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Role of dietary fibre in metabolic syndrome

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Abstract
Metabolic syndrome describes a group of metabolic irregularities that occur together in an individual. The number of individuals diagnosed with metabolic syndrome has risen dramatically in recent years. Metabolic syndrome significantly raises the risk of developing cardiovascular disease and type2 diabetes mellitus, obesity, and hypertension. Dietary fiber is deemed to be a key component in healthy eating. The main purpose of this review is to know the possible health benefits of dietary fibre intake in patients with metabolic syndrome. Dietary fibers are often simply described as any non-digestible carbohydrates that are not broken down in the intestinal tract. Dietary fibre has been distinguished for their beneficial contribution to over all health. The diet high content of fiber is helpful in prevention of metabolic syndrome. The diet with a high content of fibre such as cereals, fruits and vegetables have a positive health effect on health and also play a important role in the prevention of metabolic syndrome.

Keywords: obesity, hypertension, carbohydrate, type 2 diabetes

Introduction

In 1974 Barkitt *et al*. (1974) [1] linked dietary fiber to the prevention of a range of illnesses and conditions. More recent scientific research confirms this link (Reaven, 1988; Kaplan, 1989) [2]. Metabolic syndrome is a cluster of metabolic risk factors that come together in a single individual. These metabolic factors include insulin resistance, hypertension (high blood pressure), cholesterol abnormalities.

Metabolic syndrome is considered to be a risk factor for cardiovascular diseases and type 2 diabetes. Insulin resistance refers to the diminished ability of cells to respond to the action of insulin in promoting the transport of the sugar glucose, from blood into muscles and other tissues. Type 2 diabetes is caused by insulin resistance.

Dietary fiber is the name given to a group of components present in foods of vegetable origin (cereals, fruit, vegetables and pulses) which are not broken down by human digestive enzymes (De Vries *et al*., 1999; Dietary Fiber Definition Committee of the American Association of Cereal Chemists, 2001).The consumption of healthy, low-calorie, and nutritionally balanced foods containing dietary fiber (DFs) has become a growing focus among consumers. For some time, DFs have been distinguished for their beneficial contribution to overall health. A broad array of food applications are being enriched and advertised based on their DF content. DFs have been targeted for their positive effects regarding the treatment and prevention of constipation, the control of serum cholesterol levels, the reduction of the risk of diabetes and intestinal cancer, and the stimulation of beneficial microorganisms.

Definitions of dietary fiber

DFs are often simply described as any non-digestible carbohydrates that are not broken down in the intestinal tract. However, scientific and regulatory bodies around the world define fiber differently. In 2009, the Codex Committee on Nutrition and Foods for Special Dietary Uses (CCNFSDU) established an internationally accepted legal definition of DF. The definition states, "Dietary fiber means carbohydrate polymers with ten or more monomeric units, which are not hydrolyzed by the endogenous enzymes in the small intestine of humans and belong to the following three categories: Edible carbohydrate polymers naturally occurring in the food as consumed. Carbohydrate polymers, which have been obtained from food raw material by physical, enzymatic or chemical means and which have been shown to have a physiological effect of benefit to health as demonstrated by generally accepted scientific evidence to competent authorities. Synthetic carbohydrate polymers which have been shown to have a physiological effect of benefit to health as demonstrated by generally accepted scientific evidence to competent authorities".

