Chapter 6
Integrated Food and Nutrition in the Management of Diabetes

Ruchi Vaidya, Sudha Vasudevan, K. Manobala, R.M. Anjana, and V. Mohan

6.1 Introduction

The prevalence of chronic noncommunicable diseases (NCDs) is now reaching epidemic proportions in the developing countries [1]. Indeed, India already has the highest number of diabetic and prediabetic patients in the world, reaching 62.4 million and 72.7 million, respectively [2]. A recent study from the Indian Council of Medical Research–INdia DIABetes (ICMR– INDIAB) showed that the weighted prevalence of diabetes (both known and newly diagnosed) in the urban population of Chandigarh (14.2 %) was the highest, followed by Tamil Nadu (13.7 %), Jharkhand (13.5 %), and Maharashtra (10.9 %). At every age interval, the prevalence of diabetes in urban areas was higher compared with rural areas [2]. This national estimate shows a trend of an increasing number of people with diabetes in India over the last decade [3]. The cause behind the huge epidemic is the alteration of dietary patterns with a rise in refined-grain consumption due to growing industrialization and the country's economic conditions. A natural method of precaution that entails using functional foods present in foods may be one of the most beneficial measures in combating the growing epidemic of diabetes.

6.2 Changing Face of India

The evolution of current dietary and food habits of Indians reflects the agricultural and industrial revolutions of the country. The Bengal famine resulted in an acute decline in food production in India. The so-called Green Revolution, in the context

R. Vaidya • S. Vasudevan • K. Manobala • R.M. Anjana • V. Mohan (✉)
Madras Diabetes Research Foundation and Dr Mohan's Diabetes Specialties Centre WHO Collaborating Centre for Non Communicable Diseases Prevention & Control, IDF Centre of Education, Gopalapuram, Chennai, India
e-mail: drmohans@diabetes.ind.in; www.drmohansdiabetes.com; www.mdrf.in

S. Rastogi (ed.), *Ayurvedic Science of Food and Nutrition*,
DOI 10.1007/978-1-4614-9628-1_6,

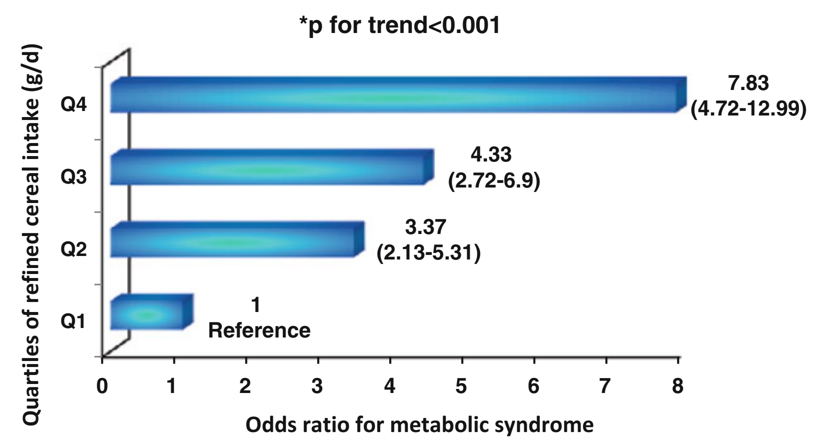
of agriculture in India, led to record grain output and ensured self-sufficiency in cereal grains and reduced hunger. The Green Revolution prominently featured cereal grains, especially wheat and rice, which resulted in a shift in dietary patterns. Today India suffers from conditions such as “affluenza,” which leads to excessive food intake, a decrease in physical activity, and urbanization. The probable reasons for the escalation of diabetes in Indians are rapid urbanization, industrialization, and demographic transitions leading to increasing income levels, all of which has resulted in altered lifestyles [4, 5]. In addition, migration to urban environments from rural settings may also be a major contributor to the epidemic of type 2 diabetes in Indians. Obesity, especially central obesity and increased visceral fat due to physical inactivity, and the consumption of a high-calorie/high-fat and high-sugar diets are other major contributing factors [6]. The results from the Chennai Urban Rural Epidemiological Study (CURES) show a high prevalence of both general and central obesity, among both men and women, with women having slightly higher rates [7].

