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SUMMARIZING EVIDENCE BASED INFORMATION ON THE MEDICAL IMPORTANCE OF DIETARY FIBRE

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Abstract
The human body functions best on a diet that is low in sodium, contains a moderate amount of protein and is high in fibre, complex carbohydrates, vegetables and fruits. Interest in dietary fibre recently resurfaced because of its potential beneficial effects for health. Associations between high fibre intake and lower incidence of human diseases, such as coronary heart disease, diabetes and bowel diseases have been reported. High fibre diet is linked with low density lipoprotein (LDL) cholesterol and total cholesterol and good cardiovascular health. It is also implicated in the alleviation of age – related diseases such as cancer and dementia. The importance of dietary fibre in human health and bodily mechanisms has continued to be a subject of discussion within the scientific community. Dietary fibre has important health benefits in childhood, especially in promoting normal laxation. Currently, children consume amounts of dietary fibre that appear to be inadequate for optimal health promotion and disease prevention. In view of the medical importance of dietary fibre viz-a-viz increases in reported cases of chronic life – threatening diseases, this paper aims at reviewing the current trend with a view to further emphasize the need for intake of foods rich in fibre for the benefit of man and animals. It was established that dietary fibre is a preventive as well as a curative agent in the daily diet and ways to improve the fibre content of popular foods should be sought.

Keywords: Dietary fibre, fruits, vegetables, antioxidant trafficker, bioregulator, chronic diseases, health, digestive system, humans, animals

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1. INTRODUCTION

Among the current dietary trends, consumption of food products with reduced content of digestible carbohydrates has gained popularity (Romero-Lopez et al. 2011). Dietary fibre (DF) is a food ingredient that is neither digestible nor absorbed in the small intestine of humans. Consumers are demanding foods with additional health benefits apart from the nutritional aspects of the food. Such foods are often called functional or nutraceutical foods. It is reported that the world is rapidly changing with attendant altered food habits and stressful life styles and awareness is increasing that a healthy digestive system is essential for the overall quality of life (Burton, 2000).

The physiological effects of DF in foods are being increasingly recognized (Punna and Paruchuri, 2003). Dietary fibre gained more importance since Burkitt et al. (1972), Burkitt (1973) and Trowell, (1973) found a direct relationship between fibre-deficient diets and the development of certain chronic and degenerative diseases such as ischaemic stroke, myocardial infarction, which are closely related to atherosclerosis that is more common in industrialised countries. Typical health benefits which are now believed to be associated with an increased intake of dietary fibre includes weight loss, protection against certain types of cancer, decrease in blood cholesterol levels, reduced insulin requirements for diabetes and blood-pressure regulation, reducing the risks of many disorders such as cardiovascular diseases, intestinal constipation, diverticulosis and obesity (Hung et al. 2003; Theuwissen and Mensink, 2008). Since an increased intake of dietary fiber is believed to be of medical importance for the prevention of chronic diseases, this review was done to further

highlight the importance of consumption of foods rich in dietary fibre for the health benefit of humans.

2. MATERIAL AND METHOD

This review was done by discussing various research works by nutritionists and clinicians to which were added some personal studies. These studies relate the consumption of dietary fibre – rich foods with lowered incidence of chronic degenerating diseases. The study on the use of bioregulators for the increase of dietary fibre content of foods (Olaiya et al., 2010) and the feasibility of harnessing pineapple pulp for edible use as a safe and acceptable powdered product to fortify wheat flour (Ackom and Tano-Debrah, 2012) were given as examples of producing high-fibre foods apart from reducing refined flour in food products.

3. RESULTS AND DISCUSSION

Definition, Sources and Composition of Dietary Fibre

Trowell (1960) and then Burkitt (1960) in separate investigations observed that a number of the diseases common to the Western societies were notably absent in Africa; and these were called non-infective diseases. They are currently known as diseases of western civilization, implying a causative agent in the environment and in the way of life in these places. The most common cause was said to be diet and the most notable thing in the diet among the countries in question was the very low content of unrefined carbohydrates, that is, the dietary fibre. Trowell (1972) suggested that it is the dietary fibre and not the crude fibre that protects against diseases.

