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Natural Dietary Fibers for Human Health

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ABSTRACT: Dietary fiber has received considerable attention from researchers for its complex composition, which exerts beneficial effects both in nutrition and in the prevention of many pathologies. With the intake of fiber not only the functionality of the gastrointestinal tract is improved but also a lower incidence of heart disease and some types of cancer has been highlighted and an improvement in the state of health for patients with chronic diseases such as diabetes mellitus and hyperlipidemia. It has been established that the physico-chemical properties of different DF vary depending on their origin, the type of processing to which they are subjected and the combination of them for which the functional characteristics and the therapeutic purpose vary. The ability to provide for the proper functioning of the gastrointestinal system and to act therapeutically in intestinal disorders is connected to the effect of fiber on the digestion and absorption of nutrients, on the regulation of intestinal transit and on the prebiotic efficiency of it that is indispensable for the health and growth of the microbiota.

KEYWORDS: Dietary fiber, fiber structure, soluble and insoluble fiber, intestinal microbiota, fiber activity

ABBREVIATIONS: **DF**: Dietary Fiber; **AOAC:**Association of Official Analytical Chemists; **DFi:** Insoluble Dietary Fibers ; **DFs**: Soluble Dietary Fibers; **TDF:** Total Dietary Fiber; **EFSA:** European Food Safety Authority; **IBD:** Inflammatory Bowel Disease; **FOS**: Fructo-Oligosaccharides; **RS**: Resistant Starch; **H-lignin:** p-Hydroxy- phenyl lignin; **G-lignin:** Guaiacyl lignin; **S-lignin**: Syringyl lignin; **CNS**: Central Nervous System; **SCFA:** Short Chain Fatty Acids; **ADHD**: Attention-Deficit/Hyperactivity Disorder ; **BDNF:** Brain-Derived Neurotrophic Factor

I. INTRODUCTION

DFs are generally present in foods of plant origin and are very complex being made up of various substances characterized by the fact that they are not absorbed by the digestive system of the human body. The definition of DF has been the subject of continuous evolution as the progress of nutritional research highlighted the physiological benefits of its components and the innovation of analytical methods allowed the identification and quantization of large numbers of them [1-3].

Hipsley E.H. first named "DF" edible plant residues consisting mainly of cellulose, hemicellulose and lignin and resistant to human digestive enzymes [4]. In the following years, following botanical-physiological studies, Trowell H.e coll. based on resistance to digestion, they also considered modified cellulose, vegetable gums, pectins, oligosaccharides and mucilages to be fibers. Therefore, all non-digestible carbohydrates have been included in the definition of fibers. [5-7]. At the same time several research groups have developed analytical protocols quantifying these new components in foods, eliminating digestible parts with specific enzymes. Prosky L. et al. in 1984 combining enzymatic and gravimetric procedures, they developed a method for the quantification of DF, which later became the AOAC method [8-10]. TDF content in both food and food was initially calculated by the difference between the weight of the residue and the weight of the proteins and ashes.

Lee S.C.e coll in 1992 modified the AOAC method having found that in DF there were substances that differed in different solubility in water. A part of the fibers, in fact, precipitates in water and constitutes the DFi,, while another part is soluble in water, but precipitates in 78% ethyl alcohol and constitutes DFs.

By determining the two fractions separately and then adding the result, the TDF was determined [11]. Although the method used to determine only the TDF, officially adopted by the AOAC, the method was improved by changing the concentration of the buffer and replacing hydrochloric acid with phosphoric acid.

As studies on DF progressed, however, these methods proved insufficient to quantify all currently known components. Following the addition of substances such as fructans,

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polydextrose, galactooligosaccharides, maltodextrins, resistant starch, -glucan, it was necessary to resort to advanced methods such as liquid chromatography for their determination [12].

The Codex Alimentarius Commission in 2009 updated the terminology of the definition of DF which consists of: "polymeric carbohydrates, with 10 or more monomer units, not hydrolyzed by endogenous enzymes of the human intestine". Therefore, both edible polymeric carbohydrates that occur naturally in food, those obtained through physical, chemical or enzymatic processes, and polymeric carbohydrates obtained by synthesis, have been included, if the health benefits have been demonstrated [13]

In 2010, EFSA's Panel defined DF as "non-digestible carbohydrates plus lignin"[14].

DF, not being digestible, do not provide any caloric or nutritional intake, but are indispensable for intestinal activity helping to prevent both numerous gastrointestinal disorders and other pathologies. Some types of fibers are able to absorb a significant amount of water, thereby stimulating bowel movements and increasing the speed of stool passage through the intestines. By eliminating constipation, some researchers believe that doing so can prevent the risk of colon cancer[15,16]. In addition, the presence of fermented fibers from the native intestinal flora becomes a fertile ground for the development of very useful intestinal bacteria such as lactobacilli and bifidobacteria.

It was then highlighted that the properties of the different fibers such as solubility, viscosity and fermentability vary depending on their origin, processing and combination of them and are specific to the functional characteristics and therapeutic possibility of their use [17].

