CHAPTER 5

RESULTS AND DISCUSSION

Recent literature review on obesity and prebiotic dietary fiber suggested that FOS is a potential prebiotic that can modulate gut-microflora and also plays a vital role in modulating molecular mechanisms that regulate and/or help modulate gut satietogenic hormones affecting appetite – satiety signaling centers in brain and achieving weight-loss. Hence, the present study entitled "Acceptability Trials of Fructooligosaccharide (FOS) Added Popular Indian Recipes and Impact Evaluation of FOS Intervention in Modulating Gut Microflora, Gut Satietogenic Hormones and Anthropometric Indices of Young Obese Bank Employees of Urban Vadodara: A FAT – FIT Study" was conducted and the results are presented, discussed and interpreted in this chapter. These results are presented in to four main phases according to the objectives of the study.

PHASE I – SNAP-SHOTING THE PRESENCE OF OBESITY IN YOUNG BANKS EMPLOYEES OF URBAN VADODARA

- Screening the subjects from various banks of Vadodara city for their anthropometric measurements, body composition analysis, random blood sugar and blood pressure.
- To classify screened bank employees in various categories of BMI
- Determining presence of obesity according to WC, WSR, WHR and Body- fat percentage in screened bank employees
- Determining the presence of hypertension in screened bank employees
- Associations and correlation amongst anthropometric and biophysical parameters of screened bank employees

PHASE II–COMPARISON BETWEEN BASELINE PARAMETERS OF NON-OBESE AND OBESE BANK EMPLOYEES WITH REGARDS TO:

- Socio economic status (SES), anthropometric measurements, family medical history, personal medical history, defecation profile, personal habits, habituation profile, physical activity pattern, hunger and satiety scale, depression scores and dietary intakes of non obese and obese subjects

- To study gut-microflora of non-obese and obese subjects with regards to
  - *Bifidobacterium*, *Lactobacillus*, *Clostridium* and *Bacteriodes*

- To determine the baseline levels of six Gut-hormones
  - Glucagon-like Peptide -1 (GLP-1) - Gut Incretin
  - Gastric Inhibitor Polypeptide (GIP) - Gut Incretin
  - Peptide YY (PYY) - Anorexigenic hormone
  - Ghrelin (Hunger hormone) - Orexogenic hormone
  - Leptin (Energy Expenditure hormone) - Anorexigenic hormone
  - Insulin - - Anorexigenic hormone

- Correlation of weight with various parameters of non-obese and obese bank employees and regression analysis to identify strongest predictor of obesity

PHASE III – TO STUDY IMPACT OF FOS INTERVENTION FOR 90 DAYS IN OBESE SUBJECTS: A RANDOMIZED CONTROL TRIAL

To Study how efficiently FOS supplementation in obese subjects for period of 90 days can change or modulate parameters in terms of:

- Anthropometric and biophysical measurements
- Dietary parameters, hunger and satiety scores
- Depression and defecation profile

- Fasting plasma levels of gut-hormones : GLP-1, GIP, PYY, Ghrelin, Leptin and Insulin post intervention
- Gut-microflora: *Bifidobacteria, Lactobacillus, Clostridium, Bacteriodes* post intervention
- Correlation of gut-hormones and gut-microflora with various parameters
- Regression analysis for identifying strongest predictor or obesity in obese bank employees
- Follow up data for time-point interval analysis

PHASE IV– ACCEPTABILITY TRIALS OF FOS ADDED POPULAR INDIAN RECIPES

- Analyzing physical properties of FOS addition at varying levels in four popular Indian snacks having different cooking methods and comparing with their standard products namely:

  - *Dudhi Muthiya* - Steamed
  - *Vegetable Cheela* - Shallow fried
  - *Handwa* - Baked
  - *Veg. Mini Samosas* - Deep Fried

- Conducting the organoleptic evaluation of the developed products using 9 point Hedonic scale.

PHASE - I

SNAP-SHOTING THE PRESENCE OF OBESITY IN YOUNG BANKS EMPLOYEES OF URBAN VADODARA

Results of Phase-I are discussed under following sections

Section 5.1.1: Screening of employees from various banks of Vadodara city for their anthropometric measurements, body composition analysis, random blood sugar and blood pressure.

Section 5.1.2: Allocation of screened bank employees in various categories of BMI

Section 5.1.3: Determining presence of obesity according to WC, WSR, WHR and body- fat percentage in screened bank employees

Section 5.1.4: Determining the presence of hypertension in screened bank employees

Section 5.1.5: Associations and correlation amongst anthropometric and biophysical parameters of screened bank employees

Section 5.1.1: Screening subjects from various banks of Vadodara city for their anthropometric measurements, body composition analysis, random blood sugar and blood pressure

The basic health screening camp organized at various private banks of Vadodara city, brought about participation of 650 bank employees. As shown in Table 5.1 and graphically represented in Figure 5.1, majority of the employees were males (74.77%) and one-fourth (25.23%) of them were females.

Table 5.1: Distribution of screened bank employees according to gender [N=650]		
Gender	**Number of Subjects [N=650]**	**Percent Subjects [%]**
Male	**486**	**74.77**
Female	**164**	**25.23**

Age wise distribution of employees ranging from 20 – 60 years in Table 5.2 revealed that 42% of obese employees belonged to age range of 26 – 30 years followed by 27% in age range of 31 – 35 years

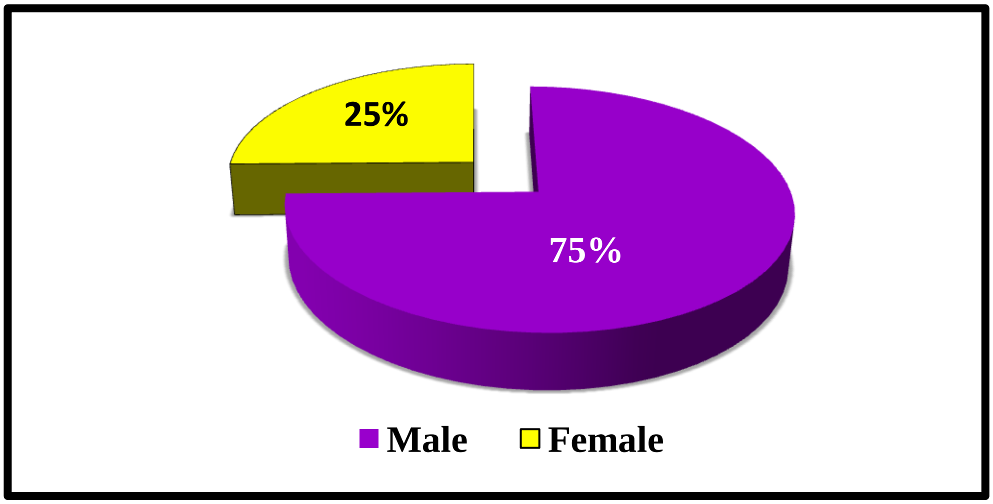

Figure 5.1: Percentage of male and female bank employees screened

Table 5.2: Distribution of screened bank employees according to various categories of age

Age Category [yrs]	Male [N=486]	Male [%]	Female [N=164]	Female [%]	Total [N=650]	Total [%]
20 – 25	85	13.07	54	8.31	139	21.38
26 – 30	202	31.08	71	10.92	273	42
31 – 35	143	22	31	4.77	174	26.77
36 - 40	49	7.54	2	0.31	51	7.85
≥ 41	7	1.08	6	0.92	13	2

Figure 5.2 represents that in age range of 26 -30, out of 42% employees 31 % were males and 11 % were females. Similarly in age range of 31 – 35, 22% were males and 5 % were females.

According to Table 5.3 depicting anthropometric profile of screened bank employees, mean age of bank employees was 29.47 ± 4.64 years with not much difference between the age of men and women.

Average height of male employees was 170.20 ± 6.16 cm and for females was 156.44 ± 6.67 cm. Mean weight of male employees was 70.62 ± 12.18 kg and their female counterparts was 58.21 ± 12.20 kg.

Mean BMI values demonstrated employees in overweight category according to Asia pacific BMI classification for Indians. Waist circumference (WC) measurements of male and female individually depicted employees not having abdominal obesity but standard deviations for male and female were too high (9.68 and 11.76 respectively).

Similarly, results for waist to stature ratio (WSR) for abdominal obesity and waist to hip ratio (WHR) for central obesity did not depict any derangement.

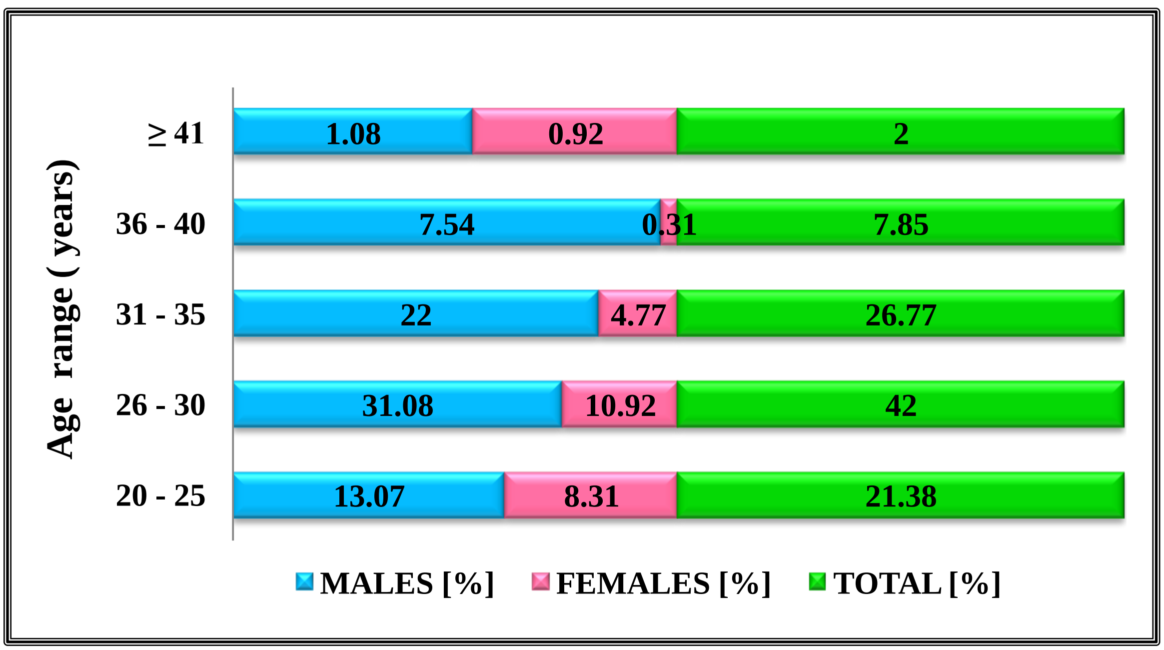

Figure 5.2: Percent gender and age wise classification of screened bank employees [N=650]

Table 5.3: Mean values of anthropometric profile of screened bank employees [N=650]

Parameter	Male [N=486]	Female [N=164]	Total [N=650]
	Mean ± SD	Mean ± SD	Mean ± SD
Age [yrs]	29.9 ± 4.56	28.18 ± 4.63	29.47 ± 4.64
Height [cm]	170.20 ± 6.16	156.44 ± 6.67	166.73 ± 8.68
Weight [cm]	70.62 ± 12.18	58.21 ± 12.20	67.49 ± 13.31
BMI [kg/m^2]	24.35 ± 3.79	23.78 ± 4.72	24.20 ± 4.05
Waist Circumference [cm]	87.90 ± 9.68	78.23 ± 11.76	85.46 ± 11.07
Hip Circumference [cm]	98.85 ± 41.94	94.45 ± 9.45	96.35 ± 9.19
WHR	0.90 ± 0.07	0.83 ± 0.07	0.89 ± 0.07
WSR	0.52 ± 0.06	0.5 ± 0.08	0.51 ± 0.06

Results of biophysical and biochemical profile of screened bank employees as shown in Table 5.4 revealed body fat % in obese category for male, female and total mean values (25.82%, 32.70% and 27.56% respectively).

Mean values of basal metabolic rate (BMR) for screened male employees were on higher side as compared to female employees. Mean values (mmHg) for systolic blood pressure (SBP) depicted that male bank employees had elevated SBP and were pre-hypertensive's according to JNC VII as compared to females depicting normal SBP values. However, diastolic blood pressure values and random blood sugar values were observed in normal range.

Table 5.4: Mean values for biophysical and biochemical profile of screened bank employees [N=650]

Parameter	Male [N=486]	Female [N=164]	Total [N=650]
	Mean ± SD	Mean ± SD	Mean ± SD
Body fat [%]	25.82 ± 5.70	32.70 ± 6.34	27.56 ± 6.59
BMR [kcals]	1607.03 ± 219.39	1309.32 ± 208.90	1531.92±252.34
Systolic B.P. [mmHg]	130.81 ± 13.59	116.65 ± 16.32	127.24 ± 15.58
Diastolic B.P. [mmHg]	79.39 ± 10.68	71.85 ± 10.42	77.49 ± 11.10
RBS [mg%]	102.47 ± 40.87	93.96 ± 14.79	100.36 ± 36.37

5.1.2: Allocation of screened bank employees in various categories of BMI

Further, classifying employees according to their BMI as shown in Figure 5.3 revealed that 20% of screened bank employees were overweight, 34% were in Grade-I category, followed by 7% in Grade-II category of obesity classification. Employees having normal BMI were found to be 32% and 7% of employees were underweight.

Moving forward with percentage of gender integrities, Table 5.5 and Figure 5.4 revealed that out of 34 % of employees belonging to Grade I obesity with moderate risk of co-morbidities, 28% were males and 6% were females followed by 20% of overweight employees posing increased risk of co-morbidities (15% males and 5% females). In Grade II obesity, out of 7% employees 5% males and 2% females were heading towards severe risk of co-morbidities. However, 32% of employees (22% male and 10% females) were in normal range of BMI (18.5 – 22.9) and 7% of employees were found to be underweight out of which 4 % males and 3% females were probable candidates for developing other clinical complications.

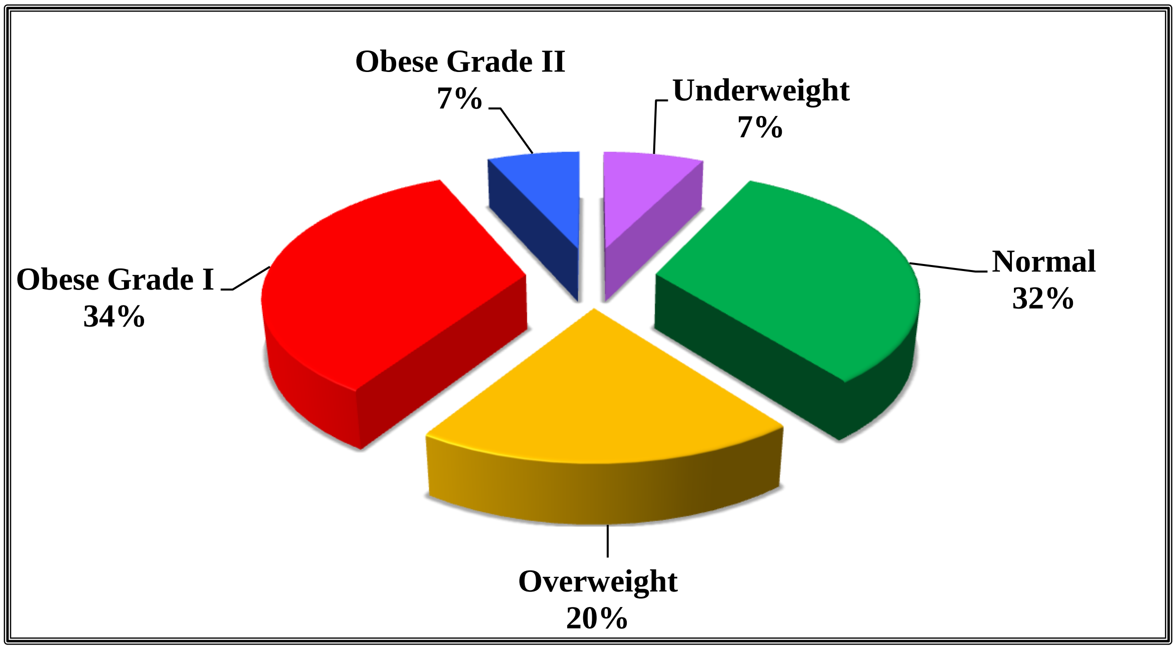

Figure 5.3: Percent presence of screened bank employees according to Asia pacific BMI classification for Indians [N=650]

Table 5.5: Distribution of screened bank employees according to Asia pacific BMI classification for Indians [JAPI 2009 & WHO 2000] N=650

Classification of BMI	Risk of Co-morbidities	Male N 486 [%]	Female N 164 [%]	Total N 650 [%]
Underweight [< 18.5]	Low	30 [4.62]	18 [2.77]	48 [7.38]
Normal [18.5 - 22.9]	Acceptable risk	147 [22.61]	62 [9.54]	209 [32.16]
Overweight [23.0 - 24.9]	Increased risk	98 [15.08]	29 [4.46]	127 [19.54]
Obese Grade I [25.0 - 29.9]	Moderate risk	182 [28]	40 [6.15]	222 [34.15]
Obese Grade II [≥ 30]	Severe risk	29 [4.46]	15 [2.31]	44 [6.77]

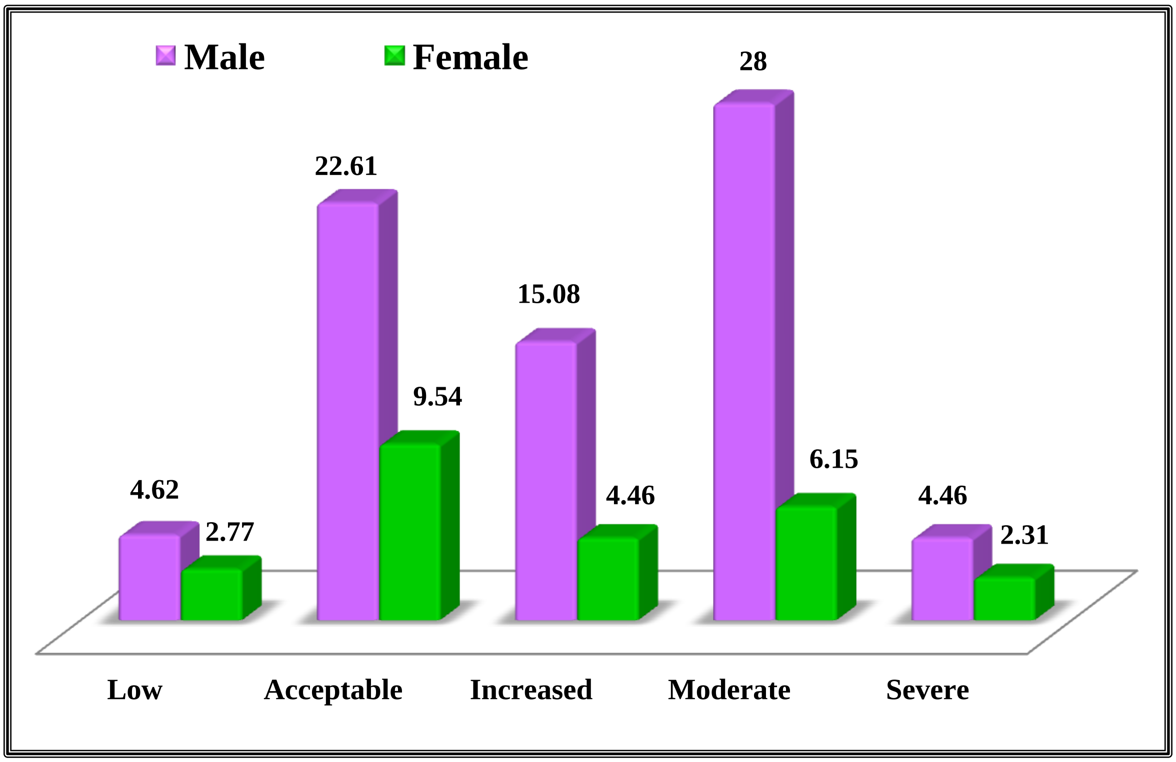

Figure 5.4: Gender wise risk of co-morbidities in screened bank employees

Table 5.6 and Table 5.7 depicts mean anthropometric and biophysical values of male bank employee's categorized according to BMI classification.

According to Table 5.6, significant variance is observed between advancement of age and increase in obesity grading. No significant variance was observed in height of male employees. Weight, BMI, WC, HC and WHR varied proportionally with increasing grades of obesity.

With respect to biophysical parameters as depicted in Table 5.7 significant variance was observed in body fat %, BMR, systolic blood pressure and diastolic blood pressure. All parameters proportionally increased with increase in obesity grading. However, no significant difference was observed in random blood sugar values of male bank employees.

As shown in Table 5.8 with respect to mean anthropometric values of female bank employees, similar trend as male employees was observed. Age advancement was proportional to increase in obesity grading.

No significant variance was observed in mean height of female employees in comparison to different categories of BMI. Weight, BMI, WC, HC and WHR varied proportionally with increasing grades of obesity of female bank employees.

Table 5.9 depicts mean biophysical values of female bank employees. Body fat %, BMR, systolic blood pressure and diastolic blood pressure values increased significantly with increasing BMI categories.

However, diastolic blood pressure was within normal category of hypertension classification. No significant variance was observed in random blood sugar values of female bank employees

Table 5.6: Mean values of anthropometric parameters of male bank employees according to BMI classification [N=486]

BMI Category	Age [yrs]	Height [cm]	Weight [kg]	BMI [kg/m2]	WC [cm]	HC [cm]	WHR
Underweight	27.57±3.85^{a}	172.26±6.68^{a}	51.59±3.86^{a}	17.40 ± 1.04^{a}	72.93 ± 4.72^{a}	84.20 ± 4.09^{a}	0.87 ± 0.05^{a}
Normal	29.00±4.83^{ab}	169.60±6.27^{b*}	60.92±6.19^{b***}	21.14 ± 1.32^{b***}	80.94 ± 6.26^{b***}	90.88 ± 5.16^{b***}	0.89 ± 0.06^{b*}
Overweight	29.84±4.00^{bc*}	169.93±6.11^{a}	69.48±5.34^{c***}	24.03 ± 0.51^{c***}	87.61 ± 4.86^{c***}	96.28 ± 3.57^{c***}	0.91 ± 0.04^{c**}
Obese Gr- I	30.93±4.36^{bd***}	170.54±5.76^{a}	78.58±6.55^{d***}	27.00 ± 1.38^{d***}	93.49 ± 6.01^{d***}	107.23 ± 67.04^{d***}	0.91 ± 0.09^{c*d}
Obese Gr- II	30.66±5.28^{bcd*}	169.97±7.33^{a}	93.40±11.86^{e***}	32.27 ± 2.93^{e***}	104.62 ± 9.65^{e***}	110.52 ± 6.02***	0.95 ± 0.06^{d***}
F value	**6.158*****	**1.391^{NS}**	**301.56*****	**813.59*****	**186.997*****	**134.335*****	**7.276*****
F critical	**4.696**	**2.39**	**4.696**	**4.696**	**4.696**	**4.696**	**4.696**

Table 5.7: Mean values of biophysical parameters of male bank employees according to BMI classification [N = 486]

BMI Category	Body-fat [%]	BMR[Kcals]	Systolic BP [mmHg]	Diastolic BP [mmHg]	RBS [mg%]
Underweight	14.98 ± 6.11^{a}	1300.57 ± 106.80^{a}	123.90 ±9.13^{a}	73.47 ± 8.82^{a}	98.83 ± 26.88^{a}
Normal	21.72 ± 3.58^{b***}	1442.20 ± 125.51^{b***}	126.25 ± 12.07^{a}	75.86 ± 9.36^{a}	95.89 ± 18.90^{a}
Overweight	26.09 ± 2.68^{c***}	1588.18 ± 120.64^{c***}	130.66 ± 12.15^{b**}	80.59 ± 8.80^{b***}	96.63 ± 14.91^{a}
Obese Gr- I	29.41 ± 2.70^{d***}	1738.31 ± 137.16^{d***}	134.14 ± 14.38^{c*}	81.61 ± 11.71^{c*}	104.83 ± 48.16^{a}
Obese Gr- II	34.44 ± 3.33^{e***}	1999.41 ± 227.45^{e***}	140.72 ± 13.05^{d*}	85.38 ± 10.36^{d*}	103.21 ± 26.82^{a}
F value	**239.232*****	**195.289*****	**14.036*****	**11.833*****	**0.473^{NS}**
F critical	**4.696**	**4.696**	**4.696**	**4.696**	**2.411**

Note: a, b, c,….k The non identical letters in any two rows within the column denote a significant difference at level of p<0.05 *, p<0.01, p<0.001 ***. The identical letters a, a, in any two rows within the column denote non-significance denoted by NS.**

Table 5.8: Mean values of anthropometric parameters of female bank employees according to BMI classification [N = 164]

BMI Category	Age [yrs]	Height [cm]	Weight [kg]	BMI [kg/m2]	WC [cm]	HC [cm]	WHR
Underweight	25.33 ± 2.28^{a}	158.01 ± 7.54^{a}	43.69 ± 4.16^{a}	17.48 ± 0.76^{a}	66.78 ± 5.52^{a}	83.06 ± 3.93^{a}	0.80 ± 0.05^{a}
Normal	26.56 ± 2.71^{a}	156.47 ± 5.29^{a}	51.06 ± 4.28^{b***}	20.85 ± 1.29^{b***}	72.18 ± 6.95^{b**}	88.77 ± 4.19^{b***}	0.81 ± 0.06^{a}
Overweight	28.62 ± 4.59^{b***}	156.68 ± 6.45^{a}	58.64 ± 4.91^{c***}	23.86 ± 0.61^{c***}	78.28 ± 7.39^{c***}	95.07 ± 3.62^{c***}	0.82 ± 0.08^{a}
Obese Gr- I	30.70 ± 5.99^{c***}	155.95 ± 8.69^{a}	66.31 ± 7.23^{d***}	27.22 ± 1.45^{d**}	85.61 ± 9.86^{d***}	101.28 ± 5.99^{d***}	0.85 ± 0.09^{a*b}
Obese Gr- II	30.67 ± 4.69^{d*}	155.31 ±5.35^{a}	82.71 ± 10.44^{e***}	34.16 ± 2.47^{e***}	97.20 ± 10.56^{e***}	112.20 ± 6.06^{e***}	0.87 ± 0.07^{b**}
F value	**10.606*** **	**0.414^{NS}**	**130.802*** **	**457.249*** **	**46.941*** **	**120.296*** **	**2.867***
F critical	**4.787**	**2.428**	**4.863**	**4.863**	**4.86**	**4.863**	**2.428**

Table 5.9: Mean values of biophysical parameters of female bank employees according to BMI classification [N = 164]

BMI Category	Body-fat [%]	BMR [kcals]	Systolic BP [mmHg]	Diastolic BP [mmHg]	RBS [mg%]
Underweight	22.42 ± 2.27^{a}	1077.33 ± 84.98^{a}	113.89 ± 9.85^{a}	70.78 ± 7.63^{a}	95.00 ± 2.83^{a}
Normal	29.18 ± 2.76^{b***}	1193.77 ± 82.86^{b***}	110.76 ± 11.78^{a}	68.50 ± 9.56^{a}	90.27 ± 12.15^{a}
Overweight	33.60 ± 2.25^{c***}	1314.24 ± 98.25^{c***}	116.24 ± 10.88^{ac*}	71.00 ± 8.43^{ab}	89.89 ± 5.46^{a}
Obese Gr- I	38.25 ± 2.60^{d***}	1440.03 ± 148.90^{d***}	125.45 ± 24.07^{ad***}	76.43 ± 12.23^{ab***d*}	94.34 ± 16.38^{a}
Obese Gr- II	43.10 ± 1.99^{e***}	1707.20 ± 203.84^{e***}	121.60 ± 10.72^{b***d}	76.47 ± 10.01^{ac**d}	104.82 ± 18.36^{b*}
F value	**217.736*** **	**85.461*** **	**6.083*** **	**4.768*** **	**2.194^{NS}**
F critical	**4.863**	**4.863**	**4.863**	**3.439**	**2.498**

Note: a, b, c The non identical letters in any two rows within the column denote a significant difference at level of p<0.05 *, p<0.01, p<0.001 ***. The identical letters a,a, in any two rows within the column denote non-significance denoted by NS.**

5.1.3: Determining presence of obesity according to WC, WSR, WHR and body-fat % in screened bank employees

Presence of abdominal obesity according to waist circumference as shown in Table 5.10 revealed 44 % of total bank employees having abdominal obesity. According to gender distribution as graphically represented in Figure 5.5, around 33 % of male employees and 11% of female bank employees had abdominal obesity.

Table 5.10: Presence of abdominal obesity according to waist circumference [WC] in bank employees subjected to screening

Abdominal Obesity	Male N = 486 [%]	Female N = 164 [%]	Total N = 650 [%]
Present [Male ≥ 90cm;Female ≥ 80cm]	**214 [32.92]**	**70 [10.77]**	**284 [43.69]**
Absent [Male < 90cm;Female < 80cm]	272 [41.85]	94 [14.46]	366 [56.31]

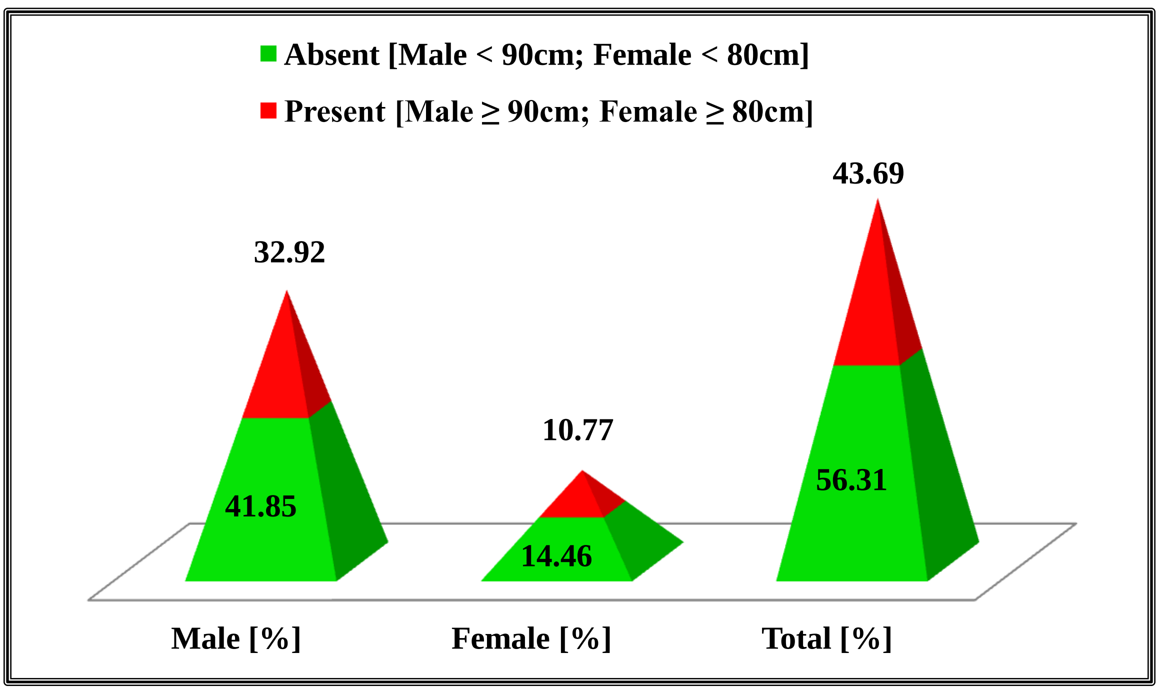

Figure 5.5: Percentage of male and female employees with abdominal obesity according to waist circumference

Table 5.11 depicts that presence of abdominal obesity according to waist stature ratio was found in 30% of bank employees.

Table 5.11: Presence of abdominal obesity according to waist stature ratio [WSR] in bank employees subjected to screening

Abdominal Obesity	Male N = 486 [%]	Female N = 164 [%]	Total N = 650 [%]
Present [Male ≥ 0.55; Female ≥ 0.53]	**143 [22]**	**54 [8.31]**	**197 [30.31]**
Absent [Male < 0.55; Female < 0.53]	343 [52.76]	110 [16.92]	453 [69.69]

According to gender distribution as graphically represented in Figure 5.6, around 22 % of male employees and 8 % of female bank employees had abdominal obesity

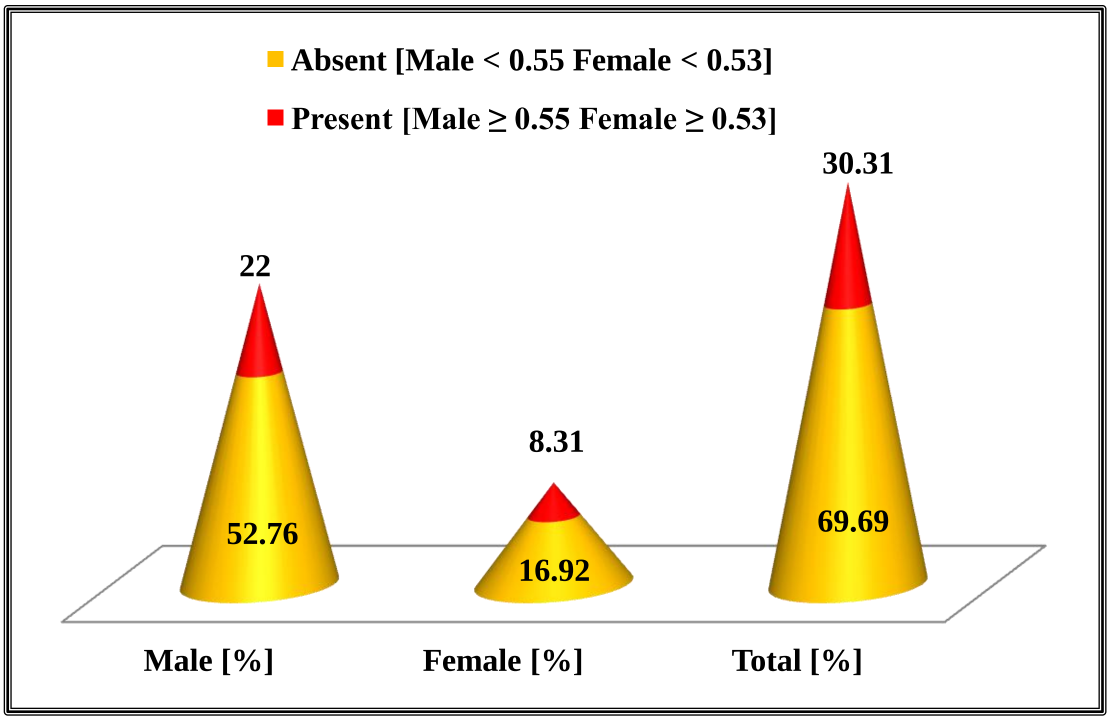

Figure 5.6: Percentage of male and female employees with abdominal obesity according to waist stature ratio [WSR]

Presence of central obesity according to waist-hip-ratio (WHR) was present in 56 % of bank employees (Table 5.12).

