1.75	7.59 ±1.57	7.89 ±1.48	7.62 ±1.57
7.5%	7.74 ±1.53	7.48 ±1.79	7.33 ±1.90	7.70 ±1.54	7.44 ±1.91
ANOVA	0.07^{NS}	0.18^{NS}	0.26^{NS}	0.17^{NS}	0.05^{NS}

- *Mean value represent the average of 5 determinants in triplicates.*
- *NS- The difference between the mean values within the column is not significant.*
- *Maximum score for all the organoleptic attributes was 10.*



(e)

Figure: 5.1.4 (a-e): Mean values for organoleptic attributes of tomato soup added with varying levels of FOS

Table 5.1.4.(b): Percent subjects indicating the color and appearance, taste, after taste, consistency and overall acceptability of FOS added tomato soup at varying levels in a difference test

Products	% FOS	TOMATO SOUP Equal	Superior	Inferior	χ^2
Color & appearance	2.5%	20 (74.1)	4 (14.8)	3 (11.1)	**16.50***
	4%	22 (81.5)	3 (11.1)	2 (7.4)	
	5%	25 (92.6)	1 (3.7)	1 (3.7)	
	6%	19 (70.4)	8 (29.6)	0 (0)	
	7.5%	15 (55.6)	10 (37)	2 (7.4)	
Taste	2.5%	16 (59.3)	8 (29.6)	3 (11.1)	6.98 NS
	4%	12 (44.4)	10 (37)	5 (18.5)	
	5%	17 (63)	9 (33.3)	1 (3.7)	
	6%	19 (70.4)	6 (22.2)	2 (11.1)	
	7.5%	13 (48.1)	11 (40.7)	3 (11.1)	
After taste	2.5%	18 (66.7)	7 (25.9)	2 (7.4)	3.11 NS
	4%	14 (51.9)	8 (29.6)	5 (18.5)	
	5%	19 (70.4)	5 (18.5)	3 (11.1)	
	6%	16 (59.3)	7 (25.9)	4 (14.8)	
	7.5%	17 (63)	6 (22.2)	4 (14.8)	
consistency	2.5%	21 (77.8)	5 (18.5)	1 (3.7)	7.86 NS
	4%	19 (70.4)	7 (25.9)	1 (3.7)	
	5%	22 (81.5)	3 (11.1)	2 (7.4)	
	6%	17 (63)	9 (33.3)	1 (3.7)	
	7.5%	15 (55.6)	9 (33.3)	3 (11.1)	
Overall acceptability	2.5%	16 (59.3)	5(18.5)	6 (22.2)	10.96 NS
	4%	11 (40.7)	9 (33.3)	7 (25.9)	
	5%	19 (70.4)	7 (25.9)	1 (3.7)	
	6%	18 (66.7)	5 (18.5)	4 (14.8)	
	7.5%	12 (44.4)	7 (25.9)	8 (29.6)	

- *NS- not significant.*
- *Figure in parenthesis represent percent of subjects.*

5.1.5 Assessment of organoleptic properties through numerical scoring and difference test for FOS added *Potato curry*

The results of this section are presented in Table 5.1.5 (a) and 5.1.5 (b).

a) Organoleptic evaluation of *potato* curry

The organoleptic scores of *potato* curry added with FOS at varying levels are presented graphically in Figure 5.1.5 (a-e) and tabulated in Table 5.1.5(a).

i) Color and Appearance: The color scores denoted that the addition of FOS at varying levels brought about no significant changes in the color and appearance of *potato curry*. Though, a non-significant gradual decrease in the scores of *potato curry* for color and appearance was reported as the level of FOS addition increased from 2.5% to 7.5%.

ii) Taste and Mouthfeel: Taste and mouthfeel scores of *potato curry* added with FOS, ranged from 7.30 (standard) to 6.85(7.5% level of FOS addition). Reduction in the scores for taste and mouthfeel was reported with the increasing level of FOS addition in *potato curry*.

iii) After taste: Mean scores for after taste for *potato curry* ranged from 7.07(2.5% level FOS addition) to 6.77 (7.5% level of FOS addition) as against 7.37 scored by the standard sample. There was no significant difference between all the samples of *potato curry* within the levels of FOS enrichment. A non-significant reduction in the scores was reported with the increasing levels of FOS addition.

iv) Consistency: Mean scores for consistency for *potato curry* ranged from 6.89 (2.5% level FOS addition) to 7.30 (7.5% level of FOS addition) as against 7.33 scored by the standard sample. Non-significant increase in the consistency scores was reported up to 4% level of FOS addition; however a non-significant decrease was found in the consistency scores with the further addition of FOS.

v) Overall acceptability: With the increase in FOS, overall scores of *potato curry* were non-significantly affected because of the reducing scores of organoleptic attributes such as color and appearance, taste and after taste.

b) Difference in the organoleptic attributes of FOS added *potato curry* at varying levels in comparison with the standard *potato curry*

As demonstrated in Table 5.1.5 (b), chi square values depicts that, significant difference was observed for the organoleptic attributes of *potato curry* in terms of color, taste, consistency and overall acceptability as compared to the standard *potato curry* as there was increase in the percent subjects who scored FOS added *potato curry* to be inferior to the standard *potato curry.* FOS added *Potato curry* was significantly ($p<0.005$) not overall acceptable by panel members.

Table 5.1.5 (a): Mean values for organoleptic attributes of FOS added *potato curry*

% FOS	*POTATO CURRY*				
	Color & appearance	Taste	After taste	consistency	Overall acceptability
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
0%	7.66 ±1.14	7.30 ±1.17	7.37 ±1.30	7.33 ±1.30	7.37 ±1.52
2.5%	7.29 ±1.26	7.11 ±1.42	7.07 ±1.46	6.89 ±1.50	7.33 ±1.30
4%	7.26 ±1.29	7.15 ±1.32	7.15 ±1.51	7.18 ±1.41	7.33 ±1.33
5%	7.33 ±1.20	7.19 ±1.36	7.11 ±1.53	7.04 ±1.40	7.07 ±1.71
6%	7.37 ±1.30	6.78 ±1.50	6.52 ±1.60	7.11 ±1.45	6.85 ±1.68
7.5%	7.11 ±1.34	6.85 ±1.45	6.77 ±1.62	7.30 ±1.26	7.03 ±1.58
ANOVA	0.57^{NS}	0.57^{NS}	1.08^{NS}	0.38^{NS}	0.51^{NS}

- *Mean value represent the average of 5 determinants in triplicates.*
- *NS- The difference between the mean values within the column is not significant.*
- *Maximum score for all the organoleptic attributes was 10.*

(a) (b)

(c) (d)

(e)

Figure: 5.1.5(a-e): Mean values for organoleptic attributes of *potato curry* added with varying levels of FOS

Table 5.1.5 (b): Percent subjects indicating the color and appearance, taste, after taste, consistency and overall acceptability of FOS added *potato curry* at varying levels in a difference test

Products	% FOS	*POTATO CURRY* Equal	Superior	Inferior	χ^2
Color & appearance	**2.5%**	18 (66.7)	7 (25.9)	2 (7.4)	**22.7****
	4%	22 (81.5)	4 (14.8)	1 (3.7)	
	5%	20 (74.1)	6 (22.2)	1 (3.7)	
	6%	18 (66.7)	7 (25.9)	2 (7.4)	
	7.5%	14 (51.9)	3 (11.1)	10 (37)	
Taste & mouthfeel	**2.5%**	16 (59.3)	10 (37)	1 (3.7)	**29.24*****
	4%	19 (70.4)	5 (18.5)	3 (11.1)	
	5%	16 (59.3)	6 (22.2)	5 (18.5)	
	6%	12 (44.4)	7 (25.9)	8 (29.6)	
	7.5%	5 (18.5)	7 (25.9)	15 (55.6)	
After taste	**2.5%**	14 (51.9)	8 (29.6)	5 (18.5)	14.926 NS
	4%	21 (77.8)	3 (11.1)	3 (11.1)	
	5%	18 (66.7)	6 (22.2)	3 (11.1)	
	6%	19 (70.4)	5 (18.5)	3 (11.1)	
	7.5%	10 (37)	7 (25.9)	10 (37)	
consistency	**2.5%**	20 (74.1)	7 (25.9)	0 (0)	**34.35*****
	4%	20 (74.1)	2 (7.4)	5 (18.5)	
	5%	16 (59.3)	10 (37)	1 (3.7)	
	6%	19 (70.4)	6 (22.2)	2 (7.4)	
	7.5%	13 (48.1)	2 (7.4)	12 (44.4)	
Overall acceptability	**2.5%**	18 (66.7)	7 (25.9)	2 (7.4)	**20.75****
	4%	17 (63)	5 (18.5)	5 (18.5)	
	5%	14 (51.9)	8 (29.6)	5 (18.5)	
	6%	14 (51.9)	7 (25.9)	6 (22.2)	
	7.5%	8 (29.6)	4 (14.8)	15 (55.6)	

- *NS- not significant.*
- *Figure in parenthesis represent percent of subjects.*

5.1.6 Assessment of organoleptic properties through numerical scoring and difference test for FOS added *dal*

The result of this section are presented in Table 5.1.6 (a) and 5.1.6 (b)

a) Organoleptic evaluation of *dal*

The organoleptic scores of *dal* added with FOS at varying levels are presented graphically in Figure 5.1.6 (a-e) and tabulated in Table 5.1.6 (a).

i) Color and Appearance: A non-significant increase in the scores of *dal* 8.04 *(*standard*)* 8.22 (7.5% of FOS addition) for color and appearance was reported.

ii) Taste and Mouthfeel: Non-significant increment in the taste and mouthfeel scores of *dal* up to 5% level of FOS addition was found after which the scores remain stable.

iii) After taste: Mean scores for after taste of *dal* ranged from 7.81 (2.5% level of FOS addition) to 7.70 (7.5% level of FOS addition) as against 7.70 scored by the standard sample. There was a non-significant increment in the scores up to 5% level of FOS addition further which scores started reducing with the increase in FOS addition.

iv) Consistency: Non-significant increase in the consistency scores (up to 5% level of FOS addition) further which scores started decreasing 7.96 (7.5% level FOS addition).

v) Overall acceptability: Overall *dal* was acceptable up to 7.5% of FOS addition. Non-significant increase in the scores was found up to 5% (7.89) level of FOS addition which decrease (7.81) and further remain stable with the increasing level of FOS addition (till 7.5%).

b) Difference in the organoleptic attributes of FOS added *dal* at varying levels in comparison with the standard *dal*

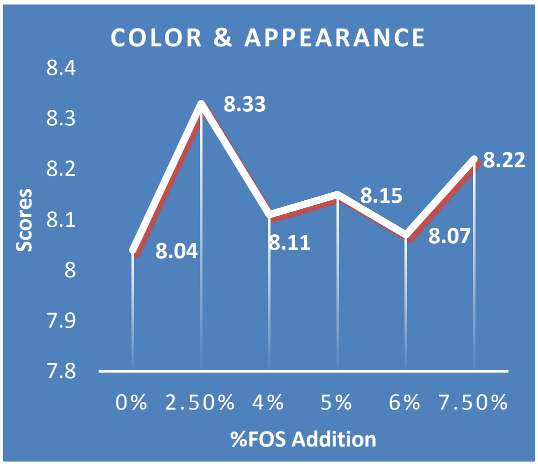
As demonstrated in Table 5.1.6 (b), chi square values depicts that, no significant difference was observed for all the organoleptic attributes of *dal* in terms of color, taste, after taste, consistency and overall acceptability. Higher percent of panel members perceived FOS added *dal* to be superior to the standard at 6% level of addition for taste and mouthfeel, after taste, consistency and overall acceptability;

however there was increase in the percent subjects who found FOS added *dal* to be inferior to the standard at 7.5% level of addition.

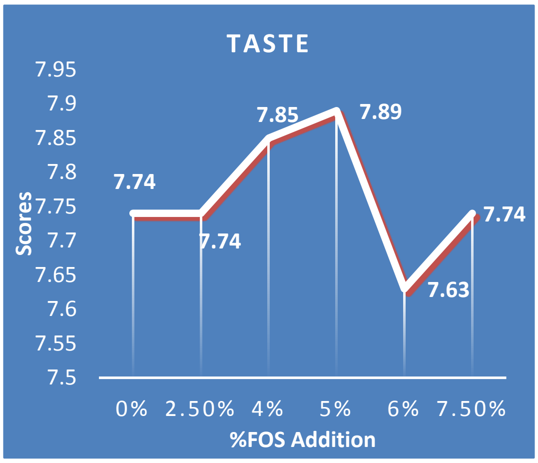
Table 5.1.6 (a): Mean values for organoleptic attributes of FOS added *dal*

% FOS	*DAL*				
	Color & appearance	Taste	After taste	consistency	Overall acceptability
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
0%	8.04 ±1.01	7.74 ±1.02	7.70 ±1.07	7.70 ±0.91	7.81 ±0.92
2.5%	8.33 ±0.83	7.74 ±1.02	7.81 ±0.96	7.96 ±0.85	7.85 ±0.95
4%	8.11 ±1.01	7.85 ±0.86	7.78 ±1.05	7.89 ±0.93	7.92 ±0.72
5%	8.15 ±0.95	7.89 ±1.12	7.89 ±1.22	8.07 ±0.91	7.89 ±1.19
6%	8.07 ±1.00	7.63 ±1.21	7.74 ±1.19	7.63 ±1.81	7.81 ±1.00
7.5%	8.22 ±1.01	7.74 ±1.23	7.70 ±1.17	7.96 ±1.31	7.81 ±1.04
ANOVA	0.34^{NS}	0.20^{NS}	0.11^{NS}	0.73^{NS}	0.06^{NS}

- *Mean value represent the average of 5 determinants in triplicates.*
- *NS- The difference between the mean values within the column is not significant.*
- *Maximum score for all the organoleptic attributes was 10.*



(a)



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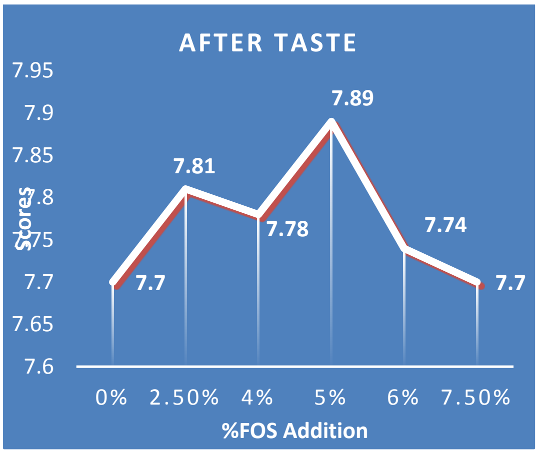
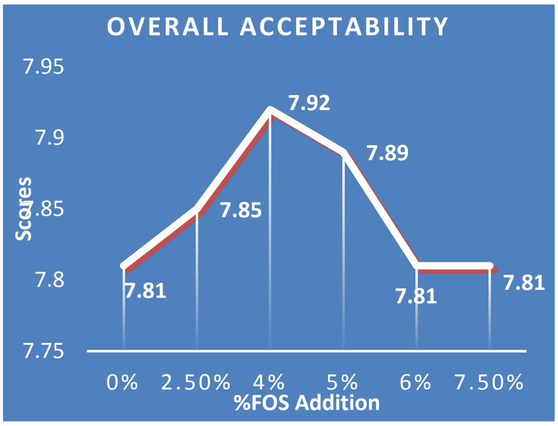


(c)

(d)



(e)

Figure: 5.1.6 (a-e): Mean values for organoleptic attributes of *dal* added with varying levels of FOS

Table 5.1.6 (b): Percent subjects indicating the color and appearance, taste, after taste, consistency and overall acceptability of FOS added *dal* at varying levels in a difference test

Products	% FOS	*DAL* Equal	Superior	Inferior	χ^2
Color & appearance	2.5%	26 (96.3)	0 (0)	1 (3.7)	8.03 NS
	4%	23 (85.2)	3 (11.1)	1 (3.7)	
	5%	23 (85.2)	2 (7.4)	2 (7.4)	
	6%	25 (92.6)	1 (3.7)	1 (3.7)	
	7.5%	21 (77.8)	5 (18.5)	1 (3.7)	
Taste & mouthfeel	2.5%	22 (81.5)	3 (11.1)	2 (7.4)	12.59 NS
	4%	18 (66.7)	6 (22.2)	3 (11.1)	
	5%	15 (55.6)	9 (33.3)	3 (11.1)	
	6%	14 (51.9)	9 (33.3)	4 (14.8)	
	7.5%	14 (51.9)	5 (18.5)	8 (29.6)	
After taste	2.5%	20 (74.1)	5 (18.5)	2 (7.4)	8.99 NS
	4%	17 (63)	7 (25.9)	3 (11.1)	
	5%	16 (59.3)	8 (29.6)	3 (11.1)	
	6%	15 (55.6)	11 (40.7)	1 (3.7)	
	7.5%	16 (59.3)	5 (18.5)	6 (22.2)	
consistency	2.5%	24 (88.9)	2 (7.4)	1 (3.7)	4.18 NS
	4%	20 (74.1)	6 (22.2)	1 (3.7)	
	5%	20 (74.1)	4 (14.8)	3 (11.1)	
	6%	19 (70.4)	6 (22.2)	2 (7.4)	
	7.5%	21 (77.8)	4 (14.8)	2 (7.4)	
Overall acceptability	2.5%	20 (74.1)	4 (14.8)	3 (11.1)	14.58 NS
	4%	14 (51.9)	10 (37)	3 (11.1)	
	5%	16 (59.3)	5 (18.5)	6 (22.2)	
	6%	14 (51.9)	8 (29.6)	5 (18.5)	
	7.5%	11 (40.7)	5 (18.5)	11 (40.7)	

- *NS- not significant.*
- *Figure in parenthesis represent percent of subjects.*

5.1.7 Assessment of organoleptic properties through numerical scoring and difference test for FOS added *kadi*

The result of this section are presented in Table 5.1.7 (a) and 5.1.7 (b)

a) Organoleptic evaluation of *kadi*

The organoleptic scores of *kadi* added with FOS at varying levels are presented graphically in Figure 5.1.7 (a-e) and tabulated in Table 5.1.7 (b).

i) Color and Appearance: A non-significant increase in the scores of *kadi* for color and appearance was reported up to 4% level of addition however a slight decrease in the scores was observed as the level of addition was further increased.

ii) Taste and Mouthfeel: Non-significant increment in the taste and mouthfeel scores of *kadi* was found after addition of FOS up to 5%; however the scores reduced at 6% level of FOS addition and increase at 7.5% level of FOS addition.

iii) After taste: Mean scores for after taste of *kadi* ranged from 7.81 (2.5% level of FOS addition) to 7.63 (7.5% level of FOS addition) as against 7.89 scored by the standard sample. *Kadi* was well accepted 4% of FOS addition which further reduced with the increasing level of FOS addition.

iv) Consistency: At 2.5% level of FOS addition panel members did not perceive any change in consistency of *kadi*; however with the further addition of FOS (4%) scores improved which further started reducing with the increase in percent addition of FOS.

v) Overall acceptability: Overall *kadi* was acceptable up to 4% level of FOS addition; after which mean organoleptic scores for overall acceptability started reducing with the further addition of FOS.

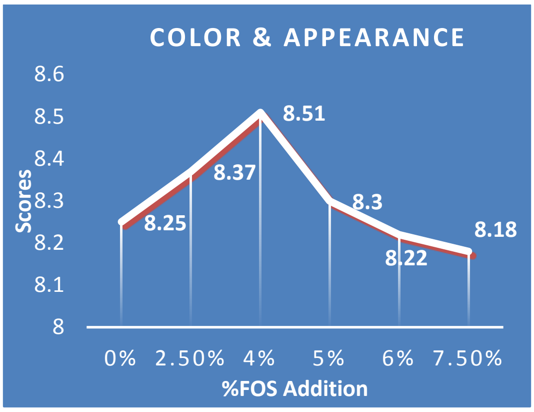
b) **Difference in the organoleptic attributes of FOS added *kadi* at varying levels in comparison with the standard *kadi***

As can be seen in Table 5.1.7 (b), no significant difference existed between 2.5% and 7.5% levels of FOS addition for color and appearance, taste, after taste, consistency and overall acceptability as compared to the standard *kadi*. There was a non-significant increase in the percent subjects who found FOS added (6% and 7.5% level) *kadi* to be inferior to the standard *kadi* for after taste, consistency and overall acceptability.

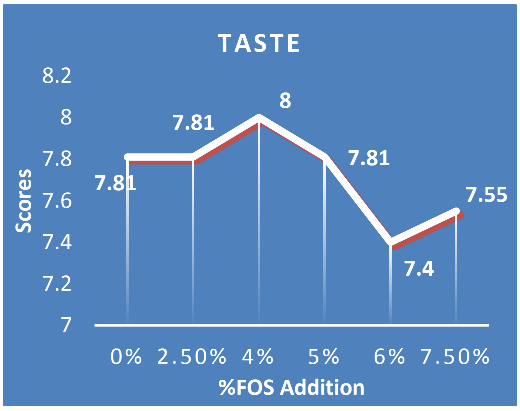
Table 5.1.7 (a): Mean values for organoleptic attributes of FOS added *kadi*

% FOS	*KADI*				
	Color & appearance	Taste	After taste	consistency	Overall acceptability
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
0%	8.25 ±1.29	7.81 ±1.39	7.89 ±1.31	8.22 ±1.01	7.92 ±1.17
2.5%	8.37 ±1.08	7.81 ±1.30	7.81 ±1.30	8.22 ±0.89	8.04 ±1.02
4%	8.51 ±0.97	8 ±1.04	7.92 ±1.10	8.37 ±0.79	8.11 ±0.97
5%	8.30 ±0.99	7.81 ±1.24	7.78 ±1.37	8.26 ±0.71	7.92 ±1.17
6%	8.22 ±1.01	7.40 ±1.42	7.41 ±1.49	8.22 ±0.80	7.59 ±1.15
7.5%	8.18 ±1.00	7.55 ±1.34	7.63 ±1.39	8.07 ±0.92	7.67 ±1.14
ANOVA	0.34 ^{NS}	0.74 ^{NS}	0.57 ^{NS}	0.37 ^{NS}	0.92 ^{NS}

- *Mean value represent the average of 5 determinants in triplicates.*
- *NS- The difference between the mean values within the column is not significant.*
- *Maximum score for all the organoleptic attributes was 10.*



(a)



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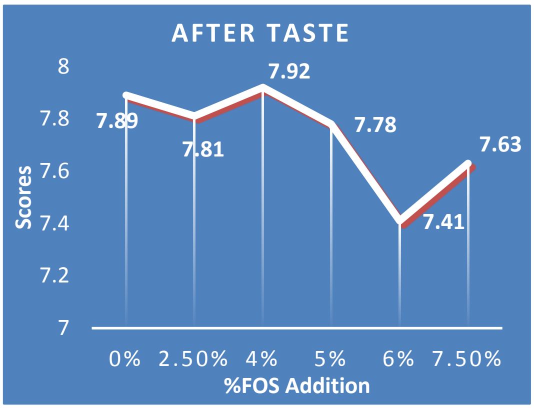

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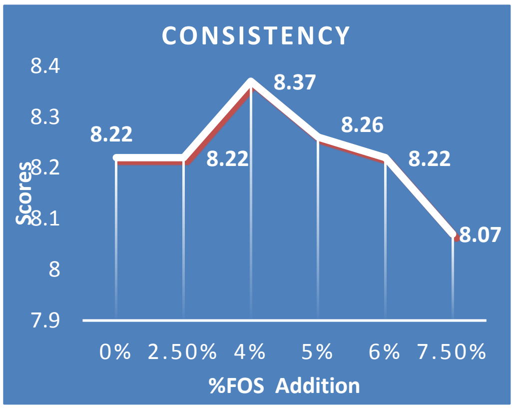

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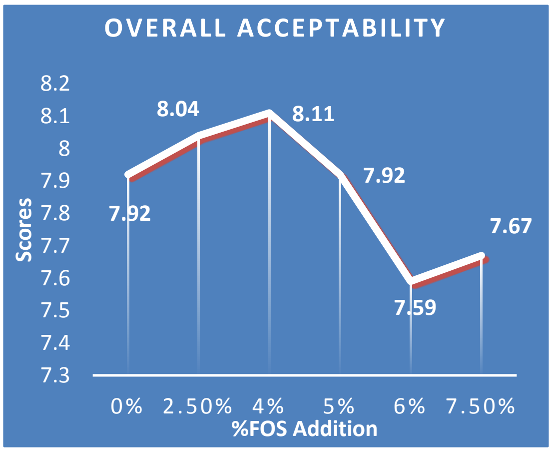


(e)

Figure: 5.1.7 (a-e): Mean values for organoleptic attributes of *kadi* added with varying levels of FOS

Table 5.1.7 (b): Percent subjects indicating the color and appearance, taste, after taste, consistency and overall acceptability of FOS added *kadi* at varying levels in a difference test

Products	% FOS	*KADI* Equal	Superior	Inferior	χ^2
Color & appearance	2.5%	24 (88.9)	3 (11.1)	0 (0)	7.61 NS
	4%	25 (92.6)	2 (7.4)	0 (0)	
	5%	23 (85.2)	4 (14.8)	0 (0)	
	6%	25 (92.6)	1 (3.7)	1 (3.7)	
	7.5%	22 (81.5)	5 (18.5)	0 (0)	
Taste & mouthfeel	2.5%	19 (70.4)	8 (29.6)	0 (0)	11.09 NS
	4%	19 (70.4)	7 (25.9)	1 (3.7)	
	5%	18 (66.7)	6 (22.2)	3 (11.1)	
	6%	13 (48.1)	8 (29.6)	6 (22.2)	
	7.5%	14 (51.9)	8 (29.6)	5 (18.5)	
After taste	2.5%	22 (81.5)	4 (14.8)	1 (3.7)	8.71 NS
	4%	22 (81.5)	4 (14.8)	1 (3.7)	
	5%	17 (63)	6 (22.2)	4 (14.8)	
	6%	17 (63)	8 (29.6)	2 (7.4)	
	7.5%	15 (55.6)	8 (29.6)	4 (14.8)	
consistency	2.5%	22 (81.5)	5 (18.5)	0 (0)	14.16 NS
	4%	25 (92.6)	2 (7.4)	0 (0)	
	5%	21 (77.8)	4 (14.8)	2 (7.4)	
	6%	23 (85.2)	3 (11.1)	1 (3.7)	
	7.5%	17 (63)	5 (18.5)	5 (18.5)	
Overall acceptability	2.5%	17 (63)	5 (18.5)	5 (18.5)	9.40 NS
	4%	17 (63)	8 (29.6)	2 (7.4)	
	5%	15 (55.6)	5 (18.5)	7 (25.9)	
	6%	17 (63)	6 (22.2)	4 (14.8)	
	7.5%	11 (40.7)	6 (22.2)	10 (37)	

- *NS- not significant.*
- *Figure in parenthesis represent percent of subjects.*

5.1.8 Assessment of organoleptic properties through numerical scoring and difference test for FOS added *kheer*

The result of this section are presented in Table 5.1.8 (a) and 5.1.8 (b)

a) Organoleptic evaluation of *kheer*

The organoleptic scores of *kheer* added with FOS at varying levels are presented graphically in Figure 5.1.8 (a-e) and tabulated in Table 5.1.8 (a).

i) Color and appearance: At all the levels of FOS addition, the color scores denoted that the addition of FOS at varying levels brought no significant difference in the color and appearance scores of *kheer*. Mean scores ranged between 8.07 (std. *kheer*) to 8.33 (7.5% level of FOS addition). A non-significant increase in the scores up to 6% level of FOS addition was observed which decreases slightly with the further FOS addition.

ii) Taste and Mouthfeel: Taste and mouthfeel scores of *kheer* added with FOS, ranged from 7.74 (standard) to 8.33(7.5% level of FOS addition) a non-significant increase in taste and mouthfeel scores was spotted as the level of FOS addition increases.

iii) After taste: Mean scores for after taste for *kheer* increases from 7.67(2.5% level FOS addition) to 7.96 (7.5% level of FOS addition) as against 7.48 scored by the standard sample. There was no significant difference between all the samples of *kheer* within the levels of FOS enrichment. At 7.5% level of FOS added *kheer* scored highest on hedonic scale as perceived by the panel members for after taste.

iv) Consistency: Mean scores for consistency for *kheer* ranged from 7.96 (2.5% level FOS addition) to 8(7.5% level of FOS addition) as against 8.07 scored by the standard sample. Non-significant decrease in the consistency scores was reported in FOS added *kheer* at varying levels.

v) Overall acceptability: Overall *kheer* was acceptable up to 7.5% of FOS addition. There was no significant difference witnessed in any of the organoleptic attributes;

however *FOS* added *kheer* scored higher as level of addition increase from 2.5% to 7.5% by the panel members.

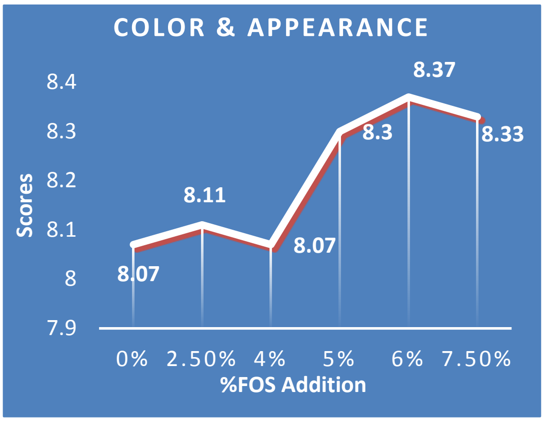
b) Difference in the organoleptic attributes of FOS added *kheer* at varying levels in comparison with the standard *kheer*

As demonstrated in Table 5.1.8 (b), chi square values depicts that, no significant difference was observed for all the organoleptic attributes of *kheer except for taste and mouthfeel as compared to the standard*. There was an increase in the person subjects from 18% to 22% who perceived FOS added *kheer* to be superior to the standard. *Kheer* was found to be equal as standard for color and appearance, after taste, consistency by majority of the panel members at 7.5% level of FOS addition, the overall acceptability of *kheer* was reported as equal and superior by almost 59% and 33% panel members respectively to the standard at 7.5% FOS addition.

