



## Significance and elucidation of mechanism of action towards beneficial effects of Dietary fiber: a review

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### ABSTRACT

Dietary fiber includes that part of the plant material which cannot be digested by the enzymes present in the human body. It includes polysaccharides such as cellulose, hemicellulose, gums, pectin, mucilages and also a non-carbohydrate component lignin. Dietary fiber can be categorized under two heads as soluble and insoluble fiber. Studies have indicated positive effects on health on consumption of diet rich in fiber such as whole cereals, nuts, fruits with peels and vegetables especially green leafy vegetables. Consumption of high dietary fiber is linked to less cardiovascular disease, good gut health, reduced body weight, lower level of sugar in blood in diabetes and more important reduced risk of colorectal cancer. They are also known by name "prebiotics" as on fermentation they encourage the growth and multiplication of healthy bacteria in the colon. It is always beneficial to take dietary fiber from sources available in nature instead of supplements as it will furnish us with other essential micronutrients as well. Excess consumption of dietary fiber may be responsible for adverse health effects.

*Keywords: Cellulose, hemicellulose, pectin, gums, mucilages, lignin, fermentation*

### Introduction

The term dietary fiber can be referred to that portion of food ingested which is not hydrolyzed by the enzymes present in our digestive tract but can be fermented by the microflora present in the gut. The undigested food components consist of polysaccharides like cellulose and hemicellulose, mucilages and gums, pectin, lignin, resistant starch and other non-digestible oligosaccharides. "Dietary fiber can be classified as soluble fiber and insoluble fiber" (Anita and Abraham, 1997). Soluble fiber easily dissolves in water to form gel and is fermented in the colon by the bacteria residing in the gut. In this process of fermentation short chain fatty acids like butyric acid, acetic acid and some gases like methane are produced which are absorbed by the large intestines and can be utilized as source of energy by epithelial cells. Fermentable fibers can also be termed as prebiotics. It includes pectin, mucilages and gums and are abundantly found in oatmeal, beans, apples, cherries. Soluble fibers assist in lowering of LDL cholesterol in the blood by modifying the process how the body absorbs dietary fat and cholesterol. It also slows down carbohydrate digestion process which eventually helps to monitor the sugar

levels in the blood. The insoluble fiber lacks the ability to dissolve in water and also digestive enzymes in our body are incapable to metabolize them further into smaller compounds. Examples of insoluble fiber include cellulose, hemicellulose and lignin. Some examples of insoluble fiber, like resistance starches, can be easily fermented in the intestinal colon. Foods with insoluble fibers include whole grain foods like wheat, brown rice, whole pulses, legumes, nuts, seeds and potato skin. Insoluble fiber assist in easy passage of as they provide bulk to the faeces and thus relieves the person of constipation symptoms.

Dietary fiber intake is linked with many health benefits. Consumption of adequate amount of dietary fiber is associated with less chances of coronary heart disease (Liu et al., 1999), hypertension (Whelton et al., 2005), controlled diabetes (Montonen et al., 2003), weight loss (Lairon et al., 2005) and many gastrointestinal disorders (Petruzzello et al., 2006). Dietary fiber is also marketed as food supplements at the commercial level and incorporated as food additives in the manufacture of some food products. They are sold to the consumers due to their proven health advantages like treatment of few gastrointestinal problems and for other associated beneficial health effects. The consumption of excess dietary fiber is linked with harmful side effects. In India dietary fiber intake varies among different socioeconomic strata from 15 to 41 g/day. Adults and children can achieve the required dietary fiber intake with inclusion of a variety of fruits and vegetables with peels, legumes, and whole-grain products. The paper reviews the beneficial effects of dietary fiber on our health and also helps us understand the mechanism underlying these benefits.

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## Benefits of Dietary Fiber Intake:

Dietary fiber has been found to play many important physiological roles in our body.

**1. Cardiovascular health and Dietary fiber:** Cardiovascular diseases seem to be one of the leading causes of morbidity and mortality spread all over the world. Higher intake of dietary fiber may help beneficial to improve serum lipid levels (Brown et al., 1999), control blood pressure (Keenan et al., 2002) and lower inflammatory marker levels (Anderson et al., 2009) which explains the importance of dietary fiber in improving cardiovascular health. "Diets with adequate amount of dietary fiber are linked with less prevalence of coronary heart disease, stroke incidence and peripheral vascular disease" (Merchant et al., 2003). Total dietary fiber intake had connection with lowering LDL - cholesterol values in serum significantly while soluble fiber was linked with reduced systolic blood pressure and total cholesterol values (He et al., 1995). "Studies with guar gum emphasized that soluble or viscous fibers have significant hypocholesterolemic effects" (Butt et al., 2007). In addition to having positive effects on serum lipoproteins and blood pressure, regular consumption of dietary fiber has good effects on reduction of weight body weight, visceral fat and insulin resistance (Delzenne and Cani, 2005; Davy and Melby, 2003; Dahl and Stewart, 2015).

