# Chapter 3
# Health Benefits of Non-nutrients. Dietary Fibre and Water

## Abbreviations

NSP Non-starch polysaccharide
$H_2O$ Water

## 3.1 Dietary Fibres and Water. Are They Needed in Human Nutrition?

Nonessential nutrients can be synthesized by the human body. As a result, food is not the only possible origin. As briefly discussed in Chap. 2, foods and beverages are considered nutrient mixtures because of three essential functions for living organisms. These edible materials are needed when speaking of sustainability of vital processes and growth of humans and animals (with reference to the animal kingdom). Moreover, their importance is notable because of the need for bioavailable energy. In fact, living organisms must take energy from each possible source, and this energy has to be promptly available. As a result, foods and beverages are needed not only for building/repairing vital organs, tissues, and so on but also as energetic sources.

In addition, and according to current technological knowledge, the composition of foods and beverages is generally identified with a tripartite structure composed of lipids (fat matters), protein, and carbohydrates. However, this description is not correct because one peculiar and absolutely needed component is absent. This component—water—is essential because of two reasons:

(1) All living microorganisms need life for survival.
(2) Secondly, all foods and beverages are solid, semi-solid, colloidal, or liquid aqueous solutions. Consequently, and taking into account also dried/semi-dried foods, it has to be considered that water is needed and always present, even at

 
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very low concentrations (in lyophilized products, a minimal aqueous content is still present).

In other words, foods (and beverages above all) are water-dissolved solutions. This is a normal condition and also a pre-requisite for all edible products in human history, also meaning that dehydration treatments may be considered as one of the many tracts of anthropic activities and civilization in general. The simple production of more or less dehydrated cheeses (high-durability preserved milk) in many countries and areas, such as the well-known *jameed* balls in Jordan or certain high-dry matter Italian cheeses (Barone et al. 2014; Haddad and Parisi 2020; Haddad et al. 2020a,b, 2021a, b; Parisi 2006; Parisi et al. 2004), should easily demonstrate this fact. In addition, the addition of water to certain products has to be mentioned from two opposite viewpoints (Hading 1995; Khan et al. 1999; Pereira et al. 2006; Poonia et al. 2017):

(a) The regulatory perspective, with particular reference to food adulterations by means of the addition of liquid water to foods, especially in the milk and dairy sector.
(b) The technological perspective, with particular reference to the need for enhanced palatability for certain products by means of the addition of fluids (and also water).

From the economical viewpoint, water is also extremely convenient because of its very low price compared with other raw materials. The simple sentence '*Water is Life*' may have not only a purely biological meaning, but also an explicit meaning when speaking of economically convenient products and reliable savings concerning production costs for food business operators (even if water addition is clearly mentioned). In addition, water is needed in the food industry in relation to production purposes without a nutritional significance. As a result, water is needed… as a technological and economical factor, and its nutritional importance is naturally included (Delgado et al. 2017; Laganà et al. 2017; Mania et al. 2018; Sharma et al. 2019). However, water is also essential for life, and the same thing can be affirmed with reference to other non-nutrients of vegetable origin (phytochemicals) briefly discussed in Chap. 2. In the ambit of phytochemistry, the class of 'dietary fibres' has been also mentioned because of:

(1) Their role as health promoters in the human diet;
(2) Their contrasting importance against certain health disorders;
(3) Their high or low water solubility;
(4) And finally, their resistance—when observable—to human-produced digesting enzymes.

Each of these points has to be examined with connection to the role of water in the human diet and foods/beverages in general.

## 3.2 Definition and Functional Properties of Water as Nutrient

From the viewpoint of human nutrition, water ($H_2O$) has six important functions (Jéquier and Constant 2010):

(1) $H_2O$ can be considered as a material needed for building human tissues and organs. This affirmation should be evaluated both on a macromolecular scale (with concern to tissues such as human skin) and a micromolecular scale, when speaking of single cells. In fact, the intercellular space is practically a liquid solution, and intercellular exchanges cannot be performed in other ways. In addition, water is contained in each cell.

