SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)
ISSN (Print) 1813-1743, ISSN (online) 2791-0547
Vol. 56:02 (2024)
Doi: https://doi.org/ 10.26692/surj-ss.v56i02.7462

Influence of Dietary Fiber and herbal supplements on Certain Health Issues: A review

MARVI SHAIKH[1*], MALEEHA MEMON[1], SHAKIL AHMED[2] , MEHNAZ SHAIKH[1], HUMA ABBASI[1], GHULAM MURTAZA[1]

[1]University of Modern Sciences, Indus Medical College, Tando Mohammad Khan, Sindh, Pakistan,
[2]Liaquat University of Medical and health sciences, Jamshoro

Cite this:
Shaikh Marvi, M. Memon, S. Ahmed, M. Shaikh, H. Abbasi, & G. Murtaza. Influence of Dietary Fiber and herbal supplements on Certain Health Issues: A review Sindh Uni. Res.J. (SS) 52:02, 2024.

Corresponding author
marvishaikh.42@gmail.com

ABSTRACT

Dietary fiber is the fraction of plant-based foods that can't be digested, while herbal supplements are critical in enhancing well-being and preventing chronic diseases. This paper looks at their effect on health at torities that include cases of cancer, diabetes, cardiovascular disease and disturbances of the gastrointestinal tract. The evidence synthesis is based on randomized controlled trials, meta-analyses, and observational and clinical studies. Among the main results obtained were the effects of soluble and insoluble fibers on digestive health and prevention of chronic diseases together with the therapeutic functions of herbal adjunct drugs such as antioxidant, anti-inflammatory, and immunomodulating drugs. Dietary fiber and herbal supplements appear to be beneficial; however, their combined efforts with medications need to be exercised with care. It is also indicated that there is a need for future studies of these supplements using standardized protocols with more extended follow-up periods to ascertain the above postulation and the ,precise parameters for converting to routine diets.

Keywords: Dietary fiber, herbal supplements, inflammatory bowel, antioxidant, Diabetes.

INTRODUCTION

Dietary fiber, roughage or bulk, is the term that refers to the indigestible parts of plant foods that travel through our digestive system. Unlike other carbohydrates, it cannot be broken down by the enzymes in our bodies. This nutrient can be obtained from various sources, including cereals, fruits, vegetables, nuts, dried peas, lentils, and grains (Nie & Luo, 2021). Sub-Saharan Africans are more likely to consume a high-fiber diet Therefore their faeces tend to be soft and bulky with a high residue but simple, big colons. Curiously they never suffer from diseases such as constipation, hemorrhoids, polyps' diverticulosis or colitis-appendicitis-hernias and cancers of the colon (Li, Tong, & Qian, 2021). The newly coined term "dietary fiber (DF)," which was first introduced in 1972, pertains to the residue obtained from plant cell walls that are resistant to hydrolysis by the digestive enzymes of man. This decision was taken to use a physiological definition of the term (Macêdo, Albuquerque, Tahan, & Morais, 2020). The Role of dietary fiber in multiple health-beneficial effects dietary fiber has a long history with multiple health beneficial effects as it can be used to

development of several common diseases such as diabetes, hyperlipidemia CVD (cardiovascular disease) series of intestinal disorders and obesity (Soliman, 2019).

DIETARY FIBER TYPES

1. SOLUBLE FIBER

It is a type of fiber that can dissolve in water and form a gel-like substance in the digestive system. It can be found in foods like nuts, seeds, oat bran, barley, lentils, beans, peas, and some fruits and vegetables. Soluble fiber is typically made up of long and branching structures composed of high molecular weight polysaccharides such as pectin, beta-glucan, and gum. When consumed, helps to slow down the emptying of the stomach and the absorption of glucose.

2. INSOLUBLE FIBER

Insoluble fiber, unlike soluble fiber, does not dissolve in water and instead moves through the digestive system mostly intact. It can be found in foods like nuts, seeds, whole grains, wheat bran, and some fruits and vegetables. The structure of the insoluble fiber is usually tough and rigid and is composed of cellulose, hemicellulose, and lignin, which are polysaccharides with a lower molecular weight and are less water-soluble than the polysaccharides found in soluble fiber. Insoluble fiber promotes regular bowel movements by adding bulk to stool (Chen, Chen, Wang, Qin, & Bai, 2017; Nie, Lin, & Luo, 2017; Nie & Luo, 2021).

The classification of fibers is grounded on their physical, chemical, and functional properties. Soluble fibers can dissolve in water and create a thick, gel-like substance. These fibers are not digested in the small intestine but rather gained by microflora native to the large intestine. Soluble fibers include pectin, gums, inulin-type fructans and some hemicelluloses. In contrast, insoluble fibers do not dissolve in water and due to their non-water-dissolvable properties, they can't form gels. As a result, they are not easily fermented in the large intestine. Insoluble fibers are mainly made up of lignin, cellulose, and some hemicelluloses (Ioniță-Mîndrican et al., 2022). Roughly two-thirds of the fiber found in fiber-rich foods is insoluble, while the remaining one-third is soluble. For optimal health, the American heart Association eating plan advises individuals to consume a variety of fiber-rich foods, aiming for a daily intake of 25-30 grams from whole food sources rather than supplements. Unfortunately, studies show that the average daily consumption of dietary fiber in the United States (US) is only 15 grams, which is only half of the recommended amount ("Increasing Fiber Intake," 2002-2023; Mearin et al., 2016). Table 1 shows a summary of the chemical and physiological properties of the most prevalent types of dietary fiber (Vahouny & Kritchevsky, 2016).

Table 1: Physiological actions of dietary fibers in man

Fiber class	Possible functions in man
Hemicellulose	It has the ability to retain water, which leads to an increase in the size of stool. It may also bind to bile acids and decrease the elevated pressure in the colon.
Cellulose	It can retain water, potentially decreasing the pressure in the colon and affecting the excretion of trace minerals. Additionally, it may reduce transit time.
Pectin, gums and mucilage	It can cause a delay in the emptying of the stomach and may bind to bile acids, potentially affecting the excretion of trace minerals.
Lignin	This substance has the potential to function as an antioxidant can retain water, may have the ability to bind trace minerals, and has an impact on the levels of fecal steroids.

Fiber has numerous physiological actions in humans, including bulking and softening of stool, delayed gastric emptying, reduced cholesterol and blood glucose levels, increased satiety, improved gut health, regulation of bowel movements, and possible reduction in the risk of certain diseases.

HEALTH BENEFITS OF DIETARY FIBER

A. OBESITY

The development of obesity can be influenced by several factors related to dietary fiber. Given that obesity is caused by an imbalance between energy intake and energy expenditure, DF effects on mechanisms that control energy intake make it an obvious factor. One theory suggests that consuming fiber may reduce energy intake by promoting feelings of fullness and satisfaction, thus helping regulate appetite (Dayib, Larson, & Slavin, 2020). Consumption of high fiber may help regulate body weight by decreasing energy absorption due to a lower overall energy intake whilst maintaining adequate levels of indispensable nutritional elements (Karim et al., 2023; Ötles & Ozgoz, 2014). The inverse relationship between dietary fiber intake and body weight has been confirmed in multiple studies, with

