World Journal of Biology Pharmacy and Health Sciences, 2020, 04(03), 059–076

World Journal of Biology Pharmacy and Health Sciences

e-ISSN: 2582-5542, Cross Ref DOI: 10.30574/wjbphs

Journal homepage: http://www.wjbphs.com

(REVIEW ARTICLE)

A comprehensive review on dietary fiber and their functional properties in human body

Shubhangi Bhide Kshirsagar *, Smita Takarkhede, Anjali Govind Jha, Ronak Pradeep Jain, Vedika Sunil Jadhav and Diksha Dharmendra Jadhav

Ideal College of Pharmacy and Research, Bhal, Kalyan - 421306, Dist- Thane, Maharashtra, India.

Publication history**:** Received on 01 December 2020; revised on 09 December 2020; accepted on 12 December 2020

Article DOI: https://doi.org/10.30574/wjbphs.2020.4.3.0104

Abstract

The term 'dietary fiber' (DF) was first presented in the 1950s, alluding to plant cell divided materials; later it was utilized to portray a class of plant-started polysaccharides, which can't be processed and retained in the gastrointestinal plot. Dietary fiber is seen as a physiologically torpid material, and although the best glycemic list building and properties of various fiber sources have for a long while been recognized. Dietary fiber isn't just attractive for its wholesome properties, yet additionally for its useful and mechanical properties. Dietary fiber can be classified in many different ways such as structure and solubility. Based on solubility, they can be divided into soluble or insoluble Dietary Fibres. Soluble Dietary Fibres incorporate oligosaccharides, including fructooligosaccharide (FOS), gelatins, β- glucans (oat and grain grains), galactomannan gums, alginate, and psyllium. Dietary fiber incorporates all non-starch polysaccharides impervious to processing in the small digestive tract and fermentable in the internal organ. Soluble dietary fibres are generally present in plants including agave, garlic, onions, and wheat. Insoluble strands, similar to those found in wheat, grain, vegetables, and organic products. Dietary Fiber analysis is regarded as one of the most tedious assays used in the food industry for nutritional labeling, quality control, and R&D purposes. Recently the food industry has investigated ways of improving the overall nutritional balance of carbohydrate-rich foods and focused on increasing their dietary fiber. This review article reports is evidence regarding fiber enrichment of cereal foods and looks out for future trends in enriched dietary fiber products.

Keywords: Dietary fiber; Insoluble; Soluble dietary fibres; Constituents; Applications

1. Introduction

Dietary fiber is an omnipresent part of plant nourishments and incorporates materials of different synthetic and morphological structures, impervious to the activity of human wholesome compounds however that might be processed by microflora in the gut. Wellspring of dietary fiber incorporates vegetables, wheat, and most different grains. Nourishments wealthy in soluble fiber incorporate natural products, oats, grain, and beans [1].

The term 'dietary fiber' (DF) was first presented in the 1950s, [2] alluding to plant cell divider materials; later it was utilized to portray a class of plant-started polysaccharides, which can't be processed and retained in the gastrointestinal plot. In recent decades, disarray existed in characterizing 'Dietary Fiber' and in arranging a lot of substances under this umbrella term. From a logical point of view, the AACC definition (2001) covers the starting point, science, and physiology parts of Dietary Fiber, in acknowledgment of the key physiological effects of fiber that have been shown over the past 30 years of exploration Therefore, it is by all accounts a generally thorough form by a long shot. In 2000, a board of trustees of the AACC was charged to build up the meaning of Dietary Fiber as 'the palatable pieces of plants or analogs starches that are impervious to processing and assimilation in the human small digestive tract with complete or halfway

* Corresponding author: Shubhangi kshirsagar
Ideal College of Pharmacy and Research, Bhal, Kalyan - 421306, Dist- Thane, Maharashtra, India.

maturation in the internal organ'. This definition likewise shows the concoction idea of materials included as polysaccharides, oligosaccharides, lignin, and related plant substances [3].

The clearest definition that is in a little while seen is "Dietary fiber fuses extras of plant cells impenetrable to hydrolysis (arranging) by the strong mixes of man", whose sections are hemicellulose, cellulose, lignin, oligosaccharides, gelatins, gums, and waxes. [4], [5] Customers' interests concerning sound eating routine and accommodation nourishments have essentially expanded in the most recent decade. These days, shoppers are keen on the quality yet additionally in the nutritive worth and wellbeing of the items they eat. Fiber is not a single substance but rather a heterogeneous group of materials, each 129 with different biologic effects. Cereals, fruits, vegetables, as well as algae, are sources 130 of abundant dietary fiber. Until now, the effects of high-fiber diets on infectious 131 diseases have been controversial [6]. Dietary fiber is considered as one of the food fixings with a critical commitment to wellbeing [7]. Dietary fiber alludes to the piece of organic products, vegetables, harvests, nuts, and vegetables that can't be processed by people [8]. Dietary Fiber sources are cell divider parts (cellulose, hemicellulose, lignin, and pectic substances) and non-basic segments (gums and adhesives) just as mechanically added substances (changed cellulose, adjusted gelatin, business gums, and algal polysaccharides) [9].

Dietary Fiber is viewed as a physiologically dormant material, even though the building and diuretic properties of numerous fiber sources have for quite some time been acknowledged. It has been appeared to assume a significant job in the anticipation of the dangers of carcinoma beginning and atherosclerosis; just as in the control and appropriate administration of diabetes mellitus and weight .df isn't just attractive for its wholesome properties, yet additionally for its useful and mechanical properties [9].

2. Types of dietary fibres

Dietary Fiber can be classified in many different ways such as structure and solubility. Based on solubility, they can be divided into soluble or insoluble Dietary Fibres [10].

A significant job of numerous sorts of fiber is their capacity to act as prebiotics—substances that adjusts the sorts and exercises of the microbes, or microflora, that live inside the human gut. While the human microflora stays a functioning zone of logical exploration, its relationship with irritation, invulnerable work, and the soundness of the colon are promising regions for seeing how fiber may offer defensive impacts against an assortment of infections.

A few extraordinary grouping frameworks to characterize the parts of dietary fiber: given their job in the plant, in light of the kind of polysaccharide, given their reproduced gastrointestinal solvency, given site of processing and dependent on items of absorption and physiological characterization. Be that as it may, none is totally good, as the cutoff points can't be completely characterized [4].

