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MDPI

*Entry*

# Mediterranean Diet, a Sustainable Cultural Asset

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**Definition:** The Mediterranean diet is a dietary pattern and associated lifestyle that adopts mainly plant foods. The Mediterranean diet (MD) has been acknowledged by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as an intangible cultural heritage of humanity since 2013, a candidacy involving seven countries in the area, including Portugal, aiming to safeguard the MD in its multiple dimensions. The corresponding food system is recognized as healthy and sustainable by the Food and Agriculture Organization of the United Nations (FAO) and by the World Health Organization (WHO), inspiring dietary guidelines around the world. The current entry examines the sustainability and resilience of the Mediterranean dietary food pattern, using the Portuguese as a case study to examine the feasibility of prospective composite indicators in assessing the sustainability of diets and food systems. Information extracted from reports and official statistics was used to assess a set of proposed metrics. Although information to fulfil most metrics was found, some data gaps were identified, highlighting the need to improve existing metrics. The current work highlights the role of science and policy in transforming four key areas of human–nature interaction: use of natural resources, food systems, production and consumption, and cities' sustainability. Since sustainable production and consumption (SGD 12) is key to the UN's 2030 agenda, it is important to analyze to what extent the dissemination of the Mediterranean diet among the population can be a way to achieve this goal.

**Keywords:** Mediterranean diet; sustainability; agriculture; health; environment; agri-biodiversity; cultural asset



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## 1. Introduction

The Mediterranean diet is much more than a food pattern and certainly not a restrictive food intake regimen. In the Mediterranean diet's concept, "food" is one piece of a large mosaic involving strong bonds to nature (sustainable agriculture, seasonality, agri-biodiversity), social features (e.g., communal festivities related to harvest seasons and religions), landscape (combining the works of humans and nature, as can be seen in geoparks of the area), architecture (use of locally sourced stones, whitewash, ceramic tiles), history (birthplace of important civilizations), art (music, crafts), and more.

The Mediterranean diet (MD) is defined, in its broad sense, by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as involving "*a set of skills, knowledge, rituals, symbols and traditions concerning crops, harvesting, fishing, animal husbandry, conservation, processing, cooking, and particularly the sharing and consumption of food. Eating together is the foundation of the cultural identity and continuity of communities throughout the Mediterranean basin*" [1].

Bach-Faig and colleagues [2] described the MD as a dietary pattern and associated lifestyle that adopts mainly plant foods. It is rich in fruits, vegetables, bread, pasta, rice, couscous, and other cereals, as well as olives, nuts, seeds, herbs, spices, garlic, onions,

legumes, potatoes, and more. Olive oil is the main fat, and 'biodiversity' and seasonality define this dietary pattern, which embraces a wide variety of plant foods of local origin and their seasonal character. This high agri-biodiversity mostly results from the adaptation of plants brought from different geographical locations that became indigenous and further diverged into cultivars. In the cuisine, this multitude of locally available ingredients [3] translates into varied textures, flavors, and colors, according to regional traits and preferences. Some people might believe these regional variations constitute different food habits, but they actually share the same principles and pillars and are hence facets of the Mediterranean diet [1–4]. In other words, such food habits share well-acknowledged features across their territories of origin, together forming the big picture of the Mediterranean diet [2,4–6]. Its diversity consists of enjoyable and affordable healthy dishes, which are quick and easy to prepare with local and seasonal ingredients, and which also help to strengthen social ties [7].

In short, the Mediterranean diet, as defined by UNESCO, encompasses a lifestyle that goes beyond a mere diet [4,6,7], and it is acknowledged by international organizations as beneficial to human health and the environment [6,8–10]. High adherence scores to this dietary pattern have been shown to significantly improve the nutritional and health status of populations [11–16], while causing low impacts on the environment [17–20] and even contributing to the safeguarding of agri-biodiversity [21–23].

This valuable food pattern has been continuously threatened, directly and indirectly, by the vulgarization of ultra-processed foods, by consumers' misinformation, and by the still insufficient actions to ensure safe and sustainable food for all, as stated in the second sustainable development goal (SDG 2) [24]. However, since food systems are complex, cross multiple SDGs, and affect us all, in 2020 and 2021, action tracks were identified and commitments were made to raise awareness of existing sustainable dietary patterns, such as the MD [6,25], and to underpin policies with science [25–28].

Efforts to safeguard the MD in Portugal and to improve its adherence scores have been acknowledged; hence, Portugal is herein taken as a case study for the baseline period of 2015–2016.

This entry starts by introducing the historical context and the main features of the Mediterranean diet. Special attention was paid to the characterization of the baseline because of its relevance in assessing the effectiveness of policies and actions to comply with the UN, European community (EC), and national agendas with respect to sustainable food systems. The prospective use of a composite indicator combining data from different sources is herein considered for the baseline period, and finally, we analyzes and discusses the advantages and limitations of the selected metrics in assessing the economic and social sustainability, nutritional aspects, and ecological footprint of the MD in Portugal.

With the present work, we aim to contribute to the discussions on how to assess the implementation of sustainable diets and supporting food systems, now and in the future.

## 2. History

### *2.1. From the Agricultural Revolution to the Inter-Continental Maritime Routes*

By the Neolithic epoch, European agricultural techniques diverged: in northern Europe, with cold winters and warm summers, the melted snow from the mountains was enough to keep the large valleys watered and fertile during the warm summers. Cattle was a valuable resource to these populations that wisely used milk, meat, leather, and even blood. The genetic evolution that allowed humans to use lactose (a sugar present in ruminants' milk) was crucial for population growth, and milk and dairy became important sources of protein and vitamin D. In these northern regions, the short summer with long daylight periods allowed the growth of enough cereals (namely barley and rye) to prepare bread for humans, and silage to feed the cattle during the long cold winters.