Table 1: Classification of dietary fibre components based on water solubility/fermentability

Characteristic	*Fibre component*	*Description*	*Main food sources*
Water insoluble/ Less fermented	*Cellulose*	Main structural component of plant cell wall. Insoluble in concentrated alkali, soluble in concentrated acid.	Plants (vegetables, sugar beet, various brans)
	Hemicellulose	Cell wall polysaccharides, which contain backbone of β-1, 4 glucosidic linkages. Soluble in dilute alkali.	Cereal grains
		Non-carbohydrate cell wall component.	Woody plants

	Lignin	Complexcross-linked phenyl propane polymer. Resists bacterial degradation.	
Water soluble/ Well fermented	*Pectin Gums Mucilages*	Components of primary cell wall with D-galacturonic acid as principal components. Generally water soluble and gel forming Secreted at site of plant injury by specialized secretary cells. Food and pharmaceutical use. Synthesized by plant, prevent desiccation of seed endosperm. Food industry use, hydrophilic, stabilizer.	Fruits, vegetables, legumes, sugar beet, potato Leguminous seed plants (guar, locust bean), seaweed extracts (carrageenan, alginates), microbial gums (xanthan, gellan) Plant extracts (gum acacia, gum karaya, gum tragacanth)

DF includes several chemical classes: *non-starch polysaccharides* (polyglucoses such as cellulose, hemicellulose and β-glucans, polyfructoses [such as inulin], natural gums and heteropolymers such as pectin), *oligosaccharides, lignin* (a non-carbohydrate complex of polyphenylpropane units functionally linked to polysaccharides, increasing resistance to digestion), *fatty acid derivatives* (waxes, cutin, suberin, serving as cross-links between the main constituents), *other plant substances* (mucilages, storage polysaccharides, phytates) *and analogous polysaccharides* (by-products of food production affecting digestibility, or purposefully synthesized compounds).

A simpler classification divides DF into *soluble* (pectins, gums, mucilages and storage polysaccharides) and *insoluble* fiber (cellulose, hemicelluloses, lignin) on the basis of water solubility. Soluble fiber has favorable effects on glucose and lipid metabolism that are partly attributed to the increased viscosity of luminal contents. Colonic fermentation of soluble fiber yields short chain fatty acids, which may have beneficial effects on lipid metabolism, cardiovascular disease prevention, mucosal differentiation or apoptosis and mucosal barrier function.9 Insoluble fiber also has a generally low fermentability, but it possesses passive water-attracting properties promoting fecal bulk, softening and laxation.

Role of dietary fibre in metabolic syndrome

The diets with a high content of fibre, such as those rich in cereals, fruits and vegetables have a positive effect on health since their consumption has been related to a decreased incidence of several types of diseases as due to its beneficial effects like increasing the volume of fecal bulk, decreasing the time of intestinal transit, 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) [8, 9].

Metabolic syndrome describes a group of metabolic irregularities that occur together in an individual. It is well documented as independent risk factors for cardiovascular disease. When grouped together in this syndrome, the risk of developing cardiovascular disease, as well as type 2 diabetes, is increased. A large number of randomized studies in humans and experimental models have demonstrated evidence of the effectiveness of foods rich in DF positively regulating body weight, appetite, gluconeogenesis, sensitivity to insulin and cardiovascular disease risk factors such as low-density lipoprotein (LDL) and hypertension. More recently, studies of DF refer specifically to the beneficial effects on most of the homeostatic abnormalities present in individuals affected by the metabolic syndrome.

DF consumption and body weight

A number of mechanisms have been suggested for how DF positively impacts weight management, including promoting satiation, decreasing absorption of macronutrients, and altering secretion of gut hormones. A large number of observational studies show an inverse, and often dose-dependent, correlation between DF intake and body weight. Effects were found with individuals in the highest vs. lowest percentile of DF consumption gaining 3.6 kg less over a period of ten years. Several short-term interventional studies conducted with whole foods high in DF and with supplemental fiber further demonstrate that notable losses of body weight can be achieved with high DF diets. Howarth *et al*. concluded that increased DF intakes have been associated with a body weight loss of 1.9 kg over 3.8 months with greater weight loss in more obese subjects.

