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DIETARY FIBERS IN PROBIOTICS AND HUMAN HEALTH

IRENE PRINCESS JOHN[1*] AND G.KALAICHELVAN[1*]

[1]*School of Biosciences and Technology, VIT University, Vellore, India*

ABSTRACT

Dietary fiber is a class of compounds, mainly of carbohydrate polysaccharides and other polymers including lignin, which, when ingested in the form of plant material, escapes hydrolysis, digestion and absorption in the small intestine, with complete or partial fermentation in the human large intestine. Dietary fibers also include oligosaccharides and lignin and associated plant substances like wax compounds, suberin and cutin. Dietary fibers bring about a range of physiological effects in humans, which in turn confer various health benefits. In developed countries, several gastrointestinal disorders (duodenal ulcers, appendicitis, haemorrhoids, colon carcinomas, constipation), diabetes, cardiovascular diseases, obesity have very low incidence among people consuming high amounts of fiber rich food. Also, previous studies in humans have suggested that dietary fibers lead to a reduction in potentially harmful microbial metabolites.

KEY WORDS: **Dietary fiber, diabetes, heart disease, obesity, cancer, probiotics**

IRENE PRINCESS JOHN
School of Biosciences and Technology, VIT University, Vellore, India

INTRODUCTION

In recent years, dietary fibers (DF) have received increased attention for their potential role in alleviating type 2 diabetes[1], reduced risk of cardiovascular diseases and in weight regulation. The term 'dietary fiber' was first used in 1953 by Eben Hipsley[2]. Earlier, it was called 'crude fiber'- a portion of plant foods that escaped acid, alkali and solvent treatment. Trowell[3]defined dietary fibers as remnants of edible plant cell polysaccharides, lignin and associated substances which escape hydrolytic enzymatic digestion in the upper GI tract. However, till date there is no universally accepted definition for dietary fiber, although a codex definition was agreed in 2009, which defines DF as carbohydrate polymers with 10 or more monomeric units which are not hydrolysed by endogenous enzymes in the small intestine of humans[4]. Currently, the demand for the by-products from fruits and vegetable sources of dietary fibers has been increasing, as these sources provide higher nutritional quality, lower caloric content, stronger antioxidant capacity, higher levels of fermentability and water retention[5]. The physiological effects of dietary fiber are greatly dependent on the physicochemical properties of the ingested material like water holding capacity, viscosity, molecular weight distribution etc. Another factor of great nutritional importance is the plant cellular structure, which may also play a role in storage stability and sensory characteristics. In order to produce foods with high nutritive qualities, there is a need to gain more knowledge on how the polysaccharides in fibers are affected by cooking and processing. During the processing, the physicochemical properties of dietary fibers may be modified and consequently the physiological effects may be altered.

Classification and Sources of DF

DF of plant foods is classified into 2 major components
(i) Soluble Dietary Fiber (SDF), which is prebiotic, viscous, and readily is fermented and metabolized by microbial flora in the colon into gas and is physiologically active by –products and
(ii) Insoluble Dietary Fiber (IDF), is metabolically inert, and generally contributes only to the water-holding capacity of the stool, absorbs water as it moves through the alimentary canal and is expelled from the body, easing defecation. DF acts by changing the nature of the contents of the GI tract. SDF absorbs water to become a gelatinous, viscous substance and is fermented by bacteria in the GI tract. IDF is not fermented and has a bulking action. Chemically, DF consists of non-starch polysaccharides such as cellulose, arabinoxylans, resistant dextrins, inulin, lignin, chitin, pectin, waxes, β – glucan and oligosaccharides. Sources of SDF include legumes, peas, soybean, oats, rye, barley, fruits (plum, berries, bananas), vegetables (carrot, broccoli), root tubers (sweet potatoes) etc. IDF is found in varying quantities in whole grain foods, wheat and corn bran, nuts and seeds, potato skins, flax, hempseed, lignans etc. Relatively, all plants contain both soluble and insoluble fibers in varying amount[s6].

