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GUIDELINES FOR A HEALTHY VEGETARIAN DIET

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FOREWORD

The National Programme for the Promotion of Healthy Eating (PNPAS)/Directorate-General of Health aims at "improving the Portuguese population's nutritional condition, providing incentive to the physical and economic availability of foodstuffs which constitute a healthy food pattern, and creating the necessary conditions to allow the population to value, enjoy and consume them, by integrating them in their daily routines." With the publishing of this "Guidelines for a Healthy Vegetarian Diet", part of those assumptions are fulfilled, given that it provides and values a model of healthy food consumption amidst the population, creating conditions in order that, for the first time, and in this format (Ministry of Health), Portuguese health professionals can gain access to information which allows them to know more and be more competent in a truly expanding area.

Pedro Graça
PNPAS Director

This book operates in an exemplary manner at different levels. Firstly, it offers a historical perspective regarding the option made by a vegetarian diet, enabling an understanding of the arguments (philosophical, religious, social, utopian and those related to human health) of vegetarians, going through the historical periods and the names of the great defenders of this diet.

Secondly, it fulfils its didactical mission of clarifying the differences between several types of diets usually associated with vegetarianism, and it offers a clear vision about the benefits of this diet and its practicability in a country like ours, which has varied production of vegetable origin all year round, and it simultaneously gives warning about the risks involved in a badly-planned vegetarian diet.

Lastly, it provides important information about nutritional adequacy in vegetarian diet, presenting tables which can be used by the vegetarian, and a bibliography which gives orientation to those interested in going deeper in the study of this diet.

This initiative by Directorate-General of Health is definitely to be praised, because it acknowledges that there is a significant number of vegetarians in Portugal and intervenes so as to provide health and education professionals with the necessary tools envisaging informed counselling.

Fátima Vieira
President of Utopian Studies Society/ Europe

ABSTRACT

Dietary patterns consisting exclusively, or mostly, of plant foods seem to have been common knowledge and followed since as far as the classical antiquity, essentially on philosophical and religious grounds, but also for health reasons. Over the last decades, alongside with an increase of knowledge on nutrition and environmental sciences, there has been an increment on scientific evidence in favour of a greater presence of plant foods in our diet. Populations showing high or exclusive consumption of plant foods seem to be less prone to develop chronic diseases, such as cardiovascular disease, certain types of cancers, diabetes and obesity.

This dietary pattern, or 'diet', is not a uniform one, as it may consist solely of plant foods (strict vegetarian or vegan) but it can also include other elements such as eggs and dairy products (lacto-ovo vegetarian). At its core there is usually fruit, vegetables, cereals, legumes, nuts and seeds, which should preferably be local ones, in season and minimally processed.

The guidelines for a healthy vegetarian diet which are proposed in this document have been designed considering the healthy adult, which is why they should not be applied to other stages of a life cycle. The adequacy of this "diet" to the different stages of life, including childhood, adolescence, pregnancy, lactation, old age, and even to athletes, requires appropriate planning and monitoring.

In order for this dietary pattern to be considered nutritionally adequate, factors such as the appropriate intake and bioavailability of certain nutrients such as protein, essential fatty acids, vitamin B12, vitamin D, iodine, iron, calcium and zinc and also caloric intake should be taken into account. Moreover, it is important to consider food diversity, the reduction in quantities of salt, sugar and saturated fats, and the adequate intake of water. In the case of vitamin B12, and due to the absence of nutritional sources in a vegan diet, it has to be provided through enriched foods or supplements.

Although this food pattern is generally healthy and easy to adopt, particularly in countries like Portugal, where there is a varied and abundant supply of fruit, vegetables and other plant foods throughout the year, and where traditional cooking methods already include plant foods in their base, there is still considerable lack of information on the part of health and education professionals, associated with poor-quality information on online formats, a situation which this manual aims at improving.

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INTRODUCTION

In the past years there has been plenty of scientific evidence in favour of an increase in the presence of plant-origin products in our diet. In a first phase, there was a description of the advantages of the intake of several substances present in plants were described, mainly vitamins and minerals, which can reduce the risks of nutritional deficiency. The discovery of new phytochemical substances contained in plant-origin products, with antioxidant and anti-inflammatory proprieties capable of protecting cells (namely carotenoids, flavonoids, isoflavones, phytosterols, lignans), has increased the interest for consumption of plant products, especially fruit and vegetables. This interest increased even further with the acknowledgement that its protecting effect could be amplified through synergistic action of the several phytochemicals present in plant-origin products, suggesting that they and their multiple combinations (for example in culinary preparations) could be more interesting in the protection of health than just as nutrients by themselves[1].

The discussion was launched and today it excites epidemiologists, public health doctors, nutritionists and other health professionals on the benefits of the consumption of plant-origin products and their role in preventing diseases, namely those which prevail in our society, such as cardiovascular disease[2], oncologic disease[3], obesity[4] and diabetes[5]. Evidence shows not only the importance of a regular consumption of plant-origin products, but also the fact that a diet based exclusively on these products is equally or even more protecting of human health. On the other hand, today we know that, if well-planned, an exclusively vegetarian diet can fill all nutritional needs of a human being and can be adapted to all phases of the cycle of life, including pregnancy, lactation, infancy, adolescence, elderly or even to the situation of athletes[6, 7].

In scientific literature, more and more interest is shown in this area, which partly reflects the growing demand for information regarding exclusively vegetarian food patterns, but also the growing evidence about the potential benefits for health which they represent. In the past 40 years there has been an increase in the number of scientific articles on vegetarian diet. According to the scientific database "PUBMED", in mid-2015 there were over 3.000 publications on the topic "vegetarian" or "vegan"[8], half of them having been published in the last 10 years.

The interest for vegetarian diets goes beyond health matters. There are many reasons which lead an increasingly high number of people in the entire world to adopt food patterns with

smaller quantities of animal-origin products (for example, without fish or meat), or even exclusively vegetarian.

One of the main reasons leading to the option for a vegetarian diet has been the environmental issue. Food choices cause significant impact upon nature. In Europe, for example, food consumption represents 20% to 30% of the environmental impact of one single family[9], and little changes such as the elimination of meat consumption can greatly influence this reduction in about 25%[10, 11]. Recently United Nations have once again insisted on the promotion of the term "Sustainable Diet", a concept which was introduced in the 1980s, which proposes a development of healthy food patterns for the consumer and for the environment[12]. Thus, a Sustainable Diet "should have low environmental impact, thus contributing to high patterns of food and health safety of future generations". A sustainable diet should protect and respect biodiversity and eco-systems, be culturally accepted, easily accessible, economically fair and, if possible, nutritionally adequate, safe and healthy. It should optimise natural resources and human resources available. Besides considering the need to produce food with low water and carbon consumption, it should promote food biodiversity and, in particular, local and traditional food products[13]. Mediterranean food patterns fit this concept perfectly, given that they are recognised for a reduced intake of animal-origin food and large quantities of vegetables, as do food patterns which have an exclusive or almost exclusive presence of plant-origin products: the vegetarian food patterns[14-16].

Other reasons help explain the option for this food patter, which can also be regarded as a model of life, namely regarding issues related to animal protection and wellbeing, as well as animal rights[17-19].

Even though in the past years there has been a change in perception regarding vegetarian diets, both in terms of the effects over health and from the social standpoint, the effective promotion of food patterns which include more plant-origin products in our diet is still very reduced[20]. In the United States of America, for example, governmental recommendations present in official food guides ("My Plate"), suggest a daily consumption of fruit and vegetables in the amount of approximately 50% of the total consumed portions. However, the Ministry of Agriculture only awards 1% of its economic grants to support research, production and marketing of fruit and vegetables[21]. In Europe too fruit and vegetable consumption has been decreasing in the last decade. In 2012 it was of approximately 386,96 g/per capita/day, a decrease of 8,7% when compared with the averages recorded in the period 2007-2011. From the 28 Member States of

the European Union, 18 present estimated consumptions below the 400g/day of fruit and vegetables recommended by the World Health Organisation[22].

