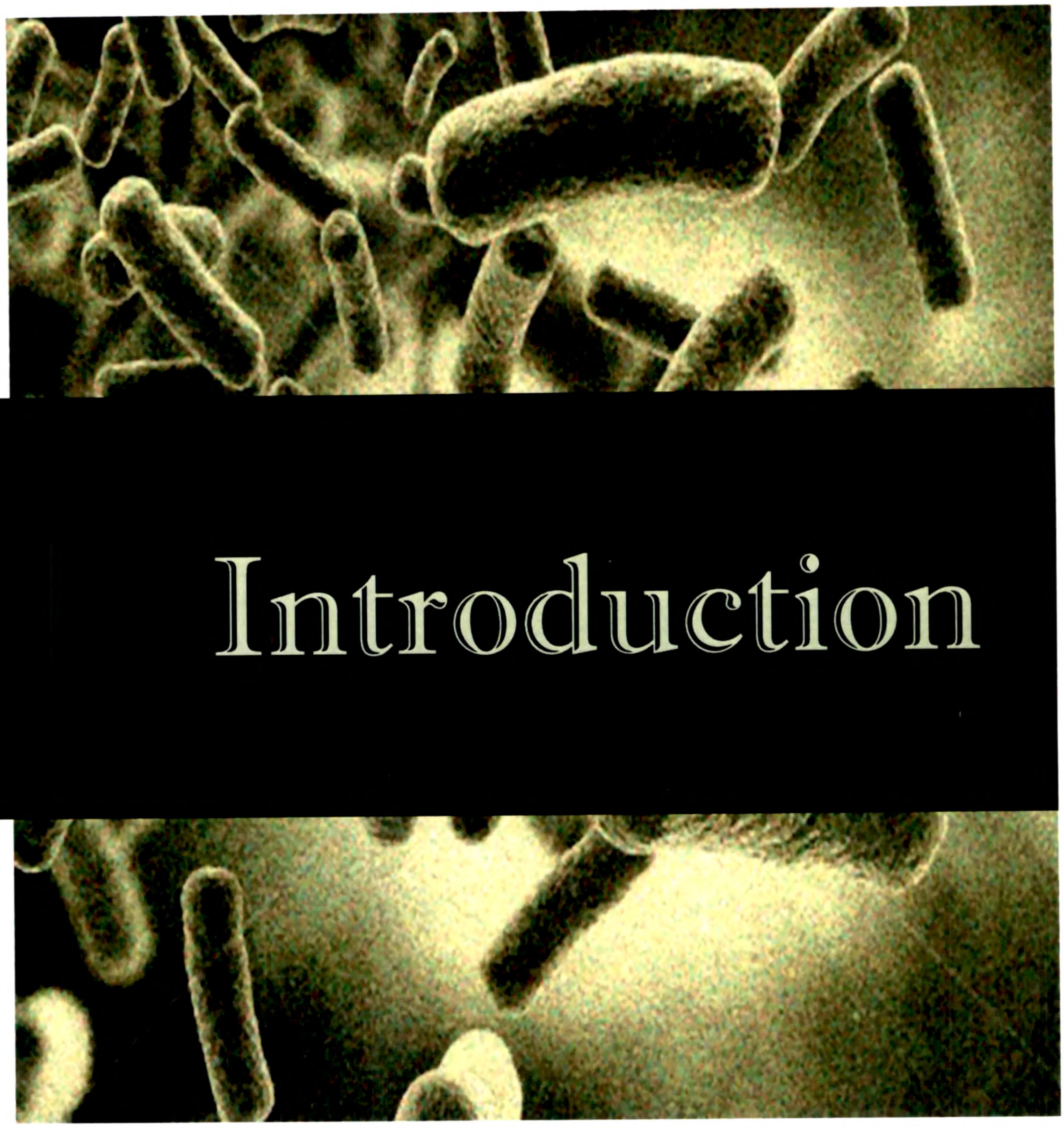

Introduction

CHAPTER 1
INTRODUCTION

Expeditious changes in diets and lifestyles that have occurred with industrialization, urbanization, economic development and market globalization, have accelerated over the past decade. The result of these changes is that Non-Communicable Diseases are increasing at alarming rates globally. The burden of NCDs in developing countries already outweighs that of communicable diseases, both in countries with high and low mortality (WHO 2004). Globally, 36 million people are being killed by these NCDs daily (WHO 2011).

