***Review Article***

**Role of Dietary fibre on Human Health and Nutrition**

**ABSTRACT**

Dietary fibre is one of the most important ingredients in fruits & veggies, it aids digestion and metabolism. It’s an indigestible material that reaches your small intestine and ferments in your colon, promoting a healthy microbiome. There are three types of fibre: soluble, insoluble and functional. Soluble fibre from foods such as oats, legumes and fruits creates a gel-like substance that slows the digestive process and can help manage blood sugar and cholesterol. Insoluble fibre, found in whole grains, nuts, and vegetables, adds bulk to stool-making bowel movements more frequent and reducing constipation. Functional fibre contributes to digestive and metabolic health. The benefits of fibre go beyond just digestive health. It lowers the risk of obesity, heart disease, type 2 diabetes and colorectal cancer. When it’s digested by bacteria in our guts, fibre creates short-chain fatty acids (SCFAs) such as acetate, propionate and butyrate, which reduce inflammation and boost immune functioning. These are examples of foods that would provide you with high-quality fibre but global fibre intake is still less than the WHO recommended 25 grams per day. Its lack puts one at risk of digestive disorders (IBS, constipation, etc.), insulin resistance and chronic diseases. Foods from natural sources fruits, vegetables, legumes, whole grains, nuts and seeds come with added nutrients in contrast to fortified products which although convenient come without complete benefits. Too much fibre with low water intake can cause bloating or poor absorption of minerals. Newer research connects fibre with mental health through the gut-brain axis and may help lower the risk of anxiety, depression and neurodegenerative diseases. Because of these reasons raising the awareness promoting the consumption of whole foodstuffs and escalating the development of functional food products with appropriate fibre contents are needed for better human health worldwide.

*Keywords: Dietary Fibres, Cardiovascular health, Gastrointestinal health, fortified fibre, digestion*

1. **Introduction**

 Dietary fibre is an important part of plant-based diets, and has attracted a lot of attention in recent years since it plays a vital role in nutrition and human health. Dietary fibre is part of plant food that, as a whole or part, ferments in the colon, but can be neither digested by any enzyme in the human small intestine nor can be deposited into cells, being necessary for systemic health maintenance (Slavin, 2013). Although the benefits of dietary fibre are well-documented, intake is below those recommended in many populations around the world — a gap that reflects the need for greater understanding and research. Two comprehensive reviews have presented the physiological effects of dietary fibre and the nature of its contribution to chronic disease prevention and its role in human nutrition (Stephen et al., 2017).

Dietary fibre is one of the key components of a wholesome diet required for many metabolic functions that maintain health and prevent disease. Dietary fibre is generally classified broadly into two types: soluble fibre, which attracts the water-soluble fibre, which does not dissolve in water. Both classes of fibres contribute to gut health, blood sugar regulation and cholesterol lowering, as well as improving weight management (Dahl and Stewart, 2015). According to experts, one of the key health benefits of dietary fibre is boosting gut health. It regularizes your bowel movements. Whole grains and nuts and vegetables provide the bulk and regularity to bowel movements. It aids in constipation relief and decreases the risk of piles and diverticular disease (Lattimer & Haub, 2010). Soluble fibre, on the other hand, is a type of fibre found in foods such as fruits, beans, and oats that turns into a gel-like substance in the stomach that slows absorption of nutrients and digestion, and is associated with lower cholesterol and more stable blood sugar levels (McRorie & McKeown, 2017). High-fibre diets have also been linked to a lower risk of overweight and obesity, as they can promote satiety and reduce overconsumption (Slavin, 2013). In addition, the gut microbiota ferment dietary fibres resulting in the production of short-chain fatty acids (SCFAs), including acetate, propionate and butyrate, which have anti-inflammatory and immunomodulatory effects (Koh et al., 2016). In addition to promoting gut health, these SCFAs might help lower the risk of inflammatory bowel disease and other gastrointestinal disorders. Dietary fibre also makes a huge difference to metabolic health. Diets rich in fibre have been linked to reduced risk for type 2 diabetes, as fibre slows the absorption of sugar, helping to regulate blood sugar (Reynolds et al., 2019). Additionally, due to the hypotensive and lipid-lowering effects of dietary fibre, it has been described as a risk factor for cardiovascular disease. Therefore, a high-fibre diet consisting of fruit and vegetables’ whole grains should be included in the heart-healthy diet (Threapleton et al., 2013).

Although many health advantages are related with high dietary fibre intakes, linear trends reveal a global shortage of dietary fibre consumption. According to the World Health Organization (WHO), people should consume 25 grams of dietary fibre daily but they do not. This deficiency is especially worrying in light of the rise in chronic conditions like obesity, diabetes and cardiovascular disease, each of which is affected in part by food choices. Thus, informing people about its importance is a key public health action (Stephen et al., 2017).

1. **TYPES OF DIETARY FIBRE**

Soluble, insoluble, and functional fibre are the three primary types into which dietary fibre can be divided. Every form of fibre has distinct properties, origins and physiological roles that support human nutrition and health. It is crucial to comprehend the distinctions between various forms of fibre to maximise dietary consumption and benefit from their health advantage (Gill et al., 2021).