"The hypocholesterolemic effects dietary fiber has been extensively studied by several researchers and reports suggest that soluble fibers have the ability to lower serum cholesterol and LDL-cholesterol amount by binding bile acids and making them unavailable for absorption in the small intestine and thereby enhancing their excretion in the faeces" (Kirby et al., 1981; Mirmiran, 2016). Also, the formation of the short-chain fatty acid like propionate by the fermentation of dietary fibers in the intestinal colon may contribute decreased levels of cholesterol (Wong et al., 2006). Short-chain fatty acids also aid in increasing the acidic environment of colon luminal. The acidic pH is well known to decrease the ease of solubility of the free bile acids, and hence contribute to increase in excretion of bile and at the same time decrease the conversion of free bile acids to more toxic secondary bile acids.

### 2) Diabetes and Dietary Fiber:

Diabetes, a prevalent lifestyle related disorder is reported to be increasing at an alarming rate across the world. "Higher levels of dietary fiber intake have been linked with a considerable decrease in the prevalence of diabetes" (Lindstrom et al., 2006; Yao et al., 2014). Insulin resistance, dyslipidemia, visceral fat deposit can be controlled by consuming high amount of dietary fiber (Anderson et al., 2008). Also, dietary fiber helps to reduce postprandial rise in blood sugar and insulinemia and thus increases insulin sensitivity (Weickret et al., 2006). Diets having higher fiber have positive impact on glycemic index which encourage diabetic people to daily consume a variety of fiber (Bantle et al., 2008). "Consumption of cereal help in lowering of fasting blood glucose and insulin concentrations. This happens as cereals made from oats and barley contain water-soluble gel-forming fibers such as beta-glucan. On reaching the small intestine these fibers form a viscous solution, hence reducing the contact and mixing of carbohydrates with the digestive enzymes. This delays the absorption of glucose which leads to reduction in postprandial plasma and insulin levels" (Bernstein et al., 2013). According to report of recent studies soluble fibers have shown to delay gastric emptying and reduce

absorption of macronutrients, contributing to reduced levels of postprandial blood glucose and insulin levels (Anderson et al., 2004; Mogos et al., 2017).

**3) Obesity and Dietary Fiber:** Obesity is a condition which occurs when there is excessive fat accumulation in the body. It is the cause of impaired health condition. Now-a-days obesity is becoming very prevalent. It further becoming a risk factor for various other non-communicable diseases. Many factors like reduced physical activity, more energy intake, less consumption of fruits and vegetables, faulty habits like smoking and drinking excess alcohol leads to obesity (Chau et al., 2012; Aronne et al., 2009). Moreover, excessive accumulation of fat in the body becomes causative factor of many chronic degenerative diseases like cardiovascular, hepatic (Kaplan, 1998), formation of gallstones (Maclure et al., 1989), disturbances in intestines (Eslick, 2012) and diabetes (Steppan et al., 2001). A lot of studies have shown an opposite relationship between the intake of dietary fiber and accounted weight loss (Slavin, 2005). Fiber content in food adversely affects the palatability of food and this might lead to reduced energy intake (Drewnowski, 1998).

Also, feeling of greater satiety due to consumption of dietary fiber as compared to simple carbohydrates have been quoted in numerous studies (Howarth et al., 2001). Pereira and Ludwig (2001) stated "that several factors of greater satiety response are primarily due to viscosity, gel formation and bulking". Dietary fiber provides bulk to the meal, thus including it in the meals lowers its energy content. Fruits and vegetables possess both soluble and insoluble components of fiber. It has been reported that by including both soluble and insoluble fiber there is increase in satiety (Yao and Roberts, 2001).

**4) Digestive Health and Dietary Fiber:** Our diet has an impact on the composition and diversity of gut microbiota. "The main carbohydrates that reach our large intestine are non-starch polysaccharides, resistant starch, non-digestible oligosaccharides and polysaccharides and some modified starches" (Elia and Cummings, 2007). These fiber components are further partially or completely metabolized and fermented with the help of gut microflora in the colon. In the process of fermentation several gases like methane, hydrogen, and carbon dioxide and compounds like short chain fatty acids (SCFA) like acetate, propionate and butyrate are made. Due carbohydrate substrate availability in the colon there is an increase in the population of bacteria leading to increase in volume of faecal mass. Also, dietary fiber possesses the ability to absorb water, hence make the stools soft. Dietary fiber helps to relieve symptoms of constipation. The SCFA thus produced has several beneficial effects. Butyrate is used by colonocytes as source of energy and thus protects the health of these cells and finally the colon.

SCFA increased the acidic environment of the colon thereby stopping the growth of pathogens and also the production of toxic products (Gray, 2006; Scott et al., 2008). SCFA absorbed into the blood supply also has a positive impact on lipid and carbohydrate metabolism. Non digested oligosaccharides possess prebiotic properties as they encourage the production of beneficial gut bacteria (Gibson et al., 2004). A prebiotic is defined as "food ingredient which is not digestible but affects beneficially the host by selectively enhancing the growth or activity of bacteria present in the colon, and thus improving host health" (Gibson and Roberfroid, 1995). Inulin and oligo fructose are examples of

prebiotics which are naturally present in several fruits and vegetables.