Table 5.12: Presence of central obesity according to waist hip ratio [WHR] in bank employees subjected to screening

Central Obesity	Male [N = 486]	Female [N = 164]	Total [N = 650]
Present [M ≥ 0.90cm; F ≥ 0.85cm]	**297 [45.69]**	**69 [10.61]**	**366 [56.31]**
Absent [M< 0.90cm; F< 0.85cm]	189 [29.08]	95 [14.62]	284 [43.69]

As graphically represented in Figure 5.7, results reveal that around 46 % of male employees and 10 % of female employees had central obesity

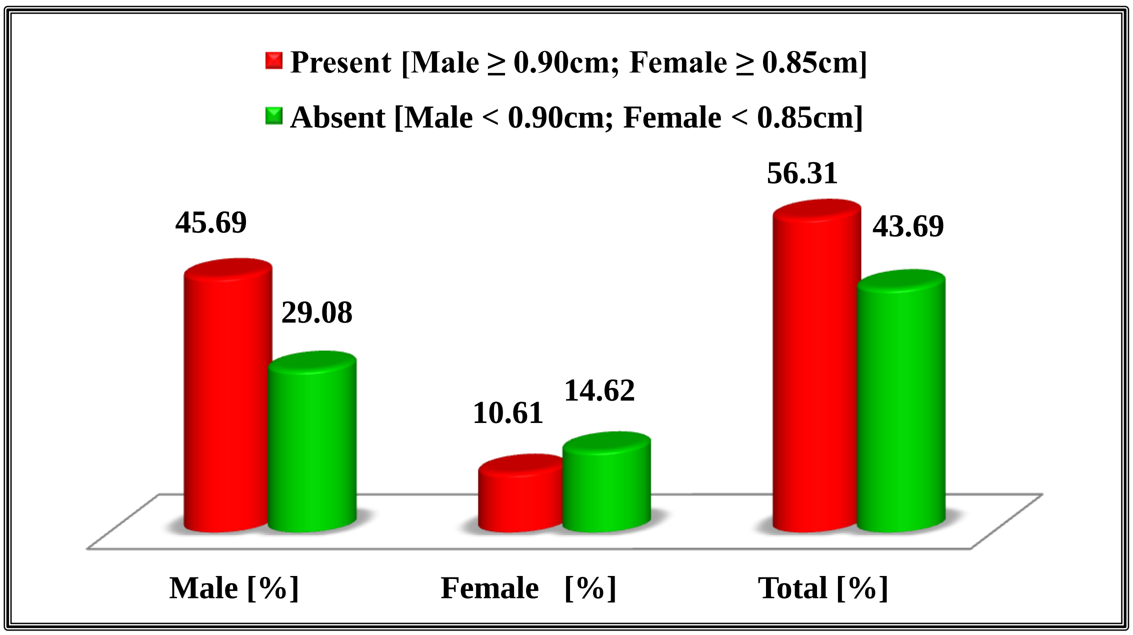

Figure 5.7: Percentage of male and female bank employees with central obesity

Biophysical profile as shown in Table 5.13 and Figure 5.8 revealed that 58% of employees had excess of body fat [>25%]. Out of 58% employees, 45% were found to be males and 13% were females. Employees in acceptable range of body fat percentage were found to be 31%. Surprisingly, only 7% of total employees had body fat in fitness level range and merely 4% of employees had body fat of 6 – 13% which is similar to athletes

Table 5.13: Distribution of screened bank employees according to body fat classification

Body fat Classification	Male Body fat [%]	Male N=486 [%]	Female [Body fat%]	Female N=164 [%]	Total N=650 [%]
Essential Fat	2 - 5	0 [0]	10 - 13	0 [0]	0 [0]
Athletes	6 - 13	15[2.31]	14 - 20	7 [1.08]	22 [3.38]
Fitness	14 - 17	31 [4.77]	21 - 24	14 [2.15]	45 [6.92]
Acceptable	18 - 24	147 [22.61]	25 - 31	57 [8.77]	204 [31.38]
Obese	**≥ 25**	**293 [45.08]**	**≥ 32**	**86 [13.23]**	**379 [58.31]**

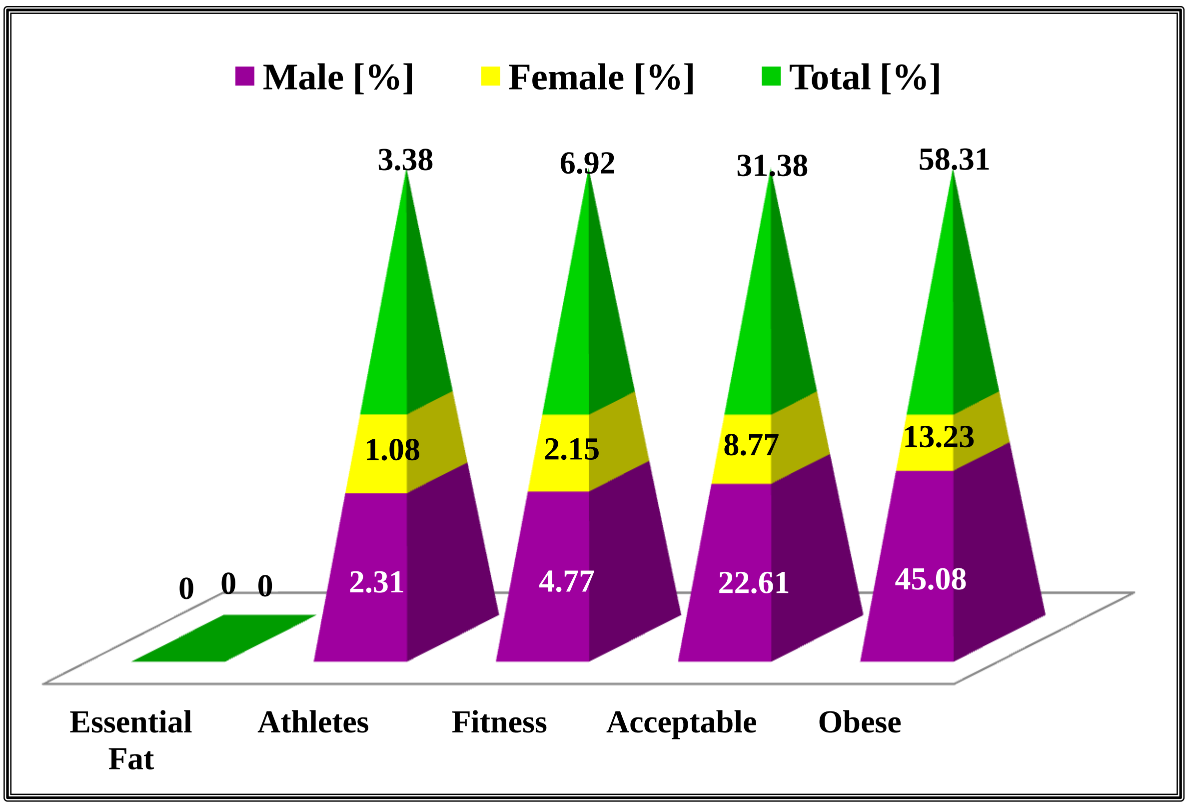

Figure 5.8: Percentage of male and female bank employees according to body fat distribution

5.1.4: Determining the presence of hypertension in screened bank employees

Measurement of blood pressure as shown in Table 5.14 and Figure 5.9 revealed that 31% of employees had normal blood pressure. Majority of the employees 48% were in pre-hypertension stage with both elevated systolic and diastolic blood pressure. However, 49% and 30% of employees had either elevated systolic or diastolic blood pressure respectively.

Employees in Stage-I hypertension with both elevated systolic and diastolic blood pressure were found to be 16%. Employees with elevated systolic blood pressure (SBP) were 16% and with elevated diastolic blood pressure (DBP) were. In Stage-II, 5% of employees with both elevated blood pressure predisposed symptoms of hypertension. Wherein, 2% had elevated systolic and 3% with elevated diastolic blood pressure.

Mean blood pressure values according to gender based analysis as shown in previous **Table 5.4 (Page 163),** male employees' depicted higher values for blood pressure both systolic and diastolic as compared to female employees'.

Table 5.14 Presence of hypertension in bank employees subjected to screening [N=650]

Blood Pressure Classification	S.B.P. [mmHg]	N [%]	D.B.P. [mmHg]	N [%]	Total N (%)
Normal	< 120	208 [32]	< 80	374 [57.54]	201 [30.92]
Pre-HT	**120 - 139**	**320 [49.23]**	**80 – 90**	**198 [30.46]**	**312 [48]**
Stage I	**140 - 159**	**105 [16.15]**	**91 – 99**	**59 [9.08]**	**106 [16.31]**
Stage II	> 160	17 [2.62]	> 100	19 [2.92]	31 [4.77]

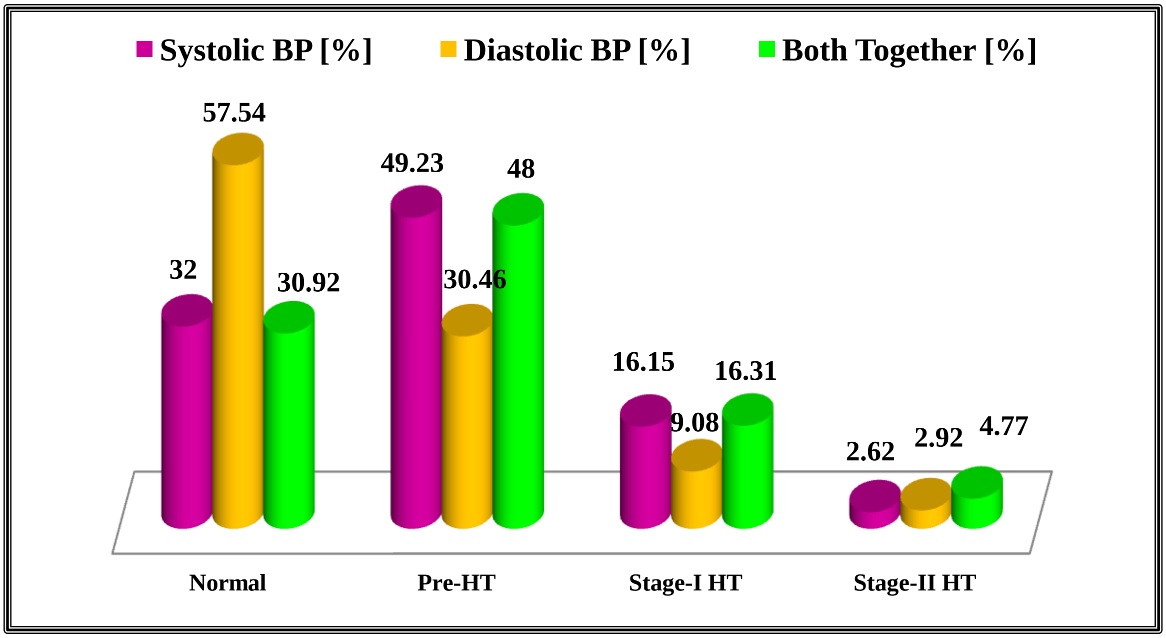

Figure 5.9: Presence of hypertension in bank employees subjected to screening [N=650]

5.1.5: Association and correlation amongst anthropometric and biophysical parameters of screened bank employees

Association of body-fat with anthropometric and biophysical parameters is shown in table 5.15. Data reveals that in 36% of bank employees, higher body-fat % coexisted with abdominal obesity and its association was highly significant ($p<0.001$).

Similarly, in 41% of bank employees central obesity [higher WHR] coexisted with higher body-fat % and their coexistence was highly significant ($p<0.001$).

The odds of abdominal and central obesity co-existing in people with higher body-fat percentage were 19.87 and 4.14 times higher than the employees with lower body-fat percentage respectively. The relative risk for abdominal and central obesity was 2.54% and 1.05% higher in people with higher body-fat percentage respectively.

The reduction of absolute risk (Absolute Risk Reduction - ARR / Risk Difference – RD) and probability of not developing abdominal obesity was 55.63 times and central obesity was 33.5 times higher for employees who could manage to reduce excess body-fat.

Also, 42% of bank employees had elevated blood pressure values (both systolic and diastolic) along with higher body-fat % and their association was highly significant ($p<0.001$).

The odds of developing hypertension due to higher body-fat percentage were 1.74 times higher in bank employees. The relative risk for developing hypertension in employees with higher body-fat percentage was 1.21 % higher than the employees with lower body-fat percentage.

The reduction of absolute risk and probability of not developing hypertension was 31.02 times higher for employees who could keep their body-fat within normal limits.

Table 5.15 Association of Body fat with Anthropometric and Biophysical parameters [N=650]

Parameters	Body fat% [Present] N=379 [%]	Body fat% [Absent] N=271 [%]	χ^2 value	OR	OR Range [95% CI]	RR	RR range [95% CI]	RD / ARR	RD/ ARR range
WC Present	**237 [36]**	**21[4]**	**197.8 *****	**19.8**	**11.87-33.54**	**2.54**	**2.21-2.91**	**55.6**	**49.82-61.45**
WC Absent	142 [22]	250 [38]							
WHR Present	**267 [41]**	**99 [15]**	**73.77 *****	**4.14**	**2.93-5.85**	**1.05**	**1.50-2.16**	**33.5**	**26.24-40.79**
WHR Absent	112 [17]	172 [27]							
HT Present	**270 [42]**	**109 [17]**	**11.11 *****	**1.74**	**1.24-2.46**	**1.21**	**1.08-1.37**	**31.0**	**23.61-38.43**
HT Absent	109 [16]	162 [25]							

NOTE: NS = non-significant, p< 0.05:*, p< 0.01:**, p< 0.001:***; χ^2 values = Chi Square values; OR = Odds Ratio; RR = Risk Ratio; CI = Confidence Interval;

Criteria for Abdominal obesity [WC] - Male > 90 cm, Female > 80 cm. Central Obesity [WHR] - Male ≥ 0.90; Female ≥0.85. Hypertension > 120/80 mmHg

Percent presence of elevated systolic blood pressure (SBP) along-with its coexistence with multiple deranged anthropometric parameters as risk factors for development of NCD's and association amongst them is shown in Table 5.16.

Table 5.16 Percent presence of elevated SBP along-with its coexistence with multiple deranged anthropometric parameters as risk factors for development of NCD's and association amongst them N = 650 [%]

	SBP [Yes] >120 mmHg	SBP [No] <120m mHg	χ^2 value	OR	OR Range 95% CI	RR	RR range 95% CI	RD	RD range 95% CI
BMI [YES]	**291 [45]**	**102 [16]**	**27.64 *****	**2.43**	**1.74-3.38**	**1.37**	**1.21-1.55**	**19.96**	**12.48-27.44**
BMI [NO]	139 [21]	118 [18]							
WC [YES]	**326 [50]**	**80 [12]**	**96.45 *****	**5.49**	**3.86-7.80**	**1.88**	**1.62-2.20**	**37.67**	**30.36-44.98**
WC [NO]	104 [16]	140 [22]							
WHR [YES]	**268 [41]**	**100 [15]**	**16.86 *****	**1.98**	**1.43-2.76**	**1.27**	**1.13-1.47**	**15.38**	**8.03–22.72**
WHR [NO]	162 [25]	120 [19]							

NOTE: = Number in parenthesis [ ] shows percentage ; NS = non-significant, p< 0.05:*, p< 0.01:**, p< 0.001:***; χ^2 values = Chi Square values; OR = Odds Ratio; RR = Risk Ratio; CI = Confidence Interval; RD = Risk Difference.

Obesity cutoffs: BMI > 23.0 kg /m^2 WC- M > 80 cm, F >90 cm, WHR –M > 0.90, F > 0.85

Coexistence of elevated systolic blood pressure along-with higher BMI was observed in 45%, abdominal obesity (WC) in 50% and central obesity (WHR) in 41% of bank employees and association between SBP and BMI, WC and WHR was highly significant (p<0.001).

The odds of developing elevated SBP in screened bank employees due to higher BMI was 2.43 times, WC was 5.49 times and WHR was 1.98 times higher as compared to employees with their anthropometric parameters in normal range. The relative risk of having elevated SBP with deranged BMI, WC and WHR was 1.37%, 1.88% and 1.27% respectively.

The reduction of absolute risk and probability for not having elevated SBP was 19.96, 37.67 and 15.38 times higher when BMI, WC and WHR could be kept within normal range, respectively.

Similarly, as shown in Table 5.17, 29% of bank employees with elevated DBP had higher BMI. Coexistence of elevate DBP with abdominal obesity (WC) and central obesity (WHR) was also found in 32% and 26% of bank employees and this association was also highly significant (p<0.001).

Table 5.17 Percent presence of elevated DBP along-with its coexistence with multiple deranged anthropometric parameters as risk factors for development of NCD's and association amongst them N = 650 [%]

	DBP [Yes] >80 mmHg	DBP [No] <80mm Hg	χ^2 value	OR	OR Range 95% CI	RR	RR range 95% CI	RD	RD range 95% CI
BMI [YES	**193 [29]**	**200 [31]**	**39.32 *****	**2.97**	**2.10-4.20**	**2.00**	**1.58-2.54**	**24.59**	**17.38-31.81**
BMI [NO]	63 [10]	194 [30]							
WC [YES]	**210 [32]**	**196 [30]**	**68.98 *****	**4.62**	**3.17–6.72**	**2.75**	**2.08-3.62**	**32.87**	**25.96-39.78**
WC [NO]	46 [7]	198 [31]							
WHR [YES]	**170 [26]**	**196 [30]**	**17.51 *****	**1.99**	**1.44–2.76**	**1.54**	**1.25-1.88**	**16.16**	**8.77-2.56**
WHR [NO]	86 [13]	198 [31]							

NOTE: = Number in parenthesis [ ] shows percentage ; NS = non-significant, p< 0.05:*, p< 0.01:**, p< 0.001:***; χ^2 values = Chi Square values; OR = Odds Ratio; RR = Risk Ratio; CI = Confidence Interval; RD = Risk Difference.
Obesity cutoffs: BMI > 23.0 kg /m^2 WC- M > 80 cm, F >90 cm, WHR –M > 0.90, F > 0.85

The odds of developing elevated DBP due to higher BMI, WC and WHR was 2.97, 4.62 and 1.99 times increased in bank employees respectively.

The relative risk of having elevated DBP due to deranged BMI, WC and WHR was 2.00%, 2.75%, 1.54% respectively. The absolute risk reduction of not having elevated DBP was 24.59, 32.87 and 16.16 times higher when anthropometric parameters are kept under control respectively.

Moving forward we also tried to look into the coexistence of multiple factors like presence of elevated systolic, diastolic and deranged anthropometric parameters. Results as shown in Table 5.18 depicts that development of hypertension was significantly associated with BMI in 42%, abdominal obesity (WC) in 47% and central obesity (WHR) in 25% of bank employees. Central obesity and hypertension coexisted in 25% of bank employees; however, its association with WHR was not significant.

The odds of developing hypertension due to deranged BMI and WC was 3.64 and 6.27 times higher in screened bank employees respectively. The relative risk for hypertension with higher BMI and WC was 1.88% and 2.67% respectively. Reduction of absolute risk and probability for not developing hypertension was 22.34 times and 42.69 times higher in employees who could keep a check on their BMI and abdominal obesity.

Table 5.18 Percent presence of hypertension along with its coexistence with multiple deranged anthropometric parameters as risk factors for development of NCD's and association amongst them N = 469 [%]

	HT [Yes] >120/80 mmHg	HT [No] <120/80 mmHg	χ^2 value	OR	OR Range 95% CI	RR	RR range 95% CI	RD	RD range 95% CI
BMI [YES]	**196 [42]**	**98[21]**	**43.26 *****	**3.64**	**2.46-5.40**	**1.88**	**1.52-2.33**	**31.24**	**22.34-40.14**
BMI [NO]	62 [13]	113 [24]							
WC [YES]	**221 [47]**	**103 [22]**	**73.77 *****	**6.27**	**4.03-9.73**	**2.67**	**2.01-3.56**	**42.69**	**33.97-51.41**
WC [NO]	37 [8]	108 [23]							
WHR [YES]	**117 [25]**	**94 [20]**	**0.029 NS**	**1.03**	**0.72-1.49**	**1.02**	**0.87-1.20**	**0.79**	**8.25 – 9.85**
WHR [NO]	141[30]	117 [25]							

NOTE: = Number in parenthesis [ ] shows percentage; NS = non-significant, p< 0.05:*, p< 0.01:**, p< 0.001:***; χ^2 values = Chi Square values; OR = Odds Ratio; RR = Risk Ratio; CI = Confidence Interval; RD = Risk Difference.

Obesity cutoffs: BMI > 23.0 kg /m^2 WC- M > 80 cm, F >90 cm, WHR –M > 0.90, F > 0.85

RESULT HIGHLIGHTS

- **69 % Screened employees were in age range of 25 – 35 yrs**
  - **Age 25 -30 yrs – 42%**
  - **Age 30 – 35 yrs – 27%**
- **All young bank employees were overweight [24.20 ± 4.05 kg/m^2]**
- **61% of young bank employees had BMI ≥ 23**
  - **20% Overweight**
  - **34% Obese Gr.-I**
  - **7 % Obese Gr.-II**
- **60.5% of young bank employees were at Increased risk of co-morbidities**
- **With Advancing Age, increase in grades of Anthropometric and Biophysical parameters was observed for all young bank employees.**
- **44% had abdominal obesity as per WC and 30% as per WSR**
- **Central obesity was present in 56% of young bank employees**
- **58 % young bank employees had higher body fat percentage**
- **69 % of young bank employees had elevated blood pressure**
- **Male employees were Pre-hypertensive: 130.81 ± 13.59 mmHg**
- **Hypertension and higher Body-fat co-existed in 42% of screened bank employees with OR - 1.74%, RR – 1.21% and RD / ARR – 31%**

DISUCSSION

Obesity was earlier epidemic but now it's pandemic. Excess weight which was earlier considered as a good sign of belonging to healthy and wealthy family is now officially recognized as a "Disease" by some of the countries. Globally, in last three decades graph for obesity prevalence is trending upwards and there are several evidences and studies that support above findings. This seems to be quite acceptable as the global BMI criteria for defining Obesity Grade-I > 30 is unchanged (WHO, 2017; EASO, 2017; NHANES, 2017; IHME, 2016; GBD, 2015).

However, according to OECD, globally 5% of the India's adult population is obese. There were two important changes in last 10 years = 1 decade. Firstly, new BMI classification was developed specifically for Asian Indians in 2009 in which obesity was categorized with BMI > 25 as compared to previous classification stating BMI > 30 and Secondly, the prevalence rates of overweight and obesity doubled from 9.3 -12.6% to 18.9 – 20.7% in India (NFHS-4). It is very much possible that both of these incidences are linked. When the obesity assessment criterion goes down below 5 points it will automatically prorate increase in number of obesity percentage. In our study obesity rates were found to be 34% in young bank employees which is a trend similar to WHO 2017 and GBD 2015 report stating obesity prevalence rates of 30 -40 % and also similar to ICMR INDIAB study that depicted prevalence rates of general obesity (GO) to be 11.8 % - 31.3% (WHO, 2017; EASO, 2017; NHANES, 2017; MOHFW, 2016; IHME, 2016; GBD, 2015).

Moreover, our study depicts majority of young bank employees (25 - 35 yrs) to be overweight (24.20 ± 4.05 kg/m^2). The primary reason for these exploding rates in Asian countries and India could be the adaptation of the new BMI classification where the criteria of obesity grade-I has dropped by 5 points as recommended by the Association of physicians of India and eventually accepted by world health organization considering higher rates of NCD's in population even at lower range of BMI. Simultaneously, if we add up overweight bank employees, then the percentage of overweight and obesity together accounts for 61% of total population of bank employees. This percentage is way too high according to available literature on Indian studies. Even NFHS 2015 – 2016 data depicts highest rate of 35%. This could be attributed to the newer BMI classification and also to the desk job of bank employees leading to urban sedentary and stressful lifestyle (Ismail et al., 2013), and erratic timings of work and dietary habits. Similar findings of lesser physical activity contributing to obesity rates in urban areas were earlier mentioned by WHO (2013) & Ramachandran et al. (2010).

If we use the global BMI classification to assess the young overweight bank employees then they all would probably have fallen in normal range of BMI.

Nevertheless, it is well said that prevention is better than cure. So, if reduction of 5 points in BMI criteria for Asians mathematically increases the prevalence rates of obesity in India then it will definitely help to develop stringent measures to curtail it too. Also, it will shake up public health professional and government agencies and organizations whose primary and the only focus was just on one aspect of malnutrition i.e. under-nutrition till date.

Even in mathematical fashion, the way obesity prevalence rates are exploding, the day seems not too far away when India will also officially recognize obesity as a "Disease".

Recent literature on obesity and metabolic syndrome emphasizes more on using a 3-pronged approach of "Adiposity" assessment of prime importance rather than just one dimensional BMI. In our study 60.5% of young bank employees were at increased risk of co-morbidities at a very young age of 25 -35 years. Also, risk of co-morbidities (grades of anthropometric and biophysical parameters) increased with advancing age within range of 10 years.

Presence of "Adiposity" in young bank employees with regards to deposition in abdominal region (WC) was present in 44% and 30% according to WSR/WHt.R. Also, overall excess of body fat was also found in 58% of young bank employees. These results could be validated with a supporting study conducted by ICMR-INDIAB group 2015. The major results that surfaced from the study depicted presence of general obesity (GO) in 11.8% - 31.3% (Average 21.1%) of residents, abdominal obesity (AO) in 16.9% - 36.1% (Average 24.6%) and central obesity in 9.8% - 26.6% (Average 17.17%). Regression analysis revealed that hypertension, diabetes, higher socio-economic status, physical inactivity and urban residence were significantly associated with GO, AO and CO (ICMR – INDIAB, 2015) along with direct association of urbanization with increased prevalence of NCD's risk factors (Yadav & Krishnan, 2008).

Adiposity is the prime confounding factor in deriving the new diagnostic term of ABCD and is the key factor in triggering the low grade inflammatory responses. From previous literature review it is very clear that obesity is a state of adiposity and fat induced prolong inflammation (Mraz & Haluzik, 2014). Several studies had demonstrated that proportion of body fat is very useful in identifying predisposition of disease. Accumulation of fat in abdominal region predisposes a person to higher risk of developing type 2 diabetes leading to insulin resistance, high cholesterol leading to cardiovascular diseases, Leptin resistance and increased level of inflammatory cytokines (Manolopoulos, Karpe & Frayn, 2010).

Hence, preventive measures can be initiated as soon as adiposity and its pattern can be detected at an early stage and prevent metabolic derangement rather than just relying on BMI assessment.

One of the major finding of our screening phase was elevated blood pressure values in 69% of young bank employees and it was more predominant in male bank employees predisposing them to pre-hypertension category. In 42% of young bank employees, where hypertension coexisted with higher body fat, the odds of developing hypertension due to higher body-fat percentage were 1.74 times higher in bank employees. The relative risk for developing hypertension in employees with higher body-fat percentage was 1.21 % higher than the employees with lower body-fat percentage. The reduction of absolute risk and probability of not developing hypertension was 31.02 times higher for employees who could keep their body-fat within normal limits. Since, sedentary life-style and stress have been demonstrated as important risk factors for hypertension in some of the epidemiological studies, a recent cross-sectional study conducted by Ismail et al. (2013), on 117 bank employees' revealed 39.3% prevalence of hypertension. The bestowing factors that were significantly associated with hypertension were found to be increasing age, BMI ≥ 25 kg/m^2, deranged WHR and family history of hypertension as compared to normotensive bank employees.

One of the studies comparing the risk assessment of disability-adjusted life-years (DALY's) and trends in exposure revealed top ten contributors in 2015 to global DALY's. Amongst that high blood pressure, smoking, high fasting plasma glucose, high BMI, high total cholesterol, alcohol use and diets high in sodium were largest contributors of DALY's. The odds for global death evaluating all risk factors together was 57·8% (95% CI 56·6–58·8) and for DALYs was 41·2% (39·8–42·8) (GBD 2015, Risk factors collaborators).

In one of the similar cross-sectional study conducted locally in city of Surat assessing prevalence of hypertension in bank employees depicted 30.4% of bank employees having hypertension and 34.5% were pre-hypertensive. Higher prevalence of hypertension was more in males (32.5%) as compared to females (23.1%).

Hence, it is very aptly said that "Obesity is the mother of all chronic degenerative diseases". It not only predisposes a person to future risk of NCD's and DALY's, but also hampers day to day functioning of mobility and physical activity and pushing an individual into a vicious cycle of physical inactivity and obesity.

Conclusion

Prevalence of Obesity and its associated risk of developing comorbidities (like hypertension) were found to be too high in bank employees of urban Vadodara.

Assessing and treating "Adiposity" at an early age and stage of prognosis will definitely help curtail obesity rates and its associated health disorders

PHASE II

COMPARISON BETWEEN BASELINE PARAMETERS OF NON-OBESE AND OBESE BANK EMPLOYEES

In Phase – II of study, we further enrolled screened employees into our study by taking informed written consent and strictly following the inclusion – exclusion criteria. Subjects were enrolled in two groups based on BMI. Group – 1 consisted of employees having normal BMI and Group – 2 consisted of employees having obesity Grade-I. Baseline data with numerous parameters was collected for both the groups and analyzed for comparing the difference non-obese and obese bank employees.

The results of comparison between non-obese and obese are discussed under following sections:

Section 5.2.1: Socio economic status (SES), anthropometric measurements, family medical history, personal medical history, defecation profile, personal habits, habituation profile, physical activity pattern, hunger and satiety scale, depression scores and dietary intakes of non obese and obese subjects

Section 5.2.2: To study gut-microflora of non-obese and obese subjects with regards to *Bifidobacterium, Lactobacillus, Clostridium, Bacteriodes*

Section 5.2.3: To determine the baseline levels of six Gut-hormones

Glucagon-like Peptide -1 (GLP-1)	-Gut Incretin
Gastric Inhibitor Polypeptide (GIP)	-Gut Incretin
Peptide YY (PYY)	-Anorexogenic hormone
Ghrelin (Hunger hormone)	-Orexogenic hormone
Leptin (Energy Expenditure hormone)	-Anorexogenic hormone
Insulin	-Anorexogenic hormone

Section 5.2.4: Correlation of weight with various parameters of non-obese and obese bank employees and regression analysis to identify strongest predictor of obesity

5.2.1: Socio economic status (SES), anthropometric profile, family medical history, personal medical history, defecation profile, personal habits, habituation profile, physical activity pattern, hunger and satiety scale, depression scores and dietary intakes of non obese and obese employees

Results of background information of selected 300 employees, divided equally into two arms (non-obese-150 and obese-150) as shown in Table 5.19 depicted higher percentage of males as compared to female employees. Socio economic data revealed that majority of the subjects surveyed were 95% Hindus and most of them resided in nuclear family as compared to joint family All employees were literate and 93.33% were graduate and above. Most of them financially belonged to middle class (93.33%) with 68% of employees had income of > 28114 and 32% with income <28114.

As shown in Table 5.20, anthropometric data analysis comparing two groups (non-obese and obese) revealed that no significant difference was observed in values of mean height (cm) in both groups. However, significantly higher values ($p<0.001$) were observed in rest all anthropometric parameters of obese employees. Obese male employees had 32% and obese female employees had >40% of mean weight as compared to non-obese. On an average total obese employees had 37.32% excess weight as compared to non-obese.

Similarly, total mean BMI was higher by 31.43%. WC in male obese employees was higher by 18.15%, for female obese employees was higher by 24.69% and total mean WC was higher by 22.42% of obese employees as compared to non-obese. Total mean HC was higher by 14% in obese employees. However, difference in WHR of female obese employees was double (10.17%) than male obese employees which was higher by 5.62% as compared to non-obese employees. Total mean WHR was 8.14% higher than non-obese bank employees.

Table 5.19: Background information of non-obese and obese subjects

Parameters	Non-obese N=150 [%]	Obese N=150 [%]	Total Percent	χ^2 Value
Gender				
Male	101 [33.67]	132 [44.00]	77.67%	18.47***
Female	49 [16.33]	18 [06.00]	22.33%	
Religion				
Hindu	145 [48.33]	140 [46.67]	95.00%	1.75 NS
Others	5 [01.67]	10 [03.33]	05.00%	
Type of family				
Joint	47 [15.67]	39 [13.00]	28.67%	1.04 NS
Nuclear	103 [34.33]	111 [37.00]	71.33%	
Education				
Graduate and above	138 [46.00]	142 [47.33]	93.33%	0.86 NS
High school	12 [04.00]	8 [02.67]	06.67%	
Family Income Per Month				
≥ 28114	98 [32.67]	106 [35.33]	68.00%	0.98 NS
≤ 28114	52 [17.33]	44 [14.67]	32.00%	
Socioeconomic Class				
Upper	8 [02.67]	12 [04.00]	06.67%	0.86 NS
Middle Class	142 [47.33]	138 [46.00]	93.00%	

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p< 0.05:*, p< 0.01:**, p< 0.001:***

Biophysical data analysis as shown in Table 5.21 also revealed 27.85% higher significant difference (p<0.001) in body fat percentage of obese bank employees as compared to non-obese. Male employees had 36.5% and female employees had 23.17% higher body fat percentage as compared to non-obese employees. Similarly, Basal metabolic rate (BMR) was also 28.35% higher in obese employees as compared to non-obese employees. Male obese employees had 23.22% and female obese employees had 30.86% higher BMR as compared to non-obese.

Table 5.20: Mean values for anthropometric parameters of non-obese [150] and obese [150] employees

Parameters		Non-obese [150]	Obese [150]	% Difference	't' Value
Height [cm]	Male	170.01±9.28	170.46±06.25		0.55 NS
Mean ± SD	Female	161.47±18.42	166.71±16.07		0.93 NS
Weight [kg]	Male	61.05±6.12	80.62±07.56	+ 32.00	21.24***
Mean ± SD	Female	55.49±8.90	77.76±10.71	+ 40.00	13.45***
	Total Subjects	57.57±7.37	79.06±08.57	+ 37.32	23.29***
BMI [kg/m^2]	Male	21.11±1.35	27.67±1.49	+ 31.07	34.82***
Mean ± SD	Female	20.8±2.34	27.45±2.73	+ 31.97	18.98***
	Total Subjects	21.03±1.29	27.64±1.48	+ 31.43	41.24***
WC [cm]	Male	81.08±6.22	95.8±07.76	+ 18.15	15.62***
Mean ± SD	Female	76.31±11.12	95.15±10.77	+ 24.69	10.87***
	Total Subjects	78.08±7.98	95.59±07.62	+ 22.42	19.43***
HC [cm]	Male	90.78±5.41	102.37±06.10	+ 12.76	15.09***
Mean ± SD	Female	89.43±9.98	102.21±10.39	+ 14.29	12.58***
	Total Subjects	90.11± 5.21	102.73±06.10	+ 14.00	19.28***
WHR	Male	0.89±0.05	0.94±0.04	+ 05.62	7.31***
Mean ± SD	Female	0.84±0.11	0.93±0.09	+ 10.71	4.49***
	Total Subjects	0.86± 0.10	0.93±0.05	+ 08.14	9.72***

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

Table 5.22 reveals significant difference in DBP ($p<0.05$) and SBP ($p<0.01$) of obese female bank employees as compared to non-obese female employees. No significant difference was observed in DBP values of male bank employees. However, males in non-obese group had elevated SBP values and were found to be pre-hypertensive's along-with obese employees having elevated SBP values. Although, the mean values for SBP and DBP of non-obese employees were in normal range (except for SBP in males), the mean standard deviation (SD) was observed to be too high in non-obese group.