6.2.1 Refined Grains, Dietary Carbohydrates, and Diabetes Risk

A population-based, epidemiological cross-sectional study, undertaken to assess the dietary patterns of the Chennai population as the urban component of the Chennai Urban Rural Epidemiological Study (CURES), shows that carbohydrates were the major source of energy (64 % E), followed by fat (24 % E) and protein (12 % E). Refined cereals contributed to the bulk of the energy (45.8 % E), followed by visible fats and oils (12.4 % E) and pulses and legumes (7.8 % E). However, energy supply from sugar and sweetened beverages was within the recommended levels of <10 % E. Intake of micronutrient-rich foods, such as fruits and vegetables (265 g/day) and fish and seafood (20 g/day), was far below the FAO/WHO recommendation [8].

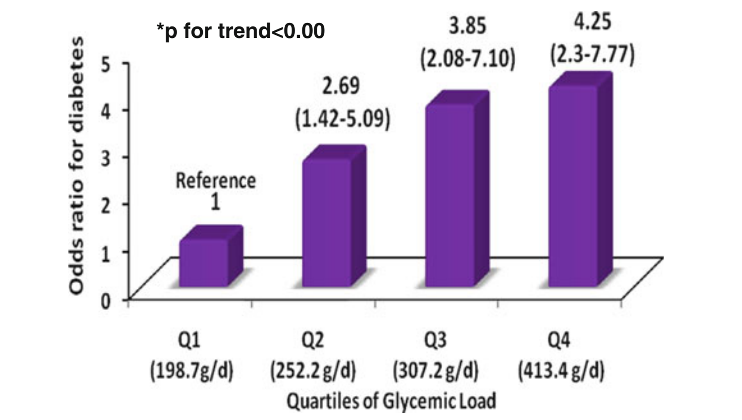
Refined grains in southern India mainly consist of polished rice, refined wheat flour (white flour), semolina, and ragi (finger millet) flour. Of these, white rice, a high glycemic index (GI) cereal staple, is the main component of the diet (76 %, mean 253 g/day) and represents the major source of energy and contributes up to 66 % of the total glycemic load (GL) [GL = GI % x amount of available carbohydrates provided by the portion of the food eaten] in urban Chennai diets. The commonly consumed highly polished white rice in India has a high GI value (approximately 75–80), and the refining process leads to a loss of fiber, vitamins, magnesium and other minerals, lignans, phytoestrogens, and phytic acid, many of which may be protective factors against diabetes and cardio vascular diseases (CVD). Research carried out in the urban Chennai population showed a higher intake of refined cereals, and a high-glycemic-load diet was associated with a metabolic syndrome in Asian Indians who habitually consume high-carbohydrate diets (Figs. 6.1 and 6.2) [9, 10].

Whole grains like brown rice were reported to have health benefits in reducing the risk of chronic diseases like diabetes. Brown rice has intact bran and a germ that



*P denotes the trend calculated using the median of each category of intake as a continuous variable in the regression model. Adjusted for age, sex, smoking, alcohol, BMI, METS, total energy, legumes, visible fats and oils, dairy products, sugars, fruits and vegetables, tubers, fish and seafood, and nuts and oil seeds

Fig. 6.1 Relation of refined cereal intake to metabolic syndrome disorders [10]



*Tests for a linear trend were conducted across increasing categories by treating the medians of intake in categories as a continuous variable. The 95% confidence interval is in parentheses. The model was adjusted for age, sex, BMI, family history of diabetes, cigarette smoking, alcohol consumption, physical activity, and Income in Indian Rupees

Fig. 6.2 Relation of glycemic load to type 2 diabetes [9]

contains micronutrients, phytonutrients, and dietary fiber as compared with fully polished white rice, as reported by studies conducted in the West [11]. Many people are unaware of the health benefits of brown rice and consider that Kerala red rice, parboiled rice, or even hand-pounded rice as brown rice. Hence, in this context, research on people's awareness of brown rice is being carried out for the first time on Indian foods by determining the GI of foods containing brown rice and comparing them with their white rice counterparts.