(2) Secondly, the 'obvious' function of $H_2O$ as a solvent medium should be clear enough. This function is observed regularly in natural foods. However, water can also be extremely important from the biochemical viewpoint because all reactions used for sustaining life need a reaction and solvent medium at the same time. As a result, $H_2O$ is needed also as a partner (reactive) species for chemical reactions. In addition, pH conditions are extremely important when speaking of reaction yields, and water—an amphoteric molecule because it exhibits acidic and basic features at the same time—can play a critical role.

(3) Moreover, $H_2O$ can act as an excellent transport medium (carrier) both for nutrient molecules and toxic catabolites (waste results from biochemical reactions) at the same time. This function, generally ignored, is absolutely critical because all vital organs and systems of the human body have to rely on the efficient transportation of nutrients such as carbohydrates, salts, etc., on the one side, and on the prompt elimination of toxic compounds and catabolites, on the other side. Consequently, ready nutrition must rely on water through the interstitial fluid (Grandjean et al. 2003), and the excretion of catabolites has to follow the same 'water ways' in the organism. Dehydration phenomena are extremely dangerous and potentially life-threatening.

(4) Another important function of water is thermoregulation (Montain et al. 1999). In fact, $H_2O$ can contain a good energetic amount of heat. As a result, water can be used with the aim of reducing thermal modifications in the human body against adverse environmental (extreme cold or warm) conditions. The perspiration process (elimination of water solutions containing catabolites) from skins can be very useful if the human body is forced to reduce its thermal amount in a relatively small time temperature (Montain et al. 1999). When sweating is elicited, evaporation of water from the skin surface is a very efficient way to lose heat.

(5) $H_2O$ can have a critical function in various environments of the human body as a lubricant agent. Actually, the role of lubricant has to be assured provided that water dissolves viscous compounds with the aim of creating a lubricating medium where requested.

(6) Finally, $H_2O$ is needed as a simple and little molecule able to model and 'protect' the cellular structures against mechanical shocks. This important

function, often neglected, is extremely evident when speaking of pregnancies and possible damages to the foetus. In this situation, an aqueous 'wall' can protect the new organism from shocks.

These roles can explain well the importance of $H_2O$ in the human body, and also the need for an efficient hydration over a 24-h period, so that losses and gains are approximately equal. For this reason, the recommended dietary intake of liquid water (excluding foods and other beverages) should be 1.5 L per day, excluding sedentary people (2.0–2.9 L). The amount of aqueous content in the human body is approximately 60% and it decreases continually over time, from the infant to adult age. In the last situation, it can be important to note that extracellular water is approximately 33% of the total amount. As a result, approximately 450 ml/day of $H_2O$ are lost by evaporation from the skin, while normal respiration and solid excretion are responsible for an additional 300 and 200 ml/day of $H_2O$ elimination, respectively (Kleiner 1999; Jéquier and Constant 2010).

## 3.3 Definition, Types, Structures, and Functions of Dietary Fibres as Nutrients

In general, dietary fibres are defined (DeVries 2003) as a fraction of (edible) vegetable organisms, which can be assimilated into a carbohydrate structure. This condition is needed but insufficient: the other necessary condition is that these carbohydrate matrices can resist the enzymatic digestion in the human small intestine with consequent fermentative reactions in the large intestine. In other words, dietary fibres cannot be absorbed through small intestine walls with the consequent destination to the large intestine and subsequent fermentation. Interestingly, laxative functions and other roles fibres can act as nutrient- and catabolite-absorbers (by means of complexation phenomena and other approaches) depending on the fermentation with consequent effects on intestinal pH and the production of useful by-products (from the physiological point: cholesterol and glucose control in the blood).