Table 1
Common sources of dietary fibers (g/100g edible portion)

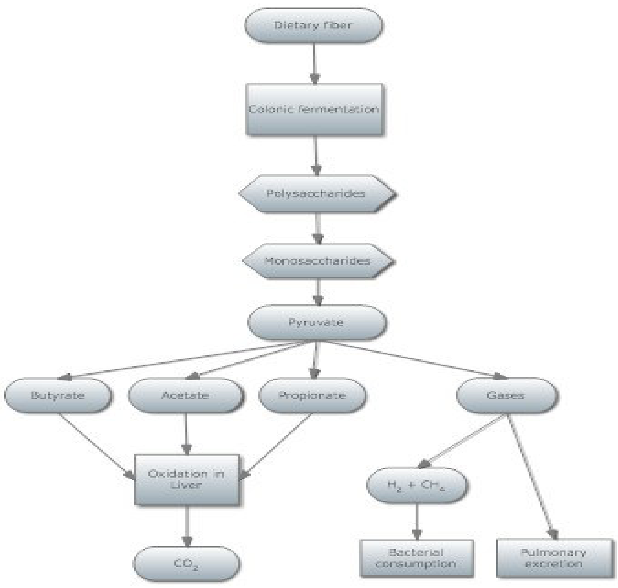
Source	Soluble Fibre	Insoluble Fibre	Total Dietary Fibre
Flax seeds	10.1	12.1	22.2
Bitter gourd	3.1	13.5	16.6
Field beans	2.1	9.3	11.4
Almonds	1.1	10.1	11.2
Broad beans	0.8	7.3	8.3
Beet root	2.4	5.4	7.8
Sesame seed	1.9	5.8	7.7
Cluster beans	0.6	6.1	6.7
Green plantain	0.2	5.8	6.0
Carrot	1.6	4.1	5.7
Brazil nuts	1.3	4.1	5.4
Fenugreek leaves	0.7	4.2	4.9
Ladys'finger	1.3	3.0	4.3
Cauliflower	0.7	3.5	4.2
Spinach	0.6	3.5	4.1
Kiwi	0.8	2.6	3.2
Potato	0.6	2.6	3.2
French beans	0.1	3.0	3.1
Apple	0.7	2.0	2.7
Banana	0.6	1.8	2.4
Pear	1.1	1.3	2.4
Strawberry	0.6	1.7	2.3
Peach	0.8	1.2	2.0
Onion	0.9	1.1	2.0
Mango	0.7	1.0	1.7
Plum	0.7	0.8	1.5
Pineapple	0.1	1.1	1.2
Grapes	0.4	0.6	1.0
Watermelon	0.2	0.3	0.5

Cereals and grains such as rice, wheat, barley and millets are known to be the staple foods of the people of the western world[7].There are a few studies on the physiological effects of whole grain foods, but the biochemical mechanisms behind the health benefits still remain speculative. In all studies, the polysaccharide moiety, was given more attention, followed by the phenolic compounds, which serve be to good antioxidants. Reports on increased intake of dietary fiber studies indicate numerous health benefits including reduced risk of diabetes, coronary heart disease (CHD), obesity and some cancers[8, 9]. In cereals and grains, the concentration of DF is higher in the bran than in other parts of grains. Oat bran and barley bran which contain mostly soluble fibers are favoured for their ability to lower blood lipid levels. Wheat bran and other insoluble fibers are typically known for their laxative properties[10]. Dietary fiber supplementation can result in foods with low calories, cholesterol and fat thereby promoting fitness. DF can also impart some functional properties to foods viz., increase water holding capacity, oil holding capacity, emulsification and or gel formation. Dietary fibers in corporated into food products (dairy products, bakery products, jams, meats, soups etc.,) can modify the textural properties, avoid synaeresis (liquid separation from gels due to contraction), stabilise high fat food and emulsions and improve shelf life[11]. Wheat bran cereal offers protection against colon cancer[12], oat bran can reduce serum cholesterol due to its capacity to bind bile acids[13].Oat bran may also improve constipation management and B_{12} bioavailability in the elderly with multiple chronic diseases[14]. Milled and fractionated pulse seeds contribute beneficial rich sources of dietary fiber to food[15].Citrus peels are good sources of DF. Consumption of citrus peel was associated with significant reduction of total and LDL- serum cholesterol levels[16]. Citrus peels also exhibit a protective role against diet induced atherosclerosis and thyroid dysfunction in a rat model[17].