II. CHARACTERIZATION OF DFs

DFs are very heterogeneous and are classified according to origin, chemical composition, physicochemical properties, degree of polymerization. Most of them have plant origin, but some, such as the chitin of crustacean shells, can have animal origin, while others, such as polyols used in the food industry, are obtained by synthesis. Fibers obtained from vegetables can be divided into fibers derived from cereals and grains and fibers obtained from fruits, vegetables, nuts and legumes. They differ in both chemical composition and physico-chemical properties and contribute to a well-diversified gut microbiota composition. Solubility, viscosity and fermentability are characteristic properties that influence their activity with beneficial therapeutic effects [18].

DFs consist of oligo-polysaccharides that differ both in the length and branching of the chains and in the presence of different functional groups. These substances are characterized by the fact that they are not assimilable by the human body and therefore are not nutritious.

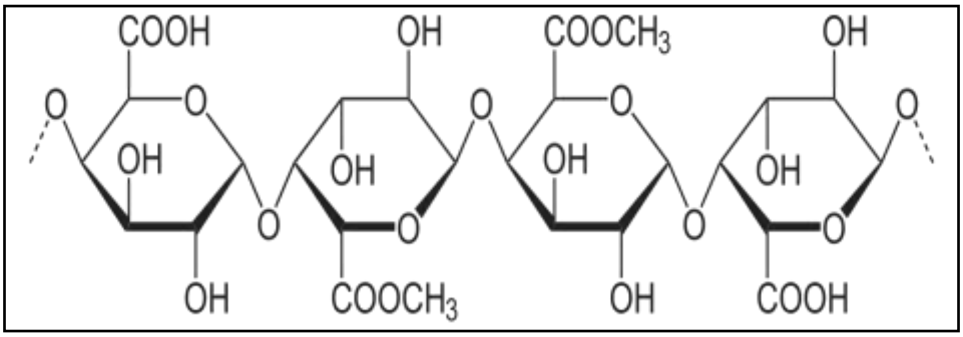

Fig 1. Pectin poli(1,4-α-D-galatturonide) It is a high molecular weight carbohydrate polymer present in all plants where it contributes to the cellular structure**.**

Pectin is a heterogeneous and complex acid heteropolysaccharide with a molecular mass between 50,000–150,000 g/mol, variable depending on the extraction method and the source material [Fig 1]. It is the best known representative of a family of polysaccharides with common characteristics, but extremely different in their structures: homogalatturonan, rhamnogalatturonan, xilogalatturonan and apiogalattu- ronan. The central structure of galacturonic acid can be free or esterified on C6 with methyl groups whose presence is variable if we consider the native pectin with high esterification compared to the low esterifying pectin present in processed foods [19]. Pectins have the characteristic of dissolving in water forming a very viscous gel that is influenced

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by the degree of esterification. Highly methylated pectin can form a gel under acidic conditions with pH ~ 3 in the presence of high concentrations of sugar, while low methylation pectin forms a gel by interaction with divalent cations, in particular Ca 2+ [20,21]

Gums are complex polysaccharides containing glucuronic and galacturonic acid, xylose, arabinose and mannose, and are contained mainly in oats and legumes[Fig 2].

FIG.2 Arabic gum Adracanth gum Guar gum

Gum Arabic is a natural gum that is extracted from two species of acacia from the sub-Saharan area: Acacia Senegal and Acacia seyal, belonging to the family of mimosoid legumes. Like all gums of plant origin, it is produced by the plant following a rubbery process that is activated spontaneously to heal lesions that have compromised its surface integrity. It is an edible substance composed of a complex mixture of glycoproteins and polysaccharides; following hydrolysis, the constituent monosaccharides such as L-arabinose, D-galactose, L-rhamnose and D-glucoronic acid are released. Freshly secreted rubber is soft, but hardens quickly in the open air and can be collected, purified and used in various industrial sectors [22,23].

Adracanth gum also called "Tragacanth gum" is a dry exudate obtained from the stems and branches of legume species of the genus Astragalus, in particular Astragalus gummifer and Astragalus tragacantha. The world's largest producer is Iran, but it is also present in Iraq, Syria, Turkish Kurdistan and Greece.

Adracanth gum today can also be obtained synthetically and consists essentially of polysaccharides with high molecular weight from which, by hydrolysis, galactonic acid, galactose, arabinose, xylose, fucose and small amounts of rhamnose and glucose are obtained. It is viscous, odorless, tasteless, hydrosoluble, free of toxicity, therefore it is used mainly in the pharmaceutical field and in the food industry as an additive [24,25].

Guar gum is obtained by pulverizing the endosperm of the seeds of a legume, Cyamopsis tetragonolobus, which contains galactomannan, a complex polysaccharide consisting of d-galactose and d-mannose units.

This polymer is rich in hydroxyl groups and in water forms hydrogen bonds giving viscosity and thickening to the solution. Due to its thickening, emulsifying, binding and gelling properties, rapid solubility in cold water, pH stability, film-forming ability and biodegradability, it finds applications in a large number of industries [26-29].

Mucilage is a polar glycoprotein formed by heterogeneous polysaccharides that in contact with water dilate forming colloidal solutions, viscous but not adhesive, unlike gums that are characterized by adhesiveness. Mucilage is a normal cellular constituent of some algae, such as agar-agar, and plants, in which it is present mainly in seeds, associated with other substances such as tannins and alkaloids, with the function of retaining water avoiding its desiccation and making them more resistant to drought [30,31].