In the south of Europe, peoples were apparently blessed with a milder climate. However, the irregularity of the terrain and the scarcity of water proved otherwise, as valleys with abundant freshwater are rare in southern Europe and the Maghreb. Mediterranean

peoples adapted to this environment by intuitively selecting robust crops and trees with low water needs. Crop rotation, mixed cultures, and other sustainable agricultural practices aimed at making the best use over time of every patch of fertile soil, including on steep hills, among rocks, or near brackish wetlands (e.g., large estuaries, marshes). Instead of horses and cattle, Mediterranean peoples preferred donkeys and small ruminants (such as goats and sheep), which are less demanding in water and feed, which they find on their own.

The wise use of natural resources and a zero-waste culture was the rule everywhere, but these two approaches to agriculture in the early times of European civilizations were probably at the root of the divergent northern and southern lifestyles and of later constraints to economic growth in the Mediterranean regions: the northern peoples, more prone to standardization and massive production vs. the southern peoples, more resourceful, resilient, and able to take advantage of biodiversity.

Going back in time, over many centuries, the mild climate, high biodiversity, and advances in food preservation techniques decreased food insecurity, allowing the necessary population growth and prosperity for the onset of the civilizations that are at the root of western culture, notably the ancient Greek and Roman civilizations. Ancient Greeks developed democracy, philosophy, mathematics, and other sciences, as well as arts. They established the link between mind and body, and Hippocrates, the father of medicine, first separated the discipline of medicine from religion, arguing that disease was not a punishment from the gods but rather caused by environmental factors, diet, and living habits. The phrases "*Let food be your medicine, and medicine be your food*" and "*Walking is man's best medicine*" are attributed to him, and his arguments are in line with the Greek word "diaita", encompassing diet and lifestyle, which best describes the Mediterranean Diet concept [7].

In turn, the Roman Empire dominated the Mediterranean Basin and its surroundings for centuries. It was the most extensive political and social structure in western civilization, and its lasting contributions are found in virtually every aspect of western culture. The Romans standardized food habits in all their provinces, ensuring food availability throughout the year by developing and improving food preservation methods, such as drying fruits, fermenting olives, and improving cheesemaking. Fresh meat and fish were less common, but their preserves were appreciated delicacies, for example, "garum" (fish preserve), *chouriço*/*chorizo*, ham/*prosciutto*, and salami (meat preserves). The Romans also introduced fish farming, in brackish water tanks. Food supplies were carefully controlled by the state and, in times of peace, wide access to cereals, pulses, olive oil, pork, and wine was granted to all [29]. Attention was given to cooking, and recipes used condiments to create tasty and unique foods and sauces.

Arabian caliphates that later occupied southern Europe introduced some fruit trees, architectural features, water management techniques, and more. In the XV and XVI centuries, Portuguese and Spanish sailed across the Atlantic Ocean in search of new commercial routes and of new lands, in a journey only comparable to the Apollo missions and the prospective colonization of Mars.

As a result, dramatic changes in the Mediterranean food landscape resulted from the introduction of crops brought from overseas (which evolved into many different varieties in adapting to the specific Mediterranean pedoclimatic conditions). In parallel with such new crops (e.g., potato, corn, tomato), an improved availability of spices from the Orient was also registered (e.g., cinnamon, cloves, saffron). The Portuguese and Spanish expeditions to the Americas, Africa, and India not only enriched the diet in the region but also exported the Mediterranean culture to the new lands, which now consume olive oil and other Mediterranean delicacies. If Mediterranean food habits include influences from the Orient (e.g., pasta), the opposite is also true (e.g., the Japanese "tempura" is a version of the Portuguese "peixinhos da horta" (a possible translation for "peixinhos da horta" is "little fishes from the kitchen garden", referring to a method of cooking bean's green pods with spices and eggs, in a resourceful and creative way of mimicking the form of fried sardines or mackerel)). Dark events such as the destruction of South American civilizations and the

development of slave markets inspired later persistent behaviors by new empires, such as the British Empire.

On the other hand, the globalization of western culture, rooted in the blend of ancient Mediterranean cultures, was fostered by the expansion of these new empires, which prospered at the cost of vast exploitation of natural resources and an intense slave trade. Later, the USA, a dominant power during the XX century, assimilated the legacy of Greco-Roman and Mediterranean cultures, adapting it in the process.

### *2.2. From the Industrial Revolution to the Onset of the XXI Century*

A common Mediterranean identity and lifestyle emerged from all the overlapping layers of history, associated with the cultural exchanges and population fluxes that succeeded in the area over many centuries. Migrations within the Mediterranean region and successive settlements refined a common way of life, aligned with the rhythms of nature, encompassing convivial meals, common food patterns, as well as similar architecture and materials (e.g., the same dyes), all grounded on similar natural resources, climate, and orography, as well as on similar codes of social conduct. Yet, this model allows and embraces regional specificities, based on the optimization of local resources and the reinforcement of social bonds. Such lifestyles, skills, and resilience helped people face the harsh living conditions and food insecurity that persisted in the region until long after the industrial revolution, aggravated by the Second World War (WWII) and by the Spanish Civil War. In the 1950s and 1960s, while northern and central Europe and the USA prospered, much of the Mediterranean world did not experience economic growth [30–32].