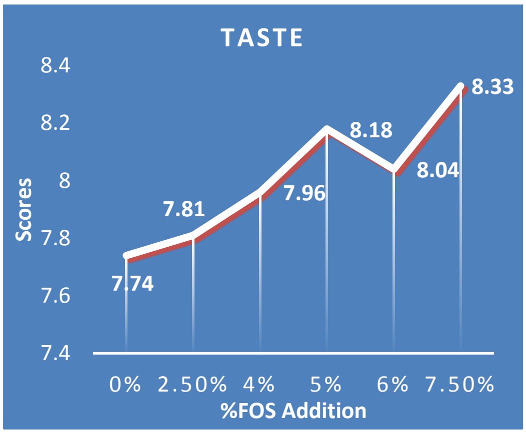
Table 5.1.8 (a): Mean values for organoleptic attributes of FOS added *kheer*

% FOS	*KHEER*				
	Color & appearance	Taste	After taste	consistency	Overall acceptability
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
0%	8.07 ±1.17	7.74 ±1.10	7.48 ±1.72	8.07 ±0.99	7.92 ±1.14
2.5%	8.11 ±1.15	7.81 ±0.96	7.67 ±1.49	7.96 ±0.90	7.89 ±1.210
4%	8.07 ±1.11	7.96 ±1.12	7.70 ±1.61	7.81 ±1.04	8.07 ±1.07
5%	8.30 ±1.14	8.18 ±0.96	7.81 ±1.47	8.00 ±1.07	8.37 ±1.15
6%	8.37 ±0.97	8.04 ±1.16	7.74 ±1.61	7.93 ±1.03	8.11 ±1.12
7.5%	8.33 ±1.04	8.33 ±1.04	7.96 ±1.34	8.00 ±1.24	8.44 ±0.89
ANOVA	0.43 ^{NS}	1.19 ^{NS}	0.28 ^{NS}	0.19 ^{NS}	1.15 ^{NS}

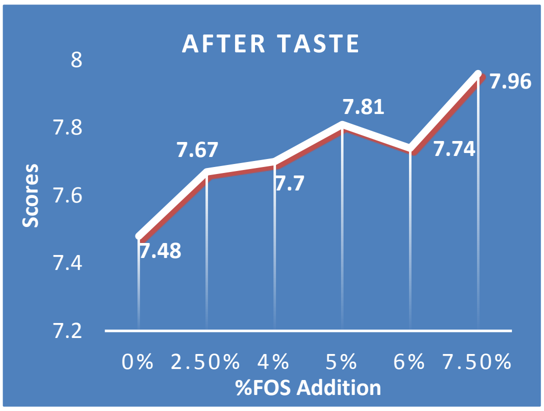
- *Mean value represent the average of 5 determinants in triplicates.*
- *NS- The difference between the mean values within the column is not significant.*
- *Maximum score for all the organoleptic attributes was 10.*



(a)



(b)



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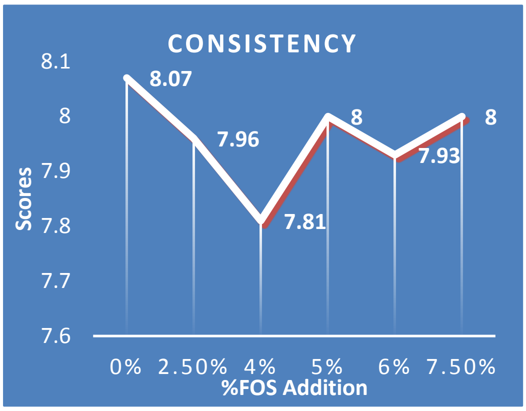

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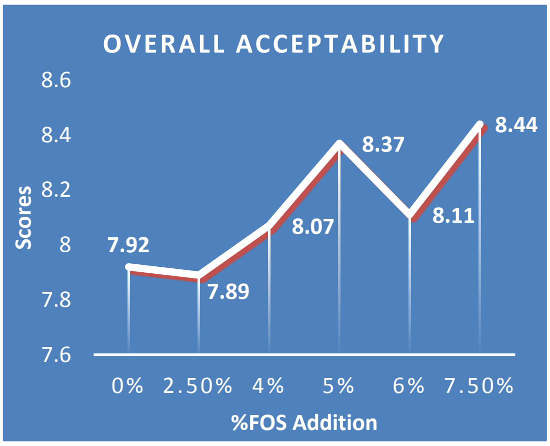


(e)

Figure: 8 (a-e): Mean values for organoleptic attributes of *kheer* added with varying levels of FOS

Table 5.1.8 (b): Percent subjects indicating the color and appearance, taste, after taste, consistency and overall acceptability of FOS added *kheer* at varying levels in a difference test

Products	% FOS	*KHEER* Equal	Superior	Inferior	χ^2
Color & appearance	**2.5%**	26 (96.3)	1 (3.7)	0 (0)	10.00 NS
	4%	26 (96.3)	1 (3.7)	0 (0)	
	5%	25 (92.6)	2 (7.4)	0 (0)	
	6%	21 (77.8)	4 (14.8)	2 (7.4)	
	7.5%	22 (81.5)	3 (11.1)	2 (7.4)	
Taste & mouthfeel	**2.5%**	22 (81.5)	5 (18.5)	0 (0)	**17.35 ***
	4%	24. (88.9)	3 (11.1)	0 (0)	
	5%	18 (66.7)	9 (33.3)	0 (0)	
	6%	16 (59.3)	9 (33.3)	2 (7.4)	
	7.5%	17 (63)	6 (22.2)	4 (14.8)	
After taste	**2.5%**	22 (81.5)	4 (14.8)	1 (3.7)	7.00 NS
	4%	24 (88.9)	1 (3.7)	2 (7.4)	
	5%	20 (74.1)	6 (22.2)	1 (3.7)	
	6%	18 (66.7)	6 (22.2)	3 (11.1)	
	7.5%	20 (74.1)	4 (14.8)	3 (11.1)	
consistency	**2.5%**	21 (77.8)	5 (18.5)	1 (3.7)	4.250 NS
	4%	22 (81.5)	4 (14.8)	1 (3.7)	
	5%	20 (74.1)	6 (22.2)	1 (3.7)	
	6%	21 (77.8)	6 (22.2)	0 (0)	
	7.5%	17 (63)	8 (29.6)	2 (7.4)	
Overall acceptability	**2.5%**	17 (63)	9 (33.3)	1 (3.7)	2.88 NS
	4%	19 (70.4)	7 (25.9)	1 (3.7)	
	5%	20 (74.1)	5 (18.5)	2 (7.4)	
	6%	18 (66.7)	8 (29.6)	1 (3.7)	
	7.5%	16 (59.3)	9 (33.3)	2 (7.4)	

- *NS- not significant.*
- *Figure in parenthesis represent percent of subjects.*

5.1.9 Assessment of organoleptic properties through numerical scoring and difference test for FOS added *khichdi*

The results of this section are presented in Table 5.1.9 (a) and 5.1.9 (b).

a) Organoleptic evaluation of *khichdi*

The organoleptic scores of *khichdi* added with FOS at varying levels are presented graphically in Figure 5.1.9 (a-e) and tabulated in Table 5.1.9 (a).

i) Color and appearance: At all the levels of FOS addition, the color scores denoted that the addition of FOS at varying levels brought no significant difference in the color and appearance scores of *khichdi.* Scores increases at 2.5% FOS addition and further decreases gradually with the increase in FOS addition.

ii) Taste and Mouthfeel: Taste and mouthfeel scores of *khichdi* added with FOS, ranged from 7.92 (standard) to 8.18(6% level of FOS addition) which further decreases at 7.5% (7.74) level of FOS addition. No significant differences in taste and mouthfeel scores were spotted amongst all the levels of FOS incorporated.

iii) After taste: Mean scores for after taste for *khichdi* increases from 8(2.5% level FOS addition) to 8.07 (6% level of FOS addition) as against 7.92 scored by the standard sample. There was no significant difference between all the samples of *khichdi* within the levels of FOS enrichment. At 7.5% level of FOS added *khichdi* scored lowest (7.88) on hedonic scale as perceived by the panel members for after taste.

iv) Consistency: Mean scores for consistency for *khichdi* increases at 2.5% FOS addition i.e. 8.07 after which it decreases and remains stable up to 6% level of FOS addition. A non-significant reduction was observed at 7.5% level of FOS.

v) Overall acceptability: Overall *khichdi* was acceptable up to 6% of FOS addition, the mean scores increases with the increase in FOS addition; however a non-significant decrease in the mean scores for overall acceptability was reported at 7.5% FOS addition.

b) Difference in the organoleptic attributes of FOS added *khichdi* at varying levels in comparison with the standard *khichdi*

As demonstrated in Table 5.1.9 (b), chi square values depicts that, no significant difference was observed for all the organoleptic attributes of FOS added *khichdi* in terms of color, taste, after taste, consistency and overall acceptability as compared to standard. 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.

Table 5.1.9 (a): Mean values for organoleptic attributes of FOS added *khichdi*

% FOS	***KHICHDI***				
	Color & appearance	**Taste**	**After taste**	**consistency**	**Overall acceptability**
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
0%	8.14 ±0.94	7.92 ±0.99	7.92 ±0.91	7.85 ±1.19	8.03 ±1.22
2.5%	8.29 ±0.77	7.81 ±0.92	8 ±0.87	8.07 ±0.87	8.07 ±0.95
4%	8.18 ±1.00	7.88 ±1.12	8.03 ± 0.85	7.85 ±1.13	8.14 ±1.02
5%	8.14 ±0.86	8 ±0.91	8 ±0.87	7.96 ±0.85	8.29 ±0.95
6%	8 ±1.07	8.18 ±0.87	8.07 ±0.95	7.96 ±0.64	8.40 ±1.08
7.5%	7.74 ±0.94	7.74 ±0.85	7.88 ±0.89	7.77 ±1.15	7.96 ±1.12
ANOVA	0.34^{NS}	0.56^{NS}	0.10^{NS}	0.25^{NS}	0.59^{NS}

- *Mean value represent the average of 5 determinants in triplicates.*
- *NS- The difference between the mean values within the column is not significant.*
- *Maximum score for all the organoleptic attributes was 10.*

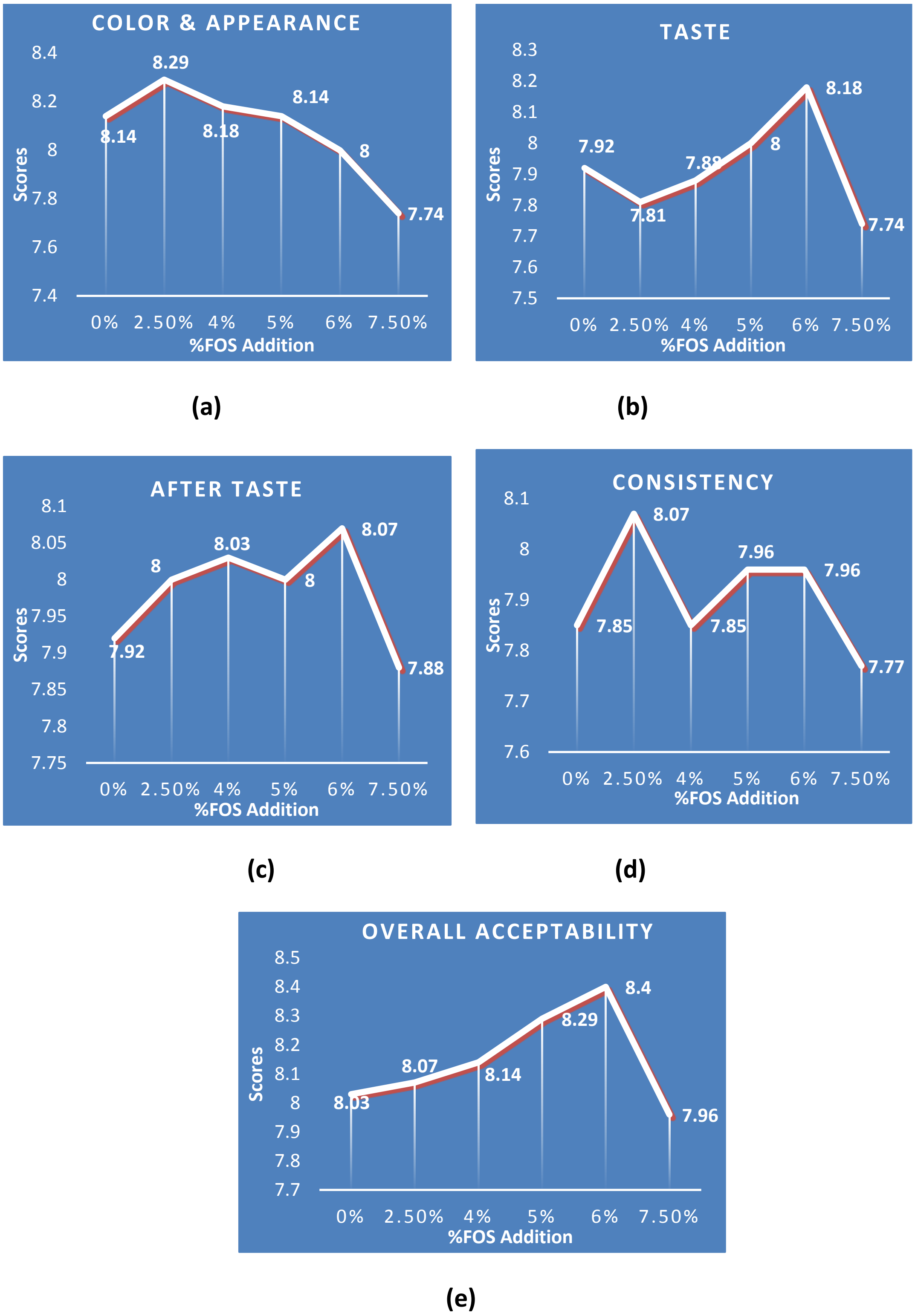


Figure: 5.1.9 (a-e): Mean values for organoleptic attributes of *khichdi* added with varying levels of FOS

Table 5.1.9 (b): Percent subjects indicating the color and appearance, taste, after taste, consistency and overall acceptability of FOS added *khichdi* at varying levels in a difference test

Products	% FOS	*KHICHDI* Equal	Superior	Inferior	χ^2
Color & appearance	2.5%	25 (92.6)	1 (3.7)	1 (3.7)	7.26[NS]
	4%	23 (85.2)	4 (14.8)	0 (0)	
	5%	24 (88.9)	3 (11.1)	0 (0)	
	6%	24 (88.9)	3 (11.1)	0 (0)	
	7.5%	22 (81.5)	3 (11.1)	2 (7.4)	
Taste & mouthfeel	2.5%	16 (59.3)	5 (18.5)	6 (22.2)	3.82 [NS]
	4%	18 (66.7)	7 (25.9)	2 (77.4)	
	5%	16 (59.3)	5 (18.5)	6 (22.2)	
	6%	18 (66.7)	5 (18.5)	4 (14.8)	
	7.5%	17 (63)	4 (14.8)	6 (22.2)	
After taste	2.5%	17 (63)	6 (22.2)	4 (14.8)	2.60 [NS]
	4%	16 (59.3)	7 (25.9)	4 (14.8)	
	5%	18 (66.7)	5 (18.5)	4 (14.8)	
	6%	20 (74.1)	5 (18.5)	2 (7.4)	
	7.5%	20 (74.1)	4 (14.8)	3 (11.1)	
consistency	2.5%	18 (66.7)	4 (14.8)	5 (18.5)	6.59 [NS]
	4%	20 (74.1)	5 (18.5)	2 (7.4)	
	5%	18(66.7)	8 (29.6)	1 (3.7)	
	6%	19 (70.4)	6 (22.2)	2 (7.4)	
	7.5%	17 (63)	5 (18.5)	5 (18.5)	
Overall acceptability	2.5%	16 (59.3)	2 (7.4)	9 (33.3)	12.42 [NS]
	4%	13 (48.1)	11 (40.7)	3 (11.1)	
	5%	14 (51.9)	5 (18.5)	8 (29.6)	
	6%	17 (63)	6 (22.2)	4 (14.8)	
	7.5%	16 (59.3)	5 (18.5)	6 (22.2)	

- *NS- not significant.*
- *Figure in parenthesis represent percent of subjects.*

Result Highlights of Phase I

- 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 after FOS addition up to 7.5% level.
- Taste and mouthfeel of *kheer* improved significantly after addition of FOS.
- Color and appearance, taste and overall acceptability of *Potato Curry* was significantly reported inferior as compared to the standard with the increasing level of FOS addition

DISCUSSION

FOS as a prebiotic is known modulator of gut health in terms of colonization of beneficial bacteria and reduced growth of enteric pathogens it was therefore butter important to study the effect of its addition in commonly consumed Indian food in terms of its acceptability and feasibility. This would help in advocating FOS to be consumed on regular basis to the population whose Indian daily diet are composed of these foods.

The result of the present study showed that FOS could be incorporated easily in nine products *viz.* **Buttermilk*, Lemon juice,* Milk*,* tomato Soup*, Potato curry, Dal, Kadi, Kheer*** and ***Khichdi*** upto 7.5% level. This can be contributed to easy solubility of FOS in these products. Few investigators have also reported feasibility and acceptability of FOS added products without altering its physico chemical properties (Mahendra and Sheth 2013; Assudani and Sheth 2013; Kholy and Mahrous 2015).

To support this another study reported that fortification of various fruit juice especially pineapple, mango, and orange juice with fructooligosaccharides resulted in successful partial substitution of sucrose with FOS without significantly affecting the overall quality. Changes in various physicochemical and sensory parameters during storage of fortified juices, at room temperature and under refrigerated conditions, were evaluated. The pH, total soluble solids, titratable acidity, and color did not change significantly during storage. The sensory properties indicated the acceptance of fortified juices (Renuka et al., 2009).

In the present study FOS added Buttermilk*, Lemon juice,* Milk*,* tomato Soup*, Potato curry, Dal, Kadi, Kheer* and *Khichdi* revealed no significant difference in color and appearance, taste and mouthfeel, consistency and overall acceptability at varying levels of FOS addition. A similar study reported that FOS addition in the *dudhi muthiya* at 10g and 15g showed no significant difference as compared to the standard product (Assudani and Sheth 2013). Another study by Mahendra and Sheth 2013 reported no significant difference in *Dhokla* and *Patra* where base material Bengal gram was substituted with FOS at four levels 6%, 10%, 16% and 20%.

In present study significantly more number of panelist indicated that consistency of FOS added buttermilk was better than standard Buttermilk. In dairy products the incorporation of FOS improves the processability and upgrades the quality, imparts a better round flavor also adding on to the total solids thus resulted in improved consistency. Similar type of finding were also reported by Parnami and Sheth 2010 where oligofructose resulted in increased consistency of Porridge, orange juice and curd. Fructooligosaccharides are very hygroscopic sugars and their viscosity is relatively higher than that of sucrose at the same concentration (Nobre,Teixeira and Rodrigues 2015).

FOS added tomato soup scored significantly superior as compared to the standard tomato soup by the panel members. This could be due the brighter color imparted by FOS after its incorporation which was perceived better than the slightly dark colored tomato soup.

Panel members reported FOS added potato curry inferior as compared to the standard at 6% addition. This could be due to the presence of small lumps of FOS in the potato curry as pieces of potatoes hindered miscibility of FOS and thus affecting to overall acceptability. However if FOS was added prior to the addition of potatoes it could lead to increased acceptability.

Kheer is sweet Indian product. With an increase in the level of FOS addition there was increase in the sweetness which could have contributed to the significantly enhanced taste and aftertaste of the modified product. As, FOS contributes to sweetness, helps in retaining moisture, has lower calories, and provides nutritional benefits it can be added, without affecting taste, aftertaste and mouthfeel of the product (Nobre,Teixeira and Rodrigues 2015).

Oligosaccharides such as oligofructose and galactooligosaccharides are much more soluble than inulin (about 80% in water at room temperature). They are mostly available as colorless viscous syrups with 75% dry substance. In the pure form, they have a sweetness of about 30–35% in comparison to sucrose (Franck, 2002; 2008). Their sweetening profile closely approaches that of sugar. The taste is very clean without any lingering effect. They mingle very well with delicate aromas and even enhance fruit flavors. These oligosaccharides provide interesting mixtures offering a rounder mouthfeel and a better sustained fruit flavor with reduced aftertaste and improved stability (Franck, 2008). Another study reported that FOS possess technological properties that are closely related to those of sugar and glucose syrups. This makes the oligosaccharides excellent ingredients to replace sugars while at the same time decreasing the caloric content of the end products and allowing prebiotic properties (Crittenden and Playne, 1996).

Oligofructose has a sweet, pleasant flavor and is highly soluble. It can be used to fortify foods with fiber without contributing any deleterious organoleptic effects, to improve the flavor and sweetness of low calorie foods. Many researches show the similar results for increased organoleptic attributes of cookies, ice-creams, meat sausages after FOS incorporation (Handa C et al 2011; Ting-ning lin and Gruen I 2012; Freitas Folly GA 2013).

Therefore it can be concluded that FOS can be added in Buttermilk*, Lemon juice,* Milk*,* tomato Soup*, Potato curry, Dal, Kadi, Kheer* and *Khichdi* and in many other products without affecting their organoleptic qualities up to 7.5% level of addition.

Concluding Remarks

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.*

Phase II

Comparative analysis of obese and normal weight subjects for their anthropometric parameters, nutrient intake, gut microflora, plasma GLP-1, plasma LPS, hunger and satiety

Obesity is considered as cluster of non-communicable diseases called 'New World Syndrome' creating an enormous socio economic and public health burden in developing countries. It is a complex multifactorial disorder affecting children as well as adults. It is one of the key risk factor for Non-Communicable Diseases (NCDs) such as diabetes mellitus, coronary heart disease, hypertension, arthritis, gallstones, etc (Aeberlil et al., 2007). It is a warning against worldwide epidemic because of metabolic changes.

The intestinal microflora may be identified as an important target for improving health through reduced disease risk. Recent studies have highlighted the associations of gut microflora 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.

The present phase was hence planned to study the various risks factors which can impact obesity and to further validate the existing information and determine the association amongst the various parameters such as gut microflora (*Bifidobacteria, LAB* and Enteric pathogen) LPS, and gut incretins of obese and normal weight subjects. In this phase of the study an attempt was made to determine the general characteristics, medical history, activity pattern, anthropometric measurements, biochemical parameters (glycemic, lipemic and gut incretins), biophysical parameters and nutrient intake of normal weight and obese subjects and studying the associations amongst these factors.

For achieving the desired objectives, a total of 94 adults were enrolled from rural industry of Vadodara. The methodology to collect the above mentioned information is elaborated in Material and Methods chapter and results are presented in sections table 5.2.1 to table 5.2.48

The results of this section are presented into following sections

- Socio demographic Information of normal weight and Obese Subjects.
- Mean Values for Anthropometric Parameters of Normal weight and Obese Subject.
- Mean Values for biophysical Parameters of Normal weight and Obese Subject.
- Family History of Diseases in normal weight and Obese Subjects.
- Personal habit of normal weight and obese subjects with respect to alcohol, cigarette, tobacco, tea, coffee and aerated drinks.
- Mean hunger and satiety scores of Normal weight and obese subjects at various meal timings.
- Dietary intakes of macronutrients and food habits of Normal weight and obese subjects
- Association of BMI with physical activity level in normal weight and obese subjects.
- Difference in LPS and GLP-1 levels of Normal weight and obese subjects.
- Mean Log values for microbial parameters of normal weight and obese subjects.
- Medical history of normal weight and obese subjects.
- Duration of obesity among subjects.
- Association of life style factors of subjects with anthropometric, hunger, satiety, biochemical, microbial and dietary parameters.

5.2.1 Socio demographic Information of normal weight and obese Subjects

Table 5.2.1 reveals socio demographic data of normal weight and obese subjects. 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. Most of the obese subjects were educated up to intermediate level.

Table 5.2.1: Socio demographic Information of normal weight and obese Subjects

Parameters	Normal wt (N=30)	Obese (N=60)
Sex		
Male	30 (100)	60 (100)
Religion		
Hindu	29 (97)	57 (95)
Muslim	1 (3)	3 (5)
Others	0 (0)	0 (0)
Type of Family		
Joint	5 (17)	12 (20)
Nuclear	17 (57)	39 (65)
Extended Nuclear	8 (26)	9 (15)
Education		
Elementary	1 (3)	0 (0)
High school	15 (50)	9 (15)
Intermediate /Diploma	7 (23)	45 (75)
Graduation/higher studies	7 (23)	6 (10)
Occupation		
Service	30 (100)	60 (100)
Business	0 (0)	0 (0)
Other	0 (0)	0 (0)
Retired	0 (0)	0 (0)
Family Income Per Month		
≥ 28114	3 (10)	3 (5)
14050-23113	11 (37)	21 (35)
7016-14049	16 (53)	36 (60)

- *Figures in parenthesis represent percent of subjects.*

5.2.2 Mean Values for Anthropometric parameters of normal weight and obese Subject

Table 5.2.2 shows the mean value for anthropometric parameters of normal weight and obese subjects. The mean BMI of the normal weight 21.47 Kg/m^2 whereas for the obese was 27.32 Kg/m^2.

Table 5.2.2: Mean Values for Anthropometric parameters of normal weight and obese Subjects

Parameters	Normal wt (N=30) Mean ± SD	Obese (N=60) Mean ± SD	't' Value
Height (cms)	1.71 ± 0.06	1.70 ± 0.05	0.197^{NS}
Weight (Kg)	62.52 ± 4.73	79.28 ± 5.74	**13.81*** **
BMI (kg/m2)	21.47 ± 1.07	27.32 ± 1.48	**21.36*** **
WC(cm)	79.70 ± 8.71	98.38 ± 4.14	**11.02*** **
HC (cm)	93.85 ± 4.37	104.32 ± 2.95	**42.64*** **
WHR	0.85 ± 0.06	0.94 ± 0.02	**33.67*** **
Body Fat (%)	22.09 ± 3.02	28.38 ± 1.84	**10.47*** **

- *NS = non-significant, p < 0.001: ****

5.2.3 Mean Values for systolic and diastolic blood pressure values of normal weight and obese Subjects

Although Table 5.2.3 reveals significant difference between the mean systolic values of normal weight and the obese subject they were well between the normal ranges. Data indicate that grade I obese subjects are not at risk of hypertension.

Table 5.2.3: Mean Values for systolic and diastolic blood pressure values of normal weight and obese Subjects

Parameters	Normal wt (N=30) Mean ± SD	Obese (N=60) Mean ± SD	't' Value
Blood Pressure Systolic (mmHg)	114.57 ± 4.56	122.27 ± 8.59	**5.56 *** **
Blood Pressure Diastolic (mmHg)	77.03 ± 4.41	76.03 ± 8.25	0.75^{NS}

- *NS = non-significant, p < 0.001:****

5.2.4 Family History of NCD's of normal weight and obese subjects

Table 5.2.4 reveals strong significant association between family history of obesity and higher BMI of obese subjects as of the various NCD's studied the odds of occurrence of obesity with positive family history of obesity was statistically significant in the obese subjects under study whereas family history of hypertension, DM and CVD were not associated with obesity.

Table 5.2.4: Number of normal weight and obese subjects with family History of NCD's

Family history of NCD's	Normal wt (n=30)	Obese (n=60)	χ2 value	Odds ratio
Obesity	7 (23)	29 (48)	**5.21***	**3.07*(1.1-8.2)**
Hypertension	12 (40)	30 (50)	0.80 NS	1.5 (0.6-3.6)
Diabetes Mellitus	5 (17)	17 (28)	1.47NS	1.97 (0.6-6.0)
CVD's	3 (10)	9 (15)	0.43 NS	1.58 (0.4-7.7)

- *Figures in parenthesis represent percent of subjects; NS = non-significant, p < 0.05:*

5.2.5 Personal habit of alcohol intake, smoking cigarette, tobacco chewing and intake of tea, coffee and aerated drinks of normal weight and obese subjects

Table 5.2.5 shows data on personal habits of normal weight and obese subjects. Results showed that tobacco chewing was found significantly higher among obese subjects (32%) as compared to normal weight subjects (7%) (p < 0.05%).

5.2.6 Mean hunger scores of normal weight and obese subjects at various meal timings

Data about the mean hunger score (Table 5.2.6) showed that the normal weight subjects had low hunger scores for breakfast and evening snacks (means higher feeling for hunger) whereas obese subjects expressed significant higher feeling of hunger for lunch and dinner. Many obese subjects skipped breakfast (Figure 5.2.1).

5.2.7 Mean satiety scores of Normal weight and obese subjects at various meal timings

Results from Table 5.2.7 showed mean satiety scores of normal weight and obese subjects, no significant difference between obese and normal weight subject for the feeling of satiety was observed.

Table 5.2.5: Number of normal weight and obese subjects with personal habit of alcohol intake, smoking cigarette, tobacco chewing and intake of tea, coffee and aerated drinks

Personal habits	Frequency	Normal wt N = 30	Obese N = 60	χ2 value
Alcohol	High	0 (0)	0 (0)	0.13 NS
	Moderate	6 (20)	14 (23)	
	Never	24 (80)	46 (77)	
Cigarette	High	6 (20)	16 (27)	0.50 NS
	Moderate	2 (7)	4 (7)	
	Never	22 (73)	40(66)	
Tobacco	High	2 (7)	19 (32)	**7.01***
	Moderate	3 (10)	4 (7)	
	Never	25 (83)	37 (62)	
Tea	High	10 (33)	15 (25)	1.13 NS
	Moderate	20 (67)	44 (73)	
	Never	0 (0)	1 (2)	
Coffee	High	0 (0)	0 (0)	0.70 NS -
	Moderate	10(33)	15(25)	
	Never	20(67)	45 (75)	
Aerated Drinks	High	4 (13)	19 (32)	5.09 NS
	Moderate	19 (64)	24 (40)	
	Never	7 (23)	17 (28)	

- *Figures in parenthesis represent percent of subjects; NS = non-significant, p < 0.05:*

Table 5.2.6: Mean hunger scores of normal weight and obese subjects at various meal timings

Meal	Normal wt(N=30) Mean ± SD	Obese(N=60) Mean ± SD	't' values
Breakfast	3.43 ± 0.86	3.90 ± 0.90	**2.36***
Lunch	4.80 ± 0.41	3.80 ± 0.82	**7.73*****
Evening	3.57 ± 0.57	4.15 ± 0.73	**3.82*****
Dinner	4.50 ± 0.73	3.85 ± 0.80	**3.74*****

- *NS = non-significant,* Significantly different from the other group at *p<0.05, **p<0.01, ***p<0.001 *; Hunger scores 1 – 5, where 1= Famished, starving 2= Headache, weak, cranky, low energy , 3= Want to eat now, stomach growls and feels empty, 4= Hungry - but could wait to eat, starting to feel empty but not there yet, 5= Not hungry, not full*

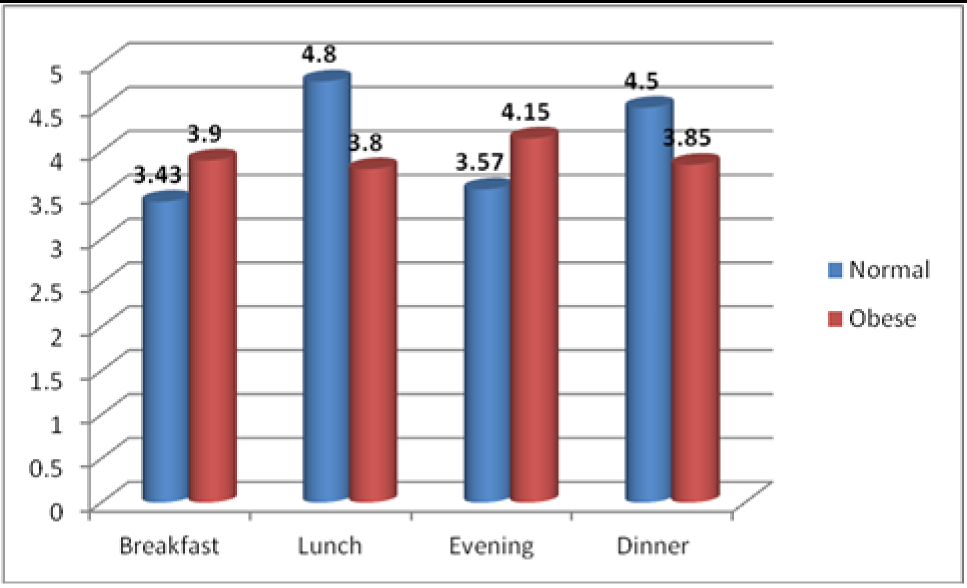


Figure 5.2.1: Mean hunger scores of normal weight and obese subjects at various meal timing

Table 5.2.7: Mean satiety scores of Normal weight and obese subjects at various meal timings

Meal	Normal wt(N=30) Mean ± SD	Obese (N=60) Mean ± SD	't' values
Breakfast	6.13 ± 0.78	5.98 ± 0.72	0.90 NS
Lunch	6.17 ± 0.59	6.03 ± 0.61	0.99 NS
Evening	5.80 ± 0.55	5.53 ± 0.81	1.84 NS
Dinner	6.40 ± 0.56	6.30 ± 0.59	0.77 NS

- *NS = non-significant ; Satiety scores 5 –10, where 5= Not hungry, not full, 6 = Feeling satisfied, stomach feels full and comfortable, 7 = Feeling full, definitely don't need more food, 8 = uncomfortably full, 9 = Stuffed, very uncomfortable, 10 = Bursting, painfully full*

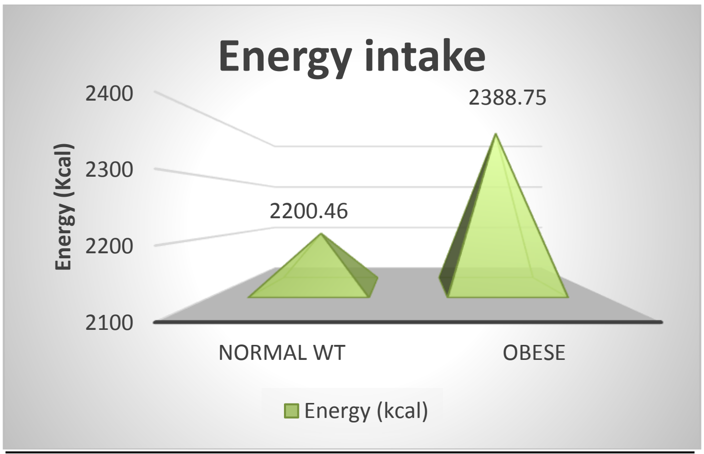
5.2.8 Dietary intakes of macronutrients of normal weight and obese subjects

Data from the dietary profile (Table 5.2.8) showed significant higher intake of macro nutrients i.e. energy and fat Figure 5.2.2 (a,b) among obese subjects as compared to normal weight subjects. This was also supported by food frequency data (Table 5.2.9) where obese subjects were reported to consume high fat snack, ice creams and papad chutney more frequently than normal weight subject.

