CHAPTER 1
INTRODUCTION

Non-communicable diseases or NCD's are those conditions that are usually not passed on from one affected person to another, but are caused as a direct result of inheritance, lifestyle and environmental factors. An alarming manner has been seen in the last decade in the unfailing rise in NCDs on a global level.

NCDs unaccountably affect low and middle income countries where nearly three quarters of NCD deaths (approx. 28 million deaths) occur. The amendable behavioral risk factors include tobacco consumption, physical inactivity, unhealthy diet and excessive intake of alcohol. (World Health Organization, 2016). Approximately 3.2 million deaths can be attributed to insufficient physical activity per year, followed by elevated blood pressure (18% of global deaths) and by overweight and obesity and raised blood glucose.(Lim et al., 2012).

Obesity is one of the most pervasive and a major contributor to the global load of chronic disease and disability. Often coexisting with under-nutrition, it is a multifaceted condition, with serious social and psychological magnitude, affecting virtually all ages and socio-economic group.

Obesity advances the odds of diabetes, hypertension, coronary heart disease and stroke, certain cancers, obstructive sleep apnea and osteoarthritis. (WHO, 2014). Overweight and obesity were anticipated for 3.4 million deaths per year and 93.6 million DALY's (Disability-adjusted life years) in 2010 (Lim et al., 2012).

Obesity outbreak has reached to an extent globally, with more than 1.9 billion adults overweight and at least 600 million of them clinically obese in 2014. 39% of adults aged 18 years and over (38% of men and 40% of women) were overweight and about 13% of the world's adult population (11% of men and 15% of women) were obese in the year 2014. The worldwide prevalence of

obesity has doubled between 1980 and 2014. Previously overweight and obesity was disease of high-income group country, but is now get higher in low and middle-income group countries, particularly in urban settings (World Health Organisation, 2016).

Obesity is escalating swiftly in India. According to the National Family Health Survey 4 (NFHS-4), the percentage of women aged 15-49 years who are overweight or obese increased from 12.6% in NFHS- 3 to 20.7% in NFHS-4 and the percentage of men aged 15-49 years who are overweight or obese increased from 9.3% in NFHS- 3 to 18.6% in NFHS-4. In urban settings 26.3 % men and 31.3% of women were obese stated NHFS-4 (MOHFW, 2016). This may be due to lesser physical activity in the urban areas. Furthermore, overweight and obesity are both higher for women than men.

Earlier India was known for malnutrition but now Indians report more frequently with overweight, obesity and their consequences. Prevalence deviates within the country because of divergence in the lifestyle, mainly in prosperity, dietary patterns, and physical activity. In addition to this urbanization and industrialization are the main culprits for the increase in the prevalence of obesity.

The prevalence of overweight or obese in women is highest in Chandigarh (41.5%), followed by Delhi (34.9%), Kerala (32.4%) and Punjab (31.3%), all of which are relatively richer states (MOHFW, 2016). The prevalence of underweight and overweight among men shows similar variations by age, education, and prosperity index.

The prevalence of overweight and obesity in Gujarat in women aged 15-49 years was 34.5% in urban area and 15.4% in rural area. For men prevalence was 25.9% in urban area and 14.4% for rural area. Overall prevalence of overweight and obesity was 34.5% for women and 25.9% for men in Gujarat in the year 2015-2016 (MOHFW, 2016).

The amplification in overweight and obesity cases is a global problem on many levels, and we can only expect it to escalate. With more and more people getting affected by obesity, our global efficiency is also getting smack.

Globalization puts junk food and fast food within easy reach of a population who often are short of time to cook healthy meals, but with more than enough money to buy a greasy lunch at a nearby restaurant. In India, these factors have contributed to the rise of poor eating habits and lack of exercise amongst a growing urban middle class, and their effects are remarkably visible.

Overweight/obesity may not be considered as a specific disease but it is certainly the mother of important degenerative diseases of adult life. Prevention and control of this problem is must, therefore, claim priority attention.