Mechanism of action of DF in GI tract

The main action of DF is to change the nature of the contents of the GI tract, and enable absorption of nutrients. SDF binds to bile acids in the small intestine, making them less likely to enter the circulation, thereby lowering cholesterol levels in the blood. SDF also attenuates the absorption of sugar, reduces sugar response after eating, normalises blood lipid levels and once fermented in the colon, produce short-chain fatty acids (SCFA's) as by-products with wide-ranging physiological activities. Although insoluble fiber is also associated with reduced risk of diabetes, the mechanisms still remain unclear. Dietary fibers, though resistant upon action of upper GI tract enzymes, are selectively degraded to various components during their passage through ileum and caecum. The susceptibility of colonic fermentation and degradation of DF is dependent on the chemical and physical composition of fiber, the nature and population of colonic bacterial flora and the colonic transit time. More than a hundred species of bacteria have been identified of which 99% are anaerobes and it has been reported that bacteria account to about 60% of the dry weight of faeces[18]. The microbial flora is highly saccharolytic and the organisms involved in fiber degradation are largely concentrated in the colon and caecum. The fiber constituents of fruits and vegetables are much more fermentable than cereal bran fibers since, bran fibers possess thicker cell walls and a high degree of lignification. The digestion of polysaccharides varies between 50 – 90%. Pectin and hemicellulose are scarcely digested and passed through the stool, whereas cellulose gets less digested. Lignin is also resistant to bacterial digestion due to its polymeric cross-linked structure and is recovered in the stool[19]. The products of fermentation of dietary fibers are SCFA's, acetate, butyrate and propionate. Some of the other products are ethanol, lactic acid, formic acid and CO_2. Fiber fermentation is a self-limiting process, as production of acidic metabolites alter the caecal H^+ concentration. Excess H^+ from regeneration of NAD is excreted by the formation of H_2. The hydrogen (H_2) and methane (CH_4) are absorbed into the circulation and excreted through the pulmonary route[20].

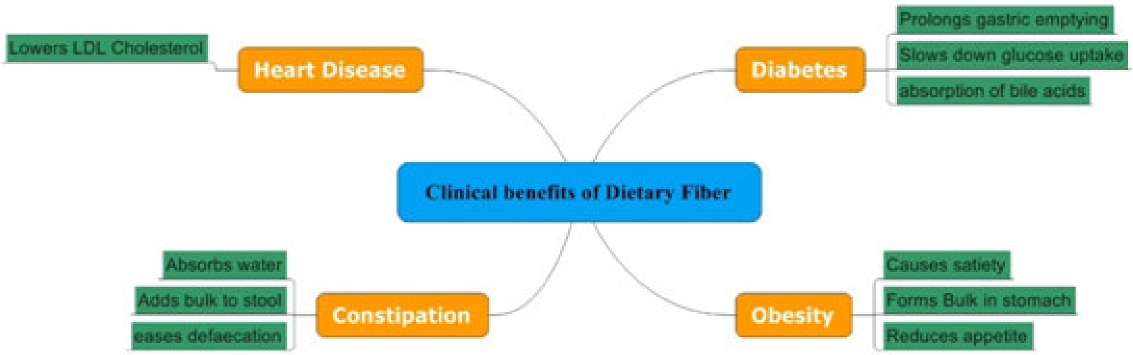
Figure 1
Metabolites from fiber degradation



Clinical significance of DF supplementation

The dietary fibers impart various health benefits directly or indirectly to the whole body or specific organs.