For many reasons, including the lack of fossil fuels, the Mediterranean region was slow in joining the industrial revolution. After WWII, major changes in agriculture and the food industry took place in the countries that had led the industrial revolution, boosted by a post-war aid mechanism—the Marshall plan—that encouraged productivity and mass production, and favored major industrial powers in Europe. Even with later investment and strategies prescribed from outside, most of the Mediterranean region seemed to resist progress and did not experience significant economic growth. The main underlying reason was probably the inadequacy of the imposed model, which did not consider the geomorphology of the territories and marine environments and disregarded biodiversity. Modern large agricultural machinery was inadequate for most fields, due to the irregularity of the terrain, with more stones than nutrients. Water scarcity during summer was an additional problem. The so-called "Green Revolution" aimed (and greatly succeeded) at tackling famine in the world, and the Mediterranean region's agricultural production has been intensified whenever possible, by replacing autochthonous plants and animal breeds by standard and (allegedly) "improved" ones. The food industry experienced unprecedented growth in the post-war period, although important collateral damage (in public health and natural capital) remains unresolved. Moreover, in such a model of industrialization, which is still mainstream, Mediterranean foods, such as fresh vegetable salads, soups, and stews (containing a large variety of seasonal plants and herbs) were considered inadequate for large-scale production. Possible explanations are the lack of scientific knowledge to support large-scale manufacturing and the reduced availability of raw materials (e.g., specific autochthonous plants). However, some attempts to globalize Mediterranean foods were economically and industrially successful. That is the case of pizza, globally known as a fast food nowadays, which is nutritionally poor, deleterious to health and the environment. The ultra-processed version of pizza (high in saturated fat, glycaemic index and sodium, and poor in nutraceuticals) strongly contrasts with the original balanced food, "pizza Napoletana", which is nutritious, healthy, and sustainable [33]. Pressures to embrace global foods in the Mediterranean region persist, despite the call for a paradigm change.

### *2.3. Globalization and the Climate Crisis Shape Food Habits in the Mediterranean Basin*

According to the assessment report from the Intergovernmental Panel on Climate Change [34], released in February 2022, climate change has already disrupted the interde-

pendent human–natural systems. Moreover, climate change impacts and risks are becoming increasingly complex and more and more difficult to manage. Climate-resilient development prospects are constrained by past and current emissions, as negative occurrences in one region of the planet may cause damages elsewhere. Commonly, food commodities flow in the direction of wealthier regions, leaving behind deforestation, biodiversity loss, soil degradation, water contamination, as well as plastics (from packaging materials) and other residues [25,26,35,36]. Despite their recent commitment and action, the USA and China have been responsible for the largest share of GHG global emissions [37], and yet the Mediterranean region, with much lower GHG emissions, is already experiencing water scarcity, and the predictions point to high or very high heat stress by mid-century [34,38]. Conversely, the enablers of climate resilience and sustainable development are inclusive governance, adequate and appropriate human and technological resources, information, capacities, and finance [25–27,34,39]. A shift towards more sustainable, healthy diets is expected to reduce GHG emissions by 41 to 74%, while improving public health, as well as productivity and resilience to climate shocks, hence unlocking sustainable growth [39].

The 2020s' crisis, in its complexity and multiple dimensions, impels top-down and bottom-up actions aimed at more frugal uses of natural capital, such as the European Climate Law [40], as well as guidance documents [28,41,42] and action from movements such as the slow food movement from Italy [43] or Annadata from India [44].

In fact, "frugality" is a cornerstone of the Mediterranean diet. Frugal eating habits prevent obesity and NCD [11–16] and promote brain health [45], while the shift to unbalanced diets, easily exceeding recommended daily caloric intake, seems to increase such risks [46–48]. Policy changes, such as limiting simple sugars and salt in certain foods, have a definite impact, as was recently observed in Portugal [49]. However, the food literacy of populations is generally still low, despite some awareness of the linkage between diet, health, and climate [50–52]. Crisis-related food supply constraints and rises in prices may further complicate the adoption of sustainable diets and may compromise the 2030 agenda. Still, comprehensive, effective, and innovative responses can harness synergies towards sustainable development [34,39,41] in mitigating such hurdles. It is noteworthy that the Mediterranean diet is rooted in a frugal use of natural resources, coping with nature instead of working against nature, thus ensuring the resilience of the systems. Examples include coping with water scarcity, and preferring robust locally adapted plants and animal breeds. Such features are highlighted in some globally important agriculture heritage systems by FAO, as is the case of Horta de Valência, in Spain [53], or the Barroso agro-sylvo-pastoral system, in Portugal [54].

Frugality also translates to a "zero-waste" approach when transforming or preserving foods, and this is very evident in the traditional ways of tackling food waste (e.g., the entire turnip is eaten, the bulb and the leaves; dry bread is used in gazpacho; etc.). In the same trend, other typical features of the MD are short distribution circuits, the celebration of seasonality, and the smart use of biodiversity in ensuring food sovereignty within regions (e.g., blending carob and wheat flour to increase the availability of bread).

In short, it is now well acknowledged that the current mainstream food system suits no one. It doesn't serve the real needs of end users, damaging their health and destroying their sustainable food cultures; or the needs of most workers, because of low wages and poor living conditions; or of indigenous peoples, who see the depletion of their natural resources and erosion of cultural assets (e.g., Amazon rainforest) [6,26,36,39]. Luckily, the agri-food sector is unique in its ability to reduce GHG emissions (e.g., from agrochemicals, refrigeration, transportation, etc.) while also sequestering $CO_2$ from the atmosphere and fixating nitrogen in the soil. All life on Earth is interconnected and the biophysical interactions in the Earth system amplify human impacts [55]. Frugality and resilience are two keywords associated with the Mediterranean diet that inspire sustainable innovations that are respectful of territories.