There are two classes of fiber and we have to eat both in our everyday consumes fewer calories, which are: soluble fiber – incorporates gelatins, gums, and adhesive, which are found fundamentally in plant cells. One of its significant jobs is to bring down LDL (awful) cholesterol levels. Great wellsprings of dissolvable fiber incorporate organic products, vegetables, oats, bran, grain, seed husks, flaxseed, psyllium, dried beans, lentils, peas, soy milk, and soy items.

Dietary fibres are soluble or insoluble, based on whether they form a solution when mixed with water (soluble), or not (insoluble). Fiber includes insoluble fiber (lignin, cellulose, and hemicelluloses) [11] and soluble fiber (pectin's, β-glucans, galactomannan gums, and a large range of nondigestible oligosaccharides including inulin) [12].

The dissolvable and insoluble nature of dietary strands includes contrasts in their innovative usefulness and physiological impacts.

2.1. Soluble dietary fiber (SDF)

Soluble Dietary Fibres are specifically characterized as df equipped for being disintegrated in a buffer and protein arrangement displayed the fluid catalyst arrangements present in the human framework [10]. Solvent strands are portrayed by their ability to build viscosity and to lessen the glycemic reaction and plasma cholesterol [13]. Soluble Dietary Fibres increment all-out travel time by deferring gastric exhausting and easing back glucose retention while non-gooey solvent filaments go about as a substrate for microbial maturation in the colon [10].

Soluble Dietary Fibres incorporate oligosaccharides, including fructooligosaccharide (FOS), gelatins, β- glucans (oat and grain grains), galactomannan gums, alginate, and psyllium. Fructooligosaccharides (FOS), otherwise called oligofructose

also, inulin is referred to all in all as fructans. They are found in plants including agave, artichokes, asparagus, leeks, garlic, onions, bacon, jicama, and wheat [10]. Soluble fiber can also help with wheat constipation. The physiological impacts of dissolvable dietary filaments are ascribed to their interesting physical-concoction properties, in particular consistency, gel arrangement, or fermentability in the colon [14]. Past examinations have exhibited the physiological impacts of solvent fiber as follows:

- Expanded thickness in the upper gastrointestinal plot and
- Incomplete or full aging in the colon
- Effort of a prebiotic impact [15]. Dissolvable filaments are perceived for their capacity to lower LDL ("terrible") cholesterol and may help control glucose.

2.2. Insoluble dietary fibres (ISD)

It is the foremost segment of the cell dividers of most plants and structures about 25% of the fiber in grains and foods grown from the ground a third in vegetables and nuts [10]. Insoluble strands are portrayed by their porosity, their low thickness, and their capacity to increment fecal mass and reduction intestinal travel [13] insoluble fiber – includes cellulose, hemicelluloses, and lignin, which make up the structural parts of plant cell walls [16]. Insoluble strands are depicted by their porosity, their low thickness, and their ability to augment fecal mass and decrease intestinal travel [12] insoluble fiber – incorporates cellulose, hemicelluloses, and lignin, which make up the auxiliary pieces of plant cell walls [14]. A significant part of insoluble fiber is to add mass to excrement and to forestall stoppage and associated, problems, for example, hemorrhoids. Great sources incorporate wheat grain, corn grain, rice grain, and the skins of products of the soil, nuts, seeds, dried beans, and wholegrain nourishments. Insoluble strands, similar to those found in wheat, grain, vegetables, and organic products have been connected to wellbeing advantages, for example, craving control, diminished frequency of creating type 2 diabetes, and the counteraction of clogging. Cellulose is a polysaccharide comprising of a straight chain of a few hundred to more than 10,000 β; 1 - 4 connected D - glucose units and is the most plentiful natural polymer on earth [10].

Compared with insoluble dietary fiber, in food preparing the solvent fraction, demonstrates a more prominent ability to give consistency, capacity to shape gels and additionally go about as emulsifiers, has neither the awful surface nor awful taste, and is simpler to consolidate into handled nourishments and drink. Marine green growth and natural product results have all the earmarks of being prevalent wellsprings of dissolvable strands, trailed by a natural product, vegetables, and oats [13].

The supplementation of dietary fiber for flour, meat, and dairy items is likewise included. The advantages and dangers of expanding utilization of dietary fiber are talked about [17] both types of fiber are beneficial to the body and most plant foods contain a mixture of both types.

Numerous investigations of the Dietary Fiber maturation center on Soluble Dietary Fiber, where aging is broad. Notwithstanding, moreover Insoluble Dietary Fiber can be at any rate halfway aged. For model, a couple of studies have demonstrated that even cellulose, which is insoluble in water, can be matured somewhat in the human colon, and some other mono-gastric residential creatures. About half of cellulose can be corrupted by colonic maturation bringing about the creation of valuable short-chain unsaturated fats (SCFA). Because of the restricted data accessible about the wellbeing impacts of insoluble dietary fiber (IDF), research is required concerning its usefulness, especially regarding aging. Insoluble Dietary Fiber makes up the major segment of complete Dietary Fiber in practically all plant nourishments. In leafy foods, apple Dietary Fiber contains 56% Insoluble Dietary Fiber while carrot contains up to 92% Insoluble Dietary Fiber [18].

In characteristic plant nourishments, extents of Soluble Dietary Fiber and Insoluble Dietary Fiber differ with the organic causes just as the development of natural products/seed. The dietary strands economically fabricated are frequently the blend, expected to accomplish certain quantifiable boundaries, for example, dissolvability, water-holding limit, or sub-atomic size range. Regardless of whether nearness is normally or removed financially, filaments are confused because of variety in types, measures just as characteristic connections. It is currently perceived that unblemished and inborn, common strands have more physiological criticalness contrasted with profoundly prepared, detached, and included filaments [19].

Table 1 Conventional classification of dietary fiber as soluble and insoluble fiber [20], [10].

	Chemical constituents from plant cell walls	**Major physiological effects and mechanism**
Soluble fiber	Non –cellulose polysaccharide oligosaccharides, pectins, β-glucans, gums	Postpone gastric exhausting, direct blood glucose levels, lower serum Cholesterol levels, due mainly to its effects of increasing viscosity of gut content and colonic fermentation.
Insoluble fiber	Cellulose, hemicellulose, lignin.	Shorten bowel transit time, improve laxation due to its bulking capacity; support the growth of intestinal microflora (esp. probiotic species) due to its fermentation in the large intestine

Table 2 Types and source of dietary fiber: [12].