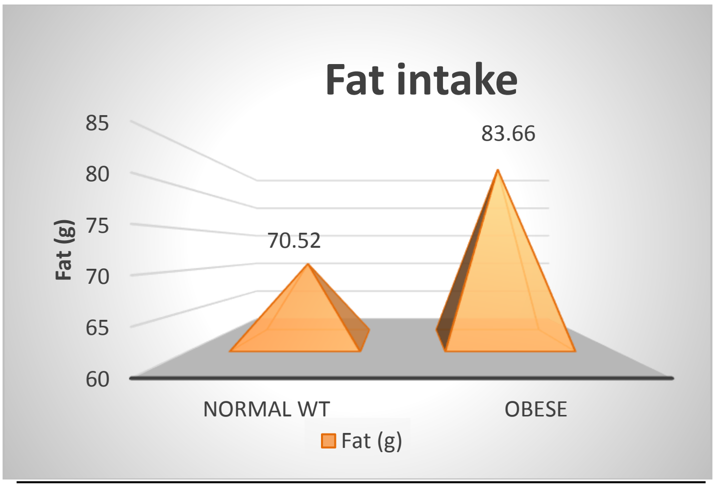
Table 5.2.8: Dietary intakes of macronutrients of normal weight and obese subjects

Macronutrients	Normal wt (N = 30) Mean ± SD	Obese (N = 60) Mean ± SD	't' values
Energy (kcal)	2200.46±331.68	2388.75±359.42	**2.40***
Protein (g)	58.19 ± 13.15	53.78 ± 8.84	1.88 NS
Fat (g)	70.52 ± 18.05	83.66 ± 14.16	**3.77*****
Carbohydrate (g)	333.25 ± 63.38	353.31 ± 43.63	1.57 NS
Soluble dietary fiber (g)	3.95 ± 1.37	3.81 ± 1.44	0.44 NS
Insoluble dietary fiber (g)	13.15 ± 4.42	11.71 ± 4.38	1.47 NS
Crude fiber (g)	7.04 ± 2.08	6.87 ± 2.19	0.35 NS
Total dietary fiber (g)	17.04 ± 5.59	15.544 ± 5.61	1.19 NS

- *NS = non-significant, p < 0.05: *, p < 0.01: **, p < 0.001: ****



(a)



(b)

Figure 5.2.2 (a,b): Dietary intakes of macronutrients of normal weight and obese subjects

5.2.9 Frequency of consumption of food from various food groups by normal weight and obese subjects

Food frequency data (Table 5.2.9) showed significant higher consumptions of Green Leafy Vegetables, fruits, nuts and oilseeds ($p < 0.05$) 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 subject.

Table 5.2.9: Number of normal weight and obese subjects showing frequency of consumption of food groups

Food Groups	Normal weight (N=30)			Obese (N=60)			χ2 value
	Frequent N (%)	Less frequent N (%)	Rarely N (%)	Frequent N (%)	Less frequent N (%)	Rarely N (%)	
Cereals	30 (100)	0 (0)	0 (0)	60 (100)	0 (0)	0 (0)	-
Wheat flour> Refined four> Whole cereals				Wheat flour> Refined four> Whole cereals			
Pulses	30 (100)	0 (0)	0 (0)	57 (95)	0 (0)	3 (5)	1.55^{NS}
Legumes > Pulses				Legumes > Pulses			
Green Leafy Vegetables	24 (80)	5 (17)	1 (3)	30 (50)	18 (30)	12 (20)	**8.23***
Roots and tubers	30 (100)	0 (0)	0 (0)	60 (100)	0 (0)	0 (0)	-
Onion-Garlic-Potato				Potato> Onion>Garlic			
Other vegetables	30 (100)	0 (0)	0 (0)	60 (100)	0 (0)	0 (0)	-
Tomato– other vegetables				Tomato– other vegetables			
Fruits	2 (7)	13 (43)	15 (50)	2 (3)	25(42)	33 (55)	**15.70***
Banana> Apple> orange> Guava				Banana> Apple > Guava> orange			
Nuts and Oil seeds	5 (17)	18 (60)	7 (23)	5 (8)	21 (35)	34 (57)	**9.01***
Fats	30 (0)	0 (0)	0 (0)	60 (100)	0 (0)	0 (0)	-
Cotton seed> Ghee/butter> Groundnut> Mustard>hydrogenated				Cotton seed> Ghee/butter> Groundnut> Coconut>hydrogenated			
Milk and milk products	25 (83)	0 (0)	5 (17)	60 (100)	0 (0)	0(0)	-
Milk buffalo> Curd> Buttermilk> Paneer> Milk cow> Cheese				Milk buffalo> Curd> Buttermilk>Cheese> Paneer> Shrikhand			
Sugar and jaggery	30 (100)	0 (0)	0 (0)	57 (95)	0 (0)	3 (5)	1.55 ^{NS}
Sugar> Jaggery> Honey				Sugar> Jaggery			
Sweets	6 (20)	16 (53)	8 (27)	9 (15)	30 (50)	21 (35)	0.77 ^{NS}
Ice-cream	1 (3)	6 (20)	23 (77)	3 (5)	30 (50)	27 (45)	**8.23***
Snacks	6 (20)	16 (53)	8 (27)	30 (50)	27 (45)	3 (5)	**12.47****
High fat> Moderate fat> low fat				High fat> Moderate fat> low fat			
Soups and beverages	0(0)	11 (37)	19 (63)	0 (0)	24 (40)	36 (60)	**13.05***
Buttermilk> Nimbu sharbat> Fruit juice> Carbonated beverage> Lassi > Soup				Buttermilk>Carbonated beverage>Nimbu sharbat>Fruit juice>Lassi> Soup			
Others (Papad , chutney)	13 (43)	7 (23)	10 (34)	42 (70)	9 (15)	9 (15)	**6.29***

- *Numbers in parenthesis indicate percentage; NS = non-significant, significantly different from the other group at *p<0.05, **p<0*

5.2.10 Type of food habits of normal weight and obese subjects

Food habits data (Table 5.2.10) revealed significant difference in the consumption of sugar as higher percent (53%) of normal subjects were reported to consume greater amount of sugar daily as compared to the obese subjects (25%) ($p<0.05$). The overall frequency of obese subject eating out was significantly higher ($p<0.001$) than normal weight subjects.

Table 5.2.10: Number of normal weight and obese subjects with varying food habits

Food habits	Normal weight (N=30)	Obese (N=60)	χ2 value
Type of diet			
Vegetarian	20 (67)	30 (50)	
Non vegetarian	10 (33)	30 (50)	2.25^{NS}
Ovo Lacto vegetarian	0 (0)	0 (0)	
Amount of sugar added / coffee/tea			
0-15g	14 (47)	42 (70)	
16-30g	16 (53)	15 (25)	**7.91***
>30g	0 (0)	3 (5)	
Alternative therapies to control obesity			
Yes	8 (27)	14 (23)	0.28 ^{NS}
No	22 (73)	46 (77)	
Diet management			
Control sugar	2 (7)	5 (8)	0.08 ^{NS}
Control CHO	5 (17)	9 (15)	0.42^{NS}
Control fat	2 (7)	6 (10)	0.26 ^{NS}
Consumption of artificial sweetener			
Yes	0 (0)	0 (0)	
No	30 (100)	60 (100)	--
Eating outside home			
Frequent	12 (40)	19 (32)	
Less frequent	8 (27)	41 (68)	**26.78*****
Rarely	10 (33)	0 (0)	

- *numbers in parenthesis indicate percentage, *p<0.05, ***p<0.001*

5.2.11 Association of BMI with physical activity levels of normal weight and obese subjects

Table 5.2.11 shows that most obese had sedentary lifestyle when compared to normal weight subjects. However, no significant difference was observed between them in terms of their physical activity level.

Table 5.2.11: Number of normal weight and obese subjects showing association of BMI with physical activity level

	Normal wt (N = 30)	Obese N = 60	$\chi 2$ value
Sedentary	15 (50)	41 (68.3)	
Moderate to Heavy	15 (50)	19 (31.7)	2.86^{NS}

- *NS = non-significant*

5.2.12 Plasma LPS and plasma GLP-1 levels of normal weight and obese subjects

Significant difference ($p<.001$) in the LPS levels of normal weight and obese subjects was reported, where obese were detected with higher LPS values (Figure 5.2.3). Significant higher GLP-1 levels ($p < 0.05$) were reported in normal weight subject as compared to obese subjects (Table 5.2.12) (Figure 5.2.4).

Table 5.2.12: Plasma LPS and plasma GLP-1 levels of normal weight and obese subjects

Parameters	Normal wt (N=20) Mean±SD	Obese (N = 20) Mean±SD	't' values
Plasma LPS (pg/ml)	18.29 ± 4.70	24.46 ± 2.71	**5.08*** **
Plasma GLP-1 (pmol/l)	3.68 ± 2.52	1.85 ± 1.00	**3.01***

- *NS = non-significant, significantly different from the other group at *p<0.05, ***p<0.001.*

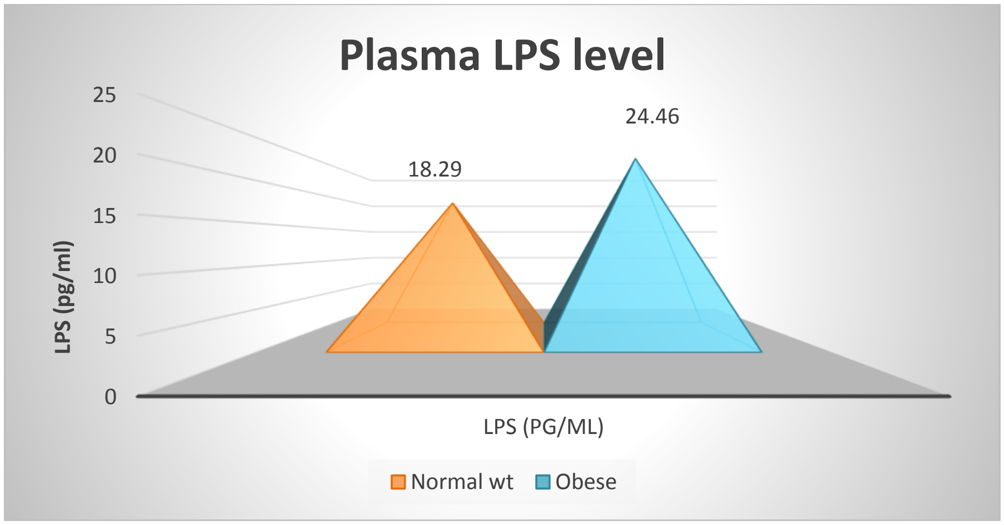


Figure 5.2.3: Plasma LPS levels of normal weight and obese subjects

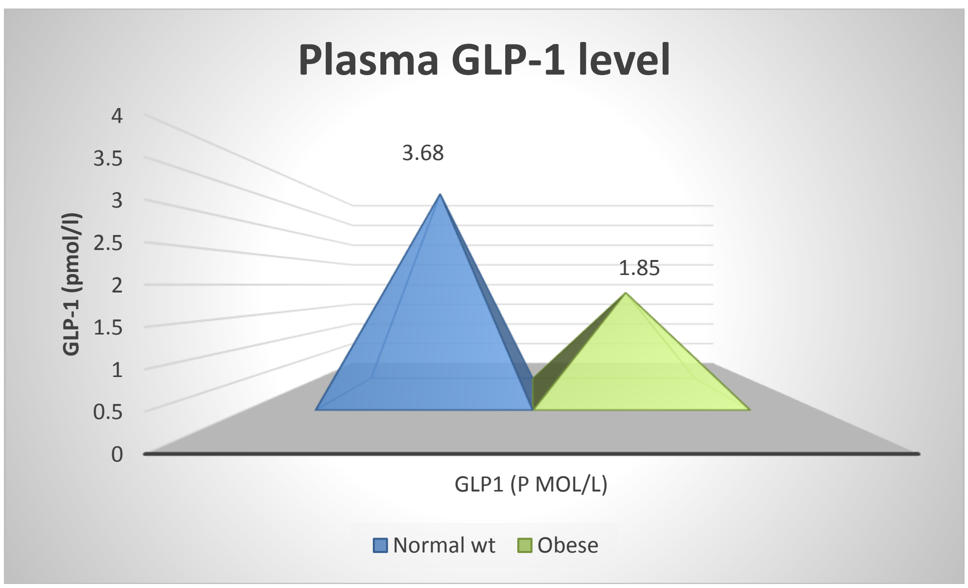


Figure 5.2.4: Plasma GLP-1 levels of normal weight and obese subjects

5.2.13 Mean log values (cfu/g) for microbial parameters in fecal sample of normal weight and obese subjects

As seen in Table 5.2.13 normal weight subjects had significantly better colonization of good bacteria i.e. *LAB* and *Bifidobacteria* whereas lower Enteric pathogen count was observed when compared to obese subjects ($p < 0.001$) (Figure 5.2.5).

Table 5.2.13: Mean log values (cfu/g) for microbial parameters in fecal samples of normal weight and obese subjects

Parameters	Normal weight (N=30) (mean±SD)	Obese (N=60) (mean±SD)	't' values
LAB (log_{10}cfu/g)	8.04 ± 2.28	6.87 ± 1.04	**2.67***
Bifido (log_{10}cfu/g)	8.65 ± 2.87	7.10 ± 1.03	**2.86***
Enteric *(log_{10}cfu/g)*	4.15 ± 1.17	5.04 ± 1.05	**3.63*****

- *NS- Non significant, significantly different from the other group at *p<0.05, **p<0.01, ***p<0.001*

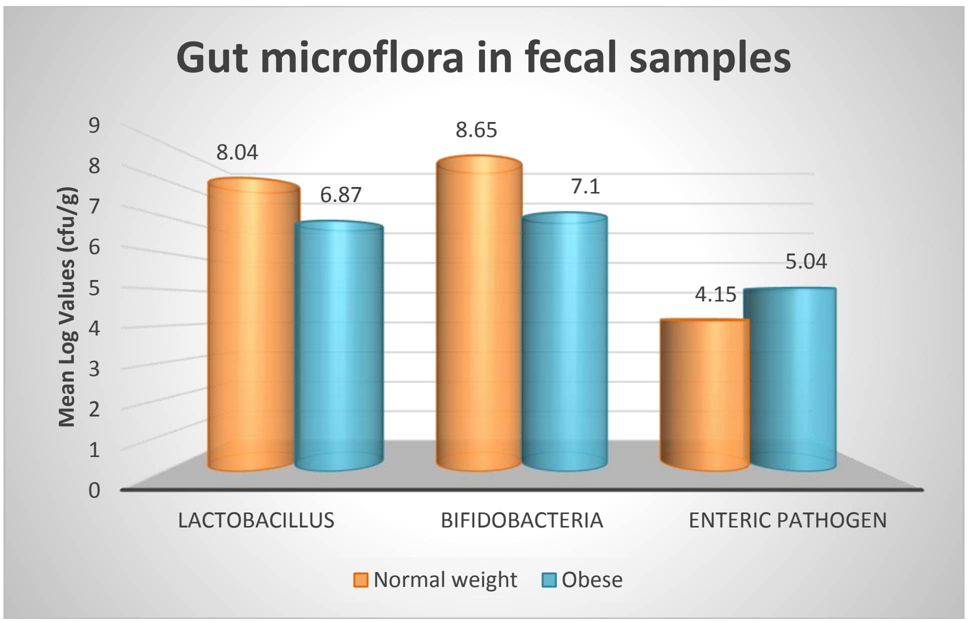


Figure 5.2.5: Mean log values (cfu/g) for microbial parameters in fecal samples of normal weight and obese subjects

5.2.14 Medical problems experienced by normal weight and obese subjects

Table 5.2.14 reveals medical history of obese and normal weight subjects. No significant difference for the occurrence of most of the diseases was reported among both the groups. However, higher percent of obese subjects were reported to have GI problems such as, abdominal pain, constipation and flatulence.

Table 5.2.14: Number of normal weight and obese subjects with medical problems

	Medical problems		Normal wt N = 30	Obese N = 60	χ2 value	Odds ratio
Dental problem	**Gum disease**	Yes	3 (10)	3 (5)	0.80^{NS}	0.47 (0.07-2.9)
		No	27 (90)	57 (95)		
	Cavities	Yes	3 (10)	7 (12)	0.05^{NS}	1.18 (0.2-6.0)
		No	27 (90)	57 (88)		
GI problem	**Nausea**	Yes	1 (3)	2 (3)	.01^{NS}	1.00 (0.07-30.4)
		No	29 (97)	58 (97)		
	Heart burn	Yes	4 (13)	6 (10)	0.22 ^{NS}	0.72 (0.1-2.7)
		No	26 (87)	54 (90)		
	Abdominal pain	Yes	1 (3)	4 (6)	0.42^{NS}	2.07 (0.2-19.3)
		No	29 (97)	57 (94)		
	Diarrhea	Yes	0 (0)	5 (8)	2.64^{NS}	----
		No	30 (100)	55 (92)		
	Dysentery	Yes	0 (0)	0 (0)	-	----
		No	30 (100)	60 (100)		
	Constipation	Yes	1 (3)	8 (13)	2.22^{NS}	4.46 (0.5-37.4)
		No	29 (97)	52 (87)		
	Flatulence	Yes	2 (7)	7 (12)	0.56^{NS}	1.84 (0.3-9.5)
		No	28 (93)	53 (88)		
Locomotor problem	**Osteoporosis**	Yes	0 (0)	0 (100)	-	----
		No	30 (100)	60 (0)		
	Osteoarthritis	Yes	0 (0)	2 (3)	1.02^{NS}	----
		No	30 (100)	58 (97)		

- *Figures in parenthesis represent percent of subjects; NS = non-significant*

5.2.15 Past history of onset of obesity among obese subjects

As seen in Table 5.2.15, 80% of the obese subjects were reported to have obesity in the past 10 years or less. Only 10% were reported to have obesity since past 15 years.

Table 5.2.15: Number of obese subjects with duration of obesity

Category	Obese subjects (N=60)
Obesity	
1-5 y	33 (55)
>5-10 y	15 (25)
>10-15 y	9 (15)
>15 y	3 (5)

- *Numbers in parenthesis indicate percentage*

Association of life style factors of subjects with Anthropometric, hunger, satiety, biochemical, microbial and dietary parameters

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

A comparison was done to assess whether family history for various NCD's impacted the anthropometric parameters, gut incretin (GLP-1) and gut microflora in fecal samples (Table 5.2.16). Results showed obese subjects without family history of obesity had comparatively lower BMI as compared to those with family history of obesity. Also the family history of obesity significantly impacted the levels of LPS ($p<0.05$) as the subjects without family history had lower levels of LPS as compared to the obese subjects with family history of NCD's. Although we can see trend of increased beneficial bacteria in the subjects without family history of obesity as compared to those with family history of obesity, this was not statistically significant.

5.2.17 Anthropometric, biochemical, microbial and dietary profile of the obese subjects based on BMI (Kg/m^2)

As can be seen from Table 5.2.17 obese subjects with higher BMI had significant higher levels of LPS ($p < 0.01$) as compared to the obese subject with less than 27 BMI.

Also, data from the diet profile shows that obese subject with higher BMI (>27 Kg/m^2) had significant higher intake of energy ($p < 0.01$) and carbohydrate ($p < 0.05$) as compared to obese subjects with lower BMI. Significant higher intake of protein was also reported among the obese subjects with BMI<27.

Table 5.2.16: Anthropometric, biochemical, microbial profile of the obese subjects based on family history of obesity

Parameters	WFH (n=29)	WoFH (n=31)	't' values
Wt (kg)	80.64 ± 6.10	78.01 ± 5.14	1.80^{NS}
BMI (kg/m²)	27.85 ± 1.47	26.82 ± 1.34	**2.82***
WC (cm)	98.28 ± 4.30	98.48 ± 4.05	0.19^{NS}
WHR	0.95 ± 0.03	0.94 ± 0.02	0.75^{NS}
% body fat	28.40 ± 1.67	28.35 ± 2.01	0.12^{NS}
GLP-1 (pmol/l)	1.63 ± 1.25	2.07 ± 0.69	0.96^{NS}
LPS (pg/ml)	25.65 ± 2.82	23.28 ± 2.10	**2.14***
LAB(log_{10}cfu/g))	6.73 ± 0.95	6.99 ± 1.12	0.98^{NS}
Bifidobacteria (log_{10}cfu/g)	6.97 ± 0.96	7.22 ± 1.10	0.93^{NS}
Enteric pathogen *(log_{10}cfu/g)*	5.19 ± 0.98	4.90 ± 1.11	1.03^{NS}

- *WFH- With family history, WoFH- Without family history, NS = non-significant, Significantly different from the other group at *p<0.05.*

Table 5.2.17: Anthropometric, biochemical, microbial and dietary profile of the obese subjects based on BMI

Parameters	BMI < 27 (n=22)	BMI >27 (n=28)	't' values
GLP-1 (pmol/l)	2.44 ± 0.58	1.36 ± 1.03	**2.78***
LPS (pg/ml)	22.49 ± 0.56	26.07 ± 2.70	**3.88****
LAB (log_{10}cfu/g)	7.07 ± 1.11	6.72 ± 0.98	1.27^{NS}
Bifido (log_{10}cfu/g)	7.18 ± 1.00	7.04 ± 1.06	0.53^{NS}
Enteric *(log_{10}cfu/g)*	4.97 ± 1.03	5.09 ± 1.08	0.46^{NS}
Energy (kcal)	2208.35±280.06	2517.62 ± 357.47	**3.60****
Protein (g)	61.33 ± 4.85	47.98 ± 7.30	**2.78***
CHO(g)	339.71 ± 50.01	363.36 ± 36.03	**2.13***
Fat (g)	80.99 ± 9.49	85.56 ± 16.59	1.23^{NS}
Total dietary fiber (g)	15.17 ± 4.75	15.81 ± 2.49	0.43^{NS}
Insoluble fiber (g)	11.46 ± 3.78	11.88 ± 4.80	0.36^{NS}
Soluble fiber (g)	3.70 ± 1.20	3.88 ± 1.60	0.49^{NS}
Crude fiber (g)	6.41 ± 1.62	7.19 ± 2.49	1.37^{NS}

- *Significantly different from the other group at *p<0.05, **p<0.01.*

5.2.18 Anthropometric, biochemical and microbial profile of the subjects based on alcohol intake

Data on the biochemical and microbial profile of the subject based on their alcohol intake (Table 5.2.18) showed no significant difference in the anthropometric parameters among the obese subjects with or without alcohol intake. Microbial data collected from their fecal samples revealed that the group of obese subjects which consumed alcohol had significant less colonization of beneficial bacteria i.e. *lactic acid bacteria* and *Bifidobacteria* (6.68 and 6.62 respectively) and more Enteric pathogen i.e. (6.06) as compared to obese subjects without alcohol consumption. Also significant higher GLP-1 value (2.14) and lower LPS levels (23.56) are reported among obese subjects with no alcohol consumption.

Table 5.2.18: Anthropometric, biochemical and microbial profile of the subjects based on alcohol intake

Parameters	Group A (n= 14)	Group B (n= 46)	't' values
Wt (kg)	81.29 ± 5.89	78.67 ± 4.62	1.50 ^{NS}
BMI (kg/m^2)	27.90 ± 1.57	27.13 ± 1.83	1.72 ^{NS}
WC (cm)	98.79 ± 4.96	98.26 ± 3.90	0.41 ^{NS}
WHR	0.94 ± 0.03	0.94 ± 0.06	0.11 ^{NS}
% body fat	28.61 ± 1.79	28.30 ± 1.86	0.55 ^{NS}
GLP-1 (pmol/l)	0.96 ± 0.89	2.14 ± 0.97	**2.60***
LPS (pg/ml)	27.14 ± 1.89	23.56 ± 2.34	**3.07****
LAB (log$_{10}$cfu/g)	6.68 ± 1.03	6.92 ± 2.56	0.75 ^{NS}
Bifido (log$_{10}$cfu/g)	6.62 ± 0.28	7.25 ± 1.13	**3.45****
Enteric *(log$_{10}$cfu/g)*	6.06 ± 0.56	4.72 ± 1.82	**6.43*****

- *Significantly different from the other group at *p<0.05, **p<0.01, ***p<0.001; Group A= Alcohol; Group B= No Alcohol*

5.2.19 Anthropometric, biochemical and microbial profile of the subjects based on personal habit of tobacco chewing

Table 5.2.19 depicts that obese subject with person habit of tobacco had no significant difference with obese subjects without personal habit of tobacco chewing in terms of anthropometric, biochemical and microbial data.

Table 5.2.19: Anthropometric, biochemical and microbial profile of the subjects based on personal habit of tobacco chewing

Parameters	Group A (n= 23)	Group B (n= 37)	't' values
Wt (kg)	79.36 ± 6.07	79.01 ± 5.60	0.79 NS
BMI (kg/m²)	27.69 ± 1.30	27.08 ± 2.15	1.57 NS
WC (cm)	97.43 ± 4.32	98.97 ± 3.96	1.41 NS
WHR	0.93 ± 0.02	0.94 ± 0.67	1.79 NS
% body fat	28.57 ± 3.54	28.25 ± 2.01	0.66 NS
GLP-1 (pmol/l)	1.95 ± 1.27	1.77 ± 0.83	0.39 NS
LPS (pg/ml)	24.53 ± 3.09	24.41 ± 2.55	0.10 NS
LAB (log_{10}cfu/g)	6.61 ± 1.08	7.02 ± 1.13	1.60 NS
Bifido (log_{10}cfu/g)	6.85 ± 1.00	7.25 ± 2.02	1.49 NS
Enteric *(log_{10}cfu/g)*	4.99 ± 1.06	5.07 ± 1.89	0.30 NS

- *Significantly different from the other group at *p<0.05, **p<0.01; Group A= Tobacco; Group B= No Tobacco*

5.2.20 Anthropometric, biochemical and microbial profile of the subjects based on personal habit of cigarette smoking

Cigarette smoking was seen to be significantly associated with increased colonization of Enteric pathogen as can be seen in Table 5.2.20 where significant difference was reported among smokers and nonsmokers (p<0.01).

Table 5.2.20: Anthropometric, biochemical and microbial profile of the subjects based on personal habit of cigarette smoking

Parameters	Group A (n= 20)	Group B (n= 40)	't' values
Wt (kg)	80.06 ± 6.25	78.89 ± 5.50	0.74 NS
BMI (kg/m^2)	27.59 ± 1.62	27.18 ± 1.80	1.02 NS
WC (cm)	98.45 ± 4.69	98.35 ± 3.89	0.08 NS
WHR	0.94 ± 0.89	0.94 ± 0.23	0.31 NS
% body fat	28.32 ± 1.75	28.40 ± 2.48	0.17 NS
GLP-1 (pmol/l)	1.64 ± 0.74	2.05 ± 1.29	0.92 NS
LPS (pg/ml)	24.61 ± 2.53	24.31 ± 3.16	0.24 NS
LAB(log$_{10}$cfu/g)	6.96 ± 1.16	6.81 ± 0.98	0.51 NS
Bifido (log$_{10}$cfu/g)	6.85 ± 1.69	7.22 ± 2.15	1.30 NS
Enteric *(log$_{10}$cfu/g)*	5.62 ± 0.94	4.75 ± 1.00	**3.26****

- *Significantly different from the other group at *p<0.05, **p<0.01; Group A= cigarette; Group B= No cigarette*

5.2.21 Anthropometric, biochemical and microbial profile of the subjects based on intake of aerated drinks

Table 5.2.21 depicts that higher consumption of aerated drinks was positively associated with higher body weight, BMI ($p<0.001$) and LPS ($p<0.01$) values and negatively associated with of GLP-1 as compared to the group where consumption was less for aerated drinks ($p<0.01$).

Table 5.2.21: Anthropometric, biochemical and microbial profile of the subjects based on intake of aerated drinks

Parameters	Group A (n= 43)	Group B (n= 17)	't' values
Wt (kg)	80.99 ± 5.12	74.95 ± 4.98	**4.14*****
BMI (kg/m^2)	27.86 ± 1.38	25.94 ± 2.17	**7.66*****
WC (cm)	98.63 ± 4.18	97.76 ± 3.89	0.72 NS
WHR	0.94 ±0.13	0.93 ± 0.35	1.14 NS
% body fat	28.90 ± 3.68	28.23 2.16	1.20 NS
GLP-1 (pmol/l)	1.35 ± 1.00	2.58 ± 0.42	**3.30****
LPS (pg/ml)	25.71 ±4.86.	22.58 ± 2.52	**3.69****
LAB (log$_{10}$cfu/g)	6.73 ± 2.00	7.21 ± 1.07	1.62 NS
Bifido (log$_{10}$cfu/g)	7.01 ± 1.08	7.35 ± 2.13	1.15 NS
Enteric *(log$_{10}$cfu/g)*	5.19 ± 1.02	4.64 ±1.56	1.88 NS

- *Significantly different from the other group at *p<0.05, **p<0.01; Group A= aerated drinks; Group B= No aerated drink*

5.2.22 Anthropometric, biochemical and microbial profile of the obese subjects based on dietary fiber intake

Obese subjects with more than 15 gm/day of total dietary fiber intake had lesser weight ($p < 0.05$) BMI, better GLP 1 value (2.63) ($p < 0.0$), ($p<0.01$) and less LPS level ($p < 0.05$), also high fiber intake positively correlated with colonization of *Bifidobacteria* ($p < 0.05$) and negatively correlated with Enteric pathogen count ($p < 0.05$) (Table 5.2.22).

Table 5.2.22: Anthropometric, biochemical and microbial profile of the obese subjects based on dietary fiber intake

Parameters	Dietary fiber <15 N= 28	Dietary fiber >15 N = 32	't' values
Weight (kg)	80.85 ± 5.69	77.90 ± 5.50	**2.04***
BMI (kg/m^2)	27.86 ± 1.53	26.83 ± 1.28	**2.83***
WC (cm)	97.75 ± 4.27	98.94 ± 4.00	1.11 ^{NS}
WHR	0.94 ± 0.02	0.95 ± 0.02	1.75 ^{NS}
% body fat	28.30 ± 1.81	28.44 ± 1.89	0.30 ^{NS}
GLP-1 (pmol/l)	1.33 ± 0.73	2.63 ± 0.86	**3.66****
LPS(pg/ml)	25.64 ± 2.81	22.70 ± 1.73	**2.77***
LAB (log_{10}cfu/g)	6.73 ± 1.07	6.98 ± 1.01	0.97 ^{NS}
Bifido (log_{10}cfu/g)	6.82 ± 0.92	7.35 ± 1.07	**2.03***
Enteric *(log_{10}cfu/g)*	5.36 ± 0.95	4.76 ± 1.07	**2.27***

- *NS = non-significant, significantly different from the other group at *p<0.05, **p<0.01*

5.2.23 Anthropometric, biochemical and microbial profile of the obese subjects based on insoluble fiber intake

Table 5.2.23 depicts that obese subjects with >11gm/day consumption of insoluble fibre had significantly lower BMI ($p < 0.05$), *LPS* ($p < 0.01$), Enteric pathogen ($p < 0.05$) and higher GLP 1 levels ($p < 0.01$) along with better colonization of *Bifidobacteria* ($p < 0.05$) as compared to the obese subject who consumed less than 11 g/day insoluble fibre.

Table 5.2.23: Anthropometric, biochemical and microbial profile of the obese subjects based on insoluble fiber intake

Parameters	Insoluble fiber <11 N = 26	Insoluble fiber >11 N = 34	't' values
Weight (kg)	80.57 ± 5.76	78.29 ± 5.59	1.54 NS
BMI (kg/m²)	27.80 ± 1.54	26.94 ± 1.34	**2.28***
WC (cm)	97.92 ± 4.27	98.74 ± 4.05	0.75 NS
WHR	0.94 ± 0.02	0.95 ± 0.02	1.50 NS
% body fat	28.41 ± 1.82	28.34 ± 1.87	0.14 NS
GLP-1 (pmol/l)	1.33 ± 0.73	2.63 ± 0.86	**3.66****
LPS (pg/ml)	25.64 ± 2.81	22.69 ± 1.23	**3.19****
LAB (log$_{10}$cfu/g)	6.62 ± 1.03	7.06 ± 1.02	1.67 NS
Bifido (log$_{10}$cfu/g)	6.76 ± 0.88	7.36 ± 1.06	**2.35***
Enteric *(log$_{10}$cfu/g)*	5.37 ± 0.98	4.78 ± 1.05	**2.19***

- *NS = non-significant, significantly different from the other group at *p<0.05, **p<0.01*

5.2.24 Anthropometric, biochemical and microbial profile of the obese subjects based on soluble fiber intake

Table 5.2.24 depicts that higher intake (more than 4 g/day) of soluble fiber had among obese subjects shown better GLP-1 values ($p < 0.01$) and less LPS levels ($p < 0.01$), better colonization of *Bifidobacteria* 7.50 ($p < 0.05$) and less Enteric pathogen ($P < 0.05$) as compared to the obese subject where consumption of soluble fiber was less than 4 gm/day.