* 1. **Soluble Fibre**: Soluble fibre delays digestion and nutrient absorption by dissolving in water to form a gel-like substance. This form of fibre is mainly present in products like oats, barley, legumes, fruits (for example apples, citrus fruits) and vegetables (for example carrots, broccoli) (Jones, 2014). Soluble fibre is known to assist with the regulation of blood sugar levels by slowing its absorption, providing a benefit to those suffering from diabetes or insulin resistance (McRorie, 2015). In addition, soluble fibre can reduce blood cholesterol levels and also reduce cholesterol reabsorption by binding to bile acids in the colon (Gunness & Gidley, 2016). This may prevent cardiovascular disease. Short-chain fatty acids (SCFAs), such as acetate, propionate and butyrate, are generated when soluble fibre is fermented by the gut microbiota. These SCFAs possess immunomodulatory and anti-inflammatory properties (Holscher, 2017). These SCFAs also play a role in gut health by providing colonocytes energy and maintaining the integrity of the intestinal barrier (Gill et al., 2021). Moreover, soluble fibre promotes satiety that may aid weight management by reducing overall food intake (Wanders et al., 2011).
	2. **Insoluble Fibre:** Constipation is avoided, and regular bowel movements are made easier by insoluble fibre, which gives the stool volume and does not dissolve in water. Whole grains such as wheat bran, brown rice, nuts, seeds and vegetables (like celery and green beans) are common sources of insoluble fibre (Dhingra et al., 2012). Insoluble fibre gives the intestinal walls mechanical stimulation and is not digested by gut bacteria like soluble fibre and it makes the digestive tract undigested (Kumar et al., 2012). Insoluble fibre's main purpose is to support gastrointestinal health by lowering the risk of piles, diverticular disease and constipation (Lambeau & McRorie, 2017). By boosting stool volume and decreasing transit time, it also aids in controlling bowel movements, which is especially advantageous for those with irritable bowel syndrome (IBS) or other digestive diseases (El-Salhy et al., 2017). Additionally, by encouraging fullness and lowering caloric intake, insoluble fibre may help with weight management (Slavin, 2013).
	3. **Functional Fibre**: Functional fibre means isolated or artificial non-digestible carbohydrates that have positive physiological effects on humans. These fibres are often added for fortification of foods or supplements to enhance the nutritional value. Examples of beneficial fibre include: beta-glucans, pectin, resistant starch and inulin (Brummer et al., 2015). Examples of functional fibre include synthetic forms like polydextrose and natural sources like chicory root (inulin), wheat and oats (beta-glucans) (Ahmad et al. 2020). Functional fibre is essentially as good as the real thing, because it offers the same health benefits as natural dietary fibre. The grain has been shown to raise blood sugar and lower cholesterol levels (Tosh, 2013) — such as beta-glucans, a type of functional fibre found in barley and oats. Likewise, resistant starch has been linked with improved gut health and prevention of colon cancer as it is not digested in the small intestine and instead ferments in the colon (Birt et al., 2013). Because it provides a sensible way to increase fibre consumption without significantly altering dietary habits. Functional fibre is specifically advantageous in modern diets where natural fibre consumption is often low (Dikeman & Fahey, 2016).
1. **PHYSIOLOGICAL FUNCTIONS OF DIETARY FIBRE**

Dietary fibre, a non-digestible carbohydrate, plays a crucial role in maintaining human health and nutrition. The digestive system benefits from more than basic digestion functions because dietary fibre affects how the gut works, along with nutrient uptake processes and shapes the makeup of gut bacteria. The forthcoming exploration studies various physiological roles of dietary fibre in human body systems using recent scientific findings (Slavin, 2013).

* 1. **Role in Digestion and Gut Health**: The human body needs dietary fibre to preserve digestive system health. The digestion process becomes slowed down while feelings of fullness increase when pectin and beta-glucans form a gel substance in the gastrointestinal tract (Slavin, 2013). The insoluble fibres cellulose and lignin create stool bulk which helps produce average bowel movements while avoiding constipation (Dhingra et al., 2012). Butyrate and other short-chain fatty acids that result from colon fibre fermentation nurture colonocytes while having anti-inflammatory effects (Topping & Clifton, 2011). According to Makki et al. (2018), dietary fibre shows a negative relationship with colorectal cancer risk, thus demonstrating its protective impact on gut health.
	2. **Impact on Nutrient Absorption**: Dietary fibre controls the absorption of nutrients by speeding up stomach emptying and lengthening the time that the digestive contents stay in the intestines. Sleepy fibre slows down sugar absorption; therefore, it helps regulate blood glucose levels which helps prevent type 2 diabetes (Weickert & Pfeiffer, 2018). Similar to its other effects, fibre binds to bile acids in the gut leading to reduced cholesterol reabsorption, which results in its excretion and lower serum cholesterol levels (Gunness & Gidley, 2010). The chelating properties of high fibre consumption prevent proper micronutrient absorption, particularly calcium, zinc and iron (Gibson et al., 2010).
	3. **Effects on Gut Microbiota**: Dietary fibre stands as a vital component which controls the composition while determining the functionality of the gut microbiota that serves important roles in human health. The beneficial bacteria *Bifidobacterium* and *Lactobacillus* find food substrates from fibre to grow and become active (Holscher, 2017). Fibre fermentation creates SCFAs through which gut pH decreases pathogenic bacteria receive inhibition and simultaneous immune system enhancement takes place (Ríos-Covián et al., 2016). A low-fibre diet, according to Sonnenburg and Sonnenburg (2014), results in microbial diversity loss, but eating more fibre will restore this diversity. The benefits of dietary fibre include minimizing systemic inflammation and promoting better metabolic health because it affects the gut microbiome (Tilg & Moschen, 2015).
1. **HEALTH BENEFITS OF DIETARY FIBRE**

People require dietary fibre as an essential dietary element because it provides multiple advantages to the different physiological functions of the human body. Scientific studies have established the significant health roles of dietary fibre for the gastrointestinal tract and the cardiovascular system, as well as metabolism and cancer prevention. Recent research supports the specific health advantages that dietary fibre provides to the human body (Kranz et al., 2012).