Figure 2
Clinical benefits of Dietary Fiber



Diabetes mellitus

DF holds a promise in the management of type 2 diabetes. The inclusion of sufficient DF in meal reduces the postprandial glycaemic and insulinemic excursions and favourably influences plasma lipid levels[21]. Soluble fiber appears to have a greater potential to reduce postprandial blood glucose, insulin and serum lipid levels than the insoluble fiber. Viscosity of the fiber is highly important; greater the viscosity, the greater is the effect. Possible mechanisms for metabolic improvements with DF include the delay of glucose absorption, increase in the hepatic extraction of insulin, increased insulin sensitivity at the cellular level and binding of bile acids[22]. The glycaemic index (GI) was developed to quantify the difference in blood postprandial glucose response to a food[23]. By definition, the GI value is the area under the blood glucose curve for the test food, expressed as a percentage of that of the standard control (usually a glucose drink or white bread). If glucose was used as the reference food, the value is multiplied by 100/70 to convert to bread scale[24]. Generally based on the bread scale, low GI foods are those that cause low post prandial glucose response. The foods classified as high GI (>90) are most breads and breakfast cereals. Based on peripheral blood glucose profiles, the beneficial effects of low GI foods are thought to be through their metabolic effect of reducing glucose absorption in the small intestine, leading to better glycaemic control. This is particularly relevant to dietary fibers because viscous fibers account for the majority of the clinical benefits observed with dietary fibers. The viscosity of these fibers slows down the digestion of nutrients by preventing bulk diffusion of foods across the intestinal lumen. This reduction in absorption lowers post prandial glucose and insulin responses which have significant implications in prevention and management of insulin resistance and type2 diabetes. Furthermore, the increased viscosity in the terminal ileum, effects on lipids and lipoprotein synthesis[25]. Possibly enhanced colonic propionate synthesis[26] and physical binding of bile acid to the fiber[27] are the principle mechanisms by which viscous fiber may reduce serum cholesterol. Therefore, consumption of low GI food reduces the rate of glucose absorption which in turn induces a lower rise in circulating insulin and lipids and also modulates gut hormones such as incretins, gastric inhibitory polypeptide (GIP) and glucagon like peptide -1 (GLP-1)[28]. This lower post prandial but sustained insulin secretion has many advantages including suppression of free fatty acids (FFA) levels and the counter regulatory hormones that occur with high glucose. Overtime, the reduction in FFA levels improves glucose receptor sensitivity and hence glucose is withdrawn from the circulation at a greater rate[29]. Another possible mechanism, by which fiber rich foods (low GI foods) can improve glycaemic control, may be through the action of phenolic compounds present in the fiber rich foods. Evidences suggest that phenolic compounds cannot directly inhibit glucose absorption[30], but increase insulin secretion[31] leading to lower post prandial glucose response in humans[32]. Insulin resistance and inflammation have been implicated in the pathogenesis of diabetes and CVD[33]. A recent meta – analysis substantiated increased relative risk of diabetes with increased white rice consumption, particularly in Asians[34]. Old age, female gender, adiposity and physical inactivity are each powerful determinants of insulin sensitivity and hence each of these may alter the relations between diet and CVD risk[35].Other recent studies have documented a negative association between DF intake and markers of inflammation and insulin resistance[36].

Heart disease

Dietary fibers appear to have a direct effect on decreasing the risk of heart disease. For the most part, association has been within soluble fiber, especially wheat bran. However viscous fiber sources are likely to play a role since they reduce lipid risk factors for CHD including total and LDL cholesterol and Apo lipoproteinB, by increasing faecal bile acid losses. In addition, soluble fiber may reduce the rate of nutrient absorption thereby altering chylomicron synthesis and reducing post prandial glucose and insulin levels and other risk factors for CHD. There are also evidences that some insoluble fibers might alter serum lipids and improve carbohydrate tolerance. Epidemiology, clinical and laboratory studies support increased consumption of high fiber foods as a part of the strategy to reduce the risk of CHD[37]. Furthermore individuals especially women, diagnosed with type 2 diabetes have a 3-5 fold increase in the risk of developing CHD[38]. It is well documented that a high – fiber diet is highly protective against inflammation, which is the vital key in the development of atherosclerosis and subsequent vascular diseases[39]. Two recent studies among adolescents have also supported an inverse relationship between fiber intake and inflammation[40].Some studies have also shown marked and stronger protective effects of soluble dietary fibers than the insoluble ones[41]. However, the beneficial effects of high fiber diets can directly impact the risk of developing CHD by alleviating risk factors such as elevated serum LDL levels[42].