Table 5.2.24: Anthropometric, biochemical and microbial profile of the obese subjects based on soluble fiber intake

Parameters	Soluble fiber < 4 N = 35	Soluble fiber > 4 N = 25	't' values
Weight (kg)	80.45 ± 5.52	77.64 ± 5.74	1.90 NS
BMI (kg/m²)	27.58 ± 1.46	26.95 ± 1.46	1.63 NS
WC (cm)	97.82 ± 4.09	99.16 ± 4.16	1.23 NS
WHR	0.94 ± 0.02	0.95 ± 0.03	1.31 NS
% body fat	28.57 ± 2.15	28.10 ± 1.27	1.07 NS
GLP-1 (pmol/l)	1.39 ± 0.83	2.69 ± 0.74	**3.44****
LPS (pg/ml)	25.66 ± 2.59	22.25 ± 0.92	**4.25****
LAB (log$_{10}$cfu/g)	6.72 ± 1.05	7.07 ± 1.00	1.33 NS
Bifido (log$_{10}$cfu/g)	6.82 ± 0.86	7.50 ± 1.3	**2.54***
Enteric *(log$_{10}$cfu/g)*	5.33 ± 0.90	4.63 ± 1.13	**2.71***

- *NS = non-significant, significantly different from the other group at *p<0.05, **p<0.01*

5.2.25 Anthropometric, biochemical and microbial profile of the obese subjects based on Crude fiber intake

Obese subject with >7g/day consumption of crude fiber showed significant less LPS levels, i.e. 23.34 pg/ml ($p < 0.05$) as compared to the obese subject where the consumption of crude fiber was less than 7gm/day (i.e. 25.83 pg/ml) as can be seen in Table 5.2.25.

Table 5.2.25: Anthropometric, biochemical and microbial profile of the obese subjects based on Crude fiber intake

Parameters	Crude fiber < 7 N= 33	Crude fiber > 7 N= 27	't' values
Weight (kg)	79.56 ± 6.15	78.94 ± 5.28	0.40 ^{NS}
BMI (kg/m^2)	27.52 ± 1.46	27.05 ± 1.49	1.22 ^{NS}
WC(cm)	97.85 ± 4.34	99.03 ± 3.85	1.10 ^{NS}
WHR	0.94 ± 0.02	0.95 ± 0.02	0.90 ^{NS}
% body fat	1.52 ± 0.95	28.43 ± 1.84	0.19 ^{NS}
GLP-1 (pmol/l)	25.83 ± 2.73	2.11 ± 1.00	1.33 ^{NS}
LPS (pg/ml)	25.83 ± 2.73	23.34 ± 2.21	**2.24***
LAB (log$_{10}$cfu/g)	6.83 ± 1.10	6.92 ± 0.98	0.31 ^{NS}
Bifido (log$_{10}$cfu/g)	6.96 ± 1.06	7.28 ± 0.98	1.17 ^{NS}
Enteric *(log$_{10}$cfu/g)*	5.00 ± 1.07	5.08 ± 1.05	0.25 ^{NS}

- *NS = non-significant, significantly different from the other group at *p<0.05*

5.2.26 Anthropometric, biochemical and microbial profile of the subjects based on energy intake of obese

Table 5.2.26 depicts that higher intake of energy (>2400 Kcal/day) was associated with higher LPS levels ($p < 0.001$), lower GLP-1 values ($p < 0.01$) and more Enteric pathogen count ($p < 0.05$) as compared to obese subjects where energy consumption was less than 2400 Kcal/day.

Table 5.2.26: Anthropometric, biochemical and microbial profile of the subjects based on energy intake of obese

Parameters	Energy< 2400 N = 29	Energy> 2400 N= 31	't' values
Weight (kg)	77.99 ± 4.44	80.48 ± 6.57	1.72^{NS}
BMI (kg/m^2)	26.51 ± 1.21	28.07 ± 1.32	4.76*
WC (cm)	98.93 ± 3.69	97.87 ± 4.51	0.99^{NS}
WHR	0.944 ± 0.03	0.94 ± 0.02	0.45^{NS}
% body fat	28.81 ± 1.81	27.97 ± 1.79	1.80^{NS}
GLP-1 (pmol/l)	2.7 ± 18.18	1.28 ± 0.69	**4.27****
LPS (pg/ml)	22.21 ± 0.84	25.96 ± 2.46	**4.87*****
LAB (log$_{10}$cfu/g)	7.06 ± 1.07	6.69 ± 0.99	1.38^{NS}
Bifido (log$_{10}$cfu/g)	7.42 ± 1.03	6.81 ± 0.95	**2.40***
Enteric *(log$_{10}$cfu/g)*	4.80 ± 0.98	5.26 ± 1.09	1.69^{NS}

- *NS = non-significant, Significantly different from the other group at *p<0.05, **p<0.01.***p<0.001*

5.2.27 Anthropometric, biochemical and microbial profile of the subjects based on fat intake of obese

Higher (>80 gm/day) of total fat intake (Table 5.2.27) is associated with higher BMI ($P < 0.05$) as compared to the obese group which consume fat less than 80 gm/day.

5.2.28 Anthropometric, biochemical and microbial profile of the subjects based on carbohydrate intake of obese

Data from Table 5.2.28 reveals that higher intake of carbohydrates (>360 gm/day) among obese subjects was associated with higher BMI ($P < 0.01$), higher LPS levels ($p < 0.01$), lower GLP-1 values ($p < 0.05$) and lower hunger scores ($p < 0.05$) as compared to the obese subject where consumption of carbohydrates was less than 360 gm/day.

Table 5.2.27: Anthropometric, biochemical and microbial profile of the subjects based on fat intake of obese

Parameters	Fat < 80 N = 31	Fat > 80 N=29	't' values
Weight (kg)	78.94 ± 4.92	79.64 ± 6.57	0.46 NS
BMI (kg/m²)	26.86 ± 1.41	27.81 ± 1.42	**2.61***
% body fat	28.57 ± 1.87	28.17 ± 1.81	0.99 NS
GLP-1 (pmol/l)	2.19 ± 1.05	1.50 ± 0.87	1.59 NS
LPS (pg/ml)	23.68 ± 2.43	25.25 ± 2.86	1.32 NS
LAB (log$_{10}$cfu/g)	6.97 ± 1.02	6.76 ± 1.07	0.80 NS
Bifido (log$_{10}$cfu/g)	7.31 ± 1.07	6.88 ± 0.96	1.61 NS
Enteric *(log$_{10}$cfu/g)*	4.86 ± 1.03	5.23 ± 1.07	1.38 NS

- *NS = non-significant, significantly different from the other group at *p<0.05*

Table 5.2.28: Anthropometric, biochemical and microbial profile of the subjects based on carbohydrate intake of obese

Parameters	CHO < 360 N = 32	CHO > 360 N = 28	't' values
Weight (kg)	78.24 4.26	80.47 ± 6.95	1.47 NS
BMI (kg/m²)	26.72 ± 1.19	27.99 ± 1.51	**3.64****
WC (cm)	98.19 ± 4.00	98.61 ± 4.35	0.39 NS
WHR	0.94 ± 0.03	0.94 ± 0.02	0.18 NS
% body fat	28.70 ± 1.62	28.01 ± 2.03	1.46 NS
GLP-1 (pmol/l)	2.41 ± 0.92	1.29 ± 0.77	**2.93***
LPS (pg/ml)	22.96 ± 1.74	25.97 ± 2.72	**2.95***
LAB (log$_{10}$cfu/g)	6.94 ± 1.09	6.78 ± 0.98	0.58 NS
Bifido (log$_{10}$cfu/g)	7.21 ± 1.04	6.98 ± 1.02	0.86 NS
Enteric *(log$_{10}$cfu/g)*	4.81 ± 0.99	5.31 ± 1.07	1.87 NS

- *NS = non-significant, Significantly different from the other group at *p<0.05, **p<0.01*

5.2.29 Anthropometric, biochemical and microbial profile based on eating pattern of obese subjects

Table 5.2.29 depicts better colonization ($p < 0.05$) of *LAB* among obese subject who consume outside food less frequently. No significant difference was reported for other anthropometric biochemical or microbial profiles.

Table 5.2.29: Anthropometric, biochemical and microbial profile based on eating pattern of obese subjects

Parameters	Frequently	Less frequently	't' values
Wt (kg)	79.89 ± 5.64	78.99 ± 5.83	0.56 NS
BMI (kg/m^2)	27.39 ± 1.46	27.28 ± 1.51	0.27 NS
WC (cm)	99.21 ± 3.97	98.0 ± 4.21	1.06 NS
WHR	0.95 ± 0.02	0.94 ± 0.03	1.61 NS
% body fat	28.69 ± 1.95	28.23 ± 1.79	0.92 NS
GLP-1 (pmol/l)	1.69 ± 1.48	1.92 ± 0.79	0.45 NS
LPS (pg/ml)	25.19 ± 3.76	24.15 ± 2.21	0.63 NS
LAB (log$_{10}$cfu/g)	6.52 ± 0.72	7.03 ± 1.13	**2.10***
Bifido (log$_{10}$cfu/g)	7.06 ± 1.18	7.13 ± 0.97	0.24 NS
Enteric *(log$_{10}$cfu/g)*	4.87 ± 1.22	5.12 ± 0.98	0.84 NS

- *Significantly different from the other group at *p<0.05*

5.2.30 Anthropometric, biochemical and microbial profile of the subjects based on physical activity pattern of obese subjects

When comparison was made among the obese subjects with respect to physical activity (higher to moderate as compared to sedentary) higher GLP-1, *LAB*, *Bifidobacteria* and lower LPS, Enteric pathogen ($P < 0.05$) was reported among obese subjects with moderate physical activity as compared to obese subjects with no physical activity (Table 5.2.30).

Table 5.2.30: Anthropometric, biochemical and microbial profile of the subjects based on physical activity pattern of obese subjects

Parameters	Sedentary (n=41)	Moderate (n=19)	‘t’ values
Wt (kg)	79.5 ± 6.09	78.81 ± 5.02	0.43 ^{NS}
BMI (kg/m^2)	27.30 ± 1.47	27.35 ± 1.55	0.10 ^{NS}
WC (cm)	98.51 ± 4.23	98.11 ± 4.03	0.35^{NS}
WHR	0.94 ± 0.02	0.94 ± 0.02	0.40 ^{NS}
% body fat	28.31 ± 1.92	28.52 ± 1.69	0.40 ^{NS}
GLP-1 (pmol/l)	1.39 ± 0.71	2.91 ± 0.77	**4.29*** **
LPS (pg/ml)	25.47 ± 2.59	22.12 ± 0.94	**4.23** **
LAB (log$_{10}$cfu/g)	6.66 ± 1.02	7.32 ± 0.96	**2.37***
Bifido (log$_{10}$cfu/g)	6.87 ± 0.95	7.61 ± 1.03	**2.72***
Enteric *(log$_{10}$cfu/g)*	5.29 ± 1.08	4.50 ± 0.77	**2.85***

- *NS = non-significant, Significantly different from the other group at *p<0.05, **p<0.01, ***p<0.001*

5.2.31 Anthropometric, biochemical, microbial and dietary profile of the subjects based on LPS levels of obese subjects

Table 5.2.31 depicts obese subjects with higher LPS values had higher BMI, lower GLP-1 levels ($p < 0.05$), higher Enteric pathogen count ($p < 0.001$) and higher feeling of hunger ($p < 0.01$) as compared to obese subjects with lower level of LPS levels (less than 23 pg/ml).

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

Higher GLP-1 levels (>1.5 pmol/L) were significantly related to reduce weight BMI, lower LPS levels, followed by higher *LAB*, *Bifidobacteria* count ($p < 0.05$), less colonization of Enteric pathogen, lower feeling of hunger ($p < 0.05$). Higher GLP-1 levels were also associated with higher intake of dietary fiber (total, insoluble, soluble, crude) (Table 5.2.32).

Table 5.2.31: Anthropometric, biochemical, microbial and dietary profile of the subjects based on LPS levels of obese subjects

Parameters	LPS<23 (n=9)	LPS ≥23 (n=11)	't' values
Weight (kg)	76.8 ± 4.31	80.42 ± 6.10	1.50 NS
BMI (kg/m²)	26.36 ± 0.87	27.92 ± 1.27	**3.11***
WC (cm)	98.44 ± 2.79	98.64 ± 5.20	0.10 NS
WHR	0.94 ± 0.03	0.95 ± 0.03	0.36 NS
% body fat	28.26 ± 1.74	28.47 ± 2.05	0.25 NS
GLP-1 (pmol/l)	2.59 ± 0.86	1.24 ± 0.64	**4.05****
LAB (log₁₀cfu/g)	7.12 ± 1.02	6.62 ± 1.05	1.08 NS
Bifido (log₁₀cfu/g)	7.40 ± 1.26	6.83 ± 0.80	1.18 NS
Enteric *(log₁₀cfu/g)*	4.16 ± 0.82	5.81 ± 0.61	**5.17*****
Fat (g)	77.84 ± 12.41	87.22 ± 18.06	1.32 NS
Total dietary fiber (g)	15.66 ± 5.73	11.45 ± 4.25	1.89 NS
Insoluble fiber (g)	11.54 ± 4.51	8.40 ± 3.08	1.84 NS
Soluble fiber (g)	4.12 ± 1.39	3.05 ± 1.24	1.82 NS
Crude fiber (g)	8.06 ± 1.84	6.69 ± 2.21	1.48 NS

- *Significantly different from the other group at *p<0.05, **p<0.01, ***p<0.001*

Table 5.2.32: Anthropometric, biochemical, microbial and dietary profile of the subjects based on GLP-1 levels of obese subjects

Parameters	GLP-1≤1.5 (n=10)	GLP-1≥1.5 (n=10)	't' values
Weight (kg)	81.8 ± 4.87	75.78 ± 4.59	**2.84***
BMI (kg/m²)	28.13 ± 1.07	26.31 ± 0.90	**4.10****
WC (cm)	99.4 ± 5.23	97.7 ± 2.83	0.90 NS
WHR	0.95 ± 0.03	0.94 ± 0.03	0.46 NS
% body fat	28.47 ± 2.19	28.28 ± 1.61	0.22 NS
LPS (pg/ml)	26.59 ± 2.19	22.34 ± 0.79	**5.78*****
LAB (log₁₀cfu/g)	6.36 ± 0.97	7.32 ± 0.91	**2.29***
Bifido (log₁₀cfu/g)	6.50 ± 0.39	7.67 ± 1.18	**2.96***
Enteric *(log₁₀cfu/g)*	5.86 ± 0.58	4.28 ± 0.89	**4.69*****
Total mean hunger score	3.55 ± 0.64	4.3 ± 0.61	**2.68***
Total mean satiety score	5.85 ± 0.47	6.15 ± 0.57	1.28 NS
Fat (g)	86.20 ± 18.73	79.81 ± 13.20	0.88 NS
Total dietary fiber (g)	10.36 ± 3.50	16.34 ± 5.18	**3.02***
Insoluble fiber (g)	7.69 ± 2.69	11.93 ± 4.11	**2.73***
Soluble fiber (g)	2.69 ± 0.87	4.40 ± 1.28	**3.53****
Crude fiber (g)	6.20 ± 1.83	8.42 ± 1.85	2.69*

- *NS- Non significant Significantly different from the other group at *p<0.05, **p<0.01, ***p<0.001*

5.2.33 Anthropometric, biochemical profile and dietary fiber of the obese subjects based on *Bifidobacteria* counts

Among obese subjects, higher *Bifidobacteria* count (more than 6.5 cfu/gm) was found significantly associated to higher *LAB* count (p<0.001) as compared the obese subjects where *Bifidobacteria* count was less than 6.5 cfu/gm (Table 5.2.33).

Table 5.2.33: Anthropometric, biochemical profile and dietary fiber of the obese subjects based on *Bifidobacteria* counts

Parameters	*Bifidobacteria* ≤6.5 log10 CFU/g MEAN ± SD (n=18)	*Bifidobacteria* >6.5 log10 CFU/g MEAN ± SD (n=42)	't' values
Wt (kg)	77.75 ± 5.92	79.93 ± 5.59	1.36 NS
BMI (kg/m²)	27.25 ± 1.32	27.35 ± 1.56	0.22 NS
WC (cm)	97.83 ± 3.81	98.62 ± 4.29	0.67 NS
WHR	0.94 ± 0.02	0.95 ± 0.03	1.65 NS
% body fat	28.27 ± 1.53	28.42 ± 1.97	0.28 NS
GLP-1 (pmol/l)	1.56 ± 0.88	1.97 ± 1.06	0.84 NS
LPS (pg/ml)	25.17 ± 3.50	24.16 ± 2.38	0.76 NS
LAB (log_{10}cfu/g)	6.10 ± 0.57	7.20 ± 1.02	**5.33*** **
Enteric (log_{10}cfu/g)	5.20 ± 0.84	4.07 ± 1.14	0.88 NS

- *NS- Non significant, Significantly different from the other group at ***p<0.001*

5.2.34 Anthropometric, biochemical profile and dietary fiber of the obese subject based on *LAB (log_{10}cfu/ml)* counts

Table 5.2.34 depicted that higher colonization of *LAB* (more than 6.5 cfu/gm) among obese subjects was significantly correlated to lower LPS levels (p < 0.05), higher *Bifidobacteria* count (p < 0.001) and lower Enteric pathogen count (p < 0.001).

Table 5.2.34: Anthropometric, biochemical profile and dietary fiber of the obese subjects based on *LAB (LOG10CFU/ML)* counts

Parameters	*LAB(LOG10CFU/ML)* ≤6.5 log10 CFU/g MEAN ± SD (n=27)	*LAB(LOG10CFU/ML)* >6.5 log10 CFU/g MEAN ± SD (n=33)	't' values
Wt (kg)	80.74 ± 5.33	78.08 ± 5.85	1.82 NS
BMI (kg/m^2)	27.59 ± 1.46	27.09 ± 1.48	1.31 NS
WC (cm)	98.22 ± 4.38	98.52 ± 3.99	0.27 NS
WHR	0.94 ± 0.02	0.94 ± 0.03	0.50 NS
% body fat	28.05 ± 1.39	28.64 ± 2.12	1.25 NS
GLP-1 (pmol/l)	1.39 ± 0.84	2.22 ± 1.00	1.98 NS
LPS (pg/ml)	25.79 ± 2.96	23.38 ± 2.00	**2.17***
***Bifido* (log$_{10}$cfu/g)**	6.59 ± 0.90	7.52 ± 0.94	**3.93*****
***Enteric* (log$_{10}$cfu/g)**	5.58 ±0.80	4.60 ±1.07	**4.04*****

- *NS- Non significant, Significantly different from the other group at *p<0.05, ***p<0.001*

5.2.35 Anthropometric, biochemical profile and dietary fiber of the obese subjects based on Enteric pathogen counts

Data from Table 5.2.35 showed that higher colonization of Enteric pathogen had significant effect on GLP-1, LPS, *LAB*, and *Bifidobacteria* count. Obese subjects with higher Enteric pathogen count (>5 cfu/gm) were reported to have lower GLP-1 values ($p < 0.05$) higher levels of LPS ($p < 0.01$), lower *LAB*, *Bifidobacteria* count ($p < 0.05$).

5.2.36 Dental and GI problem of obese subjects according to establishment of *Bifidobacteria*

Table 5.2.36 shows that obese subjects with higher *Bifidobacteria* colonization experienced lesser GI problems (constipation and flatulence) ($p < 0.01$, $p < 0.05$).

Table 5.2.35: Anthropometric, biochemical profile and dietary fiber of the obese subjects based on Enteric pathogen counts

Parameters	Enteric pathogen ≤5 log10 CFU/g MEAN ± SD (n=27)	Enteric pathogen >5 log10 CFU/g MEAN ± SD (n=33)	't' values
Wt (kg)	79.29 ± 5.81	79.28 ± 6.76	0.04 NS
BMI (kg/m²)	27.01 ± 1.33	27.57 ± 1.57	1.46 NS
WC (cm)	98.70 ± 4.38	98.12 ± 3.98	0.54 NS
WHR	0.94 ± 0.03	0.94 ± 0.02	0.11 NS
% body fat	28.2 ± 1.67	28.52 ± 1.98	0.66 NS
GLP-1 (pmol/l)	2.60 ± 0.86	1.24 ± 0.64	**4.05****
LPS (pg/ml)	22.25 ± 0.81	26.27 ± 2.32	**5.37*****
LAB (log_{10}cfu/g)	7.18 ± 0.94	6.61 ± 1.06	**2.20***
Bifido (log_{10}cfu/g)	7.60 ± 1.11	6.69 ± 0.76	**3.62****

- *NS- Non significant, Significantly different from the other group at *p<0.05, **p<0.01, ***p<0.001*

Table 5.2.36: Number of obese subjects with dental and GI problem according to establishment of *Bifidobacteria*

	Disease	*Bifidobacteria* ≤ 6.5 (n=18)	*Bifidobacteria*> 6.5 (n=42)	χ2 value
Dental problem	**Gum disease**	2 (11.11)	1 (2.38)	2.02 NS
	cavities	3 (16.67)	4 (9.52)	0.62 NS
GI problem	**Nausea**	1 (5.56)	1 (2.38)	0.39 NS
	Heart burn	1 (5.56)	5 (11.90)	0.56 NS
	Abdominal pain	2 (11.11)	2 (4.76)	0.82 NS
	Diarrhea	3 (16.67)	2 (4.76)	2.34 NS
	Dysentery	0 (0)	0 (0)	---
	Constipation	6 (33.33)	2 (4.76)	**8.90****
	Flatulence	5 (27.78)	2 (4.76)	**6.48***

- *Figures in parenthesis represent percent of subjects; NS = non-significant, p < 0.05: *, p < 0.01: ***

5.2.37 Dental and GI problem of obese subjects according to establishment of *LAB*

With respect to colonization of *LAB* among obese subjects (Table 5.2.37), better colonization (>6.5 cfu/g) was significantly associated with better GI health (p < 0.01).

Table 5.2.37: Number of obese subjects with dental and GI problem according to establishment of *LAB (LOG_{10}CFU/ML)*

	Disease	*LAB(LOG_{10}CFU/ML)* ≤ 6.5 (n=27)	*LAB(LOG_{10}CFU/ML)*> 6.5 (n=33)	χ2 value
Dental problem	**Gum disease**	3 (11.11)	0 (0)	**3.86***
	cavities	5 (18.51)	2 (60.06)	2.24 NS
GI problem	**Nausea**	1 (3.70)	1 (3.03)	0.02 NS
	Heart burn	2 (7.40)	4 (12.12)	0.37 NS
	Abdominal pain	3 (11.11)	1 (3.03)	1.56 NS
	Diarrhea	5 (18.51)	0 (0)	6.67 NS
	Dysentery	0 (0)	0(0)	---
	Constipation	8 (29.67)	0(0)	**11.28****
	Flatulence	7 (25.92)	0(0)	**9.69****

- *Figures in parenthesis represent percent of subjects; NS = non-significant, p < 0.05: *, p < 0.01: ***

5.2.38 Dental and GI problem of obese subjects according to establishment of Enteric pathogen

Results from Table 5.2.38 reported that obese subjects with more establishment of Enteric pathogen had significantly more GI problems (diarrhea, constipation and flatulence) ($p < 0.05$).

5.2.39 Dental and GI problem of obese subjects according to LPS and GLP-1 levels

Levels of LPS and GLP-1 had no significant effect on dental and GI problems among obese subjects (Table 5.2.39, 5.2.40).

Table 5.2.38: Number of obese subjects with dental and GI problem according to establishment of Enteric pathogen

	Disease	Enteric pathogens ≤ 5 (n=27)	*Enteric pathogens*> 5 (n=33)	χ2 value
Dental problem	Gum disease	0(0)	3 (9.09)	2.58 NS
	cavities	2 (7.4)	5 (15.15)	0.86 NS
GI problem	Nausea	1 (3.70)	1 (3.03)	0.02 NS
	Heart burn	1 (3.70)	5 (15.15)	2.16 NS
	Abdominal pain	1 (3.70)	3 (9.09)	0.69 NS
	Diarrhea	0 (0)	5 (15.15)	**4.46***
	Dysentery	0(0)	0 (0)	---
	Constipation	0(0)	8 (24.24)	**7.55***
	Flatulence	0(0)	7 (21.21)	**6.48***

- *Figures in parenthesis represent percent of subjects; NS = non-significant, p < 0.05 **

Table 5.2.39: Number of obese subjects with dental and GI problem according to LPS levels

	Disease	LPS≤23 (n=9)	LPS>23 (n=11)	χ2 value
Dental problem	Gum disease	0 (0)	2 (18.18)	1.82 NS
	cavities	0 (0)	2 (18.18)	1.82 NS
GI problem	Nausea	0 (0)	2 (18.18)	1.82 NS
	Heart burn	0 (0)	2 (18.18)	1.82 NS
	Abdominal pain	0 (0)	1 (9.09)	0.86 NS
	Diarrhea	0 (0)	1 (9.09)	0.86 NS
	Dysentery	0 (0)	0 (0)	---
	Constipation	0 (0)	2 (18.18)	1.82 NS
	Flatulence	0 (0)	1 (9.09)	0.86 NS

- *Figures in parenthesis represent percent of subjects; NS = non-significant.*

Table 5.2.40: Number of obese subjects with dental and GI problem according to GLP-1 levels

	Disease	GLP-1≤ 1.5 (n=10)	GLP-1>1.5 (n=10)	χ2 value
Dental problem	Gum disease	2 (20)	0 (0)	2.22 NS
	cavities	2 (20)	0 (0)	2.22 NS
GI problem	Nausea	1 (10)	1 (10)	0.00 NS
	Heart burn	1 (10)	1 (10)	---
	Abdominal pain	1 (10)	0 (0)	1.05 NS
	Diarrhea	1 (10)	0 (0)	1.05 NS
	Dysentery	0 (0)	0 (0)	---
	Constipation	2 (20)	0 (0)	2.22 NS
	Flatulence	1 (10)	0 (0)	1.05 NS

- *Figures in parenthesis represent percent of subjects; NS = non-significant.*

5.2.41 Dental and GI problem of obese subjects according to total dietary fiber intake

Table 5.2.41 depicts that Intake of dietary fiber had no significant effect on dental and GI problems. However, obese subjects with more intake of total dietary fiber (more than 15 gm/day) were reported to have better GI health as very few obese were reported to have diarrhea, constipation and flatulence as compared to obese subjects where intake of total dietary fiber was less than 15 gm/day.

Table 5.2.41: Number of obese subjects with dental and GI problem according to total dietary fiber intake

	Disease	T. diet fiber≤15g (n=28)	T. diet fiber >15g (n=32)	χ2 value
Dental problem	Gum disease	2 (7.14)	1 (3.12)	0.51 NS
	cavities	3 (10.71)	4 (12.5)	0.04 NS
GI problem	Nausea	1 (3.57)	1 (3.12)	0.01 NS
	Heart burn	1 (3.57)	5 (15.62)	2.41 NS
	Abdominal pain	2 (7.14)	2 (6.25)	0.02 NS
	Diarrhea	4 (14.28)	1 (3.15)	2.43 NS
	Dysentery	0 (0)	0 (0)	---
	Constipation	5 (17.85)	3 (9.37)	0.93 NS
	Flatulence	4 (14.28)	3 (9.37)	0.35 NS

- *Figures in parenthesis represent percent of subjects; NS = non-significant*

5.2.42 Dental and GI problem obese subjects according to insoluble fiber intake

Difference in the intake of insoluble of fiber had no significant effect on gum diseases and GI health. However, higher intake had shown non-significant better impact on maintaining oral and GI health (Table 5.2.42).

Table 5.2.42: Number of obese subjects with dental and GI problem according to insoluble fiber intake

	Disease	Insoluble fiber≤11g (n=26)	Insoluble fiber>11g (n=34)	χ2 value
Dental problem	Gum disease	2 (7.69)	1 (2.94)	0.70 NS
	cavities	3 (11.54)	4 (11.76)	0.01 NS
GI problem	Nausea	1 (3.84)	1 (2.94)	0.04 NS
	Heart burn	1 (3.84)	5 (14.70)	1.93 NS
	Abdominal pain	2 (7.69)	2 (5.88)	0.08 NS
	Diarrhea	4 (15.38)	1 (2.94)	0.98 NS
	Dysentery	0 (0)	0 (0)	---
	Constipation	5 (19.73)	3 (8.82)	1.38 NS
	Flatulence	4 (15.38)	3 (8.82)	0.62 NS

- *Figures in parenthesis represent percent of subjects; NS = non-significant*

5.2.43 Number of obese subjects with dental and GI problem according to soluble fiber intake

Table 5.2.43 depicts that intake of soluble fiber more than 4 gm/day was reported to have significant ($p < 0.05$) effect on GI health among obese subjects.

5.2.44 Dental and GI problem obese subjects according to crude fiber intake

Table 5.2.44 showed that intake of crude fiber is significantly associated with maintaining GI health ($p<0.05$) as very few percent of obese were reported to have diarrhea, constipation and flatulence where consumption of crude fiber was >7g/day.

Table 5.2.43: Number of obese subjects with dental and GI problem according to soluble fiber intake

	Disease	Soluble fiber≤4g (n=35)	Soluble fiber>4g (n=25)	χ2 value
Dental problem	Gum disease	2 (5.71)	1 (4)	0.09 NS
	cavities	5 (14.28)	2 (8)	0.56 NS
GI problem	Nausea	1 (2.85)	1 (4)	0.06 NS
	Heart burn	4 (11.42)	2 (8)	0.19 NS
	Abdominal pain	4 (11.42)	0 (0)	3.06 NS
	Diarrhea	5 (14.28)	0 (0)	**3.89***
	Dysentery	0 (0)	0 (0)	**---**
	Constipation	8 (22.85)	0(0)	**6.59***
	Flatulence	7 (20)	0(0)	**5.66***

- *Figures in parenthesis represent percent of subjects; NS = non-significant, *p < 0.05*

Table 5.2.44: Number of obese subjects with dental and GI problem according to crude fiber intake

	Disease	Crude fiber≤7g/day (n=33)	Crude fiber>7g/day (n=27)	χ2 value
Dental problem	Gum disease	2 (6.06)	1 (3.70)	0.17 NS
	cavities	4 (12.12)	3 (11.11)	0.02 NS
GI problem	Nausea	1 (3.03)	1 (3.70)	0.02 NS
	Heart burn	1 (3.03)	5 (18.5)	**3.95***
	Abdominal pain	3 (9.09)	1 (3.70)	**0.69** NS
	Diarrhea	5 (15.15)	0 (0)	**4.46***
	Dysentery	0 (0)	0(0)	---
	Constipation	7 (21.21)	1 (3.70)	**3.94***
	Flatulence	6 (18.18)	1 (3.70)	3.02 NS

- *Figures in parenthesis represent percent of subjects; NS = non-significant, *p < 0.05*

5.2.45 Number of obese subjects with dental and GI problem according to fat intake

As can be seen from Table 5.2.45 Higher intake of Fat (more than 80gm/day) had significant ($p < 0.05$) effects on GI health as higher percent of obese subjects were reported with complain of abdominal pain and flatulence where intake was >80g/day.

Table 5.2.45: Number of obese subjects with dental and GI problem according to fat intake

	Disease	Fat ≤80g (n=31)	Fat >80g (n=29)	χ2 value
Dental problem	**Gum disease**	**1 (3.22)**	**2 (6.89)**	0.43 ^{NS}
	cavities	3 (9.67)	4 (13.79)	0.25 ^{NS}
GI problem	**Nausea**	2 (6.45)	0 (0)	1.94 ^{NS}
	Heart burn	4 (12.90)	2 (6.89)	0.60 ^{NS}
	Abdominal pain	4 (12.90)	0 (0)	**4.01***
	Diarrhea	1 (3.22)	4 (13.79)	2.19 ^{NS}
	Dysentery	0 (0)	0 (0)	---
	Constipation	4 (12.90)	4 (13.79)	0.01 ^{NS}
	Flatulence	1 (3.22)	6 (20.68)	**4.34***

- *Figures in parenthesis represent percent of subjects; NS = non-significant, *p < 0.05*

5.2.46 Anthropometric, biochemical, microbial profile of the subjects based on duration of Obesity

With respect to the duration of obesity (Table 5.2.46), no significant difference was reported in the anthropometric, bio-chemical and microbial profile of the obese subjects.