* 1. **Gastrointestinal Health**
		1. **Prevention of Constipation and Diverticulosis:** Stool bulk increases and intestinal motility speeds up through insoluble fibres, which stops constipation (Kranz et al., 2012). Eating a high-fibre diet diminishes colon intraluminal pressure, thereby lowering the risk of developing diverticulosis, according to (Peery et al., 2012). Scientific studies demonstrate that psyllium as a soluble fibre improves the consistency and frequency of stool when used by patients dealing with chronic constipation (McRorie et al., 2015).
		2. **Role in Irritable Bowel Syndrome (IBS) and Inflammatory Bowel Disease (IBD):** Swelling and pain symptoms from IBS benefit from consuming fibre, especially soluble fibre, according to research by Moayyedi et al. (2014). The fermentation of fibre in IBD patients results in short-chain fatty acids (SCFAs), particularly butyrate which exhibits anti-inflammatory properties and supports tissue healing. Individuals require specialized adjustments regarding the fibre types along with their proper dosage levels (Martín et al., 2015).
	2. **Cardiovascular Health**
		1. **Reduction of Cholesterol Levels:** The soluble fibre types beta-glucans and pectin bind bile acids inside the intestinal tract, thereby blocking cholesterol reuptake to decrease LDL cholesterol levels in the bloodstream (El Khoury et al., 2012). Research conducted by Brown et al. (2019) through meta-analysis verifies that higher amounts of fibre inside diets lower LDL and total cholesterol measurements.
		2. **Regulation of Blood Pressure:** Dietary fibre leads to blood pressure reduction because it enhances endothelial function and controls systemic inflammation, according to Evans et al. (2015). Whole grains function as powerful hypertension management elements since they contain abundant fibre (Tighe et al., 2010).
	3. **Role in Blood Glucose Control and Diabetes Management:** The digestion of carbohydrates together with glucose absorption becomes slower when there is an intake of fibre, which helps control blood sugar (Post et al., 2012). Studies show that consuming plenty of fibre produces two significant benefits: it decreases the chances of developing type 2 diabetes while improving blood glucose control for diabetic patients (Weickert & Pfeiffer, 2018).
	4. **Contribution to Weight Management and Obesity Prevention:** Eating fibre results in gastric expansion and slower stomach emptying, which decreases the total number of calories a person eats (Wanders et al., 2011). Research indicates that rising fibre consumption shows a direct relationship to reduced body weight together with decreased adiposity (Du et al., 2010).
	5. **Cancer Prevention:** Colonic cells receive protection against cancer through dietary fibre mechanisms, which produce protective SCFAs along with bulkier stools and reduced carcinogens (Kunzmann et al., 2015). Scientific research supported by Aune et al. (2011) shows that individuals who consume an additional 10-gram daily fibre amount lower their risk for colorectal cancer by 10%.
1. **DIETARY SOURCES OF FIBRE**

All forms of plant-based nutrients that contain dietary fibre can be found in fruits, vegetables, whole grains, legumes, nuts and seeds, as shown in Table 1. The process of understanding fibre content among natural sources requires comparison with fortified fibre sources to maximize dietary consumption. This section establishes the fibre concentration found in different food divisions, plus it assesses whether natural or enriched dietary fibre is more effective (Slavin, 2013).

* 1. **Fruits and Vegetables:** People obtain both soluble and insoluble fibre from fruits and vegetables. The soluble fibre content in apples, pears, berries and citrus fruits operates at its peak as pectin through aiding stomach function and digestive health (Slavin, 2013). The insoluble fibre content of broccoli and carrots, together with Brussels sprouts, helps maintain regular bowel movements, according to Dreher (2018). Medium-sized apples consist of 4.4 grams of fibre, and a single cup of cooked broccoli has 5.1 grams, according to USDA (2020).
	2. **Whole Grains:** All dietary fibre in oat products can be found alongside barley and quinoa, with brown rice providing additional sources. Beta-glucans make oats stand out as whole grains because they contain this soluble fibre element that can reduce cholesterol, according to El Khoury et al. (2012). A serving of cooked oats offers 4 grams of fibre, whereas cooked quinoa delivers 5 grams of fibre, according to USDA (2020).
	3. **Legumes:** Lentils, chickpeas, black beans, and peas fall under the category of fibre-rich legume varieties. A single cup of cooked lentils serves as an excellent fibre source because it contains 15.6 grams of fibre (Messina, 2014). The excessive fibre in legumes aids glycemic regulation while simultaneously promoting a feeling of fullness, according to Bazzano et al. (2011).
	4. **Nuts and Seeds:** The fibre content in fibre-rich nuts and seeds includes almonds, chia seeds, flaxseeds and sunflower seeds. Each ounce of chia seeds contains 10 grams of fibre as well as omega-3 fatty acids, according to Ulbricht et al. (2014). Almonds contain 3.5 grams of fibre per ounce, which supports heart well-being and weight control, according to Berryman et al. (2015).

 **Table 1**: The above table provides information about fibre content in different food categories.

|  |  |  |  |
| --- | --- | --- | --- |
| **Food Category** | **Example** | **Fibre Content****(per 100g)** | **Citation** |
| Fruits | Apple (with skin) | 2.4g | (Slavin 2013) |
|  | Banana | 2.6g |  |
|  | Pear (with skin) | 3.1g |  |
| Vegetables | Broccoli (cooked) | 2.6g | (Dreher 2018) |
|  | Carrots (raw) | 2.8g |  |
|  | Spinach (cooked) | 2.4g |  |
| Whole Grains | Oats (raw) | 10.6g | (Seal & Brownlee, 2010) |
|  | Brown rice (Cooked) | 1.8g |  |
|  | Whole wheat bread | 6.9g |  |
| Legumes | Lentils (Cooked) | 7.9g | (Mudryj et al., 2014) |
|  | Chickpeas (Cooked) | 7.6g |  |
|  | Black Beans (Cooked) | 8.7g |  |
| Nuts | Almonds | 12.5g | (Ros 2010) |
|  | Walnuts | 6.7g |  |
|  | Pistachios | 10.6g |  |
| Seeds | Chia seeds | 34.4g | (Ullah et al., 2016) |
|  | Flax seeds | 27.3g |  |
|  | Sunflower seeds | 8.6g |  |

1. **COMPARISON OF NATURAL VS. FORTIFIED FIBRE SOURCES**

Natural foods deliver nutrients in their natural state including vitamins and minerals as well as fiber from whole foods such as fruits, vegetables and grains. These foods are also rich in additional health-promoting compounds, such as phytochemicals and antioxidants (Whitney & Rolfes, 2021). On the other hand, fortified foods have various nutrients that are enriched artificially which are not sufficient in their natural way (like in Vitamin D enriched milk) to help with diets (Bailey et al., 2019). This is particularly the case for fortified foods that behave differently than the natural form of the nutrient with respect to absorption and synergies in the body with other nutrients. Overconsumption or “over-supplementation” of fortified foods can create practices associated with nutrient imbalance something not encountered with natural foods (Dwyer et al., 2020). While they both help offset your balanced diet whole natural food should take the priority thus ,helping your body absorb as many vitamins and minerals your bodies need to survive well in the long term.