Among these NCDs, we are facing a global threat from the spectacular rise in the global prevalence of Type 2 Diabetes and its consequences. Type 2 diabetes epidemic is one of the most obvious disease manifestation of a massive social and public health problem. According to recent estimates, more than 371 million people have diabetes worldwide, out of which India leads the second highest position in the diabetic race with 63 million people suffering from diabetes (IDF 2012). Half of the people who are dying from diabetes are under the age of 60 in the developing countries like India, in contrast to the western countries where percent deaths from diabetes are majorly accountable to older group people (IDF 2012). The rapid rise in diabetes and its complications leads to an increased fractions of economic burden to the society especially in the developing countries. Globally there is 30% acceleration in the health care expenditure for treating diabetes and its associated complications.

There is well-established body of evidences from India, that more than a half century of individuals with diabetes have poor glycemic control (HbA_{1c}>8%), dyslipidemia, uncontrolled hypertension and long term micro and macro vascular complications of diabetes.

Unfortunately, most nations are poorly prepared to tackle this epidemic effectively. Governments remain largely unaware of, or are complacent about, the existing magnitude of the Diabetes challenge. Failure to act now will cripple the coming future of the upcoming generations. Therefore, to enhance the overall status of diabetes, diabetic care strategies becomes a major concern for health care professionals in today's scenario.

Several lines of treatment suggests that to combat the pandemic of type 2 diabetes, the upcoming strategies are primarily targeting on novel therapeutic food approaches which are proficient in persuasively handling diabetes and its long term complications. Neutraceutical avenues both at research level as well as at market level are marking their foot prints behind in dealing with type 2 diabetes and its related complications. Out of these challenging neutraceutical advancements, literature has drawn attention to Probiotics and Prebiotics as a bridge in mitigating the herculean burden of Diabetes (Voss et al 2008; Moroti et al 2012).

Probiotics are "Living micro-organisms which when administered in adequate amount conferring health benefits of the host" (FAO/WHO 2002). Over the years, it has become clear that the gut microbiota is closely linked with health. Prebiotics can be defined as non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth and/or activity of one or limited number of bacteria that can improve the host health.

The current knowledge regarding advantages of probiotics and prebiotics has attracted many researchers to manufacture designer foods that will enhance the friendly bacterias in the gut and hence deliver many health benefits (Bruno and Shah 2004; Santos BAD 2012).

The new insights of combating diseases with the use of one of the prebiotics-Fructooligosaccharide (FOS) open up new perspectives for the production and application of oilgofructose preparations. Present day consumers are more health conscious and desire to have food products which exhibit beneficial health effects (Gibson GR and Delzenne N 2008). Oligofructose is naturally found in significant amounts in edible fruits and vegetables like banana, onion, garlic, artichoke etc. Using this ingredient in food formulations allows the nutritional value of the end product to be improved by increasing the dietary fibre content, reducing the calorie content and increasing the *bifidus*-promoting capacities. As more and more scientific data become available, the nutritional benefits of oligofructose became further apparent (Roberfroid et al 1998, Roberfroid and Delzenne 1998). This ingredients offer a unique combination of nutritional and technological advantages. Therefore it is often taken as practical illustrations of active food ingredient for functional foods. However, because of their specific fermentative properties, inulin-type fructans do have characteristic features different from those of other dietary fibers.

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 upto 20 g. 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, 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 diabetic subjects.

Fat replacement by oligofructose and inulin is successfully applied in most water-based foods such as dairy products, frozen desserts, dressings, table spreads, sauces, soups and even meat products, but not in dry foods such snacks, bakery and confectionery products (Murphy, 2001). Typically, 1 g of fat can be replaced by a 0.35 g of FOS or inulin in most foods (Coussement 1999). Oligofructose delivers some functional properties similar to glucose syrup and is often used to replace sugar in various foods, mainly dairy and bakery products such as chocolate filling biscuits, chewing gums, confectionary, dairy desserts, and ice-cream (Franck 2000).