Table 5.2.46: Anthropometric, biochemical, microbial profile of the subjects based on duration of Obesity

Parameters	Group A (n=48)	Group B (n=12)	't' values
Wt (kg)	78.97 ± 5.87	80.54 ± 5.23	0.85 ^{NS}
BMI (kg/m^2)	27.26 ± 1.48	27.55 ± 1.52	0.61 ^{NS}
WC (cm)	98.60 ± 4.26	97.5 ± 3.66	0.83 ^{NS}
WHR	0.94 ± 0.03	0.95 ± 0.02	0.55 ^{NS}
% body fat	28.52 ± 1.92	27.8 ± 1.37	1.22 ^{NS}
GLP-1 (pmol/l)	1.72 ± 1.01	2.39 ± 0.88	1.21 ^{NS}
LPS (pg/ml)	24.55 ± 2.80	24.12 ± 2.63	0.28 ^{NS}
LAB (log$_{10}$cfu/g)	6.92 ± 1.06	6.67 ± 0.98	0.75 ^{NS}
Bifido (log$_{10}$cfu/g)	7.06 ± 1.01	7.29 ± 1.11	0.70 ^{NS}
Enteric *(log$_{10}$cfu/g)*	5.09 ± 1.06	4.85 ± 1.07	0.68 ^{NS}

- *Group A- obese since between 1-10 years, Group B- obese for >10 years*
- *NS- not significant*

5.2.47: Association amongst anthropometric, biophysical, biochemical, dietary and microbial parameters of obese subjects

As shown in table 5.3.47 GLP-1 was found to be positively correlated with total, soluble, insoluble ($p<0.01$) and crude fiber ($p<0.05$) intake and negatively associated with weight ($p<0.05$), BMI ($p<0.01$), Enteric pathogens ($p<0.01$), energy ($p<0.05$) and protein ($p<0.05$) intake. LPS was positively correlated with weight ($p<0.05$), BMI ($p<0.01$), Enteric pathogens ($p<0.01$), energy ($p<0.01$) and protein ($p<0.01$) intake and found to be significantly negatively associated with total dietary ($p<0.01$), soluble ($p<0.5$), insoluble ($p<0.01$) and crude fiber ($p<0.01$) intake. *LAB* was found to be negatively associated with Enteric pathogens ($p<0.01$) and protein intake ($p<0.05$). *Bifidobacteria* was found to be positively correlated with total dietary ($p<0.05$), insoluble ($p<0.05$) and crude fiber intake ($p<0.05$) and negatively correlated with Enteric ($p<0.01$), energy ($p<0.01$) and protein intake ($p<0.05$). Enteric pathogen was found to be significantly associated with increased energy ($p<0.01$) carbohydrates intake ($p<0.05$).

Table 5.2.47: Correlation values determining the degree of association amongst anthropometric, biophysical, biochemical, dietary and microbial parameters of obese subjects

Parameters	GLP-1 (p mol/l)	LPS (pg/ml)	*LAB* (LOG10CFU/ML)	*Bifido* (LOG10CFU/ML)	Enteric (LOG10CFU/ML)
WT (kg)	**-.514***	**.510***	-.076	.134	.014
BMI (kg/m^2)	**-.572****	**.708****	-.130	-.121	.159
Waist (cm)	-.182	.094	.090	.108	-.061
WHR	.028	.037	.054	.151	.013
Body Fat	-.004	-.017	.089	.140	.010
Enteric *(log$_{10}$cfu/g)*	**-.587****	**.654****	**-.353****	**-.555****	1
Energy (kcal)	**-.761****	**.708****	-.222	**-.338****	**.345****
Carbohydrates (g)	-.369	.401	-.106	-.144	**.303***
Fat (g)	-.374	.287	-.128	-.180	.140
Protein (g)	**-.630****	**.651****	**-.266***	**-.271***	**.255***
T. Dietary fiber (g)	**.659****	**-.571****	.154	**.272***	-.237
Insoluble Dietary fiber (g)	**.653****	**-.551***	.157	**.287***	-.237
Soluble Dietary fiber (g)	**.620****	**-.577****	.127	.203	-.201
Crude fiber (g)	**.543***	**-.590****	.101	**.257***	-.138

** Correlation values are significant, p<0.05, ** Correlation values are significant, p<0.01*

Result Highlights of Phase II

- The sociodemographic data reveals that all subjects were male, with more of the obese subjects belonging to the nuclear family.
- The mean BMI of normal weight and obese subjects was 21.47 and 27.32 respectively.

- Comparison between normal and obese subjects revealed a strong significant association between family history of obesity and BMI, whereas no significant association was observed between the normal weight and obese subjects for other NCD's such as hypertension, DM and CVD.
- Tobacco chewing was significantly higher among obese subjects (32%) as compared to normal weight subjects (7%).
- 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.
- Obese subjects took significantly higher intake of macro nutrients i.e. energy, fat, carbohydrate as compared to normal weight subjects. Whereas, normal weight subjects consumed significantly higher protein 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 by obese subjects as compared to normal weight subjects.
- Biochemical parameters of obese subjects revealed higher LPS and lower GLP-1 values as compared to the normal weight subjects.
- Normal weight subjects had significantly better colonization of good bacteria i.e. *LAB*, *Bifidobacteria* and lower Enteric pathogen count as compared to obese subjects.
- In obese subjects high 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.
- Higher intake of dietary fiber (>15g/day) was negatively associated with body weight, BMI, LPS, Enteric pathogen and positively correlated with GLP-1 levels and ***Bifidobacteria*.**

DISCUSSION

This phase of study was undertaken with the broad objective of comparative analysis between normal weight and obese subjects with respect to socio economic status, anthropometric parameters, personal habits, hunger and satiety scores, dietary intake, food habits, plasma LPS, GLP-1 and gut microflora profile (*LAB, Bifidobacteria* and *Enteric pathogen*s) in fecal samples. Salient findings of the results are discussed below.

Socio demographic data in the present study revealed that subjects with higher education/ graduation and higher income were less likely to be obese. This data is also supported by Pampel and Denney 2012 and Astrup 2008, which reported that subjects with higher SES were less obese, as they have better awareness and exposure of healthy eating and regular exercise.

CDC 2012 reported that people with higher levels of education and higher income have lower rates of many chronic diseases compared to those with less education and lower income levels. In 2007-2010, higher levels of education among the head of household resulted in lower rates of obesity among boys and girls 2-19 years of age. In 2007-2010, women 25 years of age and over with less than a bachelor's degree were more likely to be obese (39 percent-43 percent) than those with a bachelor's degree or higher (25 percent).

Another study by Devaux et al., 2011 reported linear relationship between the numbers of years spent in full-time education and the probability of obesity, with most educated individuals displaying lower rates of the condition. This suggests that the strength of the correlation between education and obesity is approximately constant throughout the education spectrum. Increasing education at any point along that spectrum would be expected to reduce obesity to a similar degree.

In the present study obese were reported to have significant higher systolic blood pressure as compared to the normal weight subjects. The link between obesity and hypertension has long been recognized, with obese patients having higher rates of hypertension than normal-weight individuals (Chiang and Perlman 1969; Stamler and

Riedlinger 1978). Obesity-associated arterial hypertension is characterized by activation of the sympathetic nervous system, activation of the renin-angiotensin system, and sodium retention (Re 2009). Waist circumference has been reported as the strongest independent predictor of systolic blood pressure and diastolic blood pressure (Hall et al., 2014; Lavie and Milani 2009; Hayashi et al., 2003). Furthermore, excess visceral fat has been found to be associated with hypertension (Hall et al., 2014).

Study outcome indicated that significantly higher percent of obese subjects had family history of obesity as compared to the normal weight subjects. The genetic determinants of obesity have been intensely studied in the past decades. Family studies have shown that heritability rates of total body fat mass are 50% (Topalidou and Dafopoulou 2013; Henkin et al., 2003; Katzmarzyk and Malina 2000). Another study on obesity-related genetic variants was performed in close to 250,000 individuals in whom 2.8 million single-nucleotide polymorphisms were genotyped. However, the combined effect of these genetic variants on obesity was modest, accounting for 6–11% of the genetic variation in BMI of obese individuals. Hence, factors other than DNA sequence variants alone are likely to explain the high heritability rates of obesity. These possibly include gene-gene interactions, gene-environment interactions, as well as epigenetics (Speliotes and Willer 2010).

Results with respect to personal habit indicated that tobacco chewing was found significantly higher among obese subjects as compared to the normal weight subjects. Another study investigated revealed association between smokeless tobacco use and body weight among 22,974 air Force recruits (27.4% female, mean age=20.2 years, body mass index=22.7) undergoing basic military training. Current, former, and experimental smokeless tobacco users weighed significantly more than recruits who had never tried smokeless tobacco (p values <0.05). Logistic regression analysis also indicated that the likelihood of being classified as overweight was significantly greater for daily (OR=1.29, 95% CI=1.07-1.54), occasional (OR=1.50, 95% CI=1.17-1.93), former (OR=1.33, 95% CI=1.05-1.67), and experimental (OR=1.13, 95% CI=1.02-1.24) smokeless tobacco users relative to never-users (p values <0.05) (Vander 2005). The contribution of tobacco chewing to obesity may lie in the fact that the alkaloid in tobacco can promote one's appetite by inhibiting GABA receptor, however no study have data about the intake of calories in such individuals. The assumption that the obesity in tobacco chewers is related with increased food intake needs further investigation (Chang et al., 2006).

Data on feeling of hunger for different meals reported that the normal weight subjects had high feeling of hunger for breakfast and evening snacks whereas obese subjects express significant higher cravings for lunch and dinner. Many obese subjects skipped breakfast. Skipping breakfast has been associated with a significantly higher risk of obesity (*Zeratsky 2014)*. A study has hypothesized that individuals who do not eat early in the day may tend to be hungry later on and then may consume a greater number of calories during the evening hours than individuals who eat consistently throughout the day (Mesas et al., 2012; Horikawa 2011; Hunt and Groff 1990). Greater energy intake may result in greater fat storage and, thus, may be one of the factors leading to an increase in body weight (Deshmukh-Taskar 2010; Szajewska 2010; Ma et al., 2003). Regular breakfast consumption can lead to increased satiety and decreased hunger (Zilberter, and Zilberter 2014), which is in agreement with data of Kral et al., 2011 and Levitsky and Pacanowski 2013.

Since as suggested by the studies individuals who do not eat early in the day may tend to be hungry later on and then may consume a greater number of calories during the evening hours, so they tend to eat more, late in the evening which may increase the amount of glucose stored in muscle as glycogen (*Keim et al., 1997*). In humans, muscle glycogen fluctuates in accordance with periods of muscle activity and subsequent carbohydrate consumption. Studies suggest that the consumption of carbohydrate-rich foods in the late evening leads to increased glycogen levels in the muscles (*Keim et al., 1997*). Unless this stored glycogen is burned as fuel, excess will ultimately be stored as fat. Therefore, consumption of late-evening meals with carbohydrate-rich foods may also be related to obesity through its effect on hormonal regulation of energy and lipid metabolism (Bo et al., 2014). Eating in the late evening seems to have a lower satiety value than eating in the morning (Castro 2004).

Data from the dietary profile showed significant higher intake of macro nutrients i.e. energy, fat, carbohydrate among obese subjects as compared to normal weight subjects. This was also supported by food frequency data.

The food, or ‘‘built’’ environment has shifted in ways that promote overeating: highly caloric and fat-laden foods are not only affordable but also easily accessible (i.e., numerous fast food restaurants, vending machines of energy dense items in schools and offices, etc.). These highly palatable foods are frequently available in large portions, which contribute to increased daily caloric intake (Rolls 2003). In addition to the primary influences of increased caloric intake and decreased energy expenditure, Keith et al. 2006 identified excess energy intake as contributing factors to the obesity epidemic this finding is also supported by Chaput 2014. Rolls and Morris 2002 reported that increased portion size affect energy intake thus contributing to obesity.

High intake of fat was reported among obese subjects as compared to normal weight subjects. The fat intake plays a major role in the energy imbalance and thus results in body weight changes. The dietary fat has a higher energy density and is responsible for overeating and passive over consumption of high fat diets (Poti and Duffey 2014; Morton 2006; Drewnowski, and Specter 2004).

Non-significant decrease in the fiber intake among obese individual as compared to normal weight subjects was reported. Regular fiber intake is associated with an array of health benefits including reduced risk of obesity (Brauchla and Juan 2012). Data presented in the current study support previous studies in youth (Davis and Alexander 2009; Parikh et al., 2012) by showing that the odds of central obesity are increased in obese youth with low fiber intake (Mollard et al., 2014).

Food frequency data showed significant 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. Studies revealed that, frequent consumption of fast foods, low serving of fruits, vegetables and milk and milk products per day along with frequent consumption of sweets/candy and carbonated beverages all were proctors of the obesity and overweight (Poti and Duffey 2014; Amin et al.,2008; Mollard et al., 2014). Grimes 2013 carried out a study on the 4283 participants, which reported that dietary salt intake consumption was associated with obesity risk. In addition to the known benefits of lowering blood pressure, salt reduction strategies may be useful in obesity prevention efforts.

In our study the overall frequency of obese subjects eating out was significantly higher ($p<0.001$) than normal weight subjects. Results from our study suggest that a higher frequency of eating either breakfast or dinner away from home was associated with obesity. In agreement with these findings, a study by Poti and popkin 2014 suggested that the frequency of consuming restaurant food was positively associated with increased body weight in adults. Data from the US Department of Agriculture's 1995 with regards to continuing survey of Food Intakes by Individuals suggest that food obtained away from home is generally higher in fat, saturated fat, and cholesterol (Lin 1999). People who ate lunch away from home frequently tended to be less obese, while people who ate breakfast or dinner away from home frequently tended to be more obese (Mozaffarian 2011).

In the present study when normal weight and the obese subjects were compared with respect to *Bifidobacteria, lactobacilli* and Enteric pathogens along with the metabolites released by them such as LPS and GLP-1 it was found that obese individual colonized higher numbers of Enteric pathogens and higher LPS ($p<.001$) and lower *Bifidobacteria* and *lactobacilli* colonization and lower serum GLP-1 levels ($p < 0.05$).

Studies have revealed that gut microflora play a number of physiological roles involving digestion, metabolism, extraction of nutrients, synthesis of vitamins, prevention against colonization by pathogens, and immunomodulation (Jumpertz et al., 2011; Purchiaroni et al., 2013). The gut microflora is implicated in the programing and control of many physiological functions, including gut epithelial development, blood circulation, innate and adaptive mechanisms (Mackie et al., 1999; Dethlefsen et al., 2006; Moreno-Indias et al., 2015).

A new theory shows microbiota as a contributor to the regulation of energy homeostasis. Thus, with the environmental vulnerabilities, gut microflora could provoke the development of impairment in energy homeostasis, causing metabolic diseases. The first discovery was related to the fact that mice with a mutation in the leptin gene (metabolically obese mice) have different microbiota as compared with other mice without the mutation (Ley et al., 2005). In obese animal model, the proportion of the dominant gut phyla, Bacteroidetes and Firmicutes, is modified with a significant reduction in Bacteroidetes and a corresponding increase in Firmicutes (Ley, 2010). Ley et al. 2006 were the first to report an altered gut microflora similar to that found in obese mice (a larger proportion of Firmicutes and relatively fewer Bacteroidetes). Turnbaugh et al., 2009b and Furet et al., 2010 showed a different pattern based on a lower representation of Bacteroidetes (*Bacteroides/Prevotella*) in obese individuals with no differences in Firmicutes phylum. Collado et al., 2008 reported increases in species belonging to both Firmicutes (*Staphylococcus aureus*) and Bacteroidetes (*Bacteroides/Prevotella*) in overweight women. Million et al., 2012 described changes in the composition of Firmicutes based on an increase in *L.reuteri* coupled with a reduction in *L. paracasei* and *L. plantarum*. However, other studies have found no differences between Firmicutes and Bacteroidetes at the phylum level (Duncan et al., 2008; Mai et al., 2009; Jumpertz et al., 2011; Moreno-Indias et al., 2015).

Studies have suggested that obese subjects might be able to extract more energy from nutrients due to hydrogen transfer between taxa. In fact, a simultaneous increase in both hydrogen-producing Prevotellaceae and hydrogen-utilizing methanogenic Archaea has been previously associated with obesity by Zhang et al., (2009), suggesting a higher energy harvest in obese patients. For instance, intestinal starch digestion produces hydrogen, the increase of which inhibits digestion and methanogenic Archaea are able to transform this hydrogen into methane). Thus, there is a specific microbiota that obtains more energy from the same energy intake (Turnbaugh et al., 2009a). These findings agree with the observation in which germ free mice fed with a fat-rich diet gained less weight than conventional mice (Backhed et al., 2004).

Surprisingly, the phenotype with increased capacity for energy harvest is simply transmitted by transplantation of the obesity-associated gut microflora in to healthy and lean donors (Turnbaugh et al., 2006, 2008). Thus, the alteration in the microbiota precedes the alteration in weight, an explanation that is relevant for obesity prevention.

In addition to an energy harvest from the diet, several mechanisms including chronic low-grade endotoxemia, regulation of biologically active fatty acid tissue composition, and the modulation of gut-derived peptide secretion, have been proposed as links between gut microflora and obesity (Moreno-Indias et al., 2015; Musso et al., 2010).

LPS is the major component of the outer membrane of Gram-negative bacteria and is an endotoxin that causes inflammation after entering the circulation this suggest that change in gut microflora compositions will led to increase in LPS levels (Zhao 2013; Cani et al., 2008 and 2009b). Studies reported that normal endotoxemia increased or decreased during the fed or fasted state, respectively, on a nutritional basis and that a 4-week high-fat diet chronically increased plasma LPS concentration two to three times, a threshold that has defined as metabolic endotoxemia.

Importantly, a high-fat diet increased the proportion of an LPS containing microbiota in the gut. When metabolic endotoxemia was induced for 4 weeks in mice through continuous subcutaneous infusion of LPS, fasted glycemia and insulinemia and whole-body, liver, and adipose tissue weight gain were increased to a similar extent as in high fat–fed mice. This new finding demonstrates that metabolic endotoxemia dysregulates the inflammatory tone and triggers body weight gain. Lowering plasma LPS concentration could be a potent strategy for the control of metabolic diseases (Zhao 2013; Cani et al., 2007; Cani et al., 2008; Beutler and Rietschel 2003).

LPS are absorbed by enterocytes and they are conveyed into plasma and couples to chylomicrons (Clemente Postego et al., 2012). In this way dietary fats can be associated with increased absorption of LPS which in turn can be related with change in gut microflora distinguished by decrease in *Eubacterium rectale*-C.*coccoides* group, gram negative *Bacteroides* and *Bifidobacteria* (Cacircilli and Saad, 2013).

It has been recently shown that the LPS induced signaling cascade via toll like receptor 4 (TLR4) impairs pancreatic beta cell function via suppressed glucose induced insulin secretion and decrease mRNA expression of pancreas – duodenum home box – 1 (PDX-1) (Laetitia et al., 2013). LPS binds to the CD14/TLR4 receptor present on macro phages and produces an increase in the production of pro inflammatory molecules.(Moreno-Indias et al., 2015; Jayashree et al., 2014; Cani et al., 2007a; Poggi et al., 2007). However, Cani et al 2007a, b reported that modulation in gut microflora by using prebiotic in obese mice acts favorably on intestinal barrier, lowering high fat diet induced LPS endotoxemia and systemic and liver inflammation.

Furthermore, intestinal bacteria may affect gastrointestinal hormones GLP-1 and PYY which are secreted by entero-endocrine L-cells in response to nutrient stimulus, play important role in glycemic control, satiety and energy intake. Eubiosis i.e increased colonization of beneficial bacteriac such as *LAB*, *Bifidobacteria* has been shown to increase GLP-1 and PYY in humans and rodents, which in turn inhibit gastric motility via its actions on the ileal brake. Thus, it is possible that modulation in gut microflora also delay gastric emptying thus helps in management of obesity (Parnell and Reimer 2009; Cani et al., 2009; Cani et al., 2004; Wettergren et al., 1993).

In present study higher intake of dietary fiber (>15g/day) was negatively associated with body weight, BMI, LPS ($p<0.01$), Enteric pathogen and positively correlated with GLP-1 ($p<0.01$) levels and bifidobacteria ($p<0.05$) changes.

Composition of nutrients in diets affects colonization of the gut microflora because different bacterial species are better equipped genetically to utilize different substrates (Scott et al., 2008). Many studies have demonstrated that an increase in fat intake produces an increase in the Gram-negative/Gram-positive index of our microbiota. Recent studies have found that mice [humanized germ-free (GF)] changed from a diet low in fat and rich in vegetable polysaccharides to a diet rich in fat and sugar and low in plant polysaccharides (western diet) changed their microbiota in just 1 day. Mice on the “western diet” experienced an increase in the abundance of bacteria of the phylum Firmicutes and a decrease in the abundance of those of the phylum Bacteroidetes (Turnbaugh et al., 2009a,b). Also important changes in the abundance of the gut microflora of mice after changing from a standard to a high-fat diet, which was associated with a decrease in the abundance of bacteria of the phylum Bacteroidetes and an increase in that of both Firmicutes and Proteobacteria phyla. Moreover, murine studies have shown that carbohydrate-reduced diets result in enriched populations of bacteria from the Bacteroidetes phyla (Walker et al., 2011). In a controlled-feeding study with humans consuming a high-fat/low-fiber or low-fat/high-fiber diet, notable changes were found in gut microflora in just 24 h, highlighting the rapid effect that diet can have on the intestinal microbiota (Wu et al., 2011). However, large well-controlled trials are needed to elucidate the mechanisms that link dietary changes to alterations in microbial composition as well as the implications of key population changes for health and disease.

Therefore it can be concluded that metabolic diseases can be caused by many factors, including a higher consumption of energy-rich diets, reduced physical activity, and a hereditary disposition. Much evidence suggests that gut microflora may play an important role in the regulation of energy balance and weight in animal models and in humans. However, although metagenomic tools have provided an important amount of data concerning the characterization and the potential role of this gut microflora in the development of human obesity, the causal relationship between this microbiota and obesity still needs to be confirmed in humans.

Concluding Remarks

Findings of the study affirms that effects of dietary components gut microbiota and LPS have a compelling role in the high prevalence of obesity. It can also be interpreted that obesity and microbial factors co-evolve with each other. In this context, the modification of microbiota will constitute new strategies in the treatment or modulation of metabolic disease like obesity.

PHASE III

Anthropometric and metabolic responses of obese subjects to supplementation of FOS

Obese has a multifaceted etiology and therefore can be understood correctly after determining several factors affecting it, an attempt was made to find out effect of each of these factors independently as well as jointly on the various obesity outcome after supplementing the obese subjects with 12 g of FOS daily for period of 60 days.

The methodology to collect the above mentioned information is elaborated in Material and Methods chapter and results are presented in sections table 5.3.1 to table 5.2.21.

The results of this section are divided into following sections

- Anthropometric and Biophysical profile of the obese subjects before and after supplementation trial.
- Hunger and satiety score of the obese subjects before and after supplementation trial.
- Nutrient intake of the obese subjects before and after supplementation trial.
- Biochemical profile of the obese subjects before and after FOS supplementation.
- Gut microflora in fecal sample counts of the obese subjects before and after FOS supplementation.
- Gastro intestinal profile of obese subjects before and after FOS supplementation.
- Association of life style factors of subjects with anthropometric, hunger, satiety, biochemical, microbial and dietary parameters.

5.3.1 Anthropometric changes before and after FOS supplementation

As seen in Table 5.3.1(a) 12 g FOS supplementation for 60 days resulted in significant reduction in weight, WC, WHR ($p<0.05$), BMI ($p<0.001$) and percent body fat ($p<0.001$) (Figure 5.3.1(a-c)). No significant difference was observed in the mean blood pressure values of the obese subjects (Table 5.3.1(b)).

Table 5.3.1(a): Mean anthropometric values of obese subjects before and after FOS supplementation

Parameters		Placebo control (n=30)	Experimental (n-30)	Student 't' Test
		Mean ± SD	Mean ± SD	
Height (m)	**Pre**	1.70 ± 0.040	1.71 ± 0.06	0.25 NS
	Post	1.70 ± 0.040	1.71 ± 0.06	0.25 NS
Weight(kg)	**Pre**	79.15 ± 4.8	79.41 ± 6.60	0.17 NS
	Post	79.27 ± 5.05	78.57± 6.42	0.47 NS
	Paired 't' Test	0.73NS	**4.05***	
	% difference	0.15% ↑	1.06% ↓	
BMI(kg/m2)	**Pre**	27.34 ± 1.56	27.29 ± 1.43	0.14 NS
	Post	27.38 ± 1.62	27.00 ± 1.44	0.95 NS
	Paired 't' Test	0.73 NS	**4.03***	
	% difference	0.15% ↑	1.06% ↓	
WC (cm)	**Pre**	98.1 ± 3.1	98.67 ± 4.99	0.53 NS
	Post	98.3 ± 3.2	97.03 ± 4.99	1.28 NS
	Paired 't' Test	1.71 NS	**2.52***	
	% difference	0.20% ↑	1.66% ↓	
HC (cm)	**Pre**	103.86 ± 2.6	104.77 ± 3.22	1.18 NS
	Post	104.25 ± 2.4	104.67 ± 3.18	0.56 NS
	Paired 't' Test	**2.12***	1.70 NS	
	% difference	0.38% ↑	0.10 % ↓	
WHR	**Pre**	0.94 ± 0.02	0.94 ± 0.03	0.50 NS
	Post	0.94 ± 0 .02	0.92 ± 0.02	**2.45***
	Paired 't' Test	0.74 NS	**2.41***	
	% difference	0.00% ↓	2.13% ↓	
% Body Fat	**Pre**	28.34 ± 1.52	28.40 ± 2.14	0.12 NS
	Post	28.41 ± 1.52	27.20 ± 2.02	**2.53***
	Paired 't' Test	1.20 NS	**3.53***	
	% difference	0.25% ↑	4.23% ↓	

- *NS = non-significant, p < 0.05: *, p < 0.01: **, p < 0.001: ****

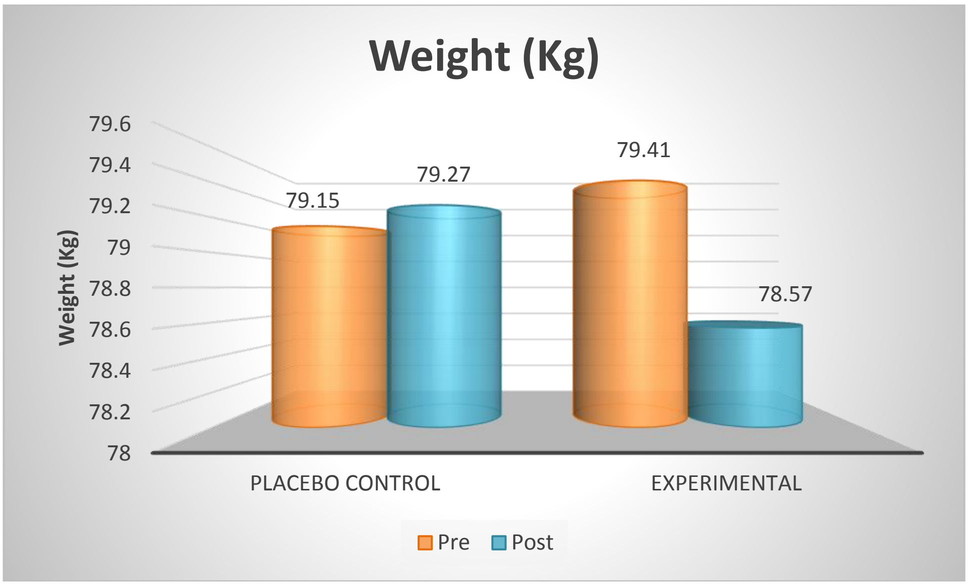


Figure 5.3.1(a): Weight (kg) of the obese subjects before and after FOS supplementation

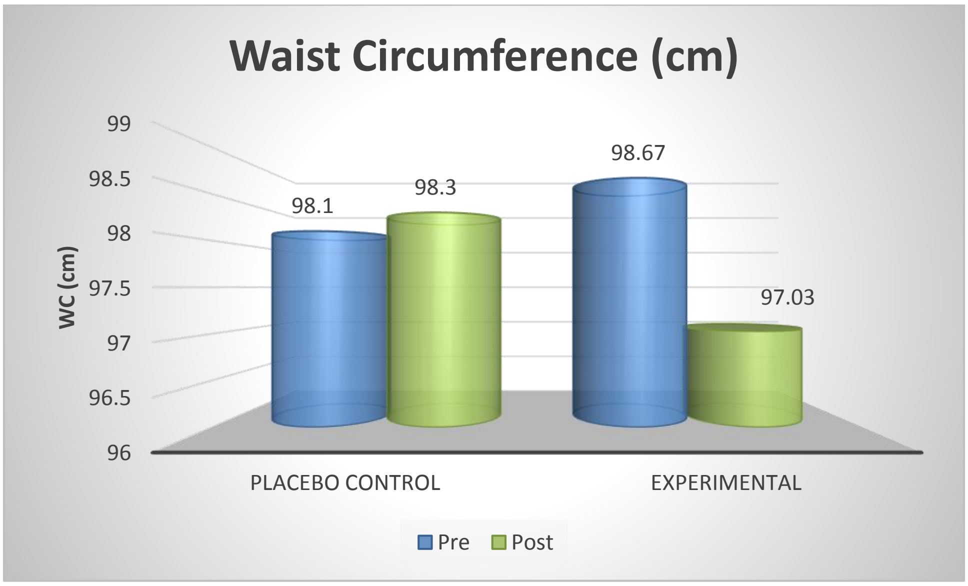


Figure 5.3.1(b): Waist circumference (cm) of the obese subjects before and after FOS supplementation

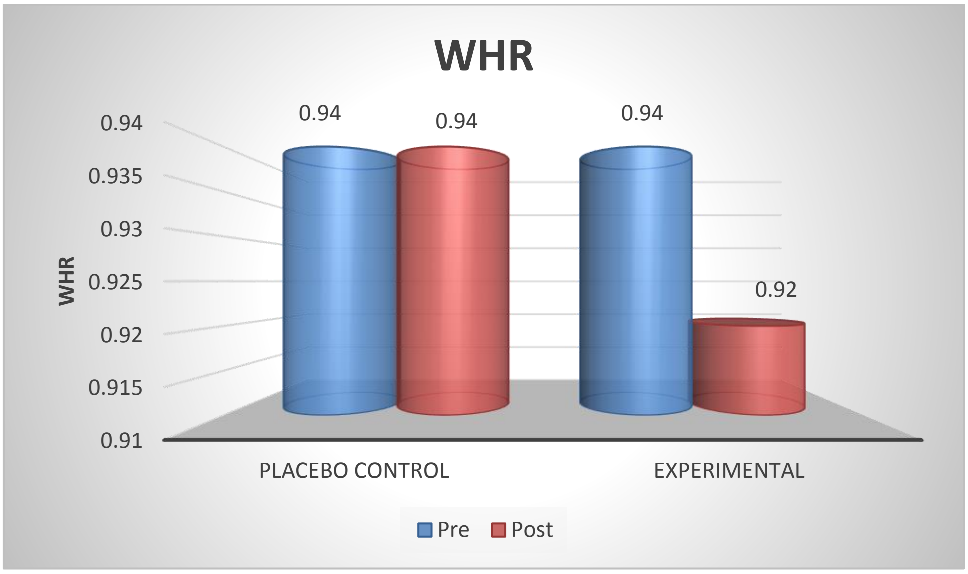


Figure 5.3.1(c): WHR of the obese subjects before and after FOS supplementation

Table 5.3.1(b): Mean blood pressure values of obese subjects before and after FOS supplementation

Parameters		Placebo control (n=30) Mean ± SD	Experimental (n=30) Mean ± SD	Student 't' Test
Systolic Blood Pressure (mm hg)	Pre	121.07 ± 9.08	122.87 ± 6.56	0.91 NS
	Post	121.33 ± 9.16	123 ± 7.10	0.46 NS
	Paired 't' Test	1.61 NS	0.48 NS	
	% difference	0.21% ↑	0.11% ↑	
Diastolic Blood Pressure (mm hg)	Pre	74.9 ± 8.14	77.07 ± 8.17	0.59 NS
	Post	75.83 ± 7.02	76.93 ± 7.39	0.59 NS
	Paired 't' Test	1.65 NS	0.32 NS	
	% difference	1.24% ↑	0.18% ↓	

- *NS = non-significant*

5.3.2 Hunger and satiety score of obese subjects before and after FOS supplementation

As shown in Table 5.3.2(a) after FOS supplementation the mean hunger score values of the obese subjects increase significantly ($p<0.05$) (Figure 5.3.2(a-e)) (feeling for hunger reduced) for lunch hours. Also a non-significant increase in the mean satiety scores after breakfast, evening, and total mean scores by 0.49%, 0.57% and 0.33 % respectively was reported (Table 5.3.2(b)).