It plays an important role in seed germination and acts as a membrane thickener; in the carnivorous plants of the genus Drosera, Pinguicula and others that have the leaves covered by glands that secrete mucilage, it has a specific role, as "fly paper", to capture insects. The mucilage of such plants, in fact, has a remarkable adhesiveness, which is an important property in order to trap and retain prey. In fact, mucilage binds to different parts of the body of insects such as waxy exoskeletons, bristles and wings of diptera and lepidopterans [32].

Isolated mucilages are difficult to preserve and for this reason they are taken directly from drugs that are particularly rich in them, such as psyllium seeds, marshmallow, mallow and flax seeds.

Mucilage extraction is achieved from a wide variety of plant parts, including rhizomes, roots and seeds. A very simple method is to use a magnetic stirrer to heat and shake a mixture of seeds/water followed by a filtration to isolate the mucilage released by the seeds. While effective, this technique takes a long time for each individual sample and often the extraction is incomplete, leaving a significant amount of mucilage adhering to the seed. To increase the yield in mucilage, other extraction methods were used: chemical with alkalis; enzymatic chemist; Enzymatic hydrolysis; microwave: sonication, then evaluating the effects on the physico-chemical and functional characteristics of dietary fiber **[**33,34**].** Yu L. et al have recently highlighted the importance of mucilage fractionation to effectively unravel the structural differences that underlie the functionality of polysaccharides **[**35**].**

Mucilage as a DFs is, in fact, used as a food additive to give foods a greater consistency, in addition to its many health benefits and pharmacological properties. Mucilage extracted from Psyllium or flaxseed is used as a thickener in many applications in the food and healthcare industry. As a natural structuring ingredient it is used in baking as a substitute for gluten and for the great variety of DFs has been shown to prevent various gastrointestinal diseases. It is known, in fact, the anti-inflammatory, antibacterial and antispasmodic activity of flax seeds that are used to relieve the symptoms of IBD [36-38].

Agar agar is a mucilage that is obtained from algae belonging to the genus Gelidium, Condrus, Caraghein and consists of hetero polysaccharides. In aqueous solution it has particular properties: it is not very soluble in cold water, while it is very soluble in hot water; once cooled, it determines the gelling of the solution. The algae are collected, washed, dried and subjected to subsequent washing with hot fresh water baths to facilitate the solubilization of hetero polysaccharides. On the surface of the tanks containing hot water and algae, a colloidal layer is formed, which is scraped and separated from the now extracted drug. Algae are a source of DFs that differ in physicochemical properties from those of land plants and therefore can induce different physiological effects. DFs of algae can show important functional activities, such as antioxidant, antimutagenic and anticoagulant effects. Due to their varied composition, algae have a high nutritional value and an increase in their consumption, it would increase the food supply to populations living in disadvantaged conditions, consequently bringing considerable health benefits [39].

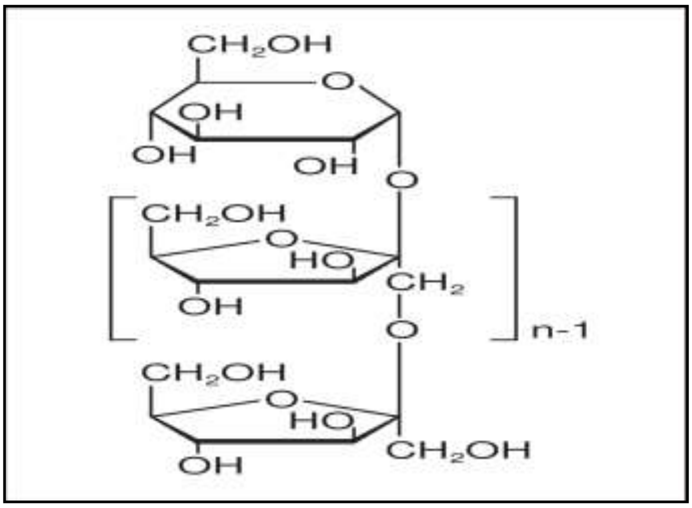

Fig. 3 Fructooligosaccharides They are short-chain fructans present in different species of plants, where they play the role of energy reserve.

FOS are DFs found in different fruits and vegetables. The best known source is inulin which is extracted mainly from chicory root, Jerusalem artichoke, white truffle and dahlia tubers. It is also present in foods such as onions, garlic, artichokes, bananas, leeks, asparagus, rye and wheat. FOS consist of 3-5 units of monosaccharides, D-glucose and D-fructose, and can also be obtained by

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enzymatic synthesis from sucrose, according to a process known as transfructosylation [Fig3].

Inulin is a reserve oligosaccharide present in plants of the Asteraceae family [Fig.4]. It is a DFs composed of about 30 units of fructo-furanose bound by □ □ glucoside bond; together with its products of hydrolysis, oligofructose and fruit oligosaccharides, it constitutes the Fructans. Due to its ability to promote digestion and regulate intestinal function, inulin is added in many dietary supplements. These fibers have the ability to regulate intestinal function by increasing the concentration of Bifidobacteria in the intestinal microbial flora and preventing the development of pathogenic bacteria, thus behaving as a prebiotics [40,41].