Table 5.21: Mean values for biophysical parameters of non-obese [150] and obese [150] subjects

Parameters	Gender	Non-obese [150]	Obese [150]	% Difference	't' Value
Body Fat[%]	Male	22.19 ± 3.06	30.29 ± 3.77	+ 36.50	17.63***
Mean ± SD	Female	25.38 ± 5.10	31.26 ± 5.24	+ 23.17	11.23***
	Total	24.49 ± 4.44	31.31 ± 4.66	+ 27.85	12.99***
BMR [kcals]	Male	1438.5 ± 124.71	1772.5 ± 189.45	+ 23.22	15.35***
Mean ± SD	Female	1304.12 ± 204.30	1706.62 ± 245.76	+ 30.86	8.59***
	Total	1355.46 ± 162.65	1739.79 ± 213.33	+ 28.35	17.55***

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

Table 5.22 : Mean values for blood pressure measurements of non-obese [150] and obese [150] subjects

Parameters		Non-obese [150]	Obese [150]	Percent Difference	't' Value
DBP [mmHg]	Male	78.82±10.07	80.96±7.29	+ 2.71%	1.88 NS
Mean ±SD	Female	75.24±11.91	80.02±9.43	+ 6.35%	2.59*
	Total	76.3± 10.13	80.45±7.34	+ 5.44%	4.06***
SBP [mmHg]	Male	127.11±12.75	128.48±8.65	+ 1.08%	0.97 NS
Mean ±SD	Female	119.97±16.86	126.67±13.48	+ 5.58%	3.03**
	Total	122.73± 3.35	127.63±8.90	+ 3.99%	3.75***

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

As shown in Table 5.23, abdominal obesity was present in 5.67 % of non-obese and 40 % of obese employees and this association between obesity and waist circumference data was highly significant at $p<0.001$.

Table 5.23: Percent presence and association of abdominal obesity [WC] with BMI

	Non-obese [N=150]			Obese [N=150]			Chi Sq Values
Abdominal Obesity	**Male [N =101]**	**Female [N = 49]**	**Total [N = 150]**	**Male [N=132]**	**Female [N = 18]**	**Total [N = 150]**	**Total**
Present [M>90; F >80]	**08 [2.67]**	**09 [3.00]**	**17 [5.67]**	**104 [34.67]**	**16 [5.33]**	**120 [40.00]**	**142.5*****
Absent [M<90 ; F<80]	93 [31.00]	40 [13.33]	133 [44.33]	28 [9.33]	02 [0.67]	30 [10.00]	

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p <0.05*, p < 0.01 **, p < 0.001 ***

According to WHR data 13.67% of non-obese and 41.33 % of obese employees were at risk of developing non communicable diseases in future (Table 5.24).

Table 5.24 : Percent presence and association of central obesity [WHR] with BMI

WHR [Central Obesity]	Non-obese N=150 [%]			Obese N=150 [%]			Chi Sq Values
	Male [N=101]	**Female [N=49]**	**Total [N=150]**	**Male [N=132]**	**Female [N=18]**	**Total [N=150]**	**Total**
Present [M >0.9; F<0.85]	**29 [9.67]**	**12 [4.00]**	**41 [13.67]**	**110 [36.67]**	**14 [4.67]**	**124 [41.33]**	**92.78*****
Absent [M <0.9 ;F <0.85]	72 [24.00]	37 [12.33]	109 [36.33]	22 [7.33]	4 [1.33]	26 [8.67]	

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p <0.05*, p < 0.01 **, p < 0.001 ***

As depicted in Table 5.25, Fitness association analysis according to body fat percentage was found to be highly significant (p<0.001) and data depicts barely 5.67% of non-obese population to be fit and none in the obese group.

Employees falling in the acceptable level of fitness were found to be 36% in non-obese arm and only 2.33% in obese arm. Surprisingly 8.33% of employees with normal BMI range and weight had excess of accumulated body fat percentage similar to 47.67 % of obese employees.

Table 5.25: Percent presence of level of fitness according to body-fat %

Level of fitness	Non-Obese N=150 [%]			Obese N=150 [%]			Chi Sq Values
	Male N=101	Female N= 49	Total N=150	Male N=132	Female N=18	Total N=150	Total
Fitness M: 14-17%; F: 21-24%	13 [4.33]	4 [1.33]	17 [5.67]	0 [0]	0 [0]	0 [0]	**171.18 *****
Acceptable M: 18-24%; F: 25-31%	71 [23.67]	37 [12.33]	108 [36.00]	7 [2.33]	0 [0]	7 [2.33]	
Obese M: ≥ 25%; F: ≥ 32%	**17 [5.67]**	**8 [2.67]**	**25 [8.33]**	**125 [41.67]**	**18 [6.00]**	**143 [47.67]**	

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p <0.05*, p < 0.01 **, p < 0.001 ***

Table 5.26 depicts odds ratio, relative risk and risk difference (absolute risk reduction) for the level of fitness. The odds for accumulating excess body fat were 88.25 times higher in employees with lower level of fitness (higher body-fat% - obese category) as compared to employees who maintain their lower body-fat% and higher level of fitness.

Relative risk for developing obesity was 6.31% higher for employees who do not maintain body-fat% in range of fitness - acceptable level. The reduction of absolute risk and probability for not developing obesity is 79.03 times higher in employees willing to reduce / maintain their lower body-fat% as compared to employees who would not make any efforts.

Table 5.26: Odds ratio and relative risk as per level of fitness

	Point Estimate	95% Confidence Interval	
Parameters: Odds-based		**Lower**	**Upper**
Odds Ratio (cross product)	**88.2514**	**36.8039**	**211.6163**
Parameters Risk-based			
Risk Ratio (RR)	**6.311**	**4.3826**	**9.0878**
Risk Difference (RD %)	**79.0321**	**72.0996**	**85.9646**

Table 5.27 depicts association of BMI with physical activity level (PAL) in non-obese and obese bank employees and as graphically represented in figure 5.10, results revealed that almost equal percentage of bank employees were found in low and moderate PAL. Employees in high PAL were found to be few to almost negligible percentage. Association between BMI and PAL did not prove to be significant ($p<0.12$).

Table 5.27: Association of BMI with physical activity level in non-obese and obese bank employees

Physical activity level	Non-obese N = 150 [%]	Obese N = 150 [%]	χ^2 value	OR [95%CI]	RR [95%CI]	RD%
Low **< 600 met min** **& < 3 days**	**71 [23.66]**	**70 [23.33]**	**0.12 NS**	**1.084** **[0.68-1.705]**	**1.05** **[0.83 – 1.31]**	**2.01** **[-9.33 – 13.33]**
Moderate **600 –1500 met min** **& 3–5 days**	**71 [23.66]**	**79 [26.33]**				
High **>1500 met min** **& 5–7 days**	**4 [1.33]**	**1 [0.33]**				

NOTE: Figures in parenthesis represent percent of subjects; NS=non-significant, p< 0.05 *, p < 0.01: **, p < 0.001: ***

Formula to calculate physical activity level is:

[(P2*P3*8) + (P5*P6*4) + (P8*P9*4) + (P11*P12*8) + (P14*P15*4)]

Criteria for - Days and Total Physical Activity Met/Min/Week

HIGH IF: 1) ≥1500 min / (P2+P11) ≥ 3days OR 2) ≥3000 min /

2) (P2+P5+P8+P11+P14) ≥ 7days

MODERATE IF: 1) (P2*P3) + (P11*P12) ≥ 60 Min / (P2+P11) ≥ 3days OR

2) (P5*P6) + (P8*P9) + (P14*P15) ≥150 min / (P5+P8+P14) ≥ 5days OR

3) ≥ 600 min / (P2+P5+P8+P11+P14) ≥5days

LOW IF: Do not fall in any of the above criteria

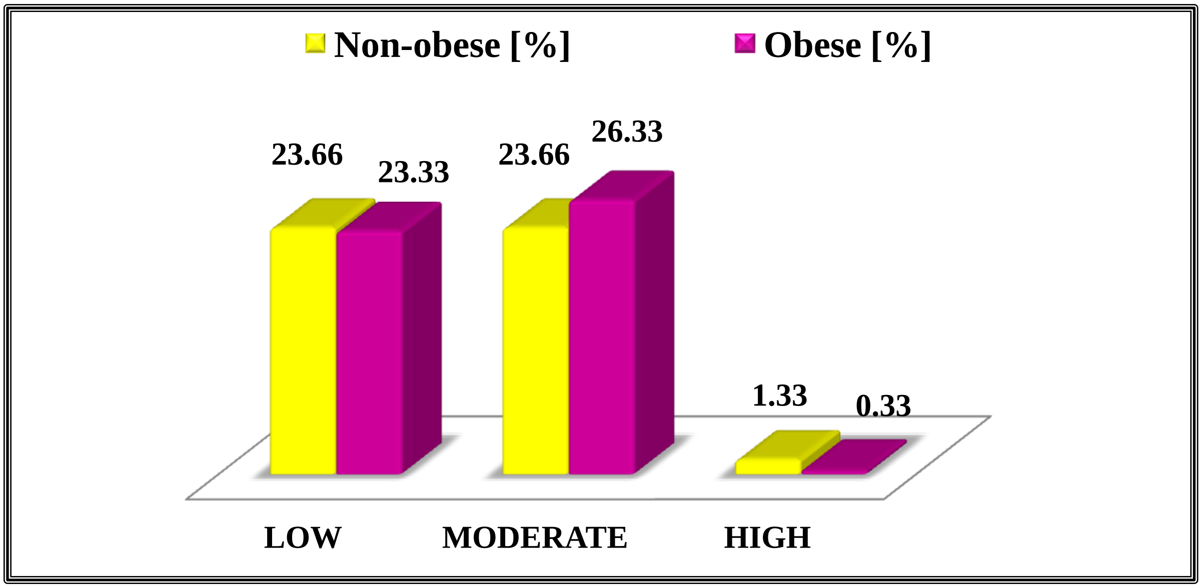

Figure 5.10: Distribution of non-obese and obese bank employees according to their level of physical activity

Table 5.28 depicts data on family medical history of bank employees. Data reveals that Family history of non-communicable diseases (NCD's) was present in both non-obese and obese bank employees.

Significantly ($p<0.001$) higher percentage of obese bank employees had family history of obesity (11.66%) and hypertension (9.34%) as compared to non-obese. Higher percentage of obese employees also had family history of diabetes (3.34%) and CVD's (5.34%).

However, statistically this difference was not significant. Degree of family history of NCD's revealed that 26.33 % of obese employees had strong family history of obesity (34.33%), hypertension (41.67%), diabetes mellitus (28.67%) and CVD's (18.67%) as compared to 7.33% of non-obese employees. Almost equal percentage of non-obese (15%) and obese (12.67%) had moderate family medical history. However, 27.67% of non-obese employees had mild family medical history and 11% of obese employees with mild family medical history already headed towards weight gain. This association of family history of NCD's with BMI was found to be strong and significant ($p<0.001$).

Table 5.28: Family history of NCD's in non-obese and obese bank employees and its association with BMI

Type of Disease	Non-obese N=150 [%]	Obese N=150 [%]	% Difference	χ^2 value
Obesity	68 [22.67]	103 [34.33]	> 11.66%	16.66***
Hypertension	97 [32.33]	125 [41.67]	> 9.34%	13.58***
Diabetes Mellitus	76 [25.33]	86 [28.67]	> 3.34%	1.34NS
CVD's	40 [13.33]	56 [18.67]	> 5.34%	3.92NS
Degree of Family History of NCD's				
Mild Family History [0-2]	83 [27.67]	33 [11.00]	< 16.67%	54.31***
Moderate Family History [3-4]	45 [15.00]	38 [12.67]	< 2.33	
Strong Family History [5-6]	22 [07.33]	79 [26.33]	>19%	

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p <0.05*, p < 0.01 **, p < 0.001 ***

Personal medical history of bank employees as shown in Table 5.29 and graphically represented in Figure 5.11 revealed that majority of non-obese and obese bank employees had medical issues related to dental problems, flatulence and constipation. Uniquely, locomotor disorders were more prevalent in obese employees followed by acidity and heartburn this association of obesity and medical history was also highly significant [p<0.001].

Table 5.29 : Personal medical history of non obese and obese bank employees

Disorders	Non-obese N = 150 [%]	Obese N = 150 [%]	Total Employees N=300 [%]	χ^2 value
UTI	3 [01.00]	2 [00.67]	5 [01.67]	67.6*** df -6
GI disorder	43 [14.00]	5 [01.67]	48 [15.67]	
Constipation	42 [14.00]	59 [19.67]	101 [33.67]	
Flatulence	50 [17.00]	68 [22.67]	118 [39.33]	
Acidity / Heartburn	27 [09.00]	39 [13.00]	66 [22.00]	
Dental problems	112 [38.00]	83 [27.66]	195 [65.00]	
Locomotor disorders	21 [07.00]	70 [23.33]	91 [30.33]	

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p <0.05*, p < 0.01 **, p < 0.001 ***

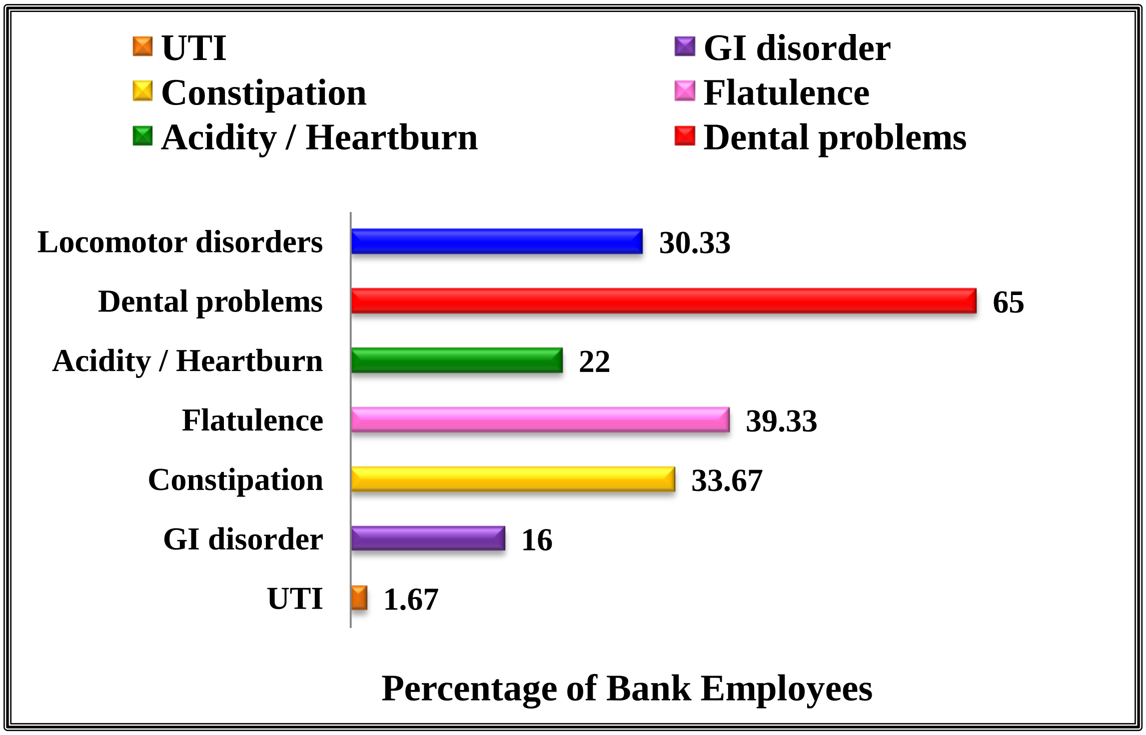

Figure 5.11: Personal medical history of young bank employees

Table 5.30 represents the frequency of habitual products consumed by non-obese and obese bank employees. The most frequently consumed product by non-obese bank employees was aerated drinks (36.33%) as compared to obese employees (29.67%). The next frequently consumed habitual product by obese employees was tea, cigarette, alcohol, coffee and tobacco products.

Alcohol was consumed moderately by large percentage of non-obese (11.33%) and obese (19.67%) employee's as compared to frequent consumption of alcohol. Tobacco and coffee were the least frequently consumed products.

Habitual products consumption profile of bank employees observed in Table 5.31 and graphically represented in Figure 5.12 revealed highest consumption of aerated drinks equally by non-obese (45.33%) and obese (43.67%), hence this association was not significant. Second highest consumed product was tea, followed by alcohol and this association was highly significant with obesity ($p<0.001$ and $p<0.0001$ respectively).

Also as compared to non-obese; almost double percentage of obese employees consumed cigarette, coffee and chewing tobacco products.

Table 5.30 : Frequency of habitual products consumed by non-obese and obese bank employees

	MODERATE CONSUMPTION		FREQUENT CONSUMPTION	
Type of Habitual Products	**Non Obese N=150 [%]**	**Obese N=150 [%]**	**Non Obese N=150 [%]**	**Obese N=150 [%]**
Alcohol	**34 [11.33]**	**59 [09.67]**	**15 [05.00]**	**30 [10.00]**
Cigarette	**04 [01.33]**	**04 [01.33]**	**17 [05.67]**	**40 [13.33]**
Tobacco products	**01 [00.33]**	**01 [00.33]**	**08 [02.67]**	**14 [04.67]**
Tea	**12 [00.40]**	**08 [02.67]**	**38 [12.67]**	**95 [31.67]**
Coffee	**17 [05.67]**	**15 [05.00]**	**02 [00.67]**	**21 [07.00]**
Aerated Drinks	**27 [09.00]**	**42 [14.00]**	**109 [36.33]**	**89 [29.67]**

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p <0.05*, p < 0.01 **, p < 0.001 ***

Table 5.31: Percent consumption of habitual products and its association with obesity in non-obese and obese bank employees

Type of Habitual Products	**Non-obese N = 150 [%]**	**Obese N = 150 [%]**	**χ^2 value**	**p-value**
Alcohol	**49 [16.33]**	**89 [29.67]**	**21.5*** **	**0.0001**
Cigarette	**21 [07.00]**	**44 [14.67]**	**10.34*** **	**0.001**
Tobacco	**9 [03.00]**	**15 [05.00]**	**1.63 NS**	**0.202**
Tea	**50 [16.67]**	**103 [34.33]**	**37.47*** **	**0.001**
Coffee	**19 [06.33]**	**36 [12.00]**	**6.43** **	**0.011**
Aerated Drinks	**136 [45.33]**	**131 [43.67]**	**0.85 NS**	**0.36**

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p <0.05*, p < 0.01 **, p < 0.001 ***

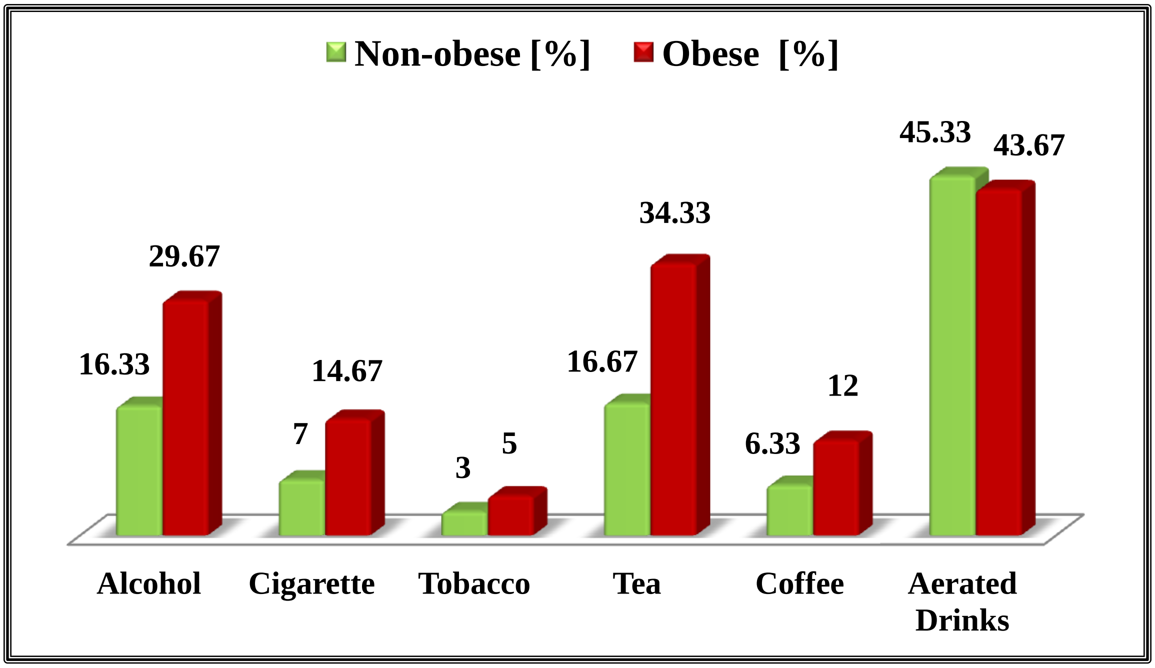

Figure 5.12: Percent consumption of habitual products by non-obese [N=150] and obese [N=150] bank employees

After analyzing consumption of habitual products individually, we also looked into their consumption of multiple habitual products in a day and its consumption frequency by bank employees. Three categories were formed: mild habituation - score <4; moderate habituation – score 5 – 10; severe habituation – score >11.

The results as shown in Table 5.32 indicate that 28% of obese employees were severely habituated as compared to 16% of non-obese employees. However, 21.33% of non-obese employees were moderately habituated as compared to 13% of obese employees. Strong significant association ($p<0.001$) was observed between BMI and varying degree of habituation (χ^2 =24.46).

The odds of developing obesity were 2.12 and 2.84 times higher with moderate and mild degree of habituation. The relative risk for weight gain was 1.64% higher in bank employees with moderate degree of habituation and 1.55% for mild degree of habituation. The reduction of absolute risk (ARR/RD) and probability for not gaining weight was 24.85% and 16.67% higher in bank employees on curtailing their degree of habituation from moderate and mild to complete avoidance.

Table 5.32: Association of BMI with varying degree of habituation in non-obese and obese subjects

Degree of Habituation	Non Obese N=150 [%]	Obese N=150 [%]	χ^2 value	OR [95% CI]	RR [95% CI]	RD%
Mild [<4]	38 [12.67]	16 [5.33]	10.93***	2.84 [1.50 - 5.37]	1.55 [1.24 - 1.93]	24.85
Moderate [5-10]	64 [21.33]	39 [13.00]	9.24***	2.12 [1.31 - 3.45]	1.64 [1.18 - 2.28]	16.67
Severe [>11]	48 [16.00]	84 [28.00]	17.53***	0.37 [0.23 - 0.59]	0.59 [0.46 - 0.77]	-24.35
χ^2 value	24.46***					

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p< 0.05*, p< 0.01**, p<0.001 ***

Table 5.33 represents mean values of anthropometric and biophysical profile of **NON-OBESE** employees according to their degree of habituation. Results clearly reflect that with increase in degree of habituation there is increase in all anthropometric and biophysical parameters. It can be interpreted that development of obesity is directly proportional to degree of habituation.

Table 5.33: Mean values of anthropometric and biophysical profile of NON-OBESE employees according to their degree of habituation

Anthropometric profile	Mild Habituation Mean ± SD	Moderate Habituation Mean ± SD	Severe Habituation Mean ± SD	ANOVA F value	F critical
	[N=38]	[N=64]	[N=48]		
Height	162.86 ± 7.93^{a}	164.41 ± 9.52^{a}	164.02 ± 5.62^{a}	01.73 NS	3.05
Weight	53.17 ± 5.90^{a}	56.60 ± 7.79^{b**}	60.98 ± 6.18^{c***}	15.98***	7.24
BMI	21.42 ±1.17^{a}	20.87 ± 1.30^{a}	22.73 ± 2.80^{b***}	17.55***	7.24
WC	75.26 ±9.33^{a}	78.00 ± 7.81^{a}	81.58 ± 5.43^{b**}	08.50***	7.24
HC	88.42 ± 4.76^{a}	90.05 ± 5.90^{a}	92.45 ± 4.11^{b**}	05.81**	4.75
WHR	0.85 ± 0.10^{a}	0.86 ± 0.06^{a}	0.88 ± 0.05^{b*}	03.58*	3.05
Body Fat	22.83 ± 2.94^{a***}	23.41 ± 4.26^{b***}	28.18 ± 4.44^{b}	22.70***	7.24
BMR	1246 ± 126^{a***}	1346 ± 178^{b***}	1419 ± 140^{c***}	16.35***	7.24
BP- Systolic	118.61 ± 13.24^{a}	121.34 ± 10.96^{a}	128.63 ± 12.95^{b**}	07.64***	7.24
BP -Diastolic	71.50 ± 9.44^{a*}	73.95 ± 6.95^{b*}	81.24 ± 9.01^{c**}	11.69***	7.24

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p< 0.05*, p< 0.01**, p<0.001 ***

Table 5.34 and graphical representation in Figure 5.13, depicts percent presence of depression and its association with BMI of non-obese and obese bank employees. Mild mood disturbances were observed in 14% of obese and 11.66% non-obese employees i.e. 2.34% of obese bank employees had more mood fluctuations than non-obese employees. However, borderline to clinical depression was more prominent in non-obese (10%) employees as compared to 3.67% of obese employees i.e. 6.33% of non-obese employees were more depressed than obese employees.

On further analysis according to gender distribution, male bank employees were found to have higher depression scores as compared to their female counterparts. Mild mood disturbance was observed more in 12% of obese males as compare to 6.67% of non-obese males had borderline to clinical depression.

Strong association was observed in previous Table 5.32 (page 197) between depression and BMI (p<0.007) of non-obese and obese bank employees. Also, significant association was observed between male employees and depression (p<0.004).

Table 5.34: Percent presence of depression and its association with BMI of non-obese and obese bank employees

	Male		**Female**		**Total**		**% Difference**
Depression level	**Non-obese N=150 [%]**	**Obese N=150 [%]**	**Non-obese N=150 [%]**	**Obese N=150 [%]**	**Non-obese N=150 [%]**	**Obese N=150 [%]**	
Normal	**65 [21.66]**	**87 [29]**	**20 [6.67]**	**8 [2.66]**	**85 [28.33]**	**95 [31.67]**	**+ 3.34**
Mild Mood Disturbance	**16 [5.33]**	**36 [12]**	**19 [6.33]**	**6 [02]**	**35 [11.66]**	**42 [14]**	**+ 2.34**
Borderline to Severe Depression	**20 [6.67]**	**9 [03]**	**10 [3.33]**	**2 [0.66]**	**30 [10]**	**11 [3.67]**	**- 6.33**
Chi square (χ^2)	**11.1**; p<0.004**		**0.65 ^{NS}; p<0.723**		**9.98**; p<0.007**		

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p< 0.05:*, p< 0.01:**, p < 0.001: ***

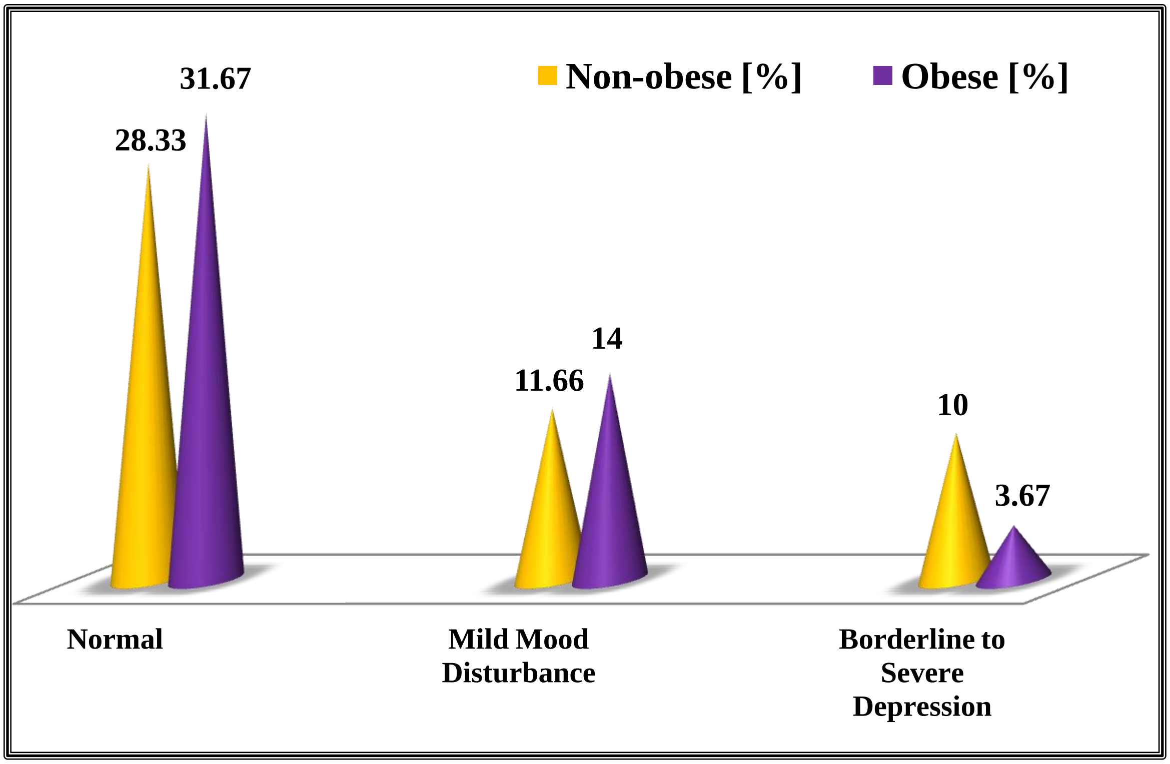

Figure 5.13: Percent presence of depression in non-obese and obese bank employees

Defecation profile data as reported in Table 5.35 according to employees' perception revealed 19.67% of obese and 14% of non-obese employees to be constipated with no strong association amongst them. Passing stool two times in a day was reported by 19% of obese and 15.33% of non-obese employees with no significant association amongst them. More percentage of obese individuals reported small quantity of stool (13.33%), hard stools (20.33%), dark colored stools (46.67%), strong odor (13.33%) and bad feeling after defecation (9.33%).

On the contrary higher percentage of non-obese individuals reported large quantity of stool (41.67%), medium to soft stools (44.33%), normal colored stools (39.33%), weak odor (47%) and good feeling after defecation (45.67%). Strong significant association was observed between hardness of stool ($p<0.000$), color of stool ($p<0.0002$), odor of stool ($p<0.000$) and feeling after defecation ($p<0.000$) of non-obese and obese bank employees

Table 5.35: Defecation profile of non obese and obese subjects				
Defecation Profile	**Non-obese N=150 [%]**	**Obese N=150 [%]**	**χ^2 value**	**p-value**
Constipation according to employees perception				
Present	42 [14]	59 [19.67]	4.13 NS	0.038
Absent	108 [36]	91 [30.33]		
Frequency (times / day)				
1	104 [34.67]	93 [31]	1.78 NS	0.18
2	46 [15.33]	57 [19]		
Quantity of Stool				
Small [1]	25 [8.33]	40 [13.33]	4.42 NS	0.036
Middle to large [2 - 3]	125 [41.67]	110 [36.67]		
Hardness of stool				
Very hard to hard [1- 2]	17 [5.67]	61 [20.33]	33.54***	0.000
Medium to soft [3 - 4]	133 [44.33]	89 [29.67]		
Color of Stool				
Blackish to middle [1-2]	118 [39.33]	140 [46.67]	13.39***	0.0002
Yellowish [3]	32 [10.67]	10 [3.33]		
Odor of Stool				
Strong [1]	9 [03]	40 [13.33]	23.44***	0.000
Medium to weak [2-3]	141 [47]	110 [36.67]		
Feeling after defecation				
Bad [1]	7 [2.33]	28 [9.33]	13.35***	0.000
Fine [2]	137 [45.67]	122 [40.67]		
Regular use of Laxatives				
Yes	15 [05]	21 [07]	1.14 NS	0.287
No	135 [45]	129 [43]		

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Defecation pattern according to score analysis as shown in Table 5.36 revealed that 11.67% of obese and 6% of non-obese bank employees were found to be constipated and this association between constipation scores and obesity was strong and significant ($p<0.005$). Degree of constipation revealed 10.67% of obese to be mild constipated and 5.33% of non-obese were moderate to severely constipated and this association was also strong and significant ($p<0.000$).

Table 5.36 Defecation pattern according to score analysis and degree of constipation in non-obese and obese bank employees

Defecation Profile	Non-obese N=150 [%]	Obese N=150 [%]	χ^2 value	p-value
Defecation Pattern According to Score Analysis				
Constipated [$\leq$ 07]	18 [06]	35 [11.67]		
Normal defecation [8-13]	102 [34]	100 [33.33]	10.5**	0.005
Watery stools [$\geq$ 14]	30 [10]	15 [05]		
Degree of constipation				
No constipation [0]	127 [42.33]	116 [05.33]		
Mild constipation [6-7]	7 [02.33]	32 [10.67]	27.4***	0.000
Moderate to Severe [1-5]	16 [05.33]	2 [00.67]		

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p < 0.05: *, p < 0.01: **, p < 0.001: ***

Table 5.37 depicts frequency of major food group consumption by non-obese and obese bank employees. Consumption of cereals was more frequent by non-obese employees (48%) compared to obese employees (42%) and this association with BMI was inversely significant (p<0.001).

Consumption of high fiber (42.67%) and moderate fiber (29.67%) fruits was significantly higher by non-obese employees as compared to obese employees. Significant inverse association between consumption of high fiber (p<0.001) and moderate fiber (p<0.001) fruits with BMI was observed.

Table 5.38 depicts data on mean values of macronutrient and types of fiber intake of non-obese and obese bank employees. Dietary recall data was collected for (24 hours) for 3 consecutive days and macronutrient and fibre intake was calculated using “Diet-soft” software. Dietary intake data was compared with the recommended dietary allowance for Indians given by Indian Council of Medical Research (ICMR, 2010). RDA values given for sedentary reference men and women were considered for comparison as most of the employees had sedentary lifestyle. Analysis of dietary data revealed significant difference in macronutrient and fiber intake of non-obese and obese employees except intake of insoluble fibre.