Table 5.3.2(a): Mean hunger scores of obese subjects before and after FOS supplementation

Meal Time		Placebo control Group (n=30)	Experimental Group (n=30)	Student 't' Test
		Mean ± SD	Mean ± SD	
Breakfast	Pre (mean ± SD)	4.0 ± 0.74	3.8 ± 1.03	0.86 NS
	Post (mean ± SD)	3.97 ± 0.61	3.9 ± 1.18	0.27 NS
	Paired t	0.44 NS	1.79 NS	
	% difference	0.75% ↓	2.63% ↑	
Lunch	Pre (mean ± SD)	4.0 ± 0.83	3.6 ± 0.77	1.90 NS
	Post (mean ± SD)	3.97 ± 0.76	3.73 ± 0.91	1.07 NS
	Paired t	0.55 NS	**2.11 ***	
	% difference	0.75% ↓	3.61% ↑	
Evening	Pre (mean ± SD)	4.23 ± 0.81	4.07 ± 0.64	0.88 NS
	Post (mean ± SD)	4.2 ± 0.76	4.19 ± 0.79	0.16 NS
	Paired t	0.57 NS	1.36 NS	
	% difference	0.71% ↓	2.95% ↑	
Dinner	Pre (mean ± SD)	3.93 ± 0.74	3.77 ± 0.86	0.80 NS
	Post (mean ± SD)	3.93 ± 0.74	3.9 ± 0.96	0.15 NS
	Paired t	0.00 NS	1.68 NS	
	% difference	0.00% ↓	3.45% ↑	
Mean scores	Pre (mean ± SD)	4.04 ± 0.65	3.80 ± 0.75	1.28 NS
	Post (mean ± SD)	4.01 ± 0.57	3.92 ± 0.88	0.47 NS
	Paired t	0.72 NS	**2.13***	
	% difference	0.74% ↓	3.15% ↑	

- *NS = non-significant, p < 0.05*: Hunger scores 1 – 5, where 1= Famished, starving 2= Headache, weak, cranky, low energy, 3= Want to eat now, stomach growls and feels empty, 4= Hungry - but could wait to eat, starting to feel empty but not there yet, 5= Not hungry, not full.*

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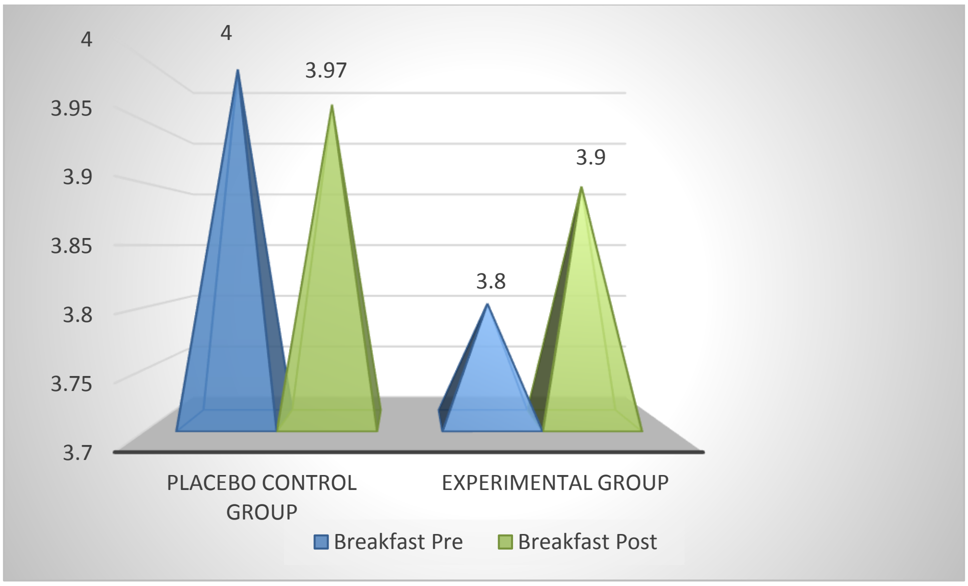

Figure 5.3.2(a): Hunger score before breakfast of the obese subjects before and after FOS supplementation

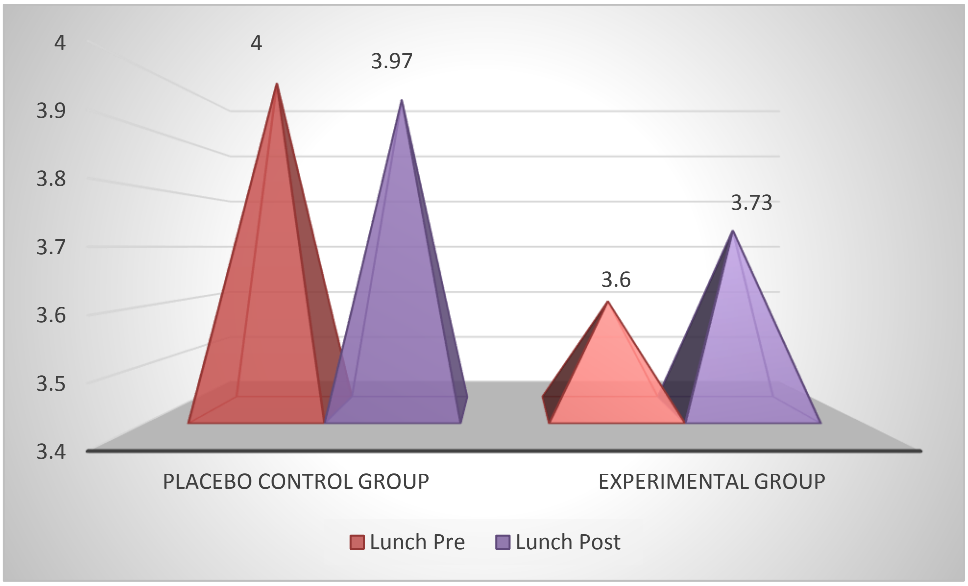

Figure 5.3.2(b): Hunger score before lunch of the obese subjects before and after FOS supplementation

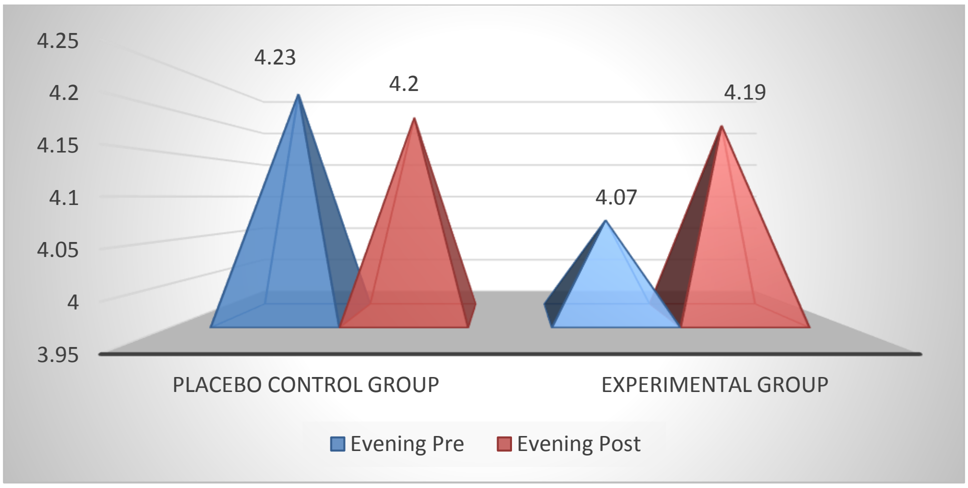

Figure 5.3.2(c): Hunger score before evening snack of the obese subjects before and after FOS supplementation

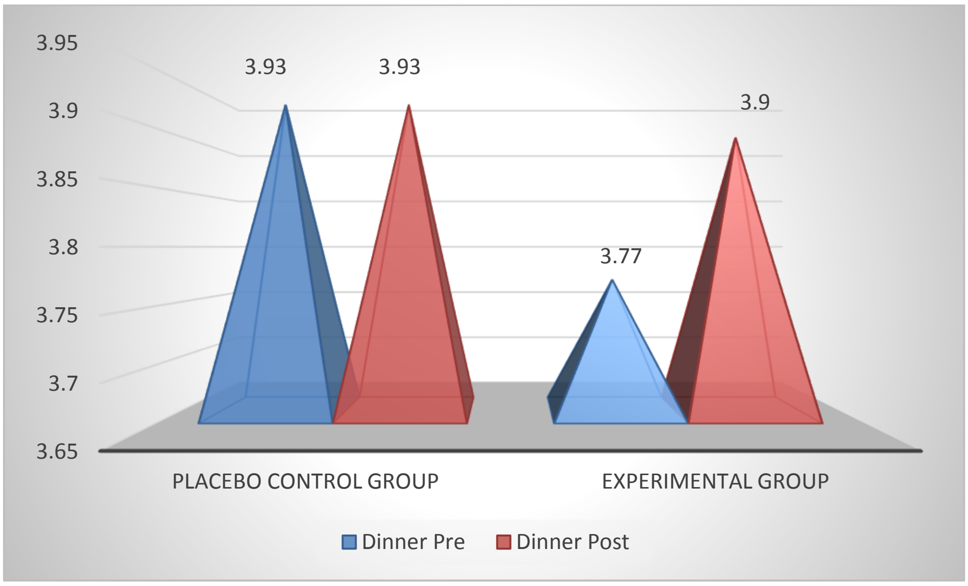

Figure 5.3.2(d): Hunger score before dinner of the obese subjects before and after FOS supplementation

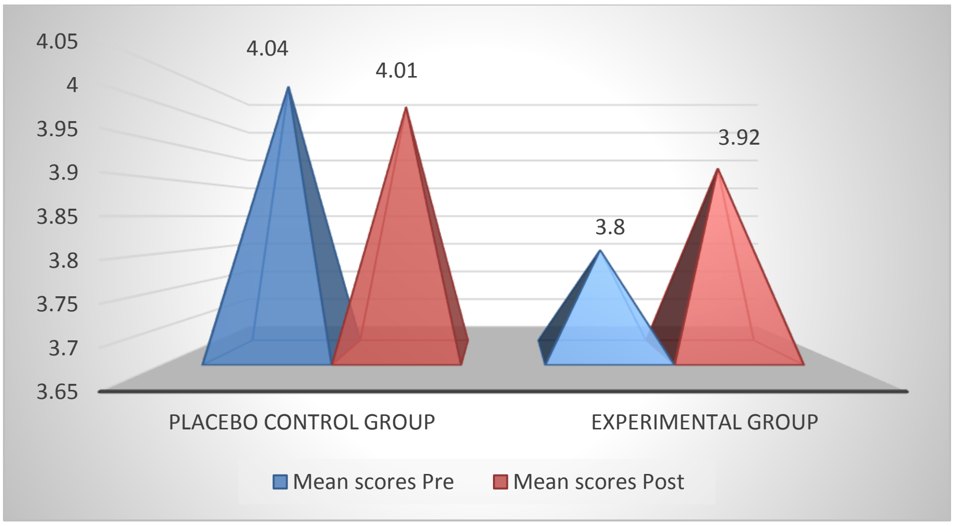

Figure 5.3.2(e): Total mean hunger score of the obese subjects before and after FOS supplementation

Table 5.3.2(b): Mean satiety scores of obese subjects before and after FOS supplementation

Meal Time		Placebo control Group (n=30)	Experimental Group (n=30)	Student 't' Test
		Mean ± SD	Mean ± SD	
Breakfast	Pre (mean ± SD)	5.90 ± 0.48	6.07 ± 0.91	0.88 NS
	Post (mean ± SD)	5.87 ± 0.35	6.1 ± 0.92	1.29 NS
	Paired t	0.57 NS	1.00 NS	
	% difference	0.51% ↓	0.49% ↑	
Lunch	Pre (mean ± SD)	6.07 ± 0.52	6.0 ± 0.69	0.42 NS
	Post (mean ± SD)	6.07 ± 0.45	6.0 ± 0.69	0.44 NS
	Paired t	0.00 NS	0.00 NS	
	% difference	0.00%	0.00%	
Evening	Pre (mean ± SD)	5.77 ± 0.63	5.30 ± 0.92	2.30 NS
	Post (mean ± SD)	5.80 ± 0.41	5.33 ± 0.88	2.61 NS
	Paired t	0.44 NS	1.00 NS	
	% difference	0.52% ↑	0.57% ↑	
Dinner	Pre (mean ± SD)	6.30 ± 0.53	6.3 ± 0.65	0.00 NS
	Post (mean ± SD)	6.23 ± 0.50	6.3 ± 0.65	0.44 NS
	Paired t	1.43 NS	0.00 NS	
	% difference	1.11% ↓	0.00%	
Mean scores	Pre (mean ± SD)	6.0 ± 0.39	5.91 ± 0.45	0.83 NS
	Post (mean ± SD)	5.99 ± 0.28	5.93 ± 0.45	0.59 NS
	Paired t	0.46 NS	1.00 NS	
	% difference	0.16% ↓	0.33% ↑	

- *NS = non-significant. Satiety scores 6 – 10, where 6= feeling satisfied, stomach feels full and comfortable 7= feeling full, definitely don't need more food, 8= uncomfortably full 9= stuffed, very uncomfortable 10= bursting painfully full.*

5.3.3 Nutrient intake of obese subjects before and after FOS supplementation

Table 5.3.3 describes a composite picture of dietary analysis of obese subjects after FOS intervention. Results revealed that there is significant reduction in the intake of Carbohydrate (p<0.005), energy, protein and fat (p<0.05) in the experimental group. (Figure 5.3.3(a-d)).

Table 5.3.3: Mean dietary intakes of obese subjects before and after FOS supplementation

Nutrient		Placebo control (n=30)	Experimental (n=30)	Student 't' Test
		Mean ± SD	**Mean ± SD**	
Energy (Kcal)	**Pre (mean ± SD)**	2345.95±351.48	2431.56±368.09	0.92 NS
	Post (mean ± SD)	2353.46±325.45	2236.86±338.12	1.36 NS
	Paired t	0.08 NS	**2.98***	
	% difference	0.32% ↑	8.01% ↓	
Carbohydrate (g)	**Pre (mean ± SD)**	350.73 ± 44.21	356.28 ± 43.62	0.48 NS
	Post (mean ± SD)	353.68 ± 56.23	328.33 ± 35.02	**2.09***
	Paired t	0.24 NS	**3.51****	
	% difference	0.84% ↑	7.84% ↓	
Protein (g)	**Pre (mean ± SD)**	52.66 ± 7.25	54.90 ±10.19	0.97 NS
	Post (mean ± SD)	53.02 ± 9.55	51.79 ± 9.63	0.49 NS
	Paired t	0.15 NS	**2.14***	
	% difference	0.68% ↑	5.66% ↓	
Fat (g)	**Pre (mean ± SD)**	80.21 ± 13.42	87.11 ± 14.25	1.90 NS
	Post (mean ± SD)	81.32 ± 18.19	80.81 ± 16.06	0.11 NS
	Paired t	0.27 NS	**2.05***	
	% difference	1.38% ↑	7.23% ↓	
Soluble Dietary Fibre (g)	**Pre (mean ± SD)**	3.80 ± 1.68	3.81 ± 1.19	0.03 NS
	Post (mean ± SD)	3.85±2.62	3.78 ±1.70	0.20 NS
	Paired t	1.01 NS	0.39 NS	
	% difference	1.31↑	0.78↓	
Insoluble Dietary Fibre (g)	**Pre (mean ± SD)**	11.20 ±4.59	12.18 ± 4.16	0.86 NS
	Post (mean ± SD)	11.31 ±3.47	12.09 ± 3.67	0.70 NS
	Paired t	1.04 NS	0.86	
	% difference	0.98↑	0.73↓	
Crude Fibre (g)	**Pre (mean ± SD)**	6.47 ± 2.13	7.25 ±2.20	1.39 NS
	Post (mean ± SD)	6.63 ±2.24	7.19 ±2.42	0.98 NS
	Paired t	2.01 NS	0.76 NS	
	% difference	2.47↑	0.82↓	
Total Fibre (g)	**Pre (mean ± SD)**	15.03 ± 6.07	16.06 ± 5.18	0.71 NS
	Post (mean ± SD)	15.16 ± 5.84	15.87 ±5.42	0.39 NS
	Paired t	1.22 NS	1.13 NS	
	% difference	0.86↑	1.18↓	

- *NS = non-significant, p < 0.05: *, p < 0.01: ***

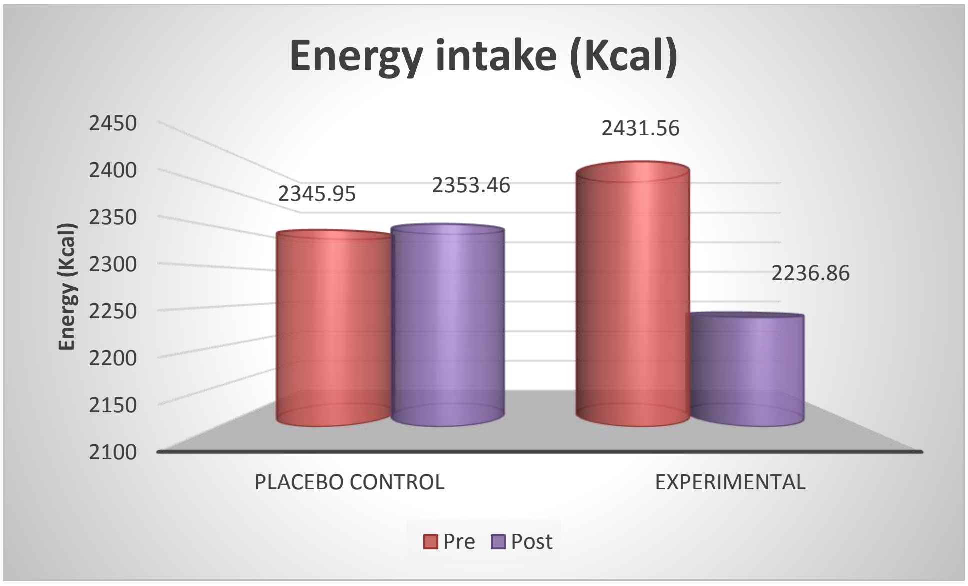

Figure 5.3.3(a): Energy intake of the obese subjects before and after FOS supplementation

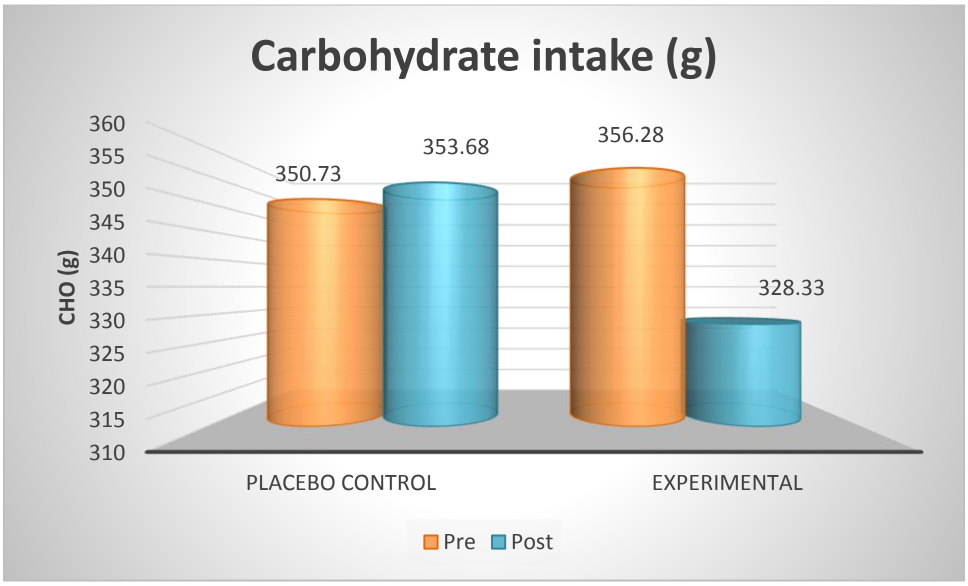

Figure 5.3.3(b): Carbohydrate intake of the obese subjects before and after FOS supplementation

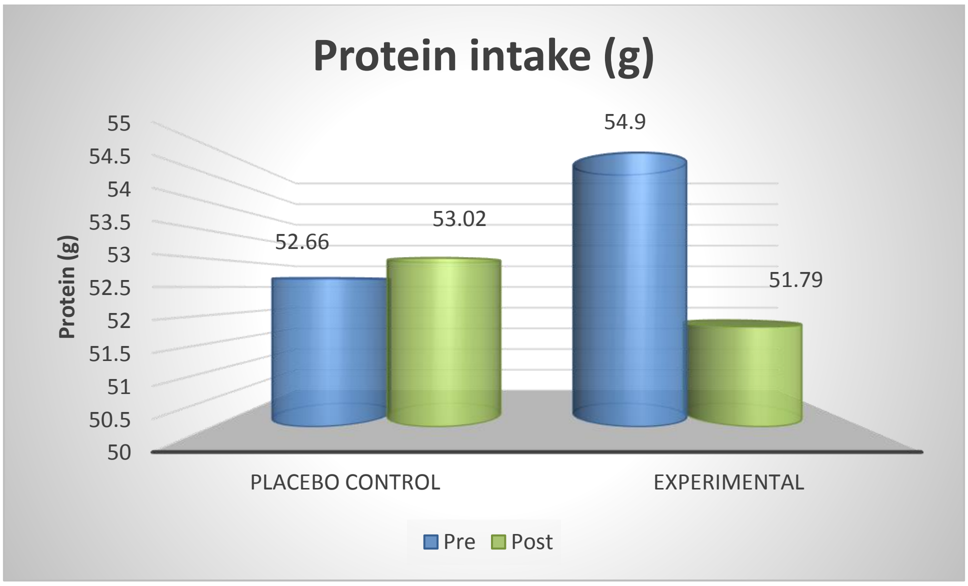

Figure 5.3.3(c): Protein intake of the obese subjects before and after FOS supplementation

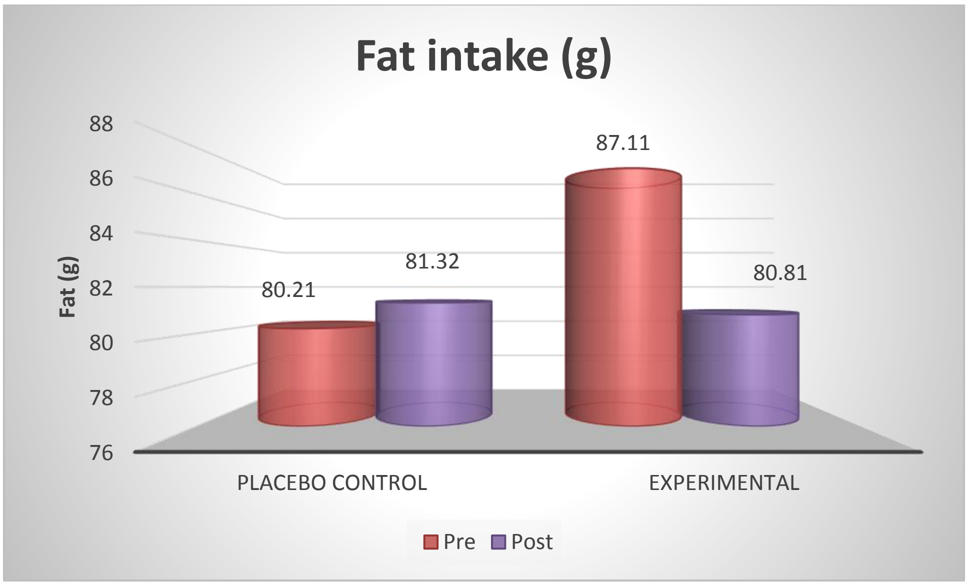

Figure 5.3.3(d): Fat intake of the obese subjects before and after FOS supplementation

5.3.4 Plasma LPS and plasma GLP-1 levels of obese subjects after FOS supplementation

As shown in Table 5.3.4 significant decrease in the mean values of LPS was reported in the experimental group a non-significant increase of 17.42% in the GLP-1 levels was observed in the obese subjects with FOS intervention. (Figure 5.3.4(a,b)).

5.3.5 Gut microflora in fecal samples of the obese subjects before and after FOS supplementation

Table 5.3.5 revealed gut microflora count in fecal samples of the obese subjects before and after FOS supplementation. The fecal log count of *Lactic acid bacteria* and *Bifidobacteria* showed significant increase by 14%, 10% respectively ($p<0.05$, $p<0.005$) (Figure 5.3.5(a-c)). There was significant reduction by 20% of fecal log counts of Enteric pathogen in obese subjects after FOS supplementation (Plate 5.3.5(a-f)).

Table 5.3.4: Mean endotoxins (pg/ml) and GLP-1 (pmol/l) levels of obese subjects before and after FOS supplementation

Parameters		Placebo control Group (n=10)	Experimental Group (n=10)	Student 't' Test
		Mean ± SD	**Mean ± SD**	
LPS	**Pre**	23.27 ± 2.15	25.66 ± 2.76	**2.16***
(pg/ml)	**Post**	23.32 ± 1.90	24.94 ± 3.29	1.34 ^{NS}
	Paired 't' test	0.37 ^{NS}	**2.29 ***	
	% difference	**0.21% ↑**	**2.81% ↓**	
GLP-1				
(pmol/l)	**Pre**	2.38 ± 1.0	1.32 ± 0.71	**2.71***
	Post	2.36 ± 1.054	1.55 ± 0.93	1.82 ^{NS}
	Paired 't' test	0.25 ^{NS}	1.80 ^{NS}	
	% difference	**0.84% ↓**	**17.42% ↑**	

- *NS = non-significant, Significant from the baseline value at p<0.05.*

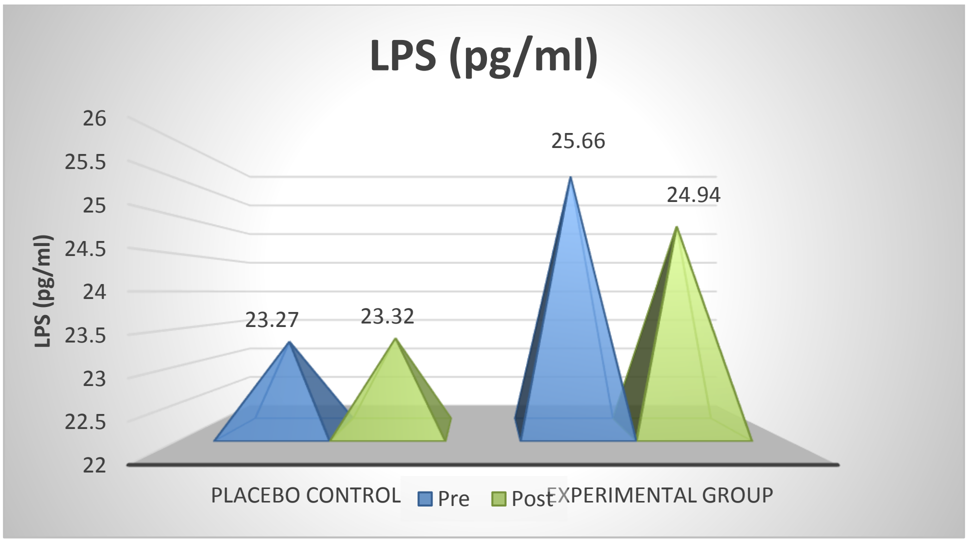

Figure 5.3.4(a): Plasma LPS levels of the obese subjects before and after FOS supplementation

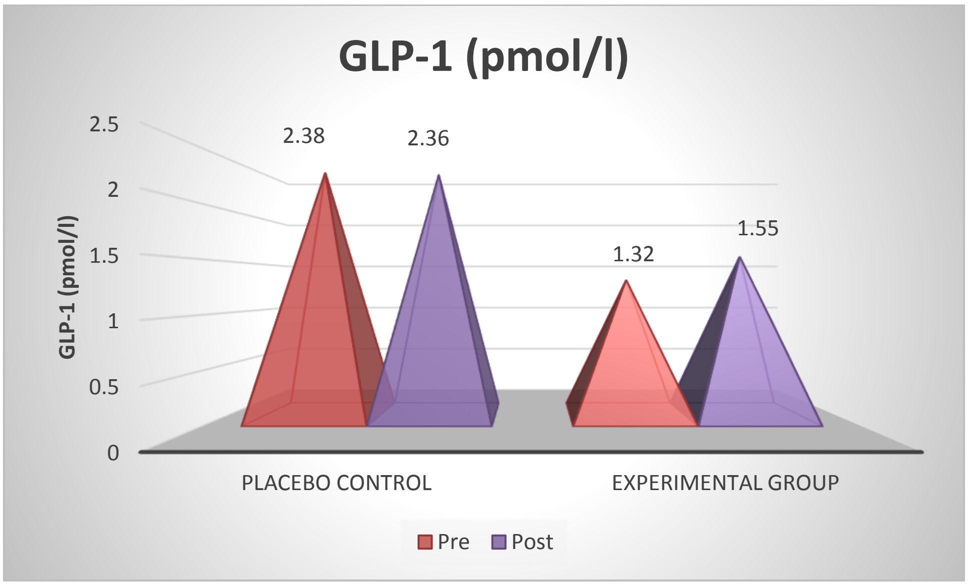

Figure 5.3.4(b): Plasma GLP-1 levels of the obese subjects before and after FOS supplementation

Table 5.3.5: Gut microbial profile of obese subjects before and after FOS supplementation

Parameters		Placebo Control (n = 30)	Experimental (n = 30)	*Student t* test
Lactic acid bacteria	**Pre**	6.66 ± 0.95	7.08 ± 1.10	**1.58** NS
(log_{10}cfu/g)	**Post**	6.51 ± 0.96	8.06 ± 1.40	**5.02*****
	Paired t test	0.77 NS	**5.70*****	
	% difference	2.25% ↓	13.84% ↑	
Bifidobacteria	**Pre**	6.93 ± 0.99	7.28 ± 1.05	**1.32** NS
(log_{10}cfu/g)	**Post**	7.02 ± .93	8.03 ± 1.21	**3.6****
	Paired t test	0.39 NS	**3.80****	
	% difference	1.30% ↑	10.30% ↑	
Enteric Pathogen	**Pre**	5.09 ± 0.94	4.99 ± 1.17	0.41 NS
(log_{10}cfu/g)	**Post**	5.19 ± 1.07	3.98 ± 0.99	**4.50*****
	Paired t test	0.35 NS	**6.20*****	
	% difference	1.96% ↑	20.24% ↓	

- *** Significant from the baseline value at p<0.01, *** Significant from the baseline value at p<0.001, NS - Non Significant*

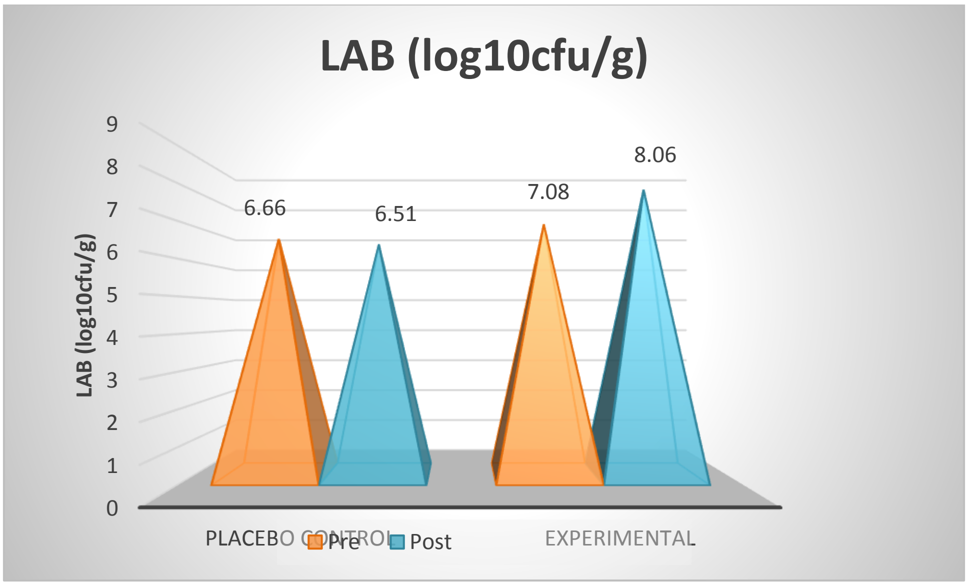

Figure 5.3.5(a) *Lactic acid bacteria* count in fecal samples before and after FOS supplementation