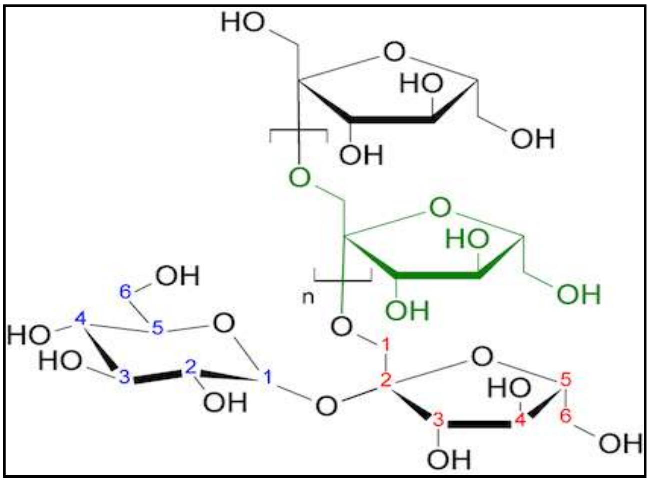

Fig.4 Inulin It is the polymer of β-D-fructose, in which monomers are joined with β-2,1-glycosidic bonds.

The β-glucans are DFs present in whole grains, especially in barley and oats; in some macroalgae such as laminaria and in some mushrooms such as Saccharomyces cerevisiae, reishi, maitake . In nature there are several types of β-glucans which are D-glucose polymers and differ in the type of bond that joins the sugar units, bonds 1,3, 1,4 or 1,6 β-glycosides [Fig 5]. The type of bond influences not only the length and branching of the structure but above all the solubility and therefore can be divided into soluble and insoluble β-glucan that have different activity. The best-known β-glucans are found in cereals where they form a linear skeleton with β(1-3) and β(1-4) glycoside bonds. The presence of β(1,6) glycosidic bonds allow the formation of molecules with branched structure with variation in molecular mass, solubility, viscosity and gelling properties, causing different physiological effects in individuals [42-44].

RS is a fraction of starch that resists the process of hydrolysis by digestive enzymes present in the small intestine, both for the particular structure of the fibrous components of the plant food and for the transformations that the food has undergone as a result of heating / cooling processes. It may whole or partially ferment in the large intestine, therefore two subtypes can be distinguished, RS1 and RS2, which are considered as DFs while the fractions RS3 and RS4 constitute the functional fiber. The ability of starch to resist digestion depends in part on its ratio of amylose to amylopectin; it has been established that resistant starch consists almost 100% of amylose and is therefore digested more slowly.

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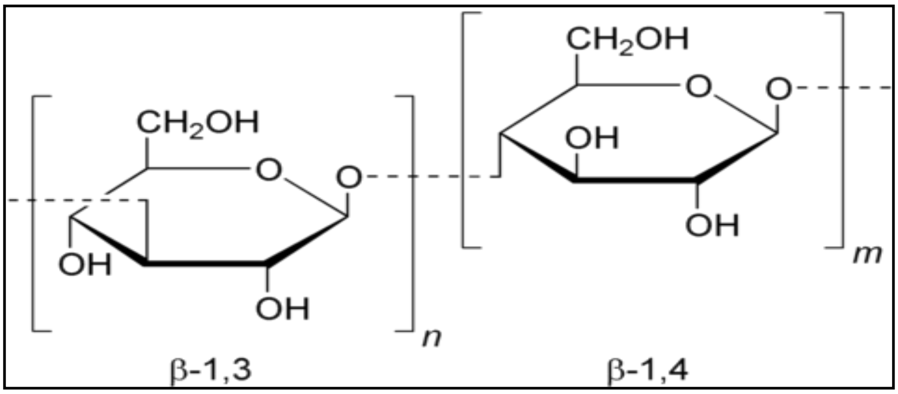

FIG 5 β-glucans They are a group of indigestible polysaccharides that make up the cell walls of cereals, bacteria and fungi.

The resistant starch content of foods is also strongly influenced by the way they are prepared and processing techniques. Some resistant starches are found naturally in some foods such as corn, some legumes, unground seeds, whole grains, uncooked oat flakes, green bananas, as well as potatoes, rice and pasta cooked and then left to cool.

Other resistant starches are synthetically produced by industry and added to foods as useful ingredients to lower their caloric intake by improving their consistency and organoleptic characteristics, with the increase in their DF content [45,46].

III. CHARACTERIZATION OF DFi

Cellulose and hemicellulose are two types of polymers that form the structural components of the plant's cell wall. They are both made up of polysaccharides, but differ because cellulose has a rigid structure and is a linear chain polymer of β-glucose monomers, while hemicellulose is a cross-linked polymer composed of different monomers such as xylose, galactose, mannose, rhamnose and arabinose. A ligned parallel chains of cellulose produce microfibers bound together by hydrogen bridges formed by the hydroxyl groups of glucose [47,48].

Hemicellulose consists mainly of D-pentose, in particular xylose, but often in plants there are also substances derived from hemicellulosic macromolecules with mannuronic and galacturonic acids, which can be considered functional foods. Hemicellulose is contained in bran, in whole grains, accounting for about 1/3 of the fiber of fruits, vegetables, legumes and nuts[49,50].

Lignin is not a polysaccharide but a complex polymer composed of highly branched cyclic units of phenylpropane with strong intramolecular bonds and is found associated with cellulose in the walls of plant cells. The lignin molecule has a high molecular weight, and is composed of the random union of different phenylpropyl acids and alcohols: cumarilic, coniferyl and synapyl that form a three-dimensional, amorphous polymeric structure. In fact, three lignin polymers have been identified, H-lignin, G-lignin and S-lignin, which have different characteristics. In particular, G-lignin is an important component of the softwood of herbaceous plants while S-lignin is abundant in the hardwood that characterizes tree plants. The S-lignin/G lignin ratio is significant for following the fruit ripening process [51,52].