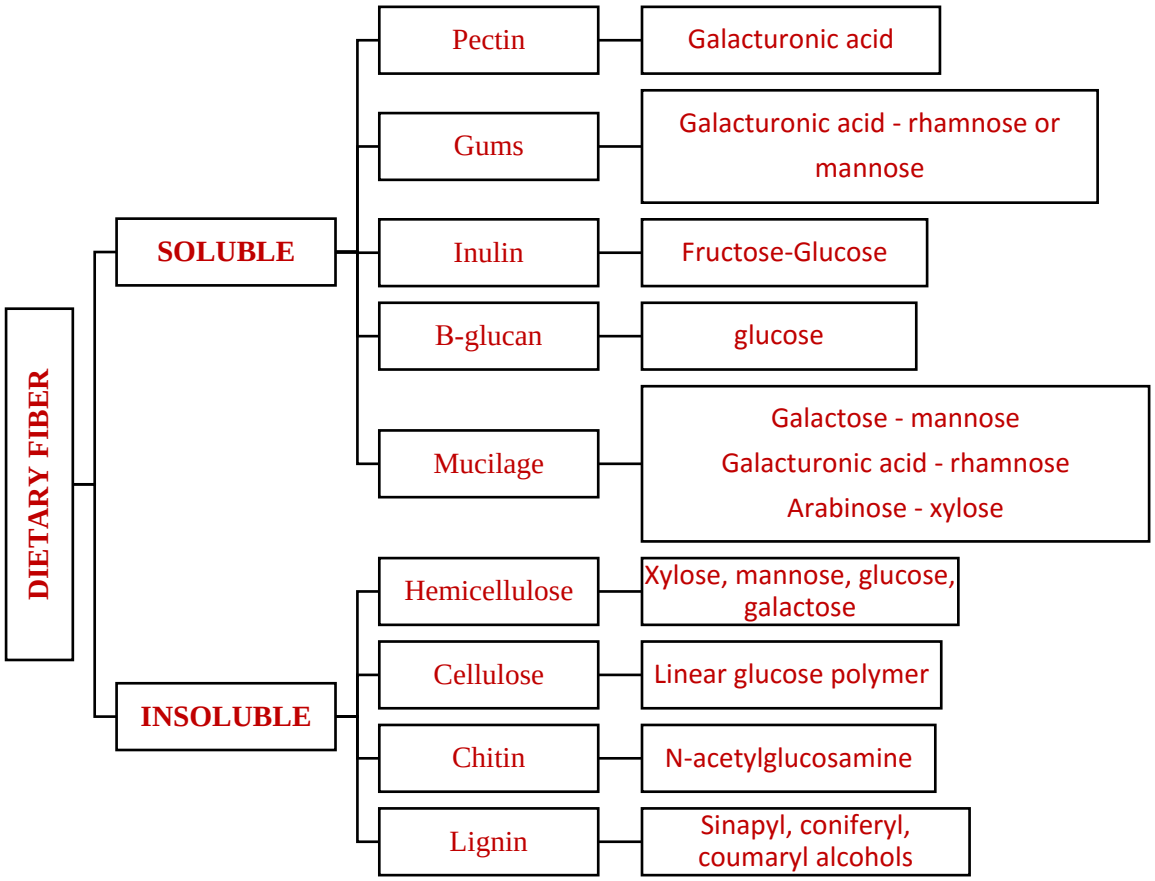

Figure 1. Classification of dietary fibers (Zahoor & Allai, 2020)

most research indicating that increasing the amount of fiber consumed can achieve significant reductions Tucker & Thomas (2009), for example, found a 4.4 pounds reduction of average body weight over a period spanned to 20 months (probably attributable to decreased fat mass) by every additional ingestion of eight grams per bogies fed from energy-equivalent quantities. Importantly, this association remained significant after adjusting for other covariates including age and baseline fiber/fat intake levels as well as physical activity level and starting energy intakes (He et al., 2022). Several factors that may contribute to DF ability to reduce body weight or slow weight gain. One of these factors is the production of gut hormones such as (GLP-1) glucagon-like peptide and (PYY) peptide YY through the fermentation of soluble fiber in the large intestine. These hormones play a crucial role in inducing feelings of fullness and satiety. Additionally, dietary fiber has been shown to significantly reduce overall energy intake, with studies indicating that women who consume higher levels of fiber also tend to consume less dietary fat. Finally, fiber may reduce the metabolizable energy (ME) of a diet, which is the gross energy minus the energy lost through feces, urine, and combustible gases (Carlson, Erickson, Lloyd, & Slavin, 2018). Research suggests that both soluble and insoluble fiber can contribute to weight loss. However, the type of fiber consumed may depend on the type of diet (high or low fat). In particular, there appears to be evidence that insoluble fiber may be more effective for weight loss when consumed as part of a high-fat diet (Surampudi, Enkhmaa, Anuurad, & Berglund, 2016)

B. CARDIOVASCULAR DISEASE

Lowering blood LDL cholesterol levels by consuming less saturated fat is one proven method of lowering the risk of getting cardiovascular disease (CVD). However, other dietary strategies, like increasing the consumption of dietary fibers that are water-soluble, are becoming more and more important (Theuwissen & Mensink, 2018).

More than 80 million individuals in the United States are affected by cardiovascular illnesses, which are the main causes of morbidity and mortality in the country. These conditions include coronary heart disease (CHD), stroke, and hypertension. An estimated 82% of CHD is linked to lifestyle factors like food, exercise, and smoking, while 60% is linked to eating

habits. Consuming high levels of dietary fiber is associated with a notable reduction in the occurrence of coronary heart disease, stroke, and peripheral vascular disease (Dower, Geleijnse, Hollman, Soedamah-Muthu, & Kromhout, 2016; Streppel, Ocké, Boshuizen, Kok, & Kromhout, 2018).

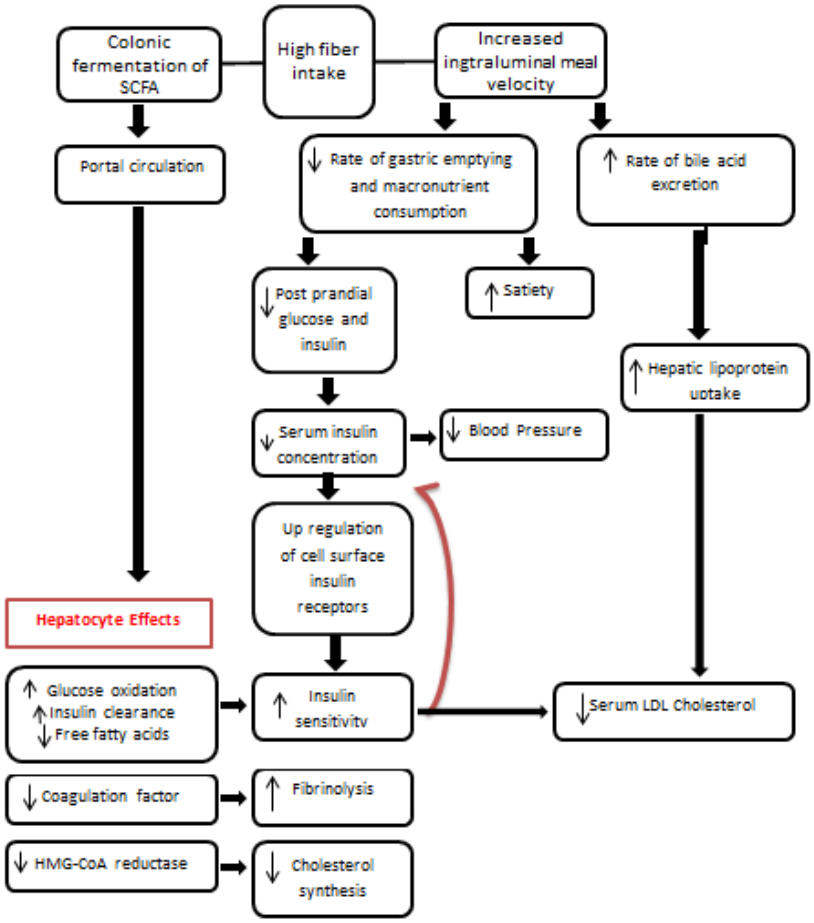

Figure 2. Mechanisms of cholesterol-lowering properties of soluble dietary fiber (Gunness & Gidley, 2010)

The protective effect of consuming dietary fiber, as observed in prospective cohort studies, closely resembles the effects of whole grains. However, the presence of accompanying nutrients like magnesium, other minerals, vitamins, and antioxidants, often referred to as "fellow travelers" with fiber, may contribute significant complementary advantages (Cho, Qi, Fahey Jr, & Klurfeld, 2013).