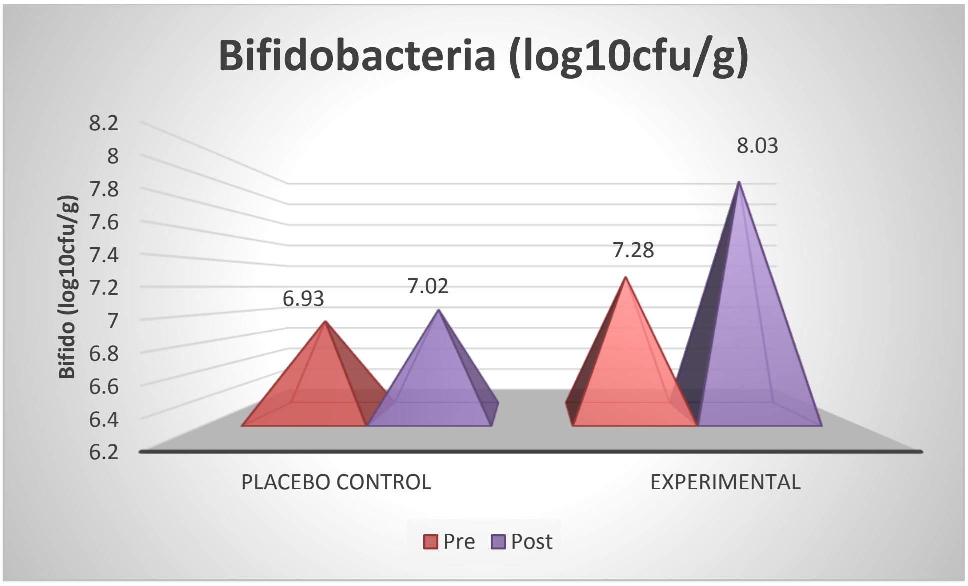

Figure 5.3.5(b) *Bifidobacteria* count in fecal samples before and after FOS supplementation

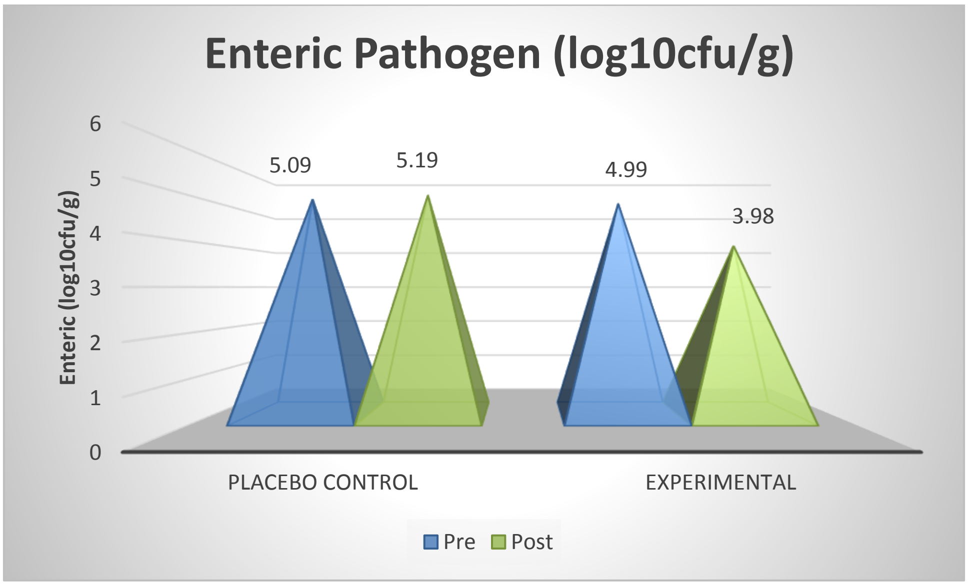

Figure 5.3.5(c) Enteric pathogen count in fecal samples before and after FOS supplementation

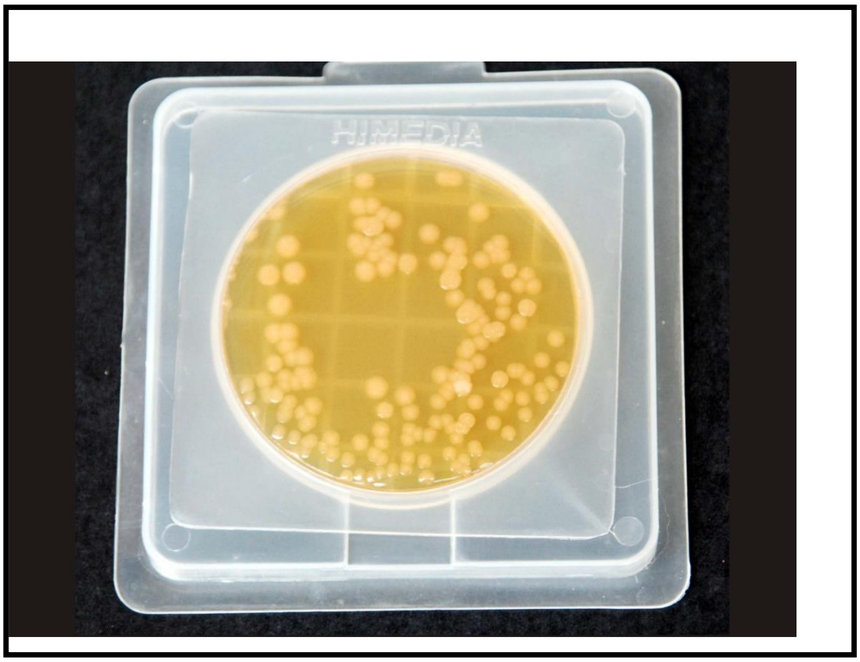

Plate 5.3.1(a): *Lactic acid bacteria* counts in fecal samples before FOS supplementation

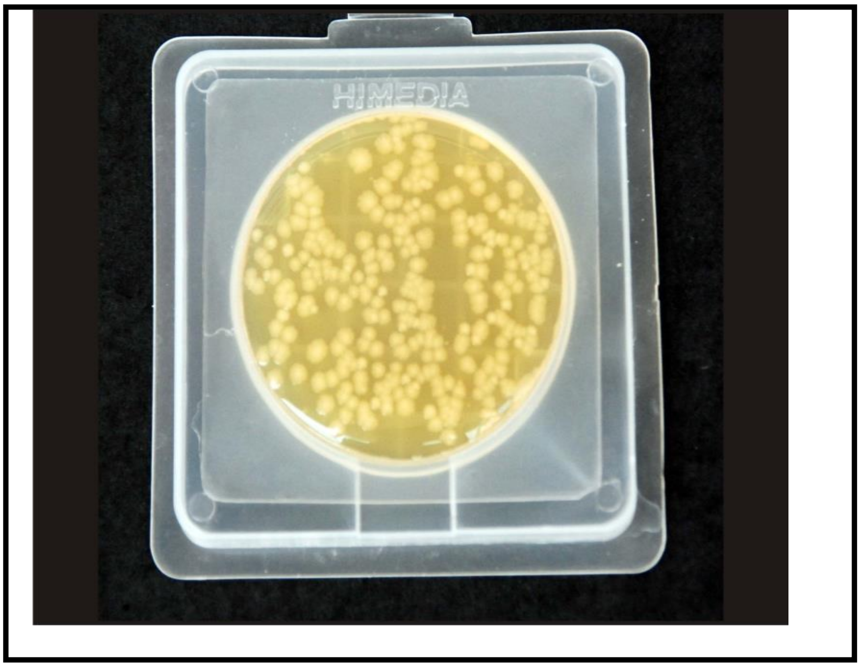

Plate 5.3.1 (b): *Lactic acid bacteria* counts in fecal samples after FOS supplementation

Plate 5.3.1(c): ***Bifidobacteria*** **counts in fecal samples before FOS supplementation**

Plate 5.3.1(d): ***Bifidobacteria*** **counts in fecal samples after FOS supplementation**

Plate 5.3.1(e): Enteric pathogen counts in fecal samples before FOS supplementation

Plate 5.3.1(f): Enteric pathogen counts in fecal samples after FOS supplementation

5.3.6 Gastro intestinal profile of obese subjects before and after FOS supplementation

As shown in Table 5.3.6, no significant difference was reported in obese subject after FOS supplementation. However, as per subject's perception the percent prevalence of constipation, diarrhea reduced from 3 % and 1% to 1 and 0% respectively. Non-significant increase in the percent subjects having flatulence was reported among obese subjects after FOS supplementation. Figure 5.3.6(a-c).

Table 5.3.6: Gastrointestinal profile of obese subjects before and after FOS supplementation

Parameters		Placebo control Group (n=30)	Experimental Group (n=30)	χ^2 Value
CONSTIPATION	**Pre Intervention**			
	Present	5 (17)	3 (10)	**0.14** NS
	Absent	25(83)	27 (90)	
	Post intervention			
	Present	5 (17)	1 (3)	**1.66** NS
	Absent	25(83)	29 (97)	
	χ^2 Value	**0.00** NS	**0.26** NS	
DIARRHEA	**Pre Intervention**			
	Present	1 (3)	1 (3)	**0.51** NS
	Absent	29 (97)	29 (97)	
	Post intervention			
	Present	1 (3)	0 (0)	**0.00** NS
	Absent	29 (97)	30 (100)	
	χ^2 Value	**0.00** NS	**1.00** NS	
FLATULENCE	**Pre Intervention**			
	Present	5 (17)	2 (7)	**0.64** NS
	Absent	25(83)	28 (93)	
	Post intervention			
	Present	6 (20)	6 (20)	**0.00** NS
	Absent	24 (80)	24 (80)	
	χ^2 Value	**0.10** NS	**2.26** NS	

- *Figures in parenthesis represent percent of subjects; NS - Non Significant*

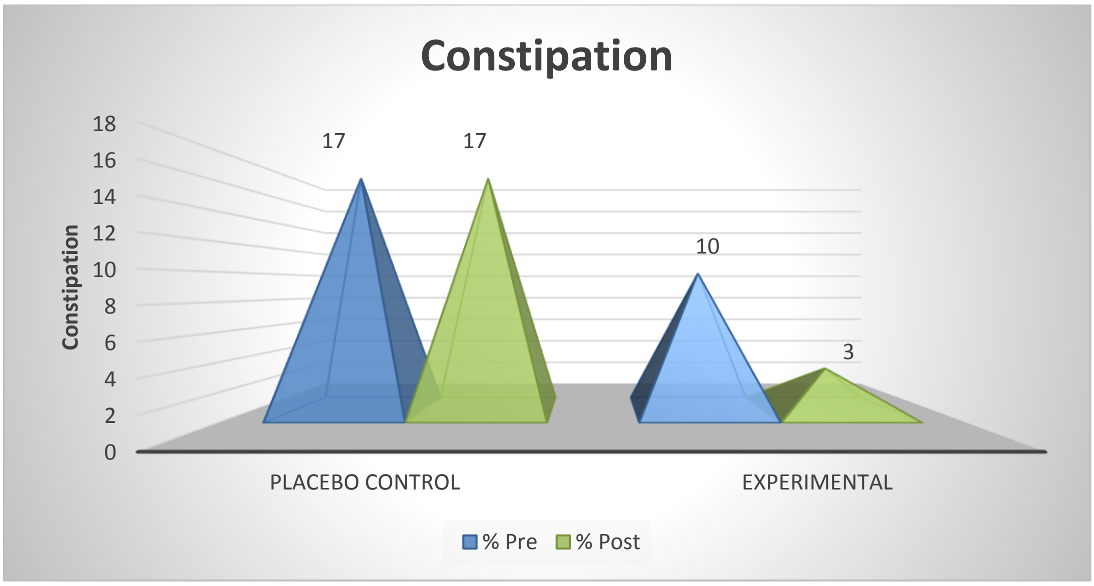

Figure 5.3.6(a): Percent subjects having constipation in obese group before and after FOS supplementation

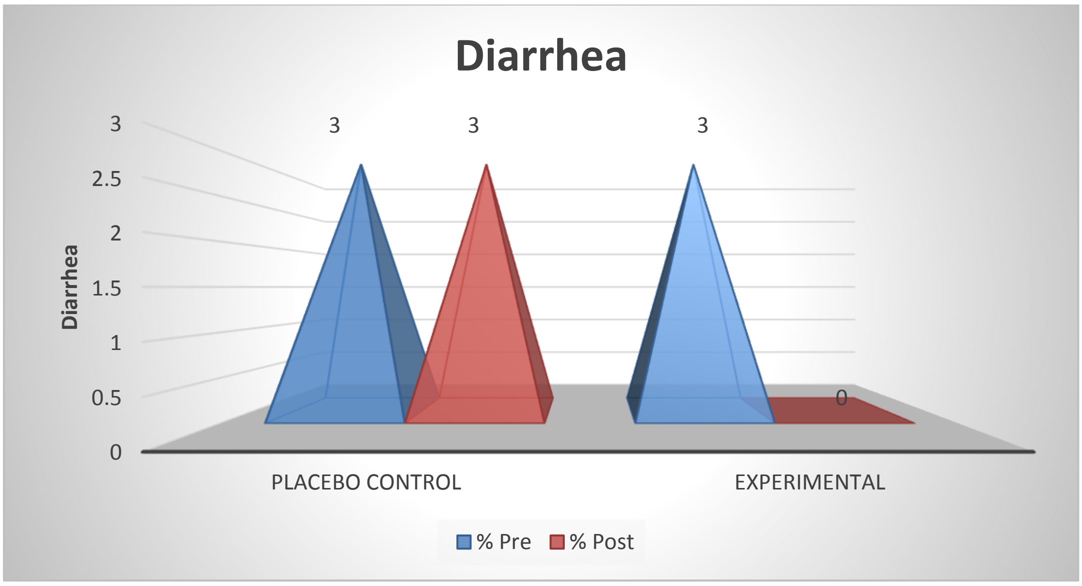

Figure 5.3.6(b): Percent subjects having diarrhea in obese group before and after FOS supplementation

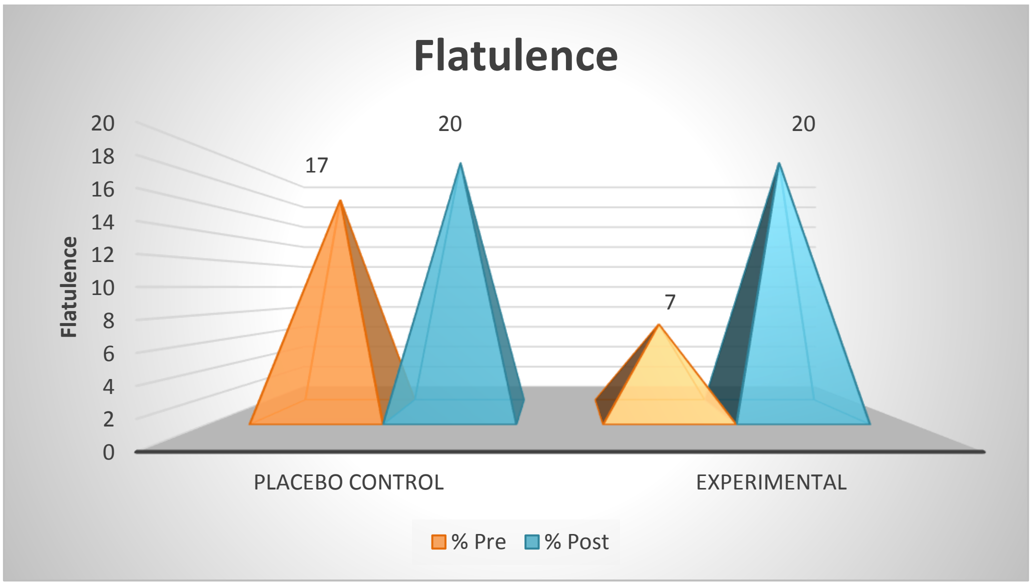

Figure 5.3.6(c): Percent subjects having flatulence in obese group before and after FOS supplementation

Association of life style factors of subjects with anthropometric, hunger, satiety, biochemical, microbial and dietary parameters

5.3.7 Anthropometric changes between category 1 (BMI 25-27kg/m^2) and category 2 (BMI >27kg/m^2) obese subjects after FOS supplementation

When the obese subjects were divided in two categories depending on their BMI, category 1 (BMI 25-27kg/m^2) and category 2 (BMI >27kg/m^2) more reduction in weight and BMI was reported in category 2 obese subjects after FOS supplementation. However the other anthropometric parameters remain more or less similar (Table 5.3.7).

Table 5.3.7: Mean anthropometric parameters of category 1(BMI 25-27kg/m^2) and category 2 (BMI >27kg/m^2) obese subjects before and after FOS supplementation

	Parameters	Category1 (n=11)	Category 2 (n=19)
Weight (kg)	**Pre**	75.09±4.59	81.92±8.35
	Post	74.79±4.21	81.55±6.44
	Paired t test	1.01 ^{NS}	**2.4***
	% difference	0.39↓	0.45↓
BMI (kg/m^2)	**Pre**	26.03 ±0.25	28.23±0.82
	Post	25.57±0.47	28.10 ±0.88
	Paired t test	0.89 ^{NS}	**2.50***
	% difference	1.77% ↓	0.46% ↓
WC (cm)	**Pre**	99.91±3.91	97.94±5.50
	Post	99.64±3.52	97.86±5.25
	Paired t test	1.39 ^{NS}	0.82 ^{NS}
	% difference	0.27% ↓	0.08% ↓
HC (cm)	**Pre**	104±3.44	106.09±2.38
	Post	103±3.41	106.00±2.28
	Paired t test	1.00^{NS}	1.45 ^{NS}
	% difference	0.96%↓	0.08↓
WHR	**Pre**	0.94±0.02	0.94±0.02
	Post	0.94±0.02	0.94±0.02
	Paired t test	1.49 ^{NS}	0.28 ^{NS}
	% difference	0.00%	0.00%
%Body fat	**Pre**	29.16±2.33	27.96±1.94
	Post	28.71±2.68	27.77±2.00
	Paired t test	1.39 ^{NS}	1.65 ^{NS}
	% difference	1.54% ↓	0.68%↓

- **Significant from the baseline value at p<0.05, NS - Non Significant*

5.3.8 Anthropometric changes with poor and good compliance of FOS intervention

An attempt was made to make a comparison between obese subjects with poor compliance (≥40- 50 days) and good compliance (>50 days) of FOS intervention. Results showed that obese subjects with good compliance of FOS supplementation had shown significant reduction in weight, BMI, WC, percent body fat as compared to the obese subjects with poor compliance of FOS supplementation (Table 5.3.8).

Table 5.3.8 : Mean anthropometric values of obese subjects with poor(≥40-50 days) and good compliance(≥51days) before and after FOS supplementation

Parameters		Poor compliance (n=11) Mean ± SD	Good compliance (n=19) Mean ± SD	Student 't' Test
Weight(kg)	**Pre**	79.11± 6.74	79.58± 6.69	0.19 NS
	Post	78.96± 6.69	78.35± 6.76	0.25 NS
	Paired 't' Test	0.39 NS	**6.15*** **	
	% difference	0.19% ↓	1.55% ↓	
BMI(kg/m2)	**Pre**	27.27±1.43	27.29± 1.46	0.31 NS
	Post	27.24± 1.29	26.87± 1.54	0.66 NS
	Paired 't' Test	0.33 NS	**6.17*** **	
	% difference	0.11% ↓	1.54% ↓	
WC (cm)	**Pre**	99.36±5.35	98.26±4.88	0.57 NS
	Post	97.27±4.14	96.89±4.65	0.22 NS
	Paired 't' Test	1.32 NS	**2.96***	
	% difference	2.10% ↓	1.39% ↓	
HC (cm)	**Pre**	105.27±3.16	104.47±3.30	0.65 NS
	Post	105.18±3.06	104.37± 3.30	0.67 NS
	Paired 't' Test	1.00 NS	1.46 NS	
	% difference	0.09%	0.10% ↓	
WHR	**Pre**	0.94± 0.02	0.94± 0.024	0.33 NS
	Post	0.92± 0.03	0.93± 0.26	0.32 NS
	Paired 't' Test	1.32 NS	**2.61***	
	% difference	2.13% ↓	1.06% ↓	
% Body Fat	**Pre**	28.95± 2.51	28.09± 1.88	1.06 NS
	Post	28.05± 2.69	26.69± 1.36	1.80 NS
	Paired 't' Test	1.29 NS	**3.96*** **	
	% difference	3.11% ↓	4.98% ↓	

- *NS = non-significant, p < 0.05: *, p < 0.01: **, p < 0.001: ****

5.3.9 Hunger and satiety score between category 1 (BMI 25-27kg/m^2) and category 2 (BMI >27kg/m^2) obese subjects after FOS supplementation

When comparison was made between category 1 and category 2 obese subjects a significantly (p>0.05) increased mean hunger values was reported in category 2 obese subjects after FOS intervention. No significant difference was observed in mean satiety scores. (Table 5.3.9(a), 5.3.9(b)).

Table 5.3.9(a): Mean hunger scores of category 1 (BMI 25-27kg/m^2) and category 2 (BMI >27kg/m^2) obese subjects before and after FOS intervention

Meal Time		Experimental		Student 't' Test
		Category1 (n=11))	**Category 2 (n=19)**	
Breakfast	**Pre (mean ± SD)**	4.18 ± 1.17	3.58 ± 0.90	1.58 ^{NS}
	Post (mean ± SD)	4.37 ± 1.36	3.63 ± 1.01	1.68 ^{NS}
	Paired t	1.49^{NS}	1.00 ^{NS}	
	% difference	4.55%↑	1.40↑	
Lunch	**Pre (mean ± SD)**	3.91 ± 0.83	3.42 ± 0.69	1.72 ^{NS}
	Post (mean ± SD)	4.00 ± 0.89	3.58 ± 0.90	1.23 ^{NS}
	Paired t	1.00 ^{NS}	1.83 ^{NS}	
	% difference	2.30%↑	4.68↑	
Evening	**Pre (mean ± SD)**	4.27 ± 0.65	3.95 ± 0.62	1.36 ^{NS}
	Post (mean ± SD)	4.27 ± 0.79	4.11 ± 0.81	0.55 ^{NS}
	Paired t	0.00 ^{NS}	1.83 ^{NS}	
	% difference	0.00%	4.05%↑	
Dinner	**Pre (mean ± SD)**	4.18 ± 0.98	3.53 ± 0.70	**2.13***
	Post (mean ± SD)	4.18 ± 1.17	3.73 ± 0.81	1.23 ^{NS}
	Paired t	0.00 ^{NS}	**2.19***	
	% difference	0.00%	5.67↑	
Mean scores	**Pre (mean ± SD)**	4.13 ± 0.81	3.61 ± 0.65	1.90 ^{NS}
	Post (mean ± SD)	4.20 ± 0.98	3.76 ± 0.80	1.33 ^{NS}
	Paired t	0.71 ^{NS}	**2.15***	
	% difference	1.69%↑	4.15%↑	

- *NS = non-significant, p < 0.05: *, Hunger scores 1 – 5, where 1= Famished, starving 2= Headache, weak, cranky, low energy, 3= Want to eat now, stomach growls and feels empty, 4= Hungry - but could wait to eat, starting to feel empty but not there yet, 5= Not hungry, not full*

Table 5.3.9(b): Mean satiety scores of category 1(BMI 25-27kg/m^2) and category 2 (BMI >27kg/m^2) obese subjects before and after FOS supplementation

Meal Time		Experimental (n=30)		Student 't' Test
		Category1 (n=11))	Category 2 (n=19)	
Breakfast	**Pre (mean ± SD)**	6.18 ± 1.25	6.00 ± 0.66	0.52 ^{NS}
	Post (mean ± SD)	6.27 ± 1.27	6.00 ± 0.66	0.77 ^{NS}
	Paired t	1.00^{NS}	0.00 ^{NS}	
	% difference	1.45% ↑	0.00%	
Lunch	**Pre (mean ± SD)**	6.18 ± 0.75	5.89 ± 0.65	1.09 ^{NS}
	Post (mean ± SD)	6.18 ± 0.75	5.89 ± 0.65	1.09 ^{NS}
	Paired t	0.00^{NS}	0.00 ^{NS}	
	% difference	0.00%	0.00%	
Evening	**Pre (mean ± SD)**	5.45 ± 0.68	5.21 ± 1.03	0.69 ^{NS}
	Post (mean ± SD)	5.54 ± 0.52	5.21 ± 1.03	1.00 ^{NS}
	Paired t	1.00 ^{NS}	0.00 ^{NS}	
	% difference	1.65%↑	0.00%	
Dinner	**Pre (mean ± SD)**	6.18 ± 0.60	6.36 ± 0.68	0.75 ^{NS}
	Post (mean ± SD)	6.18 ± 0.60	6.36 ± 0.68	0.75 ^{NS}
	Paired t	0.00 ^{NS}	0.00 ^{NS}	
	% difference	0.00%	0.00%	
Mean scores	**Pre (mean ± SD)**	6.00 ± 0.43	5.86 ± 0.46	0.81 ^{NS}
	Post (mean ± SD)	6.04 ± 0.43	5.86 ± 0.46	0.81 ^{NS}
	Paired t	1.00 ^{NS}	0.00 ^{NS}	
	% difference	0.66%↑	0.00%	

- *NS = non-significant, satiety scores 6 – 10, where 6= feeling satisfied, stomach feels full and comfortable 7= feeling full, definitely don't need more food, 8= uncomfortably full 9= stuffed, very uncomfortable 10= bursting painfully full*

5.3.10 Hunger and satiety score of obese subjects with or without weight reduction after FOS supplementation

When comparison was made between obese experimental group with weight reduction and without weight reduction a significant improvement in the mean hunger scores (reduce feeling for hunger) of lunch, evening snack and dinner by 6%, 5% and 7% was reported among the obese subjects with weight reduction after FOS intervention. Though no significant difference was observed in the satiety score of both groups (with weight reduction and without weight reduction). However, satiety scores for breakfast, evening and total mean scores by 1%, 0.9% and 0.5% respectively was reported in the obese subjects with weight reduction after FOS supplementation (Table 5.3.10(a), 5.3.10(b)).

Table 5.3.10(a): Mean hunger scores of obese subjects with weight reduction and no weight reduction before and after FOS supplementation

Meal Time		Wt reduction (n=18)	No wt reduction (n=12)	Student 't' Test
		Mean ± SD	Mean ± SD	
Breakfast	Pre (mean ± SD)	4.00 ± 1.03	3.50 ± 1.00	1.31 NS
	Post (mean ± SD)	4.17 ± 1.25	3.50 ± 1.00	1.54 NS
	Paired t	1.84 NS	0.00 NS	
	% difference	4.25% ↑	0.00%	
Lunch	Pre (mean ± SD)	3.83 ± 0.62	3.25 ± 0.87	**2.15***
	Post (mean ± SD)	4.06 ± 0.80	3.25 ± 0.87	**2.61***
	Paired t	**2.20***	0.00 NS	
	% difference	6.01% ↑	0.00%	
Evening	Pre (mean ± SD)	4.17 ± 0.62	3.92 ± 0.67	1.05 NS
	Post (mean ± SD)	4.39 ± 0.78	3.83 ± 0.72	1.97 NS
	Paired t	**2.20***	1.00 NS	
	% difference	5.28% ↑	2.30%↓	
Dinner	Pre (mean ± SD)	3.89 ± 0.83	3.58 ± 0.90	0.95 NS
	Post (mean ± SD)	4.17 ± 0.86	3.50 ± 1.00	1.95 NS
	Paired t	**2.55***	1.00 NS	
	% difference	7.20% ↑	2.23% ↓	
Mean scores	Pre (mean ± SD)	3.97 ± 0.69	3.56 ± 0.79	1.93 NS
	Post (mean ± SD)	4.19 ± 0.84	3.52 ± 0.82	1.64 NS
	Paired t	1.45 NS	1.00 NS	
	% difference	5.54%↑	1.12%↓	

- *NS = non-significant, p < 0.05: *, Hunger scores 1 – 5, where 1= Famished, starving 2= Headache, weak, cranky, low energy, 3= Want to eat now, stomach growls and feels empty, 4= Hungry - but could wait to eat, starting to feel empty but not there yet, 5= Not hungry, not full. Wt (weight).*

Table 5.3.10(b): Mean satiety scores of obese subjects with weight reduction and no weight reduction before and after FOS supplementation

Meal Time		Wt reduction (n=18)	No wt reduction (n=12)	Student 't' Test
		Mean ± SD	Mean ± SD	
Breakfast	Pre (mean ± SD)	6.00 ± 0.84	6.17 ± 1.03	.48 NS
	Post (mean ± SD)	6.06 ± 0.87	6.17 ± 1.03	0.32 NS
	Paired t	1.00NS	0.00 NS	
	% difference	1.00%↑	0.00%	
Lunch	Pre (mean ± SD)	6.11 ± 0.76	5.83 ± 0.58	1.07 NS
	Post (mean ± SD)	6.11 ± 0.76	5.83 ± 0.58	1.07 NS
	Paired t	0.00 NS	0.00 NS	
	% difference	0.00%	0.00%	
Evening	Pre (mean ± SD)	5.56 ± 0.86	4.92 ± 0.90	1.96 NS
	Post (mean ± SD)	5.61 ± 0.78	4.92 ± 0.90	**2.25***
	Paired t	1.00 NS	0.00 NS	
	% difference	0.90%↑	0.00%	
Dinner	Pre (mean ± SD)	6.28 ± 0.46	6.33 ± 0.89	0.22 NS
	Post (mean ± SD)	6.28 ± 0.46	6.33 ± 0.89	0.22 NS
	Paired t	0.00 NS	0.00 NS	
	% difference	0.00%	0.00%	
Mean scores	Pre (mean ± SD)	5.98 ± 0.47	5.81 ± 0.41	1.15 NS
	Post (mean ± SD)	6.01 ± 0.47	5.81 ± 0.41	1.15 NS
	Paired t	0.41 NS	0.00 NS	
	% difference	0.50%↑	0.00%	

- *NS = non-significant, $p < 0.05$: * satiety scores 6 – 10, where 6= feeling satisfied, stomach feels full and comfortable 7= feeling full, definitely don't need more food, 8= uncomfortably full 9= stuffed, very uncomfortable 10= bursting painfully full. Wt (weight).*

5.3.11 Hunger and satiety score of obese subjects with good and poor compliance before and after FOS supplementation

As shown in Table 5.3.11(a) and 5.3.11(b) mean hunger scores of dinner and total mean scores increased significantly in the obese subjects with good compliance as compared to obese subjects with poor compliance of FOS intervention. However, no significant difference was reported as satiety score remain more or less similar for both the groups an increase of 0.5% in the total mean scores of satiety was observed in obese subjects with good compliance of FOS intake.

Table 5.3.11(a): Mean hunger scores of obese subjects with poor(≥40-50 days) and good compliance(≥51days)before and after FOS supplementation

Meal Time		Poor compliance (n=11) Mean ± SD	Good compliance (n=19) Mean ± SD	Student 't' Test
Breakfast	**Pre (mean ± SD)**	3.54± 1.12	3.94± 0.97	1.03 NS
	Post (mean ± SD)	3.63± 1.28	4.05± 0.97	0.93 NS
	Paired t	1.00NS	1.46 NS	
	% difference	2.54% ↑	2.79% ↑	
Lunch	**Pre (mean ± SD)**	3.36± 0.67	3.73±0.80	1.29 NS
	Post (mean ± SD)	3.45± 0.82	3.89± 0.93	1.30 NS
	Paired t	1.00 NS	1.84 NS	
	% difference	2.68% ↑	4.29% ↑	
Evening	**Pre (mean ± SD)**	4.00± 0.77	4.10± 0.56	0.43 NS
	Post (mean ± SD)	4.00± 1	4.26± 0.65	0.87 NS
	Paired t	0.00 NS	1.84 NS	
	% difference	0.0%	3.90% ↑	
Dinner	**Pre (mean ± SD)**	3.63± 0.80	3.84± 0.89	0.63 NS
	Post (mean ± SD)	3.63±1.02	4.05± 0.91	1.15 NS
	Paired t	0.00 NS	**2.19***	
	% difference	0.0%	5.47% ↑	
Mean scores	**Pre (mean ± SD)**	3.63± 1.02	3.90± 0.72	0.95 NS
	Post (mean ± SD)	3.68± 0.98	4.06± 0.82	1.15 NS
	Paired t	0.43 NS	**2.59***	
	% difference	1.38% ↑	4.10% ↑	

- *NS = non-significant, p < 0.05: *Hunger scores 1 – 5, where 1= Famished, starving 2= Headache, weak, cranky, low energy, 3= Want to eat now, stomach growls and feels empty, 4= Hungry - but could wait to eat, starting to feel empty but not there yet, 5= Not hungry, not full.*

able 5.3.11(b): Mean satiety scores of obese subjects with poor (≥40-50 days) and good compliance (≥51days) before and after FOS supplementation

Meal Time		Poor compliance (n=11)	Good compliance (n=19)	Student 't' Test
		Mean ± SD	Mean ± SD	
Breakfast	Pre (mean ± SD)	6.00± 1.09	6.10± 0.80	0.30 NS
	Post (mean ± SD)	6.00±1.09	6.15± 0.83	0.45 NS
	Paired t	0.00 NS	1.00 NS	
	% difference	0.0%	0.82% ↑	
Lunch	Pre (mean ± SD)	5.63± 0.67	6.21± 0.63	**2.34***
	Post (mean ± SD)	5.63± 0.67	6.21± 0.63	**2.34***
	Paired t	0.00 NS	0.00 NS	
	% difference	0.0%	0.0%	
Evening	Pre (mean ± SD)	4.90±0.70	5.52± 0.96	1.85 NS
	Post (mean ± SD)	4.90±0.70	5.57± 0.90	**2.12***
	Paired t	0.00 NS	1.00 NS	
	% difference	0.0%	0.91% ↑	
Dinner	Pre (mean ± SD)	6.09± 0.70	6.42± 0.60	1.36 NS
	Post (mean ± SD)	6.09± 0.70	6.42± 0.60	1.36 NS
	Paired t	0.00 NS	0.00 NS	
	% difference	0.0%	0.0%	
Mean scores	Pre (mean ± SD)	5.65± 0.49	6.06± 0.36	**2.60***
	Post (mean ± SD)	5.65± 0.49	6.09± 0.35	**2.79***
	Paired t	0.00 NS	1.00 NS	
	% difference	0.0%	0.5% ↑	

- *NS = non-significant, p < 0.05: * satiety scores 6 – 10, where 6= feeling satisfied, stomach feels full and comfortable 7= feeling full, definitely don't need more food, 8= uncomfortably full 9= stuffed, very uncomfortable 10= bursting painfully full*

5.3.12 Mean nutrient intake of category 1(BMI 25-27kg/m^2) and category 2 (BMI >27kg/m^2) obese subjects before and after FOS supplementation

Among obese experimental group significant reduction in the intake of energy, carbohydrates, protein and fat was reported in category 2 obese subjects (Table 5.3.12).