The citizens' growing interest for vegetarian diets, as well as the demand for healthy food alternatives, have been stimulating the growth of a market niche. Today, more than ever, vegetarian options are accessible and it is relatively easy to adopt a vegetarian diet, given that some vegetarian food products and meals are available not only in specialised shops, but also on the Internet, in regular markets, hypermarkets and in food courts of shopping centres. The introduction of new products meant for vegetarians, such as food products (vegetarian alternatives such as vegetable beverages, and "equivalents" of meat), fortified food (such as breakfast cereals) and plant-origin food supplements (such as omega 3 from microalgae and vitamin D from specific yeasts intended for food use – often mentioned in literature as "nutritional yeast") is growing. According to some market analysis, economic perspectives are positive and they will continue to be boosted by a growing trend in consumption, not only by the vegetarian, but also by other people who seek these options[23]. From all of the new products introduced in the British market in 2009, 6% were meant for vegetarians (or "suitable for vegetarians"), and, in 2013, this percentage reached 12%. It was estimated that this market has reached amounts as high as 543 million pounds in 2009 and 625 million pounds in 2013[24]. Moreover, cook books, magazines and restaurant menus are more and more filled with appealing vegetarian options.

The growing quantity and accessibility to information available on the Internet and other generalist media may contribute to a better understanding and acceptance of this type of diets. However, they can also be means of sharing of purely commercial information, without scientific accuracy, which can jeopardise the nutritional condition of these individuals and consequently, their health.

The adoption of a vegetarian-type food pattern demands knowledge, practice in purchasing and in the confection, as well as some time for the assimilation of some food principles, namely in order to obtain the adequate amount of vitamins (e.g. vitamin B12), minerals (e.g. iron), fat (omega 3) and protein. On the other hand, the total or partial rejection of animal-origin products in one's diet, does not necessarily mean that it will automatically become healthier. In other words, if badly planned, a vegetarian diet can be as harmful as an imbalanced non-vegetarian diet. If it is rich in excessively processed products, it may provide a higher amount of fat, energy/ calories or salt.

It is also important to stress that it is possible to adopt a vegetarian diet with minimal use of food supplements or processed products alien to our food tradition. Fortunately, Portugal possesses unique conditions for a high-quality plant-origin production, given that it has a large, diversified seasonal variety. In addition, our entire gastronomic tradition is founded on plant-origin products, starting with vegetable soup, one of the central elements of Portuguese gastronomy, followed by bread and varied legumes, with olive oil as high-quality central fat, ending in the hundreds of varieties of fruit and vegetables. It is also worth mentioning the existence of some important plant-origin products available in Portugal, although insufficiently valued, as is the case of algae, watercress, purslane, chard, carob flour, some national varieties of beans and chickpeas, sweet potato, chicory, chestnuts and acorns.

The success of a sustainable vegetarian diet needs to be supported by variety, flavour and pleasure at the dinner table, inside our tradition and food culture, but also by economic sustainability, i.e., the adoption of this food pattern must be affordable by families.

Therefore, it is important that those interested in beginning or improving their diet, and who wish to adopt a long-term vegetarian diet, ask their assisting health professionals for counselling. These should be well-informed and able to inform about the benefits and risks associated to this kind of diet, but also advise and follow its execution in practical terms, as well as help them overcome the natural barriers that they might initially encounter [7, 25].

Concomitantly, the technician in charge of the food and meal-preparation services of public and private institutions, such as nurseries, schools, hospitals, nursing homes and prisons, should be made aware, trained and capacitated for the elaboration of capitations, technical sheets and menus, in order to provide adequate vegetarian meals, given the growing number of vegetarians and non-vegetarians who occasionally wish to decrease animal-origin product consumption.

This manual comes about with the double objective of informing all health professionals and people in charge of food services interested in a simplified, yet accurate and unbiased approach to the topic, and simultaneously serve as a tool of support and clarification for all potential candidates to a vegetarian diet, thus avoiding errors which might put their health at risk.

VEGETARIAN DIET

Brief History and associated concepts

Vegetarian food pattern, which we here designate as “vegetarian food” or “vegetarian diet” has been known since the times of Classical Greece. Since then, the option for this kind of eating has been determined by religious grounds, by health reasons (essentially out of fear of the potential risks on human health when eating animal meat or blood), and by philosophical reasons, in particular the relationship between humans and other animals. During that period, and until very recently, the option for a vegetarian food pattern was built almost exclusively as an opposition to meat consumption, over the advantages of consuming plant-origin products.

One of the most famous precursors of vegetarian food in Europe was Pythagoras of Samos, who in VI BC founded a community of mystical mathematicians who, it was said, “observed the prohibition of eating animals, because they had the right to a common life with mankind"[(26)]. Other thinkers of classical Greece, like Plutarch, wrote about meat consumption and abstinence. In Plutarch’s case, in his Moral Works (*Ethica or Moralia*), and in particular in his text *De esu carnium* (*About meat consumption*), there is an apology of vegetarian food based on the acknowledgement that animals possess intelligence and imagination [(27)]. The interest in the prohibition proposed by Pythagoras was later on renovated by pagan Neoplatonist philosophers who sought the purification of the soul, an ideal which persisted until at least the early XIX century. An explanation for Pythagorean vegetarianism and beliefs of some Greek thinkers from classical antiquity was the fact that they believed in the transmigration of souls, or metempsychosis of the souls. If after death the soul could pass on to the body of another animal species, then vegetarianism would be the only way to avoid cannibalism, therefore constituting a factor of dissuasion from *sarkophagia* ('meat consumption'). During the middle ages and early modern times, being a “vegetarian” meant having the pagan belief of the migration of souls, which was considered a heresy. This situation, in addition to the shortage and need for meat throughout this period, dictated the disappearance of its followers.

The rediscovery by the classical Greek authors during the Renaissance period, and especially from the XVI century onwards, renovated the interest in the notion that animals were sensitive to pain and, therefore, deserved moral consideration. Several thinkers, such as Venetian Luigi Cornaro, who produced *Tratto della Vita Sobria*, in 1548, but also Erasmus (1467-1536) or Thomas More (1478-1535), wrote about the wellbeing of animals, refusing meat consumption or condemning animal abuse practices. But it is in the XVII century that the movements in favour

of a vegetarian diet sediment themselves, based on religious, philosophical and moral aspects against animal suffering. In the XIX century, with the event of the Romantic movement and associated humanist perspective, poet Shelley, who joins vegetarianism in 1812, adds a political dimension to the cause of vegetarianism, highlighting an inefficient use of resources and unequal production and distribution of meat as a reason for the shortage of food among those in need in society. The year 1809 marks the beginning of a movement, within a branch of the English Church, towards vegetarianism with expression in Christian faith. The Christian Bible Church is founded in Saltford (United Kingdom) in 1809 and reverend William Cowherd identifies the different biblical references against meat consumption. In 1850, a part of that movement creates the North American Vegetarian Society. More radical Christian movements help boost vegetarian movement in this period, both in England and in the United States of America, among which was Adventist Church of the 7th Day. One of its most famous members is John Harvey Kellogg, preacher and inventor not only of the popular breakfast cereals, but also of a whole lifestyle, with a meat-free eating style [28].

In Portugal, and in the early XX century, there was a first movement in favour of vegetarian food in Oporto, spearheaded by Ângelo Jorge, author of the frugivorous utopia "Irmânia", accompanied by several individualities from Oporto's bourgeoisie. By then, *Sociedade Vegetariana de Portugal* (*Portugal's Vegetarian Society*) is founded, which, among other activities, would be devoted to the publicity of the naturist, and the promotion of vegetarianism, physical education, hygiene and natural cures. In these early days of the vegetarian movement in Portugal, one of its main promoters, Ângelo Jorge, defends frugivorous food, considering that "if men go back to being frugivorous, the matter will be settled"; and in "Irmânia", the utopia made up by the author, he tries to prove his point of view, putting face to face the woes of modern civilization, carnivore by excellence, with the beauty, the quietness, the pacifism, the wisdom and the easy life of frugivorous individuals [29, 30].

In the XX century and progressively, besides the moral and religious questions, consumption of vegetarian food starts to be associated more and more with a discourse turned to environmental protection and biodiversity, animal wellbeing and, fundamentally, with health questions associated with consumption of plant-origin products, which we tackle with more detail [19].