## 3. The Origin and Relevance of the Mediterranean Diet Concept

In the words of Trichopoulou and Lagiou [56], "*The Mediterranean Diet and lifestyle were shaped by climatic condition, poverty and hardship rather than by intellectual insight or wisdom. Nevertheless, results from methodological superior nutritional investigations have provided strong support for the dramatic ecologic evidence represented by the Mediterranean natural experiment*".

Such a "natural experiment" was first reported in the 1950s by an American doctor, Ancel Keys, when the USA and northern Europe were experiencing considerable economic growth and food industries were on the rise. Keys observed a very different reality in southern Europe, which he approached from a public health perspective. In the famous "Seven Countries Study", Keys and co-workers demonstrated an inverse correlation between the degree of adoption of the Mediterranean diet and the incidence of coronary heart disease [57,58].

Keys described the Mediterranean diet and lifestyle, which he observed in southern Europe shortly after the second world war, as consisting of frugal meals with wheat, wine, and olive oil as key elements. He further noted that such meals were communal events that included many vegetables and herbs and only small amounts of meat and fish, with pulses and cheeses as the preferred sources of protein. Cooking methods were simple, despite the resulting variety of flavors and colors. Seasonal fruits were the preferred desserts, and nuts and olives were eaten as snacks. Coffee and tea played an important role in these communal meals, and sweet desserts were reserved for festivities when the consumption of meat and fish also increased. The mounting evidence for the direct correlation between these eating habits and health is presented and discussed below. The Mediterranean food pattern (Table 1) first described by Keys and frequently revisited [2,4–7,56,58,59] follows common basic features, though leaving room for regional specificities:

- Strong difference between everyday and festivity meals. Frugality is the rule, although everyday meals are varied and tasty.
- Daily meals are convivial moments, during work breaks with colleagues or at home with all the family gathered around the table.
- Olive oil is the main fat and a key food ingredient, with daily intakes of about 20 mL/capita/day.
- Abundant consumption of seasonal vegetables and fruits from local orchards, kitchen gardens, and proximity markets.
- Animal-based products are used primarily to enhance the flavor of dishes, instead of being the main ingredients.

In the "good Mediterranean diet", thus named by Ancel Keys [58], scarcity was the rule and abundance was the exception. Only during festivities did people indulge in eating larger amounts of fish, meat, and sweet desserts, contrasting with everyday meals, which were simple and mostly plant-based, yet varied, flavored, and nutritionally rich (Table 1).

During the 1950s and the 1960s, middle-class Americans were regarded as prosperous and modern, while Mediterranean peoples were viewed as miserable, ignorant, and less than glamorous. Keys noted the inconvenient paradigm that humble Mediterranean people lived longer and healthier lives than Americans, by eating just what they needed, often engaging in physically demanding occupations, and socializing outdoors, in contrast with the excesses in food intake, less balanced food habits, and more sedentary lifestyles of the average middle-class American [57–59].

It has been acknowledged by many that adherence scores to the Mediterranean diet have been decreasing in the region, including in flagship countries, such as Italy and Greece [60–63]. The food habits of the population have been changing, driven by societal changes (such as long hours spent at work and commuting from suburbs to the city) and powered by marketing campaigns of multinational corporations.

**Table 1.** Main nutritional features of the Mediterranean food pattern as a function of average daily energy intake (for a reference value of 2000 Kcal/day/capita).

| Nutrients | Relevant Food Sources | Contribution to Energy Intake (%) | Average Daily Energy (Kcal) | Comments |
|---|---|---|---|---|
| Carbohydrates | Wheat and other cereals | 60–70 | 1200–1400 | >50% starch |
| Protein | Pulses, cereals and varied vegetables, dairy, eggs, fish, meat, other sources (e.g., snails) | 10 | 200 | High biological value; from animal and plant sources |
| Lipids | Olive oil, fish, nuts | 20–32 | 400–640 | Mostly mono-unsaturated and poly-unsaturated fatty acids, with an n3:n6 ratio of approximately 2:1; modest intake of saturated fats from meat and dairy |
| Dietary phytochemicals (*) | Wine (**)<br>Tea, coffee<br>Spices and herbs | 4–7<br>N.A. | 80–140 | Alcoholic drinks are forbidden by Islam, but green tea, which is a staple drink in north Africa, also contains a high level of tannins; abundant use of a large variety of culinary herbs and spices |
| Dietary fibres | Fresh and dry fruits, grains, nuts, fresh vegetables | N.A. | N.A. | The high proportion of vegetables in the diet also provides vitamins and phytochemicals |

* Dietary phytochemicals (also known as phytonutrients) are secondary plant metabolites that may beneficially affect human health, encompassing polyphenols, carotenoids, and other compounds, which are characteristic of plant foods. ** If alcohol is consumed, it should be in moderation and only by adults of legal drinking age. For those who choose to drink, moderate alcohol consumption should be incorporated into the calorie limits. Dietary guidelines do not recommend that individuals who do not drink alcohol start drinking for any reason. N.A.: not applicable. (Adapted from [4].)

With the noble goal of ending hunger, food industries developed greatly in the post-WWII period and then continued to grow and develop, aiming at tackling food insecurity and improving food safety. As with other sectors, food systems also adopted the mainstream economic model, consisting of uniformization and mass production aimed at meeting and stimulating growing demand. Highly processed and ready-to-eat foods have been marketed as convenient, tasty, and affordable, eliminating the need to cook and hence pushing basic cooking skills into oblivion. This nutritional transition, corresponding to the dominance of the so-called western diet, has caused worldwide obesity epidemics with increased prevalence of associated non-communicable diseases (NCD), thus causing a burden to national healthcare systems [64]. With the dramatic increase of food availability in nearly all countries, changes in dietary habits translate into the coexistence of obesity and malnutrition across the world. According to "our world in data", in 2017, 42% of the global adult population and one out of five children were overweight or obese (with a body mass index (BMI) > 25) [65]. For the first time in human history, overweightness and obesity surpassed hunger in many regions of the world, and a global syndemic of obesity, undernutrition, and climate change was noted [66].