Table 5.37: Frequency of major food group consumption by non-obese and obese bank employees

Food group	Non-obese N =150 [%]		Obese N = 150 [%]		
	Less frequent	Frequent	Less Frequent	Frequent	χ^2 Values
Cereals	4 [01.33]	146 [48.67]	23 [07.67]	127 [42.33]	14.69***
Millets	142 [46.67]	8 [02.67]	140 [46.67]	10 [03.33]	00.24^{NS}
Pulses	31 [10.33]	119 [39.67]	18 [06.00]	132 [44.00]	04.12^{NS}
Vegetables	52 [17.33]	98 [32.67]	46 [15.33]	104 [34.67]	00.55 ^{NS}
High Fiber Fruits [>5 g %]	28 [09.33]	128 [42.67]	58 [19.33]	92 [30.67]	16.25***
Moderate Fiber Fruits [4.99-2 g %]	61 [20.33]	89 [29.67]	102 [34.00]	48 [16.00]	22.58***
Low Fiber Fruits [1.99 -0.5 g %]	09 [03.00]	141 [47.00]	04 [01.33]	146 [48.67]	02.01^{NS}

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p < 0.05 *, p <0.01**, p< 0.001***

Dietary intake of male bank employees:

As shown in Figure 5.14, obese male employees consumed 24.61% higher calories, 38.93% higher proteins, 96.40% higher fat and 5.72% higher carbohydrate than the RDA as compared to non-obese male whose intake was 11% lower for calories, 0.85% for proteins and 22.09% lower for carbohydrate than the RDA. However, non-obese males consumed 38.38% excess intake of fat as compared to RDA. Intake of total dietary fibre was much on lower side in both non-obese (54.42%) and obese (36.41) male bank employees as compared to RDA. Similarly, intake of soluble fibre was also too low in both non-obese (54.30%) and obese (62.41%) male employees.

Intake of crude fibre was significantly higher in obese males as compared to non-obese males. However, no significant difference was observed in intake of insoluble fiber intake. As there is no reference range for insoluble fibre and crude fibre intake, comparison of percentage intake with RDA could not be established.

Dietary intake of female bank employees:

As shown in Figure 5.15, obese female employees consumed 24.10% higher calories, 9.31% higher proteins, 140.33% higher fat and 4.27% lower carbohydrate than the RDA as compared to non-obese male whose intake was 1.16% lower for calories, 5.10% for proteins and 22.36% lower for carbohydrate than the RDA. However, non-obese females consumed 37.86% excess intake of fat as compared to RDA. Total dietary fibre intake was much on lower side in both non-obese (54.64%) and obese (65.89) female bank employees as compared to RDA. Similarly, intake of soluble fibre was also too low in both non-obese (53.55%) and obese (66.50%) female employees.

However, no significant difference was observed in intake of insoluble fiber and crude fibre intake. As there is no reference range for insoluble fibre and crude fibre intake, comparison of percentage intake with RDA could not be established.

Total Dietary intake of bank employees:

In total, obese employees consumed significantly higher intakes of all macronutrients as compared to non-obese bank employees. Even intake of total fibre, soluble fibre and crude fibre was also on higher side by obese employees as compared to non-obese employees. However, the reason for this contradiction could be simply higher intakes of overall food consumption by obese employees. Intake of insoluble fibre was almost equal by non-obese and obese employees and no significant difference was observed in both the groups.

Table 5.38 : Mean values of macronutrient and types of fiber intake of non-obese and obese bank employees

Macronutrient and types of fibre [RDA for male and Female]	Non-obese Male Mean ±SD	Obese Male Mean ±SD	"t" test	Percent Difference From RDA [Non-obese / obese]	Non-obese Female Mean ±SD	Obese Female Mean ±SD	"t" test	Percent Difference From RDA [Non-obese / obese]	Non-obese Total Mean ± SD	Obese Total Mean ± SD	"t" test
	N=101	N=123			N=49	N=18			N=150	N=150	
Energy [kcals] [M: 2320; F: 1900]	2065 ±775	2891 ±566	7.98 ***	- 11.00 / + 24.61	1878 ±646	2358 ±502	2.84 **	- 01.16 / + 24.10	2004 ±738	2722 ±582	9.35 ***
Protein [g] [15%] [M: 60; F: 55]	60.51 ±20.06	83.36 ±25.41	7.54 ***	+ 00.85 / + 38.93	52.19 ±15.17	60.12 ±12.19	1.99 NS	- 05.10 / + 09.31	57.79 ±18.96	80.11 ±24.09	8.92 ***
Total Fat [g] [20%E] [M:52; F:42]	71.96 ±31.86	102.13 ±46.45	4.69 ***	+ 38.38 / + 96.40	71.69 ±33.39	100.94 ±29.78	3.27 **	+ 37.86 / + 140.33	71.87 ±32.26	96.78 ±42.40	5.73 ***
CHO [g] [65 %] [M: 377; F: 309]	293.71 ±140.72	398.55 ±88.34	6.12 ***	- 22.09 / + 05.72	239.90 ±73.29	295.80 ±66.46	2.83 **	- 22.36 / - 04.27	276.14 ±125.15	373.59 ± 86.89	7.83 ***
Soluble fibre [g][1/4th TF] 10g / 2000 kcals	4.57 ±2.00	5.45 ±1.68	2.82 **	- 54.3 / - 62.41	4.18 ±1.18	4.02 ±1.38	0.49 NS	- 53.55 / - 66.50	4.44 ±1.78	5.10 ±1.66	3.29 **
Insoluble fibre [g]	13.79 ±5.30	15.01 ±5.96	0.96 NS	-	12.66 ±3.75	11.22 ±3.95	1.37 NS	-	13.42 ±4.86	14.09 ±5.59	1.11 NS
Crude fibre [g]	7.62 ±2.78	9.47 ±2.55	5.01 ***	-	6.53 ±2.43	6.08 ±1.47	0.74 NS	-	7.26 ±2.71	8.94 ±2.55	5.51 ***
Total fibre [g] 40g / 2000 kcals	18.23 ±7.26	21.12 ±7.93	2.04 *	- 54.42 / - 36.41	17.01 ±4.72	16.03 ±5.40	0.73 NS	- 54.64 / - 65.89	17.83 ±6.55	19.73 ±7.47	2.34 **

NOTE: NS = non-significant, p < 0.05: *, p < 0.01: **, p < 0.001: *** ; ## - 24 Hour Dietary Recall for Three consecutive days

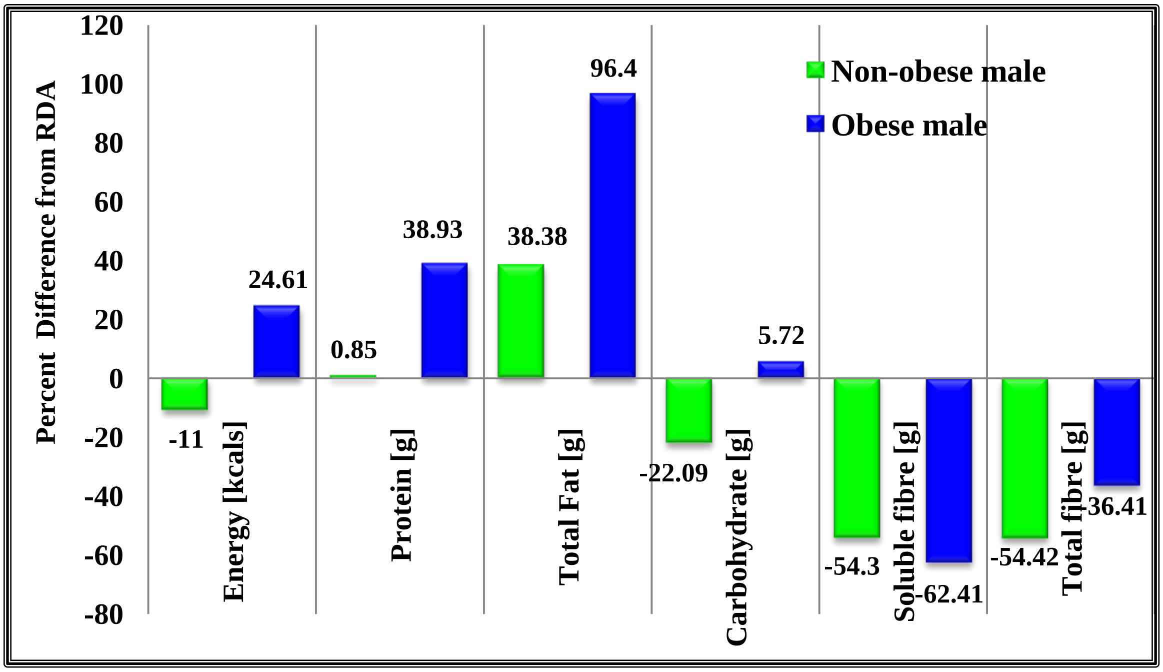

Figure 5.14 Percent difference of macronutrient and fiber intake by male bank employees as compared to RDA

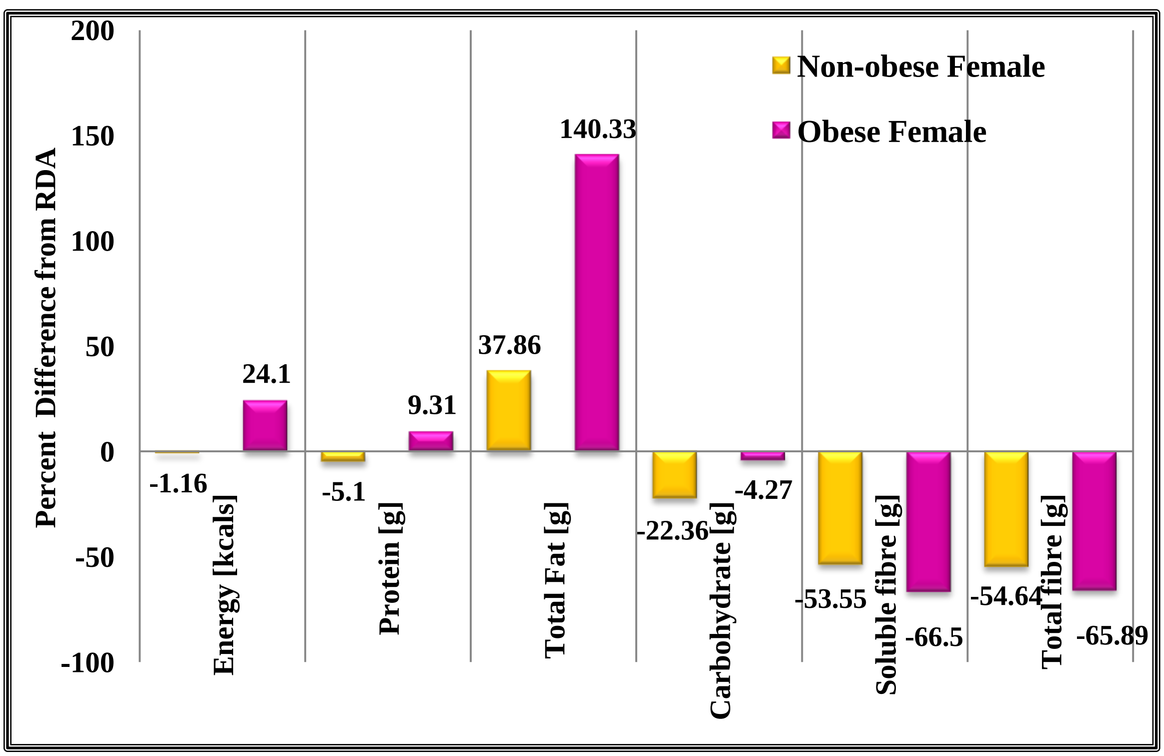

Figure 5.15 Percent difference of macronutrient and fiber intake by female bank employees as compared to RDA

The inversely related score (1 -10) based approach was used for measuring hunger and satiety, where lesser score depicts severe starvation and higher value depicts extreme fullness. Data in Table 5.39 depicts no significant difference between hunger scores of employees in both groups during all meal times.

Table 5.39 : Mean hunger scores of non-obese and obese subjects at various meal timings

HUNGER SCORES			
Meal	**Non-obese [N=150] Mean ± SD**	**Obese [N=150] Mean ± SD**	**Students "t"**
Breakfast	**4.08 ± 0.75**	**3.95 ± 0.85**	**1.37 NS**
Lunch	**3.49 ± 0.67**	**3.56 ± 0.86**	**0.82 NS**
Evening	**4.02 ± 0.91**	**4.20 ± 0.84**	**1.79 NS**
Dinner	**3.51 ± 0.74**	**3.51 ± 1.09**	**0.03 NS**
Total mean score	**15.09 ± 1.94**	**15.22 ± 2.34**	**0.51 NS**

NOTE : NS = non-significant; 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

On the contrary, as shown in Table 5.40, significant difference was observed in the satiety scores during meal time of lunch ($p<0.001$), evening ($p<0.01$) and dinner ($p<0.001$). Probably obese individuals consumed excess amount of food to fullness and hence reported higher scores for delayed satiety.

Table 5.40: Mean satiety scores of non-obese and obese subjects at various meal timings

SATIETY SCORES			
Meal	**Non-obese [N=150] Mean ± SD**	**Obese [N=150] Mean ± SD**	**Students "t"**
Breakfast	**6.13 ± 0.68**	**6.29 ± 0.79**	**1.88 NS**
Lunch	**6.31 ± 0.70**	**6.81 ± 0.93**	**5.19*** **
Evening	**5.63 ± 1.03**	**6.02 ± 0.66**	**3.86** **
Dinner	**6.64 ± 0.80**	**7.21 ± 1.03**	**5.40*** **
Total mean score	**24.73 ± 1.95**	**26.33 ± 2.37**	**6.39*** **

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

5.2.2: To study Gut-microflora of non-obese and obese subjects with regards to *Bifidobacterium, Lactobacillus, Clostridium* and *Bacteriodes*

As shown in Table 5.41 depicts mean values of gut-microbial profile and difference in their gut colonization pattern of non-obese and obese bank employees.

Significant difference in the mean $\log_{10}$ values (CFU/g) of stool sample for *Bifidobacteria*, *Clostridium and Bacteroides* was observed between non-obese and obese employees. However, no significant difference was observed in the counts of *Lactobacillus* in both the groups.

The gut microbial profile of non-obese employees depicted predominantly higher colonization of *Bifidobacterium* by 4.27% and *Bacteroides* by 8.17%. However, colonization of gut in obese employees was dominated by higher counts pathogenic bacteria – *Clostridium* by 4.32% as compared to non-obese.

Table 5.41: Mean values of gut-microbial profile and difference in their gut colonization pattern of non-obese and obese bank employees

Parameters	Non-obese [N=115] Log $_{10}$ values [CFU/g] Mean ± SD	Obese[N=115] Log $_{10}$ values [CFU/g] Mean ± SD	't' test Value	Percent Difference
Bifidobacterium	**12.63 ± 1.68**	**12.09 ± 1.12**	**2.85****	**- 4.27**
Lactobacillus	**11.84 ± 1.54**	**11.99 ± 1.61**	**0.98 NS**	**+ 1.27**
Clostridium	**11.82 ± 1.54**	**12.33 ± 1.15**	**2.70****	**+ 4.32**
Bacteroides	**12.85 ± 1.44**	**11.80 ± 1.55**	**5.19*****	**+ 8.17**

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

5.2.3: To determine the baseline levels of six gut-hormones namely GLP1, GIP, PYY, Ghrelin, Leptin and Insulin

In the study of obesity, advances are unfolding at a rapid pace, providing new hope for unraveling and potentially eradicating this disease. We do know that peptides play a significant role in the regulation of gut motility and secretion, pancreatic islet hormone secretion, food intake and energy expenditure. While much still remains unknown about the specific role they play in the cause of obesity

Six gut hormones were analyzed in subsample of 40 employees from non-obese arm and 40 employees from obese arm using fasting plasma samples. The Latest technology of Luminex X-MAP and its kit named Human Gut Hormone panel kit #HGT-68K having 96 well assay plate was used. Table 5.42 represents comparison between mean baseline values of fasting gut satietogenic hormones of non-obese and obese young bank employees.

Results revealed significant difference in the baseline values of non-obese and obese young bank employees. In young obese bank employees mean values of gut satietogenic hormones like GLP-1 (7.68pg/ml), GIP (5.04pg/ml), and PYY (41.31pg/ml) were significantly ($p<0.001$) lower as compared to the non-obese employees (20.78, 12.12, 70.21 pg/ml respectively) justifying their role in weight and appetite regulation. Percent difference in mean fasting plasma values of gut satietogenic hormones of obese employees was - 63.04% lower for GLP -1, - 58.42% for GIP, and - 41.16% for PYY. Plasma insulin values were in normal range in both groups. However, percent difference for Insulin was +172.75% in obese bank employees. Ghrelin which is an orexogenic hormone was significantly lower in obese (113.56 pg/ml; -56.14%) as compared to non-obese (258.91pg/ml) employees justifying skipping of breakfast by obese employees in morning time. Similarly, Leptin being directly proportional to fat, it was almost +200% higher in obese employees as compared to non-obese. This may also indicate Leptin resistance in obese bank employees and may behave differently though being an anorexogenic hormone.

Table 5.42: Baseline fasting gut-hormone [pg/ml] profile of non-obese and obese young bank employees

Name of hormone Fasting Values (pg/ml)	Conversion units	Non-obese [N=40] Mean ± SD	Obese [N=80] Mean ± SD	% Difference	"t" test
GLP-1 (Active) [1.6 - 30 pg/ml] [0.5 - 10 pmol / L]	pmol / L = pg/ml ÷ 3.298	20.78 ± 3.48	7.68 ± 1.84	- 63.04%	27.18***
GIP (Total) [1.6- 100 pg/ml] [0.3 - 20 pmol / L]	pmol / L = pg/ml X 0.2	12.12 ± 2.08	5.04 ± 1.66	- 58.42%	20.18***
PYY (Total) [30 - 120 pg/ml] [7.5 - 30 pmol/L]	pmol / L = pg/ml X 0.25	70.21 ± 6.24	41.31 ± 17.75	- 41.16%	9.98***
Insulin [< 1009 pg/ml] [<174 pmol/L]	pmol / L = pg/ml ÷ 172.5 OR 10 uU/ml= 0.4 ng/ml = 69pmol/L OR [1ng/ml=172.5 pmol/L]	214.30 ± 81.00	584.51 ± 247.89	+ 172.75%	9.18***
Ghrelin (Active) [200- 720 pg/ml] [59 - 215 pmol/L]	pmol/L = pg/ml X 0.296	258.91 ± 39.01	113.56 ± 44.07	- 56.14%	17.67***
Leptin [3900 - 15000 pg/ml]	ng/ml = pg/ml ÷ 1000	4039.5 ± 1413.01	12191.79 ± 2557.46	+ 199.15%	18.75***

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

5.2.4: Correlation of weight with various parameters of young bank employees and regression analysis to identify strongest predictor of obesity

5.2.4a: Pearson's Correlation of weight with various determinants of obesity in young bank employees of urban Vadodara.

Table 5.43: Positive correlation of weight with various parameters of young bank employees of urban Vadodara

Parameters	Pearson's Correlation [r value]	P value
Age	0.212*	0.002
WC[cms]	0.884**	0.000
Abdominal Obesity	0.663**	0.000
HC[cms]	0.877**	0.000
WHR	0.583**	0.000
Central Obesity	0.489**	0.000
Body fat[%]	0.459**	0.000
BMR	0.951**	0.000
SBP[mmHg]	0.421**	0.000
DBP [mmHg]	0.365**	0.000
Family History	0.200*	0.028
Defecation-Frequency	0.241**	0.008
PH-alcohol	0.283**	0.002
PH-cig	0.244**	0.007
PH-Tea	0.452**	0.000
PH-coffee	0.255**	0.005
Severe Habituation	0.435**	0.000
Satiety Total Score	0.418**	0.000
Energy [Kcal]	0.340**	0.000
Protein [gms]	0.463**	0.000
Fat [gms]	0.236**	0.009
Insoluble Dietary fiber	0.257**	0.005
Soluble Dietary fiber	0.545**	0.000
Total Dietary Fiber [gms]	0.282**	0.002
Leptin (pg/ml)	0.667**	0.000
Insulin (pg/ml)	0.539**	0.000

****. Correlation is significant at the 0.01 level (2-tailed).*. Correlation is significant at the 0.05 level (2-tailed).**

Table 5.43 depicts positive correlation of weight with various parameters of young bank employees of urban Vadodara. A positive significant (p<0.001) correlation of weight was observed with body fat (r=0.459), systolic blood pressure (r=0.421), diastolic blood pressure (r=0.365), defecation frequency (r=0.241), alcohol intake (r=0.283), tea consumption (r=0.452), severe habituation (r=0.435), total satiety scores (r=0.418), energy intake (r=0.340), protein (r=0.463), fat (r=0.263), soluble dietary fiber (r=0.545), Leptin (r=0.667) and Insulin (r=0.539)

Table 5.44: Negative correlation of various parameters with weight of young bank employees of urban Vadodara

Parameters	Pearson's Correlation [r value]	P value
Gender – Male	**-0.443****	**0.000**
Defecation-Hardness	**-0.295****	**0.001**
Defecation-Colour	**-0.193***	**0.034**
Defecation-Odour	**-0.249****	**0.006**
Feeling after Defecation	**-0.337****	**0.000**
Defecation Total Score	**-0.268****	**0.003**
Mild Habituation	**-0.275****	**0.002**
Moderate Habituation	**-0.273****	**0.003**
Heavy Physical Activity	**-0.205***	**0.025**
Hunger-Dinner	**-0.330****	**0.000**
Hunger Total Score	**-0.307****	**0.001**
Hunger-Mean Scores	**-0.307****	**0.001**
BDI-boderline	**-0.233***	**0.010**
High Fiber Fruits	**-0.391****	**0.000**
Moderate Fiber Fruits	**-0.222***	**0.015**
Low Fiber Fruits	**-0.205***	**0.025**
Bacteriodes[Log10 Values][CFU/g]	**-0.258****	**0.004**
Ghrelin active [pg/ml]	**-0.700****	**0.000**
GIP [TOTAL] [pg/ml]	**-0.610****	**0.000**
GLP-1 [Active] [pg/ml]	**-0.717****	**0.000**
PYY [Total] [pg/ml]	**-0.763****	**0.000**

****. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).**

Table 5.44 depicts negative correlation of weight with various parameters of young bank employees of urban Vadodara. Significant ($p<0.001$) negative correlation of weight was observed with defecation odor (r=0.249), feeling after defecation (r=0.337), physical activity (r=0.205), total hunger scores (r=0.307), hunger scores at dinner time (r=0.330), depression (r=0.233), insoluble dietary fiber (r=0.257), soluble dietary fiber (r=0.545), total dietary fiber (r=0.282), high fiber fruits (r=0.391), moderate fiber fruits (r=0.222), *Bacteroides* (r=0.258), GLP-1 (r=0.717), GIP (r=0.610), PYY (r=0.763) and Ghrelin (r=0.700).

5.2.4b: *Stepwise linear multiple regression analysis for strongest predictor of obesity in young bank employees*

Table 5.45 reflects results of step wise linear multiple regression model summary for strongest predictor of obesity in young bank employees of urban Vadodara. The criterion for probability of factor to enter was 0.05 and to remove was 0.100. Gut hormone PYY alone was the strongest predictor of obesity to the accuracy of 58% in young bank employees. PYY along with intake of soluble dietary fiber could predict obesity with accuracy of 64%. Further, adding up factors like alcohol intake (67%), frequent tea consumption (70%), fat intake (74%), *Bacteroides* counts (75%), Ghrelin (77%) and *Clostridium* counts (78%).

When all factors are present in a person, obesity could be predicted with accuracy of 78% in population of young bank employees.

Factors that contribute maximum towards development of obesity are ranked in order of gut hormone PYY, soluble dietary fiber, tea, alcohol, Ghrelin hormone, fat, protein, *Clostridium* and crude fiber.

Table 5.45 : Stepwise regression model summary for strongest predictor of obesity in young bank employees of urban Vadodara

Model	R	R Square	Adjusted R	Std. Error of the
1	.763[a]	.582	.579	8.6008
2	.803[b]	.645	.639	7.9599
3	.822[c]	.676	.668	7.6409
4	.844[d]	.712	.702	7.2347
5	.854[e]	.730	.718	7.0349
6	.864[f]	.747	.733	6.8428
7	.871[g]	.758	.743	6.7173
8	.878[h]	.770	.753	6.5805
9	.886[i]	.786	.768	6.3828
	[j]			

Predictors: [Constant], a] PYY; b] Soluble Dietary fibre; c] Alcohol; d] Tea; e] Fat; f] Bacteriodes; g] Gherlin ; h] Clostridium; i] Protein ; j] Crude fibre
k] Dependent Variable: Weight [kg]

Coefficients[a]

Sr.no.	Model	Unstandardized		Standardized	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	97.947	2.136		45.866	.000
	Gut hormone - PYY	-.500	.039	-.763***	-12.828	.000
	Soluble Dietary fibre	1.027	.225	.276***	4.557	.000
	Alcohol	1.215	.367	.177***	3.313	.001
	Tea	.814	.215	.208***	3.793	.000
	Fat	-.054	.020	-.153**	-2.761	.007
	Bacteriodes	-1.061	.388	-.135**	-2.737	.007
	Gherlin active	-.029	.013	-.175*	-2.294	.024
	Clostridium	-1.290	.540	-.115*	-2.388	.019
	Protein [gms]	.094	.033	.149**	2.825	.006
	Crude fibre [gms]	.465	.225	.105*	2.061	.042

a. Dependent Variable: Weight [kg]

ANOVA[k]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	16588.316	10	1658.832	41.919	.000[j]
	Residual	4313.368	109	39.572		
	Total	20901.684	119			
j. Predictors: (Constant), PYY (Total) (pg/ml), Soluble Dietary fibre [gms], PH-alcohol, PH-Tea, Fat [gms], Bacteriods[Log10 Values] [CFU/g], Gherlin active (pg/ml), Clostridium[Log10 Values] [CFU/g], Protein [gms], Crude fibre [gms]						
k. Dependent Variable: Weight[kg]						

RESULT HIGHLIGHTS

- With increase in 1% of Body-fat, increase in BMR by 1% was observed
- Young Obese employees reported
  - Locomotor disorder (23%)
  - Flatulence (23%)
  - Constipation (20%)
  - Acidity (13%)
- Aerated drinks, Tea and Alcohol were the most frequently consumed habitual products
- Young obese employees consumed excess of all macronutrients as compared to RDA.
- Fat intake was exceptionally high 97% as compared to RDA
- Fiber intake was 50% lower than RDA
- Young obese employees had delayed satiety during lunch, evening and dinner meal time
- 14% of young obese employees had mild mood disturbance
- 12% of young obese employees were constipated and reported small quantity, hardness, dark colour, foul strong odour of stool and bad feeling after defecation
- Gut of young obese employees was dominated by 4.32% higher counts of pathogenic bacteria - *Clostridium*
- They also had diminished secretion of gut satietogenic hormone.
- Leptin and Insulin levels were higher in obese employees
- Strong predictors of obesity in young bank employees was found to be PYY, soluble dietary fibre, alcohol, tea, fat, and protein intake, counts of *Bacteriodes and Clostridium* to the accuracy of 79.4%

RESULT HIGHLIGHTS

- **A positive significant ($p<0.001$) correlation of weight was observed with body fat ($r=0.459$), systolic blood pressure ($r=0.421$), diastolic blood pressure ($r=0.365$), defecation frequency ($r=0.241$), alcohol intake ($r=0.283$), tea consumption ($r=0.452$), severe habituation ($r=0.435$), total satiety scores ($r=0.418$), energy intake ($r=0.340$), protein ($r=0.463$), fat ($r=0.263$), soluble dietary fiber ($r=0.545$), Leptin ($r=0.667$) and Insulin ($r=0.539$).**

- **Significant ($p<0.001$) negative correlation of weight was observed with defecation odor ($r=0.249$), feeling after defecation ($r=0.337$), physical activity ($r=0.205$), total hunger scores ($r=0.307$), hunger scores at dinner time ($r=0.330$), depression ($r=0.233$), insoluble dietary fiber ($r=0.257$), soluble dietary fiber ($r=0.545$), total dietary fiber ($r=0.282$), high fiber fruits ($r=0.391$), moderate fiber fruits ($r=0.222$), *Bacteroides* ($r=0.258$), GLP-1 ($r=0.717$), GIP ($r=0.610$), PYY ($r=0.763$) and Ghrelin ($r=0.700$)**

- **Gut hormone PYY alone was the strongest predictor of obesity to the accuracy of 58% in young bank employees. PYY along with intake of soluble dietary fiber could predict obesity with accuracy of 64%. Further, adding up factors like alcohol intake (67%), frequent tea consumption (70%), fat intake (74%), *Bacteroides* counts (75%), Ghrelin (77%) and *Clostridium* counts (78%).**

RESULT HIGHLIGHTS

FUTURE LIABILITIES FOR HEALTHCARE

NON-OBESE YOUNG ADULTS AT HIGHER RISK FOR DEVELOPING NCD's

Elevated SBP [mmHg]:	127.11±12.75	(n=150)
Abdominal obesity :	5.67%	(n=17)
Central obesity:	13.67%	(n=41)
Higher Body –fat%:	08.33%	(n=25)
Family History of NCD's:	22.33%	(n=67)
Aerated drinks	45%	(n=136)
Alcohol	16%	(n=49)
Moderate habituation	21.33%	(n=64)
Depression	10%	(n=30)
Constipation :	6%	(n=18)
Lower Intake of Fiber :	54%	(RDA)
Higher Fat Intake:	38%	(RDA)

DISCUSSION

In present phase of study we tried compare non-obese and obese employees and wanted to look into differences in various parameters between them. Our aim was to understand how obese body type differs from non-obese body type with respect to few known and unknown parameters regulating underlying mechanisms of gut-brain axis like anthropometric measurements, family medical history, personal medical history, defecation profile, personal habits, habituation profile, physical activity pattern, hunger and satiety scale, depression scores and dietary intakes, gut-microflora with regards to *Bifidobacterium*, *Lactobacillus*, *Clostridium*, *Bacteriodes* and fasting plasma levels of six gut hormones namely GLP-1, GIP, PYY, Ghrelin [Hunger hormone], Leptin [Energy Expenditure hormone] and Insulin levels of non obese and obese subjects

As selection of comparative groups of non-obese and obese was a purposive choice, it was not very uncommon to find differences in their anthropometric profile. Obese employees had 37.2% higher body weight, 24.69% higher BMI, 22.42% higher WC, 8.14% WHR, 27.85% higher body fat percentage as compared to non-obese.

Generally, it is a very common mindset that obese people have lower BMI as compared to non-obese and it is often correlated with physical inactivity. However, in our study BMR was 28.35% higher in obese employees as compared to non-obese. Though the mean values of BMR (1739 Kcals) was not that too high to induce weight loss. Also, as previously mentioned that body fat was 27.85 (approx ≈ 28 %) higher and percent difference in BMR was also 28.35% (approx ≈ 28 %). From this finding it could be inferred and probably stated that with every 1 % increase in body fat, the basal metabolic rate increases by 1%. It seems as if in employees with higher fat percentage, body has to exert more to perform basic metabolic functions. Similar results were also observed in nearly 100 studies on doubly-labeled water in industrialized countries, and found that they did not had lower rate of daily energy expenditure as compared to populations in developing countries (Dugas et al., 2011). This indicates clearly that obese individuals have higher habitual energy expenditure due to their larger body size and resting metabolic rates as compared to normal weight individuals (Ravussin et al., 1982). Moving further, Leibel, Rosenbaum and Hirsch (1995) demonstrated that increase in 10% of weight increases daily energy expenditure from 370 to 530 kcal, depending on their initial baseline weight. The very obvious implication of this condition results in increase in rate of energy intake accordingly, otherwise resultant weight loss will ensure (Leibel, Rosenbaum & Hirsch, 1995).

With regards to personal medical history 23% of obese employees suffered form locomotor disorder, 23% with flatulence, 20% with constipation and 13% with acidity. One of the primary modifiable risk factor recommended by orthopedic doctors is to focus on keeping check on their weight to prevent the onset and progression of musculoskeletal conditions of bone joints, fracture and osteoarthritis. Recent evidence indicates profound impact of obesity on soft tissue structures such as tendon, fascia and cartilage (Wearing, 2016). In USA, around 27 million adults are affected with osteoarthritis which is one of the most prevalent musculoskeletal conditions and association between obesity and joint pain is very well documented. Bourne et al. (2007) stated that the relative risk of having total hip or knee replacement increases as BMI increases (Akiko & Hare, 2015; Lee et al., 2012; Lee & Kean, 2012; Lohmander et al., 2009; Lawrence et al., 2008; Bourne et al., 2007). A study conducted by Pourhoseingholi et al. (2009) found 459 adults having functional constipation with BMI 26.5 ± 4.7. Along with obesity he found age and education to be significantly associated with obesity and functional constipation in 60% of adult subjects (Pourhoseingholi et al., 2009). Links between obesity and increasing risk of developing gastric acid reflux disease (GERD) has been very well established though GERD being a multifactorial disease. The proinflammatory signals derived from visceral adipose tissue and direct mechanical factors in overweight and obese subjects may account for an increased occurrence of reflux episodes (Kafia et al., 2014; Pandolfino et al., 2006; Hampel et al., 2005).

With regards to habituation profile, our study demonstrated frequent consumption of aerated drinks, tea and alcohol by obese employees. Aerated drinks were the easy source of temporarily relieve stress induced by their job profile as they provide an influx of caffeine and are loaded with sugar. According to Centers for Disease Control and

Prevention 2017 data collected during 2011 – 2014 depicted that, 63% of young adults and 49% of adults consumed one SSB per day. Approximately, 143 calories / day was consumed by U.S. youth and 145 calories /day by U.S. adult from SSB intake (Rosinger et al., 2017). On an Average 65% of Americans from different geographical locations consumed minimum one SSB per day (Park, McGuire & Galuska, 2015). Also, 52% of Americans drink SSB at home and 48% of people drink away from home (Kit et al., 2013).

Similar was the case with tea consumption, along with caffeine tea was an excellent source of sugar consumption. Along with aerated drinks tea can also be added to the list of sugar-sweetened beverage [SSB]. In Gujarat, people have inclination for tea and also have liking for sweet food products. For bank employees tea and aerated drinks were the easy and affordable stress busters to cope with their job profile.

Even consumption of alcohol was justified as a means to relieve body ache and work stress at the end of day for peaceful sleep. Alcohol was also consumed for enjoyment and weekend fun. There are several health issues associated with alcohol intake, but relationship between alcohol intake and weight gain has been extensively explored in cross-sectional, longitudinal and experimental studies (Bendsen et al., 2013; Sayon-Orea et al., 2011; Yeomans, 2010). In a study conducted by Rosalind et al. (2013) on diets of drinkers in US and data collected from NHANES 2003-2008 survey data reported that intake of calories due to alcohol consumption are exorbitantly high on drinking days. Alcohol intake also influences immediate appetite and effects energy storage. Oxidation of fat is inhibited by alcohol intake suggesting fat sparing action leading to higher body fat in long term (Traversy & Chaput 2015; Yeomans, 2003).