Dietary fibres	**Features**	**Sources**
Soluble Fibres		
Pectin	It is been galacturonic corrosive, rhamnose, arabinose, the high substance of galactose, middle of the road overlay, and on the essential divider	Whole grains, apple, legumes, cabbage, root Vegetables.
Gum	Generally are composed of monomers of hexose and pentose	Oatmeal, haricot bean, legumes
Mucilages	Compounds which is synthesized in plants that contain a glycoprotein	Food additives
Insoluble fibres		
Cellulose	It is the main component of cell walls which consisting of glucose monomers.	Whole grains, bran, peas, root vegetables, beans family of cruciferous, apple
Hemicelluloses	Primary and secondary the cell walls	Bran, whole grains
Lignin	It is been consist of aromatic alcohols and the components of another cell wall	Vegetables, flour

3. Content/Constituents of dietary fibres

Dietary fiber incorporates all non-starch polysaccharides impervious to processing in the small digestive tract and fermentable in the internal organ. Non-starch polysaccharides incorporate celluloses, hemicelluloses, for example, arabinoxylans and arabinogalactans, gelatins, adjusted celluloses, fructans (oligomers and polymers of fructose, for example, inulin), gums, and adhesives. Oligosaccharides, for example, oligofructose, incorporate the lower sub-atomic weight analogs of the absorption safe polysaccharides.

Practically equivalent to sugars, for example, polysaccharides having the assimilation opposition, aging, and physiological properties of normally sourced dietary strands, are incorporated. Lignin and the plant's substances related to the non-starch polysaccharides are a necessary piece of the stringy segment of plants. Lignin, a polyfunctional polymer, is personally framed with and penetrates the cellulose of plant cell dividers and is impervious to assimilation, even with solid corrosive. In like manner waxes and cutin, found as waxy layers at the outside of the cell dividers, are comprised of exceptionally hydrophobic, long-chain hydroxy aliphatic unsaturated fats and are impervious to absorption and presumably render the related tissues impervious to processing. The constituents of dietary fiber are summarized in Table No.1 [1].

Components of dietary fiber according to the American Association of Cereal Chemists

3.1. Non-starch polysaccharides and oligosaccharides:

- Cellulose
- Hemicellulose
- Arabinoxylans
- Arabinogalactans
- Polyfructoses
- Inulin
- Oligofructans
- Galacto-oligosaccharides
- Gums
- Mucilages
- Pectins

3.2. Analogous carbohydrates

- Indigestible dextrins
- Resistant maltodextrins
- Resistant potato dextrins
- Synthesized carbohydrates compounds
- Polydextrose
- Methylcellulose
- Hydroxypropyl methylcellulose
- Resistant starches

3.3. Lignin substances associated with the NSP and lignin complex

- Waxes
- Phytate
- Cutin
- Saponins
- Suberin
- Tannin [21].

Table 3 Constituents of Dietary fiber: [1].

Fiber constituent	Chief gathering	Fiber parts/sources
Non-starch polysaccharides and oligosaccharides	Hemicellulose	Arabinogalactans,β-glucans, arabinoxylans, glucuronoxylans, xyloglucans, galactomannans, pectic substances
	Cellulose	Cellulose-Plants (vegetables, sugar beet, different grains).
	Gums and Mucilages	Seedextricates (galactomannans – guar and locust bean gum), tree exudates (gum acacia, gum karaya, gum tragacanth), algal polysaccharides (alginates, agar, carrageenan), psyllium.
	Polyfructoses	Insulin, oligofructans.
	Pectin	Fruits, Vegetables, Legumes, potato, sugarbeet.
Carbohydrates analogs	Safe starches and maltodextrins	Different plants, for example, maize, pea, potato Polydextrose, lactulose, cellulose subordinate (MC, HPMC).

	Chemical synthesis /Concoction union Enzymatic synthesis/ combination	No sugar or short-chain fructooligosaccharides (FOS), transgalactooligosaccharides (TOS), levan, xanthan gum, thickener, oligofructose, xylooligosaccharides (XOS), guar hydrolysate, curdlan.
Lignin	Lignin	Woody plants
Substances related to non-starch polysaccharide	Waxes, cutin, Suberin	Plant Fiber
Animal origin fibres	Chitin, chitosan, collagen, chondroitin	Fungi, yeasts, invertebrates

Table 4 Dietary fiber content of various ingredient sources [22].

Source category	Source type	Ingredients	Typical total Df range (%
Plant-derived	Bamboo, wood, cottonseed, etc.	Cellulose	80-90
	Modified cellulose	Microcrystalline cellulose	80-90
		Methylcellulose	80-90
	Gums seaweed extracts	Carrageenan, alginates	80-90
	Plant extracts	Gum acacia, gum karaya, tragacanth gum	80-90
	Seed extracts	Guar gum, locust ben gum	80-90
	Microbial fermented	Xanthan, gellan, pullan	80-90
	Chicory roots, Jerusalem artichoke, etc.	Insulin and fructooligosaccharides	~90
	Konjac tuber	Konjac flour	~95
	Peas, the outer shell	Pea fiber	75-80
	Potatoes, corn, etc.	Resistant starch	1-40
	Sugar beets	Sugar beet fiber	~75
	Western larch tree	Arabinogalactan	~80-95
	Psyllium seed coat	Psyllium	~80
Fruits	Prunes dates figs, raisins	Whole or fruit pieces	5-8
		Powder	10-65
	Apple pear	Powder	20-70
	Apple, citrus	Pectin	50-80
Other	Shellfish	Chitin	~80
	Bacterial fermentation	Curdlan	~95
	Synthetically produced	Polydextrose	~95

Table 5 Recommended daily requirement of fiber intake[22].

Age group	Years	Needed fiber (g)
Men	19-50	38
	(over 50)	30
Women	19-50	25
	(over 50)	21
Girls	9-18	26-36
Boys	9-18	31-38

Table 6 Classification of fiber components based on fermentability: [1].

Characteristics	Fiber component	Main food source
Partial or low fermentation	Cellulose	A plant (vegetables, sugar beet,)
	Hemicellulose	Cereal grains
	Lignin	Woody plants
	Cutin/suberin/other plant waxes	Plant fibres
	Chitin and chitosan, collagen Resistant starches	Fungi, yeast, invertebrates A plant (corn, potatoes, grains, legumes, bananas)
Well fermented	Curdlan	Bacterial fermentation
	Beta-glucans	Grains (oats, barley, rye)
	Pectins	Fruits, vegetables, legumes, sugar beet, potato
	Gums	Leguminous seed plants (guar, locust bean), seaweed extracts (carrageenan, alginates), plant extracts (gum acacia, gum karaya, gum tragacanth), microbial gums (xanthan, gellan)
	Insulin	Chicory, Jerusalem artichoke, onions, wheat
	Oligosaccharide/analogous	Various plants and synthetically produced (polydextrose, resistant maltodextrin, fructooligosaccharides, galactooligosaccharides, lactulose
	Animal origin	Chondroitin

Despite stimulating effects, dietary fiber has helpful properties, for instance, water confining cutoff (WBC) fat limiting breaking point (FBC). Thusly, the Addition of dietary fiber to a wide extent of things will add to the improvement of critical worth included substances or utilitarian substances that at present are looked after; furthermore, it can give these helpful properties to the substances [23].