The concept of Vegetarian Diet and its classification

"Vegetarian diet" is a term which is generally attributed to a food consumption pattern which uses predominantly plant-origin products. It always excludes meat and fish, but it can include eggs or dairy products. Inclusion of dairy products and/ or eggs is one of the main differentiation factors in vegetarian diets[7, 31]. Cereals, vegetables, fruit, legumes, oleaginous fruits and seeds are the food which is common to the various types of vegetarian diets.

Vegetarian food can be classified as:

- Lacto-ovo vegetarian – excludes meat and fish, allows eggs and dairy products
- Lacto vegetarian – excludes meat, fish and eggs, allows dairy products
- Ovo vegetarian – excludes meat, fish and dairy products, allows eggs
- Strict vegetarian and vegan – excludes all animal-origin food[6, 25].

In the case of strict vegetarian and vegan diets, all animal-origin food is excluded:

Meat, fish and eggs (and their derivatives), dairy products, honey, jelly (except of plant origin), lard, fish eggs, insects, molluscs, crustaceans, among others, and all products containing them.

Some processed products may contain ingredients and additives of animal origin, such as: albumin, animal fat, dyestuffs (such as carminic acid - E120), casein and glycerine[32]. Some additives may be apt for a lacto-ovo vegetarian diet, but not for a vegan diet.

The adoption of a specific type of vegetarian diet is often associated with the different reasons which lead people to follow this food pattern (health, animal wellbeing, environment, religion, spiritual or ethical reasons)[33]. For instance, a vegan who follows a strict vegetarian food pattern, besides excluding consumption of animal-origin food also excludes all animal-origin products, such as clothes (hides, leather, wool, silk, suede), accessories (pearls, plumes, feathers, ivory…), animal-tested products (hygiene and make-up products) and condemns use of animals as a way of entertainment (bull fights, circuses and zoos)[31].

Some individuals claim they have a semi vegetarian diet ("flexitarians"). Although there is no single definition for semi-vegetarian, it is commonly accepted that this is a pattern which only

excludes meat or fish, or someone who occasionally consumes meat or fish. This type of food, however, is not considered vegetarian[31].

Macrobiotic food pattern, not being vegetarian, is based predominantly on plant-origin products. Whole grain is the food base, and it is complemented with vegetables, legumes, algae and vegetable oils. Fish can also be included in this diet, and that is the main difference when compared with vegetarian diet. Meat, eggs and dairy products are at the top of the macrobiotic pyramid, and its consumption should be optional, occasional or merely during a transitional period[34].

In this document, the term "vegetarian" will be used in reference to lacto-ovo, lacto-, ovo-vegetarian, strict vegetarian or vegan food, unless otherwise stated.

It is not known for sure how many vegetarians exist in the world. Yet, estimates indicate that their number is growing every year. Statistics show that in the U.S.A. 7.3 million people may be vegetarian[35], as well as 3.6 million in the United Kingdom[36] and 30.000 in Portugal[37].

Benefits/ risks in a vegetarian diet

Diversity of food patterns is an important characteristic in human culture, and there are many different ways for a human to feed healthily. A healthy diet is one which takes into consideration the individual needs of each person, and it should be sufficient, balanced, diversified and adapted to each situation and circumstance[38].

Vegetarian diet has been thoroughly studied in the past years, namely in the prevention of diseases which are very prevalent in our society. Epidemiologic studies have been documenting important, measurable benefits associated with vegetarian diets and with others based on plant-origin products, such as reduction prevalence of oncologic disease[39-48], obesity[4, 40, 49-53], cardiovascular disease[2, 39, 41, 54, 55], hyperlipidaemias[56-58], hypertension[39, 52, 53, 59, 60], diabetes[5, 39, 42, 52, 53, 61], as well as increased longevity[39, 53, 62].

It is important to mention that a vegetarian diet may be associated with a healthy lifestyle, namely in terms of tobacco[63], alcohol consumption[40, 63], physical activity and leisure[63]. Therefore, it is important to remind that both food and "non-food" aspects bring benefits to health and they may be confused when comparing vegetarian food patterns with other non-vegetarian ones. In any case, quality epidemiologic investigation takes these confounding factors into consideration.

The benefits associated with a vegetarian diet can be justified with a lower consumption of animal-origin products and/ or higher consumption of plant-origin products. On the one hand, excessive consumption of animal-origin products has been connected with increased risk of several types of chronic diseases. On the other hand, food products such as fruit and vegetables, legumes, whole grain and oleaginous fruits have been associated with a lower risk of chronic diseases and longer longevity, which seems, by itself, to bring benefits possibly as or more relevant than the harm caused by excessive consumption of animal-origin products[25].

The adoption of a vegetarian diet does not automatically imply better health. Adequate food choices and a healthy lifestyle are needed, the same happening in a non-vegetarian diet[64]. If badly planned, for example, with nutrient deficit or excess salt or fat, a vegetarian diet can be very harmful to health[25].

The benefits found in scientific literature regarding vegetarian diet should not be seen in light of some isolated food or nutrients, but rather as the result of a constant, diversified and synergetic presence of several plant-origin products, as well as a probable association with a healthy lifestyle.

Food present in a vegetarian diet

In order to be complete and balanced, vegetarian food can include the following food groups:

Fruit

Vegetables

Dairy products or plant-origin alternatives - milk*, vegetable beverages, yoghurt*, cheese* (or its plant-origin alternatives), fermented milk*

Legumes and derivatives, algae - legumes (beans, chick peas, peas, lentils, broad beans), derivatives (tofu, miso), algae

Cereals and tubers - rice, wheat, rye, corn, quinoa, oat and derivative products (bread, toast, biscuits, pastas, cereal flakes) – preferably wholemeal – and potato

Oleaginous fruits e seeds - peanuts, oleaginous fruits (whole nuts, almonds, cashew), oleaginous fruits shortening (peanut and almond butter), seeds (chia, linseed, poppy, sesame)

Fats – vegetable oils, vegetable shortening and butter*

Egg* - egg, egg white, egg yolk, egg products and eggs of other species.

*Not included in vegan diet.

Food choices should privilege local foodstuffs and respect seasonality of plant-origin products, thus helping to preserve environmental and economic sustainability. The adoption of a varied and nutritionally adequate vegetarian diet, using chiefly products of Portuguese traditional diet instead of excessively processed food products, is feasible and desirable.

The designation "suitable for vegetarians" displayed in some processed products does not necessarily imply that they are nutritionally adequate, as they may contain excess added salt, fat or sugar in their composition. The adoption of this information is foreseen in paragraph b, no 3, Article 36, Chapter V, of EU Regulation no 1169/2011[65] and, despite voluntary, it is more and more present in this type of products. Nonetheless, given the inexistence of a settled definition at a European level of what is "vegetarian" or "vegan", it is advisable to carefully read the lists of ingredients in those products.

NUTRITIONAL ADEQUACY IN VEGETARIAN DIET

As long as it is well-planned, a vegetarian diet is healthy, adequate, and may be beneficial for health, namely in prevention and treatment of some diseases[33, 66]. In order to be nutritionally adequate to different cycles of life, level of physical activity and comorbidity, this diet should take into account energy value of food products, macronutrients and micronutrients - vitamins, minerals and trace minerals, as well as its bioavailability.

The most relevant recommendations for a vegetarian diet in terms of acceptable macronutrient distribution ranges, recommended intakes for individuals and tolerable upper intake levels of micronutrients can be consulted in the Appendix at the end of this manual.

It is important to stress the fact that, in nutritional terms, each cycle of life demands special needs. In this manual, the analysis of the nutritional adequacy of vegetarian diet considered a healthy adult, which is the reason why it should not be extrapolated to other phases of cycle of life. Pregnancy, lactation, childhood, adolescence and old age have different nutritional needs, which implies adequate and individualised planning of food intake with clinical monitoring.

A paradigmatic example could be that of feeding until 6 months old where breastfeeding is exclusively recommended. Breastfeeding is still advisable during food diversification process, but, still in vegetarians, breastfeeding should be extended until 2 years of age, so as to guarantee the input of biologic high-value protein, among other nutrients, in this important growth and development phase. Likewise, during this period of life, food diversification in a vegetarian diet must be well-planned, well-executed and well accompanied.