Obesity

Obesity is the fifth leading risk for global deaths and 2.8 million people die across the globe every year of obesity and its associated complications. Pandemic obesity is increasing due to both extrinsic factors, such as decreased physical activity, increased sedentary lifestyles, wide availability and consumption of cheap, high-calorie foods and as well with intrinsic factors such as genetic, epigenetic and developmental factors[43]. Obesity is also known to be associated with multi-morbidities such as cardiovascular diseases, type 2 diabetes and cancers. Functional food products for obesity management may pose a risk from adverse effects, by aiding in the consumption of bioactives such as dietary fibers[44]. Also evidences suggest that the gut microbiota collectively play a vital role in obesity management. Hence, a symbiotic medium holds a potential strategy in the management of weight loss. Also DF supplementation has been proved to boost the immune system and stimulate the growth of beneficial microbiota condensed in the colon[45]. There are various findings linking higher intake of dietary fiber to an improved management of body weight. A study with over 5000 subjects showed that higher fiber intake was associated with lower body mass index (BMI) in both men and women[46]. The BMI of subjects assigned fiber rich foods or low GI foods reduced significantly to those on a low fat diet[47]. In a dietary intervention involving overweight and obese children, it was shown that low GI foods are more effective in reducing weight than low fat diets. Also, a recent meta- analysis stated that low GI diets are more effective in inducing weight loss when compared to high GI or low fat diets[48]. There are also evidences that hyperinsulinemia, due to its lipogenic effects, is linked with obesity[49]. Therefore, it can be concluded that diets that elicit a low insulin response such as fiber rich and low GI foods, may play a significant role in weight loss. Also, the consumption of fiber – rich foods that are low in GI prove to be an effective tool in weight loss. This can in turn lower the risk of type 2 diabetes and CHD[50]. Overall, a DF supplemented diet appears to be more effective for weight reduction in overweight or obese individuals[51].

Cancer

The relationship between various types of fibers and cancer risk was hypothesised by Burkitt in 1971[52]. Several case control studies have reported a protective effect of fiber on colon and rectal cancer cases. High levels of cereal DF's such as from wheat and rice have been associated with the prevention of colorectal cancers. Both animal and experimental studies have substantiated that whole grain products have positive beneficial effects on prostate cancer progression, delayed tumor growth and enhanced tumor cell apoptosis. Logistic regression results have elucidated the total fiber intake to be significantly and inversely associated with the risk of oesophageal cancer. Significant alleviations in cancer risk were observed with high intakes of fruit and vegetable fibers, whereas no significant association was found upon cereal fiber consumption with respect to oesophageal cancer. The protection was stronger for vegetable fibers than for grain ones[53]. Fibers, particularly soluble fibers may reduce glycaemic load and improve insulin resistance favourably influencing insulin like growth factor (IGF -1) which is a promoter of the process of colorectal carcinogenesis[54]. Along this line, a clinical history of diabetes mellitus is related to colorectal cancer risk. There are enough documentations stating hyperinsulinemia, in affected individuals, may promote cancer, as insulin can exert its oncogenic potential via abnormal stimulation of multiple cellular signalling cascades, enhancing growth factor dependent cell proliferation and/or by directly affecting cell metabolism[55]. It is evident that more fiber may modify the bacterial microflora, influence bowel transit time and fermentation. Several mechanisms have been proposed the way by which dietary fibers might protect against colorectal cancer[56] both by direct action or in which the dietary fiber may have an indirect effect as a consequence of it being degraded by colonic bacterial enzymes, and the products fermented. That is how some dietary fibers protect directly or indirectly[57]. The direct mechanisms operate by reducing the exposure of colonic mucosal cells to carcinogens or promoters (e.g. secondary bile acids). Undegradable dietary fibers may protect by adsorbing carcinogens in the digestive tract and thus carrying them out of the body[58]. For these mechanisms to work, it is essential that the cell walls remain largely intact as they pass through the colon. However, there are evidences that parenchyma cell walls and other cell walls with similar compositions which are present in food plants are extensively degraded in the human colon. It seems unlikely that enough of these parenchyma cell walls would remain in the colon to protect by adsorbing carcinogens[59]. The presence of lignin in cell walls protects the cell wall polysaccharides from degradation by colonic bacterial enzymes. Poorly degraded, dietary fibers can increase faecal bulk by their physical presence by absorbing water. This increased faecal bulk results in shortened transit times through the GI tract. Both increased faecal bulk and short transit times reduce the exposure of colonic mucosal cells to carcinogens.