The specific process through which water-soluble fibers reduce the levels of LDL cholesterol in the bloodstream remains uncertain. However, available evidence indicates that water-soluble fibers may disrupt the metabolism of lipids and/or bile acids. Several potential mechanisms have been proposed, including the inhibition of cholesterol production in the liver through the action of fermentation byproducts, and the slowing down of the absorption of macronutrients, resulting in enhanced insulin sensitivity (Surampudi et al., 2016).

Most clinical trials have centered their attention on investigating the hypolipidemic properties of four specific types of water-soluble fibers, namely oat, psyllium, guar, and pectin. Of these, psyllium and guar have exhibited the most significant effects in terms of lowering lipid levels in humans (McRorie Jr & McKeown, 2017).

In a recent meta-analysis focusing on the impact of psyllium on reducing lipid levels, it was found that consuming an average of 10.4 grams of psyllium for a duration of 8 weeks resulted in a significant reduction of 6.7% in LDL-cholesterol. This finding suggests that psyllium can effectively contribute to lowering LDL-cholesterol levels when incorporated into the diet over a relatively short period of time (Jenkins et al., 2014).

C. TYPE-II DIABETES MELLITUS

The worldwide burden of type 2 diabetes continues to increase so that up to 90% of all adult cases now stand as T2D. By 2040 it is estimated that the number of patients with T2D will increase up to 642 million (Hayward, Watkins, & Ariti, 2020). It significantly affects mortality and morbidity, generating acute & chronic complications. It is a major risk factor for kidney disease, retinopathy (disease of the retina that leads to blindness), neuropathy and cardiovascular diseases. Western lifestyle diets are typically high in fat and sugar, which leads to the reduction of specific bacterial taxa as well as gut microbial diversity. Changes in the gut microbiota might alter metabolic and immune pathways within the intestine leading to type II diabetes. Dietary interventions, especially those containing high dietary fiber are suggested by researchers and health care providers in diabetes care and management (Woldeamlak, Yirdaw, & Biadgo, 2019). Commensal bacteria ferment the undigested carbohydrates that make it to the colon, producing

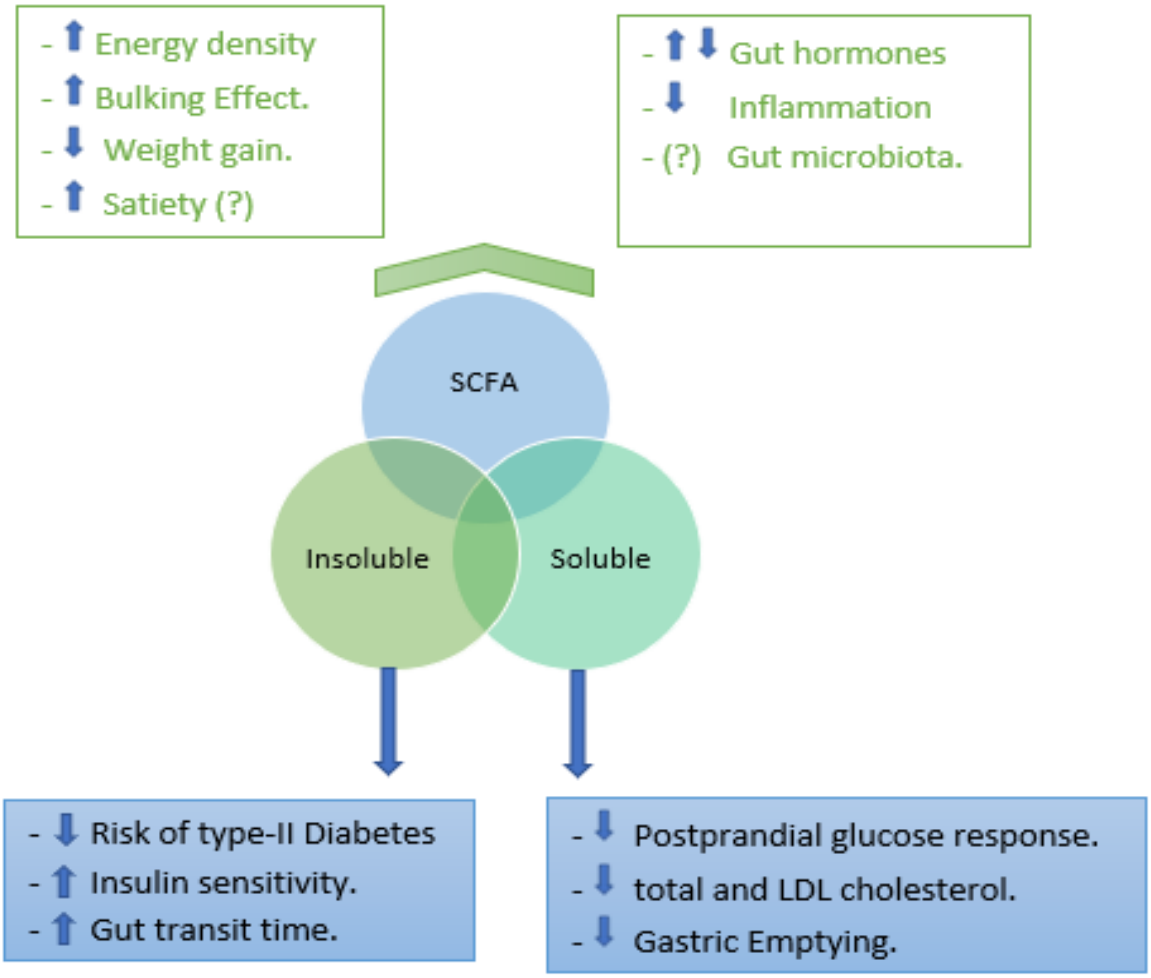

Figure 3. Potential effects of dietary fiber consumption: Colonic fermentation resulting in SCFA production occurs with most types of dietary fiber, though it is generally more pronounced with soluble fiber found in natural foods.

short-chain fatty acids (SCFAs) such as acetic acid, propionic acid and butyric acid which are absorbed into our bloodstream where they provide a major part of our energy supply. SCFAs also can regulate host metabolism and inflammation by inducing the secretion of gastric inhibitory polypeptide (GIP), glucagon-like peptide-1(GLP-1) and Peptide YY(PYY) in adipocytes, which decrease fat deposition (Roshanravan et al., 2020). Therefore, a fibrous diet can screw up your gut environment to increase the growth and density of some microbes, by the fermentation produce higher SCFAs (Healey et al., 2018).