Dietary fibre is a complex of non-digestible carbohydrates and lignin that are intrinsic and intact in plants and are resistant to digestion and absorption in the small intestine. Dietary fibre has beneficial physiological effects, such as laxation, reduction in blood cholesterol and post-prandial blood glucose modulation (Babio *et al*. 2010). Traditionally, dietary fibre has been classified on the basis of its solubility in water (soluble and insoluble). However, the National Academy of Sciences Panel for the definition of dietary fibre recommended that the terms soluble and insoluble should be gradually replaced by terms referring to the specific beneficial physiological effects associated with the fibre, viscosity and fermentability (IMFNB, 2002).

Dietary fibre can be found in foods like cereals grains, legumes, vegetables and fruits (tropical), nuts and seeds (Van Soest *et al*. 1982; Schauss et al., 2006). The higher the maturity of plants, the higher the lignin content and the higher the fibre quality (Van Soest *et al*. 1982). Total dietary fibre has two main components: (i). The insoluble dietary fibre which includes cellulose, hemicellulose, lignin, cutin and plant waxes. (ii). The soluble dietary fibre such as the pectins, the plant gums, the ß-glucans and other gums. In terms of physiological activity, generally, the soluble dietary fibre is more effective in reducing hyperlipidaemias, while the insoluble dietary fibre is better for preventing alimentary system dysfunctions, like constipation (Prosky and DeVries, 1992). The recommended daily intake for total fibre is: adult males, under age 50 (38g); adult males, over age 50 (30g); adult females, under age 50 (25g); adult females, over age 50 (21g) and adult pregnant females (25-35g).

Dietary fibre is important in the management of some metabolic disorders and may independently protect against the onset of other diseases (Anderson *et al*., 1990). Studies on humans have demonstrated that addition of Slowly Digestible Starch (SDS) and Resistant Starch (RS) in the diet can produce health benefits (Hendrich, 2010). It was suggested that a diet rich in non-refined carbohydrates and fibre is associated with a lower prevalence of chronic diseases (Trowell, 1972; Burkitt and Trowell, 1975).

Dietary Fibre and Coronary Heart Diseases

Many epidemiological studies have strongly suggested a reversal correlation between dietary fiber intake and type-2 diabetes mellitus and mortality due to coronary heart disease (Rimm *et al*. 1996; Babio *et al*. 2010; Mosa-

Al-Reza *et al*. 2012). Cardiovascular disease is reported to be uncommon in those parts of the world where dietary fibre intakes are high. Hypercholesterolaemia is one of the most important risk factors for coronary heart disease (CHD) (Bhatnagar et al., 2008). It is reported that soluble fibres can lower serum cholesterol levels by 20 to 30%, thus significantly reducing CHD risk (Anderson *et al*., 1990). The risk for CHD is reported to be closely linked to increased LDL-cholesterol and apolipoprotein B-100 levels (Durrington, 2003). CHD risk is inversely linked to HDL-cholesterol and apolipoprotein A-1 levels. Dietary fibre effects on triglycerides and HDL-cholesterol are variable for different dietary fibres. Most soluble fibre sources generally reduce LDL-cholesterol while oat-bran selectively lowers LDL-cholesterol and maintains or increases HDL-cholesterol (Gold and Davidson, 1988).

Dietary changes leading to decreases in Apolipoprotein B (APLP-B) and to increases in APLP-A would therefore be desirable as an indicator of reduced risk to heart disease. The APLP-A and APLP-B levels would better relate to heart disease and their quantitation is more accurate and precise than the quantitation of LDL and HDL-cholesterol (Vega *et al*. 1982). Babio *et al*. 2010 reported that clinical studies consistently show that the intake of viscous dietary fibre decreases the low density lipoprotein cholesterol and post-prandial glucose levels and induces short term satiety.

Dietary Fibre and Serum Hyperlipidaemia

Serum hyperlipidaemia refers to the elevated levels of a number of entities in the blood stream relating back in some way to an increased risk of coronary heart disease. Serum lipid levels are probably one of the most metabolic risk factors for cardiovascular disease and abnormalities in plasma lipoprotein and increase in lipid metabolism rank among the most firmly established and very important risk factors for atherosclerosis (Theuwissen and Mensink, 2008). Triglycerides and cholesterol are biological lipids and increase in their intake in the diet is associated with the cause of two prevalent cardiovascular risk factors, hypertriglyceridaemia (Samarghandian *et al*. 2011) and hypercholesterolaemia (Walldius *et al*. 2004). Dietary fibre has received attention for its protective role against high plasma total cholesterol. The soluble parts of various dietary fibre sources, as found in barley, bran and oat, have the potential for lowering plasma total cholesterol and low density lipoprotein cholesterol (Mosa-Al-Reza *et al*. 2012).