In addition, oligofructose depresses the freezing point of frozen desserts and acts as a binder in nutrition bars, in much the same way as sugar. Preparation of gluten free bread with combination of inulin, oligosaccharide syrup and bitter free chicory flour with 3%, 5% and 8% additions exhibited best effects on sensory features with medium level of 5% incorporation (Korus J et al 2008).

However, there is scarcity of Indian food products of Gujarat region prepared from fructooligosaccharides in the market which are consumed on day to day lives. Therefore, first phase of the study was taken up to study the acceptability and recovery of FOS incorporated food products such as *chapati, thepla, dhokla* and *patra*.

Moreover, research surrounding probiotics and prebiotics has focused more on digestive health. However, recent research has shown that probiotics play a role in metabolic disorders such as obesity, diabetes, cardiovascular diseases etc. (Delzenne NM 2002; Mcflarane 2006; Cani PD 2007; Ooi and Liong 2010). A balanced intestinal flora is a precondition for a fairly stable ecosystem. Research has shown beneficial bacteria, particularly *Bifidobacteria* and *Lactobacilli* keep these potential disease-causing organisms under control, preventing several disease-related dysfunctions related to an imbalances GI situation (Elmer GW et al 1996).

Fructooligosaccharide (FOS) has also been recently recognized a potential prebiotic which is emerging as an important factor in the bacterial ecology of human health (Vuyst de Luk and Leory F 2011; Mendlik K et al 2012). FOS 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 extremes of pH found in the human gastrointestinal tract. Therefore, oligofructose escape hydrolysis in the upper intestine and reach the colon intact, where they are selectively fermented by indigenous bacteria which results in the end products like methane, hydrogen bicarbonates and short chain fatty acids (SCFA) including acetate, propionate and butyrate (Gibson GR and Delzenne NM 2008).

SCFA contribute to the normal large bowel function and prevent pathology through actions in the lumen and on the colonic musculature and vasculature through their metabolism by colonocytes. FOS lowers the glycemic responses by increasing the secretion of gastric inhibitory polypeptide (GIP) and glucagon like polypeptide (GLP-1) a secretagogue that stimulates the release in insulin. These modifications of gut microflora *via* SCFA through ingestion of FOS have been associated with reduced glycemic and lipemic responses (Cani PD et al 2005; Cicek et al 2009).

A study investigated on effect of FOS on post prandial insulin on veal calves revealed an increase in insulin levels after supplementation of 10g/d FOS for 3 weeks (Kaufhold J et al 2001). Voss et al (2008) evaluated the postprandial glycemic, insulinemic, and GLP-1 responses of 48 individuals with type 2 diabetes, after the consumption of 10.7 g tube feed formula consisted of FOS a significant reduction in post prandial blood glucose and an increment in plasma insulin and GLP-1 levels was witnessed. Studies have also shown significant serum TG and TC reduction in hypercholesterolemic and hyperlipidemic subjects, consuming 20 g inulin and OFS (Jackson KG et al 1999, Causey JL et al 2000). Therefore, FOS may have favorable advantages in treating diabetic and hyperlipidemic patients.

Apart from these health benefits, FOS has more additional benefits like increasing mineral absorption, lowering colonic pH, preventing constipation, decreased production of mutagenic and toxic compounds, obesity etc.

Consequently, progress in understanding the mechanisms by which the gut microbiota interact with host after consumption of FOS will provide new basis for putative ground. Moreover, the tremendous lack of data restricts the current knowledge of the complexity between gut, host and metabolic alterations.

Thus present study entitled "**Acceptability trials of fructooligosaccharide (FOS) substituted food products and impact evaluation of FOS supplementation in type 2 diabetic adults in terms of their glycemia, gut incretin (GLP-1) and gut microbiota**" was undertaken in the following three phases:

Phase I: Development of FOS incorporated food products and studying their various organoleptic attributes, overall acceptability and the recovery of FOS during processing of these products using HPLC technique.

Phase II: Collection of baseline data of type 2 diabetic subjects attending health clinic of M.S. University of Baroda in terms of anthropometry, dietary, biophysical, glycemic, lipemic, GLP-1 and gut microbiota (*LAB*, *bifidobacteria* and enteric pathogen) and understanding the correlations between various parameters.

Phase III: Effect of Fructooligosaccharide (FOS) supplementation on Glycemic, lipemic parameters, Gut incretin (GLP-1) and Gut Microflora in type 2 diabetic adults.