Low dietary fiber intake can decrease gut bacteria diversity and also reduce the production of SCFAs, which afterwards facilitate the utilization of less preferred substrates (i.e. those from diet and endogenic protein sources) by microbiota. Gut microorganisms use proteins and amino acids as fermentation substrates, leading to decreased total SCFA concentrations and butyrate production with increased levels of cytotoxic metabolites (e.g., TMAO), proinflammatory mediators that contribute towards the development of chronic diseases such as type 2 diabetes (Ismael et al., 2021). Candela et al., (2016) demonstrated that a high-fiber diet and control diets decreased fasting blood glucose level as well as postprandial 1-h plasma blood level in patients with type II diabetes, but the high-fiber group experienced more intense improvement than control (Candela et al., 2016). Similarly, Soare et al., (2017) reported a significantly greater reduction in glycated hemoglobin ($p = 0.002$) levels in the high-fiber diet group than in the control group. Moreover, Soare et al., (2017) found that although both diet groups maintained their benefits beyond 21 days, the high-fiber diet group showed greater improvement in glycemic control after six months of intensive monitoring (Ismael et al., 2021).

D. INFLAMMATORY BOWEL DISEASE

With a rising incidence rate, inflammatory bowel disease (IBD), which encompasses Crohn's disease and ulcerative colitis, is characterized by recurrent episodes of chronic intestinal inflammation. It is a rapidly expanding worldwide health concern. It is thought that an individual's genetic sensitivity to gut bacteria causes an aberrant and enduring immune response that leads to IBD. While the exact cause of IBD remains largely unknown, it involves a complex interplay between genetic, environmental, microbial factors, and immune responses (Zhang & Li, 2019). DF is very important when it comes to IBD. In 1973, Burkitt proposed that a high-fiber diet may have a preventive effect against intestinal diseases. His studies in African nations revealed that the population's diet was generally high in dietary fiber and that there was a low prevalence of non-infectious intestinal illnesses, including colon cancer. Nonetheless, it is frequently noted that IBD patients, regardless of the severity of their illness, always follow a low-fiber diet (Ferenc, Jarmakiewicz-Czaja, & Filip, 2022). Although DF has several uses in the human body, its influence on the gut microbiome—which may help fend off certain illnesses—is among its most important roles. Numerous variables influence how well the gut flora uses dietary fiber (Fig. 4). Dietary fiber, known as MAC (microbiota-accessible carbohydrates), is available only to the intestinal microbiota and serves as a primary energy source. Lower levels of MAC are the result of a Western-style diet that is deficient in dietary fiber. Decreased MAC can harm the host by reducing the amount of advantageous commensal microorganisms (Hytting-Andreasen et al., 2018). According to Usuda et al., lower MAC can lead to increased intestinal permeability and colitis. This is probably because there is less synthesis of receptor agonists for GLP-1 and GLP-2, which are essential for intestinal regeneration following mucosal inflammation (Yasuda et al., 2022). Adequate mucus production is essential for maintaining intestinal health, and dietary fiber stimulates the intestinal epithelium to secrete mucus through mechanical action. Short-chain fatty acids like acetate, butyrate, and propionate regulate pH in the intestinal lumen and provide energy to enterocytes, also influencing mucus production (Makki, Deehan, Walter, & Bäckhed, 2018). There is growing interest in the role of diet in the etiopathogenesis and progression of IBD. The quality of life for patients with IBD can be enhanced by a well-planned diet that lowers the chance of remission and helps ensure it. Because it promotes intestinal dysbiosis, throws off the immune system, and compromises intestinal permeability, the pro-inflammatory Western diet that is common in industrialized nations can raise the risk of immunological-mediated bowel disease (IBD) (Owczarek, Rodacki, Domagała-Rodacka, Cibor, & Mach, 2016). As a result, many researchers are exploring the therapeutic potential of diet and specific nutrients for IBD patients (Sasson, Ananthakrishnan, & Raman, 2021).

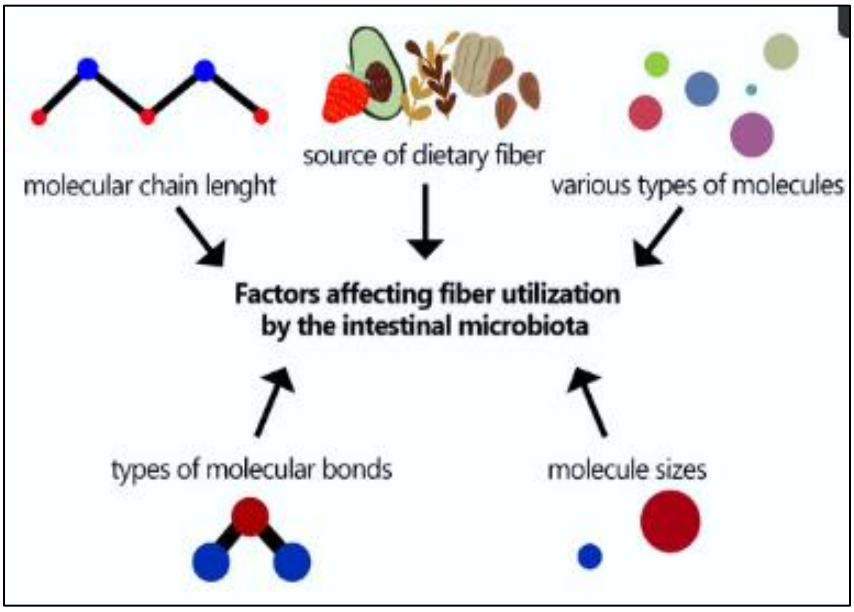

Figure 4. Factors influencing the gut microbiota's utilization of fiber (Abreu et al., 2021)

High fiber consumption may help prevent and lessen inflammation, according to a review by Swann et al. This is probably because it changes pH and improves intestinal permeability. IBD patients have a higher risk of cancer because of their weakened immune systems and persistent gut inflammation, which accounts for 10 to 15% of all deaths each year (Swann, Kilpatrick, Breslin, & Oddy, 2020). A diet high in dietary fiber may help prevent cancer, according to research. High fiber consumption, especially from cereals, has been linked in recent studies to a lower risk of colon cancer development and progression (Hullings et al., 2020; Song et al., 2018; Stidham & Higgins, 2018).

Due to their distinct effects in the setting of IBD, researchers are increasingly concentrating on investigating particular dietary fiber components, such as β-glucan, starch, inulin, pectin, fructo-