Dietary Fibre and Diabetes

In 1981, Trowell claimed to have first observed a relationship between dietary fibre intakes and diabetes. This was when he observed that the stout Akikuyu nurse-maid of a British employer had an obvious case of non-insulin-dependent diabetes mellitus (NIDOM) whereas none of the rest of his patients had developed this syndrome. Prior to his postulation of this relationship, (Kiehm *et al*., 1976; Anderson and Ward, 1979 and Rivellese *et al*., 1980) had designed and carried out a number of studies that showed beneficial effects of high-fibre diets for individuals afflicted with the disease. Numerous beneficial effects were exhibited in both insulin-dependent (Type 1) and non-insulin dependent (Type 2) diabetes by dietary regimens restricted in fat and incorporating high levels of, or supplemented with, dietary fibre and complex digestible carbohydrates. The benefits are reduced insulin requirements, increased peripheral tissue insulin sensitivity, decreased serum cholesterol and serum triglycerides, better weight control and potentially lower blood pressure (Anderson *et al*., 1987).

The soluble dietary fibres and low glycaemic index foods appear to exhibit the greatest therapeutic effects for individuals suffering from this malady (Wolever, 1990; Maritim et al., 2003).

Dietary Fibre and Hypertension

Various studies on population groups have indicated that the vegetarians have a relatively lower blood pressure compared to those who insist on an omnivorous diet. Further comparative studies, either between vegetarians and control groups, or between individuals on high-fibre diets and those on more traditional diets, have confirmed that increased dietary

fibre intakes can reduce hypertension (Anderson *et al*. 1990). Castelli and Anderson, (1986), tabulated the results of sixteen studies measuring the effect of dietary fibre on hypertension and fifteen of these studies showed a significant reduction in blood pressure, as a result of dietary fibre inclusion.

Dietary fibre may play only a part in the effect observed on hypertension. Shils (1988) has pointed out that increasing magnesium intakes could significantly reduce hypertension. Studies by (McCaman and Moris, 1987 and Meneton et al., 2005) have also indicated a possible mineral intervention in controlling the blood pressure. Increasing the level of calcium either in the diet or by supplementation significantly reduced the blood pressure in roughly one-half of the hypertensive patients studied. Dietary fibre sources, many of which are whole grains, vegetables, fruits or legumes are also very often sources of both magnesium and calcium.

Dietary Fibre and Colon Cancer

The relationship between dietary fibre and colon cancer incidence has been the primary focus of studies seeking a relationship between the intake of dietary fibre and cancer. Colon cancer, whose incidence and mortality rates have not changed significantly for the past fifty years or more in the technologically-advanced countries, is second only to lung cancer (Lanza, 1990). This disease has the greatest impact in these areas, since dietary fibre has profound impact on the other functions of this organ.

Burkitt, (1971) did postulate that larger-bowel cancer could be prevented or its incidence reduced, by increasing the level of dietary fibre consumed by individuals in a population. The factors involved with, or relating to large-bowel cancer incidence, or to its reduction, as influenced /effected by dietary fibre are: (i) Increased stool weight (ii) Colonic content dilution (iii)Intestinal transit-time (iv) Colonic microbial metabolism (v) Faecal enzymes (vi) Colonic fermentation (vii) Production/ distribution pattern of short-chain fatty acids produced in the colon (viii) Increased faecal nitrogen excretion (ix) Bile acids and mutagens present in the colon and (x) The colon pH.

Indications that the risk of colon cancer is reduced with increased dietary fibre intakes are borne out by studies, where Lanza, (1990) summarized some 48 different studies on the relationship of dietary fibre to colon cancer. 38 cases (79%) of the studies showed a positive inverse relationship, seven cases (15%) showed a negative inverse relationship. It has been hypothesized that the excess straining and the increased hardness of the faecal content resulted from low-fibre intakes, especially of cereal fibre (Burkit, 1985) probably sub-optimal in some vitamins, and minerals.

Recent research has shown that dietary fibre act as an antioxidant trafficker by safely transporting antioxidant nutrients to the colon thereby protecting and insulating the intestines from cancer.