A negative correlation has been indicated in research studies in the occurrence of diverticular disease and fiber intake. Diverticulosis is a typical condition which is characterized by the formation of sac-like structures, diverticula within the colon. Diverticula formation occurs due to pressure induced damage to the colon. Low fiber intake in the diet leads to hard stools formation and thus increases intracolonic pressure (Escott and Raymond, 2012; Abdullah, 2015). It was found that by taking dietary fiber the chances of diverticular disease incidence is reduced to an extent (Burkit, 1973).

**5) Cancer and Dietary Fiber:** Colorectal cancer is the one of the most common types of cancer. Fiber intake has been linked to reductions in colorectal cancer risk. Whole grain foods rich in dietary fiber have been correlated with the reduced risk of colorectal cancer by enhancing stool bulk, diluting carcinogens present in faeces and decreasing transit time, hence reducing the contact time between the carcinogens and the lining of colorectum (Lipkin et al., 1999). Also, the SCFA produced by the fermentation of fiber by bacteria has protective effects against colorectal cancer (Slavin, 2000). "Other components of whole grains that exert protective effects against colorectal cancer include antioxidants, vitamins, minerals, phytate, phenolic acids, lignans and phytoestrogens" (Aune et al., 2011; Cotterchio et al., 2006). Also, fruits and vegetables rich in dietary fiber have been reported to be protective against colorectal cancer (Santarelli et al., 2008). Dietary fiber has also been linked with the reduction in gastric cancer risk. Bravi et al., (2009) reported an inverse relationship between prevalence of stomach cancer risk and intake of fiber. The role of dietary fiber in preventing other types of cancers is not clear stated.

### Side Effects of Consuming Excess Dietary Fiber

Consuming excess amounts of dietary fiber may pose adverse health effects in our body. Main symptoms include production of gas, feeling of bloating and diarrhea. These symptoms are worsened if with increase in fiber is not accompanied by adequate fluid intake and proper physical activity. At higher levels of consumption there is flatulence and abdominal fullness. Also, there is always a risk of binding of important minerals like calcium, magnesium and phosphorus with the fiber. Long time consumption of high fiber diet may result in deficiency of these minerals. It may also reduce effectiveness of some medications. Another important concern is diet rich in fiber is usually bulky and low in energy density. Hence, in underweight individuals high fiber diets may satisfy the appetite but will not be able to meet the energy and other nutrient requirement of a person. This can cause poor nutritional status of an individual.

These days there are numerous fiber supplements available in the market. Psyllium, which is also called ispaghula, is commonly used supplement. It is made from the seed husks of the plantago ovata plant. It contains 70 percent soluble fiber and some amount of insoluble fiber, so it passes through the gut unchanged, providing bulk and help us in passing stools on regular basis. But, instead of buying these supplements consumption of naturally occurring fiber rich food like whole grains, fruits and vegetables with peels should be advised. This will improve the nutritional value of the diet by supplying other important nutrients as well (Stanner et al., 2004). It will also reduce the likelihood of harmful effects of dietary fiber.

### Recommendations for Dietary Fiber

"The ICMR recommends that the daily diet of an adult should have at least 40 gram of dietary fiber as based on 2000 Kcal diet" (Rao, 2010). It is recommended to include a variety of whole grains and their products and also to have at least four to five servings per day of fruits and vegetables. In addition to dietary fiber a sufficient amount of water should be taken daily. Some tips to include more fiber in our daily life are:

- Read the Food Label carefully: Simply mentioning whole grains is not sufficient on the food label. The nutrition facts have to be checked properly. A good thumb rule is to choose a food that has at least 2-3-gram fiber per serving.
- Know good sources of fiber: Oats, barley, vegetables specially greens and fruits (with peels), brown rice, nuts, legumes, peas, and whole-grain breads are few examples of foods to look for on shelves.
- Incorporate a variety of foods: Most foods have combination of both soluble and insoluble fiber. So, pick more variety of foods.
- Low intake of processed and refined foods: Processed foods are poor source of fiber. Instead of snacking on them have healthy fiber rich choices like salads, nuts, fruits and veggie slices to satisfy hunger between the meals.
- Go Slow: Do not abruptly increase the fiber in your diet. Go slow and give time to your body to adjust with fiber. Also include ample water in your daily routine.

### Conclusion

Dietary fibers are known to have a wide range of physicochemical properties and corresponding beneficial physiological effects. The role of fiber in health includes improved laxation, reducing risk factors for cardiovascular disease, weight management, improving immune function, and better colonic health. Characteristics such as solubility, fermentability, and viscosity are important determinants of the effects which are exerted by the fiber in the body. Increasing fiber consumption in our diet will certainly lead to health improvement and disease prevention. Food sources of dietary fiber, as compared to the supplements have the added benefit as they possess micronutrients and phytochemicals that may further improve human health. In addition, a higher fiber intake provided by foods is likely to be less calorically dense. Health benefits from consuming dietary fiber must be actively communicated to the public in awareness programs to reduce the occurrence of many chronic degenerative diseases.

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