Table. 2. Common herbal supplements and their role	
Herb	**Role**
Aloe Vera	Applied topically to treat osteoarthritis, psoriasis, and burns. Used orally to treat digestive problems like constipation and gastritis. Maintain a healthy lipid profile and blood sugar level (Zarrintan, Mobasseri, Zarrintan, & Ostadrahimi, 2016).
Black cohosh (*Actaea racemosa*)	Fairy candle is another name for it. This forest herb is used to relieve menopausal symptoms such as night sweats and hot flashes (Castelo-Branco et al., 2021).
Chamomile	Used to cure gas, diarrhoea, upset stomach, anxiety, and insomnia. It is applied topically to treat skin ailments as well. Those who are allergic to ragweed should use caution (Srivastava, Shankar, & Gupta, 2019).
Echinacea	Purple coneflower, coneflower, or American coneflower is a common name, used to treat cold and flu symptoms, boost immunity, and play a part in cancer (Espinosa-Paredes et al., 2021; Rondanelli et al., 2018).
Flaxseed	Plant-based food is high in fiber, antioxidants, and healthy fat flaxseed. It is sometimes referred to as a "functional food," meaning that consuming it can improve one's health. Additionally used to treat heart disease, hepatic and neurological diseases, blood pressure, cholesterol, and excellent source of omega-3 fatty acids and fiber (Ebrahimi et al., 2021).
Peppermint oil	Used to treat intestinal disorders, nausea, indigestion, and stomach issues related to digestion (Nee et al., 2021).
Soy	Used to treat elevated cholesterol levels and memory issues. Soy supplements and processed soy foods like soy hot dogs are not as good as organic, whole soy food (Xiao, Zhang, Tong, & Shi, 2018).
Tea tree oil	Applied topically to cure a variety of ailments, such as dandruff, cold sores, growth, acne, athlete's foot, nail fungus, wounds, infections, lice, and oral yeast infection (thrush) (Liu et al., 2023; Puvača et al., 2020).
Willow bark	The bark of the willow tree comes in a variety of forms. One uses the bark to manufacture medication. Willow bark functions similarly to aspirin. The most common uses are for fever and discomfort. However, there isn't any solid scientific proof that it treats these ailments any better than aspirin.
Garlic (*Allium sativum*)	To reduce cholesterol; to cure and avoid colds and other illnesses. This can result in excessive bleeding in patients receiving anticoagulant therapy (Londhe, Gavasane, Nipate, Bandawane, & Chaudhari, 2019).
Nettle (*Urtica dioica*)	Help combat rheumatism, kidney and bladder stones, and urinary tract infections. Dandruff is managed externally using it. People who have decreased heart or kidney function and fluid retention should not use Nettle.
Ginger	Help reduce blood cholesterol, platelet aggregation, nausea and motion sickness, and serve as an antioxidant and digestive aid (Danwilai, Konmun, Sripanidkulchai, & Subongkot, 2017).
Hawthorn (*Crataegus sp.*)	To address hypertension and congestive heart failure (Cloud, Vilcins, & McEwen, 2020).
Licorice root (*Glycyrrhiza glabra*)	Help cure stomach ulcers, cirrhosis, and coughs. Additives for feeding (Alagawany et al., 2019; Murray, 2020).

oligosaccharides, or hemicellulose (Abreu et al., 2021). By lowering pro-inflammatory cytokines, altering the intestinal microbiota, and lessening gastrointestinal side effects, dietary fiber has been proposed to be crucial in the prevention of inflammatory bowel disease (IBD) (Reddel, Putignani, & Del Chierico, 2019).

For adult males, the recommended daily consumption of dietary fiber is 38g, while for adult women; it is 25g (or 14g per 1000 kcal). This recommendation is predicated on the lowest quantity of fiber required to have a beneficial effect on health and illness (Rosa et al., 2018). The colon's bacteria that produce butyrate as a byproduct of short-chain fatty acid (SCFA) metabolism are primarily responsible for the advantages of dietary fiber for inflammatory bowel disease (IBD). In addition to providing colonocytes with a vital source of energy, SCFAs also have trophic effects on the colon, promote the absorption of water and electrolytes, and improve colonic blood flow. Additionally, SCFAs and dietary fiber are crucial for

maintaining the integrity of the colonic barrier functions (Castro & de Souza, 2019).

E. CONSTIPATION

Almost 20% of people worldwide suffer from the health issue of constipation. This uncomfortable illness raises the risk of colon cancer and has a detrimental effect on quality of life. There are many different kinds of treatments. The initial line of treatment is typically lifestyle modification, such as increased fluid consumption or exercise, however, there is little information available on how successful these interventions are (Singh, Tuck, Gibson, & Chey, 2022). It has been suggested that adults and children suffering from constipation should consume more dietary fibre. Rome discovered that, regardless of age range and age of constipation onset, dietary fibre intake was independently adversely linked with chronic constipation in a large-population case-control research (Algera et al., 2022). Several randomised controlled trials have examined the connection between constipation and dietary fibre.

Because dietary fibers increase intraluminal volume, improve stool frequency and consistency, and shorten intestinal transit time, they are essential for preserving a healthy stool patterns (Micka, Siepelmeyer, Holz, Theis, & Schön, 2017). This was also seen in two meta-analyses, wherein inulin-type fructans improved stool pattern while fiber supplements helped increase stool frequency. More than 25g of fiber per day was observed to increase the frequency of stools by Anti et al. (Watson et al., 2019). This effect was especially noticeable in patients who drank more than 2L of water per day during a two-month intervention. Following a 42-day intervention, a high-fiber diet of 28 g/day was equally helpful in treating constipation in women with pelvic floor issues (De Vries, Le Bourgot, Calame, & Respondek, 2019).

HERBAL SUPPLEMENTS

Dietary supplements are defined by the National Center for Complementary and Integrative Health as a range of goods, such as probiotics, vitamins, and minerals, as well as herbs. An estimated 20% to 25% of patients taking prescription medications also use dietary supplements. Between 40% and 60% of American adults with chronic diseases are estimated to use dietary supplements (Asher, Corbett, & Hawke, 2017). As a result, there is growing concern about the possibility of dietary supplements—especially herbal supplements—interacting with prescription drugs (Marupuru, Axon, & Slack, 2019).

Herbal supplements are used by 80% of the world's population. More than 750 herbs are available in the market derived from plants and/or their oils, roots, seeds, berries or flowers. They are believed to have healing properties (Alamgir & Alamgir, 2017). The forms of herbal products include: Liquid extracts, Teas, Tablets and capsules, Bath salts, Oils and Ointments.

CONCLUSION

Dietary fiber and herbal supplements are essential in managing and preventing chronic diseases such as cardiovascular disease, type 2 diabetes and gastrointestinal disorders. Soluble and insoluble fiber promotes digestive health and support weight management, while herbal supplements provide therapeutic benefits due to their anti-inflammatory, antioxidant and immune-modulatory properties.

RECOMMENDATIONS

Future research should establish standardized methodologies and conduct long-term, controlled studies to validate the effects of dietary fiber and herbal supplements and ensure their sustainability.

ACKNOWLEDGEMENTS

We would like to thank Prof. Dr Naseem Aslam Channa who assisted us in any way.

CONFLICT OF INTEREST

Authors declare that they have no conflict of interest

FUNDING (IF ANY)

There was not any funding resource

REFERENCES

Alagawany, M., Elnesr, S. S., Farag, M. R., Abd El-Hack, M. E., Khafaga, A. F., Taha, A. E., . . . Marappan, G. (2019). Use of licorice (Glycyrrhiza glabra) herb as a feed additive in poultry: Current knowledge and prospects. *Animals*, *9*(8), 536.

Alamgir, A., & Alamgir, A. (2017). Cultivation of herbal drugs, biotechnology, and in vitro production of secondary metabolites, high-value medicinal plants, herbal wealth, and herbal trade. *Therapeutic Use of Medicinal Plants and Their Extracts: Volume 1: Pharmacognosy*, 379-452.

Algera, J. P., Demir, D., Törnblom, H., Nybacka, S., Simrén, M., & Störsrud, S. (2022). Low FODMAP diet reduces gastrointestinal symptoms in irritable bowel syndrome and clinical response could be predicted by

symptom severity: A randomized crossover trial. *Clinical Nutrition, 41*(12), 2792-2800.

Asher, G. N., Corbett, A. H., & Hawke, R. L. (2017). Common herbal dietary supplement–drug interactions. *American family physician, 96*(2), 101-107.

Candela, M., Biagi, E., Soverini, M., Consolandi, C., Quercia, S., Severgnini, M., . . . Pozzilli, P. (2016). Modulation of gut microbiota dysbioses in type 2 diabetic patients by macrobiotic Ma-Pi 2 diet. *British Journal of Nutrition, 116*(1), 80-93.

Carlson, J. L., Erickson, J. M., Lloyd, B. B., & Slavin, J. L. (2018). Health effects and sources of prebiotic dietary fiber. *Current developments in nutrition, 2*(3), nzy005.