Energy

A vegetarian food pattern, regardless of the age group, does not mean there is an increased energetic input when compared with non-vegetarian diet[64]. Achieving energy needs is, however, essential, in order to achieve macro and micronutrient needs. An adult whose intake is of less than 2.000kcal per day will have difficulties in achieving the recommended daily intake of some vitamins and minerals[67].

In vegetarian diet it is easy to achieve or even exceed adequate energy input, because it includes food with high energy density, namely oleaginous fruits, seeds, vegetable fats, among others[64].

Macronutrients

Protein

Proteins are intra- and extracellular constituents and are part of most biological processes and they have several functions: structural (collagen, actin, myosin), biochemical (enzymes), transporting (haemoglobin), immunological (immunoglobulins), among others[68]. For that reason, adequate protein intake is essential for cellular growth and repair, normal muscle functioning, nervous impulses transmission and immunity function. Proteins can also be used as energy source, despite not being the organism's preferential energy source. That will only occur if the consumed quantity of carbohydrates and fat is insufficient, which could compromise muscle tissue, growth and immunity function[69].

Proteins are nitrogenous substances composed by chains of twenty different amino acids, and these can be considered essential or non-essential[70]. Amino acids are classified as nutritionally essential, not synthesised by the organism, being obtained from diet, or non-essential, synthesised by the organism. Inside the group of non-essential amino acids, cysteine, tyrosine, taurine, glycine, arginine, glutamine and proline, in specific physiological conditions and in some stages of disease, are considered conditionally essential[69].

In comparison with adults, infants and children have more demands regarding both nutritionally essential amino acids and some conditionally essential amino acids.

Classification of amino acids

Nutritionally Essential	Nutritionally Non-essential
Phenylalanine	Aspartate
Histidine	Glutamate
Isoleucine	Alanine
Leucine	Arginine*
Lysine	Asparagine
Methionine	Cysteine *
Threonine	Glycine*
Tryptophan	Glutamine*
Valine	Proline*
	Serine
	Tyrosine*

* Conditionally essential[69]

Protein quality is determined by two factors: contents in amino acids and digestibility, not disregarding its bioavailability.

Contents in amino acids

Food with high content in essential amino acids is considered of high biological value. Among these are included some animal-origin foodstuffs (such as meat, fish, dairy products and eggs) and plant-origin products (such as soy, quinoa and amaranth). Proteins in different plant-origin food are composed by all essential amino acids; however, the quantity of one or two amino acids may be low/ limiting. Cereals, for example (especially wheat), are particularly limited in their content of lysine and threonine, and vegetables present low quantity of sulphur amino acids (methionine, cysteine). In a vegetarian diet, diversified plant-origin food products allow to easily achieve protein and amino acids recommendations through the complementarity of their amino acids[69, 71].

When ingested isolated, plant-origin food can achieve protein and amino acid needs, provided that a sufficient quantity of the food is ingested. The lower the protein quality of the ingested food, the more quantity thereof will the individual need to ingest in order to achieve amino acid needs[69, 71].

There is no need to, in one single meal, achieve all the needs of essential amino acids, nor arrange food combinations to assure adequate protein intake, given that the organism stores a pool of amino acids, provided that energy and protein needs are achieved during the day[69, 71]. These essential amino acids accumulate themselves in their free form in the intracellular musculoskeletal space, and are also synthesised by the intestinal microbiota, compensating meals which are less rich in essential amino acids[71, 72].

Digestibility

Protein digestibility of food in a vegetarian diet is usually lower than that of food in a non-vegetarian diet (85% vs 95%). This difference is justified essentially with the role played by the plant cell wall, which, if removed, allows a digestibility similar to that of animal-origin foodstuffs, the same happening to the isolated protein of soy or peas, wheat gluten or wheat flour (>90% digestibility). Whole millet, beans, and some breakfast cereals have lower digestibility, which can go from 50 to 80%[71]. Soaking, peeling and germinating legumes increases their protein

digestibility. Cooking with a pressure pot, compared with the traditional method, is the most effective way of increasing protein digestibility[73].

Anti-nutritional factors usually present in food can compromise their protein digestibility, namely fibre, phytates in cereals, tannins in legumes and cereals, and trypsin inhibitors and hemagglutinins in legumes. Food processing may also interfere with protein digestibility, once it can originate anti-nutritional factors, such as compounds deriving from Maillard and lisinoalanine reactions [71, 74].

The quality of a specific food protein can be determined by Protein Digestibility- Corrected Amino Acid Score (PDCAAS), which assesses protein quality based on its amino acid composition and digestibility[69, 71]. The majority of animal-origin protein (including eggs and milk) and soy protein have a PDCAAS value near or equal to 1.0 (the maximum score), but scores for other plant-origin proteins are usually lower. However, a combination of plant-origin proteins and adequate energy consumption provides sufficient amino acids to achieve protein needs[69].

By consuming adequate quantity and variety of cereals and legume and achieving energy needs, protein quality will be assured, being similar to that of meat[75, 76] . For this reason, consumption of a mix of several foodstuffs (between legumes and cereals, for example), provides all essential amino acids[64] and these do not even have to be ingested in the same meal[7, 69, 75], except in children, for whom the intake of complementary food in the same meal is recommended[71].

Scientific publications do not demonstrate a risk increase in protein deficiency[75], which is why today's evidence does not support the existence of different recommendations for vegetarians, when compared with non-vegetarians[69, 76].

Alike what happens with non-vegetarians, protein deficiency can occur when energy needs are not achieved, or when ingested calories come mainly from high energy density food or low nutritional density food[33].

Food sources: legumes, soy-based products, whole grain, pseudocereals (quinoa, amaranth and buckwheat), oleaginous fruits, seeds, dairy products and eggs.

Fat

Fat represents the largest form to storage energy in the organism, due to its high energy density (9 Kcal/g). Fats are important constituents in cellular structure and, from a metabolic standpoint,

they participate in several essential mechanisms, also being carriers of liposoluble vitamins. In a diet, lipids should correspond to between 30% and 35% of total energy value, and these can be triglycerides, phospholipids, or steroids[68].

In the context of a healthy diet, fats coming from different foodstuffs are essential to good functioning of the organism and, when consumed in recommended doses, they are well tolerated and have beneficial effects[77]. It should be stressed that the type of consumed fatty acids is more important than the quantity of ingested fat[61].

Vegetarian food pattern usually includes a lower quantity of total fat and saturated fat comparatively with non-vegetarian pattern. Given the restriction of animal-origin products, saturated fats consumption is diminished, being fatty monounsaturated acids consumption similar. On the other hand, consumption of vegetable oils, oleaginous fruits and seeds promote an increased ingestion of polyunsaturated fatty acids[31, 64, 71].

Food sources: vegetable oils and shortenings, oleaginous fruits, seeds.

Essential Fatty Acids

Polyunsaturated fatty acids include omega-3 and omega-6, and are necessary for good physiological functioning, including oxygen carrying, energy storage, constitution of cellular membrane, regulation of cellular proliferation and immunity function (including inflammation). Animals, including human beings, are incapable of synthesising omega-3 and omega-6 fatty acids, which is why they are denominated essential fatty acids. However, human organism can convert alfa-linoleic acid (ALA; 18:3n-3) into eicosapentaenoic acid (EPA; 20:5n-3), which, in its turn, is converted into docosahexaenoic acid (DHA; 22:6n-3). Linoleic acid (LA; 18:2n-6) is converted into arachidonic acid (AA; 20:4n-6). It is important to mention that the conversion of ALA and LA is low, varying between 1% and 10%, taking into account polymorphisms in the gene of the enzyme responsible for the conversion (fatty acids desaturase) and the ratio omega 6:omega 3 of the diet, given that both compete for the same enzymes[33, 78]. Inadequate nutritional intake of protein, vitamins and minerals, and excess consumption of trans fatty acids, alcohol and caffeine compromise that conversion[78]. Excess linoleic acid intake may compromise conversion of ALA into EPA and DHA, which contributes to production of pro-inflammatory eicosanoids and increase of LDL (low-density lipoproteins) oxidation[71].