Food industries have been developing and marketing a wide variety of ultra-processed foods, based on just a few crops and animal species, which are dismantled into components and later reassembled in variable formulas. Cosmetic ingredients and additives

(e.g., emulsifiers and colorants) are used to make those foodstuffs appealing. Such calorie-dense foods with low nutritional density values have been aggressively marketed towards children [67–69], with deleterious consequences. Besides damaging human health, the production of such foods contributes to deforestation (especially rainforests), soil degradation, water contamination, plastic pollution, and so on, while also reducing agri-biodiversity, and disregarding historical and cultural assets [67]. In other words, as acknowledged in the 2021 UN Food Summit, our current food systems have been important drivers of climate change, failing to meet SDG 2, 12, 13, 14, and 15. However, changes have not been seen as a priority because a large part of the population has access to foods once associated with wealth, like sodas, pre-cooked meals, steaks, and so on. An excessive food intake at reduced prices is within the reach of many. Recommended portions are often doubled or tripled, in addition to the food that is wasted.

The COVID-19 pandemic and the 26th UN Climate Change Conference of the Parties (COP26) provided the timing and the necessary commitments for a paradigm change towards sustainable food systems through increased civic participation, as advocated by many [25,66–71]. The resulting policies and actions need to be respectful of nature, local food cultures, and seasonality [36,39]. In the Mediterranean basin, the best and more natural option is to enhance the adherence scores to the Mediterranean diet, the nutrient and environmental traits of which are summarized in Figure 1. Given its superiority, this model has been adapted to other regions of the world.

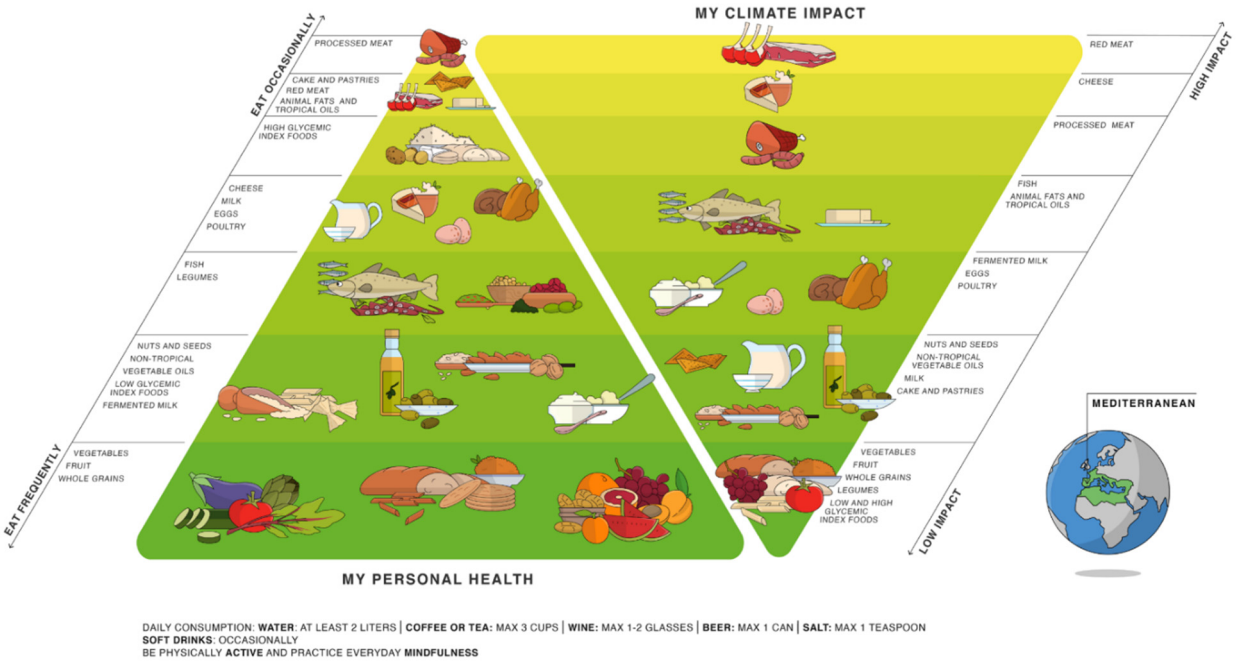


**Figure 1.** The double pyramid model for the Mediterranean region presented here is a recreation from the work jointly realized by the research team of the Barilla Foundation and the University of Naples Federico II. It concerns health aspects of food habits (noting the frequency of intake) and the environmental impact of corresponding foods. Such a model highlights the desired nutritional balance of foods (upward pyramid on the left), in parallel with the environmental impact of such foods (downward pyramid on the right) [70].

In Portugal, the traditional food culture is the MD, which respects the pace of nature, is culturally adequate, and values natural assets, notably agri-biodiversity.

As shown in Figure 1, the foods that are recommended to be frequently eaten have the lowest environmental impact, occupying the base of the left pyramid (human health) and the top of the reversed right pyramid (climate). In short, Figure 1 shows that such a dietary pattern provides high benefits to human health with a low environmental impact, not to

mention the potential benefits to biodiversity and more. As mentioned above, the MD is classified as an intangible heritage of humankind by UNESCO, and Portugal is among the signatory countries of this 2013 convention [1,72].