Lignin along with cellulose and hemicellulose are an important DF and is found in foods such as cereals, vegetables and in many varieties of fruits. Lignin is not degraded or absorbed by the human gastrointestinal system and therefore has no nutritional value. Recent research has shown that it has various anticancer and antioxidant functions that could benefit human health[53-55].

Chitin, discovered by the chemist and pharmacist French Henri Braconnot in 1811, is one of the main components of the exoskeleton of insects and other arthropods, of the perisarchus of hydroids and in the surface structures of other invertebrates. Chemically it is a polymer consisting of units of D-N-acetyl-glucosamine bound together by alpha 1-4 glycoside bonds [Fig 6].

Ledderhose in 1878 determined the structure of chitin and demonstrated that it could be synthesized from molecules of glucosamine and acetic acid. Chitin is insoluble in water, dilute acids and alkalis; it is also the main component of the

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cell wall of fungi in which there is also a deacetylated derivative, chitosan[56-58].

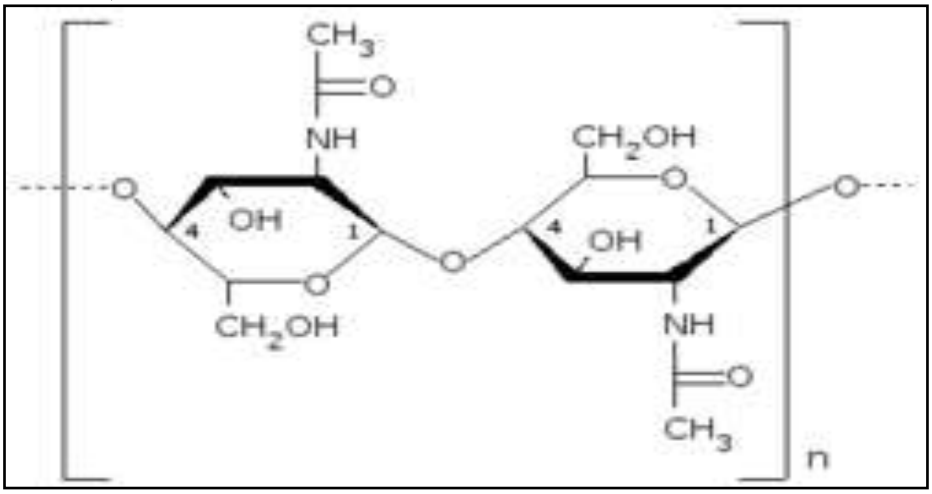

Fig. 6 Chitin It is a nitrogenous polysaccharide, (C8H13NO5)n, consisting of units of N-acetyl-D-glucosamine joined together with β (1-4) glycosidic bonds to form long chains. aggregated in sheets and joined by hydrogen bond**.**

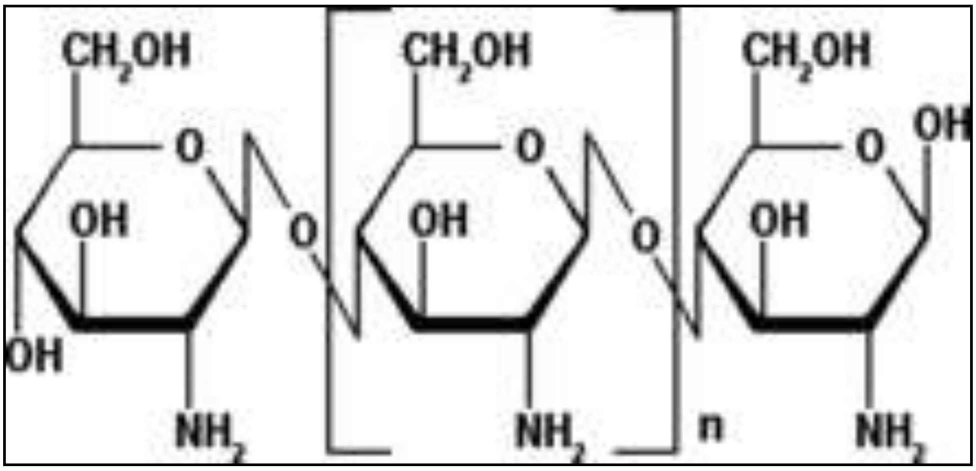

Fig 7. Chitosan It is a linear polysaccharide, composed of D-glucosamine and N-acetyl-D-glucosamine present in the exoskeleton of marine crustaceans and insects, in fungi,

Chitosan was accidentally discovered in 1859 by Professor C. Rouget while trying to produce a natural soap by boiling chitin in alkali, thus obtaining chitosan following the deacetylation process. Currently chitosan is obtained from the waste of crustaceans through processes of demineralization, deproteinization and finally purification to obtain a compound with the desired molecular weight [59]. One of the best known applications of chitosan is in the dietary field, for the ability to act as a non-digestible DF by intervening in the absorption of ingested fatty substances, before they are metabolized. In this sense, it prevents the absorption and accumulation of excess calories and is then eliminated from the body together with lipid substances [60,62].