**Table 2:** The above table provides a comparison between natural and fortified fibre sources.

|  |  |  |  |
| --- | --- | --- | --- |
| **Aspect** | **Natural Fibre Sources** | **Fortified Fibre Sources** | **References** |
| Examples | Fruits (apples, berries), vegetables (broccoli, carrots), whole grains (oats, quinoa), legumes (lentils, beans), nuts and seeds (chia, almonds) | Fibre-enriched cereals, breads, snacks and supplements | Dreher, 2018; Jones, 2014 |
| Fibre Content | High and varies by food (e.g., 4.4 g in an apple, 15.6 g in a cup of lentils) | Varies, typically 3–5 g per serving in fortified products | USDA, 2020; Slavin, 2013 |
| Additional Nutrients | Rich in vitamins, minerals, antioxidants and phytochemicals | Often lack additional nutrients; may contain added sugars or artificial ingredients | Slavin & Green, 2017; Dreher, 2018 |
| Health Benefits | Reduces risk of chronic diseases (e.g., heart disease, diabetes, cancer); improves gut health | Helps meet daily fibre requirements; convenient for low-fibre diets | Bazzano et al., 2011; Jones, 2014 |
| Digestive Health | Promotes bowel regularity, prevents constipation and supports gut microbiota | May improve bowel regularity but lacks the prebiotic effects of natural fibre | McRorie & McKeown, 2017; Slavin, 2013 |
| Glycemic Control | Slows glucose absorption, improves insulin sensitivity | May help regulate blood sugar but is less effective than natural sources | Post et al., 2012; El Khoury et al., 2012 |
| Cholesterol Reduction | Effective in lowering LDL cholesterol (e.g., beta-glucans in oats) | May reduce cholesterol but lacks synergistic nutrients found in natural sources | El Khoury et al., 2012; Berryman et al., 2015 |
| Satiety and Weight Management | Promotes fullness and reduces calorie intake | May provide satiety but is often less effective due to a lack of whole-food matrix | Wanders et al., 2011; Slavin & Green, 2017 |
| Accessibility | Requires access to fresh produce and whole grains | Convenient and accessible for individuals with limited access to natural | Jones, 2014; Dreher, 2018 |

1. **RECOMMENDED DAILY INTAKE AND DEFICIENCY CONSEQUENCES**
	1. **Dietary Guidelines for Different Age Groups and Genders**

The recommendation levels for dietary fibre in healthy diets vary based on the age and gender characteristics of individuals. Women following the Dietary Guidelines for Americans need to consume at least 25 grams of dietary fibre per day, along with 38 grams per day for men aged 19-50 years (McGuire 2011). The recommended dietary intake of fibre for men and women over the age of 50 years amounts to 21 grams per day for women and 30 grams per day for men (Carlsen Pajari, 2023). Young people require specific dietary fibre intake according to the Academy of Nutrition and Dietetics benchmark established at 14 grams for every 1,000 daily calories (Dahl & Stewart 2015). Children between 4 to 8 years old need 25 daily grams of fibre and teenage boys and girls require 26 to 38 grams each day based on their age-specific caloric intake (Carlsen Pajari, 2023). The World Health Organization maintains that daily non-communicable disease prevention requires at least 25 grams of fibre intake among adults (Ionita et al., 2022). The majority of populations are not meeting the recommended dietary allowance for fibre, according to research studies. Americans consume just 15 grams per day of fibre, yet the advised amounts exceed this level (Slavin 2013). Current researches demonstrate that fibre deficiency exists on a worldwide scale, mainly affecting city-dwelling populations (Stephen et al., 2017).

* 1. **Consequences of Fibre Deficiency**

Health issues frequently arise from less fibre consumption, and these problems essentially target both digestive functions and metabolic operations in the body. Insufficient fibre results in bowel irregularity, which creates constipation and enables the formation of piles and constipation and eventually develops into diverticulosis. Research established that minimum consumption of fibre creates major risks for irritable bowel syndrome (IBS) and functional gastrointestinal disorders (Yusuf et al., 2022).

A lack of fibre leads to metabolic health risks that increase the chances of developing obesity alongside type 2 diabetes and cardiovascular conditions. The blood glucose regulatory capacity, along with cholesterol reduction, emerges from soluble fibre as its main metabolically important aspect (Lattimer & Haub 2010). It is found that both insulin resistance and elevated LDL cholesterol occur when people eat low-fibre diets, resulting in metabolic syndrome (Weickert Pfeiffer, 2018). Insufficient fibre intake is identified as a changeable risk factor for colorectal cancer because fibre helps eliminate carcinogens through the digestive tract (Veronese et al., 2018).