In recent years, there has been increasing interest in the imperative nutritional roles of prebiotics as functional food ingredient. Several dietary fibers are often cited as being of particular interest with regard to their putative role in the management of obesity and metabolic disorders because they affect food intake, body weight, glucose homeostasis, plasma lipid profile, gut flora and LPS which are all associated risk factors for obesity, diabetes and cardiovascular diseases. A number of recent studies provide novel insight that might help establish a link between dietary non digestible carbohydrate that changes the composition of gut microbiota, obesity and insulin resistance (M. K. Sheth & Gupta, 2014). These compounds are called prebiotics because they promote growth of certain bacteria in the gut (eg. bifidobacteria and lactobacilli), whose number correlates with a contraction of obesity and several features of metabolic syndrome. Among all the natural prebiotics, Fructooligosaccharide (FOS) or Oligofructose is currently endorsed as promoting the growth of healthy intestinal bacteria. As a result FOS as a food ingredient has prompted much research on their possible health effects in managing obesity, lowering glycemic index and blood cholesterol, modulating gut flora and lowering endotoxemia.

A study in a rodent model demonstrated that obesity can be associated with an altered gut microbiota (Ley et al., 2005). Animal and human data have suggested that the specific colonization of gut microflora may be a vital agent of the risk of obesity (Delzenne and Cani, 2011). Several studies reported that the gut microbiota disagrees at phylum level depending upon the weight status of an individual (Eckburg et al., 2005, Turnbaugh et al., 2006). Inulin type fructans effective in humans and animal models and stimulate the growth of health promoting species belonging to *bifidobacteria* and *lactobacillus* (Flamm, Glinsmann, Kritchevsky, Prosky, and Roberfroid, 2001, Macfarlane, Macfarlane, and Cummings, 2006).

Fructooligosaccharide (FOS) is a prebiotic dietary fiber is an inulin type fructans with relatively short chains (degree of polymerization 2-4). It is linear polymer consisting of fructose monomers linked to each other by β-(2-1) bonds. These bonds are resistant to mammalian digestive enzymes and extreme pH levels which is found in human gastrointestinal tract. Therefore, it escapes hydrolysis in the upper intestine and reaches the colon intact, where it is selectively fermented by indigenous bacteria (Gibson et al., 2010).

Prebiotic dietary fibers (oligofructose, OFS) were known to exclusively amplify the gut bifidobacteria content in high-fat fed mice. Studies confirmed that mice fed a high-fat diet exhibit a higher endotoxemia, a phenomenon completely abolished through dietary supplementation with the prebiotic dietary fibers (Al-Disi et al., 2015, Sun et al., 2010). Cani et al (2007) reported that in prebiotic treated-mice, bifidobacterium-spp. significantly and positively correlated with improved glucose-tolerance, glucose- induced insulin-secretion, and normalized low-grade inflammation (decreased endotoxemia, plasma and adipose tissue pro-inflammatory cytokines). Scientists also found that metabolic endotoxemia correlated negatively with Bifidobacterium spp. (Patrice D. Cani et al., 2007). Another study reported that supplementation with liquid FOS (10ml) for 45 days is an attractive strategy for the management of type 2 diabetic subjects which resulted in

reduction in the blood glucose (FBS, PP2BS and HbA1c), blood lipid (TG, TC, LDL, VLDL), and hs-CRP levels, increase in HDL (M Sheth and A Thakuria, 2015).

Bacterial lipopolysaccharide (LPS, also termed endotoxin) released from dead Gram-negative bacteria in the gut and under conditions of gut damage can displace into the circulation (or as can whole bacteria) where it activates an inflammatory response (Ulevitch, 1999).

Studies showed that metabolic concentrations of plasma LPS are modulated by food content, higher the fat food content, higher the concentration of plasma LPS. Studies also reported that the metabolic concentration of plasma LPS is a sufficient molecular mechanism for triggering the high-fat diet–induced metabolic diseases such as obesity and diabetes (Amar et al., 2008).

Taken collectively, these human studies provide evidence that the gut microbiota can be modulated by using prebiotics which affects energy homeostasis, circulating LPS levels and body weight. However, few data about the putative mechanisms involved in these effects are provided.