Studies have also been conducted to determine differences in the effects of fermentable and non-fermentable DFs with regard to weight loss and satiety. Surprisingly, no clear difference regarding weight gain or loss has been shown between SDF and IDF and fermentable and non-fermentable DF, or between foods naturally high in DF and fiber supplements in human studies. Nevertheless, reductions in the body weight of subjects consuming high DF diets most surely contribute to a reduced risk of the development of metabolic syndrome as well as type 2 diabetes [16]. One of the reasons that weight loss programs mandating a diet high in fiber are consistently more successful is that DF has been found to reduce hunger, especially in low fat diets. The fibers expand creating a bulking effect while promoting a feeling of “fullness” making it easier for the dieter to adhere to their program.

Hypertension

Hypertension associated with MS may originate from several participating factors. These factors may include the degree of sympathetic activity within the central nervous system, adjustments in salt sensitivity and management in the kidneys, endothelin-1 mediated vasoconstriction, and angiotensin II. Moreover, increases in FFA have been shown to impair vascular reactivity in humans, which is detrimental to sustaining normal blood pressure. CO has also been considered to influence hypertension, being an even stronger risk factor than general obesity. Visceral adipose tissue secretes more angiotensinogen than subcutaneous fat, which may increase blood pressure via altering the renin-angiotensin system through increasing this system’s main substrate (angiotensinogen) resulting in vasoconstriction.

Glycemic Control

Dietary fiber has been shown to effectively regulate both IR and T2DM. Fiber has the unique ability to adsorb certain molecules within the gastrointestinal tract. Enzymes involved with carbohydrate digestion may be affected by viscous fibers creating a wall that hinders their action as a catalyst. Fiber viscosity is particularly important by temporarily suspending glucose assimilation, slowing transfer time, lowering blood glucose concentrations, and having a positive influence upon hormone responses, such as insulin and glucagon-like peptide 1, ultimately influencing nutrient uptake. In addition to these unique features, data from epidemiological studies discovered a inverse correlation with insoluble fiber intake and developing T2DM.

Breast and colorectal cancer

The research by John *et al*. showed that high dietary in-takes of fruit and vegetables are associated with reduced risk of cancer [18]. Many studies on antioxidant bioavailability indicate that food microstructure affects the release of several nutrients, mostly antioxidants. Around 50% of the total dietary antioxidants (mainly polyphenolics) are linked to dietary fibre, being released in the colon.

The meta analysis by Dong *et al*. provides evidence of a significant inverse dose response association between dietary fibre intake and breast cancer risk (10 g/d increment in dietary fibre was associated with a 7% risk reduction). The Aune *et al*. systematic review and meta analysis of prospective observational studies showed that high intake of fibre from cereals and wholegrain food is significantly associated with reduced risk of colorectal cancer. The results showed a 10% reduction in risk of colorectal cancer for each 10 g intake of fibre daily. Whole grains are a rich source of many components which also may have protective effects: antioxidants, vitamins (folate), minerals (calcium, magnesium), phytate, phenolic acids, lignans and phytoestrogens. Higher intakes of dietary fibre from plant foods and whole grains are associated with other healthy behaviors: higher intakes of calcium and folate, higher physical activity, better weight maintenance, lower prevalence of smoking, and lower intakes of red meat and alcohol. The biological mechanisms responsible for beneficial effects of fibre include: increased stool bulk, dilution of faecal carcinogens in the colonic lumen, reduced transit time, and production of short fatty acids by bacterial fermentation. Recently the science of nutrigenomics suggested the effects of fibre on the genome and interaction between human and micro biota genomes modifying their gene expression.

Conclusion- The plant material in diet resistant to enzymatic digestion is termed as dietary fibre. It includes cellulose, hemicellulose, pectic substances, gums, mucilages and lignin etc. Dietary fibre is naturally present in cereals, fruits, vegetables and nuts. The diets with high content of fibre have been reported to have a positive effect on health. Dietary Fibre exerts clinical benefits on all the abnormalities. Dietary fibre play crucial role in prevention of metabolic syndrome such as Obesity, Diabetis, Hypertension etc. Apart from the prevention of metabolic syndrome dietary fibre is helpful in maintenance of good health.

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