Dietary Fibre and Diverticular Disease

This disease appears to coincide with significant drops in dietary fibre intakes (Dreher, 1987). It is one of the diseases that provide a clear-cut case of cause-effect relationship with dietary changes and is virtually unheard-of in developing countries (Painter, 1985). It is quite prevalent in countries that have greater availability of processed foods; however, there is no total agreement on the relative incidence of the disease, particularly with regards to historical trends. Eastwood, (1990) has pointed out that some of the extensive differences in the findings on the incidence of the disease may be related to the availability of barium enemas, since the disease is hard to diagnose without the aid of this technique.

Generally, diverticulosis is asymptomatic, with the individual never realizing its presence. In cases where it becomes symptomatic, the unfortunate victim suffers intermittent periods of low-grade fever and pain both of which become steady, with the pain often becoming similar to that of appendicitis. Painter, (1985) and later Eastwood (1990) indicated that, in general, dietary fibres were not necessarily effective in treating this ailment but that coarse wheat bran, on the other hand, was very effective.

Dietary Fibre and Immunomodulation

Chronic inflammation is associated with increased risk of cancer development (Grivennikov et al 2010), and patients with inflammatory bowel diseases, such as ulcerative colitis and Crohn's disease, have increased risk of developing CRCs (Coussens, 2002). Dietary fibre is reported to protect against development of colorectal cancer (CRC) (Burkitt, 1973). Plasma levels of the acute phase protein C - reactive protein (CRP), a marker of inflammation are elevated in persons who subsequently develop CRC (Erlinger *et al*. 2004). Increased intake of dietary fibre is reported to reduce the levels of CRP (Ajani *et al*. 2004; King *et al.* 2007) and also the levels of the proinflammatory cytokines IL-6 and TNFα (Ma *et al*. 2008). Barley ß-glucan has been shown to increase the effect of anti-tumour antibodies in mice (Hong *et al*. 2004).

In general, dietary fibre possibly affects inflammatory processes and immune responses by several mechanisms. Among the mechanisms are those exerted by butyrate, a short chain fatty acid produced in the colon following fermentation of dietary fiber. Butyrate has anti-inflammatory (Andoh and Fujiyama, 2004), apoptotic and anti-proliferative activities on cancer cells (Bordonaro *et al*. 2008). Dietary fibre, depending on their structures, can affect intestinal immune system by being taken up by M-Cells in the Peyer's patches and transported to underlying immune cells and other cells, resulting in a local cytokine production which can influence T-cells, B-cells, antigen presenting cells and other immune cells. Fibre may also be taken up by intestinal macrophages or dendritic cells (i.e. antigen presenting cells) and transported to lymph nodes, spleen and bone marrow (Yamada and Kiyohara, 2007).

Also direct interaction of fibre with colonic epithelial cells or leukocytes may induce changes in immune reactions relevant to inflammation and the development of cancer. *In vitro and in vivo* experiments on ß-glucan preparations from yeast and fungi have shown immunomodulating properties and a potential to increase host resistance against infections (Volman *et al*. 2008). Intraperitoneal injections of barley ß-glucan into fish enhanced the leucocyte count, phagocytic activity, lysozyme activity and complement activity via the alternative pathway and serum bactericidal activity (Misra *et al*. 2006).

Producing Fibre-rich foods

The production of fibre- rich foods is a current challenge to food technologists and dietetic professionals. One possible strategy is the use of plant bioregulators. For example, results on studies with tomato showed that low concentrations of Indole-acetic acid (IAA), Indole butyric acid (IBA) and Naphthalene acetic acid (NAA), particularly the 100mg.L^{-1}NAA enhanced the fibre content of the tomato fruit (Olaiya et al.,2010). Also, Ackom and Tano-Debrah (2012) has demonstrated that processing of pineapple pulp waste from a processing plant, into a powdered product could be used as a dietary fibre supplement. The availability of such foods and the reduction of refined flour in food products in the market will help nutritionists, dietetic professionals and clinicians to act with an insight into the prevention and management of emerging non communicable, chronic human diseases.

4. CONCLUSIONS

The evidences available show that the intake of foods that are high in fibre has benefits regarding the reduction in the risk of chronic diseases. Adults should be encouraged to adhere to the intake of fibre-rich diets. Diets rich in fibre should be recommended to improve the lipid profile and to reduce the risk of cardiovascular disease and other chronic diseases.

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