Not only employees consumed excess calories from the above mentioned SSB and alcohol but their overall macronutrient intake was also higher than the recommended dietary allowance (RDA) with 38% higher protein intake and exceptionally higher intake of total fat (97%) above RDA. On the worst flip side their fiber intake was 50% lower than the RDA. To worsen the scenario, obese employees reported higher scores for delayed satiety. Unlike carbohydrate and fat, role protein in weight gain and obesity has been uncontroversial forever. Protein has been very well accepted as a weight loss macronutrient. Growing evidence from various researches indicates that it plays a very important role in promoting satiety and achieving weight-loss (Mathews, 2018; Westerterp-Plantenga, Lemmens & Westerterp, 2012; Keller, 2011; Douglas et al., 2008). The mechanism through which protein exerts or aids in weight loss could be attributed to satiation effect, thermogenesis Effect, Maintenance of Fat Free Mass (FFM), Enhanced glycemic control and stimulation of gut hormone release (Nakamura et al., 2011). The mechanism by which protein helps in promoting satiety is through peptides formed during protein digestion. It involves intestinal gluconeogenesis in the control of food intake. These peptides lead to the suppression of µ-opioid (Mu-opioid) receptors (MORs) lined up on walls of portal vein that acts as communication channel between gut and brain. MORs sends appetite stimulating signals to brain and these signals are inhibited by the protein peptides and communicate satiety signals to brain by suppressing MORs and curbing appetite (Carreiro et al., 2016; Duraffourd et al., 2012).

In our study though protein intake was 38% higher than RDA in obese employees still they reported higher weight and delayed satiety which is contradictory to the above findings. However, protein intake was also accompanied with exceptionally higher intakes of fat which could be the prime reason of nullifying the weight loss and satiety effects of protein. Also, there were other intruding factors like excess consumption of SSB and alcohol which also would have hampered the weight loss effect of protein. It could be inferred that to optimize the effect of protein on weight loss, other confounding variables needs to be controlled.

Delayed satiety could be possibly because of not consuming proper meals on time. During office hours bank employees did consume lunch but meal time was never consistent and used to fluctuate every day. They consumed tea and SSB to curb the hunger pangs on day when meal was delayed. At the end of day on reaching home though their hunger pangs were not too intensified but satiety signals were definitely delayed. Though these SSB are loaded with sugar and calories and are calorie dense, after its consumption it fails to provide sense of satiety. Resultant people continue eating their solid food in addition to the intake of SSB and end up putting on weight due to excess of total calorie intake. Studies have very well established a strong correlation between development of obesity and consumption of SSB (CDC 2016; Ervin, 2013; US Department of Agriculture, 2015; Pan & Hu, 2011; Hu & Malik, 2010; Woodward-Lopez Kao & Ritchie, 2011; Johnson et al., 2009; Malik, Schulze, & Hu, 2006). Also, studies conducted by Röjdmark, Calissendorff, & Brismar (2001) and Raben et al. (2003) demonstrate that alcohol intake influences number of hormones linked to satiety. Alcohol may influence energy intake by inhibiting the effects of Leptin, or GLP-1.

Obese employees (14%) exhibited mild mood disturbance though clinical depression was not prevalent in our study group. Although obesity and depression feed each other but it was not the case in obese bank employees. Dr. Miller also explains his views stating that in obesity parts of brain that regulate mood gets affected leading to low energy and motivation that gets translated into less activity and exercise resulting into weight gain. Also, if both problems have a hold on an individual then he enters into a vicious cycle (Miller, 2013). Till date it was assumed that obesity and depression coincidentally existed together. However, in a meta-analysis of longitudinal studies conducted by Luppino & colleague (2010), they found that in American studies the development of depression was strongly influence by obesity. In our study these 14% of obese employees with mild mood disturbance are potential candidates for entering into vicious cycle leading them further to the development of depression.

Nevertheless, 12% of young obese employees also reported having constipation, small quantity of stool, hardness and dark color of stool along with foul strong odor and bad feeling after defecation. Defecation is one of the least understood and studied human bodily function. Constipation affects nearly 2% – 28% of the general population (Adibi et al., 2007) and is one of the functional gastrointestinal disorder that results from an initial inflammatory insult to GI tract modifying motility and releasing proinflammatory cytokines (Mohamad et al., 2009; Bercik, Verdu & Collins, 2005).

The difference observed in the defecation pattern between obese and non-obese employees in our study with respect to frequency, quantity, hardness, color and odor of stools, all of which suggest that intestinal transit is slower in obese as compared to the non-obese employees. Obese people as a rule are constipated bipeds. The fact that they are obese, presupposes an abuse of starches and sugars and a disuse of fibre foods—the use of the former and the disuse of the latter producing colonic lethargy. The inactivity of the obese also induces constipation (Erik et al., 2011). The longer food remains in the colon the more nutrient and fluids are absorbed, and making stools harder and dark colored both influencing the scales unfavorably. Constipation may exist even though the obese subject eats plenty of high residue foods. The flabby abdomen of the obese prevents the adequate intra-abdominal pressure which starts the defecation reflex. The most consistent finding in the study was that obese bowel function is different from that of non-obese. Obese defecate less often and their stool types tend towards the constipated end of the range compared with non-obese (Mohamad et al., 2009; Bercik, Verdu & Collins, 2005).

Since, microbiota has a crucial role in obesity then probably the phenotype of obese individuals should have a distinct microbial composition than lean individuals (Ley et al., 2005). In our study gut of young obese employees was dominated by 4.32% higher counts of pathogenic bacteria – *Clostridium* and had lower counts of *Bifidobacterium* and *Bacteroides* as compared to non-obese employees. In initial studies exploring relationship between gut flora and obesity have earlier demonstrated that number of *Firmicutes* were more and the number of *Bacteriodetes* was less in obese humans and mice as compared to lean individuals (Delzenne, et al., 2011).

During the study conducted on ob/ob mice, lean ob/C and wild-type counterparts analyzing differences in their gut microflora Ley et al. (2006) found that genetically obese mice had less of *Bacteroidetes* and more of *Firmicutes* as compared to lean mice. *Firmicutes* helped to draw more calories form the ingested diet leading to obesity (Dahiya et al., 2017; Turnbaugh, 2006). Ley et al. (2006) also observed similar findings in his study where *Bacteroidetes* were less and *Firmicutes* were more. Likewise, many studies have proven the anti-obesity activity of *Bifidobacterium* and also its negative correlation with obesity (Dahiya et al., 2017; Delzenne et al., 2011; An et al., 2011; Yin et al., 2010).

Obese employees as previously mentioned consumed 97% of excess total dietary fat as compared to RDA. There are several studies that demonstrate high fat diet induced gut dysbiosis and metabolic endotoxemia. Cani PD. et al., in one of his studies demonstrated that high fat diet group had elevated LPS levels and were associated with a decrease abundance of *Bacteroides* and *Bifidobacterium* species and increased *Clostridium* species (Cani et al., 2007). Also, dramatic reduction in population of *Lactobacillus* spp., *Bifidobacterium* spp., and *Bacteroides* spp., was observed in high fat diet group (Cani et al., 2013; Wang et al., 2006).

To summarize, gut microflora of obese individual probably gets altered due to ingestion of high fat diet leading to increase in pathogenic bacteria and indirectly causing low grade inflammation – Obesity (Magnuson et.al., 2015; Progatzky et al., 2014; Fei & Zhao, 2013; Teixeira et.al., 2012).

Over the last few decades, gut hormones have been extensively studied and their intricate interplay between regulation of food intake through appetite modulation and with central nervous system (Perry & Wang, 2012; Hameed, Dhillo & Bloom, 2009; Woods & D'Alessio, 2008). From the vast ocean of several gut hormones only few of these circulating hormones have been known to influence appetite in humans (Batterham et al., 2003) namely Ghrelin, the only known hunger hormone (orexigenic hormone) (Tschop et al., 2001) and group of anorexigenic gut hormones that includes Cholecystokinin (CCK), Pancreatic Polypeptide (PP), Peptide YY (PYY), Oxyntomodulin (OXM) and Glucagon-like peptide (GLP-1) (Batterham et al., 2003).

Moving further, with yet another research question of how gut satietogenic hormones differ in obese and non-obese young bank employees, our study results revealed diminished secretion of gut satietogenic hormones in obese employees as compared to non-obese employees. Gut incretin GLP-1 was lower by 63.04%, GIP by 58.42%, PYY by 41.16% and Ghrelin by 56.14%.

Gut hormones like Ghrelin, GLP-1, PYY, PP and CCK are known to induce satiety and meal termination leading to dramatic impact on energy balance homeostasis (Mishra, Dubey, & Ghosh, 2016). Studies have also reported diminution of postprandial PYY in relation to obesity (Cahill et al., 2011; Brownley et al., 2010; Zwirska-Korczala et al., 2007; Essah et al., 2007; Feinle-Bisset et al., 2005). In obese adult, children and infants, fasting PYY negatively correlated with obesity markers and have shown blunted postprandial response (Mishra, Dubey, & Ghosh, 2016; Batterham RL. et al., 2003). In a study conducted by Adam and Westerterp-Plantenga (2005) revealed that pre-prandial GLP-$1_{(7\text{-}36)}$ levels were similar for obese adults as compared to normal weight individual. However, the postprandial GLP-$1_{(7\text{-}36)}$ was significantly attenuated in obese adults after 30 min as compared to controls (Adam & Westerterp-Plantenga, 2005). In yet another study conducted by Carroll et al. (2007) revealed that in obese subjects GLP-$1_{(7\text{-}36)}$ levels declined markedly in the first 20 min as compared to normal weight subjects where GLP-$1_{(7\text{-}36)}$ levels increased 10 min after a standard liquid meal (Lean & Malkova, 2016; Carroll et al., 2007).

Ghrelin which is also known as “Hunger hormone” was found to be on lower side in obese bank employees by 56.14% as compared to non-obese bank employees. This finding is supported by studies depicting bodies’ adaptation to a compensatory mechanism towards prolonged positive energy balance by lowering down Ghrelin levels as Ghrelin acts on indication of energy insufficiency. Korek et al. (2013) demonstrated that obesity was associated with lowered basal plasma Ghrelin level. Findings of previously published studies also demonstrated that fasting plasma Ghrelin levels are negatively correlated with body fat percentage and body weight (Korek et al., 2013; Tschop et al., 2001) and also supports our results.

Our results demonstrated 200% higher concentrations of hormone Leptin in obese employees as compared to non-obese. Wondering with the results as what was known till date that hormone Leptin which means “Thin” in greek and also known as “Hormone of energy expenditure” amused us with extreme higher concentration. On looking for the literatures on Leptin and obesity we came across a fact that it is also directly proportional to fat and hence as obesity is also a state of “Adiposity” Paradoxically, higher levels of

Leptin are observed in obesity and emotional stress (Otsuka, 2006). Leptin levels are increased by insulin (Kolaczynski, 1996). In obesity, similar to insulin resistance, despite of high energy stores and high levels of Leptin, decreased sensitivity to Leptin occurs resulting in an inability to detect satiety (Pan, Guo, & Su, 2017). Leptin and Ghrelin hormones regulating energy homeostasis through neuroendocrine control develop resistance. The development of resistance of both hormones is a hallmark of obesity

Furthermore, looking into the correlations between weight and all studied parameters we found significant ($p<0.001$) positive relationship with body fat ($r=0.459$), systolic blood pressure ($r=0.421$), diastolic blood pressure ($r=0.365$), defecation frequency ($r=0.241$), alcohol intake ($r=0.283$), tea consumption ($r=0.452$), severe habituation ($r=0.435$), total satiety scores ($r=0.418$), energy intake ($r=0.340$), protein ($r=0.463$), fat ($r=0.263$), soluble dietary fiber ($r=0.545$), Leptin ($r=0.667$) and Insulin ($r=0.539$).

Significant ($p<0.001$) negative correlation of weight was observed with defecation odor ($r=0.249$), feeling after defecation ($r=0.337$), physical activity ($r=0.205$), total hunger scores ($r=0.307$), hunger scores at dinner time ($r=0.330$), depression ($r=0.233$), insoluble dietary fiber ($r=0.257$), soluble dietary fiber ($r=0.545$), total dietary fiber ($r=0.282$), high fiber fruits ($r=0.391$), moderate fiber fruits ($r=0.222$), *Bacteroides* ($r=0.258$), GLP-1 ($r=0.717$), GIP ($r=0.610$), PYY ($r=0.763$) and Ghrelin ($r=0.700$).

Underlying the Interactions between Gut Sateitogenic Hormones and Gut-flora, affecting obesity outcomes

This finding depicts perfect picture of factors influencing energy homeostasis and helps us establish relationships amongst them. From the entire review of literature it is clearly evident that obesity is directly proportional to adiposity measured by various methods specific to the deposition site and validating with their deranged values of BMI, WC, WSR and body fat, which in turn is also directly proportional to levels of Leptin hormone and higher BMI and body fat are also responsible for higher fasting levels of insulin indicating diminished optimal utilization by body cells due to adiposity around trunk and over all body fat. Higher Insulin levels further again elevates Leptin leading to overall development of Leptin resistance and decreased sensitivity to inhibit actions of Ghrelin, which in turn delays the satiety signaling at appropriate time till the individual consumes food till his abdomen is distended or stomach starts hurting or to the level of bursting leading to excess intake of food and overall energy intake and especially high fat diet and reduced fiber intake. In addition, their erratic lifestyle where stress, mild mood disorders, sedentary lifestyle and irregular meal times pushes them towards consumption of sugar sweetened beverages like aerated drinks and tea and habituation products like alcohol which further contributes to accumulation of body fat and leading to further weight gain. It also results into irregularities in defecation pattern and may lead to constipation. All these factors like adiposity, high fat diet, intake of alcohol, low fiber diet, etc…induce dysbiosis and reduce counts of gut friendly bacteria leading a state of low grade inflammation. Dysbiosis and alcohol intake both independently influence secretion of gut satietogenic hormones and modulates appetite signaling pathways. Secretion of gut incretins like GLP-1, GIP and PYY diminishes leading to short circuit in overall metabolism.

After looking into individual parameters we also made an effort to look into the most influential parameter in our study population of young bank employees and findings depicted that Gut hormone PYY alone was the strongest predictor of obesity to the accuracy of 58% in young bank employees. PYY along with intake of soluble dietary fiber could predict obesity with accuracy of 64%. Further, adding up factors like alcohol intake (67%), frequent tea consumption (70%), fat intake (74%), *Bacteroides* counts (75%), Ghrelin (77%) and *Clostridium* counts (78%).

NON-OBESE YOUNG ADULTS AT HIGHER RISK FOR DEVELOPING NCD's

It was very surprising to find that hypertension can prevail in young bank employees and that too in 150 non-obese bank employees. Elevated mean systolic blood pressure (127 mmHg) along with large range of deviation (±12.75 SD) was observed in young non-obese bank employees. Similar finding were also observed by DeVenecia, Lu, & Figueredo (2016) and they reported psychological factors contributing to the increasing incidence of hypertension in younger population. They also found increased thickness and mass of left ventricular wall on routine echocardiograms predicting future cardiovascular events.

Non-obese employees were also found to have abdominal obesity (5.67%), central obesity (13.67%), higher body fat % (8.33%), having family history of NCD's (22.33%), consuming aerated drinks (45%), intake of alcohol (16%) and moderate degree of habituation (21.33%), low fiber intake (54%) and high fat intake (38%). These non-obese employees are heading towards overweight category and eventually if they continue these habits will very soon become obese in near future. If they become obese then the primary reason would be there all faulty dietary habits mentioned above.

Hence, the prevention strategies and health care policies should primarily focus on protecting and re-routing individuals who are not obese but are heading in a wrong direction. These non-obese employees are future liabilities for health care if cost was born by the government and even at personal level for their families.

Hence, to conclude Obesity is a very complex disorder affecting entire body metabolism and is also a "Complication Centric" for development of future NCD's. This phase clearly demonstrates significant difference in all specified parameters and specifically habituation profile, gut flora and gut satietogenic hormones.

Conclusion

"How easy for those who do not bulge and so difficult to not overindulge! "

- ***This phase clearly demonstrates statistically significant difference between Obese phenotype and Non-obese phenotype***
- ***Adiposity was very prominent in obese phenotype and was attributed to intake of sugar sweetened beverages (aerated drinks and tea), alcohol and high dietary fat intake.***
- ***Effect of higher consumption of sugar sweetened beverage, alcohol and excess of dietary fat consumption induced statistically higher risk of developing NCDs in Non-obese phenotype Deranged defecation profile and dysbiosis was quite evident in obese phenotype.***
- ***Secretion of gut satiety hormones like GLP-1, GIP and PYY was attenuated in obese phenotype as compared to non-obese phenotype.***
- ***Reduced Leptin sensitivity and attenuated Ghrelin levels indicated development of resistance in obese phenotype as compared to Non-obese phenotype which is a classic hallmark of Obesity.***
- ***This comparative study highlighted the complexities of fine regulation of the underlying mechanisms and how they interact and influence each other.***
- ***It was possible to establish fasting baseline values of 6 gut hormones of non-obese and obese phenotype along with comparative data of gut flora and rest all parameters***

PHASE III

IMPACT EVALUATION OF FOS INTERVENTION FOR 90 DAYS IN OBESE SUBJECTS: A RANDOMIZED CONTROL TRIAL

In Phase – III, 150 obese employees were enrolled who agreed to consume FOS (20g) or Placebo maltodextrin (10g) and comply with study protocol during intervention phase of 90 days. It was taken care that both the products provide an equal amount of calories – 40 Kcals was provided by consuming 20g FOS and 10g Placebo maltodextrin. Obese employees were randomly divided into two equal groups of intervention: placebo arm – N=75 and experimental arm – N=75.

Bank employees who discontinued study were 5 (6.6%) from placebo arm and 3 (4%) from experimental arm. Total of 10.6% of employees dropped out of study and could not complete due to job transfer to different city. Results were collected for N=70 in placebo group and N=72 in experimental group of obese bank employees and are discussed under following heads:

Section 5.3.1:	Anthropometric and biophysical measurements
Section 5.3.2:	Dietary parameters, hunger and satiety scores
Section 5.3.3:	Depression and Defecation profile
Section 5.3.4:	Fasting plasma levels of gut-hormones GLP-1, GIP, PYY, Ghrelin, Leptin and Insulin post intervention
Section 5.3.5:	Gut-microflora: *Bifidobacteria, Lactobacillus, Clostridium, and Bacteriodes* post intervention
Section 5.3.6:	Correlation of gut-hormones and gut-microflora with various parameters
Section 5.3.7:	Regression analysis for identifying strongest predictor or obesity in obese bank employees
Section 5.3.8:	Follow up data for time-point interval analysis

5.3.1: Anthropometric and biophysical measurements

Table 5.46 reveals effect of FOS supplementation on anthropometric profile of obese bank employees. Significant reduction ($p<0.001$) in mean ± SD values were observed in most of the anthropometric parameters of obese employees in experimental group as compared to placebo group.

In experimental group, weight reduced significantly ($p<0.001$) from initial mean weight of 80.58 kg to 77.96 kg. Total weight reduced by 2.52 kg in 90 days (3 months) i.e. 3.25% as compared to placebo group, where there was reduction of 0.24% which was not significant. Mean BMI values also significantly ($p<0.001$) reduced by 0.86 kg/m^2 i.e. 3.25% as compared to placebo group. Reduction in WC was observed by 2.23 cm (2.31%) as compared to placebo group where reduction was only 0.37 cm (0.39%) and was not significant. WHR also reduced significantly ($p<0.001$) by 1 point (1.07%) in experimental group as compared to placebo group. However, no significant difference was observed in hip circumference neither of employees in experimental group nor in placebo group.

With regards to biophysical parameters as shown in Table 5.47, FOS supplementation also significantly helped reduce body-fat percentage by 3.39% in experimental group as compared to placebo group where there was non-significant increase by 0.74%. Pre intervention there was significant difference in the SBP values of placebo and experimental group. Experimental group obese employees were found to be pre-hypertensive. However, post intervention significant decrease was observed only in experimental group by 1.51% and no change was observed in placebo group. The basal metabolic rate of obese employees differed significantly in placebo and experimental group pre intervention. However, post intervention the values remained same in both the groups and no significant difference was observed in either of group post FOS supplementation.

Similarly, significant difference was observed in baseline values of diastolic blood pressure values of both the group pre intervention. However, no significant change was observed in diastolic blood pressure values of both the group post intervention.

Table 5.46: Mean anthropometric values of obese bank employees before and after intervention

Parameter	Intervention Phase	Placebo Group [N=70]	Experiment Group [N=72]	Student 't' Test
Height [cm]	Pre	168.78 ± 11.32	169.49 ± 7.01	**0.44 NS**
	Post	168.78 ± 11.32	169.49 ± 7.01	**0.44 NS**
Weight [kg]	Pre	77.74 ± 10.82	80.58 ± 8.29	**1.75 NS**
	Post	77.55 ± 10.59	77.96 ± 7.93	**0.36 NS**
	Paired 't'	**1.24 NS**	**27.61 *****	
	% ↑ / ↓	**0.24 %↓**	**3.25 %↓**	
BMI [kg/m^2]	Pre	27.18 ± 1.38	27.95 ± 1.50	**1.63 NS**
	Post	27.12 ± 1.44	27.09 ± 1.41	**0.09 NS**
	Paired 't'	**1.10 NS**	**29.14 *****	
	% ↑ / ↓	**0.22 %↓**	**3.25 %↓**	
WC [cm]	Pre	94.31 ± 7.43	96.74 ± 7.57	**1.92 NS**
	Post	93.94 ± 6.29	94.51 ± 7.67	**0.49 NS**
	Paired 't'	**1.16 NS**	**7.92 *****	
	% ↑ / ↓	**0.39 %↓**	**2.31 %↓**	
HC [cm]	Pre	102.06 ± 7.49	103.35 ± 5.69	**1.15 NS**
	Post	102.03 ± 7.55	103.03 ± 5.48	**1.75 NS**
	Paired 't'	**0.62 NS**	**1.83 NS**	
	% ↑ / ↓	**0.03 %↓**	**0.31 %↓**	
WHR	Pre	0.92 ± 0.04	0.93 ± 0.05	**1.48 NS**
	Post	0.92 ± 0.05	0.92 ± 0.05	**1.68 NS**
	Paired 't'	**0.66 NS**	**5.43 *****	
	% ↑ / ↓	**0 %↓**	**1.07 %↓**	

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

Table 5.47: Mean biophysical values of obese bank employees before and after intervention

Parameter	Intervention Phase	Placebo Group [N=70]	Experiment Group [N=72]	Student 't' Test
% Body Fat	**Pre**	32.24 ± 5.64	31.56 ± 3.87	**0.85 NS**
	Post	32.48 ± 5.24	30.58 ± 3.75	**2.49 ***
	Paired 't'	**0.92 NS**	**3.39****	
	% ↑ / ↓	**0.74 %↑**	**3.11 %↓**	
BMR (Kcals)	**Pre**	1719.41 ± 199.90	1779.67 ± 193.09	**2.69 ****
	Post	1708.57 ± 194.15	1775.5 ± 173.13	**3.39 *****
	Paired 't'	**1.63 NS**	**0.43 NS**	
	% ↑ / ↓	**0.63 %↓**	**0.23 %↓**	
Systolic Blood Pressure (mmHg)	**Pre**	122.37 ± 9.72	127.88 ± 8.71	**3.55 *****
	Post	122.11 ± 9.41	125.96 ± 7.22	**2.73 ****
	Paired 't'	**0.58 NS**	**4.53 *****	
	% ↑ / ↓	**0.21 %↓**	**1.51 %↓**	
Diastolic Blood Pressure (mmHg)	**Pre**	78.11 ± 6.93	81.19 ± 7.79	**2.49 ***
	Post	78.47 ± 6.10	80.85 ± 6.29	**2.28 ***
	Paired 't'	**1.08 NS**	**0.84 NS**	
	% ↑ / ↓	**0.46 %↑**	**0.42 %↓**	

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

5.3.2: Dietary parameters, hunger and satiety scores

As shown in Table 5.48, no significant difference was observed in baseline values of macronutrient intake in placebo and experimental group before intervention. However, after intervention significant reduction was observed in most of the dietary parameters of experimental group from baseline.

Significant reduction in mean energy intake was observed by 247 kcal/day i.e. 8.84% per day in experimental group ($p<0.001$) as compared to placebo group where reduction was only12 Kcals/day.

Mean carbohydrate intake reduced significantly from 363g/day to 331g/day i.e. (8.67%) in experimental group as compared placebo group (0.70%) where reduction was non-significant.

Mean total fat intake (visible and invisible) significantly reduced in the experimental group by 10.78%. Similarly, soluble fiber and total fiber intake also reduced by 10.82% and 10.17% in experimental group after intervention. Reduction in fiber intake could be possibly due to overall reduction in food intake.

However, no significant difference was observed in protein, insoluble fiber and crude fiber of both groups

Table 5.49 depicts that, hunger pangs significantly ($p<0.001$) reduced in experimental group during meal time of lunch (14.76%) and dinner (3.83%) as compared to placebo group.

Also, the experimental group achieved early satiety significantly ($p<0.001$) during meal time of lunch (10.22%) and dinner (12.58%) (Table 5.50).

Table 5.48 : Mean dietary intakes of obese bank employees before and after intervention

Nutrients		Placebo Group	Experimental Group	't' test
		Mean ± SD [N = 70]	**Mean ± SD[N = 72]**	
Energy [Kcal]	**Pre**	2784.85 ± 549.60	2785.02 ± 589.97	**0.002NS**
	Post	2772.95 ± 558.87	2538.88 ± 552.63	**1.92 NS**
	Paired 't'	**1.65 NS**	**6.01*** **	
	% ↑ / ↓	**0.43 ↓**	**8.84 ↓**	
Carbohydrate [g]	**Pre**	374.19 ± 91.54	362.76 ± 70.12	**0.84 NS**
	Post	371.57 ± 91.03	331.31 ± 73.93	**2.48***
	Paired 't'	**1.71 NS**	**6.36 *** **	
	% ↑ / ↓	**0.70 ↓**	**8.67 ↓**	
Protein [g]	**Pre**	77.96 ± 15.10	80.76 ± 20.17	**0.93NS**
	Post	77.71 ± 15.06	79.34 ± 21.89	**0.51 NS**
	Paired 't'	**1.97 NS**	**1.65 NS**	
	% ↑ / ↓	**0.32 ↓**	**1.76 ↓**	
Fat [g]	**Pre**	104.22 ± 36.36	106.16 ± 40.61	**0.30 NS**
	Post	104.01 ± 36.71	94.72 ± 36.29	**1.25 NS**
	Paired 't'	**0.66 NS**	**5.33 *** **	
	% ↑ / ↓	**0.20 ↓**	**10.78 ↓**	
Soluble Dietary Fibre [g]	**Pre**	5.23 ± 1.52	5.36 ± 1.73	**1.19 NS**
	Post	5.19 ± 1.48	4.78 ± 1.88	**0.60 NS**
	Paired 't'	**0.89 NS**	**8.42 *** **	
	% ↑ / ↓	**0.76 ↓**	**10.82 ↓**	
Insoluble Dietary Fibre [g]	**Pre**	14.27 ± 5.49	15.43 ± 6.24	**1.17 NS**
	Post	14.06 ± 5.41	15.42 ± 5.95	**1.89 NS**
	Paired 't'	**1.87 NS**	**0.06 NS**	
	% ↑ / ↓	**1.47 ↓**	**0.06 ↓**	
Crude Fibre [g]	**Pre**	9.26 ± 3.51	9.34 ± 2.25	**0.11 NS**
	Post	9.41 ± 3.33	9.20 ± 2.18	**0.56 NS**
	Paired 't'	**1.69 NS**	**1.03 NS**	
	% ↑ / ↓	**1.62 ↓**	**1.52 ↓**	
Total Fibre [g]	**Pre**	19.19 ± 4.76	21.43 ± 8.21	**1.32 NS**
	Post	18.99 ± 4.65	19.25 ± 8.31	**0.25 NS**
	Paired 't'	**1.85 NS**	**7.28 *** **	
	% ↑ / ↓	**1.04 ↓**	**10.17 ↓**	

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p< 0.05*, p< 0.01**, p<0.001***

Table 5.49 : Mean hunger scores of obese bank employees before and after intervention

Meal time		Placebo Group [N = 70]	Experimental Group [N = 72]	't' test
		Mean ± SD	**Mean ± SD**	
Breakfast	Pre	4.06 ± 0.68	3.92 ± 1.00	**1.70 NS**
	Post	3.97 ± 0.76	4.04 ± 0.83	**0.05 NS**
	Paired t	**1.62 NS**	**1.04 NS**	
	% ↑ / ↓	**2.21 ↓**	**3.06 ↑**	
Lunch	Pre	3.79 ± 1.01	3.32 ± 0.95	**2.60****
	Post	3.51 ± 0.56	3.81 ± 0.72	**0.54 NS**
	Paired t	**1.99 NS**	**4.09*****	
	% ↑ / ↓	**7.38 ↓**	**14.76 ↑**	
Evening	Pre	3.83 ± 1.02	4.25 ± 0.82	**2.35***
	Post	4.07± 1.05	4.38 ± 0.78	**4.23*****
	Paired t	**2.46***	**1.19 NS**	
	% ↑ / ↓	**6.26 ↑**	**3.05 ↑**	
Dinner	Pre	3.46 ± 1.33	3.25 ± 1.07	**0.36 NS**
	Post	3.48 ± 1.06	3.76 ± 0.76	**0.66 NS**
	Paired t	**0.01 NS**	**3.83*****	
	% ↑ / ↓	**0.58 ↑**	**15.69 ↑**	
Mean Scores	Pre	3.78 ± 0.70	3.68 ± 0.72	**0.97 NS**
	Post	3.75 ± 0.58	4.00 ± 0.57	**1.64 NS**
	Paired t	**0.56 NS**	**3.30****	
	% ↑ / ↓	**0.79 ↓**	**8.69 ↑**	

NOTE: NS = non-significant, 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

Table 5.50: Mean satiety scores of obese bank employees before and after intervention

Meal time		Placebo Group [N = 70] Mean ± SD	Experimental Group [N = 72] Mean ± SD	Students 't'
Breakfast	Pre	6.13 ± 0.70	6.35 ± 0.82	**1.70 NS**
	Post	6.17 ± 0.83	6 .17 ± 0.77	**0.05 NS**
	Paired t	**0.59 NS**	**1.53 NS**	
	% ↑ / ↓	**0.65 ↑**	**2.83 ↓**	
Lunch	Pre	6.66 ± 0.74	7.04 ± 1.00	**2.60****
	Post	6.40 ± 0.94	6.32 ± 0.82	**0.54 NS**
	Paired t	**2.49***	**5.75*****	
	% ↑ / ↓	**3.90 ↓**	**10.22 ↓**	
Evening	Pre	6.30 ± 0.77	6.01 ± 0.68	**2.35***
	Post	6.63 ± 0.68	6.13 ± 0.73	**4.23*****
	Paired t	**4.93*****	**0.95 NS**	
	% ↑ / ↓	**5.24 ↑**	**1.99 ↑**	
Dinner	Pre	7.24 ± 1.00	7.31 ± 1.07	**0.36 NS**
	Post	6.50 ± 1.03	6.39 ± 0.97	**0.66 NS**
	Paired t	**6.11*****	**6.64*****	
	% ↑ / ↓	**10.22 ↓**	**12.58 ↓**	
Mean Scores	Pre	6.58 ± 0.50	6.68 ± 0.65	**0.97 NS**
	Post	6.43 ± 0.57	6.25 ± 0.69	**1.64 NS**
	Paired t	**2.95****	**4.88*****	
	% ↑ / ↓	**2.28 ↓**	**6.44 ↓**	

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

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

5.3.3: Depression and Defecation profile

Table 5.51 depicts improvement was also observed in the depression scores obtained by Becks Depression Inventory. Significant reduction ($p<0.001$) of 26.77% in scores was observed in experimental group as compared to placebo arm. Obese employees in experimental group felt psychologically much better after FOS intervention as interpreted from the BDI scores and personal responses.

Table 5.51 : Mean depression scores of obese bank employees before and after intervention

	Placebo Group [N = 70]	Experimental Group [N = 72]	Students 't'
	Mean ± SD	Mean ± SD	
Pre	8.20 ± 5.26	8.89 ± 7.12	**0.65 NS**
Post	8.64 ± 5.39	6.51 ± 6.45	**2.13***
Paired-t	**1.97 NS**	**4.40*** **	
% ↑/↓	**5.36 ↑**	**26.77 ↓**	

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p< 0.05: *, p< 0.01: **, p< 0.001: ***

As shown in Table 5.52, post FOS consumption post 90 days, significant improvement in overall defection profile was observed in experimental group.

Reduction in constipation was reported in 14% of obese employees. Frequency of passing stool twice increased in 15% of them and improved by clearing bowels completely. Quantity of stool (bulk) increased in 8%, hardness reduced in 17%, foulness in stool odor reduced in 8% and 17% of obese employees felt much better after defecation with FOS intervention.

Table 5.52A : Association between defecation profile of obese bank employees before and after intervention

Defecation Profile		Placebo Group N = 70 [%]	Experiment Group N = 72 [%]	χ^2 Value
Constipation (Subjects Perception)				
Pre	Present	34 [23.94]	27 [19.01]	**1.78 NS p – 0.18**
	Absent	36 [25.35]	45 [31.69]	
Post	Present	24 [16.90]	7 [4.93]	**12.55 *** p-0.000**
	Absent	46 [32.39]	65 [45.77]	
	χ^2 Value	**2.95 NS; p-0.08**	**15.40 ***; p-0.000**	
Frequency (times / day)				
Pre	1	50 [35.21]	38 [26.76]	**5.24 NS P – 0.02**
	2	20 [14.08]	34 [23.94]	
Post	1	43 [30.28]	17 [11.97]	**20.8 *** p-0.000**
	2	27 [19.01]	55 [38.73]	
	χ^2 Value	**1.57 NS; p-020**	**12.97 ***; p-0.000**	
Quantity of Stool				
Pre	Small	23 [16.20]	16 [11.27]	**2.02 NS p-0.16**
	Middle to large	47 [33.09]	56 [39.44]	
Post	Small	18 [12.68]	4 [2.82]	**11.02 *** p-0.0009**
	Middle to large	52 [36.62]	68 [47.89]	
	χ^2 Value	**0.86 NS; p-0.35**	**8.36 **; p-0.0038**	
Hardness of stool				
Pre	Very hard to hard	34 [23.94]	34 [23.94]	**0.02 NS p-0.87**
	Medium to soft	36 [25.35]	38 [26.76]	
Post	Very hard to hard	27 [19.01]	10 [7.04]	**11.23 *** p-0.0008**
	Medium to soft	43 [30.28]	62 [43.66]	
	χ^2 Value	**1.42 NS; p-0.23**	**18.85 ***; p-0.000**	
Color of Stool				
Pre	Black to middle	59 [41.55]	70 [49.29]	**7.14 ** p - 0.007**
	Yellowish	11 [7.75]	2 [1.41]	
Post	Black to middle	61 [42.96]	69 [48.59]	**3.46 NS p - 0.064**
	Yellowish	9 [6.34]	3 [2.11]	
	χ^2 Value	**0.233 NS , p - 0.63**	**0.21 NS, p - 0.65**	
Odor of Stool				
Pre	Strong	17 [11.97]	17 [11.97]	**0.01 NS p - 0.92**
	Medium to weak	53 [37.32]	55 [38.73]	
Post	Strong	12 [8.45]	5 [3.52]	**3.50 NS p - 0.06**
	Medium to weak	58 [40.84]	67 [47.18]	
	χ^2 Value	**1.09 NS, p - 0.29**	**7.73 **, p - 0.005**	

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p< 0.05:*, p<0.01:**, p<0.001: ***

Table Continued…….