Castelo-Branco, C., Gambacciani, M., Cano, A., Minkin, M., Rachoń, D., Ruan, X., . . . Pickartz, S. (2021). Review & meta-analysis: isopropanolic black cohosh extract iCR for menopausal symptoms–an update on the evidence. *Climacteric, 24*(2), 109-119.

Castro, F., & de Souza, H. S. (2019). Dietary composition and effects in inflammatory bowel disease. *Nutrients, 11*(6), 1398.

Chen, J.-P., Chen, G.-C., Wang, X.-P., Qin, L., & Bai, Y. (2017). Dietary fiber and metabolic syndrome: a meta-analysis and review of related mechanisms. *Nutrients, 10*(1), 24.

Cho, S. S., Qi, L., Fahey Jr, G. C., & Klurfeld, D. M. (2013). Consumption of cereal fiber, mixtures of whole grains and bran, and whole grains and risk reduction in type 2 diabetes, obesity, and cardiovascular disease. *The American journal of clinical nutrition, 98*(2), 594-619.

Cloud, A., Vilcins, D., & McEwen, B. (2020). The effect of hawthorn (Crataegus spp.) on blood pressure: a systematic review. *Advances in Integrative Medicine, 7*(3), 167-175.

Danwilai, K., Konmun, J., Sripanidkulchai, B.-o., & Subongkot, S. (2017). Antioxidant activity of ginger extract as a daily supplement in cancer patients receiving adjuvant chemotherapy: a pilot study. *Cancer management and research*, 11-18.

Dayib, M., Larson, J., & Slavin, J. (2020). Dietary fibers reduce obesity-related disorders: mechanisms of action. *Current Opinion in Clinical Nutrition & Metabolic Care, 23*(6), 445-450.

De Vries, J., Le Bourgot, C., Calame, W., & Respondek, F. (2019). Effects of β-fructans fiber on bowel function: a systematic review and meta-analysis. *Nutrients, 11*(1), 91.

Dower, J. I., Geleijnse, J. M., Hollman, P., Soedamah-Muthu, S. S., & Kromhout, D. (2016). Dietary epicatechin intake and 25-y risk of cardiovascular mortality: the Zutphen Elderly Study. *Am J Clin Nutr, 104*(1), 58-64.

Ebrahimi, B., Nazmara, Z., Hassanzadeh, N., Yarahmadi, A., Ghaffari, N., Hassani, F., . . . Hassanzadeh, G. (2021). Biomedical features of flaxseed against different pathologic situations: A narrative review. *Iranian Journal of Basic Medical Sciences, 24*(5), 551.

Espinosa-Paredes, D. A., Cornejo-Garrido, J., Moreno-Eutimio, M. A., Martínez-Rodríguez, O. P., Jaramillo-Flores, M. E., & Ordaz-Pichardo, C. (2021). Echinacea angustifolia DC extract induces apoptosis and cell cycle arrest and synergizes with paclitaxel in the MDA-MB-231 and MCF-7 human breast cancer cell lines. *Nutrition and cancer, 73*(11-12), 2287-2305.

Ferenc, K., Jarmakiewicz-Czaja, S., & Filip, R. (2022). Components of the fiber diet in the prevention and treatment of IBD—an update. *Nutrients, 15*(1), 162.

Gunness, P., & Gidley, M. J. (2010). Mechanisms underlying the cholesterol-lowering properties of soluble dietary fibre polysaccharides. *Food & function, 1*(2), 149-155.

Hayward, R. C., Watkins, J., & Ariti, C. (2020). Differences in rates of uptake of NICE clinical guidelines between Type 1 diabetes mellitus (T1DM) and Type 2 diabetes mellitus (T2DM) as evidenced by National Diabetes Audit of England and Wales. *medRxiv*, 2020.2008. 2005.20168914.

He, Y., Wang, B., Wen, L., Wang, F., Yu, H., Chen, D., . . . Zhang, C. (2022). Effects of dietary fiber on human health. *Food Science and Human Wellness, 11*(1), 1-10.

Healey, G., Murphy, R., Butts, C., Brough, L., Whelan, K., & Coad, J. (2018). Habitual dietary fibre intake influences gut microbiota response to an inulin-type fructan prebiotic: a randomised, double-blind, placebo-controlled, cross-over, human intervention study. *British Journal of Nutrition, 119*(2), 176-189.

Hullings, A. G., Sinha, R., Liao, L. M., Freedman, N. D., Graubard, B. I., & Loftfield, E. (2020). Whole grain and dietary fiber intake and risk of colorectal cancer in the NIH-AARP Diet and Health Study cohort. *The American Journal of Clinical Nutrition, 112*(3), 603-612.

Hytting-Andreasen, R., Balk-Møller, E., Hartmann, B., Pedersen, J., Windeløv, J. A., Holst, J. J.,

& Kissow, H. (2018). Endogenous glucagon-like peptide-1 and 2 are essential for regeneration after acute intestinal injury in mice. *PloS one, 13*(6), e0198046.

Increasing Fiber Intake. (2002-2023). *UCSF Health*.

Alagawany, M., Elnesr, S. S., Farag, M. R., Abd El-Hack, M. E., Khafaga, A. F., Taha, A. E., . . . Marappan, G. (2019). Use of licorice (Glycyrrhiza glabra) herb as a feed additive in poultry: Current knowledge and prospects. *Animals, 9*(8), 536.

Alamgir, A., & Alamgir, A. (2017). Cultivation of herbal drugs, biotechnology, and in vitro production of secondary metabolites, high-value medicinal plants, herbal wealth, and herbal trade. *Therapeutic Use of Medicinal Plants and Their Extracts: Volume 1: Pharmacognosy*, 379-452.

Algera, J. P., Demir, D., Törnblom, H., Nybacka, S., Simrén, M., & Störsrud, S. (2022). Low FODMAP diet reduces gastrointestinal symptoms in irritable bowel syndrome and clinical response could be predicted by symptom severity: A randomized crossover trial. *Clinical Nutrition, 41*(12), 2792-2800.

Asher, G. N., Corbett, A. H., & Hawke, R. L. (2017). Common herbal dietary supplement–drug interactions. *American family physician, 96*(2), 101-107.

Candela, M., Biagi, E., Soverini, M., Consolandi, C., Quercia, S., Severgnini, M., . . . Pozzilli, P. (2016). Modulation of gut microbiota dysbioses in type 2 diabetic patients by macrobiotic Ma-Pi 2 diet. *British Journal of Nutrition, 116*(1), 80-93.

Carlson, J. L., Erickson, J. M., Lloyd, B. B., & Slavin, J. L. (2018). Health effects and sources of prebiotic dietary fiber. *Current developments in nutrition, 2*(3), nzy005.

Castelo-Branco, C., Gambacciani, M., Cano, A., Minkin, M., Rachoń, D., Ruan, X., . . . Pickartz, S. (2021). Review & meta-analysis: isopropanolic black cohosh extract iCR for menopausal symptoms–an update on the evidence. *Climacteric, 24*(2), 109-119.

Castro, F., & de Souza, H. S. (2019). Dietary composition and effects in inflammatory bowel disease. *Nutrients, 11*(6), 1398.

Chen, J.-P., Chen, G.-C., Wang, X.-P., Qin, L., & Bai, Y. (2017). Dietary fiber and metabolic syndrome: a meta-analysis and review of related mechanisms. *Nutrients, 10*(1), 24.

Cho, S. S., Qi, L., Fahey Jr, G. C., & Klurfeld, D. M. (2013). Consumption of cereal fiber, mixtures of whole grains and bran, and whole grains and risk reduction in type 2 diabetes, obesity, and cardiovascular disease. *The American journal of clinical nutrition, 98*(2), 594-619.