Table 5.3.12 Mean nutrient intake of category 1(BMI 25-27kg/m^2) and category 2 (BMI >27kg/m^2) obese subjects before and after FOS supplementation

Parameters		Experimental (n=30)		Student 't' test
		Category1 (n=11)	Category 2 (n=19)	
Energy (kcal)	**Pre**	2126.70±182.94	2608.06±331.70	**4.41****
	Post	2170.57±407.84	2275.23±295.87	0.81 NS
	Paired t test	0.41 NS	**5.06*****	
	% difference	2.06% ↑	12.76% ↓	
CHO (g)	**Pre**	334.55 ± 59.28	368.85 ± 25.66	**2.21***
	Post	324.90 ± 41.02	330.32 ± 32.08	0.40 NS
	Paired t test	0.70 NS	**4.20****	
	% difference	2.88% ↓	10.45% ↓	
Proteins (g)	**Pre**	47.77 ± 10.25	59.02 ± 7.73	**3.40****
	Post	46.92 ± 11.42	54.61 ± 7.35	**2.25***
	Paired t test	0.26 NS	**3.46****	
	% difference	1.78% ↓	7.47% ↓	
Fat (g)	**Pre**	80.18 ± 10.45	91.12 ± 14.84	**2.14***
	Post	82.81 ± 17.67	79.66 ± 15.43	0.51 NS
	Paired t test	0.52 NS	**3.33****	
	% difference	3.28% ↑	12.58% ↓	
Soluble fiber (g)	**Pre**	3.45 ± 0.82	4.02 ±1.31	1.27 NS
	Post	3.64 ±1.09	3.85 ±1.19	1.41 NS
	Paired t test	1.15 NS	1.96 NS	
	% difference	5.79↑	4.22↓	
Insoluble fiber (g)	**Pre**	11.66 ±3.15	12.47 ±4.70	0.50 NS
	Post	11.54 ± 3.40	12.40 ± 4.89	0.54 NS
	Paired t test	0.59 NS	0.60 NS	
	% difference	1.03↓	0.56↓	
Crude fiber (g)	**Pre**	6.57 ± 1.33	7.65 ±2.53	1.29 NS
	Post	6.49 ± 1.51	7.59 ±2.46	1.33 NS
	Paired t test	0.39 NS	0.75 NS	
	% difference	1.22↓	0.78↓	
Total fiber (g)	**Pre**	15.14 ± 3.78	16.50 ± 5.87	0.73 NS
	Post	15.48 ± 3.09	16.26 ± 5.92	0.54 NS
	Paired t test	0.13 NS	2.01 NS	
	% difference	0.26↑	1.45↓	

- **Significant from the baseline value at p<0.05, ** Significant from the baseline value at p<0.01, *** Significant from the baseline value at p<0.001, NS - Non Significant.*

5.3.13 Mean nutrient intake of obese subjects with weight reduction and no weight reduction before and after FOS supplementation

When comparison was made between obese subjects with weight reduction to without weight reduction, a significant reduction in the mean intake of energy, protein, CHO and fat was reported in the experimental group with weight reduction after FOS supplementation (Table 5.3.13).

5.3.14 Mean dietary intakes of obese subjects with poor (≥40-50 days) and good compliance (≥51days) before and after FOS supplementation

Results from Table 5.3.14 revealed that significant reduction in the intake of energy, CHO and protein by 11%, 12% and 4 respectively was found among the experimental group with good compliance of FOS supplementation. However, a non-significant reduction in energy, CHO, Protein and fat by 2.65%, 0.29%, 0.58% and 0.76 % respectively was found in the experimental group with poor compliance of intervention.

5.3.15 LPS and GLP-1 values of category 1(BMI 25-27kg/m^2) and category 2 (BMI >27kg/m^2) obese subjects before and after FOS supplementation

Significant difference was reported among both the categories (category1 and category2) (Table 5.3.15) with respect to the mean values of LPS and GLP-1 after FOS supplementation.

5.3.16 LPS and GLP-1 levels of obese subjects with weight reduction and no weight reduction before and after FOS supplementation

No significant difference was reported among experimental group with or without weight reduction (Table 5.3.16) with respect to the mean values of LPS and GLP-1.

Table 5.3.13 Mean nutrient intake of obese subjects with weight reduction and no weight reduction before and after FOS supplementation

Nutrient		Wt reduction (n=18)	No wt reduction (n=12)	Student 't' test
		Mean ± SD	Mean ± SD	
Energy (Kcal)	Pre (mean ± SD)	2384.84 ± 342.11	2501.64 ± 409.15	0.84 NS
	Post (mean ± SD)	2088.97 ± 306.11	2458.68 ± 259.07	**3.44****
	Paired t	**6.07*****	**3.11***	
	% difference	12.41% ↓	1.72% ↓	
CHO (g)	Pre (mean ± SD)	360.32 ± 15.49	350.21 ± 67.66	0.61 NS
	Post (mean ± SD)	318.19 ± 21.22	343.55 ± 46.00	**2.04***
	Paired t	**7.73*****	0.39 NS	
	% difference	11.69% ↓	1.90% ↓	
Protein (g)	Pre (mean ± SD)	54.67 ± 8.98	55.23 ± 12.19	0.14 NS
	Post (mean ± SD)	48.21 ± 9.39	57.16 ± 7.48	**2.76***
	Paired t	**5.40*****	0.74 NS	
	% difference	11.82% ↓	3.49% ↑	
Fat (g)	Pre (mean ± SD)	87.04 ± 16.43	87.19 ± 10.88	0.28 NS
	Post (mean ± SD)	74.69 ± 15.76	90.00 ± 11.94	**2.85***
	Paired t	**3.97****	0.54 NS	
	% difference	14.19% ↓	3.22% ↑	
Soluble Dietary Fibre (g)	Pre (mean ± SD)	3.92 ± 1.18	3.64 ± 1.23	0.63 NS
	Post (mean ± SD)	3.72 ± 1.76	3.86 ±2.01	0.31 NS
	Paired t	1.83 NS	1.19 NS	
	% difference	5.10↓	6.04↑	
Insoluble Dietary Fibre (g)	Pre (mean ± SD)	12.75 ± 4.13	11.30 ± 4.22	0.93 NS
	Post (mean ± SD)	12.53 ± 4.20	11.41 ± 4.51	0.71 NS
	Paired t	1.35 NS	1.97 NS	
	% difference	1.72↓	0.97↑	
Crude Fibre (g)	Pre (mean ± SD)	7.58 ± 2.11	6.76 ± 2.34	1.00 NS
	Post (mean ± SD)	7.33 ± 2.20	6.97 ±1.98	0.42 NS
	Paired t	**2.21***	2.01 NS	
	% difference	3.30↓	3.10↑	
Total Fibre (g)	Pre (mean ± SD)	16.79 ± 5.11	14.95 ± 5.31	0.94 NS
	Post (mean ± SD)	16.25 ± 6.16	15.28 ± 5.56	0.50 NS
	Paired t	1.98 NS	2.01 NS	
	% difference	3.20↓	2.21↑	

- **Significant from the baseline value at p<0.05, ** Significant from the baseline value at p<0.01, *** Significant from the baseline value at p<0.001, NS - Non Significant. Wt (weight)*

Table 5.3.14 Mean dietary intakes of obese subjects with poor (≥40-50 days) and good compliance (≥51days) before and after FOS supplementation

Nutrient		Poor compliance (n=11)	Good compliance (n=19)	Student 't' Test
		Mean ± SD	Mean ± SD	
Energy (Kcal)	Pre (mean ± SD)	2376± 324	2463± 396	0.62 NS
	Post (mean ± SD)	2313± 225	2192± 387	0.94 NS
	Paired t	0.56 NS	**3.52****	
	% difference	2.65% ↓	11.00% ↓	
Carbohydrate (g)	Pre (mean ± SD)	344±69	363±46	1.16 NS
	Post (mean ± SD)	343± 44	319± 25	1.86 NS
	Paired t	0.05 NS	**7.07*****	
	% difference	0.29% ↓	12.12% ↓	
Protein (g)	Pre (mean ± SD)	52± 10	56± 9	0.88 NS
	Post (mean ± SD)	54± 5	50± 11	1.13 NS
	Paired t	0.58 NS	**4.73****	
	% difference	3.85%↑	10.71% ↓	
Fat (g)	Pre (mean ± SD)	88± 17	86± 12	0.26 NS
	Post (mean ± SD)	83± 17	79± 15	0.73 NS
	Paired t	0.76 NS	2.05 NS	
	% difference	5.68% ↓	8.14% ↓	
Soluble Dietary Fibre (g)	Pre (mean ± SD)	4.09 ± 1.48	3.65 ± 0.99	0.97 NS
	Post (mean ± SD)	4.00 ±1.85	3.59 ± 1.08	0.80 NS
	Paired t	0.60 NS	0.04 NS	
	% difference	2.20↓	3.01↓	
Insoluble Dietary Fibre (g)	Pre (mean ± SD)	13.44 ± 5.04	11.44 ± 3.49	1.27 NS
	Post (mean ± SD)	13.26 ± 5.84	11.31 ± 3.55	1.17 NS
	Paired t	1.43 NS	0.24 NS	
	% difference	1.33↓	1.14↓	
Crude Fibre (g)	Pre (mean ± SD)	7.16 ± 2.45	7.31 ± 2.11	0.18 NS
	Post (mean ± SD)	7.07 ± 2.68	7.25 ± 2.29	0.20 NS
	Paired t	0.76 NS	0.47 NS	
	% difference	1.25↓	0.82↓	
Total Fibre (g)	Pre (mean ± SD)	17.61 ± 6.37	15.15 ± 4.29	1.26 NS
	Post (mean ± SD)	17.26 ± 6.46	15.05 ± 4.89	1.14 NS
	Paired t	1.30 NS	0.46 NS	
	% difference	1.98↓	0.66↓	

- *Significant from the baseline value at p<0.05, ** Significant from the baseline value at p<0.01, *** Significant from the baseline value at p<0.001, NS - Non Significant.*

Table 5.3.15: LPS and GLP-1 values of category 1(BMI 25-27kg/m^2) and category 2 (BMI >27kg/m^2) obese subjects before and after FOS supplementation

Parameters		Experimental		Student ‘t‘test
		Category1 (n=11)	Category 2 (n=19)	
LPS	Pre	22.14 ± 0.65	27.17 ± 1.56	5.25***
(pg/ml)	Post	21.07 ± 1.78	26.59 ± 2.13	3.91**
	Paired t test	1.62 NS	1.50 NS	
	% difference	4.83% ↓	2.13% ↓	
GLP-1	Pre	2.25 ± 0.14	0.92 ± 0.37	5.84***
(pmol/l)	Post	2.67 ± 0.41	1.07 ± 0.58	4.24**
	Paired t test	1.46 NS	1.12 NS	
	% difference	18.67% ↑	16.30% ↑	

- **Significant from the baseline value at p<0.05, ** Significant from the baseline value at p<0.01, *** Significant from the baseline value at p<0.001, NS - Non Significant.*

Table 5.3.16: LPS and GLP-1 levels of obese subjects with weight reduction and no weight reduction before and after FOS supplementation

Parameters	Wt reduction (n=18)	No wt reduction (n=12)	Student ‘t’ test
LPS (pg/ml)			
Pre	24.81 ± 2.53	26.93 ± 2.94	1.22 NS
Post	23.54 ± 2.93	27.05 ± 2.90	1.86 NS
Paired t test	3.43NS	1.42 NS	
% difference	5.12% ↓	0.45% ↑	
GLP-1 (pmol/l)			
Pre	1.47 ± 0.68	1.09 ± 0.80	0.81NS
Post	1.85 ± 0.94	1.11 ± 0.83	1.27 NS
Paired t test	1.97 NS	0.72 NS	
% difference	25.85% ↑	1.83% ↑	

- *NS - Non Significant.*

5.3.17 LPS and GLP-1 levels of obese subjects with poor (≥40-50 days) and good compliance (≥51days) before and after FOS supplementation

No significant difference was reported among experimental group with good and poor compliance of FOS supplementation (Table 5.3.17) with respect to the mean values of LPS and GLP-1.

Table 5.3.17: Mean endotoxins (pg/ml) and GLP-1 levels of obese subjects with poor (≥40-50 days) and good compliance (≥51days) before and after FOS supplementation

Parameters		Poor compliance (n=11)	Good compliance (n=19)	Student 't' Test
		Mean ± SD	**Mean ± SD**	
LPS	**Pre**	25.78± 2.53	25.60± 3.04	0.09 NS
(pg/ml)	**Post**	24.88± 2.13	24.96± 3.84	0.03 NS
	Paired 't' test	1.01 NS	2.09 NS	
	% difference	**3.49% ↓**	**2.50% ↓**	
GLP-1	**Post**	1.65± 0.93	1.50± 0.99	0.22 NS
(pmol/l)	**Paired 't' test**	1.13 NS	1.33 NS	
	% difference	**25.95% ↑**	**13.64% ↑**	

- *NS = non-significant.*

5.3.18 Fecal gut microflora counts in fecal samples of category 1(BMI 25-27kg/m^2) and category 2 (BMI >27kg/m^2) obese subjects before and after FOS supplementation

Table 5.3.18 revealed that, FOS supplementation resulted in higher significant increase in fecal log counts of *Lactic acid bacteria* and *Bifidobacteria* and reduction in fecal log counts of Enteric pathogens in category 2 experimental group as compared to category 1.

5.3.19 Fecal gut microflora count in fecal samples of obese subjects with weight reduction and no weight reduction of obese subjects before and after FOS supplementation

Table 5.3.19 showed effect of FOS supplementation on gut microflora in fecal samples in relation to the experimental group with weight reduction and without weight reduction after FOS supplementation. Results revealed that subjects with weight reduction had a significant increase in the fecal log counts of *Lactic acid bacteria* (p<0.001) and *Bifidobacteria (*p<0.005) after intervention. Percent decrease in the fecal log count of Enteric pathogen was significantly higher in the obese subjects with weight reduction (24%) as compared to with no weight reduction (14%) after FOS supplementation.

5.3.20 Fecal gut microbial profile of obese subjects with poor (≥40-50 days) and good compliance (≥51days) before and after FOS supplementation

As seen in Table 5.3.20 the fecal log counts of *Lactic acid bacteria* and *Bifidobacteria* showed a higher significant increment by 16%, 15% respectively in experimental group with good compliance of FOS intake. There was significant reduction in the Enteric log count among both groups, however high percent reduction by 23% was reported by the obese subjects with good compliance as compared to poor compliance of FOS supplementation.

Table 5.3.18: Fecal gut microflora counts of category 1(BMI 25-27kg/m^2) and category 2 (BMI >27kg/m^2) obese subjects before and after FOS supplementation

Parameters	Experimental		Student 't' test
	Category1 (n=11)	Category 2 (n=19)	
LAB **(log_{10}cfu/g) Pre**			
Post	7.39 ± 1.26	6.89 ± 0.99	1.18 ^{NS}
Paired t test	8.29 ± 1.62	7.93 ± 1.28	0.67 ^{NS}
% difference	**3.04***	**4.7*** **	
	12.18% ↑	15.09 ↑	
Bifido **(log_{10}cfu/g)**			
Pre	7.32 ± 0.95	7.25 ± 1.12	0.16 ^{NS}
Post	7.94 ± 1.22	8.09 ± 1.24	0.32 ^{NS}
Paired t test	1.91 ^{NS}	**3.33****	
% difference	8.47% ↑	11.59% ↓	
Enteric (log_{10}cfu/g)			
Pre Post	4.99 ± 1.10	4.98 ± 1.24	0.01 ^{NS}
Paired t test	4.11 ± 1.08	3.91 ± 0.96	0.51 ^{NS}
% difference	**3.41****	**5.15*****	
	17.64% ↓	21.49% ↓	

Significant from the baseline value at p<0.05, ** Significant from the baseline value at p<0.01, * Significant from the baseline value at p<0.001, NS - Non Significant*

Table 5.3.19: Fecal gut microflora count of obese subjects with weight reduction and no weight reduction of obese subjects before and after FOS supplementation

Parameters		Wt reduction (n=18)	No wt reduction (n=12)	Student 't' test
LAB **(log_{10}cfu/g)**	**Pre**			
Post		7.04 ± 1.15	7.13 ± 1.06	0.21 NS
Paired t test		8.37 ± 1.28	7.59 ± 1.50	0.51 NS
% difference		**6.94*** **	1.75NS	
		18.89% ↑	6.45% ↑	
Bifido **(log_{10}cfu/g)**	**Pre**			
Post		7.33 ± 1.02	7.21 ± 1.14	0.29 NS
Paired t test		8.50 ± 1.04	7.34 ± 1.15	**2.85** **
% difference		**4.65** **	0.62 NS	
		15.96% ↑	1.80% ↑	
Enteric (log_{10}cfu/g)	**Pre**			
Post		4.99 ± 1.13	4.97 ± 1.28	0.07 NS
Paired t test		3.79 ± 0.78	4.28 ± 1.22	1.32 NS
% difference		**6.42*** **	**2.56***	
		24.05% ↓	13.88% ↓	

- **Significant from the baseline value at p<0.05, ** Significant from the baseline value at p<0.01, *** Significant from the baseline value at p<0.001, NS - Non Significant.*

Table 5.3.20: Fecal microbial profile of obese subjects with poor (≥40-50 days) and good compliance (≥51days) before and after FOS supplementation

Parameters		Poor compliance (n = 11)	Good compliance (n=19)	*Student t test*
Lactic acid bacteria **(log_{10}cfu/g)**	**Pre**	7.07± 1.07	7.07± 1.14	.001 NS
	Post	7.77± 1.26	8.22±1.47	0.84 NS
	Paired t test	1.94NS	**6.67*** **	
	% difference	9.90% ↑	16.27% ↑	
Bifidobacteria **(log_{10}cfu/g)**	**Pre**	7.35± 1.04	7.23± 1.07	0.29 NS
	Post	7.53± 1.42	8.32± 1.00	1.77 NS
	Paired t test	0.57 NS	**5.06*** **	
	% difference	2.45% ↑	15.08% ↑	
Enteric Pathogen (log_{10}cfu/g)	**Pre**	4.89± 1.25	5.03± 1.15	0.31 NS
	Post	4.16± 1.28	3.88± 0.79	0.76 NS
	Paired t test	**2.18***	**7.26*** **	
	% difference	14.93%↓	22.86% ↓	

- **Significant from the baseline value at p<0.05, *** Significant from the baseline value at p<0.001, NS - Non Significant.*

5.3.21: Gastrointestinal profile of category 1(BMI 25-27kg/m^2) and category 2 (BMI >27kg/m^2) obese subjects before and after FOS supplementation

Non-significant difference was reported in category 1 and category 2 (Table 5.3.21) with respect to gastrointestinal profile after FOS supplementation.

Table 5.3.21: Gastrointestinal profile of category 1(BMI 25-27kg/m^2) and category 2 (BMI >27kg/m^2) obese subjects before and after FOS supplementation

Parameters		Experimental Group (n=51)		χ^2 Value
		Category1 (n=11)	Category 2 (n=19)	
Constipation	**Pre Intervention**			
	Present	0(0)	3(84)	**0.57** NS
	Absent	11(100	16(16)	
	Post intervention			
	Present	0(0)	1(6)	**0.07** NS
	Absent	11(100)	18(94)	
	χ^2 Value	**0.00** NS	**0.27** NS	
Diarrhea	**Pre Intervention**			
	Present	0(0)	1(6)	**0.07** NS
	Absent	11(100)	18 (94)	
	Post intervention			
	Present			
	Absent	0(0)	0 (0)	**0.00** NS
		11(100)	19 (100)	
	χ^2 Value	**0.00** NS	**0.01** NS	
Flatulence	**Pre Intervention**			
	Present	0(0)	2 (11)	**0.12** NS
	Absent	11(100)	17 (89)	
	Post intervention			
	Present	1 (9)	3 (16)	**0.001** NS
	Absent	10 (91)	16 (84)	
	χ^2 Value	**0.01** NS	**0.01** NS	

- *Figures in parenthesis represent percent of subjects; NS - Non Significant*

5.3.22: GI profile of obese subjects with weight reduction and no weight reduction before and after FOS supplementation

No significant difference was reported among experimental group with weight reduction and without weight reduction (Table 5.3.22). An increase in the percent subjects suffering with flatulence among both groups was reported after FOS supplementation.

Table 5.3.22: GI profile of obese subjects with weight reduction and no weight reduction before and after FOS supplementation

Parameters		Wt reduction	No wt reduction	χ^2 Value
		(n=18)	(n=12)	
Constipation	**Pre Intervention**			
	Present	3 (17)	0 (0)	**0.75** NS
	Absent	15 (83)	12 (100)	
	Post intervention			
	Present	1 (6)	0 (0)	**0.04** NS
	Absent	17 (94)	12 (100)	
	χ^2 Value	**0.28** NS	**0.00** NS	
Diarrhea	**Pre Intervention**			
	Present	1 (6)	0 (0)	**0.04** NS
	Absent	17 (94)	12 (100)	
	Post intervention			
	Present	0 (0)	0(0)	**0.00** NS
	Absent	18 (100)	12 (100)	
	χ^2 Value	**0.01** NS	**0.00** NS	
Flatulence	**Pre Intervention**			
	Present	2 (11)	0(0)	**0.20** NS
	Absent	16 (89)	12 (100)	
	Post intervention			
	Present	3 (17)	1 (8)	**0.01** NS
	Absent	15 (83)	11 (92)	
	χ^2 Value	**0.01** NS	**0.01** NS	

- *Figures in parenthesis represent percent of subjects; NS - Non Significant.*

Result Highlights of Phase III

- Anthropometric parameters revealed that there was significant reduction 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.
- Hunger and satiety score data revealed that total mean hunger score of the supplemented group increased by 3.15% after FOS supplementation.
- Total mean hunger score increased significantly in category 2 obese subjects, with weight reduction and good compliance of FOS intervention.
- The dietary profile data showed that there was reduction in the energy, protein, CHO and fat BY 8%, 6%, 8%, 7% after FOS supplementation.
- Significant reduction in the intake of calories was found in experimental group with weight reduction and good compliance of FOS intervention.
- GLP-1 values increased by 17% and LPS values significantly decreased by 2.81% 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.

Discussion

Obesity is a multi-factorial disease which may be managed by innovative means through the use of nutraceuticals such as prebiotics. Very little information is available on effects of FOS supplementation on weight reduction in obese adults. This study tried to address this issue with an aim to study the metabolic and gut microbial compositional changes in FOS supplemented obese adults. In the present study 12 g FOS supplementation for 60 days brought noteworthy improvements in gut incretin (GLP-1), gut microbial composition (*LAB, Bifidobacteria* and Enteric pathogen), hunger score, dietary intake anthropometric parameters and reduction in LPS (endotoxin) levels.

Daily intake of 12 g FOS for 60 days brought about a significant reduction in the anthropometric parameters i.e. weight, BMI, WC, WHR and percent body fat. The mechanism of achieving weight loss and improved anthropometric parameters can be explained through improved gut health in terms of increased colonization of *lactobacilli* and *Bifidobacteria* with reduction in Enteric pathogen counts. This eubiosis may have caused improved GLP-1 secretion (17%) and lowered LPS level among obese adults. This improved GLP-1 may have affected the hunger and satiety centers of hypothalamus as reported in results where significant reduction in the feeling of hunger ($p<0.05$) was reported among the experimental group, thus affecting the total calorie intake, which was reported to get reduced by 8% resulting in weight loss (Cani and Delzenne 2009).

Evidence from animal studies has generally shown that oligofructose supplementation promotes weight loss and improves energy homeostasis in obese models (Parnell Reimer 2009; Urias-Silvas et al., 2008). Cani and Delzenne in 2011 studied the effects of oligofructose supplementation on weight loss, gut flora and gut satiety hormones using randomized, double-blind, placebo-controlled in obese adults, the results of the present trial support the findings of these studies that also showed a significant reduction in body weight because of fat loss that is independent of any other lifestyle changes. Similar results were also reported in recent study where in, oligofructose supplementation for 12 weeks, resulted in decrease body weight by 1.23 % (1.03 ± 0.43kg), primarily by losing fat mass (2.73%), and could help manage caloric intake in overweight and obese adults (Parnell Reimer 2009). Another study by Lairon 2005 reported that FOS intervention suppresses high-fat diet-induced body fat accumulation, and inhibit intestinal absorption of dietary fat.

Cani and coworkers in 2009 reported effect of FOS on weight reduction where 48 healthy adults with a body mass index (in kg/m^2) > 25 received 21 g FOS/day or placebo (maltodextrin) for 12 weeks. There was a reduction in body weight of 1.03 ± 0.43 kg with FOS supplementation, whereas the control group experienced an increase in body weight of 0.45 ± 0.31 kg over 12 weeks ($p = 0.01$). These investigators also attributed the weight loss in FOS fed subjects to reduced orexogenic hormone ghrelin which further reduced hunger in obese subjects.

Present study revealed 14% and 10% increment in fecal log counts of LAB and *Bifidobacteria* respectively and 20% reduction in Enteric pathogen counts as a result of 12 g FOS supplementation. A similar study conducted in mice showed that FOS intake increased the counts of *Bifidobacteria* (Cani and Delzenne 2010; Kok et al., 1998). *Lactic acid bacteria* and *Bifidobacteria* were screened for their ability to ferment FOS showed that of 28 strains of *LAB* and *Bifidobacteria* examined, 12 of 16 LAB strains and 7 of 8 *Bifidobacteria* strains fermented FOS (Handan K and Robert WH, 2000). Similar increments in the *LAB* and *Bifidobacteria* counts were reported in a study where, in the small intestine, the viable counts of *Bifidobacterium* and *lactobacillus* significantly increased in broilers, fed diet with 4g/kg FOS (ZR XU et al., 2003). Several researches also supports present study findings they assessed the effects of oligofructose consumption in healthy volunteers and found increased content of *Bifidobacteria* and *Lactobacillus* in faeces while *Bacteroides* get reduced (Shinohara et al., 2010; Giovanni et al., 2010).

The most widely reported mechanism with oligofructose in management of obesity is via modification of satiety hormone response. As food moves through the upper and lower gastrointestinal (GI) tract, various satiety-related hormones are released and signals are sent to the brain. Many of these gut hormones (i.e., ghrelin, polypeptide YY, glucagon-like peptide) are thought to regulate satiety, food intake, and overall energy balance (Chaudhari and Salem 2008). Cani and Delzenne 2010 have reported increased plasma GLP-1, GIP and PYY with inulin-type fructans in rodents, where feeding rats with the prebiotic fibre oligofructose led to an increase in jejunal GIP concentrations and caecal GLP-1 (Kok 1998). FOS fed to the animals (mice) was also associated with increased portal GLP-1 levels. Prebiotic feeding promotes GLP-1 synthesis (mRNA and peptide content) in the proximal colon by a mechanism linked to the differentiation of precursor cells into enteroendocrine cells (Knop et al., 2010). Moreover, in another set of experiments performed in high-fat diet induced obesity and type 2 diabetes, the modulation of gut microbiota using prebiotic protects against body weight gain, fat mass development (visceral, epidydimal and subcutaneous), glucose intolerance, and hepatic insulin resistance (Cani et al., 2006).

In our study the feeling of hunger during lunch hours reduced significantly in the obese subjects fed with 12g FOS ($p<0.05$) by 3.15% thus, resulting in their decreased food intake. Another mechanism reported for reduced hunger has been explained by increased breath hydrogen excretion by ≈3 folds (a marker of gut microbiotia fermentation) followed by prebiotic treatment (Cani et al., 2009). Prebiotic supplementation was associated with increase in plasma gut peptide concentration (GLP-1, PYY) as reported earlier which may contribute in part to changes in appetite sensation and glucose excretion response after a meal in healthy subjects (; Cani et al., 2006: Whelan et al., 2006; Parnell and Reimer 2009; Genta et al., 2009).

Recently in a randomized, double-blind, placebo-controlled clinical study in 100 overweight healthy Chinese adults investigated the effect of different dosages of dietary supplementation with wheat dextrin, on satiety over time. Subjects were randomized by body mass index and energy intake and assigned to receive either placebo or 8, 14, 18, or 24 g/day of wheat dextrin (*n* = 20 volunteers per group). On days −2, 0, 2, 5, 7, 14, and 21, short-term satiety (up to 120 min) was evaluated with a visual analog scale, and hunger feeling status was assessed with Likert scale. Wheat dextrin increased short-term satiety, which was time and dosage correlated. The hunger feeling status was evaluated for 21 days. The hunger feeling decreased significantly from day 5 to the end of the evaluation for the group 24 g and from day

7 for the groups 14 and 18 g. By day 5, the group 24 g showed significantly longer time to hunger between meals compared with placebo. The caloric intake per day was evaluated during a 9 week study. A significant decrease in caloric intake was seen from week 2 to the end of the 9 week study for the groups 14 g, 18 g and 24 g of wheat dextrin (Guerin-Deremaux et al., 2011). This data also support our result finding where good compliance of FOS intervention (≥50 days) results in eubiosis, better GLP-1 levels and more weight reduction.

As reported earlier that FOS intervention resulted in reduced feeling for hunger thus affecting food intake which is reflected in this study where total dietary intake of subjects reduced significantly this was also supported by Cani et al., 2009 who reported that in prebiotic treated subjects total dietary intake (energy, protein, carbohydrate, fat, dietary fiber) was lowered by ≈ 6%.

The evidences from animal models suggest that diet plays an important role in changing the gut microflora composition (Walker et al., 2011; Scott et al., 2008; Wu et al., 2011). If the firmicutes colonize more they are likely to produce LPS which is a known inflammatory marker for various NCD's including obesity (Zhao 2013; Laetitia et al., 2013). Present findings of the study revealed supplementation of 12g FOS bring about significant reduction (2.81%) in LPS levels of obese adults.

Zhao 2013; Cani et al., 2007; Neves et al., 2013 reported that administration of oligofructose to high-fat-fed mice increased the abundance of *Bifidobacterium* and lactobacilli (Everard et al., 2013; Slavin 2013) and normalized endotoxaemia () and the inflammatory tone associated with the high-fat diet (Martin et al., 2009; Million et al., 2013). The administration of oligofructose to genetically obese mice induced increases in the levels of *Lactobacillus, Bifidobacterium, and C. coccoides, E. rectale* , which led to a reduction in intestinal permeability and an improvement in tight junction integrity and inflammatory markers, such as lipopolysaccharides and cytokines (Cani et al., 2007; Million et al., 2013).

Another study revealed that administration of prebiotics in HF-fed mice abolished metabolic endotoxemia and normalized the CD11c subpopulation of macrophages in adipose tissue, which is the primary population of increased adipose tissue macrophages in obesity. Administration of prebiotics also reduced the total fat mass, the mass of the different fat pads (i.e., s.c., mesEnteric, and epididymal), and the body weight (Osborn and Olefsky 2012).

Together these results suggests role of fermentable FOS in explaining the reduced weight and the underlying mechanism behind it. Thus, it can be concluded that FOS is an encouraging therapy for management of obesity in terms of increasing satiety, increasing beneficial gut microbiota and reducing harmful pathogens in the colon, stimulating production of GLP-1 and reducing endotoxemia. Longitudinal studies are needed to determine the sustainability of the effects of FOS consumption on the weight reduction.

<u>Concluding Remarks</u>

FOS is an attractive therapy for the management of obesity. As FOS supplementation resulted in reduction in the body weight, hunger, LPS and GLP-1 through the mechanism of colonization of beneficial microorganisms. Indicating an overall control on the metabolic diseases like obesity.