Table 5.52B : Association between defecation profile of obese bank employees before and after intervention				
	Defecation Profile	**Placebo Group N = 70 [%]**	**Experimental Group N = 72 [%]**	**χ^2 Value**
	Feeling after defecation			
Pre	Bad [1]	11 [7.75]	18 [12.68]	**1.88 NS p - 0.17**
	Fine [2]	59 [41.55]	54 [38.02]	
Post	Bad [1]	8 [5.64]	1 [0.70]	**6.02 ** p - 0.01**
	Fine [2]	62 [43.66]	71 [50.00]	
	χ^2 Value	**0.55 NS, p - 0.46**	**17.52 ***, p - 0.000**	
	Regular use of Laxatives			
Pre	Yes	17 [11.98]	12 [8.45]	**1.26 NS p - 0.26**
	No	53 [37.32]	60 [42.25]	
Post	Yes	16 [11.27]	6 [4.22]	**5.71** p - 0.01**
	No	54 [38.03]	66 [46.48]	
	χ^2 Value	**0.04 NS, p - 0.84**	**2.29 NS , p - 0.13**	
	Defecation Profile as per score analysis			
Pre	Constipated	16 [11.27]	19 [13.38]	**2.32 NS p- 0.127**
	Normal defecation [8-13]	41 [28.88]	50 [35.22]	
	Watery stools	13 [9.15]	3 [2.10]	
Post	Constipated	12 [8.54]	0 [0.00]	**18.58 *** p - 0.000**
	Normal defecation [8-13]	46 [32.39]	35 [24.65]	
	Watery stools	12 [8.45]	37 [26.05]	
	χ^2 Value	**0.89 NS , p - 0.638**	**50.5 ***, p - 0.000**	
	Degree of constipation			
Pre	No constipation	54 [38.02]	53 [37.32]	**0.238 NS p - 0.625**
	Mild constipation	16 [11.27]	17 [11.98]	
	Moderate-Severe	0 [0.00]	2 [1.40]	
Post	No constipation	58 [40.84]	71 [50.00]	**0.37 NS p - 0.54**
	Mild constipation	12 [8.45]	1 [0.70]	
	Moderate-Severe	0	0	
	χ^2 Value	**0.71 NS, p - 0.398**	**18.8 ***, p - 0.000**	

NOTE: Figures in parenthesis represent percent of subjects; NS= non-significant, p< 0.05*, p< 0.01**, p< 0.001***

Table 5.53 depicts association between flatulence profile of obese bank employees before and after intervention.

Results revealed that before intervention flatulence was present in 23 – 25 % of bank employees in both the group and after intervention also it was between 19 – 25% and no significant difference was observed between both the groups and neither before and after intervention. Similarly, no significant difference was observed in frequency of flatulence.

However, significant difference was observed in reduction of medium foul odor of flatulence in experimental group.

Reduction (13.38%) was observed in medium category of odor of flatulence from 16.90% to 3.52% and this association was highly significant.

Also, significant reduction was observed in use of herb / laxative products / medicine from. Percentage of employees who used any kind of substance reduced from 3.53%to 0.07% and reported reason as passing proper stool

Moreover, reduction (11.25%) was also observed in degree of flatulence. Employees in experimental group with strong degree of flatulence before intervention was reported to be 22.53% and after intervention it dropped to 11.28% and this association was also highly significant

Table 5.53 : Association between flatulence profile of obese bank employees before and after intervention

Flatulence Profile		Placebo Group N =70 [%]	Experimental Group N = 72 [%]	χ^2 Value
		Flatulence		
Pre	Present	33 [23.24]	36 [25.35]	**0.11 NS p -0.73**
	Absent	37 [26.05]	36 [25.35]	
Post	Present	27 [19.01]	35 [24.65]	**1.45 NS p - 0.23**
	Absent	43 [30.28]	37 [26.05]	
	χ^2 Value	**1.05 NS, p - 0.31**	**0.03 NS, p - 0.86**	
		Frequency (day/week)		
Pre	1	41 [28.88]	40 [28.16]	**3.90 NS p - 0.142**
	2	19 [13.38]	13 [9.15]	
	3or >3	10 [7.04]	19 [13.38]	
Post	1	50 [35.21]	40 [28.16]	**6.23 * p - 0.044**
	2	8 [5.63]	20 [14.08]	
	3or >3	12 [8.45]	12 [8.45]	
	χ^2 Value	**5.55 NS, p - 0.062**	**3.07 NS, p - 0.216**	
		Odor of Flatulence		
Pre	Weak	52 [36.62]	46 [32.39]	**2.62 NS p - 0.270**
	Medium	15 [10.56]	24 [16.90]	
	Strong	3 [2.11]	2 [1.40]	
Post	Weak	49 [34.50]	63 [44.36]	**12.5 ** p - 0.002**
	Medium	20 [14.08]	5 [3.52]	
	Strong	1 [0.70]	4 [2.81]	
	χ^2 Value	**1.8 NS, p -0.406**	**15.8***, p- 0.000**	
		Regular use of any herb / product/ medicine		
Pre	Yes	6 [4.22]	5 [3.52]	**0.131 NS p-0.717**
	No	64 [45.07]	67 [47.18]	
Post	Yes	4 [2.81]	1 [0.70]	**1.95 NS, p - 0.162**
	No	66 [46.47]	71 [50.00]	
	χ^2 Value	**0.431 NS, p - 0.512**	**2.78 * p - 0.05**	
		Degree of Flatulence		
Pre	Mild	21 [14.78]	24 [16.90]	**1.41 NS, p-0.495**
	Moderate	6 [4.22]	3 [2.11]	
	Strong	27 [19.01]	32 [22.53]	
Post	Mild	28 [19.72]	21 [14.78]	**10.4** p - 0.005**
	Moderate	5 [3.52]	19 [13.38]	
	Strong	23 [16.19]	16 [11.28]	
	χ^2 Value	**1.37 NS, p - 0.503**	**17.1 ***, p - 0.000**	

NOTE: Figures in parenthesis represent percent of subjects; NS = non-significant, p < 0.05*, p < 0.01**, p < 0.001 ***

5.3.4: Fasting plasma levels of gut-hormones GLP-1, GIP, PYY, Ghrelin, Leptin and Insulin post intervention

After FOS intervention in experimental group, significant increase was observed in gut-incretin's, GLP-1 (3.34%, p<0.01) and GIP (0.77%, p<0.05). Other hormones like PYY increased significantly (p<0.001) by 3.11% along-with increase in Ghrelin secretion (14.77%). Reduction was observed in hormone Leptin by 5.87% and Insulin by 6.23%, which was also highly significant (p<0.001)

Table 5.54 : Mean values of fasting plasma gut hormone values of obese subjects before and after intervention

Name of Gut Satietogenic Hormones [pg/ml]		Placebo Group Mean ± SD [N = 40]	Experimental Group Mean ± SD [N = 40]	"t" test
GLP-1 [Active]	PRE	7.75 ± 1.88	7.77 ± 1.69	**0.05 NS**
	POST	7.69 ± 1.76	8.03 ± 1.65	**0.89 NS**
	Paired t-test	0.55 NS	3.29**	
	% ↑ / ↓	**0.77 % ↓**	**3.34 % ↑**	
GIP [Total]	PRE	4.81 ± 1.52	4.96 ± 1.30	**0.48 NS**
	POST	4.91 ± 1.63	5.57 ± 2.10	**1.56 NS**
	Paired t-test	0.85 NS	2.37 *	
	% ↑ / ↓	**2.08 % ↑**	**12.29 % ↑**	
PYY [Total]	PRE	42.45 ± 17.93	42.04 ± 18.15	**0.10 NS**
	POST	42.53 ± 18.25	43.35 ± 18.26	**0.21 NS**
	Paired t-test	0.39 NS	6.83***	
	% ↑ / ↓	**0.18 % ↑**	**3.11 % ↑**	
Ghrelin[Active]	PRE	115.77 ± 42.54	113.32 ± 41.88	**0.26 NS**
	POST	113.21 ± 41.13	130.06 ± 40.92	**1.84 NS**
	Paired t-test	0.63 NS	4.28 ***	
	% ↑ / ↓	**2.21 % ↓**	**14.77 % ↑**	
Leptin	PRE	11488.05 ± 3106.42	12643.63 ± 2032.58	**1.97 NS**
	POST	11637.48 ± 2991.39	11901.93 ± 1827.06	**0.48 NS**
	Paired t-test	1.52 NS	5.33 ***	
	% ↑ / ↓	**1.31 % ↑**	**5.87 % ↓**	
Insulin	PRE	571.70 ± 235.18	570.42 ± 238.99	**0.02 NS**
	POST	572.90 ± 230.18	534.87 ± 222.23	**0.75 NS**
	Paired t-test	0.19 NS	7.58***	
	% ↑ / ↓	**0.21 % ↑**	**6.23 % ↓**	

NOTE: Figures in parenthesis represent percent of subjects; NS= non-significant, p< 0.05:*, p<0.01:**, p<0.001: ***

5.3.5: Gut-microflora: *Bifidobacterium, Lactobacillus, Clostridium, and Bacteriodes post* intervention

FOS intervention significantly improved the gut microbial profile of experimental group obese employees. Gut health improved with significant increase in colonization of gut with *Lactobacillus* by 22.64% and *Bifidobacterium* by 7.99%. However, counts of pathogenic bacteria, *Clostridium* reduced significantly by 4.49% and No significant change was observed in *Bacteroides* counts in experimental group.

Table 5.55 : Gut-microbial profile of obese bank employees before and after intervention

Parameters	Trial Phase	Placebo Group [N=40] $\log_{10}$ Values [CFU/g] Mean ± SD	Experiment Group [N=40] $\log_{10}$ Values [CFU/g] Mean ± SD	Student 't' Test	% ↑ / ↓
Bifidobacterium	**Pre**	12.43 ± 1.05	12.02 ± 1.14	**1.69 NS**	–
	Post	11.99 ± 1.15	12.98 ± 1.15	**3.68 ****	**8.26 ↑**
	Paired 't'	**1.60 NS**	**3.90 *****		
	% ↑ / ↓	**3.54 ↓**	**7.99 ↑**		
Lactobacillus	**Pre**	11.80 ± 1.29	11.31 ± 1.35	**1.65 NS**	–
	Post	10.86 ± 1.37	13.87 ± 1.15	**10.61 *****	**27.72 ↑**
	Paired 't'	**3.51 ****	**10.32 *****		
	% ↑ / ↓	**7.97 ↓**	**22.64 ↑**		
Clostridium	**Pre**	11.86 ± 0.70	12.04 ± 0.91	**0.97 NS**	–
	Post	11.56 ± 0.39	11.50 ± 0.27	**0.81 NS**	–
	Paired 't'	**2.16***	**3.67 *****		
	% ↑ / ↓	**2.53 ↓**	**4.49 ↓**		
Bacteroides	**Pre**	11.76 ± 1.48	11.90 ± 1.77	**0.39 NS**	–
	Post	13.28 ± 0.40	12.15 ± 0.26	**15.01 *****	**8.51 ↓**
	Paired 't'	**6.52*****	**0.86 NS**		
	% ↑ / ↓	**12.93 ↑**	**2.1 ↑**		

NOTE: NS=Non-significant , $p < 0.05$: *; $p<0.01$:**; $p < 0.001$: ***

5.3.6: Correlation of weight, BMR, gut-hormones and gut-microflora with various parameters of obese bank employees

As depicted in Table 5.56, weight positively correlated with BMR (r=0.891), systolic blood pressure (r=0.316) and diastolic blood pressure (r=0.259). It also positively correlated with dietary components like energy (r=0.184) and carbohydrate (r=0.273). Amongst gut hormones, weight positively correlated with Leptin (r=0.351). Weight negatively correlated with hunger scores during evening snack time (r=0.219) and total depression score (r=0.276). It also negatively correlated with Gut hormones like GLP-1 (r=0.546), GIP (r=0.178), PYY (r=0.498) and Ghrelin (r=0.302).

Table 5.56: Pearson correlation of weight with various parameters of obese bank employees [r value]

Parameters	Positive Correlation	Parameters	Negative Correlation
BMR [Kcals]	0.891***	Hunger – Evening	- 0.219***
SBP[mmHg]	0.316***	Depression Score	- 0.276**
DBP [mmHg]	0.259***	GLP-1 [pg/ml]	- 0.546***
Energy [Kcal]	0.184*	GIP [pg/ml]	- 0.178*
CHO [g]	0.273***	PYY [pg/ml]	- 0.498***
Leptin [pg/ml]	0.351***	Gherlin [pg/ml]	- 0.302***

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

As shown in Table 5.57, BMR positively correlated with weight, systolic and diastolic blood pressure. This could be attributed to the feeling of uneasiness that people with elevated blood pressure feel. It also positively correlated with intake of crude fiber as body had to work hard to digest it. Also, it positively correlated with hormone Leptin which also known as “Hormone for Energy Expenditure”

Negative correlation of BMR was observed with depression scores, hormone Ghrelin, GLP-1 and PYY.

Table 5.57: Pearson correlation of BMR with various parameters of obese bank employees [r value]

Parameters	Positive Correlation	Parameters	Negative Correlation
Weight	**0.891*** **	**Depression Score**	- **0.282*** **
SBP[mmHg]	**0.324*** **	**Ghrelin [pg/ml]**	- **0.311*** **
DBP [mmHg]	**0.327*** **	**GLP-1 [pg/ml]**	- **0.459*** **
Crude Fiber [g]	**0.220*** **	**PYY[pg/ml]**	- **0.437*** **
Leptin [pg/ml]	**0.302*** **		-

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

Table 5.58 depicts correlation of fasting plasma gut hormones and various parameters of obese bank employees

GLP-1 positively (p<0.001) correlated with depression scores (r=0.203), soluble dietary fiber (r=0.21), PYY (r=0.709), Ghrelin (r=0.315) and *Bifidobacterium* (r=0.359) and **negatively** (p<0.001) correlated with weight (r=0.546), body fat (r=0.204), Leptin (r=0.441), Insulin (r=0.258).

GIP positively correlated with dinner satiety scores (r=0.225) and **negativel**y correlated with weight (r=0.178), body fat (r=0.289), systolic blood pressure (r=0.220).

PYY positively correlated with Ghrelin (r=0.332), GLP-1 (r=0.709) and *Bifidobacterium* (r=0.344) and **negatively** correlated with weight (r=0.498), body fat (r=0.333), diastolic blood pressure (r=0.266), energy intake (r=0.249), Leptin (r=0.495).

Ghrelin positively correlated with GLP-1 (r=0.315) and PYY (r=0.332) and **negatively** with weight (r=0.302), body fat (r=0.358), lunch satiety scores (r=0.203), soluble dietary fiber (r=0.201), total dietary fiber (r=0.204) and Leptin (r=4.00).

Leptin positively correlated with weight (r=0.351), body fat (0.778), lunch satiety scores (r=0.225), energy intake (r=0.220) and fat (r=0.310) and **negatively** correlated with Ghrelin (r=4.00), GLP-1 (r=0.441), PYY (r=0.495), *Bifidobacterium* (r=0.291).

Insulin negatively correlated with GLP-1 (r=0.258) and no significant positive correlation were observed

Table 5.58: Pearson's correlation of Gut-hormones with various parameters						
Parameters	**GLP - 1**	**GIP**	**PYY**	**Ghrelin**	**Leptin**	**Insulin**
Weight [kg]	**-0.546****	**-0.178***	**-0.498****	**-0.302****	**0.351****	**0.142 NS**
BMR [kcals]	**-0.459****		**-0.437****	**-0.311****	**0.302****	
Body Fat [%]	**-0.204****	**-0.289****	**-0.333****	**-0.358****	**0.778****	**0.032 NS**
BP – Systolic [mmHg]	-	**-0.220***	-	-	-	-
BP – Diastolic [mmHg]	-	-	**-0.266***	-	-	-
Hunger Scores – Breakfast					**0.221***	
Satiety Scores - Lunch				**-0.203**	**0.225***	
Satiety Scores – Dinner		**0.225***				
BDI - Total Scores	**0.203**					
Energy [Kcals]			**-0.249***		**0.22**	
Fat [g]					**0.310****	
SDF [g]				**-0.210**	**0.212**	
IDF [g]	**0.21**					
CF [g]		**-0.321****				
TDF [g]				**-0.204**		
Ghrelin [pg /ml]	**0.315****		**0.332****	-	**-0.400****	
Leptin [pg /ml]	**-0.441****		**-0.495****	**-0.400****		
GLP – 1 [pg /ml]			**0.709****	**0.315****	**-0.441****	**-0.258***
PYY [pg /ml]	**0.709****			**0.332****	**-0.495****	
Insulin [pg /ml]	**-0.258***					
***Bifidobacterium* Log10 [CFU/g]**	**0.359****		**0.344****		**-0.291****	
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).						

Table 5.59 depicts correlation of Gut microbes with various parameters of obese bank employees

Bifidobacterium **positively** correlated with gut satietogenic hormone GLP-1 (r=0.359), PYY (r=0.344) and *Lactobacillus* (r=0.401) and **negatively** correlated with weight (r=0.323), body fat (r=0.247), satiety scores for dinner (r=0.219), fat intake (r=0.222) and Leptin (r=0.291).

***Lactobacillus* positively** correlated with hunger scores for dinner (r=0.243), satiety scores for breakfast (r=0.298) and *Bifidobacterium* (r=0.401) and **negatively** correlated with hunger scores for breakfast (r=0.228) and depression scores (r=0.260).

***Clostridium* positively** correlated with weight (r=0.270), body fat (r=0.232) and LPS (r=0.250) and **negatively** correlated with mean satiety scores (r=0.234), *Bifidobacterium* (r=0.317) and *Lactobacillus* (r=0.245).

***Bacteroides* positively** correlated with hunger scores for breakfast (r=0.235) and **negatively** correlated with systolic blood pressure (r=0.283) and soluble fiber (r=0.328).

Table 5.59: Pearson's correlation of Gut-microbes with various parameters

Parameters	*Bifidobacterium*	*Lactobacillus*	*Clostridium*	*Bacteroides*
Weight	**-0.323****		**0.270***	
Body-fat	**-247****		**0.232***	
SBP				**-0.283***
Hunger Scores - Breakfast		**-0.228***		**0.235***
Hunger Scores - Dinner		**0.243***		
Satiety Scores - Breakfast		**0.298*****		
Satiety Scores - Dinner	**-0.219***			
Satiety Scores – Mean			**-0.234***	
Depression - Total Scores		**- 0.260***		
Carbohydrate				
Fat	**- 0.222****			
Soluble fiber				**- 0.328 ****
Insoluble fiber				
Crude fiber				
Total fiber				
Ghrelin				
Leptin	**- 0.291****			
GLP – 1	**0.359****			
PYY	**0.344****			
Insulin				
Bifidobacterium		**0.401****	**- 0.317****	
Lactobacillus	**0.401****		**- 0.245***	
Clostridium				

5.3.7: Regression analysis for identifying strongest predictor or obesity in obese bank employees

Table 5.60 depicts step-wise regression model summary for strongest predictor of obesity in obese bank employees. Results revealed BMR and GLP-1 to be the strongest predictor of obesity to the accuracy of 89% followed by satiety scores for dinner, total dietary fiber, and depression scores.

The sequences in which factors contribute to the development of obesity are as follows:

1] Basal metabolic rate ß = 0.84

2] GLP – 1 hormone ß = 0.15

3] Satiety scores for dinner ß = 0.127

4] Depression status ß = 0.084

5] Total dietary fiber ß = 0.079

Table 5.60: Stepwise Regression model summary for strongest predictor of obesity in obese bank employees of urban Vadodara

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.934a	0.873	0.871	3.8542
2	.944b	0.891	0.888	3.6045
3	.948c	0.899	0.895	3.4757
4	.952d	0.906	0.901	3.3781
5	.955e	0.912	0.906	3.3032
a. Predictors: [Constant], Basal Metabolic Rate [BMR]				
b. Predictors: [Constant], BMR, GLP-1 [Active] [pg/ml]				
c. Predictors: [Constant], BMR, GLP-1 [Active] [pg/ml], Satiety scores –Dinner				
d. Predictors: [Constant], BMR, GLP-1 [Active] [pg/ml], Satiety scores –Dinner, Total Dietary Fiber [g]				
e. Predictors: [Constant], BMR, GLP-1 [Active] [pg/ml], Satiety scores –Dinner, Total Dietary Fiber [g], Depression scores				
f. Dependent Variable : Weight [kg]				

Coefficients a						
		Unstandardized Coefficients	**Std. Error**	**Standardized Coefficients Beta**	**t**	**Sig.**
1	[(Constant]	37.121	7.118		5.215	0
	BMR	0.037	0.002	0.84	19.426	0
	GLP-1 (Active) (pg/ml)	-0.908	0.245	-0.15	-3.709	0
	Satiety scores –Dinner	-1.518	0.461	-0.127	-3.294	0.002
	Total Dietary Fiber [g]	0.125	0.058	0.079	2.158	0.034
	Depression Scores	-1.8	0.855	-0.084	-2.107	0.039
a. Dependent Variable: Weight [kg]						

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ANOVA						
Mode l		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7965.906	1	7965.906	536.252	.000a
	Residual	1158.674	78	14.855		
	Total	9124.58	79			
2	Regression	8124.144	2	4062.072	312.643	.000b
	Residual	1000.436	77	12.993		
	Total	9124.58	79			
3	Regression	8206.471	3	2735.49	226.441	.000c
	Residual	918.109	76	12.08		
	Total	9124.58	79			
4	Regression	8268.721	4	2067.18	181.15	0
	Residual	855.859	75	11.411		
	Total	9124.58	79			
5	Regression	8317.156	5	1663.431	152.453	.000e
	Residual	807.423	74	10.911		
	Total	9124.58	79			

e. Predictors: (Constant),[a] BMR, [b] GLP-1 [Active] [pg/ml], [c] Satiety scores for Dinner, [d] Total Dietary Fiber, [e], Depression scores

f. Dependent Variable: Weight [kg]

5.3.8: Follow up data for time-point interval analysis

Table 5.61 reveals time point interval difference in anthropometric and biophysical parameters of obese bank employees in experimental arm. Data reveals that there was gradual decrease in most of the anthropometric and biophysical parameters except hip circumference and BMR.

First month follow-up results after intervention

On first month follow-up visit, highest reduction was observed in body-fat % by 1.39 % followed by systolic blood pressure by 1.33% and waist circumference by 1.23 %. Reduction in weight and WHR was observed by 1.06 % individually. However, negligible difference was observed in BMI (0.75%), followed by hip circumference (0.29%), diastolic blood pressure (0.06%) and BMR (0.001).

Second month follow-up results after intervention

During second month follow-up visit, highest reduction was observed in body-fat % by 1.74% followed by weight by 1.32 % and WHR by 1.07%. Consistent reduction was observed in BMI by 0.72% similar to first month difference. However, lower % difference was observed in waist circumference (0.76%) and systolic blood pressure (0.82%) as compared to first month follow-up result of WC and SBP 1.23% and 1.33% respectively. Little higher education was observed in diastolic blood pressure (0.49%) and BMR (0.38%) as compared to first month with negligible difference of 0.06% and 0.001% respectively.

Third month follow-up results after intervention

Declining trend was observed in body-fat % (1.28%), weight (0.91%), waist circumference (0.33%) and systolic blood pressure (0.23%) as compared to the first and second follow-up results. Consistence reduction was observed in diastolic blood pressure (0.48%) as compared to second month (0.49%). However, drastic reduction was observed in BMI by 1.81% in third month compared to initial two months and on the contrary zero difference was observed in WHR.

Table 5.61 Time point interval difference in anthropometric and biophysical parameters of obese employees in experimental group [N=72]

Time Point Interval for Weight	Weight [kg]	BMI Kg / m^2	WC Cm	HC cm	WHR	Body fat %	BMR kcals	BP-systolic mmHg	BP-diastolic mmHg
At Beginning [PRE]	80.58 ± 8.29	28.00 ± 1.5	96.74 ±7.56	103.35 ± 5.69	0.94 ± 0.05	31.56 ± 3.87	1779.67 ± 193.09	128.88 ± 8.711	81.19 ± 7.78
First Month	79.72 ± 8.03	27.79 ± 1.54	95.55 ±7.61	103.06 ± 5.59	0.93 ± 0.05	31.12 ± 3.58	1779.64 ± 176.37	127.17 ± 8.15	81.14 ± 6.20
% Difference at 1st mo	**1.06 %**	**0.75 %**	**1.23 %**	**0.29 %**	**1.06 %**	**1.39 %**	**0.001%**	**1.33 %**	**0.06 %**
Second Month	78.67 ± 8.10	27.59 ± 1.67	94.82 ±6.65	103.07 ± 5.59	0.92 ± 0.05	30.58 ± 3.80	1786.44 ± 180.12	126.13 ± 7.48	80.74 ± 6.27
% Difference at 2nd mo	**1.32 %**	**0.72 %**	**0.76 %**	**- 0.009%**	**1.07 %**	**1.74 %**	**0.38 %**	**0.82 %**	**0.49 %**
At End [POST]	77.96 ± 7.93	27.09 ± 1.41	94.51 ± 7.67	103.03 ± 5.48	0.92 ± 0.05	30.19 ± 3.80	1775.50 ± 173.121	125.96 ± 7.22	80.35 ± 6.29
% Difference at 3rd mo	**0.91%**	**1.81 %**	**0.33 %**	**0.04 %**	**0 %**	**1.28 %**	**0.62 %**	**0.23 %**	**0.48 %**
Total Difference	**2.62 ± 0.80**	**0.91**	**2.23**	**0.32**	**0.02**	**1.37**	**4.17**	**2.92**	**0.84**
Percent [%] Difference	**3.25 ↓**	**3.25 ↓**	**2.30 ↓**	**0.31 ↓**	**2.13 ↓**	**4.34 ↓**	**0.23 ↓**	**2.27 ↓**	**1.03 ↓**

Table 5.62 depicts weight-loss in obese bank employees based on compliance data also graphically represented in Figure 5.16. Highest weight reduction of 2.7 kg (3.5%) was observed in bank employees who sincerely consumed FOS for at least 90 – 75 days i.e. 83% - 100%. As days of compliance reduced to 75 – 50 days i.e. 83% – 55 % weight-loss percentage also reduced to 3.03% followed by < 55% with 1.94% of weight loss.

Table 5.62: Weight-loss in obese bank employees according to days of compliance [N = 72]

Time Point Interval	Days of Compliance		
	90 – 75 Days [> 83%]	75 – 50 Days [83 – 55%]	< 50 Days [< 55%]
Number of Subjects [%]	45 [62.50%]	17 [23.61%]	10 [13.90%]
Pre Weight [kg]	83.04	76.34	76.68
Weight - 1st Month [kg]	82.30	75.15	75.86
Weight - 2nd Month [kg]	81.07	74.47	75.49
Post Weight [kg]	80.34	74.02	75.19
Total Weight Loss [kg]	2.70	2.32	1.49
Percent Weight Loss	3.5 %	3.03%	1.94 %

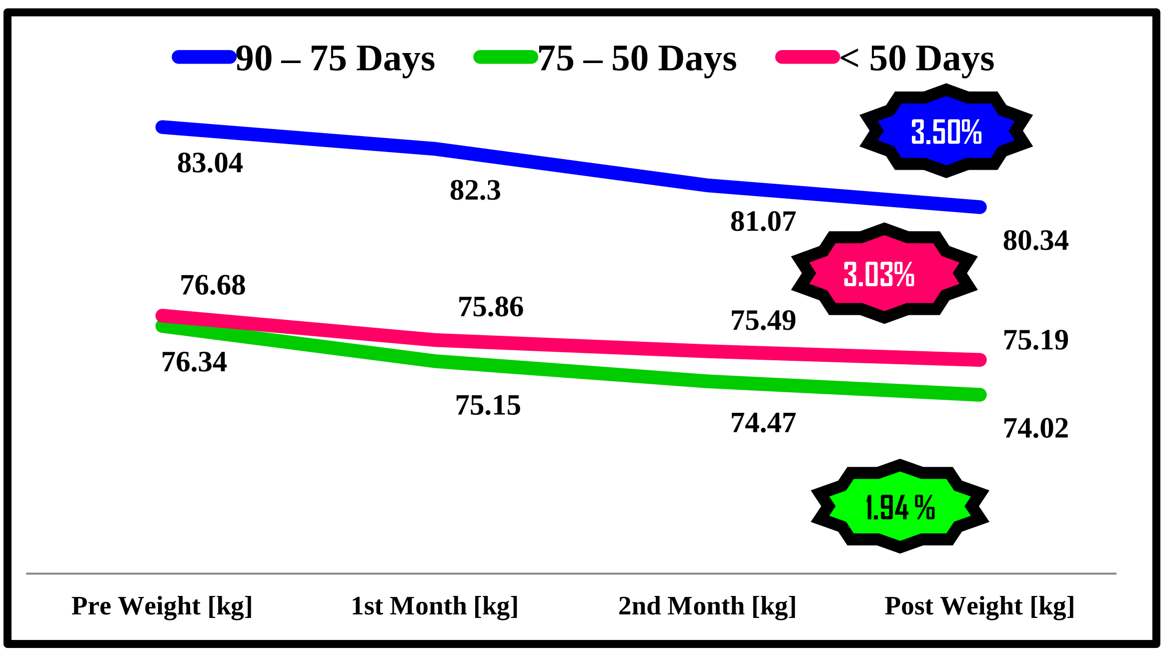

Figure 5.16 Weight-loss in obese bank employees according to days of compliance

RESULT HIGHLIGHTS

- **Statistically significant weight loss of 2.52 kg (3.25%) was achieved after FOS consumption for 90 days without any lifestyle changes**
- **FOS intervention reduce hunger pangs and induced early satiety**
- **Reduction in Energy intake of 247kcal/d; CHO-32g/d and Fat - 11.44g/d was observed post intervention. No significant difference was observed in protein intake.**
- **Normalization of defecation pattern via reduced constipation was also observed post intervention resulting in reduced flatulence in obese adults.**
- **Statistically significant reduction in depression scores by 26.77% was observed resulting in feel good factor in obese bank employees**
- **FOS intervention effectively and positively modulated gut flora and sensitized secretion of gut satietogenic hormones**
- **Highest weight-loss of 1.32%was achieved at the end of second month then it dropped a bit**
- **BMI, BMR and Diastolic blood pressure reduced over period of 3 months**
- **Compliance data revealed that, higher the compliance, higher is weight loss. 3.5% of weight loss was achieved with >83% of compliance. Only 1.94% of weight loss was achieved with <55% compliance**
- **Strongest predictor of obesity in obese bank employees was found to be BMR and GLP-1 to the accuracy of 88%**
- **Adding other factors in obesity assessment like satiety scores, total fibre intake and depression status could predict obesity with accuracy of 90%**

DISCUSSION

To our knowledge, this is the first randomized, double-blind, placebo-controlled clinical trial to systematically evaluate the long-term effects of Fructooligosaccharide supplementation on weight loss, gut flora and gut satiety hormones in obese adults. With an objective to evaluate the impact of 20g FOS supplementation for 90 days on primary parameter weight, gut flora and gut hormones; FOS proved to be a successful strategy to bring about positive changes in overall health outcomes.

With respect to anthropometric parameters, FOS supplementation helped reduce weight by 2.52 kg in duration of 3 months (3.25%) without any lifestyle changes. Weight loss induced per month averages out to be 0.84 kg without any lifestyle changes, which seems to be promising weight loss supplement. FOS supplementation in combination with lifestyle changes may work wonders in achieving weight loss along with improvement in other established health outcomes. FOS supplementation also induced reduction in WC by 2.23cm (3.35%) and WHR by 1(1.07%). As weight reduced change in BMI reduction was calculated to be 0.86 kg/m^2 (3.25%) which was equal to percentage of weight loss.

There are hardly few studies on FOS supplementation and weight loss to support our findings. Studies conducted on obese animal models that oligofructose supplementation promotes weight loss and improves energy homeostasis The results of this clinical trial support the findings of animal studies that showed a significant reduction in body weight because of fat loss that is independent of any other lifestyle changes (Nakamura et al., 2017; Parnell & Reimer, 2012; Parnell et al., 2009; Urias-Silvas et al., 2008).

A very recent departmental study conducted by Sheth & Gupta, 2014 on 12g FOS supplementation for 12 weeks and weight loss in industrial setting depicted weight loss of 1.44% and reduction in BMI by 1.32% ($p<0.001$). Significant reduction in body fat, WC and WHR was also reported.

Supplementation study conducted by Abrams et al. (2007) using Inulin–type fructans prebiotic (8g/day) for one year demonstrated significant benefit in the maintenance of BMI and fat mass in non-obese young adolescents (Abrams et al., 2007).

Similar results were also obtained in recent study where in, oligofructose supplementation for 12 weeks, primarily helped losing fat mass by 2.73% independently from any lifestyle changes and were able to decrease body weight by 1.23 % (1.03 ± 0.43 kg) and could help manage caloric intake in overweight and obese adults. These results indicate that dietary FOS suppresses high-fat diet-induced body fat accumulation, and inhibit intestinal absorption of dietary fat (Nakamura et al., 2017; Parnell & Reimer, 2012; Parnell et al., 2009).

Consumption of dietary fiber alters high body weight and obesity by SCFA–mediated physiological effect influencing satiety in addition to their satiating abilities and formation of fat-fibre complex (Slavin, 2013). Nevertheless, reduction in body weight, body fat and adipocyte size is brought about by microbiota modulation coupled with SCFA-mediated satiety effect (Gerard, 2016).

Present clinical trial also demonstrated reduction in body fat mass by 3.39% as supported by findings of Parnell et al. (2009). FOS intervention also helped reduce hunger pangs by 14.76% during lunch time and 3.83% during dinner time. It also helped achieve early satiety by 10.22% in lunch time and 12.58% in dinner time, resulting in reduced dietary intake and calorie consumption. Supplementation of FOS helped reduce 247 kcal/day (8.84%), CHO by 32g/day (8.67%) and Fat intake by 11.44 g/d (10.78%).

In human interventional studies prebiotic fiber have been reported to be involved in appetite regulation by modulating gut peptides, induce satiety and increase breath-hydrogen excretion. It also prompted the growth of *Bifidobacteria* and *Lactobacilli*. However, it was unknown whether these prebiotic fibers stimulated growth of whole *Bifidobacteria* genus or a particular species (Dahiya et al., 2017; Parnell & Reimer, 2009; Cani et al., 2009, Cani et al, 2006; Gibson et al., 2004).

A study on healthy individuals with 16g/d of prebiotic supplementation for two weeks depicted modulation of gut peptides with increase in GLP-1, PYY and GIP resulting in an effect that correlated with a reduction in glycemic response and reduced energy intake (Cani PD et al., 2009). This study further postulated the possibilities of improvement in obesity outcomes by prebiotic supplementation through modulation of endocrine function of gut and proliferation of number of L cells in jejunum and colon (Cani & Delzenne, 2011).