Cloud, A., Vilcins, D., & McEwen, B. (2020). The effect of hawthorn (Crataegus spp.) on blood pressure: a systematic review. *Advances in Integrative Medicine, 7*(3), 167-175.

Danwilai, K., Konmun, J., Sripanidkulchai, B.-o., & Subongkot, S. (2017). Antioxidant activity of ginger extract as a daily supplement in cancer patients receiving adjuvant chemotherapy: a pilot study. *Cancer management and research*, 11-18.

Dayib, M., Larson, J., & Slavin, J. (2020). Dietary fibers reduce obesity-related disorders: mechanisms of action. *Current Opinion in Clinical Nutrition & Metabolic Care, 23*(6), 445-450.

De Vries, J., Le Bourgot, C., Calame, W., & Respondek, F. (2019). Effects of β-fructans fiber on bowel function: a systematic review and meta-analysis. *Nutrients, 11*(1), 91.

Dower, J. I., Geleijnse, J. M., Hollman, P., Soedamah-Muthu, S. S., & Kromhout, D. (2016). Dietary epicatechin intake and 25-y risk of cardiovascular mortality: the Zutphen Elderly Study. *Am J Clin Nutr, 104*(1), 58-64.

Ebrahimi, B., Nazmara, Z., Hassanzadeh, N., Yarahmadi, A., Ghaffari, N., Hassani, F., . . . Hassanzadeh, G. (2021). Biomedical features of flaxseed against different pathologic situations: A narrative review. *Iranian Journal of Basic Medical Sciences, 24*(5), 551.

Espinosa-Paredes, D. A., Cornejo-Garrido, J., Moreno-Eutimio, M. A., Martínez-Rodríguez, O. P., Jaramillo-Flores, M. E., & Ordaz-Pichardo, C. (2021). Echinacea angustifolia DC extract induces apoptosis and cell cycle arrest and synergizes with paclitaxel in the MDA-MB-231 and MCF-7 human breast cancer cell lines. *Nutrition and cancer, 73*(11-12), 2287-2305.

Ferenc, K., Jarmakiewicz-Czaja, S., & Filip, R. (2022). Components of the fiber diet in the prevention and treatment of IBD—an update. *Nutrients, 15*(1), 162.

Gunness, P., & Gidley, M. J. (2010). Mechanisms underlying the cholesterol-lowering properties of soluble dietary fibre polysaccharides. *Food & function, 1*(2), 149-155.

Hayward, R. C., Watkins, J., & Ariti, C. (2020). Differences in rates of uptake of NICE clinical guidelines between Type 1 diabetes mellitus (T1DM) and Type 2 diabetes mellitus (T2DM) as evidenced by National

Diabetes Audit of England and Wales. *medRxiv*, 2020.2008. 2005.20168914.

He, Y., Wang, B., Wen, L., Wang, F., Yu, H., Chen, D., . . . Zhang, C. (2022). Effects of dietary fiber on human health. *Food Science and Human Wellness, 11*(1), 1-10.

Healey, G., Murphy, R., Butts, C., Brough, L., Whelan, K., & Coad, J. (2018). Habitual dietary fibre intake influences gut microbiota response to an inulin-type fructan prebiotic: a randomised, double-blind, placebo-controlled, cross-over, human intervention study. *British Journal of Nutrition, 119*(2), 176-189.

Hullings, A. G., Sinha, R., Liao, L. M., Freedman, N. D., Graubard, B. I., & Loftfield, E. (2020). Whole grain and dietary fiber intake and risk of colorectal cancer in the NIH-AARP Diet and Health Study cohort. *The American Journal of Clinical Nutrition, 112*(3), 603-612.

Hytting-Andreasen, R., Balk-Møller, E., Hartmann, B., Pedersen, J., Windeløv, J. A., Holst, J. J., & Kissow, H. (2018). Endogenous glucagon-like peptide-1 and 2 are essential for regeneration after acute intestinal injury in mice. *PloS one, 13*(6), e0198046.

Increasing Fiber Intake. (2002-2023). *UCSF Health*.

Ioniță-Mîndrican, C.-B., Ziani, K., Mititelu, M., Oprea, E., Neacșu, S. M., Moroșan, E., . . . Negrei, C. (2022). Therapeutic benefits and dietary restrictions of fiber intake: A state of the art review. *Nutrients, 14*(13), 2641.

Ismael, S., Silvestre, M. P., Vasques, M., Araújo, J. R., Morais, J., Duarte, M. I., . . . Vaz, J. (2021). A pilot study on the metabolic impact of Mediterranean diet in type 2 diabetes: is gut microbiota the key? *Nutrients, 13*(4), 1228.

Jenkins, D. J., Chiavaroli, L., Mirrahimi, A., Srichaikul, K., Wong, J. M., Jones, P., & Kendall, C. W. (2014). 28 Nutraceuticals and Functional Foods for Cholesterol Reduction. *Clinical Lipidology: A Companion to Braunwald's Heart Disease E-Book*, 326.

Karim, M. R., Iqbal, S., Mohammad, S., Lee, J. H., Jung, D., Mathiyalagan, R., . . . Kang, S. C. (2023). A review on Impact of dietary interventions, drugs, and traditional herbal supplements on the gut microbiome. *Microbiological Research, 271*, 127346.

Li, Y., Tong, W.-D., & Qian, Y. (2021). Effect of physical activity on the association between dietary fiber and constipation: evidence from the national health and nutrition examination survey 2005-2010. *Journal of neurogastroenterology and motility, 27*(1), 97.

Liu, Y., Xu, L., Du, H., Feng, J., Zhang, W., Li, H., . . . Zhao, X. (2023). Effects of adding tea tree oil on growth performance, immune function, and intestinal function of broilers. *Poultry Science, 102*(11), 102936.

Londhe, V., Gavasane, A., Nipate, S., Bandawane, D., & Chaudhari, P. (2019). Role of garlic (Allium sativum) in various diseases: An overview. *Angiogenesis, 12*(13), 129-134.

Macêdo, M. I. P., Albuquerque, M. d. F. M., Tahan, S., & Morais, M. B. d. (2020). Is there any association between overweight, physical activity, fat and fiber intake with functional constipation in adolescents? *Scandinavian Journal of Gastroenterology, 55*(4), 414-420.

Makki, K., Deehan, E. C., Walter, J., & Bäckhed, F. (2018). The impact of dietary fiber on gut microbiota in host health and disease. *Cell host & microbe, 23*(6), 705-715.

Marupuru, S., Axon, D. R., & Slack, M. K. (2019). How do pharmacists use and recommend vitamins, minerals, herbals and other dietary supplements? *BMC Complementary and Alternative Medicine, 19*, 1-9.

McRorie Jr, J. W., & McKeown, N. M. (2017). Understanding the physics of functional fibers in the gastrointestinal tract: an evidence-based approach to resolving enduring misconceptions about insoluble and soluble fiber. *Journal of the Academy of Nutrition and Dietetics, 117*(2), 251-264.

Mearin, F., Ciriza, C., Mínguez, M., Rey, E., Mascort, J. J., Peña, E., . . . Júdez, J. (2016). Clinical practice guideline: irritable bowel syndrome with constipation and functional constipation in the adult. *Rev Esp Enferm Dig, 108*(6), 332-363.

Micka, A., Siepelmeyer, A., Holz, A., Theis, S., & Schön, C. (2017). Effect of consumption of chicory inulin on bowel function in healthy subjects with constipation: a randomized, double-blind, placebo-controlled trial. *International journal of food sciences and nutrition, 68*(1), 82-89.