Whereas ALA consumption is similar between vegetarians and non-vegetarians, LA consumption tends to be higher in vegetarian population[78]. EPA and DHA are limited in lacto-ovo vegetarian diets, and are almost inexistent in vegan diets[64, 72]. However, some plant-origin foodstuffs,

namely fortified ones, may compensate omega 3 needs, being algae/microalgae sources of EPA and DHA[79], and seeds and linseed oils, chia and hemp, soy (and soy oil), and whole nuts are sources of ALA[33, 64, 75, 79]. Purslane, *Portulaca aleracea*, is also an excellent source of ALA, being the plants with higher known content of this essential fatty acid, about 400mg per 100g of product (about 40% of an adult's Recommended Daily Intake)[76, 80, 81].

In some cases, like pregnancy or lactation, intake of DHA-fortified foodstuffs and/ or supplementation (from microalgae) is recommended[7].

Vegetarians usually consume lower EPA and DHA quantities than non-vegetarians, also presenting lower, though stable, serum values. There is no evidence that vegetarians present nutritional deficits concerning these fatty acids, nor adverse effects resulting from its low consumption[7].

It is important to ensure an adequate omega 6:omega 3 ratio, which should be from 2:1 to 4:1. However, some vegetarians present a diminished omega-3 consumption, so this ratio does not apply. Food like flax seeds and its oil contribute to a better n-6:n-3 balance, given that the proportion is of about 1:5. One tablespoonful of ground lax seeds provides between 1,9 and 2,2g of n-3[75].

Those following a vegetarian food pattern should privilege monounsaturated fats consumption (such as olive oil) and avoid consumption of hydrogenated and trans fats present in processed food[78].

Food sources: algae, microalgae, seeds and linseed oils, chia and hemp, soy (and soy oil), whole nuts and purslane.

Carbohydrates

There are no increased carbohydrates needs in vegetarian population. Vegetarians usually consume carbohydrates quantities similar to those of non-vegetarians[31, 64]. Regarding fibre, and given the higher consumption of fruit, vegetables and legumes, vegetarians usually consume a higher quantity than non-vegetarians[64].

Food sources: cereals and derivatives, tubers, legumes and fruit.

Vitamins

Vitamin B12

Vitamin B12 (cobalamin) is an essential vitamin for DNA (deoxyribonucleic acid) synthesis and for the maintenance of the integrity of myelin in nerve cells. All vitamin B12 is synthesised by microorganisms, bacteria, fungi and algae. Plants and animals do not have the ability to synthesise it; animals acquire it through food intake or production of intestinal microbiota. Plant-origin products rarely contain this vitamin.

It is estimated that about 1 µg of cobalamin is excreted daily by bile, which corresponds to about 0,1 to 0,2% of the body reserves (2500 µg). About 65 to 75% of vitamin B12 excreted in bile is reabsorbed, as a result of an extremely efficient enterohepatic circulation mechanism. This explains why, at times, depletion of body reserves comes about only after years after the beginning of a diet poor in this vitamin. Nonetheless, it is important to stress that, in some individuals, deficiency symptoms can arise after two to five years after the beginning of a diet which does not include sources of this vitamin[71, 82]. Vitamin B12 deficiency can result in megaloblastic anaemia, diminishing cellular division and neurological alterations, including dementia[71, 82-84].

Vegetarian food pattern is usually rich in folic acid, which may mask anaemia caused by vitamin B12 deficiency, and that condition might be revealed only with the appearance of neurological symptoms[79, 83], such as paraesthesia, diminishing peripheral sensitiveness, difficulty in walking and loss of concentration, and these symptoms may be irreversible[75, 83]. Haematological indicators, such as alterations in serum levels of holotranscobalamin II[83], methylmalonic acid (serum and urinary) and homocysteine[79, 82-84], tend to appear later[75]. The determination of these markers should be regular, so as to allow precocious intervention, if necessary[83]. Homocysteine levels can be high due to deficiency in folates and vitamin B6, even though these are rare in vegetarians[83].

Vegetarian population may be at risk of vitamin B12 deficiency, given that consumption of this vitamin is usually low, and because its active form is only present in animal-origin and fortified foodstuffs[64]. Lacto-ovo vegetarian food pattern can provide this vitamin thorough eggs and dairy products[64, 84]; however, and even so, its intake might not be enough[75]. Vegan population, however, will not have any significant source of this vitamin in their diet in a natural manner, so they will need to ingest fortified food and/ or supplements, in order to prevent deficiency[83]. Fortified foodstuffs, such as vegetarian alternatives to meat, yeast extract, vegetable beverages,

breakfast cereals and/ or supplements are suitable for both patterns since the moment of their adoption[7, 83, 84].

The elderly can also benefit from vitamin B12 supplementation, due to diminishing gastric acidity and proteases which, consequently, diminish their absorption[7, 33]. Supplementation is also recommended for children, pregnant women and infants, as well as for individuals who chronically take proton pump inhibitors[75, 79].

Algae are sometimes mentioned as food alternatives rich in vitamin B12. However, they have inactive analogues of this vitamin, and should not be used as vitamin B12 sources, as they can actually interfere with its absorption[7, 64, 71].

In many of the so-called "rich in vitamin B12" foodstuffs, between 5% and 30% of this vitamin is present in the form of low bioavailability analogues, and in some cases it is totally in its inactive form[71]. For this reason, additional care is needed when selecting food sources and supplements for this vitamin.

To meet the needs regarding this vitamin, the following is necessary:

- consuming 2 portions of fortified foodstuffs supplying 1,5 to 2,5 micrograms of B12 each, or;

- taking supplement with 5 to 10 micrograms of B12 daily, or;

- taking supplement with 1.000 micrograms of vitamin B12 three times a week[70] or 2.000 micrograms once a week[71, 82].

Given that only a small quantity of vitamin B12 is absorbed at one time, some hold that it is preferable to take divided small doses of vitamin B12 (higher frequency), than taking larger quantities[70, 83].

The objective of vitamin B12 supplementation should not be directed only to deficiency treatment, but, above all, to maintenance of body reserves[82].

Food sources: dairy products, eggs and fortified foodstuffs, such as vegetarian alternatives to meat, yeast extract, vegetable beverages and breakfast cereals.

Vitamin D

Vitamin D is a liposoluble vitamin obtained from sun exposure, diet and/ or food supplements. Some foodstuffs may contain vitamin D, naturally or through fortification[85]. Vitamin D2 (ergocalciferol) is produced through ultraviolet irradiation of yeast ergosterol, and vitamin D3 through ultraviolet irradiation of lanolin 7-dehydrocholesterol[85]. Vitamin D2 currently seems to be effective in maintenance of 25-hydroxyvitamin D serum levels[79].

Vitamin D is directly related to bone mineral density and increases efficacy of calcium intestinal absorption (30 to 40%) and phosphorus (approximately in 80%). Besides its classical function in phosphor-calcium metabolism, vitamin D regulates muscular, immunity and cardiovascular systems. Skeletal muscles have a vitamin D receptor, being that vitamin necessary for its performance and, in addition, deficiency in that vitamin can cause pain and muscular weakness. Also brain, prostate, breast and colon, as well as immunity cells, have receptors of this vitamin and respond to 1,25-dihydroxyvitamina D, the active form of vitamin D[85, 86].

Directly or indirectly, 1,25-dihydroxyvitamina D controls more than 200 genes, including genes responsible for cellular proliferation regulation, differentiation, apoptosis and angiogenesis[85].

There are several causes leading to vitamin D deficiency, namely synthesis reduction by the skin, absorption reduction and acquired or hereditary diseases of this vitamin's metabolism. Non-diagnosed presence of vitamin D deficiency is common. Determination of serum dosage of 25-hydroxyvitamin D is a good indicator of vitamin status[85].

In some conditions, vitamin D can be endogenously synthesised in sufficient quantities. Solar exposure (UVB radiation) of arms and legs for 5 to 30 minutes between 10 a.m. and 3 p.m., twice a week (Spring and Summer) may be enough to achieve the needs. Nonetheless, produced amount relies on factors such as duration of sun exposure, exposed skin surface, time of day, season of the year, latitude of place, cutaneous pigmentation, atmospheric pollution, use of sun screen and age of individual (due to dermic synthesis diminishing and lower expression of vitamin D receptors). This ensemble of factors makes synthesis capacity of this vitamin potentially insufficient in Autumn and Winter months in countries such as Portugal[70, 79, 85].

