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Review Article

Role of Dietary Fibre in Management of Lifestyle Related Diseases

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A B S T R A C T

Diet has a major impact on gut microbiota and different components of diet will shape the gut bacteria communities. A diet rich in fiber contributes to the maintenance of a healthy gut microbiota associated with increased diversity and functions such as production of short chain fatty acids. Significant changes in our lifestyle and increasing urbanization has impact on our diet too, it has resulted in consumption of more processed and packed food along with high sugar and protein intake; These dietary changes have altered the normal flora of the human gut. This results in significant reduction in their ability to produce short chain fatty acids and is associated with the appearance of chronic inflammatory diseases. High fiber intake and production of short chain fatty acids by the gut bacteria enhances mucous and antimicrobial peptide production. The gut microbiota and diet are two important components to maintain a normal structure and for the production of the intestinal mucus. Dietary fiber is an indigestible portion of food which helps in fighting against several diseases mainly associated with modern lifestyle. Dietary fiber is the remnants of the plant cells resistant to hydrolysis(digestion) by the alimentary enzymes of human beings. It consists of hemicellulose, cellulose, lignin, oligosaccharide, pectins, gums and mucilages. There are two types of dietary fiber i.e., soluble (pectin, gums) and insoluble dietary fiber (cellulose, hemicellulose, lignin). Some water-soluble fibers such as pectins, gums and hemicellulose have a high-water holding capacity and forms viscous solution with in the gastrointestinal tract. Foods rich in dietary fiber (like cereals, pulses, fruits, vegetables and edible herbs) are known to have safeguarding effects on human health since their consumption has been related to decreased incidence of several lifestyle diseases due to its beneficial effects like increasing the volume of fecal bulk, decreasing the intestinal transit time, cholesterol and glycemic levels. Fiber rich foods are generally seen to have low calories, fat but have high volume along with high micronutrient content. Therefore, it is suggested that healthy adults should eat between20 to 35g of dietary fiber each day. High fiber diet increases satiety and delays gastric emptying by releasing certain gut hormones. Dietary fiber exerts its beneficial effects by speeding the passage of feces through the large intestine so that the contact of carcinogens with the intestinal is significantly reduced.

Keywords

Dietary Fiber, Gut health, Life Style Diseases, Soluble Fiber

Introduction

Food is a basic need for our survival and well beings. It is not only essential to maintain human growth, reproduction and health, but it also modulates and support the symbiotic microbial communities that colonize the digestive tract- the gut microbiota. Type, quality and origin of our food shape our gut microbes. Diet has a major impact on gut microbiota and different components of diet will shape the gut bacteria communities. A diet rich in fiber contributes to the maintenance of a healthy Gut microbiota associated with increased diversity and functions such as production of short chain fatty acids with industrialization of diet, low fiber intake and high protein and sugar consumption, the diversity of gut bacteria is reduced and their function is altered, including significant reduction in their ability to produce short chain fatty acids and associated with the appearance of chronic inflammatory diseases. Dietary fiber consists of remnants of plants cells resistant to hydrolysis (digestion) by the alimentary enzyme of human''. In 2008, the Scientific Advisory Committee on Nutrition (SACN) defined dietary fiber as non-starch polysaccharides (NSP). The definition of dietary fiber was revised in 2015 to include all carbohydrates that are neither digested nor absorbed in the small intestine and have some degree of polymerization of three or more monomeric units and lignin. Traditionally, dietary fibre is defined as the proportion of plant foods that were resistant to digestion by the human digestive enzyme, this includes polysaccharide and lignin. More recently, the definition has been expanded to include oligosaccharide, such as insulin and resistant starches (Jones *et al.,* 2006). The amount and composition of fiber differ from food to food (Desmedt and Jacobes, 2001). A fiber rich diet is lower in energy density, often has a lower fat content, is larger in volume and is richer in micronutrients.

The human microbiota is the collection of microbes that live in human body, with the largest and most diverse cluster of microorganisms inhabiting the gut (Logan and Jacka, 2016). The microbiome contributes to homeostasis regulation in different tissue in our body (Schroedar and Backhed, 2016) However, although the overall interrelationship of human with their microbiota can be considered a mutualistic symbiosis (Walter *et al.,* 2011) eubiosis, which refers to a healthy balance of microbes in the gut, can be disrupted, leading to the development of various chronic diseases with an underlying inflammatory condition (Hand *et al.,* 2016).

The "Gut Microbiota" constitute a complex community that interacts with each other and with the host which modulate biological process essential for health. Our understanding of the biological role of gut microbiome, which include modulating juvenile growth (Schwarzer *et al.,* 2016), maturation of immune system (Rescigno, 2014) and modulation of glucose and lipid metabolism (Backhod *et al.,* 2004) has increased dramatically in the past decade. Change in the modern lifestyle, lead to the reduction of intestinal micro-organism, abundance and diversity, which effect the health of the body (Martinez, I, Stegen *et al.,* 2013).