6.2.2 Oil Intake and Metabolic Syndrome

Edible oil is an important source of fat in the Indian diet. Besides being a source of energy, it adds a special flavor and palatability to food. The quality of fat in terms of essential fatty acids and the ratio of omega 6:3 are very essential to maintaining good health. A community-based study carried out in Chennai showed that almost 63 % of the Chennai population preferred modern sunflower oil and only 7 % preferred traditional groundnut oil (7 %) and sesame oil (2 %) [8]. The use of omega-6 poly unsaturated fatty acids (PUFA) PUFA-rich vegetable oils like sunflower/safflower oil can aggravate the risk of obesity and its consequences, particularly among Asian Indians, who habitually consume a cereal-based diet consisting mainly of refined grains with low intakes of omega-3 fats [12]. The use of traditional oils such as groundnut/sesame/mustard and even soybean oils or blends of oils seems to be a better option because it could ensure an optimal ratio of saturated, monounsaturated, omega-3 and omega-6 fatty acids and reduce the risk of metabolic problems, a pre-event that leads to diabetes and cardiovascular disorders.

6.2.3 Functional Foods

The erosion of healthy diet as an outcome of modernization and industrialization has led to the development of dietary supplements and functional foods. Functional foods are foods, including whole foods and fortified, enriched, or enhanced foods or dietary components, that may reduce the risk of chronic disease and provide a health and physiological benefit beyond the traditional nutrients it contains. Functional food is a key concept for the future of nutrition. Some functional foods that play a major role in the prevention of chronic diseases and the promotion of health are mentioned in what follows.

6.2.4 Omega-3 Fatty Acids

Apart from being a source of energy, fatty acids build up cellular membranes, regulate gene expression, and function as signaling molecules. There are indeed indications that omega-3 PUFAs have a positive effect on glucose tolerance by reducing insulin resistance, as demonstrated by animal models of obesity [13]. For the benefits in cardiovascular disorders, the American Heart Association recommends that the degree of PUFAs in the diet should be increased and the ratio of omega 6:3

PUFAs needs to be reduced. This can be achieved by increased consumption of α linolenic acid, which is abundant in fatty fish like salmon, herring, and mackerel, as well as in lean fish liver, which contains large amounts of EPA and DHA, plant oils derived from flaxseed, soybean, and rapeseed and nuts like walnuts.

6.2.5 Medium-Chain Triglycerides

Medium-chain triglycerides (MCTs) have a number of unique characteristics related to energy density, absorption, and metabolism. MCTs can decrease body fat in the long term because it provides an approx. 50 % increase in diet-induced thermogenesis, which over time may help to induce weight loss and prevent weight gain [14]. The satiating properties of MCTs involve multiple preabsorptive and postabsorptive mechanisms, which further help in appetite control and, hence, obesity. Daily consumption of MCT oil by humans is safe up to 1 g/kg of body weight; there are few naturally occurring sources of MCTs, but they include milk fat, palm kernel oil, and coconut oil. A comparison trial with MCT (35 g) and LCT (32 g) supplementation showed that food intake was lower following consumption of MCT, suggesting an important role of MCTs in satiation, but energy expenditure did not significantly differ between groups [15]. Very few studies have been recorded on MCT supplementation and its effect on satiety and energy expenditure, and more research should be done on improvements in body composition, energy expenditure, and diminished weight gain resulting from MCT consumption [16].