Our Interventional trail with FOS also demonstrated reduction in depression by 26.77% measured through Beck's Depression Inventory scores. In one of the study conducted by Faulconbridge (2009), Society for the Study of Ingestive Behavior on 51 clinically depressed individuals compared with non-depressed subjects. They were enrolled for supervised weight loss program including lifestyle modification and meal replacement for 6 months. Results revealed 8% reduction in body weight of depressed subjects and 11% in non-depressed subjects. Depressed individuals also showed improvement in symptoms of depression, reduction in TG and improvement in glucose, insulin and HDL cholesterol. Study results further suggested that clinically significant amounts of weight was lost by depressed obese individuals and that weight loss could further reduce symptoms of depression (Faulconbridge, 2009).

Till date it was assumed that obesity and depression coincidentally existed together. However, in a meta-analysis of longitudinal studies conducted by Luppino and colleague (2010) found that in American studies the development of depression was strongly influence by obesity. As obesity and depression both are associated with inflammation, brain responds in a manner leading to elevated pro-inflammatory cytokines. Since in obese individuals fat tissues are loaded with macrophages, they release inflammatory hormones such as TNF-alpha and interleukin-6 that constantly activate the immune system at a low level, leading to chronic inflammatory state (Gwyn & Cready, 2018; Bastard et al., 2006).

Impact evaluation of present clinical trial also demonstrated significant improvement in defecation profile. Constipation was reduced in 14% of subjects, frequency of passing stool increased twice in 15%, quantity / bulk of stool increased in 8%, hardness reduced in 17%, foul odor in 8% and feeling after defecation improved in 17% of obese employees and demonstrating statistically significant association between them ($p<0.001$). Since there was improvement in defecation profile, simultaneous improvement in flatulence profile was also observed.

Since prebiotics are soluble dietary fibers, there are few studies that demonstrate their role in relieving constipation. Fermentation of dietary components lead to an increase in bacterial mass and consequently fecal mass, as a result produces stool bulking effect. Approximately 30g of bacteria are produced for every 100g of fermented carbohydrate (Slavin, 2013).

In a recent study conducted by Yu et al. (2017) determining the effects of prebiotics and synbiotics on functional constipation (FC) in adults. Study comprised of 13 RCTs with participation of 199 patients intervened with prebiotic and 825 patients with symbiotic administration. Results reveal that prebiotics increased weekly frequency of stool (1.01 bowel movements/week, 95%CI: 0.04-1.99) and improved stool consistency (-0.59, 95% CI:-1.16 to -0.02). Analysis of subgroup revealed specific effects for galacto-oligosaccharides on stool frequency, consistency, ease of defecation and abdominal pain. Synbiotics also significantly improved stool frequency (1.15bowel movements/week, 95% CI: 0.58-1.71), consistency (0.63, 95% CI: 0.33-0.92) and reduced whole-gut transit time (13.52, 95% CI: -26.56 to -0.49) in patients with FC. Detailed analysis revealed effects of Fructooligosaccharide and prebiotic combinations on stool frequency, consistency, straining defecation and bloating. The authors from their findings concluded that Galactooligosaccharide and synbiotic made up of Fructooligosaccharide with probiotic combinations may improve stool frequency, consistency and some other symptoms related to constipation (Yu et al., 2017).

Vandeputte et al. (2017), set up a randomized, double-blind, placebo-controlled; cross-over trial in chicory-derived Orafti inulin was supplemented to healthy adults with mild constipation with dose of 12 g/day of for a 4-week treatment period. Study results established significant increase in stool frequency resulting from Inulin consumption (Micka et al., 2017) leading to a first positive opinion by the European Food Safety Authority on chicory inulin and 'maintenance of normal defecation' (EFSA Panel, 2015). Moving further onto gut hormones like Ghrelin, GLP-1, PYY, PP and CCK are known to induce satiety and meal termination leading to dramatic impact on energy balance homeostasis (Mishra, Dubey & Ghosh, 2016).

The efficacy trials of FOS in modulating gut satiety hormones, post intervention after 90 days brought significant improvement in sensitizing the secretion of GLP-1 by 3.34%, Leptin by 5.87%, GIP by 0.77%, Insulin by 6.23%, PYY by 3.11% and Ghrelin by 14.77%.

A study on healthy individuals with 16g/d of prebiotic supplementation for two weeks depicted modulation of gut peptides with increase in GLP-1, PYY and GIP resulting in an effect that correlated with a reduction in glycemic response and reduced energy intake (Cani et al., 2009). This study further postulated the possibilities of improvement in obesity outcomes by prebiotic supplementation through modulation of endocrine function of gut and proliferation of number of L cells in jejunum and colon (Cani & Delzenne, 2011).

Bomhof et al. (2014) designed a study to assess the efficacy of supplementing prebiotic oligofructose (OFS) and probiotic BB-12 and their independent and combined effects in obese rats. Study results revealed prebiotic significant weight loss via reducing fat mass and reduced energy intake, elevated secretion of portal GLP-1 and amplified colonization of *Bifidobacteria* and *Lactobaclli* in OFS group rats ($p<0.05$). However, secretion of GLP-2 was stimulated with probiotic BB-12 ($p<0.05$). BB-12 alone failed to demonstrate bifidogenic properties (Bomhof et al., 2014).

Studies have also demonstrated that administration of PYY reduces food intake with a significant reduction in cumulative 24 hour caloric intake in obese and lean humans (Bewick, 2012). Also, SCFAs produced from microbial fermentation of dietary oligosaccahride have direct influence on L cells resulting in rise of intestinal and plasma GLP-1 levels. There are several studies in animal and human studies that demonstrate the up regulation of GLP-1 and PYY through microbial fermentation of indigestible oligosaccahride and production of SCFAs (Tolhurst et al., 2012; Tarini & Wolever, 2010; Zhou et al., 2008).

One of the interventional studies conducted on 31 healthy subjects aged 28 years were enrolled to examine effect of 10g and 16g FOS supplementation for 13 days on appetite profiles and satiety hormone concentration and energy intake in human subjects. Study results revealed significant reduction in energy intake by 11% in 16g FOS group and enhanced concentrations of PYY and GLP-1 (Sanne, Diederick, & Klaas, 2011).

Nina et al (2015) attempted a study objective with aim to examine the effect of OFS in different types of obesity predisposition using diet-induced obese rats (DIO) and diet-resistant (DR) rats. They were further randomized to two more groups of high-fat/high-sucrose (HFS) diet and HFS diet 10% OFS for 6 weeks. Results revealed reduction in fat mass, body weight, energy intake in both phenotypes ($p<0.05$). Plasma Ghrelin was not modified by OFS but PYY levels were elevated and reduction in GIP was observed ($p<0.05$). Authors concluded that rats in both groups' prone and resistant obese phenotypes observed reduction in body weight and adiposity when OFS was supplemented. Also OFS induced modulation of gut hormones and gut microbial profile in DIO and DR rats, contributed to sustained lower body weight (Nina et al., 2015).

Sheth et al. (2015) with an aim to study impact of FOS supplementation on inflammatory markers and lipid profile in NIDDM patients revealed that 10 ml of liquid FOS supplementation for 45 days significantly reduced FBS (6.3%), PP2BS (9.8%), HbA1c (10.6%) and lipid profile (7.9% - 14.4%). Reduction in hs-CRP and BMI was observed by 27.2% and 1.3% respectively (Sheth et al., 2015).

After 90 days post intervention FOS also proved effective in colonizing gut of obese employees with beneficial bacteria *Lactobacilllus* by 22.64% and *Bifidobacterium* by

7.99% *Clotstridium* reduced significantly by 4.49% and no significant change was observed in *Bacteroides* counts in experimental group. Similar results were also observed in a study of 17 human volunteers supplemented with oligofructose led to significant increase in *B.longum* and *B.adolescentis* species (Joossens et al., 2011). In similar kind of study in obese women demonstrated increase in population of *Bifidobacterium, F.prausnitzii* and *Lactobacilli*. Correlation analaysis speculated that serum LPS levels negatively correlated with *Bifidobacterium* and *F. prausnitzii*. Also positive correlation with changes in body composition and glucose homeostasis was demonstrated by *B. intestinalis* and *B. vulgates* (Dewulf et al., 2012).

Investigators also tried to establish correlation between metabolic markers and *Bifidobacterium* species and SCFAs. Results of Salazar et al. 2015 also depicted increase in colonies of *B. longum* and *B. adolescentis* and they negatively correlated with serum cholesterols. Surprisingly, *B. longum* negatively correlated with serum LPS (Salazar et al., 2015). Authors , concluded that prebiotics helps in reducing weight by inducing satiety via L cells in gut and reducing production of LPS by modulating gut microbiota (Dahiya et al., 2017).

A meta-analysis conducted by da Silva and colleagues (2013) with 61 original articles described the relationship between the microbiota and obesity and the possible impact of prebiotic and prebiotic exploring the fact that the main effect of associated weight loss was related to an increase in *Bifidobacteria* (da Silva et al., 2013).

Hence, FOS, OFS and Inulin are well established prebiotics and can significantly increase fecal *Bifidobacteria* and *Lactobacillus* at fairly low levels of consumption of 5 -8 g/day (Slavin, 2013).

To establish relationship between gut satietogenic hormones, gut flora and various other parameters the pearsons correlation data revealed significant negative correlation between GIP - SBP and PYY – DBP. Ghrelin negatively correlated with soluble dietary fiber and total fiber. *Bifidobacterium* counts positively correlated with GLP-1 and PYY.

Leptin negatively correlated with *Bifidobacterium* and PYY. BMR positively correlated with Leptin and negatively with Ghrelin.

Stepwise regression model summary revealed that, strongest predictor of obesity in Obese Population was BMR to the accuracy of 87%, Followed by GLP-1 to the accuracy of 88%. Obesity can be predicted to the accuracy of 90% when all factors like BMR, GLP-1, satiety scores for dinner, total fiber intake and depression scores are considered

Conclusion

- ***FOS is a promising agent in achieving or maintaining a healthy body weight, Improving defecation profile, healthy gut flora, modulating gut satietogenic hormones***
- ***Fructooligosaccharide has potential to modulate several metabolic aberrations and modulate underlying mechanism regulate appetite signalling pathways via gut flora and gut hormones through gut-brain axis.***
- ***This study also proves the existence of bidirectional mechanism and relationship between gut flora and gut hormones***

PHASE IV

ACCEPTABILITY TRIALS OF FOS ADDED POPULAR INDIAN RECIPES

Currently, the new area emerging in the management of obesity concentrates on use of prebiotic as health supplement. Fortification of foods and beverages with novel functional ingredients like Prebiotic Fructooligosaccharide is a recent development in this direction. The market for functional foods in global market is thriving as consumers are more inclined towards consuming foods and beverages containing prebiotic.

Prebiotic Fructooligosaccharide being a carbohydrate and having a sweet taste which is very similar to that of sucrose but contributes minimum calories compared to sucrose. Apart from being classified as a sweetener, it is also classified as a soluble fibre and can be used to increase the fibre without increasing the viscosity of food products. Fructooligosaccharide are also considered as bulking agents and fat substitutes in some foods, they have high solubility, and they do not have any after taste or artificial taste. These properties of FOS can play a vital role in developing products affecting satiety and managing weight.

Various FOS based products like beverage concentrates, spreads and honey have been studied successfully and their processes have been patented. FOS added soups and beverages namely butter milk, lemon juice, milk and tomato soup have also been studied and were highly acceptable at 7.5% level of addition (Gupta & Sheth, 2016).

Feasibility of FOS substitution in Indian recipes commonly consumed in Gujarat region were attempted and successful substitution was achieved in *Dhokla and Patra* at highest level of 10g, whereas *Thepla* was acceptable at 5 – 8 g and C*hapati* was least accepted (Mahendra & Sheth, 2013).

As Fructooligosaccharides (FOS) have a potential to be added into various other Indian cuisines, which can become a part of daily diet (staple food), there is a need for developing database of such FOS added popular recipes and study them for their feasibility and acceptability trials using scientific method. Hence, the present study attempted to determine the extent to which FOS can be added into another four popular Indian recipes with four different cooking techniques, namely steamed *Dudhi Muthiya*, shallow fried *Vegetable Cheela*, baked *Handwa* and deep fried *Veg. Mini Samosa*

For this section of study, FOS was added at varying levels of 5g, 10g, 15g, and 20g in selected four food products namely steamed *Dudhi Muthiya*, shallow fried *Vegetable Cheela*, baked *Handwa* and deep fried *Veg. Mini Samosa*. They were assessed for their physical and organoleptic properties.

The results of this phase are explained under following sections:

Section 5.4.1: Physical characteristics of FOS addition at varying levels in

A] Steamed *Dudhi Muthiya*.
B] Shallow fried *Vegetable Cheela.*
C] Baked *Handwa.*
D] Deep fried *Veg. Mini Samosas*

Section 5.4.2: Organoleptic evaluation of

A] Steamed *Dudhi Muthiya*.
B] Shallow fried *Vegetable Cheela*.
C] Baked *Handwa.*
D] Deep fried *Veg. Mini Samosas*

5.4.1A: Physical characteristics of FOS addition at varying levels in Steamed *Dudhi Muthiya*

Table 5.63 represents the physical characteristics of standard *Dudhi Muthiya*, modified product and its dough. It was observed that, with the increase in the level of FOS addition, significant variance was observed with increase in weight of dough ($p<0.001$). However, stickiness in the dough of *Dudhi Muthiya* increased along-with increase in level of FOS addition. At 20g addition of FOS, it was difficult to give proper cylindrical shape to the dough to form *Dudhi Muthiya*.

Reduction in the water absorption power (WAP %) of the dough was observed by 50% at 20g addition of FOS. At 15g of FOS addition, WAP (%) reduced by 33.33 % and at 10 g of FOS addition by 16.67 % as compared to standard product.

Comparing the percent moisture loss between the dough and the cooked product it was observed that, highest percent of moisture loss was observed in 10g FOS added product (18.89 %), followed by 20 g (15.67%) and least was observe in 15 g of FOS added *Dudhi Muthiya* (13.62 %) as compared to the standard product (20.49 %).

Significant increase in the yield of *Dudhi Muthiya* was observed at all three levels of FOS addition. At 10g of FOS addition yield increased by 7.99%, at 15g addition it was 18.22% and at 20g of addition it was 18.22%. Increase in percent yield could be attributed to increase in the water retention.

However, at 20g of addition not much difference (18.15%) was observed in yield of cooked product as compared to 15g of addition. Highest increase in bulk density was observed in 15g and 20g of FOS added *Dudhi Muthiya* (0.86g/cc).

Gradual increase in length, width and thickness was also observed with varying levels of FOS addition as compared to standard product and this variance was highly significant ($p<0.001$).

Table 5.63: Physical characteristics of steamed *Dudhi Muthiya* with FOS addition at varying levels [One Serving]

Physical Characteristics	STD	10 g	15 g	20g	F-value	F-critical	p-value
Characteristics of dough							
Dough weight [g]	181.5 ± 0.5	192.12± 0.29	197.5 ± 0.5	202.2 ± 0.28	**2922.49*** **	15.89	1.70E-12
WAP [ml]	30	25	20	15			
Percent WAP [%]	100	83.33↓	66.67↓	50 ↓			
Characteristics of Cooked Product							
Cooked weight [g]	144.3 ± 1.15	155.83 ± 1.04	170.6 ± 0.53	170.5 ± 1.32	**449.41*** **	15.83	2.9725E-09
% Yield	-	7.99 % ↑	18.22 % ↑	18.15% ↑			
Moisture loss [g]	37.2	36.29	26.9	31.7			
Percent Moisture loss [%]	20.49	18.89↓	13.62 ↓	15.67 ↓			
Bulk density [g/cc]	0.79	0.81 ↑	0.86 ↑	0.86 ↑			
Length [cm] / Piece	2.5 ± 0.02	2.7 ± 0.03	3.0 ± 0.01	3.5 ± 0.15	**39.31*** **	15.83	3.90533E-05
Width [cm] /Piece	2.5 ± 0.02	2.7 ± 0.03	3.0 ± 0.01	3.0 ± 0.02	**61.54*** **	15.83	7.20039E-06
Thickness [cm] /Piece	1.25 ± 0.03	1.4 ± 0.03	1.7 ± 0.02	1.9 ± 0.03	**331.46*** **	15.83	9.95368E-09

5.4.2B: Physical characteristics of shallow fried *Vegetable Cheela* with FOS addition at varying levels

Table 5.64 represents the characteristics of standard and modified *Vegetable Cheela* and its batter. With the increase in the level of FOS addition, significant variance in batter weight was observed ($p<0.001$). Also, thinness in the batter increased with the increase in the level of FOS addition and the water absorption power of the batter reduced gradually with increase in amount of addition.

At 10g, 15g and 20g level of FOS addition, WAP (%) reduced by 12.5%, 18.75% and 25% respectively. At 20g of FOS addition, difficulty in flipping of *Vegetable Cheela* was observed due to the thinning of the batter, during shallow frying on regular pan.

Comparing the percent moisture loss between the batter and the cooked product, no major difference was observed in loss of moisture at 10g, 15g and 20g of FOS added *Vegetable Cheela* compared to the standard product.

With increase in level of FOS addition, increase in the yield of cooked product of *Vegetable Cheela* was also observed. Highest yield of 12.10% was obtained at 20g of FOS addition, followed by 10.52% at 15g and 8.06% at 10g of level of addition as compared to standard product and this variance was highly significant ($p<0.001$).

Slight increase in the bulk density and width was observed upto15g as compared to standard product. Decrease in bulk density and width was observed at 20g.

However, gradual increase in thickness was observed at 10g, 15g, and 20g FOS addition and this variance was highly significant ($p<0.001$).

The spread ratio of the FOS added *Vegetable Cheela* at 20g of addition reduced by 25% as compared to the standard product. Variance in reduction of spread ratio with increasing level of FOS addition of was highly significant ($p<0.001$).

Table 5.64: Physical characteristics of shallow fried *Vegetable Cheela* with FOS addition at varying levels [One Serving]

Characteristics of Batter							
Physical Characteristics	**STD**	**10 g**	**15 g**	**20g**	**F-value**	**F crtical**	**p value**
Batter weight / Serving	145.13 ± 0.42	155.20 ± 0.2	160.40 ± 0.4	165.33 ± 0.42	1490.36***	15.83	2.5E-11
WAP [ml]	80	70	65	60			
Percent WAP [%]	100	87.5↓	81.25↓	75↓			
Characteristics of Cooked Product							
Cooked weight /Serving	116.97 ± 0.45	126.1 ± 0.1	129.27 ± 0.30	131.12 ± 0.21	1406.42***	15.83	3.15E-11
Percent Yield [%]		8.06 ↑	10.52↑	12.10↑			
Moisture loss [g]	28.16	29.10↑	31.13↑	34.21↑			
Percent Moisture loss [%]	19.4	18.75↓	19.41↑	20.69↑			
Bulk density	0.8	0.81 ↑	0.81↑	0.79↓			
Width [cm]/Piece	13.2 ± 0.02	13.4 ± 0.03	13.4 ± 0.01	13.2 ± 0.03			
Thickness [cm]/Piece	0.3 ± 0.003	0.35 ± 0.002	0.35 ± 0.001	0.40 ± 0.002	1111.11***	15.83	8.08E-11
Spread Ratio [SR]	44	38.28	38	33			
Percent SR	100	87↓	86.36↓	75↓	69.57***	15.83	4.5E-06

5.4.3C: Physical characteristics of baked *Handwa* with FOS addition at varying levels

Table 5.65 represents the physical characteristics of standard *Handwa*, modified product and its batter. It was observed that, with the increase in the level of FOS addition, consistency of batter got thinner as compared to standard product.

Also, with increase in level of FOS addition at 10g, 15g and 20g increase in cooked weight of *Handwa* was observed by 3.76%, 4.96% and 2.25% respectively. Variance in cooked weight was highly significant at $p<0.04$. This could be due to water retention.

Comparing the percent moisture loss between the dough and the cooked product it was observed that, highest percent of moisture loss was observed in standard product (16.19%) and least was observed in 15g FOS added product (8.95 %).

At higher level of addition (20g) percentage of moisture loss increased by 1% as compared to 15g added product. Increase in bulk density was also observed with increase in level of FOS addition.

5.4.4D: Physical characteristics of deep fried *Vegetable Mini Samosa* with FOS addition at varying levels

Table 5.66 represents the physical characteristics of standard *Vegetable Mini Samosa*, modified product, its dough and stuffing. For *Vegetable Mini Samosa*, level of FOS addition was reduced to 5g, 10g and 15g instead of 10g, 15g, and 20g as during trial at 15g addition as due to increase oozing of liquid from stuffing it was very hard to fold samosa.

Hence, 3 lower levels 5g, 10g and 15g of FOS addition were selected. Refined wheat flour weighing 300g was kneaded into dough using 55 ml of water. Total dough weight was 453.20g for 4 servings and vegetable stuffing was 576g. Dough and stuffing was divided into 4 equal parts weighing 113.25g and 144g respectively with total weight of 257.25g for one serving consisting of 12 small size uncooked samosa.

Results revealed that the cooked weight of standard product was 233g with 10.41% of loss in moisture content. With increase in level of FOS addition, we observed retention in moisture content instead of loss during deep frying method of cooking which was contradicting to other three products.

Also, increase in bulk density was observed with every level of increase in FOS addition. This could be due to moisture retention and excess absorption of oil due to high moisture content. Absorption of oil was observed to be least in standard product (4%) and at 5g level of addition (5%). However, at 10g and 15g, absorption of oil was two – three fold times higher as compared to standard product.

Table 5.65: Physical characteristics of baked *Handwa* with FOS addition at varying levels

Physical Characteristics	STD	10 g	15 g	20g
Characteristics of Batter				
Batter weight [g]	295.75	295.75	295.75	295.75
Oil [ml]	30	30	30	20
Characteristics of cooked product				
Cooked weight [g]	247.87 ± 15.20	257.2 ± 17.78	269.27 ± 11.90	266.4 ± 9.92
	F-value : 4.36 * ; F-critical : 4.26 ; p-value: 0.04758			
Percent Yield [%]	100	3.76↑	4.69↑	2.25↑
Moisture loss [g]	47.88↓	38.55↓	26.48↓	29.35↓
Percent Moisture loss [%]	16.19↓	13.10↓	08.95↓	09.92↓
Bulk density [g/cc]	0.83↓	0.87↑	0.91↑	0.91↑

Table 5.66: Physical characteristics of deep fried *Vegetable Samosa* with FOS addition at varying levels

Physical Characteristics	STD	5g	10g	15g
Characteristics of Dough [One serving = 12 Mini Samosa]				
Refined Wheat Flour [g]	300	300	300	300
Water Added [ml]	55	55	55	55
Dough weight [g / 4 Serving]	453.2 g/4s	453.2 g/4s	453.2 g/4s	453.2 g/4s
Dough weight [g / 1 Serving]	113.25	113.25	113.25	113.25
Vegetable Stuffing				
Stuffing [g / 4 Serving]	576	576	576	576
Stuffing [g / 1 Serving]	144	144	144	144
Total Weight of Uncooked Samosa				
Uncooked Weight / 1 Serving	257.25	257.25	257.25	257.25
Characteristics of Cooked Product				
Cooked weight [g]	233 ± 0.5	303.53 ± 0.5 ↑	336.13 ± 3.81↑	306.26 ± 1.42 ↑
	F-value : 0.000576 NS ; F-critical : 4.26 ; p-value: 0.999424			
Percent Yield	100	130.27↑	144.26↑	131.44↑
Moisture loss [g]	-24.25↓	+46.28↑	+78.88↑	+49.01↑
Percent Moisture Loss / Retention [%]	-10.41↓	+19.86↑	+33.85↑	+21.03↑
Bulk density [g/cc]	0.90↓	1.18↑	1.31↑	1.19↑
Oil for Frying [12 mini Samosa]				
Initial Volume [ml]	300	300	300	300
End Volume [ml]	288	285	278	270
Difference [ml]	12	15	22	30
Percent Difference [%]	4%	5% ↑	7.33% ↑	10% ↑

5.4.2A: Organoleptic attributes of steamed *Dudhi muthiya* at varying levels of FOS addition

As seen in Table 5.67 and graphically represented in Figure 5.17, there was increase in scores of all attributes of the *Dudhi Muthiya* at 10, 15g and 20g of FOS addition except scores for *texture* that improved only at 20g of FOS addition. However, the variance in mean scores was statistically significant only for *taste and after-taste* ($p<0.001$ and $p<0.01$ respectively).

Significant ($p<0.001$) improvement was observed in *taste* by 16.64% *and after-taste* by 15.02% at 20g addition of FOS as compared to standard product.

Color and appearance was enhanced maximum by 3.9% at 10g and 3.25% at 20g level of FOS addition as compared to the standard product. It was least enhanced at 15g of FOS addition.

Overall the *color and appearance* of the product enhanced by 3.25% and did not deteriorate at the highest level of 20g addition of FOS. This could be attributed to little darkening (browning) of surface of *Dudhi Muthiya.* However, the variance in mean scores was statistically non-significant.

Mouthfeel enhanced at 10g and 20g level of FOS addition by 8.52% and 8.21% respectively. However, the variance in mean scores was statistically non-significant.

Texture was not much affected by FOS addition at level of 10g and 15g. Decrease in the mean scores for *texture* was observed by -0.98 % at 15 g addition of FOS which was non-significant. At 10 g level only 0.7 % increase was observed in the mean *texture* scores. However, non-significant improvement in texture was observed by 2.11% at 20g addition.

Taste attribute gradually kept on improving by 14.26% at 10g, 14.74 % at 15g and 16.64% at 20g as compared to standard product. The variance in mean scores was highly significant at p<0.001. *Taste* improved significantly at highest level of 20g of FOS addition (p<0.001).

Aftertaste also similarly increased by 13.89 % at 10g, 14.54% at 15g and 15.02% at 20g level of FOS addition as compared to standard product. The variance in mean scores was highly significant at p<0.01. *Aftertaste* improved significantly at highest level of 20g of FOS addition (p<0.001).

Overall Acceptability was significantly high [p<0.05] for 20g FOS added *Dudhi Muthiya* (9.27%) followed by 8.22% at 10g as compared to the standard product. However, variance in scores was not significant.

5.4.2B: Organoleptic attributes of shallow fried *Vegetable Cheela* at varying levels of FOS addition

As seen in Table 5.68 and graphically represented in Figure 5.18, there was an improvement and increase in the scores of all the attributes of the *Vegetable Cheela*.

Significant increase (p<0.001) of 18.44% was observed in *taste*, 16.17% in *aftertaste*, 11.18% in *mouthfeel* (p<0.01) and 6.48% in *texture* was observed at the highest level of FOS addition of 20g. *Overall acceptabilit*y of *Vegetable Cheela* was 12.81% significantly higher (p<0.001) as compared to the standard product. Analysis of variance in mean scores was statistically significant for *mouthfeel* (p<0.05), *taste* (p<0.001), *aftertaste* (p<0.01) and *overall acceptability* (p<0.05).

Table 5.67: Effect of varying levels of Fructooligosaccharide addition on the organoleptic quality of steamed *Dudhi Muthiya*

Level of addition		Color & appearance	Mouth feel	Texture	Taste	After taste	Overall acceptability
STD Product	Mean	7.38 ± 0.94	6.69 ± 1.12 [a]	7.14 ± 1.18	6.31 ± 1.28 [a]	6.19 ± 1.33 [a]	6.69 ± 1.07 [a]
	Range	5 – 9	4 – 9	4 – 9	3 – 9	4 – 9	5 – 9
10 g FOS	Mean	7.67 ± 0.85	7.26 ± 1.21[b]	7.19 ± 1.17	7.21 ± 1.14 [b]	7.05 ± 1.23 [b]	7.24 ± 1.08 [b]
Addition	Range	6 – 9	4 – 9	4 – 9	5 – 9	4 – 9	5 – 9
	t – test	1.47 [NS]	2.25*	0.18 [NS]	3.43**	3.07***	2.34*
	%↑ or ↓	**3.93↑**	**8.52↑**	**0.71↑**	**14.26↑**	**13.89↑**	**8.22↑**
15 g FOS	Mean	7.48 ± 0.97	7.05 ± 1.25 [b]	7.07 ± 1.24	7.24 ± 1.38 [c]	7.09 ± 1.36 [c]	7.10 ± 1.16 [b]
Addition	Range	6 – 9	4 – 9	4 – 9	5 – 9	4 - 9	4 – 9
	t – test	0.46 [NS]	1.38*	0.27 [NS]	3.21**	3.09***	1.66*
	%↑ or ↓	**1.35↑**	**5.38↑**	**0.98↓**	**14.74↑**	**14.54↑**	**6.13↑**
20 g FOS	Mean	7.62 ± 0.94	7.24 ± 1.28 [b]	7.29 ± 1.2	7.36 ± 1.28 [d]	7.12 ± 1.31 [d]	7.31 ± 1.32 [b]
Addition	Range	6 – 9	4 – 9	4 – 9	4 – 9	4 - 9	4 – 9
	t-test	1.16 [NS]	2.08*	0.55 [NS]	3.75**	3.22***	2.36*
	%↑ or ↓	**3.25↑**	**8.21↑**	**2.11↑**	**16.64↑**	**15.02↑**	**9.27↑**
	F value	**0.85**	**1.98**	**0.31**	**6.09**	**4.96**	**2.38**
	F critical	**2.66**	**2.66**	**2.66**	**5.68**	**3.90**	**2.66**
	ANOVA	**NS**	**NS**	**NS**	*******	******	**NS**

Mean values represent the average of 42 determinants in triplicates.
a, b- The non identical letters in any two rows within the column denote a significant difference at a minimum of $p < 0.05$; $p < 0.01$ and $p < 0.001$ level.
a,a; b,b – The identical letters in any two rows within the column denote no difference.
NS – The difference between the mean values within the columns is not significant. Maximum score for all the organoleptic attributes was 9.

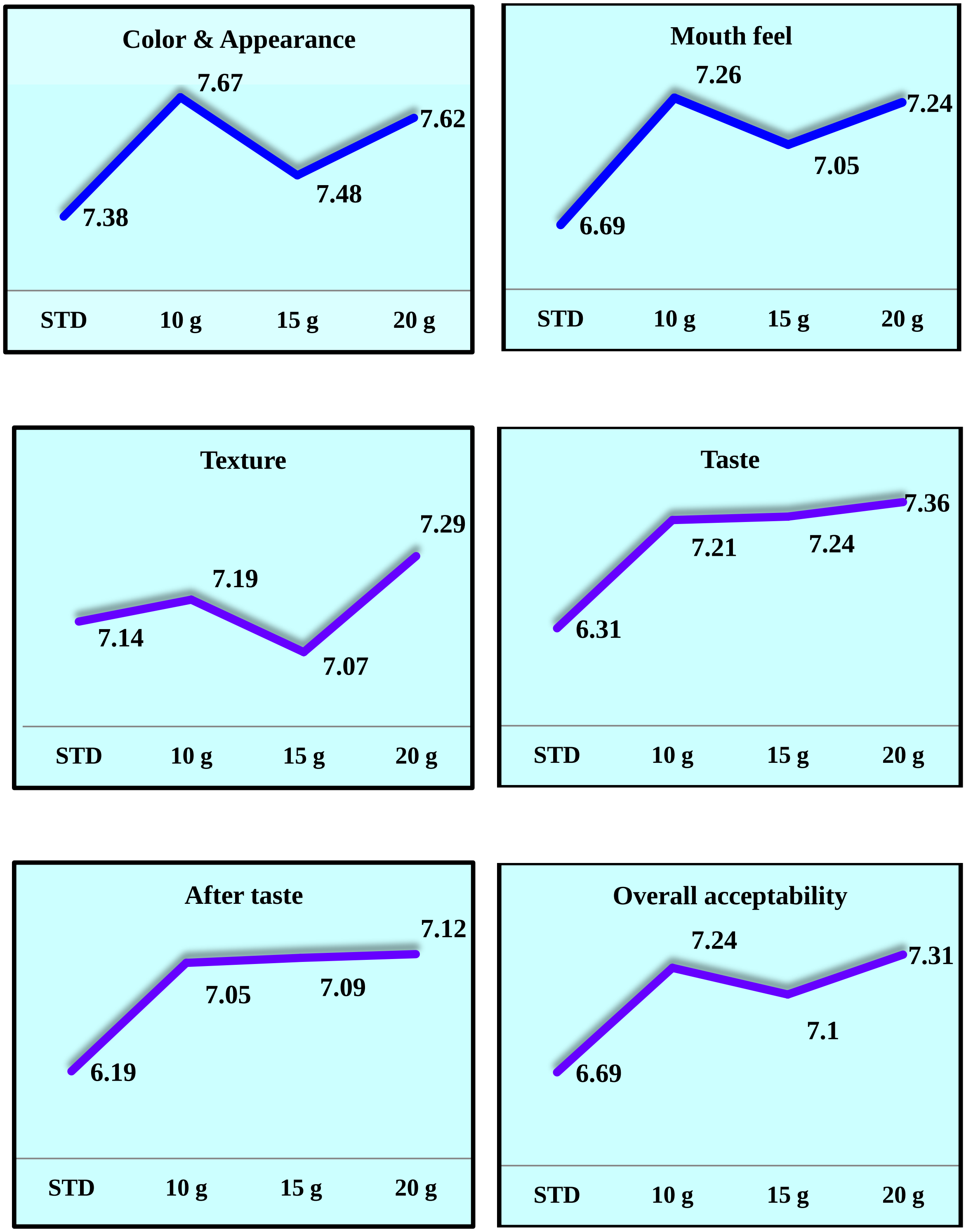

Figure 5.17: Organoleptic attributes of steamed *Dudhi Muthiya* at varying levels of FOS addition

Color and appearance was enhanced by 2.98% at 10g and 2.22% at 20g level of FOS addition as compared to the standard product. It was least enhanced at 15g of FOS addition. Overall the *color and appearance* of the product enhanced by 2.22% and did not deteriorate at the highest level of 20g addition of FOS. This could be attributed to crispiness and little darkening (browning) of surface of *Vegetable Cheela*. However, the variance in mean scores was non-significant

Mouthfeel was significantly enhanced at 15g ($p<0.05$) and 20g ($p<0.01$) level of FOS addition by 7.56% and 11.18% respectively as compared to standard product. This could be attributed to the crispiness from outside and overall softness while chewing. Analysis of variance in mean scores was also highly significant at $p<0.05$

Texture was not much affected by FOS addition at level of 10g and 15g. Non-significant increase was observed in mean texture scores at 10g and 15g of FOS addition. However, significant increase ($p<0.05$) was observed at the highest level of FOS addition by 6.48%. This could be attributed to increased crunchiness of *Vegetable Cheela*. However, variance in overall mean scores was non-significant.

Taste mean scores consistently increased at 10g by 6.36% (NS), at 15g by 11.61% ($p<0.01$) and at 20g by 18.44% ($p<0.001$) as compared to standard product. *Taste* of *Vegetable Cheela* improved significantly and was most accepted at highest level of FOS addition at 20g. The variance in mean scores was also highly significant at $p<0.001$.

Aftertaste also consistently increased at all three levels of addition with highest and significant ($p<0.001$) increase at 20g level of FOS addition by 16.17% as compared to standard product. The variance between groups was highly significant at $p<0.01$.