Free water, momentary water, and bound water are three kinds of water in food. As a critical aspect of various sustenances, water influences food's rheological characteristics and its substance and physical properties. The proximity, apportionment, and combination of water earnestly sway the getting ready qualities, steadfastness, and protecting properties of food [24].

4. Marketed formulation of dietary fibres

4.1. Arabica filter coffee powder

Ingredients: Roasted coffee beans (medium-dark roasted).

Description: Coffee Arabica, in any case, called the Arabian coffee, "coffee shrub of Arabia", "mountain coffee" or "Arabica coffee", is a sort of Coffee. It is acknowledged to be the essential sorts of coffee to be created, and is the overall cultivar, addressing about 60% of overall creation. Espresso made from the (less acidic, even more serious, and even more significantly squeezed) Robusta bean (C. canephora) makes up a huge bit of the remainder of the coffee creation. Channel espresso is known worldwide for its strong scent and taste. It improves the imperativeness levels, helps in devouring fat, improves physical activity, keeps the cerebrum dynamic adversary a long time.

4.2. Natural sugar control

Ingredients: Contains dietary fiber (100% wheat dextrin) (source of soluble dietary fiber)

Description: It is a 100% plant cause, dissolvable fiber sustenance supplement that is clinically shown to help and regulate glucose, ordinarily. It moreover helps control with blooding sugar changes routinely saw after dinners. Over a long stretch, it causes you to accept accountability for your prosperity to supervise diabetes better. Natural Sugar Control has Zero Additives and Preservatives and is 100% Sugar-Free. It is Easy-to-Consume and can be mixed in with any food or reward you love. It separates adequately with no taste, aroma, or concealing therefore fitting into your standard eating routine without any problem. It is not hard to use. It can be added to any food or drink. It separates successfully and doesn't have any concealing, taste, or smell. So it is a bit of a consistent diet, to accept better accountability for diabetes."

4.3. Dietary wheat fiber

Ingredients: wheat fiber (Gluten-free).

Description: Lift the admission of dietary fiber with an interesting extricate and a sans gluten concentrate of wheat fiber. It improves stomach related wellbeing and aides in weight the board.

4.4. Nutria choice ragi biscuit

Ingredients: Ragi cookies.

Description: Britannia NutriChoice is one of India's driving wellbeing brands today, changing how Indians think, feel, and act about wellbeing and solid living. NutriChoice gives a scope of 'influence stuffed' snacks exceptionally made for individuals who look for a solid lifestyle. Nutri choice Essentials are diabetic-accommodating scones from Britannia. They help oversee glucose levels and are diabetic amicable as they have:

- High dietary fiber
- 0% added sugar
- 0% transfat
- Complex starches
- Low Glycemic Index

4.5. Organic psyllium whole husk

Ingredients: Active fibres.

Description: Geo new natural psyllium entire husk (100g) Psyllium is a sort of fiber that goes about as a delicate, mass framing purgative. Psyllium, compared to other solvent strands, goes through the small digestive tract without being separated or ingested. Rather, it assimilates water and turns into a gooey intensify that benefits clogging, looseness of the bowels, glucose, pulse, cholesterol, and weight reduction.

5. Properties of dietary fibres

The substance idea of filaments is perplexing; dietary strands are comprised of a blend of concoction elements. The decision of diagnostic strategy to explore filaments relies upon the organization of every specific fiber "immaculate fiber" ought to have the accompanying attributes:

Ideal properties

- It must not contain any parts that are healthfully hostile.
- To amplify its utilization, it must be of high gather in a little amount.
- It ought to have no taste and no negative scent, shading, or surface impacts.
- It ought to contain a harmony among dissolvable and insoluble fiber with a worthy nearness of bioactive mixes.
- Its option must not influence the food it is being added to; however, it should likewise have a long period of usability.
- It should work amicably with food handling.
- It should have a positive purchaser picture.
- It ought to be at a satisfactory cost.
- It ought to contain normal physiological impacts [12].
- lower cholesterol and diminished danger of creating cardiovascular sickness diminished mortality hazard from circulatory, stomach related, and fiery ailments
- Decreased danger of building up certain types of malignant growth
- Improved insulin affectability and glycemic control
- Weight and hunger control
- Avoidance and help from obstruction
- Diminished aggravation
- Expanded calcium ingestion and bone mineral density.
- Ciliate gulping (job in dysphagia treatment)
- Give luminal mass (fusing water retention) and advance gut travel
- Impact supplement processing and ingestion in the small digestive tract
- Help forestall/oversee diverticulitis
- Tie microorganisms – which might be helpful in disease control and maybe fiery
- Gut malady whenever related to microorganisms
- Go about as a prebiotic carbon source.
- Give a wellspring of SCFAs as an outcome of maturation in the colon
- Animate the gut-related lymphoid tissue (GALT) framework.
- Animate recuperating topically [26].
- Dietary fiber is its ability to increase fecal output in man [27].

Nourishments that are normally high in fiber additionally contain numerous different supplements that are valuable to wellbeing. Nutrients, minerals, minor components, polyphenols, alkylresorcinols, and carotenoids found in fiber-rich nourishments, for example, wholegrain wheat and rye have been appeared to diminish the hazard for creating type 2 diabetes, cardiovascular ailment, and overweight.

Table 7 Parameters response actions

Characteristics	Response to the small intestine	Physiological implication
Water dispersibility	Provides an aqueous phase for penetration of microbes	Increase microbial breakdown of polysaccharide structure
Bulk	Increase material entering the large intestine; affects mixing contents.	Provides substrate for micro-flora, aids laxation
Viscosity	Increase the number of bile acids in the large bowel	Excretion is increased; opportunity for microbial modification of bile acids.
Adsorb/bind compounds	Growth of micro-flora; microbial adaptation to polysaccharide substrate	Increased microbial mass and product of metabolism

Table 8 Properties of dietary fiber and their response to large intestinal function: [22].