Vitamin D recommendations are usually achieved neither by vegetarian nor by non-vegetarian population[7, 33, 64]. Some food products such as milk, vegetable beverages and margarine,

breakfast cereals and bread are fortified in this vitamin, generally in the form of ergocalciferol[33, 79].

Supplementation in vitamin D with 5 to 10 micrograms a day is safe and adequate, according to some authors, both for vegetarians and non-vegetarians. Vitamin D3 supplements are usually of animal-origin. However, lately there have been new cholecalciferol supplements produced through lichens and mushrooms exposed to ultraviolet radiation. Vitamin D2 supplements are of plant origin[64].

Hence, vitamin D supplementation or consumption of fortified foodstuffs with this vitamin are recommended in some situations, especially in Winter[7, 33, 64, 79].

Food sources: fortified food products such as milk, vegetable beverages and vegetable margarine, breakfast cereals and bread; egg (from algae-fed hens).

Vitamin A

The designation "vitamin A" refers to a group of compounds - retinol, retinaldehyde and retinoic acid – which are essential to vision, growth, cellular differentiation and proliferation, reproduction and immune system integrity. Vitamin A, in the form of retinol, is found in animal-origin foodstuffs and in some fortified foodstuffs such as vegetable shortening and breakfast cereals[71]. In order to meet this vitamin's needs, vegetarian population should consume foodstuffs rich in pro-vitamin A (betacarotene), such as fruit and green, orange and yellow vegetables[76]. Consumption of retinol equivalents, such as carotenoids, is increased in vegetarian diet[64], although in diets with very low fat levels absorption of carotenoids may be compromised because they are liposoluble[71].

Food sources: fruit and vegetables; fortified plant-origin shortening.

Remaining vitamins

Ingestion of vitamin E, vitamin K, vitamin C, folates, riboflavin and thiamine in vegetarians is usually adequate[64, 71].

Minerals and Trace minerals

Iron

Iron is an essential nutrient for health, participating in the formation of haemoglobin and myoglobin in electron transport chain at mitochondrial level, enzyme production, among other functions. A major part of our needs in iron is assured by iron turnover in blood. Iron reserves are regulated through intestinal absorption, given that we have limited capacity to excrete its excess[87].

When iron needs are not achieved, this mineral's reserves start to diminish. When reserves run out, iron serum levels decrease and haemoglobin production decreases, which could result in anaemia caused by iron deficiency. Another indicator of low iron levels could be the increase of transferrin levels[71].

According to World Health Organisation[88], iron deficiency is the most common nutritional deficiency in the world (vegetarian and non-vegetarian population)[31, 33, 75, 79], affecting about 25% of global population, particularly women and children, being followers of a very restrictive vegetarian diet those who are at greater risk[87]. In general, iron consumption seems to be similar or higher in vegetarians, when compared with non-vegetarians. However, there is no consensus among the several studies[64, 71, 79].

Although vegetarian adults possess lower iron reserves than those of non-vegetarians, ferritin serum levels (iron reserve protein whose levels reflect bodily iron reserves) are within normal parameters[84].

Iron available in foodstuffs can be of heme and non-heme type[33, 76, 87]. In animal-origin products, 40% of the existing iron is of heme type, and 60% is non-heme, whereas plant-origin foodstuffs only contain non-heme iron[71, 87]. Heme iron is absorbed by 15% to 35% in the gastrointestinal tract, whereas non-heme iron presents lower absorption, between 2 and 20%[31]. Due to this lower bioavailability, iron Recommended Daily Intake is increased in 80% in vegetarian population[7, 64, 76].

The quantity of absorbed non-heme iron is determined mainly by its reserves. People with low iron reserves or very increased needs (for example, pregnant women) will have a physiological adaptation, increasing absorption and decreasing excretion, making non-heme iron almost as well absorbed as heme iron[31, 64, 79, 87].

The following foodstuffs are rich in iron: legumes, fortified breakfast cereals, whole grain, tofu, dark green vegetables, seeds, oleaginous fruits and tempeh[33, 87]. For lacto-ovo vegetarian pattern eggs are also an iron source[87].

Non-heme iron bioavailability is influenced by several diet components, which can increase or diminish its absorption, in which case, inhibiting and potentiating factors can annul each other in diets where a great variety of foodstuffs is included[79, 87].

Non-heme absorption may be diminished due to factors like calcium, phytate and polyphenols (tannins and catechins) present in tea, coffee, spices (saffron, chili) and cocoa, reduction of gastric acidity and increased inflammatory conditions[31, 79, 84, 87]. Ingestion of fibre *per se*, even if in high quantities, has very reduced interference in absorption of minerals in the diet. The inhibiting effect of iron absorption is due to the presence of phytates and not the presence of fibre, an effect which can be minimised with the adoption of culinary methods[31]. Inhibiting action of oxalic acid in iron absorption is currently considered marginal[87]. Calcium, which is considered an inhibitor of iron absorption, should not be ingested at meals in the form of a supplement, as this inhibition does not occur if the calcium quantity is lower than 40mg[87]. Low consumption of lysine (an essential amino acid found particularly in legumes) may interfere with iron absorption[70].

Vitamin C is the most important facilitating factor in iron absorption, since it promotes conversion of ferric iron into ferrous iron, which is the best absorbed form. This could originate from diet, or in the form of supplements, being its effect higher than the inhibiting effect of phytate, polyphenol or calcium[87]. About 75mg of vitamin C increases non-heme iron absorption in 3 to 4 times[25]. Also organic acids, fructooligosaccharides, vitamin A and betacarotene stimulate non-heme iron absorption[33, 75, 79].

Soaking and germinating legumes, grain and seeds diminishes phytate content and improves iron absorption[75, 79]. Fermented foodstuffs (such as sauerkraut), soy sauce and old dough bread increase iron absorption[71]. Using old iron pots increases levels of this mineral in food, especially if these are acid or if they boil[33], although its quantification is uncertain[31]. Adding acidifying substances (citrus or vinegar) to food also promotes phytate diminishing[84].

Important – No iron deficiency, whether in vegetarians or non-vegetarians, can be corrected exclusively through food. Iron deficiency should be treated with iron using medication, for a prolonged period, and in quantities which are impossible to obtain through food consumption[75].

Food sources: legumes, whole grain, dark green vegetables, seeds, oleaginous fruits, tofu, tempeh, egg and fortified foodstuffs, such as breakfast cereals.

Zinc

Zinc is necessary for normal growth and development of taste acuity. This mineral is essential for metabolic functions, including catalysing, structural and regulating functions, and it plays an important role in the immunity system[25, 89].

Zinc can be broadly found in animal- and vegetable-origin foodstuffs, although zinc absorption from plant-origin foodstuffs is lower[70].

Vegetarian population usually consumes less zinc than non-vegetarian one. Yet, their plasma levels are not different between the two groups, which suggests the existence of adaptation mechanisms[64, 79, 89]. These optimization mechanisms maintain zinc levels adequate, both by reducing losses, and by increasing absorption efficacy[89]. Even consuming lower zinc quantities, vegetarians present adequate serum levels[71, 89].

In literature there is no clinical evidence on zinc deficiency in western vegetarian population[75, 79]. However, in vegans, pregnant women, infants and adolescents, consumption of fortified foodstuffs might be advisable[64].

Zinc bioavailability is compromised by the presence of phytate in plant-origin foodstuffs and, for this reason, zinc needs are increased by 50% in vegetarians[64, 76]. Fibre and calcium, once considered inhibitors of zinc absorption, are presently considered innocuous. Because zinc is present “in the outer layer” of cereals, higher levels of this minerals are found in whole-grain products, although they also present higher phytate levels[89]. Low lysine consumption (an essential amino acid found particularly in legumes) may interfere with zinc absorption[70].

Soaking, germinating and fermenting legumes, grains and seeds, as well as cooking roots (carrot, turnip, beetroot), diminishes phytate content[71]. Sulphur amino acids (found in seeds, oleaginous fruits, cereals and vegetables) and organic acids (such as citric acid found in citruses, malic acid in apples, lactic acid in sour milk and tartaric acid in grapes) connect to zinc and boost its absorption[79, 89].