## 4. Methodology and Data Sources in Assessing Diet Sustainability

We present herein the baseline status for the MD in Portugal, mainly regarding health, nutrition, and environmental features. To do so, data on the food habits and physical activity of the Portuguese population was collected in 2015–2016, shortly after the UNESCO convention was signed, aimed at informing decision makers in designing adequate nutritional guidelines and supporting policies. This information was complemented with demographic data and agricultural statistics for the same period. These official statistics were produced by the National Institute of Statistics (INE).

### *4.1. Data on Food Habits and Physical Activity of Portuguese Population*

The survey about food habits and physical activity of the Portuguese population (IAN-AF) was conducted in 2015–2016, supported by the national healthcare authority, DGS, the central services of the Portuguese public healthcare system, and the European Food Safety Authority (EFSA). It relied on questionnaires and face-to-face interviews to volunteer participants randomly selected among users of the National Healthcare System (SNS) and was mostly conducted during regular preventive health monitoring (familiar medicine). Data analysis and interpretation of results were performed at the University of Oporto. The resulting report [73] is an important source of information in our analysis below.

### *4.2. Demographic Statistics*

Demographics and other relevant Information of the Portuguese population are based on national official statistics from 2015 compiled by Pordata [74].

### *4.3. Agricultural Statistics and Food Availability Data*

Agricultural statistics were obtained from INE for the year 2016 [75]. The granularity of the datasets allowed us to retrieve information about cereals, meat, and plant species, discriminated at the level of main local varieties in the case of some fruits (e.g., different Citrus sp.) and green vegetables (e.g., discriminating several members of Brassicaceae). Production and availability of some industrial products (e.g., olive oil) and environmentally relevant information (e.g., fertilizers' use) was also available in agricultural statistics from INE.

Information on food availability (2015 and 2016) of main food groups, macronutrients, micronutrients, and so on was also obtained from INE, including subcategories and the origin of items within each group [76]. Information on deviations from the Mediterranean dietary model (by using the Mediterranean Adequacy Index, MAI) and more was also available from the same source [76].

### *4.4. Proposed Sustainability Metrics for a Potential Composite Indicator*

A list of metrics to determine the sustainability of a diet was developed by Lacirignola et al. [77] and further developed by Donini et al. [78], taking the Mediterranean diet as a reference for comparisons. These authors devised a list of 13 metrics or indicators, having in mind a prospective composite sustainability index. The monitoring along time of these set of indicators, or of a composite index integrating them, is expected to allow analysis of the evolution of a diet's sustainability status through five dimensions: biochemical characteristics of food, food quality, environment, lifestyle, and health. In the present work, the 13 indicators were calculated for the above-mentioned case study, with the intentions of characterizing the baseline status for the safeguarding of the DM in Portugal and examining the feasibility of the use of such metrics in assessing the sustainability of a given dietary pattern.

Definitions, Assumptions, and Calculations

The proxy for all indicators corresponds to the ideal MD model; in other words, the values obtained for each indicator, in a given case, should be as near as possible to the standard value that would be defined for the (ideal) MD [77,78]. According to these authors, the sustainability of a diet comprises aspects related to food composition and diet quality, and to the environmental impact of food choices, lifestyles, and clinical aspects, resulting in the five groups of indicators detailed below:

- The biochemical composition of foods is characterized by: (A1) the vegetable/animal protein consumption ratio; (A2) average dietary energy adequacy (expressing the dietary energy supply as a percentage of the average dietary energy requirement in the country); (A3) dietary energy density, which is the amount of energy in a given mass of daily ingested food (kcal/g); and (A4) nutrient density of the diet, which is the amount of the various necessary nutrients and fibres present in a given daily diet per g of ingested food.
- Food quality is characterized by: (A5) fruit and vegetable consumption/intake, which is a measure of the consumption (g/capita/day) of fruits and vegetables, including pulses, nuts, and seeds; and (A6) dietary diversity score, which is a qualitative measure of the household access to and consumption of a wide variety of foods. It is based on the assumption that a greater dietary diversity protects against the double burden of obesity and malnutrition.
- The environmental dimension of the diet is characterized by: (A7) The food biodiversity composition and consumption. In the context of human nutrition, biodiversity refers to foods identified at a taxonomic level below species (e.g., cultivar, breed), and it is a count of items; however, it is distinct from A6. (A8) The rate of local/regional foods and the seasonality of the diet. This metric is generally associated with the sustainable agriculture concept, in which most foods are sourced and distributed in a limited geographical area (proximity between producer and consumer) and are "in season", meaning that heated greenhouses are avoided as well as long-term cold storage. (A9) The rate of eco-friendly food production and/or consumption, which is the percentage of consumers buying organic foods and the frequency of consumption, or alternatively, the percentage of the organic market volume.
- The lifestyle dimension is characterized by: (A10) the ratio of physical activity/sedentarism prevalence, obtained from physical activity questionnaires/national surveys; and (A11) the adherence scores to the Mediterranean diet, from the IAN-AF national survey using the Mediterranean diet score.
- The clinical aspects' dimension relates food habits with concrete health outcomes as (A12) diet-related morbidity/mortality statistics, reflecting the prevalence of individuals with non-communicable diseases such as obesity, cardiovascular diseases, type II diabetes, osteoporosis, and so on; and (A13) nutritional anthropometry, which is based on body mass index distribution, noting the prevalence of BMI < 18.5 (undernutrition) and BMI > 25 (overweight and obesity).

## 5. Baseline Assessment of the Sustainability Dimensions of the DM in Portugal

The values/information for the indicators above were obtained as described in Sections 4.1–4.3, and are as follows:

According to the IAN-AF report [73], A1 (the average daily caloric intake) was estimated as 1910 kcal/capita/day in the pre-selected period 2015/2016, which is below the reference value of 2000 kcal/capita/day.