The fibers of chitosan in contact with water swell and in the stomach form a jelly that gives a sense of fullness by reducing the stimulus of hunger. It binds firmly to lipid substances following the electrostatic force between the positive charge present in the molecule and the negative charge present in the fats. The safety of use of chitosan administered at dietary dosages in humans has confirmed that fibers are well tolerated and the absence of deficiency states related to fat-soluble vitamins and minerals [63,64]. Chitosan in the form of soluble fibers has demonstrated a particular action, such as acting as a prebiotic. It is able to restore and increase the development of the native intestinal microflora, especially if damaged as a result of inflammatory diseases of the intestinal tract or the intake of certain drugs such as antibiotics. A trial conducted on rats showed a bifidogenic effect of chitosan and chito-oligosaccharides. These short-chain polymers, formed by two to ten units of D-glucosamine, and at a concentration between 0.1-0.5%, increased the concentration of bifidobacteria and lactobacilli while simultaneously reducing the concentration of Enterococcus and enterobacteria [65,66].

Less evident is the protective action against the liver where it acts not only protecting it from intoxications of heavy metals and organochlorine compounds, but also as an antioxidant by counteracting the formation of free radicals and as an anticancer agent [67,68].

IV. ACTIVITIES AND BENEFITS OF DF

The consumption of fibers has a series of benefits for which it must be considered an integral part of any balanced diet with the aim of keeping the body in a good state of health. The physiological effects of DF can vary greatly, due to the very diverse nature of the group of substances of which it is made. In fact, it affects the speed with which food passes through the gastrointestinal tract, reducing the time of stay in the intestine of substances toxic to the intestinal mucosa and showing a protective effect against colon and rectal cancer [69].

DFs have the characteristic, once hydro solubilized , of forming very viscous gels important for their metabolic function. They slow down gastric emptying giving a sense of satiety useful in the case of low-calorie diets; affect the progression of the bolus by interfering with the action of digestive enzymes; they perform a lubricating action on the stool, reducing friction and facilitating intestinal function. DFs also have the ability to lower pH, thus making the intestinal lumen a hostile environment for many harmful bacteria.

They are not digested in the upper part of the intestine, but undergo a fermentation process at the level of the colon, where they are broken down by the bacterial flora present there. During fermentation, hydrogen, carbon dioxide and methane develop, gases that are normally expelled with feces or eliminated by the respiratory route [70-72].

Gut bacteria play an essential role in nutrition since they facilitate the digestion and absorption of various nutrients, carbohydrates, proteins and lipids that have not been degraded by human digestive enzymes and that can only be assimilated following degradation by microbial enzymes.

The composition of the native bacterial flora is very complex and metabolically diversified: the taxonomic group most present are the Firmicuti and the Bacterioids, followed by the Proteobacteria, the Actinobacteria, the Fusobacteria and the Verrucomicrobia. Its primary function is to recover energy from undigested carbohydrates in the upper intestine, through fermentation and absorption of the main products consisting of short-chain fatty acids, acetic, propionic and butyric acids.

Propionic acid restricts cholesterol synthesis while also improving the antiproliferative property of butyrate against cancer [73,74].

Butyric acid is not only the main source of energy for the intestinal epithelial cells whose growth it stimulates, but also intervenes in the production of cytokines while maintaining their integrity [75]. Acetic acid is produced in large quantities during fermentation and is absorbed and metabolized in muscles, kidneys, heart and brain tissues where it intervenes in the maturation of microglia and in the microbioma-microglia interaction in disorders of the central nervous system [76,77].

Microglia are the fundamental immune cells of the NSC and their characteristics are dependent on the composition of the microbiota [78,79]. In fact, it is known that intestinal bacteria continuously modulate the maturation and function of microglia through the production of SCFA. Brain studies have revealed that most CNS diseases caused by the gut microbiome are closely associated with microglial dysfunction, including Alzheimer's disease, Parkinson's disease and even autism spectrum disorder and depression [80-83].

Animal studies have shown that short-chain fatty acids are implicated in maintaining the integrity of the intestinal barrier and regulating appetite by stimulating gluconeogenesis in the liver [84,85]. These acids by reducing the luminal pH, protect gastrointestinal homeostasis, which is important in preventing colonization and inhibiting the growth of acid-sensitive enteropathogens [86, 87]. The bacterial flora also increases the intestinal surface, the size of the microvilli and the number of epithelial cells, responsible for the absorption of nutrients. Many researchers have shown that, with the use of suitable DFs, for a prebiotic effect, that is stimulating, it is possible to significantly increase the selective growth of the beneficial bacterial

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species of Lactobacilli and Bifidobacteria, preventing the development, within the digestive tract, of pathogenic species [88-90].

The importance of such microbial communities, beneficial for many aspects of human physiology, has grown considerably in recent years. It has been noted that animals raised in aseptic environments have impaired immune and metabolic function. Similarly, the decrease in beneficial bacterial species in the human intestine is associated with an increasing number of diseases [91]. The alteration of the intestinal flora and the consequent inflammatory processes can negatively affect the development of the nervous system since the fetal period and be the cause of psychiatric pathologies and mood disorders.

The psychiatrist French Philipe Pinel (1745-1828) after having assisted for a long time patients suffering from various mental disorders, in 1807 concluded: "The main place from which mental disorders come is the gastrointestinal tract".