Murray, M. T. (2020). Glycyrrhiza glabra (licorice). *Textbook of natural medicine*, 641.

Nee, J., Ballou, S., Kelley, J. M., Kaptchuk, T. J., Hirsch, W., Katon, J., . . . Iturrino, J. (2021). Peppermint oil treatment for irritable bowel syndrome: a randomized placebo-controlled trial. *Official journal of the American College of Gastroenterology| ACG, 116*(11), 2279-2285.

Nie, Y., Lin, Q., & Luo, F. (2017). Effects of non-starch polysaccharides on inflammatory bowel disease. *International journal of molecular sciences*, *18*(7), 1372.

Nie, Y., & Luo, F. (2021). Dietary Fiber: An Opportunity for a Global Control of Hyperlipidemia. *Oxidative Medicine and Cellular Longevity*, *2021*.

Ötles, S., & Ozgoz, S. (2014). Health effects of dietary fiber. *Acta scientiarum polonorum Technologia alimentaria*, *13*(2), 191-202.

Owczarek, D., Rodacki, T., Domagała-Rodacka, R., Cibor, D., & Mach, T. (2016). Diet and nutritional factors in inflammatory bowel diseases. *World journal of gastroenterology*, *22*(3), 895.

Puvača, N., Tomić, D. H., Popović, S., Đorđević, S., Brkić, I., Lalić, N., . . . Lika, E. (2020). Influence of tea tree (Melaleuca alternifolia) essential oil as feed supplement on production traits, blood oxidative status and treatment of coccidiosis in laying hens.

Reddel, S., Putignani, L., & Del Chierico, F. (2019). The impact of low-FODMAPs, gluten-free, and ketogenic diets on gut microbiota modulation in pathological conditions. *Nutrients*, *11*(2), 373.

Rondanelli, M., Miccono, A., Lamburghini, S., Avanzato, I., Riva, A., Allegrini, P., . . . Perna, S. (2018). Self-care for common colds: the pivotal role of vitamin D, vitamin C, zinc, and echinacea in three main immune interactive clusters (physical barriers, innate and adaptive immunity) involved during an episode of common colds—practical advice on dosages and on the time to take these nutrients/botanicals in order to prevent or treat common colds. *Evidence-Based Complementary and Alternative Medicine*, *2018*(1), 5813095.

Rosa, R., Ornella, R., Maria, G. C., Elisa, S., Maria, N., Chiara, M., . . . Gioacchino, L. (2018). The role of diet in the prevention and treatment of Inflammatory Bowel Diseases. *Acta Bio Medica: Atenei Parmensis*, *89*(Suppl 9), 60.

Roshanravan, N., Alamdari, N. M., Jafarabadi, M. A., Mohammadi, A., Shabestari, B. R., Nasirzadeh, N., . . . Ghavami, A. (2020). Effects of oral butyrate and inulin supplementation on inflammation-induced pyroptosis pathway in type 2 diabetes: A randomized, double-blind, placebo-controlled trial. *Cytokine*, *131*, 155101.

Sasson, A. N., Ananthakrishnan, A. N., & Raman, M. (2021). Diet in treatment of inflammatory bowel diseases. *Clinical Gastroenterology and Hepatology*, *19*(3), 425-435. e423.

Singh, P., Tuck, C., Gibson, P. R., & Chey, W. D. (2022). The role of food in the treatment of bowel disorders: focus on irritable bowel syndrome and functional constipation. *Official journal of the American College of Gastroenterology| ACG*, *117*(6), 947-957.

Soliman, G. A. (2019). Dietary fiber, atherosclerosis, and cardiovascular disease. *Nutrients*, *11*(5), 1155.

Song, M., Wu, K., Meyerhardt, J. A., Ogino, S., Wang, M., Fuchs, C. S., . . . Chan, A. T. (2018). Fiber intake and survival after colorectal cancer diagnosis. *JAMA oncology*, *4*(1), 71-79.

Srivastava, J. K., Shankar, E., & Gupta, S. (2019). Chamomile: A herbal medicine of the past with a bright future. *Molecular medicine reports*, *3*(6), 895-901.

Stidham, R. W., & Higgins, P. D. (2018). Colorectal cancer in inflammatory bowel disease. *Clinics in colon and rectal surgery*, *31*(03), 168-178.

Streppel, M. T., Ocké, M. C., Boshuizen, H. C., Kok, F. J., & Kromhout, D. (2018). Dietary fiber intake in relation to coronary heart disease and all-cause mortality over 40 y: the Zutphen Study. *Am J Clin Nutr*, *88*(4), 1119-1125.

Surampudi, P., Enkhmaa, B., Anuurad, E., & Berglund, L. (2016). Lipid lowering with soluble dietary fiber. *Current atherosclerosis reports*, *18*, 1-13.

Swann, O. G., Kilpatrick, M., Breslin, M., & Oddy, W. H. (2020). Dietary fiber and its associations with depression and inflammation. *Nutrition Reviews*, *78*(5), 394-411.

Theuwissen, E., & Mensink, R. P. (2018). Water-soluble dietary fibers and cardiovascular disease. *Physiology & Behavior*, *94*(2), 285-292. doi:https://doi.org/10.1016/j.physbeh.2008.01.001

Vahouny, G. V., & Kritchevsky, D. (2016). *Dietary fiber in health and disease*: Springer Science & Business Media.

Watson, A. W., Houghton, D., Avery, P. J., Stewart, C., Vaughan, E. E., Meyer, P. D., . . . Brandt, K. (2019). Changes in stool frequency following chicory inulin consumption, and effects on stool consistency, quality of life and composition of gut microbiota. *Food hydrocolloids*, *96*, 688-698.

Woldeamlak, B., Yirdaw, K., & Biadgo, B. (2019). Role of gut microbiota in type 2 diabetes mellitus and its complications: Novel insights and potential intervention strategies. *The Korean Journal of Gastroenterology, 74*(6), 314-320.

Xiao, Y., Zhang, S., Tong, H., & Shi, S. (2018). Comprehensive evaluation of the role of soy and isoflavone supplementation in humans and animals over the past two decades. *Phytotherapy Research, 32*(3), 384-394.

y Abreu, A. A., Milke-García, M., Argüello-Arévalo, G., Calderón-de la Barca, A., Carmona-Sánchez, R., Consuelo-Sánchez, A., . . . Icaza-Chávez, M. (2021). Dietary fiber and the microbiota: A narrative review by a group of experts from the Asociación Mexicana de Gastroenterología. *Revista de Gastroenterología de México (English Edition), 86*(3), 287-304.

Yasuda, A., Mizote, A., Miyata, M., Kurose, M., Ogawa, T., Sadakiyo, T., . . . Aga, H. (2022). Development of a method for preparing cyclic nigerosylnigerose syrup and investigation of its value as a dietary fiber. *Bioscience, Biotechnology, and Biochemistry, 86*(6), 780-791.

Zahoor, I., & Allai, F. (2020). Food Antioxidants: Functional Aspects and Preservation During Food Processing (pp. 131-153).

Zarrintan, A., Mobasseri, M., Zarrintan, A., & Ostadrahimi, A. (2016). Effects of Aloe vera supplements on blood glucose level and lipid profile markers in type 2 diabetic patients–a randomized clinical trial. *Pharmaceutical Sciences, 21*(2), 65-71.

Zhang, Y.-Z., & Li, Y.-Y. (2019). Inflammatory bowel disease: pathogenesis. *World journal of gastroenterology: WJG, 20*(1), 91.