Characteristics	Response to the small intestine	Physiological implication
Water dispersibility	Provides an aqueous phase for penetration of microbes	Increase microbial breakdown of polysaccharide structure
Bulk	Increase material entering the large intestine; affects mixing contents	Provides substrate for micro-flora, aids laxation
Viscosity	Increase the number of bile acids in the large bowel	Excretion is increased; opportunity for microbial modification of bile acids
Adsorb/bind compounds	Growth of micro-flora; microbial adaptation to polysaccharide substrate	Increased microbial mass and product of metabolism

Table 9 Technological and physiological properties of dietary fiber: [28], [12].

Technological property	Physiological functionality
Water swelling capacity	Reduction of blood cholesterol
Water retention capacity	Reduction of blood glucose
Water solubility	Reduction the risk of chronic disorder e.g. coronary heart disease, diabetes, obesity, and some forms of cancer
Oil holding capacity	
Viscosity	
Texturizing	
Stabilizing	
Gel –forming capacity	
Antioxidant capacity	

5.1.1. Cation trade properties

The practical limit of dietary fiber for cation trade is entrenched. The impact is identified with the number of free carboxyl gatherings on the sugar buildups. Calcium restricting can be anticipated based on the uronic corrosive

substance of fiber buildups Formation of cation edifices with acidic polysaccharides is considered in their belongings mineral equalization, electrolyte assimilation, and substantial metal poisonousness.

5.1.2. Heritability of dietary fiber

The water-holding limit of dietary fiber has significant physiological impacts in both the upper and lower digestive system. Hydration of fiber happens by adsorption to the outside of the macromolecules and by capture inside the interstices of the stringy or gel lattice. The fiber immersion limit or maximum constraint of water held is controlled by the science and morphology of the macromolecules and by the pH and electrolyte centralization of the encompassing medium. The nearness of sugar buildups with free polar gatherings gives a noteworthy hydrophilic ability to polysaccharides while intermolecular holding, for example, the ether cross-linkages between chains of cellulose atoms, has the contrary impact [1].

6. Processing of dietary fibres

The processing required to make some vegetables and legumes [29] (chick-pea, bean, lentil, etc.) suitable for eating causes a decrease in several components of the fiber. For example, during the cooking of lentils previously dipped, the quantity of fiber diminishes, fundamentally due to a great decrease in hemicelluloses. They studied the modifications that happen during the thermal processing of kidney beans and reported that the solubilization of the polysaccharides resulted in decreased total fiber content mainly due to the loss of soluble fiber [4].

The sources of the fiber, its history, and the operating conditions influence the impact of the treatment. Chemical and enzymatic treatment, if appropriate chemicals and enzymes are chosen, resulting in an increase in the amount of water-soluble fiber with possible depolymerization of soluble fiber at the expense of the water-insoluble. Soluble fiber depending on their molecular weight and concentration can contribute to building up the viscosity of the liquid phase in the food system. The insoluble fiber matrix can exhibit higher swelling through probably an increase of its porosity and lower or higher water retention depending on the pore size distribution [30].

Fermentation is a type of plant food processing that causes modifications of the composition and structure of Dietary Fiber. These changes are motivated by the enzymatic activity developed during the fermentative process and principally consist of solubilization of different cell wall polysaccharides. The main enzymes that have been detected in the fermentative brine are amylase, proteinase, polygalacturonase, cellulose, and b-galactosidase that selectively degrade distinct cell wall polysaccharides and as a consequence provoke a decrease of the fiber content that mainly consists of losses of Soluble Fiber, although a portion of the Insoluble Fiber can also be released. The polysaccharides that are released into the brines include both soluble compounds such as neutral polysaccharides and pectins, and constituents of the Insoluble Fiber such as hemicelluloses and cellulose [31].

Seeds processing although usually in which seeds are discarded for the obtaining of DFC due to their high lipid content, their Dietary Fiber content is considerably high and therefore could represent a good feedstock to prepare concentrates. Seeds must be firstly roasted (30 min) to inhibit germination enzymes. A defatting process is needed to remove lipids. This step could be conducted using cold pressing or by solvent extraction, usually hexane. It was reported that DFC from lemon, orange, and grapefruit seeds defatted with hexane contained lower Soluble Dietary Fiber than cold-pressed seeds. As expected, these differences also impacted the WHC, OHC, and SC values [32].

A physical process was employed to isolate Insoluble Dietary Fiber. The substrates chosen were: two fruits (Pink Lady apples, Cavendish bananas) and three vegetables (baby spinach leaves, carrot roots, celery stalks), all of which were purchased from a local supermarket. To extract the Insoluble Dietary Fiber, the basic protocol was followed, but with enzymatic digestion, steps were substituted by thorough washing with water. Briefly, fruits were washed, peeled, cored, and weighed, while vegetables, once washed, were cut and weighed. All substrates were minced using an electric mincer. Minced fruits and vegetables were centrifuged (14,000g, 10 min, 25 C) to separate the liquid from the solid. The solids were washed (up to 25 times) with milli-Q water using a 500 μm sieve until the water was clear. Subsequently, samples were once again centrifuged, and the collected wet solids (Insoluble Dietary Fiber) were used as substrates for fermentation. These solids were accurately weighed into serum bottles, kept under nitrogen gas, and stored at 4 C until required. Commercially produced wheat bran was used as a control in all in vitro fermentation experiments [18].

7. Method of analysis

Dietary Fiber analysis is regarded as one of the most tedious assays used in the food industry for nutritional labeling, quality control, and R&D purposes. The standard Association of Official Analytical Chemists (AOAC) and AACC methods

for Dietary Fiber analysis involve a series of enzymatic digestion and filtration treatments, which are labor-intensive, time-consuming, and also require a large amount of laboratory space and glassware [3].

According to it generally, there are three methods to gain dietary fiber: Chemical method, physical method, and microbial fermentation. Removal of starch and protein can be more complete using the chemical method, but the poor selectivity, side-effects, and difficultly controlled extraction conditions greatly limit its use. A physical method, such as extrusion cooking, does not cause degradation of the polymer structure or some other deep damage. Therefore, the side chain group can be preserved almost intact, which enables the cation exchange capacity not to be impacted. Recently, microbial fermentation of dietary fiber has been widely recognized and accepted due to the high selectivity, mild and easily controlled reaction conditions [12].

A recent development in dietary fiber methodology has adopted two general approaches: enzymic gravimetric and enzymic chemical methods [13].

7.1. Enzymic-gravimetric methods

It involves enzymic treatments for starch and protein removal, precipitation of soluble fiber components by aqueous ethanol, isolation, and weighing of the dietary fiber residue, and correction for protein and ash in the residue.