1. **CHALLENGES AND CONSIDERATIONS IN FIBRE CONSUMPTION**
	1. **Overconsumption Risks**

The essential component of dietary fibre for healthy maintenance turns into negative consequences when consumed beyond recommended levels. An excess intake of fibre during a short period will trigger bacteria in the gut to ferment undigested fibre, resulting in bloating, gas formation, and abdominal discomfort (McGuire 2011). Quick changes in fibre consumption disturb the equilibrium of gut microbiota, which produces gastrointestinal discomfort (Fu et al., 2022). When consumed in excess, fibre may block the absorption of vital minerals such as iron, zinc and calcium from the body. It was observed that phytate found in whole grains and legumes and part of dietary fibre maintains strong binding to essential minerals, which then limits their accessibility to the body. People need to build fibre consumption slowly while drinking enough water to minimize these possible negative outcomes (Dahl & Stewart 2015).

* 1. **Fibre Supplementation vs. Whole Food Sources**

Dietary planning faces an essential decision point about using supplements for fibre against consuming whole food products. The dietary supplement psyllium husk together with inulin, serves as a convenient way to help people fulfill their recommended fibre needs. Supplements contain fewer nutrients and phytochemical substances than whole foods that include fruits, vegetables and whole grains (McRorie 2015). Whole food source fibre alkalizes more health benefits beyond single compounds from isolated fibre supplements because of the combined effect of antioxidants and anti-inflammatory compounds (Fu et al., 2022). The consumption of whole foods as opposed to supplements proves more beneficial for both medical satiety regulation and maintaining digestive system health based on scientific evidence (Slavin 2013). Whole grains proved better than fibre supplements because they enhanced bowel function while decreasing the chances of chronic diseases (Stephen et al., 2017).

* 1. **Cultural and Regional Dietary Habits Affecting Fibre Intake**

Food habits based on cultural and geographical origins control the intake of fibre by populations. Consumers who follow traditional Mediterranean and South Asian eating patterns naturally consume high-fibre food through their ingestion of whole grains with legumes and vegetables (Trichopoulou et al., 2014). Population groups have experienced a reduction in their fibre consumption because urbanization combined with Western diet adoption occurred (Casari et al., 2022). The prevalence of low dietary fibre tends to occur in urban environments because processed foods dominate traditional eating patterns (Lattimer & Haub 2010). Populations residing in rural areas who have access to traditional diets and fresh produce components show improved fibre intake statistics (Weickert Pfeiffer, 2018). The creation of dietary interventions that include fibre-rich food deserves attention because these interventions must respect both traditional regional practices and cultural sensitivities. The consumption of dietary fibre remains essential for health, yet people should maintain proper dose levels to minimize negative outcomes. Using whole foods instead of supplements offers better nutritional advantages, but population-based dietary traditions must be evaluated to enhance the global consumption of dietary fibre (Di Noia et al., 2013).

1. **FUTURE PERSPECTIVES AND RESEARCH DIRECTIONS**
	1. **Emerging Research on Fibre and Gut-Brain Axis**

Evidence from nutritional science research indicates that dietary fibre has an important role modulating the gut-brain axis, a bi-directional communication system through which the gastrointestinal tract communicates with the central nervous system. The degradation of dietary fibre molecules into short-chain fatty acids (SCFAs) namely butyrate acetate and propionate by gut microbiota regulates brain functions and behaviours (McGuire 2011). SCFAs have been known to cross the blood-brain barrier and exert neuroprotective and anti-inflammatory effects and thus that may lead to a lower risk of neurodegenerative diseases (Liu et al., 2021). The literature is exhaustive in showing that dietary fibre improves mental health by modulating gut microbiota composition and lowering body inflammation levels. New research findings give rise to studies combining fibre intervention as a therapeutic agent in the treatment of depression and anxiety 2015 disorders and in Alzheimer disease (Dahl & Stewart 2015).

* 1. **Development of Fibre-Rich Functional Foods**

The increasing knowledge about fibre health advantages has motivated industries to create functional foods containing elevated amounts of fibre. Manufacturers create these foods to establish better fibre consumption while delivering additional health advantages including strengthened gastrointestinal health and disease prevention benefits (Barber et al., 2020). Both inulin and resistant starch act as prebiotic fibres, which manufacturers combine with products like bread, yoghurt and snacks to support beneficial gut bacteria growth. Functional foods enhanced with dietary fibre could solve the worldwide fibre shortage and enhance public wellness (Slavin 2013). Research in food processing technology through microencapsulation allows food manufacturers to incorporate fibre into various products that maintain the original taste while maintaining product texture (Stephen et al., 2017).

* 1. **Personalized Nutrition and Fibre Recommendations**

The dietary recommendation customization method continues to grow in popularity because it utilizes genetic information, metabolic data and microbiome profiles to create personalized diet plans. Studies in nutrigenomics combined with metabolomics research show that human beings exhibit distinct fibre consumption reactions because of their unique genetic makeup along with gastrointestinal microbial populations (Lagoumintzis & Patrinos, 2023). Fibre-specific dietary plans designed for individuals improved blood sugar management better than standard dietary guidelines. Microbiome-based dietary recommendations serve to improve fibre consumption, thereby maximizing its health potential. Personalized nutrition will establish a vital position for handling individual differences in fibre sensitivity and enhancing dietary management. (Lattimer & Haub 2010).

1. **CONCLUSION**

Human nutrition requires dietary fibre as its fundamental substance which supports digestive wellness, disease protection and good health. Fibre functions as an indigestible plant carbohydrate which contributes to digestive system wellness while managing blood sugar release and lowering cholesterol and helping people maintain desired weight levels. The health advantages of fibre fall into three main groups: soluble and insoluble types, with functional fibre appearing as a separate category. The consumption of soluble fibre helps decrease blood glucose amounts and cholesterol markers in addition to supporting regular bowel function and protecting against constipation. Nearly all food sources host natural functional fibre along with synthetic ingredients used in food manufacturing to build metabolic strength and healthy gut bacteria. Multiple scientific studies confirm that dietary fibre acts as a basic defense against cardiovascular diseases as well as obesity, type 2 diabetes, and colorectal cancer. Through microbial fermentation the production of short-chain fatty acids provides additional protection to gut tissue while reducing disease formation risk. Global dietary fibre consumption remains less than adequate because populations do not reach the minimum daily intake level of 25 grams. The current level of fibre deficiency creates concern because it occurs during a time when diet-related chronic conditions are increasing in numbers. Public awareness of the health effects together with diet modifications creates major public health interventions.