The microbiota plays an essential role in the development of the immune system as has been evidenced in animals raised in germ-free environments that show a lower density of lymphoid cells in the intestinal mucosa and a lower level of immune globulins in the serum.

The gut microbiome can also influence neural development, cognition, and behavior, as there is communication between the central nervous system and the gastro-intestinal system. Behavior changes, in fact, are a signal of the alteration of the composition of the microbiota that, due to this modification, can lead to depressive manifestations [92-95].

The development of the nervous system begins early in the embryo, and its fragile structures are affected by the metabolic and immunological state of the mother. Infections, malnutrition, stress and antibiotic use during gestation have been associated with neuro - development disorders in the future child with manifestations of anxiety, autism, ADHD, depression and schizophrenia [96-98].

The structuring of the central nervous system continues even after birth, followed by a period of up to 2 years characterized by morphological changes, cell differentiation and functional acquisition. Currently it has been ascertained that the evolutionary process continues even in adulthood in the regions of the hippocampus and the olfactory bulb. The hippocampus has considerable importance for cognition and mood. Hippocampal neurogenesis is necessary for certain types of learning dependent on the hippocampus itself and is supported by many factors such as hormones, growth factors, drugs, neurotransmitters, and exercise, while aging, stress, glucocorticoids act negatively on memory and mood [99-102].

Simultaneously with the evolutionary process of the central nervous system occurs the maturation and structuring of the human microbiome on which the immune, neuroendocrine and metabolic expression of the whole organism depends. Dietary behavior is an essential factor for the structure and function of the human gut microbiota and also influences brain behavior. Recent studies have shown the benefits of a low-calorie diet on health, longevity and reduction of cognition related to aging. An experiment in rats revealed the importance of nutrition in adolescence for cognitive function in adulthood. Experimental observation showed that a low-calorie diet during adolescence would increase both hippocampal and prefrontal BDNF levels, as well as proliferative cells and the number of neurons, thus positively affecting memory space in adulthood. Consistent exercise also proved beneficial, having observed an improvement in learning and memory in rats[103-107].

Sometimes an alteration of the gut microbiota, known as dysbiosis, occurs as a result of changes in composition, function, or microbiota-host interactions that may be related to several gastrointestinal diseases.

Very common are inflammations of the colon, colorectal cancer or irritable bowel syndrome; both liver or respiratory diseases such as allergy, bronchial asthma and cystic fibrosis can also intervene; bacterial infections with Clostridium difficile. The multiplication of epithelial cells is a very important effect as it improves the immune status, consequently strengthening the patient's defenses and reducing the likelihood of tumor development [108,109].

DFs such as pectins, mucilages, gums, hemicelluloses and oligosaccharides form viscous gels important for metabolic function: they slow down gastric emptying and increase the sense of satiety, useful in the case of low-calorie diets. They also affect the progression of the bolus by interfering with the action of digestive enzymes, which remain entangled in the viscous gel; they slow down the absorption of fats and sugars thus helping to control disorders such as blood sugar, diabetes, high cholesterol and blood pressure [110,111].

Among the soluble fibers, -glucan, psyllium, pectin and guar gum were also effective in reducing the levels of low-density lipoproteins, without affecting the level of high-density ones contributing to a decrease in blood cholesterol. □-glucan also contributes to glycemic control, strengthening of the immune system, control of blood pressure. The immune-stimulating action of □ □ □ glucan has been highlighted in the prevention of colds, influenza, some recurrent infections in immune-suppressed patients and cancer [112-116].

Another area of application of □-glucan is dermatology. Applied to the skin in addition to its moisturizing properties, it can play a protective action against oxidative stress induced by solar radiation; it stimulates the proliferation of fibroblasts, important in tissue regeneration; increases collagen production with significant reduction in the depth and height of wrinkles. It is also used as an active adjuvant to heal wounds, sores, diabetic ulcers and burns [117,118].

DFi, unlike DFs, are not degraded by contact with liquids and, as a result, show different effects on the digestive system. They have the characteristic of absorbing a lot of water and, swelling, exert mechanical action on the intestinal contents, increasing fecal mass and accelerating intestinal transit. This action of increasing peristalsis is very useful for those who suffer from constipation and also complain of an annoying abdominal swelling. The reduction of the residence time of the fecal mass in the intestine, reduces the possibility that toxic substances can cause serious pathologies such as cancer diseases, while the sense of fullness felt in the stomach with reduced appetite is a valid aid for weight control [119].

DFi are composed of four main components: cellulose, hemicellulose, lignin and pectin. Some researchs documented that hemicellulose and pectin can induce in humans an increase in the excretion of fecal bile acids, which may be accompanied by a decrease in serum cholesterol. Cellulose is an insoluble fiber that is not attacked by mammalian enzymes and also little fermented by intestinal bacteria.

An increase in cellulose in the diet alters the composition of the intestinal microbiota by preventing ulcerative colitis and autoimmune diseases of the central nervous system by increasing the concentration of long-chain fatty acids and activating the immune responses of Th2 lymphocytes[120,121]. The addition of cellulose nanofibers to the diet of rats subjected to a high-fat diet showed a decrease in body weight and fat mass as well as better glucose tolerance. The composition of the gut microbiota has also been changed with increased beneficial bacteria. At the same time, a greater liveliness and an increase in voluntary exercise were noted, which exerted an anti-obesity effect [122].