7.2. Enzymic-chemical methods

This method involves enzymic removal of starch, precipitation with 80% (v/v) ethanol to separate the soluble dietary fiber polysaccharides from low molecular weight sugars and starch hydrolysis products. They employed the GLC method for the characterization of gravimetrically determined soluble dietary fiber residues [4].

7.3. Post-fermentation analysis

Analysis was performed on different phases of fermented samples from serum bottles. After pH measurement, samples for SCFA and NH4+ analysis were taken from the top of the bottle (liquid phase) while samples for microscopic observation were taken from the bottom (pellet and associated liquid) of the bottle. The remaining samples were centrifuged (5,000 rpm, 10 min, 4 C); to separate the supernatant from the pellet before the pellet was frozen and freeze-dried. Samples for cellulose, starch, and uronic acid analyses were taken from the freeze-dried residual pellets.[18]

7.4. Statistical analysis

SASs procedures (Version 8.2; Statistical Analysis System, Cary, NC, USA) were used for data analysis. Energy and nutrient values were calculated as individual means of the values of three recorded days. P-values below 0.05 were considered as significant. For infants, dietary fiber intake was displayed at 6, 9, and 12 months. Infants 3 months old were not included in the analysis, because they usually do not consume dietary fiber-containing foods. For children and adolescents, records were stratified into four age groups (1.5–3-, 4–8-, 9–13- and 14–18-year olds). The latter two age groups were also classified by sex, according to the age grouping of the US Institute of Medicine (2002) [33].

7.5. Fiber Analysis

Sesame tests were de-fatted before analyses, as recommended in analytical methodologies relating to dietary fibres. Two methods are used for chemical analysis of dietary fibres (i.e.) the enzymatic-gravimetric AOAC (Association of Official Agricultural Chemists) [34] method described and an enzymatic-chemical method (a modification of the AOAC method) [13].

8. Uses of dietary fibres

- Hacks down cholesterol levels, Soluble fiber found in beans, oats, flaxseed, and oat wheat may help lower with proposing blood cholesterol levels by cutting down low-thickness lipoprotein, or "vile," cholesterol levels.
- Studies likewise have demonstrated that high-fiber nourishments may have other heart-medical advantages, for example, diminishing circulatory strain and aggravation.
- Helps control with blooding sugar levels. In individuals with diabetes, fiber — especially dissolvable fiber — can slow the retention of sugar and help improve glucose levels.
- A sound eating routine that incorporates insoluble fiber may likewise lessen the danger of creating type two diabetes.

- Helps in accomplishing sound weight. High-fiber nourishments will in general be more filling than low-fiber food sources, so you're probably going to eat less and remain fulfilled longer.
- High-fiber nourishments will in general take more time to eat and to be less "vitality thick," which implies they have fewer calories for a similar volume of food.
- Encourages you to live more. Studies recommend that expanding your dietary fiber admission — particularly oat fiber — is related to a diminished danger of passing on from cardiovascular sickness and all tumors.
- Dietary fiber has a marked effect on bowel habits [35].

9. Side-effects of dietary fibres

As referenced already there are a few medical advantages related to dietary fiber utilization. In any case, there are negative symptoms that join expanded utilization. "Checking a gigantic proportion of fiber senselessly convenient can advance intestinal gas, stomach making and beating" Drinking a lot of water is suggested while expending more significant levels of fiber since it takes into consideration the assimilation of water by the digestive organs and, accordingly, produces a gentler and bulkier solid discharge. When considering expanding dietary fiber utilization it is likewise prescribed to progressively build admission so the body can modify. Note that an enormous assortment of proof demonstrates that the advantages of dietary fiber significantly exceed the potential negative symptoms related to utilization [36].

Ongoing investigations uphold this opposite connection between dietary fiber and the improvement of a few sorts of malignancies including the colorectal, small digestive tract, oral, larynx, and bosom [37], [21].

Dietary strands have been appeared to bring about diminished blood glucose trips and weakened insulin reactions. This might be expected to either a deferred or diminished intestinal retention [37].

The stomach related and consistency qualities of dietary fiber are the conceivable methods of activity which influence diabetes and weight hazard. These systems seem to diminish supplement retention, accordingly, diminishing metabolizable vitality. Dietary fiber may likewise have the option to diminish the net vitality of food due to its lower vitality thickness [37].

Increased intake of DF may also cause a potentially negative effect on mineral absorption in the body. The addition of brans from oat and wheat to the diet of adult males resulted in decreased absorption rates for copper (Cu), calcium (Ca), magnesium (Mg), and zinc (Zn) [3].

Notwithstanding the unfriendly impacts of included fiber pastry shop merchandise, it is likewise announced that figuring pasta with DF produces changes that may mess some up like the last product. It was accounted for that fuse of significant levels of DF expected alterations to the pasta making measure. Additionally, the option of vegetable flours prompted a reduction in pasta quality characteristics, for example, more prominent cooking misfortune and less fortunate surface property [3].

Several studies indicate that an increased intake of total Dietary Fiber is inversely associated with insulin resistance, body weight, and inflammation [38].

10. Application of dietary fibres

The fiber in nourishments can change their consistency, surface, rheological conduct and tactile attribute of the final results, the rise of novel wellsprings of fiber, has been offering new open doors in their utilization in the food business. Fiber can even be produced from sources that might otherwise be considered waste products. For example, wheat straw, soy hulls, oat hulls, peanut and almond skins, corn stalks and cobs, spent brewer’s grain and waste portions of fruits and vegetables processed in large quantities can be converted into fiber ingredients, which may be highly functional in certain food applications. Dietary fiber holds all the characteristics required to be considered as an important ingredient in the formulation of functional foods, due to its beneficial health effects. Among foods enriched in fiber, the most known and consumed are breakfast cereals and bakery products [39] such as integral bread and cookie, as well as milk and meat, derived products. In bread making, the incorporation of fiber ingredients was reported to increase the water hydration values of flour. 15% of orange peel and pulp could be incorporated as an ingredient in making biscuits, as they are a suitable source of dietary fiber with associated bioactive compounds (flavonoids,

carotenoids, etc.). The addition of dietary fiber to bakery products also improves their nutritional quality since it makes it possible to decrease the fat content, by using dietary fiber as a substitutive for fat without loss of quality [4].