6.2.6 Resistant Starch

Depending upon food consumption practices and individual gastrointestinal processes, it is possible that some starch will actually pass through the small intestine undigested and contribute to the amount of resistant starch (RS). RS is defined as “starch and starch degradation products not absorbed in the small intestine of healthy humans” [17]. RS is associated with nutritional, metabolic, and physiological changes that make it an essential ingredient for the management of diabetes and its complications [18]. The presence of RS in foods reduces their caloric density. Researchers have shown that RS acts as a prebiotic in the gut and produces short-chain fatty acid (SCFA); it has also been proposed that it affects carbohydrate and lipid metabolism. RS is present in a physically inaccessible form in legumes, cereals, roots, and tubers, but the formation of RS in these foods varies with processing and storage conditions. A study on the effect of processing on RS content of staple Indian cereal foods showed that roasting, baking, and pressure cooking increased the RS content, whereas frying and steaming decreased the naturally present RS content in Indian foods [19]. Hence, appropriate processing technologies for RS formation in foods and clinical trials with RS supplementation are needed to assess its health benefits.

6.2.7 Nondigestible Oligosaccharides

Nondigestible oligosaccharides (NDOs) resist hydrolysis and digestion in the human digestive system and are partially or completely fermented by the colonic microbiota in the large intestine. The ingestion of NDOs may thus lead to the advantageous proliferation of certain types of beneficial bacteria (*lactobacilli and bifidobacteria*) and suppression of harmful bacteria [20]. The major products of NDO metabolism are SCFAs and gases. SCFAs are absorbed in the blood stream of the host. Butyrate is absorbed and used by colonocytes as the preferred fuel, whereas the other SCFAs are transferred to various organs, primarily the liver, where they enter various metabolic pathways. Some of the essential NDOs are fructooligosaccharides, inulin, galactooligosaccharides, lactulose, galactomannan, and cyclodextrin.

6.2.7.1 β-Glucan

β-glucan, found in oats and barley, is a highly viscous, soluble, and fermentable polysaccharide shown to have a positive effect on weight control management. It acts as a prebiotic and has been suspected to influence the glucose metabolism by modulation of glycemia or insulin response to a meal. It works by slowing the rate of nutrient absorption and lowering the glycemic index of foods and postprandial glucose [21]. It also has properties similar to those of prebiotics and produces SCFAs, which helps in various metabolic pathways and in turn in the management of metabolic syndrome by reducing weight, glycemic and insulinemic response, and inhibiting cholesterol synthesis [20].

6.3 Conclusions

Modernization and lifestyle modifications have resulted in poor nutrition (quantity and quality). Conversely, improved nutrition is important in preventing diabetes. Many functional foods may help in diabetes prevention and control. However, there is a need for a more systematic research approach to incorporate these functional foods in the newer evidence-based health foods for the management of the physiological and metabolic consequences of diabetes and related chronic disorders.

References

1. International Diabetes Federation, Unwin N, Whiting D, Gan D, Jacqmain O, Ghyoot G (eds) (2009) IDF diabetes atlas, 4th edn. International Diabetes Federation, Belgium, p 12
2. Anjana RM, Pradeepa R, Deepa M, Datta M, Sudha V, Unnikrishnan R et al (2011) Prevalence of diabetes and prediabetes (impaired fasting glucose and/or impaired glucose tolerance) in

urban and rural India: Phase I results of the Indian Council of Medical Research–INdia DIABetes (ICMR–INDIAB) study. Diabetologia 54:3022–3027