Overall Acceptability was significantly high ($p<0.001$) for 20g FOS added *Vegetable Cheela* by 12.81% followed by 15g by 8.33% as compared to the standard product.

5.4.2C: Organoleptic attributes of baked *Handwa* at varying levels of FOS addition

As seen in Table 5.69 and graphically represented in Figure 5.19, there was an improvement and increase in the scores of all the attributes of FOS added *Handwa* as compared to standard product.

Significant increase ($p<0.01$) in most of the attributes was observed at highest level (20g) of FOS addition except *color and appearance* and *texture*. Significant increase of 10.12% ($p<0.001$) was observed in *taste,* followed by 9.57% ($p<0.01$) in *aftertaste* and 8.32% in *mouthfeel* ($p<0.01$). Also, increase in mean scores of *texture* by 3.39% and *colour and appearance* by 1.13% was observed as compared to standard *Handwa.*

*Overall acceptabilit*y of *Handwa* was 7.43% significantly higher at 20g addition of FOS as compared to the standard product ($p<0.01$).

Color and appearance of baked *Handwa* enhanced by 1.13% at highest level of FOS addition (20g). However, the variance in mean scores was not significant.

Mouthfeel was significantly ($p<0.010$) enhanced at 20g and 10g level of FOS addition by 8.32% and 6.44% respectively as compared to standard product. This could be attributed to overall softness in *mouthfeel*. Also, variance in mean scores was observed to be highly significant at $p<0.05$

Texture was not much affected by FOS addition at any level. Non-significant increase was observed in mean texture scores at all level of FOS addition.

Table 5.68: Effect of varying levels of Fructooligosaccharide addition on the organoleptic quality of shallow fried *Vegetable Cheela*

Level of addition		Color & appearance	Mouth -feel	Texture	Taste	After taste	Overall Acceptability
STD Product	Mean ± SD	7.05 ± 0.88	6.62 ± 1.03[a]	6.95 ± 0.91[a]	6.29 ± 1.15[a]	6.31± 1.14[a]	6.48 ± 0.97[a]
	Range	5 -9	4 – 9	5 – 8	4 – 9	3 – 9	4 – 8
10 g FOS	Mean ± SD	7.26 ± 0.78	6.8 ± 1.20[a]	7.05 ± 1.10[a]	6.69 ± 1.42[a]	6.56 ± 1.34[a]	6.81 ± 1.21[a]
Addition	Range	6 – 9	4 – 9	4 – 9	4 – 9	3 – 9	4 – 9
	t – test	1.17[NS]	0.97[NS]	0.44[NS]	1.43[NS]	1.05[NS]	1.39[NS]
	%↑ or ↓	**2.98↑**	**2.72↑**	**1.44↑**	**6.36↑**	**3.96↑**	**5.09↑**
15 g FOS	Mean ± SD	7.17 ± 0.93	7.12 ± 0.99[b]	7.21± 0.90[a]	7.02 ± 1.35[b]	6.83 ± 1.31[b]	7.02 ± 1.18[b]
Addition	Range	5 – 9	4 – 9	6 – 9	4 – 9	4 – 9	4 – 9
	t – test	0.60[NS]	2.25*	1.33[NS]	2.69**	1.96[NS]	2.33*
	%↑ or ↓	**1.70↑**	**7.56↑**	**3.74↑**	**11.61↑**	**8.24↑**	**8.33↑**
20 g FOS	Mean ± SD	7.21± 1.18	7.36 ± 1.06[c]	7.40 ± 0.86[b]	7.45 ± 1.11[c]	7.33 ± 1.07[c]	7.31 ± 1.24[c]
Addition	Range	4 -9	5 – 9	6 – 9	5 – 9	5 – 9	4 – 9
	t-test	0.73[NS]	3.24***	2.35*	4.73***	4.24***	3.43***
	%↑ or ↓	**2.22↑**	**11.18↑**	**6.48↑**	**18.44↑**	**16.17↑**	**12.81↑**
	F-value	**0.39**	**3.72**	**1.85**	**6.43**	**3.95**	**3.89**
	F-critical	**2.66**	**2.66**	**2.66**	**5.68**	**3.44**	**2.66**
	ANOVA	**NS**	*	**NS**	***	**	*

Mean values represent the average of 42 determinants in triplicates.
a, b- The non identical letters in any two rows within the column denote a significant difference at a minimum of $p < 0.05$; $p < 0.01$ and $p < 0.001$ level.
NS – The difference between the mean values within the columns is not significant. Maximum score for all the organoleptic attributes was 9

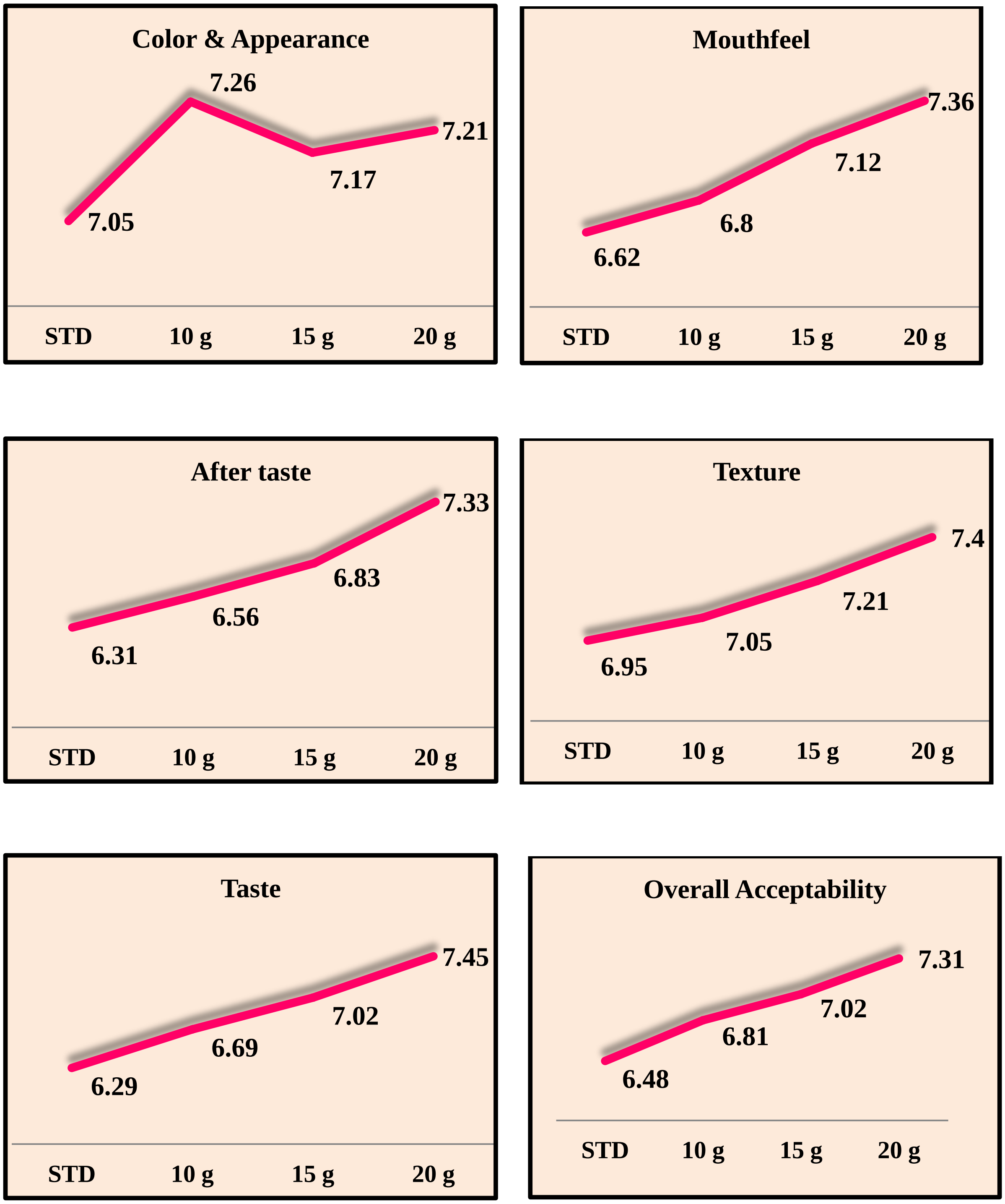

Figure 5.18: Organoleptic attributes of shallow fried *Vegetable Cheela* at varying levels of FOS addition

Taste improved significantly at 20g level of FOS addition by 10.12% ($p<0.001$) as compared to standard product. The variance in mean scores was highly significant at $p<0.001$.

Aftertaste also increased at all three levels of addition with highest and significant increase at 20g level of FOS addition by 9.57% as compared to standard product. The variance between groups was highly significant at $p<0.01$.

Overall Acceptability was significantly high ($p<0.001$) for 20g FOS added *Handwa* by 7.43% followed by 10g by 6.22% as compared to the standard product.

5.4.8: Organoleptic attributes of deep fried *Vegetable Samosa* at varying levels of FOS addition

As seen in Table 5.70 and graphically represented in Figure 5.20, there was reduction in scores but no significant difference was observed in most of the sensory attributes upto 10g of FOS addition in *Vegetable Mini Samosa* as compared to standard product. However, at 15g of FOS addition *Vegetable Mini Samosa* were not acceptable.

Color and appearance scores gradually decreased for deep fried *Vegetable Mini Samosa* but drop in scores was not significant up to 10g addition of FOS. However, at 15g of FOS addition it dropped significantly by 8.49 % ($p<0.05$). This could be attributed to darkening of outer surface due to high moisture content and caramelization of FOS. Analysis of variance of decrease in scores was significant at $p<0.05$

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Mouthfeel scores also decreased gradually up to 2.56% at 15g of FOS addition; however this reduction in scores was not significant.

Texture also got affected and scores dropped by 3.13% at 5g, 5.99% at 10g and 8.47% at 15g with increase in level of FOS addition.. However, the overall variance in scores for texture was not significant

This could be attributed to the oozing of fluid from stuffing and making it soggy and sticky which is contradictory to the prerequisite attributes before deep frying. Also as we attempted our trial on *Vegetable Mini Samosa's* where the layer of dough was very thin with multiple folds, this could be the reason for oozing of the liquid before and during deep frying. Assuming that if we attempted similar trial on big *Punjabi Samosa* where layer of dough is thick and has only 2 fold it would have retained liquid inside and prevented oozing before and during frying and would probably have been a successful attempt as previous three recipes.

Taste scores were almost similar to standard product. No significant variance was observed in taste scores of FOS added product from 5 – 15 g.

Aftertaste scores also dropped by 4.47% , 2.30% and 3.25% at 5g, 10g and 15g level of addition. However, no significant variance was observed in aftertaste of FOS added product from 5 – 15g.

Overall Acceptability of *Vegetable Mini Samosa* was similar to standard product up to 10g of FOS addition. Scores dropped by 5.32% at 15g of addition; however, variance in reduction of scores was not significant.

Table 5.69: Effect of varying levels of Fructooligosaccharide addition on the organoleptic quality of baked *Handwa*

Level of addition		Color & appearance	Mouth -feel	Texture	Taste	After Taste	Overall acceptability
STD Product	Mean ± SD	7.98 ± 0.95	7.45 ± 0.92 [a]	7.67 ± 0.93	7.31 ±1.02 [a]	7.21 ± 1.16 [a]	7.40 ± 0.89 [a]
	Range	5 – 9	6 – 9	5 - 9	4 – 9	4 – 9	5 – 9
10 g FOS	Mean ± SD	8.14 ± 0.93	7.93 ± 0.89 [b]	7.86 ± 0.89	7.74 ± 0.96 [ab]	7.67 ±1.00 [ab]	7.86 ± 0.93 [b]
Addition	Range	6 – 9	4 – 9	5 - 9	5 – 9	6 – 9	6 – 9
	t – test	0.81 [NS]	2.41*	0.95 [NS]	1.97 [NS]	1.91 [NS]	2.28*
	%↑ or ↓	**2.01↑**	**6.44↑**	**2.48↑**	**5.88↑**	**6.38↑**	**6.22↑**
15 g FOS	Mean ± SD	7.88 ± 1.06	7.67 ± 0.75 [a b]	7.83 ± 0.76	7.74 ± 1.06 [ab]	7.60 ±1.11 [ab]	7.64 ± 0.96 [ab]
Addition	Range	5 – 9	6 – 9	6 - 9	5 – 9	5 – 9	5 – 9
	t – test	0.43 [NS]	1.17 [NS]	0.89 [NS]	1.88 [NS]	1.54 [NS]	1.18
	%↑ or ↓	**1.25↓**	**2.95↑**	**2.09↑**	**5.88↑**	**5.41↑**	**3.24↑**
20 g FOS	Mean ± SD	8.07 ± 1.02	8.07 ± 0.75 [bc]	7.93 ± 0.89	8.05 ± 0.82 [b]	7.90 ± 0.93 [b]	7.95 ± 0.96 [b]
Addition	Range	5 – 9	7 – 9	6 – 9	6 – 9	6 – 9	6 – 9
	t-test	0.44 [NS]	3.40***	1.32 [NS]	3.64***	3.01***	2.71**
	%↑ or ↓	**1.13↑**	**8.32↑**	**3.39↑**	**10.12↑**	**9.57↑**	**7.43↑**
	F-value	**0.55**	**4.60**	**0.67**	**4.08**	**3.10**	**2.86**
	F-critical	**2.65**	**3.90**	**2.65**	**3.90**	**2.65**	**2.65**
	ANOVA	**NS**	**	**NS**	**	*	*

Mean values represent the average of 42 determinants in triplicates.
a, b- The non identical letters in any two rows within the column denote a significant difference at a minimum of $p < 0.05$; $p < 0.01$ and $p < 0.001$ level.
NS – The difference between the mean values within the columns is not significant.
Maximum score for all the organoleptic attributes was 9

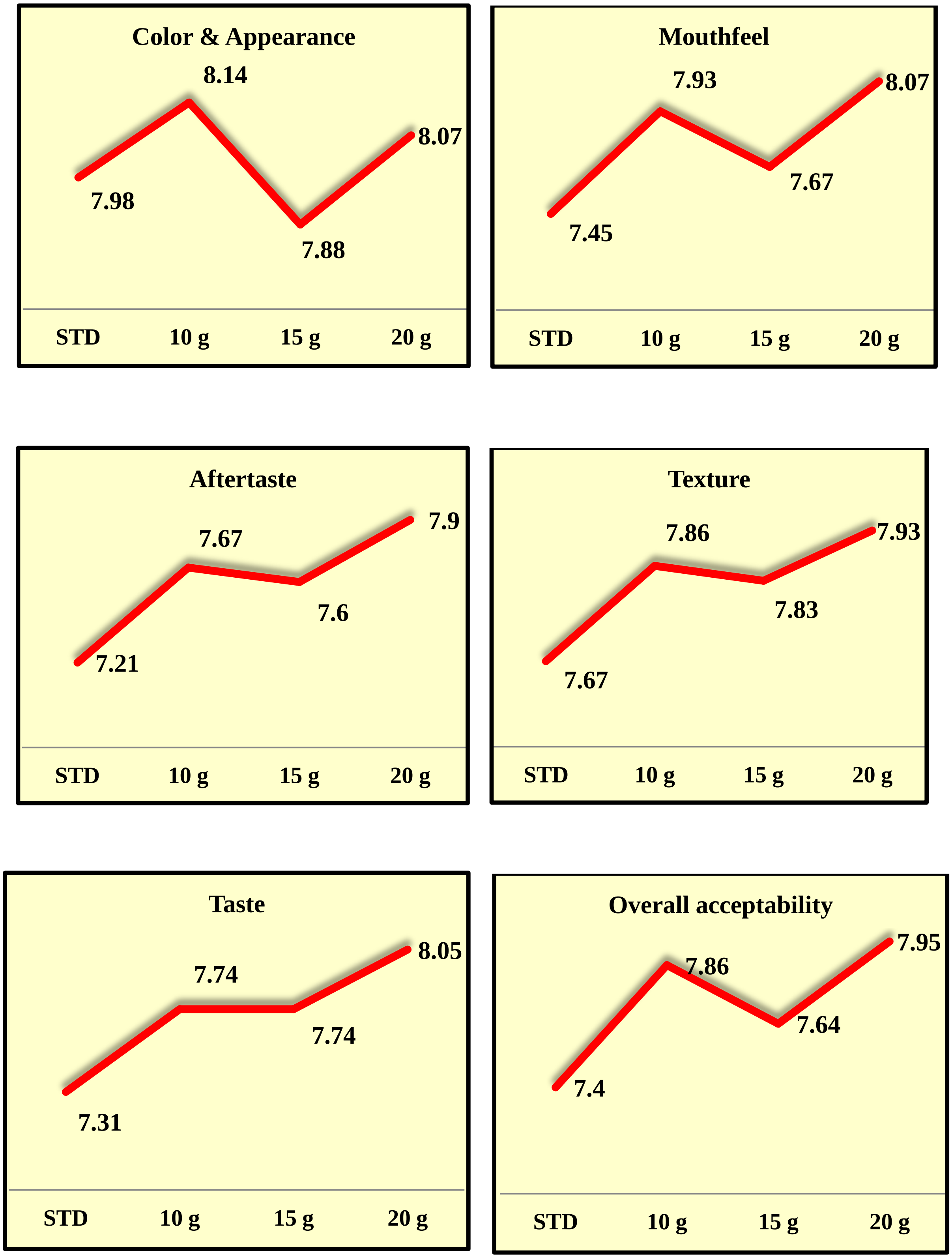

Figure 5.19: Organoleptic attributes of Baked *Handwa* at varying levels of FOS addition

Table 5.70: Effect of varying levels of Fructooligosaccharide addition on the organoleptic quality of deep fried *Vegetable Samosa*

Level of addition		Color & appearance	Mouth -feel	Texture	Taste	After taste	Overall acceptability
STD Product	Mean ± SD	7.93 ± 0.89 [a]	7.43 ± 1.02	7.67 ± 0.98 [a]	7.48 ±1.09	7.38 ±1.15	7.52 ± 0.99
	Range	6 - 9	6 - 9	6 - 9	5 – 9	5 – 9	6 – 9
05 g FOS Addition	Mean ± SD	7.81 ± 0.74 [a]	7.14 ± 1.03	7.43 ± 1.15 [a]	7.24 ± 1.01	7.05 ± 1.17	7.24 ± 0.93
	Range	6 - 9	4 - 9	5 - 9	4 – 9	4 – 9	5 – 9
	t - test	0.66 [NS]	1.28 [NS]	1.02 [NS]	1.04 [NS]	1.32 [NS]	1.36 [NS]
	%↑ or ↓	**1.52↓**	**3.90↓**	**3.13↓**	**3.21↓**	**4.47↓**	**3.72↓**
10 g FOS Addition	Mean ± SD	7.79 ± 0.87 [a]	7.26 ± 1.01	7.21 ± 1.05 [b]	7.4 ± 1.01	7.21 ± 1.14	7.45 ± 0.83
	Range	5 – 9	4 – 9	4 - 9	5 – 9	4 – 9	6 – 9
	t – test	0.74 [NS]	0.75 [NS]	2.04*	0.31 [NS]	0.67 [NS]	0.36 [NS]
	%↑ or ↓	**1.79↓**	**2.28↓**	**5.99↓**	**1.07↓**	**2.30↓**	**0.94↓**
15 g FOS Addition	Mean ± SD	7.31 ± 1.28 [b]	7.24 ± 1.14	7.02 ± 1.2 [c]	7.4 ± 1.25	7.14 ± 1.22	7.12 ± 1.29
	Range	4 – 9	5 - 9	5 - 9	5 – 9	4 – 9	4 – 9
	t-test	2.57*	0.81 [NS]	2.69**	0.28 [NS]	0.92 [NS]	1.61 [NS]
	%↑ or ↓	**8.49↓**	**2.56↓**	**8.47↓**	**1.07↓**	**3.25↓**	**5.32↓**
	F-value	**3.35**	**0.54**	**2.67**	**0.36**	**0.61**	**1.40**
	F-critical	**2.66**	**2.66**	**2.66**	**2.66**	**2.66**	**2.66**
	ANOVA	*****	**NS**	**NS**	**NS**	**NS**	**NS**

Mean values represent the average of 42 determinants in triplicates.
a, b- The non identical letters in any two rows within the column denote a significant difference at a minimum of $p < 0.05$; $p < 0.01$ and $p < 0.001$ level.
NS – The difference between the mean values within the columns is not significant.
Maximum score for all the organoleptic attributes was 9

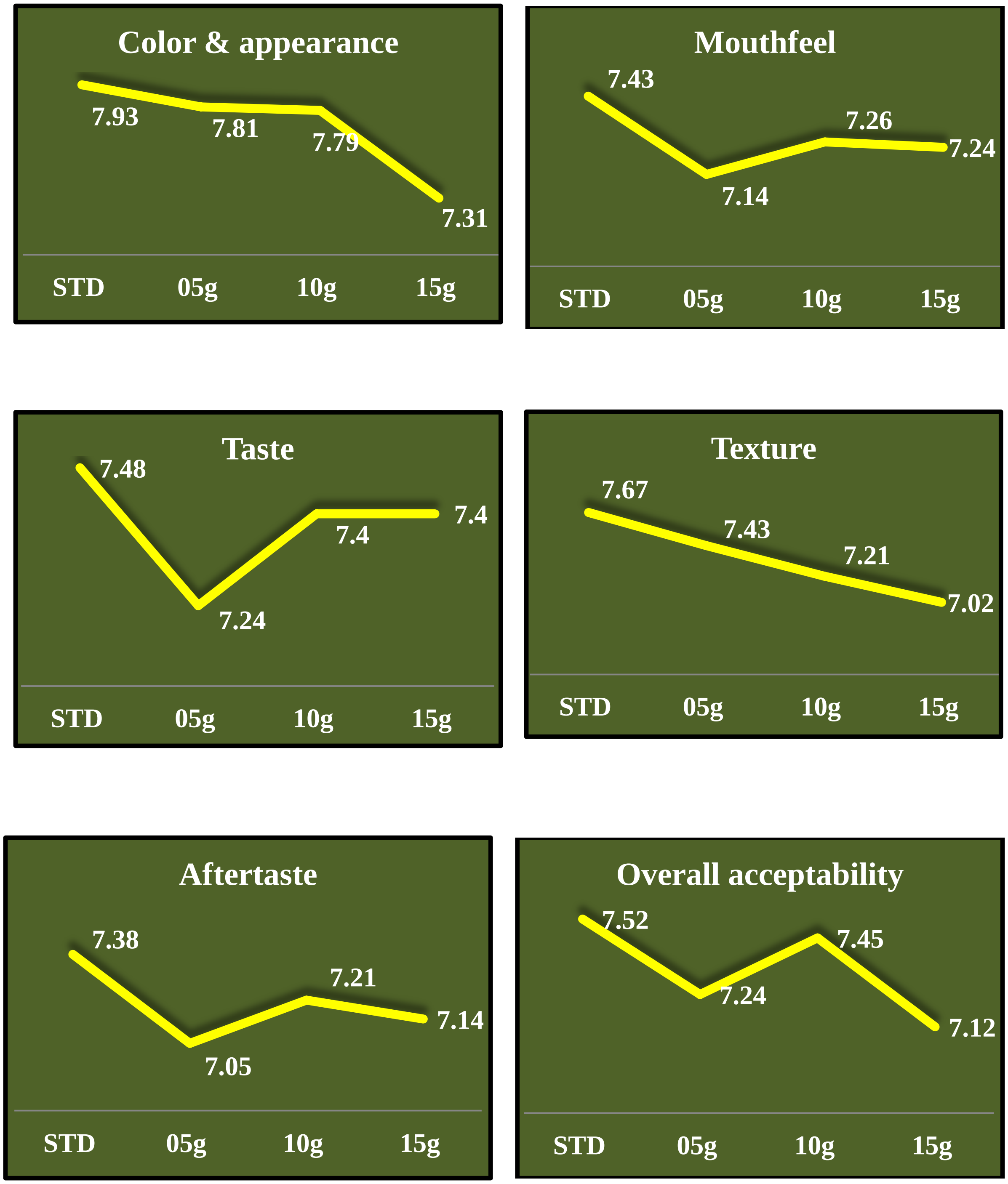

Figure 5.20: Organoleptic attributes of deep fried *Vegetable Samosa* at varying levels of FOS addition

RESULT HIGHLIGHTS

PHYSICAL ATTRIBUTES

20g FOS ADDITION

- ***Dudhi Muthiya***

  WAP % reduced by 50 %
  Moisture loss was observed by 15.67 %
  Highest percent yield of 18.22 %
  Highest increase in bulk density of 0.86g/cc

- ***Vegetable Cheela***

  WAP % reduced by 25 %
  Moisture loss - Nil
  Highest percent yield of 12.10 %
  Highest increase in bulk density of 0.81 g/cc
  Spread ratio reduced by 25%

15g FOS ADDITION

- ***Handwa***

  WAP % reduced by 25 %
  Moisture loss was observed by 8.95%
  Highest percent yield of 4.96 %
  Highest increase in bulk density of 0.91 g/cc

- ***Vegetable Mini Samosa***

  Moisture retention was highest 21.03%
  Highest percent yield of 4.96%
  Highest increase in bulk density of 1.19 g/cc

RESULT HIGHLIGHTS

ORGANOLEPTIC EVALUATION

- ***Dudhi Muthiya*** **(p<0.001)**

  Significant improvement was observed in all attributes 20g of FOS addition.

Taste	**16.64%**
Aftertaste	**15.02%**

- ***Vegetable Cheela*** **(20g , p<0.001)**

  Significant improvement in

Taste	**18.44%**
Aftertaste	**16.17%**
Mouthfeel	**11.18%**
Texture	**6.48%**
Overall	**12.81%**

- ***Handwa*** **(p<0.01)**

  Significant increase in most of the attributes was observed at highest level [20g] of FOS addition except *Color & Appearance* and *Texture*.

- ***Vegetable Mini Samosa*** **(NS)**

  There was reduction in scores but no significant difference was observed in most of the sensory attributes up to 10g of FOS addition in *Vegetable Mini Samosa* as compared to standard product

DISCUSSION

A potential prebiotic candidate that can enhance satiety along with retaining positive organoleptice and bifidogenic properties which can foster incorporation into various recipes is Fructooligofructose (FOS) [Boulangé et al., 2016; Van Hoffen et al., 2008; Cani et.al., 2006; Daddaoua, 2006; Delzenne et.al., 2001). Obesity primarily being a state of energy imbalance, it becomes sort of mandatory to develop "designer novel foods" that can dilute the energy density of foods without compromising on the sensory and organoleptic attributes and in addition promotes satiety. Eventually, these "designer foods" would provide first line of defense in maintaining energy homeostasis (Franck 2008; Valéria Maria Caselato de Sousa et al. 2011; Amar et.al 2008).

Aim of this phase of study was to assess physical attributes and organoleptic evaluation of FOS added popular Indian products at varying levels namely *Dudhi Muthiya, Vegetable Cheela*, *Handwa* and *Vegetable Mini Samosa.*

In steamed *Dudhi Muthiya* and shallow fried *Vegetable Cheela*, FOS could be successfully added up to 20g level of addition. However, in baked *Handwa* and deep fried *Vegetable Mini Samosa* it could be added up to 15g and 10g level of addition

Physical evaluation of *Dudhi Muthiya, Vegetable Cheela, Handwa* and *Vegetable Mini Samosa* revealed increase in the stickiness of the dough and thinness of batter respectively as per the recipe. Stickiness is particularly an undesirable property in good quality dough. A number of studies have looked at the rheological properties of dough prepared with FOS or inulin and similar results have been observed (Cecile Morris & Gordon Morris, 2012). This can be attributed to the humectants properties of FOS that has solubility of 80% in water at room temperature, sweetness of about 35% in comparison with sucrose (Franck, 2008). FOS is very hygroscopic in nature and with the increase in the degree of polymerization, the water holding capacity of sugars also increases (Hager, 2011).

Water absorption power (WAP %) decreased with the increase in the addition level of FOS in dough of *Dudhi Muthiya*, *in* batter of *Handwa* and *Vegetable Cheela*. Reduction in the WAP (%) has been observed in several studies with prebiotic dietary fibers (Mahendra & Sheth, 2013; Parnami & Sheth, 2010). In a recent study there was a reduction in WAP (%) by 32% in the dough of *Chapatti* and *Thepla* and for steamed products like *Dhokla* and *Patra* it reduced by 30 % and 18.8% respectively 23. Other studies also revealed reduction in WAP (%) with the increase in addition of up to 7.5 % of inulin. Reduction in WAP (%) was more pronounced for the shorter chain inulin which was explained by a lubricating effect of the sugars and oligosaccharides present in inulin. (Hager, 2011; Parnami & Sheth, 2010).

Increase in the yield of cooked weight and bulk density of *Dudhi Muthiya, Vegetable Cheela, Handwa* and *Vegetable Mini Samosa* was also observed. This could be attributed to FOS being a soluble fibre and having high solubility of 80 % at room temperature, which helps in retaining moisture and reducing moisture loss. Incorporation of FOS is an ideal ingredient for increasing bulk properties of the product and requires only minor adaptation of the production process, if any (Guggisberg, Piccinali, & Schreier, 2011). Increase in bulk density of FOS added products have been observed in many studies. This could be attributed to FOS being a soluble fibre and having high solubility of 80 % at room temperature, which helps in retaining moisture and reducing moisture loss. Incorporation of FOS is an ideal ingredient for increasing bulk properties of the product and requires only minor adaptation of the production process, if any (Guggisberg, Piccinali, & Schreier, 2011; Wang et al., 2002; Crittenden & Playne, 1996).

Organoleptic evaluation revealed increase in scores of all attributes of the *Dudhi muthiya* at 10, 15g and 20g of FOS addition except scores for *texture* that improved only at 20g of FOS addition. However, the variance in mean scores was statistically significant only for *taste and after-taste* ($p<0.001$ and $p<0.01$ respectively). Significant ($p<0.001$) improvement was observed in *taste* by 16.64% *and after-taste* by 15.02% at 20g addition of FOS as compared to standard product.

In *Vegetable Cheela*, Significant increase ($p<0.001$) of 18.44% was observed in *taste*, 16.17% in *aftertaste,* 11.18% in *mouthfeel* ($p<0.01$) and 6.48% in *texture* was observed at the highest level of FOS addition of 20g. *Overall acceptabilit*y of *Vegetable Cheela* was 12.81% significantly higher ($p<0.001$) as compared to the standard product. Analysis of variance in mean scores was statistically significant for *mouthfeel* ($p<0.05$), *taste* ($p<0.001$), *aftertaste* ($p<0.01$) and *overall acceptability* ($p<0.05$).

Sensory evaluation of *Handwa* depicted Significant increase ($p<0.01$) in most of the attributes was observed at highest level (20g) of FOS addition except *color and appearance* and *texture*. Significant increase of 10.12% ($p<0.001$) was observed in *taste*, followed by 9.57% ($p<0.01$) in *aftertaste* and 8.32% in *mouthfeel* ($p<0.01$). Also, increase in mean scores of *texture* by 3.39% and *colour and appearance* by 1.13% was observed as compared to standard *Handwa.*

Vegetable Mini Samosa depicted reduction in scores but no significant difference was observed in most of the sensory attributes up to 10g of FOS addition in *Vegetable Mini Samosa* as compared to standard product. However, at 15g of FOS addition *Vegetable Mini Samosa* were not acceptable.

Similar results were observed in a study conducted by Mahendra and Sheth (2013) for steamed *dhokla and patra* at the highest level (10 g) of FOS substitution where *texture* scores were reduced by 3.75 % in *dhokla* due to increase in hardness and decrease in cell size leading to sponginess in *dhokla*. As FOS contributes to the sweetness, it blended very well with the *taste* and *aftertaste* attribute of *Dudhi Muthiya, Cheela* and *Handwa.*

Addition of sugar in the staple food is a common trend in Gujarat region and the recipe of ideal *Dudhi Muthiya* is little sweet in taste. 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. (Franck, 2008; Mahendra & Sheth, 2013; Gonzalez, Adhikari & Sancho-Madriz, 2011).

However, as the level of FOS addition increased it contributed to the browning on the surface of *Dudhi Muthiya* and *Handwa* and burn spots on *Vegetable Cheela and Vegetable Mini Samosa,* which could be related to non-enzymatic maillard reaction and caramelization of sugars. In *Vegetable Mini Samosa*, *Texture* also got affected and scores dropped by 3.13% at 5g, 5.99% at 10g and 8.47% at 15g with increase in level of FOS addition. This could be attributed to the oozing of fluid from stuffing and making it soggy and sticky which is contradictory to the prerequisite attributes before deep frying. Also as we attempted our trial on *Vegetable Mini Samosa* where the layer of dough was very thin with multiple folds, this could be the reason for oozing of the liquid before and during deep frying. Assuming that if we attempted similar trial on big *Punjabi Samosa* where layer of dough is thick and has only 2 fold it would have retained liquid inside and prevented oozing before and during frying and would probably have been a successful attempt as previous three recipes.

Similar results were also observed for *chapatti* and *thepla* at the highest level of 10 g FOS addition in a recent study (Mahendra & Sheth, 2013). With addition of inulin at the lowest level of 2.5 %, darker curst colour was reported. (Hager et al 2011). Increase in burn spots and darker colour of FOS / Inulin enriched products have been explained by a greater number of reducing ends involved in a maillard reaction. Shorter chain inulin thus results in even darker colour as it possesses lower molecular weight fructans (Poinot et al., 2010).

Various FOS based products like beverage concentrates, spreads and honey have been studied successfully and their processes have been patented (Renuka et al., 2009; Ramesh et al., 2004). FOS added soups and beverages namely butter milk, lemon juice, milk and tomato soup have also been studied and were highly acceptable at 7.5% level of addition (Gupta & Sheth, 2011).

In a recent study on coconut cookies where FOS was added at 6 different levels of 0% (Standard), 10%, 12.5%, 15%, 17.5% and 20%. Coconut cookies showed good acceptability at all lower levels up to 15% showing no statistical difference amongst them. However, cookies were highly acceptable at specific 15% level of addition along with improvement in physic-chemical composition in response to higher fiber concentration and lower moisture ($p<0.05$) as compared to standard coconut cookies (Stadler et al., 2017).

However, consumers today not only expect food products to satisfy hunger and provide nutrients but also, they demand fabricated food which can prevent and/or manage nutrition-related diseases and enhance physical and mental well-being. Hence, FOS is promising prebiotic dietary fibres that can be added into the staple diet and enhance the organoleptic attributes of the products along with established range of health benefits.

Conclusion

- ***Feasibility of Fructooligosaccharide addition was possible up to 20g in steamed, baked and shallow fried product.***
- ***Feasibility in Deep fired product was up to 10g.***
- ***FOS addition to base product increased percent yield and bulk density of all four products ranging from 4% - 18%.***
- ***Vegetable Cheela was the most appreciated product in terms of enhanced sensory attributes at 20g FOS addition, followed by Handwa and Dudhi Muthiya.***
- ***Vegetable Mini Samosa was rated similar to standard product at 10g FOS addition. Addition of FOS at higher levels >10g was not possible due to technological functionalities and calls for modification in recipe.***