Classification of Dietary Fiber

Classification of Dietary Fiber

Depending on the solubility dietary fiber are classified in two groups-

Soluble dietary fiber

Soluble fiber are indigestible but soluble in water. Soluble dietary fibers increase total transit time by delaying gastric emptying and also slowing glucose absorption

Table.1 Physiochemical, Physiologic and clinical aspect of fibre

Physiochemical property	Types of Fiber	Physiological effect	Clinical implication
Viscosity	Gums, mucilage, pectin	Decreased gastric emptying Increased mouth to cecum transit, Decreased rate of small intestinal absorption(e.g., of glucose bile acids) Reduction of cholesterolaemia	Dumping Syndrome Diabetes Hypercholesterolemia
Particle formation and water holding capacity	e.g. Wheat bran, pentosane content, polysaccharide-lignin mixtures	Increased Gastric emptying Decreased mouth cecum transit, Decreased total transit time, Decreased Colonic intraluminal pressure, Increased Faecal bulk Fermentation in colon	Peptic ulcer Constipation Deverticular disease Dilute potential carcinogens
Adsorption and non- specific effect	Lignin, pectin, mixed fibres	Increased fecal steroids output Increased fecal fat and nitrogen losses(small)	Hypercholesterolemia Cholelithiasis
Cation exchange	Acid polysaccharide e.g. pectins	Increased Small intestinal losses of minerals, trace element, heavy metals. Reduction of nutrient availavility	Negative mineral balance, probably compensated for by colonic salvage, antitoxic effect
Antioxident	Lignin (Reducing phenolic groups)	Decreased free redicals in digestive tract	Anticarcinogenesis
Degradability (colonic bacteria)	Polysaccharide(free of lignin)	Increased Gas and SCFAs production, Decreased cecum pH	Flatus, energy production

Eastwood M. A, Kay, R. M and Kay, R. M Strasberg S. M, Kendall *et al.,* (2010), Rastall (2010); Viuda-Martos *et al.,* (2010), Brownlee, 2011

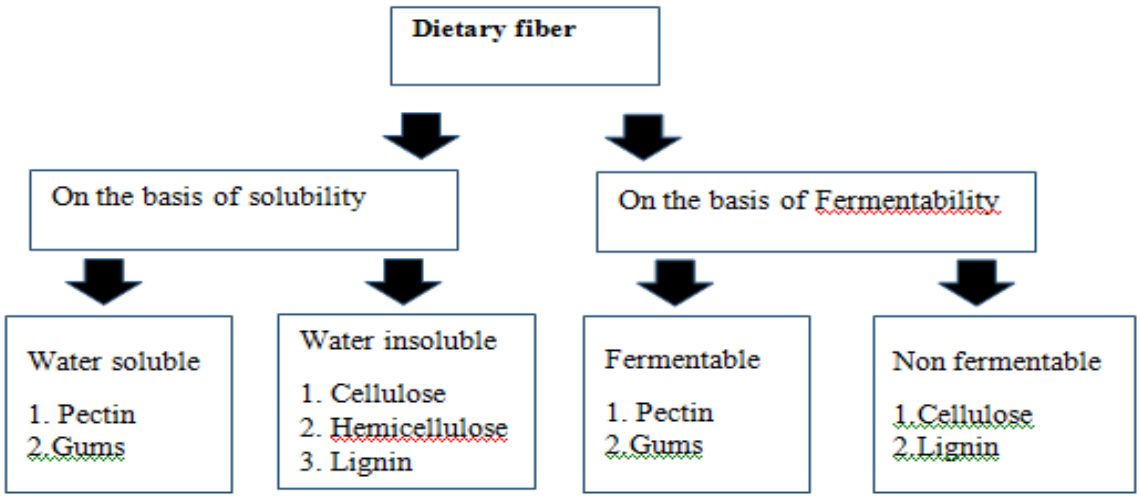
Table.2 Role of Fiber in Prevention and Management of lifestyle related diseases

Disease	Type of fibre involved	Physiological mechanism
Constipation Diverticulosis Irritable bowel syndrome Varicose vein Piles (Haemorrhoids)	Insoluble fibre Cellulose Cereal bran, whole wheat flour, roots vegetable, legumes, outer covering of legumes seeds, apple	Increase the water holding capacity. Increase stool weight. Reduce the transit time. Enhance gastric motility. The consumption of inulin-type fructans affects intestinal microbiota and stimulates bowel movements normalizing stool frequency in constipated patients (Quigley 2011). Volatile fatty acids which are released by the bacteria have a laxative effect. Faster bowel emptying due to increased intra luminal mass bulk.