Fiber and probiotics

The intestinal microflora constitutes a complex, dynamic and diverse collection of microbes usually harboured in the GI tract. Functional foods with probiotics, prebiotics and fibers are available to the consumers for years. Probiotics are the live micro-organisms which when administered in adequate amounts confer health benefits on the host. Once taken up by the host, they become a part of the microbiota that acts in intestinal micro ecology. They act largely within the micro ecology to neutralize some toxic substances, possibly carcinogens and help in the process of colonic fermentation. There are approximately more than 20 strains or organisms employed as probiotics. Prebiotics are non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth and activity of one or a few number of bacteria in the colon, thereby improving host health[60], whereas dietary fibers are edible parts of plants that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Thus all carbohydrate prebiotics are fibers, but since prebiotics should be utilised by beneficial microbes, all fibers are not necessarily prebiotic[61].Synbiotics define the combination of pro- and pre-biotics which are believed to be more efficient when to either of them alone, in terms of health and function. There are adequate evidences that gut microflora render to tumors. Animal and invitro studies strongly validate the use of these bio therapeutics in cancer prevention. Probiotics, especially from the genera of Lactic acid bacteria (LAB) and Bifidum (BF) with prebiotics, especially from inulin and oligofructose or the combination of both in a symbiotic medium, significantly aid in cancer prevention[62]. Probiotics such as *S.boulardii, B.lactis, B.longum, S.thermophilus, L.rhamnosus, L.casei, L.plantaram* have been affirmed to have protective effects against antibiotic associated disorders (AAD) [63]. Hence, food products combining probiotics with prebiotics are gaining more interest in the market. The water soluble prebiotic fibers such as lactose derivatives, galacto-oligosaccharides (GOS), fructo-oligosaccharides (FOS), inulin and polydextrose and other water insoluble fibers could act as potential probiotic protectants[64].Fruit by-products such as peels of apple, banana and passion fruit, markedly because of their content of soluble and insoluble DF, pectins and fructooligosaccharides, serve to be efficient prebiotics adhering to probiotics[65]. In freeze – drying and stability studies, wheat dextrins and polydextrose proved to be promising carriers for bacterial strains whereas, apple fiber and inulin carriers were fairly good but the difference was not statistically significant[66]. Since polydextrose and wheat dextrins are not identical fibers, but differ regarding their structure, degree of polymerisation and average molecular weight.

Dietary fibre as Nanoencapsulant

Encapsulation process has proven to be a viable method for targeted delivery of bioactive substances in humans. In addition, increased efficacy of the encapsulation process can also be achieved by reducing the particle size and thus microencapsulation has paved the way for nanoencapsulation. The success of targeted delivery depends on the type of the encapsulant. Food grade macromolecules such as lipids, proteins, and polysaccharides are widely used for encapsulation since they are biocompatible, biodegradable, with low toxic effects and exhibit mucoadhesiveness. However, the acidic and the alkaline conditions prevailing in the gastro-intestinal tract coupled with strong digestive enzymes render these materials as ineffective encapsulating agents. The afore-said issues can be circumvented by using dietary fibres for encapsulation. The concept by preparing resistant starch (RS) dietary nanofibers from soyabean meal using ultrasonication is clearly demonstrated[67]. The resultant nano resistant starch survived the in-vitro stimulated stomach and intestinal conditions by 30% and resisted the pancreatic enzyme digestion by 20%. Further this novel nano RS fiber served as good substrate for the probiotic strains Bifidobacterium brevis and Lactobacillus casei clearly showing that the particle reduction has not affected its prebiotic property. A novel way to utilise the agro waste was tested by electro spinning the Lactobacillus acidophilus with soluble dietary fiber (SDF) from agro wastes, okara (soybean solid waste), oil palm trunk (OPT), and oil palm frond (OPF) and found that the SDF from oil palm fond showed superior viability of the microbe during the electro spinning process when compared to non-encapsulated electro spun and conventional freeze drying methods. The organism was able to withstand high voltage and shear stress during electro spinning due to the nanoscaling of dietary fibers[68]. This finding is a promising technology to the food manufacturers who strive to incorporate probiotics in thermally processed foods. The successful production of dietary nanofibers using electrospinning is also further substantiated[69]. They isolated soluble fibrous residues from corn cob and wheat straw and converted them into nano-dietary fiber and showed that these can be used for targeted delivery of drugs and nutrients.

Commercial DF in health

The dietary intake of fibers exerts a positive impact on the development of intestinal microbiota and is known to relieve constipation and reduce the incidence of colon cancer. These prebiotics are in fact able to selectively stimulate the growth and activity of the gut microbiota, particularly LAB and Bifidobacteria. Prebiotics are also known to alleviate the uptake of calcium, iron and zinc, thereby aiding a significant decrease in colon cancers, triglyceride levels and total cholesterol. Among the plant derived prebiotics, FOS, GOS and inulin are known to be the best sources, followed by raffinose and resistant starch. Pectins and xylans have also been identified as potential sources of polysaccharides to synthesis prebiotics. Legumes which are also known to be rich sources of dietary fiber, account to enhance the growth of colonic bifidobacteria, thereby contributing to gut health[70]. Hence the plants housing these prebiotics are genetically engineered to enhance the production of prebiotic polysaccharides[71]. Some of the promising fiber rich plant sources and their corresponding fiber variant are given below.