Buckwheat hull hemicellulose and quinoa fiber fractions at different concentrations were formulated in bread making. Quinoa fiber up to 3 % addition in the formulations of bologna-type sausages. The addition increased the emulsion stability, decreased water activity, and lipid oxidation and affected the color of the sausage. Different polysaccharides have been chemically modified such as sulfation, phosphorylation carboxymethylation, acetylation, and selenization for improved functionalities [40].

Dietary fibres based on pectins, cellulose, soy, wheat, maize or rice isolates and beet fiber can be used for improving the texture of meat products, such as sausages, salami and at the same time, are adequate to prepare low-fat products, such as 'Dietetic hamburgers'[4].

Table 10 Food applications of fiber polysaccharides and fractions of pseudo-cereals [5].

Grain type	Fiber form	Uses	Major findings
Buckwheat	Hull hemicellulose up to 0.7 % was Added.	Bread making	The addition of the hemicellulose 0.5%improved the rheological and fermentation. The addition of 0.7 % hemicellulose negatively affected the fermentation and gas development of the dough. The addition increased the softness and elasticity of the bread during storage of 3 days.
Quinoa	Fiber-rich fractions from dry and wet Milling.	Bread making	Adding fiber fraction (5 %) nutritionally improved the bread quality with more fiber and higher in vitro antioxidant activity. Adding fraction from dry milling increased the specific volume and reduced the firmness of the bread.
Buckwheat (Tartary)	Polysaccharides were extracted using an alkaline solution.	Food packaging for tilapia (Oreochromis niloticus) fillets.	The fillets were coated with buckwheat polysaccharides solution containing resin before Storage (4 °C, 12 days). The coating improved the microbiological, physicochemical sensory properties of fillets. The properties included a total viable count of microorganisms, PH, thiobarbituric acid, and total volatile base nitrogen contents. The coating increased the shelf life of fillet from 4 to 8 days.
Quinoa	Wet milling coproducts (Dietary fiber content of 38 %)	As binder replacer (3 % addition) in bologna-type Sausages.	The addition of fiber rich quinoa products increased the emulsion stability, decreased the Lipid oxidation and water activity, and changed the color of the sausage. The nitrite addition may not be needed when the quinoa product was added.
Buckwheat (common)	A fiber-rich fraction from buckwheat	Modifications (cross-linking, hydroxypropylation and carboxymethylation)	α-amylolysis of wheat starch. Modified buckwheat fibers had more hydration than Carboxymethylation increased the solubility and the amount of water-soluble fiber, whereas Cross-linking and hydroxypropylation had the opposite effect. The modified fibers decreased modified rice fibers.

11. Conclusion

The prevalence of obesity is increasing rapidly in most urbanized and industrialized countries like India. Obesity has an extraordinary number of negative healths, social, and financial results. Mortality and grimness rates are higher among overweight and corpulent people than lean individuals. Increased BMI is linked with a greater risk of Coronary heart disease (CHD), hypertension, hyperlipidemia, NIDDM, and certain cancers. The most important reason is the economic and cultural differences between the countries and individuals in particular.

Therefore the management of obesity through developing novel approaches, assessing current interventions, and proposing measures needed to transform the "obesogenic" environment are the needs for urgent attention in India and throughout the world. In this context, diet incorporated with underexploited bran and exercise plays a vital role in the management of lifestyle disorders. Diet is the most crucial part of the individual's life as it is emphasized on exceptionally high fiber foods such as bran along with lifestyle modifications. The incorporation of fiber can change the consistency, texture, rheological behavior, and sensory attributes of the end products.

From the present study, it was concluded that supplementation of the high fiber breakfast mix is highly helpful to control and manage blood sugar levels among obese, obese diabetic, and obese hyperlipidemic subjects. Wheat bran and oat bran can be considered functional foods because of their hypoglycemic and hypolipidemic effect. The supplementation given is a low cost, locally available, and can be incorporated in an acceptable form which was highly effective in the management of weight reduction, diabetes mellitus, and hypercholesterolemia without any side effect.

Recommendation

The findings of the study recommend the following thrust areas:

- More research works can be carried out to find out the acceptability, digestibility coefficient of cereal fibres incorporated into recipes for regular consumption.
- Elaborate studies are needed to analyze the nutritional essentials of fiber that are necessary for the prevention of non-communicable diseases.
- Construct people in general about way of life alteration and embrace suitable exercise with solid food propensities for actual wellness.
- Create awareness to the public on the importance of high fiber foods available on our doorsteps which help in better management of obesity and avoid further complications.

Compliance with ethical standards

Acknowledgments

I would like to thank our professor Mrs. shubhangi Bhide Kshirsagar for their expert advice and encouragement throughout this project as well as DR. SMITA TAKARKHEDE, [IDEAL COLLEGE OF PHARMACY AND RESEARCH] for creating enthusiasm and dedication to our work. And to all my colleagues for a wonderful collaboration. You supported me greatly and were always willing to help me.

Disclosure of conflict of interest

We declare that we have no financial and personal relationship with other people or organization that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/company that could be construed as influencing content of the paper.

This Review article does not contain any studies with animal subject perform by the any of the author. All institutional and national guidelines for the care were followed.

References

[1] Adrian Caprita, Rodica Caprita, Vasile Octavian Gianet Simulesca, Raluca Madalina Drehe, Dietary fiber chemical fiber chemical and functional properties, journal of Agroalimentary processes and technologies 2010, 16(4).

[2] IA. Brownlee. The physiological roles of dietary fiber," Food Hydrocolloids. Mar. 2011; 25(2): 238–250.

[3] YO Li, AR Komarek. Dietary fiber basics: Health, nutrition, analysis, and applications, Food Quality and Safety Mar 2017; 1(1): 47–59.

[4] D Dhingra, M Michael, H Rajput, RT Patil. Dietary fiber in foods: a review, J Food Sci Technol. Jun. 2012; 49(3): 255–266.

[5] F Zhu. Dietary fiber polysaccharides of amaranth, buckwheat, and quinoa grains: A review of chemical structure, biological functions, and food uses, Carbohydrate Polymers. Nov. 2020; 248: 116819.

[6] H Yang, Y Sun, R Cai, Y Chen, B Gu. The impact of dietary fiber and probiotics in infectious diseases, Microbial Pathogenesis. Mar. 2020; 140: 103931.

[7] S Cho, L Prosky, ML Dreher. Eds., Complex carbohydrates in foods. New York: Marcel Dekker. 1999.

[8] BV McCleary, N Sloane, A Draga. Determination of total dietary fiber and available carbohydrates: A rapid integrated procedure that simulates *in vivo* digestion, Starch - Stärke. Sep. 2015; 67(9–10): 860–883.