		It has been demonstrated that galacto-oligosaccharides seemed to promote the intestinal peristalsis and relieve constipation (Li et al. 2013).
Cancer of Large intestine	Insoluble fibre	Change in the population of microbes in the GI tract. Increased binding of intestinal bile acids. Food residue remains in the colon for less time for carcinogen to be absorbed. Increased stool weight and volume. Increased frequency of defaecation. Bulk and water of faeces may dilute the carcinogen to a non- toxic level. Fibre induced effects on faecal nitrogen. Influence on bile acids and mutagens in the colon. Adsorbing cancer producing hydrocarbons (lignins)
Coronary Heart Disease Gall stone	Soluble fibre, β glucon content, oats, pectin. Guargum, psyllium, husk, beans fruits& vegetables	Cholesterol synthesis is inhibited by acetic, propionic, butyric acids produced by bacterial fermentation. Clearence of LDL cholesterol. Slow gastric emptying and binds bile acids. Increases excretion of steroids. Reduces serum fibrinogen and therefore reduce blood clot formation. Reduce fatty acid absorption. Lowers the blood pressure through increased absorption of calcium and magnesium. Fibre binds faecal bile acid and increases excretion of bile acid derived cholesterol.
Diabetes Mellitus	Soluble fibre, legumes seed coverings.	Rate of glucose absorption is decreased because of physical barrier for the outer coating of legumes. Reduced the requirement of insulin. Increased insulin peripheral sensitivity. Alters gut hormones to enhance glucose metabolism in liver. Administration of soluble fibers, such as oligofructose and long-chain inulin, corrected gut dysbiosis, reduced body weight gain and low-grade inflammation, and improved glucose metabolism, which was at least attributed to decreased intestinal permeability and endotoxemia (Cani et al., 2007, 2008). most soluble NSPs, especially polymers with high molecular weight such as guar gum, certain pectins, b-glucans, and psyllium, are viscous, meaning that they are able to form a gel structure

		in the intestinal tract that can delay absorption of glucose and lipids influencing post-prandial metabolism (Deehan et al., 2017).
Obesity	Soluble fibre	Gastric emptying is delayed and feeling of satiety is increased. Diet high in fibre is low in calories. High fiber intake is associated with increased gut microbial diversity and lower long-term weight gain (Menni et al., 2017).

Fig.1 Classification of Dietary Fiber



Pectin

They are the structural components of plant cell walls and also act as intracellular cementing substances. Pectin is highly water soluble and is almost completely metabolized by colonic bacteria. Due to their gelling behavior, these soluble polysaccharides, may decrease the rate of gastric emptying and influence small intestinal transit time. They explain their hypoglycemic properties (Jenkins *et al.,* 1978)

Gums and mucilages

These are type of plant fiber that are not cell wall components but are formed in the specialized secretory plant cells (Van Dennffer *et al.,* 1976.). These are reported to be highly branched polysaccharides that forms gels, bind water and other organic material. Partial enzymatic hydrolysis results in a product that can be used as a soluble dietary fibre. Gum Arabic is exudated from the acacia tree, is a complex arabinogalactan polysaccharide in admixture with a glycoprotein. Mucilage are secreted into the endosperm of the plant seeds where they act to prevent excessive dehydration.

Insoluble dietary fiber

Insoluble fibers are indigestible and insoluble in water. Insoluble dietary fibre are also associated with decrease in intestinal transit time that help to prevent and relive constipation.

Cellulose

It is the major cell wall component in plants, in plants, an unbranched linear chain of several thousand glucose units with β-1,4 glucosidic linkages. Cellulose's mechanical strength, resistance to biological degradation, low aqueous solubility and resistance to acid hydrolysis result from hydrogen bonding within the microfibrils. Aspinall (1970) studies that cellulose is insoluble in strong alkali and there is portion (10-15%) of cellulose, referred to 'amorphous'' that is more readily acid hydrolyzed. Cellulose is not digested to any extent by the enzymes of human gastrointestinal system.

Hemicellulose

These are cell wall polysaccharides by aqueous alkali after removal of water soluble and pectic polysaccharides. They contain backbone of glucose unit β-1,4 glucosidic linkages, but differ from cellulose in that they are smaller in size, contains variety of sugars and are usually branched (Kay 1982). They contain mostly xylose and some galactose, mannose, arabinose and other sugars (Anita and Abraham 1997).

Lignin

It is the woody parts of plant cell wall contributes to the structural rigidity of plants. It is thought to responsible for the resistance of cell wall to microbial degradation. Insoluble in water, and is not digested by colonic bacteria. Lignin demonstrates greater resistance than any other naturally occurring polymer.

Role of dietary fiber in management of lifestyle related diseases

Dietary fiber are important energy sources for cecum and colan-residing microbiota. The diets with a high content of fiber, such as those rich in cereals, fruits and vegetables have a positive effect on health since their consumption has been related to decreased incidence of several type of lifestyle related diseases as due to its beneficial effect like increasing the volume of fecal bulk, decreasing the intestinal transit time, cholesterol and glycemic levels, trapping substances that can be dangerous for the human organism(mutagenic and carcinogenic agents), stimulating the proliferation of the intestinal flora etc.(Heredia *et al.,* 2002, Beecher 1999).

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