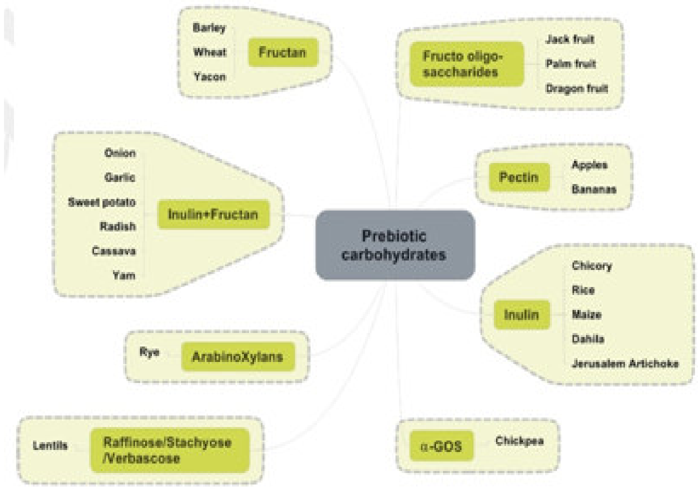


Figure 3
Sources of prebiotic carbohydrates

The commercial DF foods are mostly shredded grain cereals and fruit peels, naturally rich in fiber, sugar-coated or sugar-free, flavoured and less crunchy. Also, the commercial foods are calorie controlled with lesser sodium and sugar levels. Some foods include artificial sweeteners, to minimize the sugar content. These fiber supplements come in a variety of forms, as powders dissolved in water or added to food, chewable tablets, wafers etc. Many processed foods have considerable amounts of added fiber, either to replace the lost amounts during processing or to add extra health benefits. This added fiber is considered to be ''functional fiber''. The commonly added fibers are usually soluble, as cellulose, guar gums, carrageenan, inulin, pectin and some of the added insoluble fibers are bran and polydextrose. One of the best examples is Psyllium fiber, a common fiber supplement marketed under the brand name Metamucil. Metamucil which constitutes to about 70% of soluble fiber and 30% insoluble fiber satisfies the health benefits of both dietary fiber types. Polycarbophil, is another fiber supplement aiding to alleviate constipation due to its bulk forming capability. It is also used as a laxative in treating irritable bowel syndrome. Common brand names of polycarbophil include Fiberlax, Fibernorm, FiberCon etc. Methyl cellulose is another fiber supplement approved by the U.S FDA as a laxative. Methyl cellulose is not fermented in the intestines, hence does not cause excess gas or bloating. It just adds bulk to the stool. Citucel is the fiber brand that uses methyl cellulose as the active ingredient. Wheat dextrins are also used as fiber supplements extracted from cooked wheat flour. Benefiber is a branded wheat dextrin active supplement.

CONCLUSION

A large body of scientific evidence is currently available on a range of dietary fibers and their protective roles to human health. Dietary fibers exert clinical benefits as they are known to improve insulin sensitivity, reduce dyslipidaemia and the risk of CHD and improve weight management. It has also been proved that DF reduces the risk of cancers. Taking into account the various physiological and physicochemical properties, it is difficult to establish and confirm the mechanisms accounting to the beneficial effects exerted by fibers. Dietary fiber is a complex mixture of chemical entities and its composition in different sources is neither uniform nor constant. This physical and chemical diversity explains the complexity of the physiological roles attributed to dietary fiber. The impact of isolated dietary fibers on the large intestinal whole gut transit in humans is not well described in literature. No previous study has assessed the impact of dietary fiber on the human mucus barrier. Interesting mechanisms of dietary fiber retention to the GI tract and the molecular charges on the fibers and their mechanisms of adherence to the intestinal walls, the structural modifications that occur as a result of the above mentioned biological changes still remain unclear. More clinical studies are necessary to establish the relevance and involvement of dietary fibers with regard to human health. In conclusion, these dietary strategies hold promise and appear to be beneficial to human health in various aspects.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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