In vegetarian pattern, bread, cereals, legumes, oleaginous fruits and seeds are zinc food sources and in lacto-ovo vegetarian pattern, eggs and dairy products are also sources of this mineral[33,

[89]. Zinc recommendations may not be achieved if there is little intake of these foodstuffs or fortified foodstuffs, particularly in men, and supplementation may be necessary[71].

Food sources: whole grain and derivatives, legumes, oleaginous fruits, seeds, eggs and dairy products.

Calcium

Calcium is an important mineral in order to maintain bones and teeth healthy, but also to assure normal nervous and muscular function, as well as blood coagulation function[90].

Calcium intake in lacto-ovo vegetarians tends to be similar or higher than that observed in non-vegetarians, whereas those following a vegan pattern present a slightly lower intake, which is why foodstuffs rich in this mineral should be privileged[64, 79, 84].

Some studies suggest that vegetarians can absorb and retain higher quantities of calcium than non-vegetarians, due to adaptation mechanisms, and that they present bone mineral density similar to that of non-vegetarians[84]. Factors such as lifestyle, smoking habits, weight and genetic factors seem to play a more important role in bone mineral density than the quantity of calcium ingested and its origin (animal or plant)[91].

A diet with excessive protein intake is associated with increased glomerular filtration rate and diminished calcium absorption by kidneys, leading to an increase in urinary excretion of this mineral. On the other hand, insufficient protein consumption is also harmful. Excessive sodium consumption is unfavourable, as it increases urinary excretion of calcium. For each gram of ingested sodium, there is an additional loss of 25 mg of calcium in urine[25].

Lacto-ovo vegetarian includes excellent sources of calcium: milk, cheese and yoghurt, being two or three portions a day enough to achieve the needs for this nutrient in most age groups. Those following a vegan pattern can obtain necessary calcium through plant-origin food products[33]. Food such as dark green vegetables, legumes, seeds and oleaginous fruits, and fortified food products such as tofu, vegetable beverages from soy, oats, almonds or rice and breakfast cereals can be calcium sources[33, 79]. Other foodstuffs like beetroot leaves, rhubarb, spinach, chard and amaranth contain calcium, although, due to their content in oxalates, in less bioavailability[33, 79]. Even though it contains phytates and oxalates, soy preserves good bioavailability of calcium[75]. Using less salt (replacing it with herbs, for example) diminishes calcium losses in urine[79].

Maintaining vitamin D adequate levels and limiting consumption of caffeine are beneficial aspects regarding calcium levels maintenance[75, 90].

Food sources: dairy products, dark green vegetables, legumes, seeds and oleaginous fruits; fortified foodstuffs such as tofu, vegetable beverages from soy, oats, almonds or rice and breakfast cereals.

Iodine

Iodine is an essential trace mineral for correct thyroid functioning, namely for synthesis of thyroid hormones. These are responsible for cellular metabolism regulation, namely basal metabolism rate and body temperature, and they play a key role in organ development and growth, especially the brain[92-95]. During pre-conception, pregnancy and breastfeeding the relevance of this mineral is particularly important, given the role it plays in the development of the foetus[70, 95].

Iodine content in plants is variable, but usually low, given that it depends on its concentration in the soils, which is habitually scarce, usually higher in locations on the coast[70, 92] . Those following a vegetarian food pattern who do not consume fortified foodstuffs or supplements might have insufficient consumption of this micronutrient.

In order to contribute to appropriate iodine intake, those who follow a vegetarian diet should have a varied diet, including rich/ fortified foodstuffs in this micronutrients[70]. Algae, iodised salt or supplements should be used regularly[7, 64], being careful not to exceed iodine maximum recommended doses[70].

It is recommended to replace common salt with iodised salt in recommended salt quantities. Given the variability of iodine quantity in algae, precaution in its use is recommended, which should not be higher than 3 to 4 times a week[70].

Food sources: iodised salt, algae and dairy products.

Selenium

Selenium is necessary for selenoproteins functioning. This micronutrient is a component of enzyme glutathione peroxidase, protecting cellular membranes from damage caused by the action of free radicals. It also regulates the action of thyroid hormones[71, 82].

Main selenium food sources which are adequate to a vegetarian food pattern are Brazil nuts, seeds, egg, molasses, mushrooms, cereals and derivatives. Selenium levels are more affected by its quantity in the soil in a specific region than by the food pattern[71]. Vegetarian population usually ingests less selenium quantity; however, its ingestion relies on selenium availability in the soils[64, 76]. Although ingestion is diminished, it usually meets recommendations[64, 76, 96], and plasma levels are similar to those of non-vegetarian population, therefore existing a probable physiological adaptation[64, 76].

Food sources: Brazil nuts, egg, seeds, molasses, mushrooms, cereals and derivatives.

Potassium

Potassium is present in countless foodstuffs and is particularly abundant in fruit and vegetables. It is associated with higher calcium retention in bone, reduction of cardiovascular disease risk and it is vital in regulating blood pressure[71]. Vegetarian diet frequently provides more potassium than non-vegetarian one[64].

Food sources: fruit, vegetables, tubers, legumes and oleaginous fruits.

Magnesium

Magnesium plays an important role in several functions in the organism, including enzymatic activation and bone homeostasis. It can be found, for example, in the outer layer of whole grain cereals. Vegetarian diet usually included more magnesium than non-vegetarian. Fibre and phytates can diminish its absorption, but it maintains itself adequate comparatively with a non-vegetarian diet. Thus, high magnesium level found in vegetarian diets compensates its lower bioavailability[71].

Food sources: whole grain and derivatives (for example, breakfast cereals), algae, legumes, oleaginous fruits and seeds.

Phosphorus

Phosphorus has several functions with high physiological importance, such as bone and dental mineralisation, energetic metabolism, nutrient absorption and transport, regulation of protein

activity and base-acid balance. It is also a constituent of structural phospholipids of cellular membranes, of nucleic acids and ATP (adenosine triphosphate) molecules[82].

Approximately 85% of body phosphorus is located in the bone, being essential for its development and maintenance. In a vegetarian diet, phosphorus absorption is lower than in non-vegetarian diet, due to higher phytates quantity. Phosphorus absorption may be compromised by use of anti-acids with aluminium and calcium supplements (calcium carbonate). Phosphorus intake is similar or higher in vegetarians than in non-vegetarians and, despite bioavailability being potentially lower, it is considerably higher than that recommended, being occurrence of deficiency very unlikely[71].

Food sources: dairy products, whole grain, eggs, oleaginous fruits and legumes.

Sodium

Sodium has functions in extracellular volume regulation and base-acid balance, being salt its major source[71]. Excessive salt consumption and, consequently, sodium consumption, is related with blood pressure increase and renal calcium excretion. In vegetarians, sodium consumption is usually lower when compared with non-vegetarians[97], being it possible that vegans consume less than half of the amount observed in non-vegetarians[98]. Only a minor amount of consumed sodium (about 10%) comes naturally from foodstuffs, being salt added to food processing or confection that contributes the most for the daily intake of this mineral[71]. Labels on processed food should be carefully read, as many vegetarian-suitable products may contain excess salt.

Food sources: salt, processed food.

Remaining minerals and trace minerals

Intake of manganese, chlorine, fluorine, and molybdenum is usually adequate in vegetarian individuals[71].

CONCLUDING REMARKS

There has been an increasing number of vegetarian and non-vegetarian individuals who are interested in adopting vegetarian meals, for varied reasons ranging from health to environmental protection.

Portugal has a varied production of high-quality plant-origin food all year round, as well as a gastronomic tradition which values the presence of vegetables, starting with soup.

The adoption and maintenance of a vegetarian diet, and, in particular, a vegan diet, demands a minimum specific knowledge in terms of food and nutrition, which, despite simple, is not intuitive.

When appropriately planned, vegetarian diets, including lacto-ovo vegetarian or vegan, are healthy and nutritionally adequate for all cycles of life, and they can be useful in prevention and treatment of some chronic diseases. However, as in any food pattern, vegetarian diets may be inadequate.