In the search to determine the role of prebiotics in the control of body weight and fat mass development, a study showed that supplementation with a prebiotic had a significant benefit for the maintenance of an appropriate body mass index and fat mass in primarily non-obese young adolescents, in addition to its benefit in bone mineralization (van den Heuvel, Muijs, Brouns, and Hendriks, 2009).

Many studies have shown lipid lowering effects of fructooligosaccharide (FOS). Because FOS is not hydrolyzed by enzymes in the small intestine of humans, so reach the colon unharmed where they are fermented by the colonic microflora (Alles et al., 1996). End products of this fermentation are some gases and short chain fatty acids such as acetate, propionate and butyrate. These SCFA's are absorbed by the colonic mucosa. It is known that butyrate act as an energy substrate for the mucosa and, whereas acetate and

propionate enter the portal blood and may influence systemic carbohydrate and lipid metabolism (Cummings, Pomare, Branch, Naylor, and Macfarlane, 1987).

In addition to these benefits of FOS, a study demonstrated that in healthy humans, feeding of 16g/day FOS promoted satiety followed after breakfast and dinner and reduced hunger after dinner. This was accompanied by a significant 10% lower total energy intake (P D Cani, Joly, Horsmans, and Delzenne, 2006).

Another study has found that prebiotic supplementation was associated with reduced appetite sensation after a meal (P. D Cani et al., 2009). Studies suggested that prebiotics in the diet may reduce energy and food intake, increase satiety, reduce hunger and appetite and reduce total daily calorie intakes. Prebiotics may also have positive effects on blood sugar balance in the body which can also impact appetite (DiBaise et al., 2008). Prebiotic supplements affected the hormones associated with satiety. Prebiotic treatment was associated with a threefold reduction in hunger rates and an increase in hormones which are associated with feelings of satiety/fullness (P. D Cani et al., 2009).

FOS has been studied for its organoleptic properties and it has been widely used as sugar and fat replacer. According to FAO-WHO (2001), FOS is regarded as safe when consumed up to 20 g (FAO-WHO, 2001). For nutrition labeling purposes, Roberfroid (1999) recommends that inulin and oligofructose, as well as all non-digestible oligosaccharides that are mostly fermented in the colon (Roberfroid, 1999), be assigned a caloric value of 1.5 kcal/g (6.3 kJ/g), which is very low in calorie and hence, provide an attractive agent for obese subjects.

Nonetheless, progress in understanding the mechanisms by which the gut microbiota interact with the host will provide new basis for putative nutraceutical or dietary intervention. Moreover, the tremendous lack of data limits our current knowledge of the concreteness of gut microbiota-host

interactions and proposal of exact mechanisms linking dietary habits, gut microbiota and metabolic disorders. Multidisciplinary research in this field will be helpful to provide evidence-based data, which will be taken into account to consider the gut microbiota as a putative target to prevent metabolic disorders including obesity.

Hence, this study was designed with the following hypothesis that

"Sensory evaluation of fructooligosaccharide (FOS) added popular recipes of India and its role in modulating anthropometric indices, gut flora and lipopolysaccharide (LPS) in obese young adults of urban Vadodara". The study was undertaken in the following four phases:

Phase I Development and standardisation of FOS incorporated popular recipes of India and studying their various organoleptic attributes and overall acceptability.

Phase II Situational analysis: mapping the prevalence of various grades of obesity in banks employees of urban Vadodara (A cross-sectional design).

Phase III Comparison of grade-I obese subjects with non-obese subjects in terms of anthropometry profile, medical history, family history of diseases, defecation profile, hunger and satiety, psychological depression status, dependency on habits, dietary intakes, biophysical profile, atherogenic profile, endotoxemia and gut microbiota (*LAB, bifidobacteria, bacteroides and clostridium*) and understand the correlations amongst various parameters.

Phase IV Effect of fructooligosaccharide (FOS) supplementation on anthropometry, defecation, hunger and satiety, depression, dietary, lipemic parameters, LPS and gut microflora in obese grade-I adults.