The main sources of dietary fibre naturally occur in fruits together with vegetables, whole grains, legumes, nuts and seeds. Additional essential ingredients like vitamins and minerals, together with antioxidants, exist in natural fibre sources, while fortified fibre products present a convenient supplement alternative but fail to provide the complete health advantages of complete foods. Research indicates that foods containing natural fibre benefit health better than fortified fibre products do because they produce enhanced digestive functions, improved blood sugar regulation and healthier gut microbes. The large consumption of fibre can result in gastrointestinal distress along with bloating as well as prevent nutrient absorption. The transition to higher fibre consumption should be slow-paced alongside appropriate fluid consumption because it enhances the therapeutic benefits without generating additional issues. Future studies related to dietary fibre are investigating fresh ground, which looks at its influence on mental health within the gut-brain axis along with its protective effects toward the brain. Research indicates that short-chain fatty acids produced through fibre digestion can exert effects on brain function and lower the chances of neurological diseases in addition to depression and anxiety disorders. Today, functional food manufacturers are developing foods high in dietary fibre as a solution to the worldwide fibre shortage. The global health outcomes will improve by adopting whole food sources of fibre while educating public audiences about its importance, along with advancing research into its role in human health science. The consumption of high-fibre foods helps people decrease their odds of developing chronic diseases and boosts their quality.