Regarding protein, although it is possible to assure an adequate amino acid profile to the needs of most people following a vegan diet, to obtain this profile there has to be a very careful selection of foodstuffs, which may prove difficult for most consumers. As examples of high biological value sources of protein, three foodstuffs are presented in this text: soy, quinoa and amaranth, which could create higher risk in terms of food monotony, as the combinations of food products which improve the biological value of the ingested protein might not be obvious to the consumer.

Attention should be given to adequacy of energy intake, as well as of some micronutrients, namely vitamin B12, vitamin D, calcium, zinc, iron, iodine and essential fatty acids. Vegetarians should be informed and encouraged to consume foodstuffs which contain these ingredients. Food should be the primary option to achieve nutritional needs and, especially in vulnerable groups, it might be necessary to recommend fortified food and/ or supplements, as a complement to food. Supplements should not be used as a substitute for a varied, balanced diet. However, in the case of vitamin B12, and given the inexistence of nutritional sources in a vegan diet, it should be obtained through enrichened food or supplements. It is prudent that vegetarians preventatively do B12 vitamin supplementation, especially during pregnancy and lactation.

As in any food pattern, the need for tools of support which allow safe choices for those who intend to follow a vegetarian diet is a reality.

This knowledge is more necessary in specific phases of the cycle of life, such as during infancy or pregnancy, or in individuals with special food necessities (for example, in the cases of allergies, chronic disease or athletes).

Because there is not just one single food pattern characterising the vegetarian diet (in fact, several patterns are identified), and adequate attention being necessary alongside the cycle of life, health professionals and all those who provide food care or advise populations on healthy eating habits should grasp a minimum set of competences described in this manual.

This manual, which intends to be the first of other documents with pedagogical character in the area of vegetarian food, suggests that it is possible to adopt a vegetarian food pattern using plant-origin products of national origin, seasonal and within our culinary tradition. It also suggests that it is possible and desirable to join variety, flavour, tradition and health at the dining table.

Lastly, following a vegetarian diet does not imply, *per se*, improved health. More and better health depends on the choice of a healthy lifestyle, where food is but one of the different choices.

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APPENDICES

TABLE 1 – Summary of Acceptable Macronutrient Distribution Ranges

Acceptable Macronutrient Distribution Ranges[a]					
	Fat	**Omega-3 fatty acids**	**Omega-6 fatty acids**	**Carbohydrates**	**Protein**
Children					
1 to 3 years old	30 - 40	0,6 - 1,2	5 – 10	45 - 65	5 – 20
4 to 18 years old	25 - 35	0,6 - 1,2	5 – 10	45 - 65	10 – 30
Adults					
(+) 18 years old	20 – 35	0,6 - 1,2	5 - 10	45 - 65	10 - 35

[a] (in % of total energetic value)

Adapted from Dietary Reference Intakes for Energy, Carbohydrate, Fibre, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients)[(76)].

TABLE 2 – Summary of Recommended Intakes for Individuals

Recommended Intakes for Individuals													
	Calcium (mg/d)	Iodide (µg/d)	Iron (mg/d)	Magnesium (mg/d)	Phosphurus (mg/d)	Selenium (µg/d)	Zinc (mg/d)	Potassium (g/d)	α-Linoleic Acid (g/d)	Vitamin A (µg/d)	Vitamin D (µg/d)	Vitamin B12 (µg/d)	Sodium (g/d)
Children													
0 to 6 months	200	110	0,27	30	100	15	2	0,4	0,5	400	10	0,4	0,12
7 to 12 months	260	130	11	75	275	20	3	0,7	0,5	500	10	0,5	0,37
1 to 3 years old	700	90	7	80	460	20	3	3,0	0,7	300	15	0,9	1
4 to 8 years old	1000	90	10	130	500	30	5	3,8	0,9	400	15	1,2	1,2
Men													
9 to 13 years old	1300	120	8	240	1250	40	8	4,5	1,2	600	15	1,8	1,5
14 to 18 years old	1300	150	11	410	1250	55	11	4,7	1,6	900	15	2,4	1,5
19 to 30 years old	1000	150	8	400	700	55	11	4,7	1,6	900	15	2,4	1,5
31 to 50 years old	1000	150	8	420	700	55	11	4,7	1,6	900	15	2,4	1,5
51 to 70 years old	1000	150	8	420	700	55	11	4,7	1,6	900	15	2,4	1,3
(+) 70 years old	1200	150	8	420	700	55	11	4,7	1,6	900	20	2,4	1,2
Women													
9 to 13 years old	1300	120	8	240	1250	40	8	4,5	1,0	600	15	1,8	1,5
14 to 18 years old	1300	150	15	360	1250	55	9	4,7	1,1	700	15	2,4	1,5
19 to 30 years old	1000	150	18	310	700	55	8	4,7	1,1	700	15	2,4	1,5
31 to 50 years old	1000	150	18	320	700	55	8	4,7	1,1	700	15	2,4	1,5
51 to 70 years old	1200	150	8	320	700	55	8	4,7	1,1	700	15	2,4	1,3
(+) 70 years old	1200	150	8	320	700	55	8	4,7	1,1	700	20	2,4	1,2
Pregnancy													
14 to 18 years old	1300	220	27	400	1250	60	12	4,7	1,4	750	15	2,6	1,5
19 to 30 years old	1000	220	27	350	700	60	11	4,7	1,4	770	15	2,6	1,5
31 to 50 years old	1000	220	27	360	700	60	11	4,7	1,4	770	15	2,6	1,5
Lactation													
14 to 18 years old	1300	290	10	360	1250	70	13	5,1	1,3	1200	15	2,8	1,5
19 to 30 years old	1000	290	9	310	700	70	12	5,1	1,3	1300	15	2,8	1,5
31 to 50 years old	1000	290	9	320	700	70	12	5,1	1,3	1300	15	2,8	1,5

Note: Recommended intake for iron in vegetarians is 80% higher than that of non-vegetarians, as well as the needs for zinc, which are increased in 50%.

Adapted from *Dietary Reference Intakes for Energy, Carbohydrate, Fibre, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients)*[76] and *Dietary Reference Intakes for Calcium and Vitamin D*[99].

TABLE 3 – Summary of Tolerable Upper Intake Levels

Tolerable Upper Intake Levels													
	Calcium (mg/d)	Iodine (µg/d)	Iron (mg/d)	Magnesium (mg/d)	Phosphorus (g/d)	Selenium (µg/d)	Zinc (mg/d)	Potassium (g/d)	α-Linolenic Acid (g/d)	Vitamin A (µg/d)	Vitamin D (µg/d)	Vitamin B12 (µg/d)	Sodium (g/d)
Children													
0 to 6 months	1000	-	40	-	-	45	4	-	-	600	25	-	-
7 to 12 months	1500	-	40	-	-	60	5	-	-	600	38	-	-
1 to 3 years old	2500	200	40	65	3	90	7	-	-	600	63	-	1,5
4 to 8 years old	2500	300	40	110	3	150	12	-	-	900	75	-	1,9
Men and Women													
9 to 13 years old	3000	600	40	350	4	280	23	-	-	1700	100	-	2,2
14 to 18 years old	3000	900	45	350	4	400	34	-	-	2800	100	-	2,3
19 to 30 years old	2500	1100	45	350	4	400	40	-	-	3000	100	-	2,3
31 to 50 years old	2500	1100	45	350	4	400	40	-	-	3000	100	-	2,3
51 to 70 years old	2000	1100	45	350	4	400	40	-	-	3000	100	-	2,3
(+) 70 years old	2000	1100	45	350	3	400	40	-	-	3000	100	-	2,3
Pregnancy													
14 to 18 years old	3000	900	45	350	3,5	400	34	-	-	2800	100	-	2,3
19 to 50 years old	2500	1100	45	350	3,5	400	40	-	-	3000	100	-	2,3
Lactation													
14 to 18 years old	3000	900	45	350	4	400	34	-	-	2800	100	-	2,3
19 to 50 years old	2500	1100	45	350	4	400	40	-	-	3000	100	-	2,3

Adapted from *Dietary Reference Intakes for Energy, Carbohydrate, Fibre, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients)*[76] and *Dietary Reference Intakes for Calcium and Vitamin D*[99].

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