3. Mohan V, Deepa M, Deepa R, Shanthirani CS, Farooq S, Ganesan A, Datta M (2006) Secular trends in the prevalence of diabetes and impaired glucose tolerance in urban South India – the Chennai Urban Rural Epidemiology Study (CURES-17). Diabetologia 49:1175–1178
4. Mohan V, Sandeep S, Deepa R, Shah B, Varghese C (2007) Epidemiology of type 2 diabetes: Indian scenario. Indian J Med Res 125:217–230
5. Pradeepa R, Mohan V (2002) The changing scenario of the diabetes epidemic: implications for India. Indian J Med Res 116:121–132
6. Deepa R, Sandeep S, Mohan V (2007) Abdominal obesity, visceral fat and type 2 diabetes – "Asian Indian Phenotype". In: Mohan V, Gundu HRR (eds) Type 2 diabetes in South Asians: epidemiology, risk factors and prevention, Under the Aegis of SASAT. Jaypee Brothers Medical Publishers, New Delhi, pp 138–152
7. Deepa M, Farooq S, Deepa R, Manjula D, Mohan V (2009) Prevalence and significance of generalized and central body obesity in an urban Asian Indian population in Chennai, India (CURES: 47). Eur J Clin Nutr 63:259–267
8. Radhika G, Sathya RM, Ganesan A, Saroja R, Vijayalakshmi P, Sudha V, Mohan V (2010) Dietary profile of urban adult population in South India in the context of chronic disease epidemiology (CURES – 68). Public Health Nutr 14:591–598
9. Radhika G, Van Damb RM, Sudha V, Ganesana A, Mohan V (2009) Refined grain consumption and the metabolic syndrome in urban Asian Indians (Chennai Urban Rural Epidemiology Study 57). Metab Clin Exp 58:675–681
10. Mohan V, Radhika G, Rangaswamy MS, Selvi Ramjothi T, Ganesan A, Sudha V (2009) Dietary carbohydrates, glycemic load, food groups and newly detected type 2 diabetes among urban Asian Indian population in Chennai, India (Chennai Urban Rural Epidemiology Study 59). Br J Nutr 102:1498–1506
11. Sun Q, Spiegelman D, van Dam R, Holmes M, Malik V, Willett W, Hu F (2010) White rice, brown rice and risk of type 2 diabetes in US men and women. Arch Intern Med 170:961–969
12. Lakshmipria N, Gayathri R, Praseena K, Vijayalakshmi P, Geetha G, Sudha V, Krishnaswamy K, Anjana RM, Henry J, Mohan V (2012) Type of vegetable oils used in cooking and risk of metabolic syndrome among Asian Indians. Int J Food Sci Nutr 64(2):131–139
13. Storlien LH, Higgins JA, Thomas TC, Brown MA, Wang HQ (2000) Huang XF and else PL diet composition and insulin action in animal models. Br J Nutr 83(Suppl 1):S85–S90
14. Clegg ME, Golsorkhi M, Henry CJ (2013) Combined medium-chain triglyceride and chilli feeding increases diet-induced thermogenesis in normal-weight humans. Eur J Nutr 52(6):1579–1585
15. Wymelbeke VV, Louis-Sylvestre J, Fantino M (2001) Substrate oxidation and control of food intake in men after a fat-substitute meal compared with meals supplemented with an isoenergetic load of carbohydrate, long-chain triacylglycerols, or mediumchain triacylglycerols. Am J Clin Nutr 74:620–630
16. Rego Costa AC, Rosado EL, Soares-Mota M (2012) Influence of the dietary intake of medium chain triglycerides on body composition, energy expenditure and satiety; a systematic review. Nutr Hosp 27(1):103–108
17. Asp NG (1992) Resistant starch – proceedings from the second plenary meeting of EURESTA: European Flair Concerted Action no.11 on the physiological implications of the consumption of resistant starch in man. Eur J Clin Nutr 46(Suppl 2):S1
18. Higgins JA (2004) Resistant starch: metabolic effects and potential health benefits. J AOAC Int 87:761–768
19. Vaidya RH, Sheth MK (2010) Processing and storage of Indian cereal and cereal products alters its resistant starch content. J Food Sci Technol 48(5):622–627
20. Roberfroid M, Gibson GR, Hoyles L, McCartney AL, Rastall R, Rowland I et al (2010) Prebiotic effects: metabolic and health benefits. Br J Nutr 104(S2):S1–S63
21. Battilana P, Ornstein K, Minehira K, Schwarz JM, Acheson K, Schneiter P, Burri J, Jequier E, Tappy L (2001) Mechanism of action of β glucan in postprandial glucose metabolism in healthy men. Eur J Clin Nutr 55(5):327–333