A2, the average dietary energy adequacy, corresponds to the grey bar displayed in Figure 2, and the conformity with the dietary recommendations for the MD can be noted by comparing with the green and red bars that establish the limits for each macronutrient. This finding is consistent with the reported values for the Mediterranean dietary score (predominance of high and moderate adherence scores), as well as with the Mediterranean Adequacy Index (MAI), which is >1. This last index (estimated from food availability data)

has been monitored for a long time and seems to follow a recovery trend line from 2014 onwards [76].

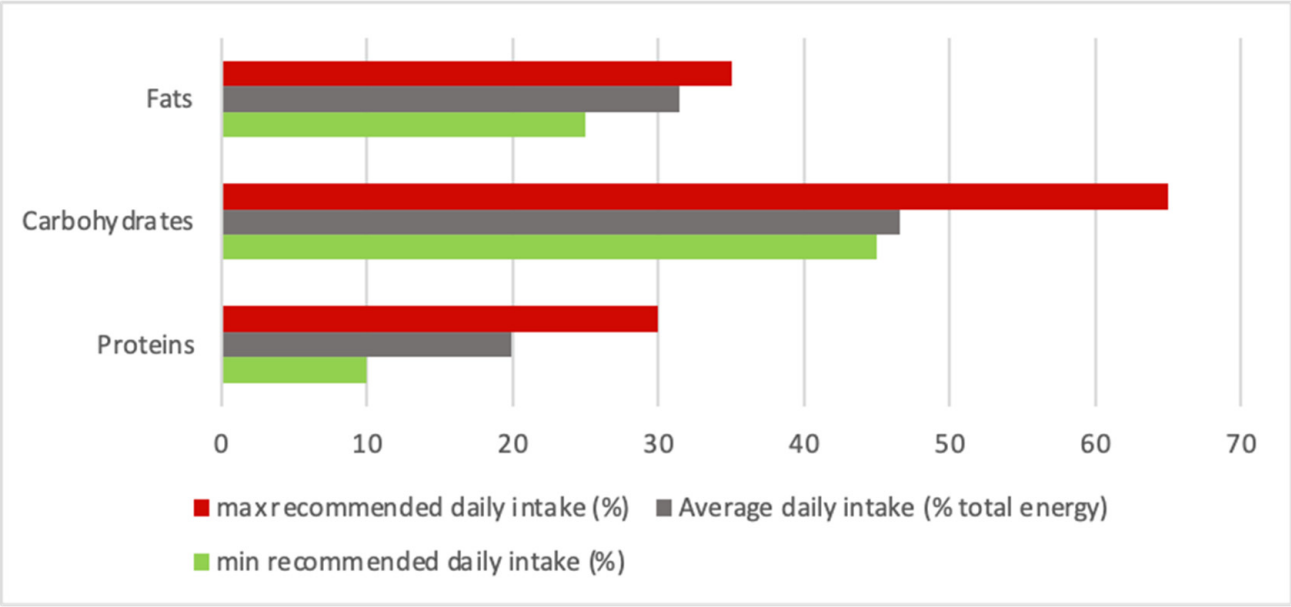


**Figure 2.** Average % of the contribution of macronutrients to the daily energy intake in the diet of the Portuguese (in 2015–2016), and nutritional recommendations by the national healthcare authority (DGS). Maximum values: red; average daily intake of fats, carbohydrates, or proteins: grey; minimum values: green; data values and recommendation intervals for nutrient's daily intakes were obtained from [73].

As can be deduced from observation of Figure 2, the diet of the Portuguese (in 2015–2016) seemed quite balanced with respect to the energy contributed by each major class of nutrients.

Concerning A3 (the animal-protein-to-plant-protein ratio), based on the available information, a tendency for a higher consumption of animal protein than recommended seems to be on the rise. The estimated A3 value for the current case study reveals an intake of twice as much animal protein (61.9% of total daily protein intake) as plant protein (36%); note that nutritional guidelines refer to a desirable daily animal protein intake of 30–35%. The baseline status of this indicator highlights this divergent tendency from the MD model, mostly due to high consumption levels of poultry and pork [76].

A4 is 1458 Kcal/g (this was calculated by dividing A1 by a daily mass of ingested food (assumed as 1310.4 g, according to Section 4.1)). In this respect, it is noteworthy that the food habits of the Portuguese include vegetable soups and salads in main meals. The ingestion of these low-calorie and nutrient-dense traditional soups may have contributed to lowering the total quantity of ingested food, due to the satiating effect of soups.

A5, the dietary nutritional density, was herein assessed from the concentration of 18 micronutrients/g of food, including 11 vitamins and 7 minerals, according to the data and criteria from the IAN-AF report [73]. It is noteworthy that respondents that included soup in the main courses seem to more easily comply with the dietary guidelines for fruits and vegetables than the others. Conversely, respondents who declared that they eat a traditional soup of vegetables seldom or rarely were less likely to comply with the necessary daily intake of fruits and vegetables [73]. This indicator (dietary nutritional density) seems to be better assessed when information from questionnaires on food habits is combined with information from food composition databases and nutritional guidelines. Other approaches may carry more risk of error.

With regard to A6, according to [73], the Portuguese diet in 2015–2016 included 46 food sub-groups and can thus be considered as highly diversified.

Indicators related to the environment (A7: agri-biodiversity in food habits; A8: proportion of local and seasonal foods in the diet; A9: preference for organic foods) were assessed from national agriculture statistical data for the same period [75] and are summarized in Table 2.