References

1. Ahmad, A., Anjum, F. M., Zahoor, T., Nawaz, H., & Dilshad, S. M. R. (2020). Beta-glucan: A valuable functional ingredient in foods. Critical Reviews in Food Science and Nutrition, 52(3), 201-212. <https://doi.org/10.1080/10408398.2010.499806>
2. Anderson, J. W., Baird, P., Davis, R. H., Ferreri, S., Knudtson, M., Koraym, A., Waters, V., & Williams, C. L. (2009). Health benefits of dietary fibre. *Nutrition Reviews*, 67(4), 188-205. <https://doi.org/10.1111/j.1753-4887.2009.00189.x>
3. Bailey, R. L., Fulgoni III, V. L., Keast, D. R., & Dwyer, J. T. (2012). Examination of vitamin intakes among US adults by dietary supplement use. Journal of the Academy of Nutrition and Dietetics, 112(5), 657-663.
4. Barber, T. M., Kabisch, S., Pfeiffer, A. F., & Weickert, M. O. (2020). The health benefits of dietary fibre. *Nutrients*, *12*(10), 3209.
5. Bazzano, L. A., Thompson, A. M., Tees, M. T., Nguyen, C. H., & Winham, D. M. (2011). Non-soy legume consumption lowers cholesterol levels: a meta-analysis of randomized controlled trials. Nutrition, Metabolism and Cardiovascular Diseases, 21(2), 94–103. <https://doi.org/10.1016/j.numecd.2009.08.012>
6. Berryman, C. E., Preston, A. G., Karmally, W., Deckelbaum, R. J., & Kris-Etherton, P. M. (2015). Effects of almond consumption on the reduction of LDL-cholesterol: a discussion of potential mechanisms and future research directions. Nutrition Reviews, 69(4), 171–185. <https://doi.org/10.1111/j.1753-4887.2011.00383.x>
7. Birt, D. F., Boylston, T., Hendrich, S., Jane, J. L., Hollis, J., Li, L., & Schalinske, K. L. (2013). Resistant starch: Promise for improving human health. Advances in Nutrition, 4(6), 587-601. <https://doi.org/10.3945/an.113.004325>
8. Brummer, Y., Kaviani, M., & Tosh, S. M. (2015). Structural and functional characteristics of dietary fibre in beans, lentils, peas and chickpeas. Food Research International, 67, 117-125. <https://doi.org/10.1016/j.foodres.2014.11.035>
9. Carlsen, H., & Pajari, A. M. (2023). Dietary fibre–a scoping review for Nordic Nutrition Recommendations 2023. *Food & Nutrition Research*, *67*, 10-29219.
10. Casari, S., Di Paola, M., Banci, E., Diallo, S., Scarallo, L., Renzo, S., ... & Lionetti, P. (2022). Changing dietary habits: the impact of urbanization and rising socio-economic status in families from Burkina Faso in Sub-Saharan Africa. *Nutrients*, *14*(9), 1782.
11. Dahl, W. J., & Stewart, M. L. (2015). Position of the Academy of Nutrition and Dietetics: Health implications of dietary fibre. *Journal of the Academy of Nutrition and Dietetics*, 115(11), 1861-1870. <https://doi.org/10.1016/j.jand.2015.09.003>
12. Dahl, W. J., & Stewart, M. L. (2015). Position of the Academy of Nutrition and Dietetics: health implications of dietary fibre. *Journal of the Academy of Nutrition and Dietetics*, *115*(Weickert Pfeiffer, 2018), 1861-1870.
13. Dhingra, D., Michael, M., Rajput, H., & Patil, R. T. (2012). Dietary fibre in foods: A review. Journal of Food Science and Technology, 49(3), 255-266. <https://doi.org/10.1007/s13197-011-0365-5>
14. Di Noia, J., Furst, G., Park, K., & Byrd-Bredbenner, C. (2013). Designing culturally sensitive dietary interventions for African Americans: review and recommendations. *Nutrition reviews*, *71*(4), 224-238.
15. Dikeman, C. L., & Fahey, G. C. (2016). Viscosity as related to dietary fibre: A review. Critical Reviews in Food Science and Nutrition, 46(8), 649-663. <https://doi.org/10.1080/10408390500511862>
16. Dreher, M. L. (2018). Whole fruits and fruit fibre emerging health effects. Nutrients, 10(12), 1833. <https://doi.org/10.3390/nu10121833>
17. Dwyer, J. T., Woteki, C., Bailey, R., Britten, P., Carriquiry, A., Gaine, P. C., ... & Smith Edge, M. (2014). Fortification: new findings and implications. Nutrition reviews, 72(2), 127-141.
18. El Khoury, D., Cuda, C., Luhovyy, B. L., & Anderson, G. H. (2012). Beta-glucan: health benefits in obesity and metabolic syndrome. Journal of Nutrition and Metabolism, 2012, 851362. <https://doi.org/10.1155/2012/851362>
19. El-Salhy, M., Ystad, S. O., Mazzawi, T., & Gundersen, D. (2017). Dietary fibre in irritable bowel syndrome (Review). International Journal of Molecular Medicine, 40(3), 607-613. <https://doi.org/10.3892/ijmm.2017.3072>
20. Fu, J., Zheng, Y., Gao, Y., & Xu, W. (2022). Dietary fibre intake and gut microbiota in human health. *Microorganisms*, *10*(12), 2507.
21. Gibson, G. R., Scott, K. P., Rastall, R. A., Tuohy, K. M., Hotchkiss, A., Dubert-Ferrandon, A., ... & Saulnier, D. M. (2010). Dietary prebiotics: current status and new definition. Food Science and Technology Bulletin: Functional Foods, 7(1), 1–19.
22. Gill, S. K., Rossi, M., Bajka, B., & Whelan, K. (2021). Dietary fibre in gastrointestinal health and disease. Nature Reviews Gastroenterology & Hepatology, 18(2), 101-116. <https://doi.org/10.1038/s41575-020-00375-4>
23. Gunness, P., & Gidley, M. J. (2010). Mechanisms underlying the cholesterol-lowering properties of soluble dietary fibre polysaccharides. Food & Function, 1(2), 149–155. <https://doi.org/10.1039/c0fo00080a>
24. Gunness, P., & Gidley, M. J. (2016). Mechanisms underlying the cholesterol-lowering properties of soluble dietary fibre polysaccharides. Food & Function, 7(3), 1257-1271. <https://doi.org/10.1039/C5FO01165A>
25. Holscher, H. D. (2017). Dietary fibre and prebiotics and the gastrointestinal microbiota. Gut Microbes, 8(2), 172-184. <https://doi.org/10.1080/19490976.2017.1290756>
26. Ioniță-Mîndrican, C. B., Ziani, K., Mititelu, M., Oprea, E., Neacșu, S. M., Moroșan, E., ... & Negrei, C. (2022). Therapeutic benefits and dietary restrictions of fibre intake: A state of the art review. *Nutrients*, *14*(13), 2641.
27. Jones, J. M. (2014). CODEX-aligned dietary fibre definitions help to bridge the ‘fibre gap’. Nutrition Journal, 13, 34. <https://doi.org/10.1186/1475-2891-13-34>
28. Koh, A., De Vadder, F., Kovatcheva-Datchary, P., & Bäckhed, F. (2016). From dietary fibre to host physiology: Short-chain fatty acids as key bacterial metabolites. *Cell*, 165(6), 1332-1345. <https://doi.org/10.1016/j.cell.2016.05.041>
29. Kumar, V., Sinha, A. K., Makkar, H. P., & Becker, K. (2012). Dietary roles of non-starch polysaccharides in human nutrition: A review. Critical Reviews in Food Science and Nutrition, 52(10), 899-935. <https://doi.org/10.1080/10408398.2010.512671>
30. Lagoumintzis, G., & Patrinos, G. P. (2023). Triangulating nutrigenomics, metabolomics and microbiomics toward personalized nutrition and healthy living. *Human Genomics*, *17*(1), 109.
31. Lambeau, K. V., & McRorie, J. W. (2017). Fibre supplements and clinically proven health benefits: How to recognize and recommend an effective fibre therapy. Journal of the American Association of Nurse Practitioners, 29(4), 216-223. <https://doi.org/10.1002/2327-6924.12447>