[9] Z Kohajdová, J Karovi, M Jurasová, K Kukurová. Application of citrus dietary fiber preparations in biscuit production. 10.

[10] F.-J. Dai, C.-F. Chau. Classification and regulatory perspectives of dietary fiber, Journal of Food and Drug Analysis. Jan. 2017; 25(1): 37–42.

[11] K. Makki EC, Deehan J, Walter, F Bäckhed. The Impact of Dietary Fiber on Gut Microbiota in Host Health and Disease, Cell Host & Microbe. Jun. 2018; 23(6): 705–715.

[12] F Yangilar. The Application of Dietary Fibre in Food Industry: Structural Features, Effects on Health and Definition, Obtaining and Analysis of Dietary Fibre: A Review, Journal of Food and Nutrition Research. 12.

[13] M Elleuch, D Bedigian, O Roiseux, S Besbes, C Blecker, H Attia. Dietary fiber and fiber-rich by-products of food processing: Characterisation, technological functionality, and commercial applications: A review, Food Chemistry. Jan. 2011; 124(2): 411–421.

[14] H Zhang et al. Effects of soluble dietary fibres on the viscosity property and digestion kinetics of corn starch digesta, Food Chemistry. Feb. 2021; 338: 127825.

[15] SN Salleh, AAH Fairus, MN Zahary, N Bhaskar Raj, AM. Mhd Jalil. Unravelling the Effects of Soluble Dietary Fibre Supplementation on Energy Intake and Perceived Satiety in Healthy Adults: Evidence from Systematic Review and Meta-Analysis of Randomised-Controlled Trials, Foods. Jan. 2019; 8(1): 15.

[16] AK Das et al. A comprehensive review on antioxidant dietary fiber enriched meat-based functional foods, Trends in Food Science & Technology. May 2020; 99: 323–336.

[17] Q Guo, J Kang, Y Bai, F Xu. Dietary Fiber: Chemistry, Structure, and Properties, Journal of Chemistry. Sep 2018; 1–2.

[18] Widaningrum BM, Flanagan BA, Williams F, Sonni D, Mikkelsen, and MJ Gidley. "Fruit and vegetable insoluble dietary fiber in vitro fermentation characteristics depend on cell wall type," Bioactive Carbohydrates and Dietary Fibre. Jul. 2020; 23: 100223.

[19] Y Zhou, S Dhital, C Zhao, F Ye, J Chen, G Zhao. Dietary fiber-gluten protein interaction in wheat flour dough: Analysis, consequences, and proposed mechanisms, Food Hydrocolloids. Jul. 2020; 106203.

[20] R Chawla, GR Patil. Soluble Dietary Fiber, Comprehensive Reviews in Food Science and Food Safety. Mar. 2010; 9(2): 178–196.

[21] JM Lattimer, MD Haub. Effects of Dietary Fiber and Its Components on Metabolic Health, Nutrients. Dec. 2010; 2(12): 1266–1289.

[22] V Rana, RK Bachheti, T Chand, A Barman. Dietary fibre and human health, IJFSNPH. 2011; 4(2/3/4): 101.

[23] V Fadaei, M Salehifar. Some chemical and functional characteristics of dietary fiber from five fiber sources. 2012; 4: 2012.

[24] L Li et al. Relationship of Moisture Status and Quality Characteristics of Fresh Wet Noodles Prepared from Different Grade Wheat Flours from Flour Milling Streams, Journal of Chemistry. Aug 2018; 1–8.

[25] X Qi, RF Tester. Utilisation of dietary fiber (non-starch polysaccharide and resistant starch) molecules for diarrhea therapy: A mini-review, International Journal of Biological Macromolecules. Feb. 2019; 122: 572–577.

[26] AM Stephen, JH Cummings. Water-holding by dietary fiber *in vitro* and its relationship to fecal output in man, Gut. Aug. 1979; 20(8): 722–729.

[27] Y Zhang, J Qi, W Zeng, Y Huang, X. Yang. Properties of dietary fiber from citrus obtained through alkaline hydrogen peroxide treatment and homogenization treatment, Food Chemistry. May 2020; 311: 125873.

[28] A Ah. Effect of processing on dietary fiber contents of selected legumes and cereals. 5.

[29] F Guillon, M Champ. Structural and physical properties of dietary ®bres, and consequences of processing on human physiology, Food Research International. 13, 2000.

[30] R Rodríguez, A Jiménez, J Fernández-Bolaños, R Guillén, A. Heredia. Dietary fibre from vegetable products as source of functional ingredients, Trends in Food Science & Technology. Jan. 2006; 17(1): 3–15.

[31] LE Garcia-Amezquita, V Tejada-Ortigoza, SO Serna-Saldivar, J Welti-Changes. Dietary Fiber Concentrates from Fruit and Vegetable By-products: Processing, Modification, and Application as Functional Ingredients, Food Bioprocess Technol. Aug. 2018; 11(8): 1439–1463.

[32] U Alexy, M Kersting, W Sichert-Heller. Evaluation of dietary fiber intake from infancy to adolescence against various references – results of the DONALD Study, Eur J Clin Nutr. Jul. 2006; 60(7): 909–914.

[33] FT Macagnan, LP da Silva, LH Hecktheuer. Dietary fiber: The scientific search for an ideal definition and methodology of analysis, and its physiological importance as a carrier of bioactive compounds, Food Research International. Jul. 2016; 85: 144–154.

[34] JH Cummings. Constipation, dietary fiber and the control of large bowel function., Postgraduate Medical Journal. Nov. 1984; 60(709): 811–819.

[35] N Stewart. The health benefits of dietary fiber consumption of adults in the United States. 44.

[36] Y Park, LA Brinton, AF Subar, A Hollenbeck, A Schatzkin. Dietary fiber intake and risk of breast cancer in postmenopausal women: the National Institutes of Health–AARP Diet and Health Study, The American Journal of Clinical Nutrition. Sep. 2009; 90(3): 664–671.

[37] P Jr, Y W. A Review of Physiological Effects of Soluble and Insoluble Dietary Fibres, J Nutr Food Sci. 2016; 06(02).

[38] M Arslan, A Rakha, Z Xiaobo, MA Mahmood. Complimenting gluten-free bakery products with dietary fiber: Opportunities and constraints, Trends in Food Science & Technology. Jan. 2019; 83: 194–202.

[39] F Zhu. Dietary fiber polysaccharides of amaranth, buckwheat, and quinoa grains: A review of chemical structure, biological functions, and food uses, Carbohydrate Polymers. Nov. 2020; 248: 116819.