**Table 2.** Estimation of environmental features of typical Portuguese food habits, based on agriculture statistics for 2015–2016 [75].

| Indicator | Description | Estimated Value |
|---|---|---|
| A7 | Agri-biodiversity in diet composition and consumption | Data gap |
| A8 | Average proportion of local and seasonal foods in the diet | Data gap |
| A9 | Preference for organic produce in % of overall consumption of vegetables, dairy, meat, eggs | 11.6% |

Presently, agri-biodiversity is seldom valued by consumers and food producers, and hence, in the present case study, data collection on this matter is very limited or does not exist at all, therefore impairing the assessment of A7 and A8. The data's granularity, referred to in Sections 4.2 and 4.3, is insufficient. Thus, the information required to assess these metrics is expected to be available only when it will be considered useful to agricultural markets.

Thus, the assessment of the environmental dimension seems to currently face difficulties in obtaining sufficiently detailed information.

The metrics on the health impact of the diet (A10: physical activity level; A11: adherence score to the Mediterranean diet; A12: mortality and morbidity from non-communicable diseases; A13: obesity rate) are summarized in Table 3.

**Table 3.** Estimation of health impacts of typical Portuguese food habits, based on [73] and on national statistics on health data for the period 2015–2016 [73,74].

| Indicator | Description | Estimated Value |
|---|---|---|
| A10 | Level of physical activity [1] | Active: 27.1%; moderate: 30.3%; sedentary: 42.6% |
| A11 | Adherence score to the Mediterranean diet [1] | High: 18.2%; moderate: 50.4%; low: 31.4% |
| A12 | Mortality and morbidity from non-communicable diseases [2] (NCD) | NCD caused 85.6% of deaths (2016), mostly by cardiovascular diseases; data gaps on morbidity |
| A13 | Anthropometric data: obesity's prevalence (% of the population) [1] | Obesity 22.3%; excess weight: 34.8% |

[1] Source [73]; [2] Source [74]; NCD, non-communicable diseases, include cancer, diabetes mellitus, cardiovascular diseases, digestive diseases, skin diseases, musculoskeletal diseases, and congenital anomalies. The adherence score to the MD (A11) refers to the Mediterranean diet score used in [73].

With respect to anthropometric and health features related to lifestyle, it can be seen in Table 3 that 57.4% of the survey's respondents were declared to have an active or moderately active lifestyle, while 42.6% were assumed to have a sedentary lifestyle (A10). With respect to food habits, A11 concerns the MD's level of adherence, given by the Mediterranean diet score [73], which is one among several existing scores, each one using its own metrics. The values for this indicator are thus strongly dependent on the methodology, which is usually not normalized. According to data provided by [73], high and moderate adherence scores to the Mediterranean diet predominate, but the proportion of respon-dents shifting away from the Mediterranean diet pattern was significant and deserves attention. Incorrect lifestyles, monotonous menus, and the preference for calorie-dense and nutrient-poor ultra-processed

foods have been acknowledged as underlying causes for the prevalence of obesity and the incidence of non-communicable diseases [64,71]. Aggressive marketing campaigns by large food corporations may aggravate this problem [67–69] and the environmental burden. A negative association, or syndemy [66], may further aggravate climate change and human health. As argued by many, human health and the health of the planet are non-dissociable [10,17,20,28,66,70].

Despite the robustness of the design, data collection, and analysis of results of the IAN-AF, as with any study, limitations and constraints may be noted. Firstly, family medicine should have universal coverage with regular monitoring of the health status of the population, but for several reasons, deviations may occur, such as the exclusion of those that intentionally avoid medical appointments, and a possible predominance of elderly patients, patients from lower socio-economic strata, and patients with chronic conditions. Other possible limitations may include incorrect answers by respondents and subjects withdrawing from the study, thus reducing the sample size.

However, without the data from such a survey, it would not be possible to assess aspects related to the diet's food composition and nutritional quality, or the lifestyle and health-related dimensions.

On the other hand, national demographics and agricultural statistics rely on large data sets (with very high statistical significance) but are not exempt from data gaps. We found a discrepancy between the data required and the information available with respect to the environmental dimension of diets. Moreover, the use of different methodologies in data analysis may complicate or impair the combination of data from different sources. One such example is the use of different tools to assess the adherence scores to the MD, since no harmonized methodology exists.

## 6. Conclusions and Prospects

The current global food system is a major driver of climate change, putting our planet under unforeseen pressure and compromising our capacity to produce food in the future.

The Mediterranean diet that resulted from ancient wisdom—a masterpiece of the commons—is now acknowledged to have clear competitive advantages over other dietary options in addressing current issues, such as food security and climate change. This concept is rooted in resilience, frugality (smart use of resources), coping with nature (enhancing biodiversity), and adaptation (tackling climate change). During the UN Food Systems Summit and COP26, it was acknowledged that the food system's transformation is crucial in tackling the climate crisis. Such changes will need top-down and bottom-up actions and the commitment of all stakeholders in the value chain. To manage such changes, it is ne-cessary to measure them; therefore, suitable metrics are crucial. The present work reports the assessment of a set of indicators using the MD as the standard for a healthy and sustainable diet. Issues to overcome include identified data gaps, different granularity of datasets, and lack of harmonization of methodologies to allow the combination of information from different sources.

The development of a suitable composite indicator to assess the overall sustainability of a given diet depends on the resolution of such issues. The rapid development of information and communication technologies (ICT) will certainly facilitate this job to accelerate the efforts to produce and consume healthier and more nutritious foods while addressing climate change, biodiversity loss, soil health, and water pollution. As a result, several ongoing initiatives aim at raising awareness and enabling suitable policies [49–52]. This is the case for the Portuguese Innovation Agenda for this decade, in which the Ministry of Agriculture defined a 20% increase in adherence to the DM as a target [79]. Success in implementing more sustainable food production and consumption systems will certainly depend on the quality of the metrics to assess progress.

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