Plants are the main source of cellulose, but its extraction requires a very long and laborious process to eliminate the substances present at the same time such as hemicellulose and lignin. Scholars have found an alternative method of producing cellulose without resorting to long purification processes, which consists of synthesis with the help of bacterial strains. The first report of cellulose produced by bacteria, particularly Acetobacter xylinum, was announced by Brown in 1886 [123]. The bacterial cellulose thus produced has various characteristics, in relation to the different strains used, such as high crystallinity, high tensile strength, high water retention capacity and thin mesh structure. Due to its exceptional properties it can be applied as a renewable natural polymer in many sectors: food packaging, transparent coating or film, pharmaceutical industries, cosmetic industries, such as biomaterials, artificial blood vessels and scaffoild for tissue engineering, also as a food additive, having been studied the possibility of changing the characteristics during production. Currently the research is mainly aimed at the search for a method of easy application and at advantageous costs to use bacterial cellulose on an industrial scale [124,125].

Hemicelluloses in plants play the important function of interacting with other polymers both to strengthen the cell wall and ensure proper support and to function in the seeds as an energy reserve. Hemicelluloses give important properties to many feeds and products for human nutrition related to their complex composition: xyloglucans, xylans, mannans and glucomannans and β glucans are the main constituents, which have various functions.

Mannans were the first polysaccharides highlighted in hemicellulose and their presence was also found in algae [126, 127]. These polysaccharides are used in the food industry as stabilizers and gelling agents [128]. While mannans are found only in some legume seeds and in the tuber of Amorphophallus konjac, the xylans are much more widespread. They are contained in abundance in the sugar cane, stems and cobs of corn. They constitute an important part of the cell walls of starchy endosperm, especially wheat, rye and corn, being the main components of DF obtained from the processes of separation of wheat and corn starch.

Xylans are used for beneficial health activities: they are considered anticarcinogenic and capable of increasing the beneficial growth of the bacterial population in the colon [129]. Arabinoxylans are copolymers consisting of arabinose and xylose, pentose sugars that are found in the cell walls of plants along with phenolic acids, including ferulic acid that perform several biological functions in the plant, including defense against fungal infections. Some studies have highlighted the beneficial effects of arabinoxylans on the gut microbiota in rats with type 2 diabetes by promoting the growth of fiber-degrading bacteria to increase short-chain fatty acids, reducing the concentration of hydroxylated bile acids and opportunistic pathogens [130].

Arabinoxylans have also shown promising results as bakery additives where they can be used to improve the processing and nutritional quality of bread doughs.

Experimental scientific studies have highlighted the benefits of DF on the human body by examining foods rich in fibers, vegetables, fruits, whole grains, not isolated components. In fact, the use of fibers based supplements, prolonged for a long period of time, could cause negative effects, interfering in the absorption of vitamins, minerals, proteins, especially in fragile patients who already have pathological or deficiency states such as children and the elderly. This drawback does not occur if fibers are derived from natural foods, as with the introduction of foods containing fibers, other micronutrients are also acquired. Some types of fibers are important prebiotics, that is, they promote the growth and development of specific bacterial strains in the colon, lactobacilli and bifidobacteria, which contribute to the well-being of the body.

They are fermentable fibers that are a source of energy for the intestinal microbiota and exert both a preventive effect for inflammatory bowel diseases, such as Crohn's disease and ulcerative colitis, and also involve the immune system in the prevention of tumor diseases.

V. CONCLUSIONS

Numerous studies have shown that a healthy lifestyle, with correct eating habits and regular physical activity contributes to the achievement and maintenance of a good state of health, with a lower risk of chronic diseases at all stages of life, resulting in active aging. The current diet includes a high consumption of refined and processed foods, white cereals instead of whole grains, juices and fruit extracts to replace whole fruits, limited intake of vegetables, legumes, nuts and seeds. This type of diet is not well tolerated by the gastrointestinal system being often the cause of inflammatory states with painful symptoms. Regular consumption of fibers, on the other hand, can help maintain the regularity of the intestine and resolve situations of constipation; to achieve this goal it is important that the consumption of fibers is always accompanied by an adequate consumption of liquids.

The European Food Safety Authority (EFSA) recommends an intake of 30g daily of DF to be achieved by consuming foods rich in fibre and not by taking food supplements.

DF, in fact, have peculiar physico-chemical characteristics that allow the action on the gastrointestinal tract both through beneficial effects and on the availability of micronutrients, intestinal transit, stool formation and microbial specificity. The complex composition of them constitutes a strong limitation for their use, determined by the fact that neither the doses nor the particular types of fibers are provided for the treatment of various gastrointestinal diseases.

In addition, the results of various trials in both animals and humans have provided conflicting responses regarding the nature of the symptoms and their improvement after fibers intake. Such differences can be attributed both to the subjective diversity of individuals and to the diversity of the microbiota of a healthy patient compared to a patient with somatic and psychological comorbidities[131].

Future research should be directed mainly on the choice of DF, on the composition and physicochemical characteristics of which the effect of improving symptoms in gastrointestinal disorders will depend. It will be appropriate to compare the reactions between individuals different in sex, age, type of work and social status to obtain a univocal answer without environmental interference. At the same time, the individual response must be analyzed, especially in the long term, to exclude that the chosen treatment is effective and does not involve alterations on the state of health of the organism.

Conflict of Interest
The author declares she has no conflicts of interest

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