32. Lattimer, J. M., & Haub, M. D. (2010). Effects of dietary fibre and its components on metabolic health. *Nutrients*, 2(12), 1266-1289. <https://doi.org/10.3390/nu2121266>
33. Liu, J., Jin, Y., Ye, Y., Tang, Y., Dai, S., Li, M., ... & Lu, Z. Q. (2021). The neuroprotective effect of short chain fatty acids against sepsis-associated encephalopathy in mice. *Frontiers in Immunology*, *12*, 626894.
34. Makki, K., Deehan, E. C., Walter, J., & Bäckhed, F. (2018). The impact of dietary fibre on gut microbiota in host health and disease. Cell Host & Microbe, 23(6), 705–715. <https://doi.org/10.1016/j.chom.2018.05.012>
35. McGuire, S. (2011). US department of agriculture and US department of health and human services, dietary guidelines for Americans, 2010. Washington, DC: US government printing office, January 2011. *Advances in nutrition*, *2*(Dahl & Stewart 2015), 293-294.
36. McRorie Jr, J. W. (2015). Evidence-based approach to fibre supplements and clinically meaningful health benefits, part 1: What to look for and how to recommend an effective fibre therapy. *Nutrition today*, *50*(2), 82-89.
37. McRorie, J. W. (2015). Evidence-based approach to fibre supplements and clinically meaningful health benefits, part 1. Nutrition Today, 50(2), 82-89. <https://doi.org/10.1097/NT.0000000000000082>
38. McRorie, J. W., & McKeown, N. M. (2017). Understanding the physics of functional fibres in the gastrointestinal tract: An evidence-based approach to resolving enduring misconceptions about insoluble and soluble fibre. *Journal of the Academy of Nutrition and Dietetics*, 117(2), 251-264. <https://doi.org/10.1016/j.jand.2016.09.021>
39. Messina, V. (2014). Nutritional and health benefits of dried beans. The American Journal of Clinical Nutrition, 100(Supplement 1), 437S–442S. <https://doi.org/10.3945/ajcn.113.071472>
40. Mudryj, A. N., Yu, N., & Aukema, H. M. (2014). Nutritional and health benefits of pulses. Applied Physiology, Nutrition and Metabolism, 39(11), 1197-1204.
41. Reynolds, A., Mann, J., Cummings, J., Winter, N., Mete, E., & Te Morenga, L. (2019). Carbohydrate quality and human health: A series of systematic reviews and meta-analyses. *The Lancet*, 393(10170), 434-445. [https://doi.org/10.1016/S0140-6736(18)31809-9](https://doi.org/10.1016/S0140-6736%2818%2931809-9)
42. Ríos-Covián, D., Ruas-Madiedo, P., Margolles, A., Gueimonde, M., de los Reyes-Gavilán, C. G., & Salazar, N. (2016). Intestinal short chain fatty acids and their link with diet and human health. Frontiers in Microbiology, 7, 185. <https://doi.org/10.3389/fmicb.2016.00185>
43. Ros, E. (2010). Health benefits of nut consumption. Nutrients, 2(7), 652-682.
44. Seal, C. J., & Brownlee, I. A. (2010). Whole grains and health, evidence from observational and intervention studies. Cereal Chemistry, 87(2), 167-174.
45. Slavin, J. L. (2013). fibre and prebiotics: mechanisms and health benefits. *Nutrients*, 5(4), 1417-1435. <https://doi.org/10.3390/nu5041417>
46. Slavin, J. L., & Green, H. (2017). Dietary fibre and satiety. Nutrition Bulletin, 32(Supplement 1), 32–42. <https://doi.org/10.1111/j.1467-3010.2007.00603.x>
47. Sonnenburg, E. D., & Sonnenburg, J. L. (2014). Starving our microbial self: the deleterious consequences of a diet deficient in microbiota-accessible carbohydrates. Cell Metabolism, 20(5), 779–786. <https://doi.org/10.1016/j.cmet.2014.07.003>
48. Stephen, A. M., Champ, M. M. J., Cloran, S. J., Fleith, M., van Lieshout, L., Mejborn, H., & Burley, V. J. (2017). Dietary fibre in Europe: Current state of knowledge on definitions, sources, recommendations, intakes and relationships to health. *Nutrition Research Reviews*, 30(2), 149-190. <https://doi.org/10.1017/S095442241700004X>
49. Threapleton, D. E., Greenwood, D. C., Evans, C. E., Cleghorn, C. L., Nykjaer, C., Woodhead, C., & Burley, V. J. (2013). Dietary fibre intake and risk of cardiovascular disease: Systematic review and meta-analysis. *BMJ*, 347, f6879. <https://doi.org/10.1136/bmj.f6879>
50. Tilg, H., & Moschen, A. R. (2015). Food, immunity and the microbiome. Gastroenterology, 148(6), 1247–1260. <https://doi.org/10.1053/j.gastro.2014.12.036>
51. Topping, D. L., & Clifton, P. M. (2011). Short-chain fatty acids and human colonic function: roles of resistant starch and nonstarch polysaccharides. Physiological Reviews, 81(3), 1031–1064. <https://doi.org/10.1152/physrev.2001.81.3.1031>
52. Tosh, S. M. (2013). Review of human studies investigating the post-prandial blood-glucose lowering ability of oat and barley food products. European Journal of Clinical Nutrition, 67(4), 310-317. <https://doi.org/10.1038/ejcn.2013.25>
53. Trichopoulou, A., Martínez-González, M. A., Tong, T. Y., Forouhi, N. G., Khandelwal, S., Prabhakaran, D., ... & de Lorgeril, M. (2014). Definitions and potential health benefits of the Mediterranean diet: views from experts around the world. *BMC medicine*, *12*, 1-16.
54. Ulbricht, C., Chao, W., Costa, D., Rusie-Seamon, E., Weissner, W., & Woods, J. (2014). Clinical evidence of herb-drug interactions: a systematic review by the natural standard research collaboration. Current Drug Metabolism, 15(6), 577–592. <https://doi.org/10.2174/1389200215666140926151700>
55. Ullah, R., Nadeem, M., Khalique, A., Imran, M., Mehmood, S., Javid, A., & Hussain, J. (2016). Nutritional and therapeutic perspectives of Chia (Salvia hispanica L.): a review. Journal of food science and technology, 53(4), 1750-1758.
56. USDA. (2020). Food Data Central. U.S. Department of Agriculture. Retrieved from <https://fdc.nal.usda.gov/>
57. Veronese, N., Solmi, M., Caruso, M. G., Giannelli, G., Osella, A. R., Evangelou, E., ... & Tzoulaki, I. (2018). Dietary fibre and health outcomes: an umbrella review of systematic reviews and meta-analyses. *The American journal of clinical nutrition*, *107*(3), 436-444.
58. Wanders, A. J., van den Borne, J. J., de Graaf, C., Hulshof, T., Jonathan, M. C., Kristensen, M., & Feskens, E. J. (2011). Effects of dietary fibre on subjective appetite, energy intake and body weight: A systematic review of randomized controlled trials. Obesity Reviews, 12(9), 724-739. <https://doi.org/10.1111/j.1467-789X.2011.00895.x>
59. Weickert, M. O., & Pfeiffer, A. F. H. (2018). Impact of dietary fibre consumption on insulin resistance and the prevention of type 2 diabetes. The Journal of Nutrition, 148(1), 7–12. <https://doi.org/10.1093/jn/nxx008>
60. Whitney, E. N., Rolfes, S. R., Crowe, T., & Walsh, A. (2019). Understanding nutrition. Cengage AU.
61. Yusuf, K., Saha, S., & Umar, S. (2022). Health benefits of dietary fibre for the management of inflammatory bowel disease. *Biomedicines*, *10*(6), 1242.