As a result, the composition of dietary fibre relies on the abundance of cellulose and hemicellulose (with associated fibrous aspect). The importance of dietary fibres can be discussed at least from the viewpoint of vegetable sources and/or with reference to their chemical and technological/functional characterization, as reported often in the scientific literature (Boers et al. 2017a, b; Boukid et al. 2019; Davis et al. 2018; Fahim et al. 2019; Jan et al. 2017; Kalala et al. 2018; Lila et al. 2017; Madane et al. 2020; Millar et al. 2019; Priya et al. 2019; Qi and Tester 2019; Sasaki et al. 2018; Sofi et al. 2017; Van Soest and Jones 2021; Venkidasamy et al. 2019; Vijayasteltar et al. 2017). In detail, the complete list should be more challenging, as briefly explained here by means of a block-like classification (Buttriss and Stokes 2008; Ha et al. 2000):

First block: non-starch polysaccharides (NSP) and digestion-resistant oligosaccharides;

Second block: 'analogous carbohydrates';
Third block: lignins, (when associated with NSP and lignin complexes).

The first block concerns water-insoluble cellulose, soluble and insoluble hemicellulose, and other non-digestible polysaccharides. According to the above-mentioned definition, these (generally) water-insoluble compounds—polyglucoses, polyfructoses, β-glucans, different heteropolymers, soluble mucilages, pectins (relatively water-soluble and gel-forming complexes), and soluble gums—are fermentable. The second block concerns water-soluble analogous carbohydrates produced by means of physical or chemical reactions. This step occurs normally during food processing operations, and it influences the digestion of starches. Substantially, the main and necessary feature of 'analogous carbohydrates' (polydextrose; methyl cellulose; dextrins from maize, potatoes, etc.; synthetic carbohydrates; digestion-resistant starches) is the resistance to digestion, followed by difficult fermentation. Finally, the third block (lignins, intrinsically linked with hemicelluloses in spite of their non-carbohydrate nature) includes a heterogeneous group of water-insoluble natural polymers: waxes, cutin, suberin (fatty acid derivatives with strong resistance to digestion: these substances remain relatively undegraded by the microbial population in the large intestine), saponins, tannins, etc.(Ha et al. 2000).

Anyways, and with specific relation to potential health effects on human health, it has to be considered that dietary fibres are reported to have beneficial effects when speaking of cardiovascular diseases, glycaemic control, and gastrointestinal functionality. Actually, there is need for further studies in this ambit, because the group of dietary fibres is extremely variegated and also correlated with a wide—too wide—range of vegetables, from whole grains to red fruits (Mann and Cummings 2009). It is essential to recognize that these effects are probably linked with solubility in water. In fact, and as briefly anticipated in Chap. 2, these complex compounds could be differentiated on the basis of their high solubility in water (e.g. psyllium, one of the most known components of anti-constipation mixtures), or low aqueous solubility (e.g. wheat bran). On the other side, it has been reported that the soluble/insoluble differentiation may not have a remarkable importance on the practical ground because all undigestible fibers have a variable degree of resistance to digestion. With reference to fermentation and claimed physiological effects, the above-mentioned discrimination has not been demonstrated to have important and conclusive influences (Buttriss and Stokes 2008). The lack of evidence is more important at present because of the wide range of food products with claimed properties justified by the presence of dietary fibres, and the problem of reliable food labelling is a current issue, nowadays. Another worry depends on the removal of fibres from a number of transformed food products, with associated effects on the human health and the possibility of digestion-related disorders, tumours, and other diseases (the opposite situation, abundance of added fibres, is reported to be correlated with the reduction of coronary heart diseases, obesity, and some tumours. However, more research is still needed.

Certainly, the use of dietary fibres is well-promoted in the food industry even if the possible health effects are not researched as the first objective. In fact, dietary fibres actively improve and modify the textural appearance of foods and other organoleptic features because of their strong gel-forming attitude with water and also anti-sticking and anti-clumping features. In addition, cooking yields and fat binding are reported to be enhanced if dietary fibres are added to the food mass mixture. For these reasons, the research should investigate the use and consequences of dietary fibres in the industry because of their wide applications.

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