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Resources, Strategies and Potentialities for Food System Sustainability in the Mediterranean Area

Edited by:
Noelia Betoret and Ester Betoret.

AJUNTAMENT DE VALÈNCIA
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CEMAS World Sustainable Urban Food Centre of València
GENERALITAT VALENCIANA
Conselleria d'Agricultura, Desenvolupament Rural, Emergència Climàtica i Transició Ecològica
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PROLOGUE

Feeling a sense of identity in everyday life, the pride of belonging and the pleasure of being part of a culture that guides our existence is, surely, one of the aspects that gives the greatest value to our lives. Our Mediterranean land radiates with knowledge and ancestral wisdom. “The place between two lands” is the etymological meaning of the beautiful word. The Mediterranean also offers permanent exchange like few other places on the planet. This cannot be the case if interaction between all its components does not take place. The area defined by history, thought and human development that it always has been and should continue to be is very much due to our unique and excellent agri-food environment. Throughout the world, peace is symbolised by the olive branch, just as the United Nations is symbolised by an azimuthal projection of the earth inscribed in a wreath of crossed olive branches.

The fabulous research work of Noelia Betoret and Ester Betoret offers, like few others, the opportunity to be part of our common space of encounter, peace, and wisdom. The passion and expertise of this brilliant team places CEMAS in a prestigious publishing environment. I can only sincerely thank them and the entire team of experts spread throughout the Mediterranean in research centres, universities, etc. who have been part of this exemplary work.

The book is divided into three parts:

- Crops, land, and water use
- Climate change mitigation strategies
- Potential of the Mediterranean area.

This implicitly offers us a structure of analysis analogous to the “past, present and future” that perfectly guides any reader. One of the several wonders of this book that the reader has now in his hands, or on his screen, is that it allows a reading of high scientific level, but at the same time it has taken care of making such an interesting area of knowledge accessible to people not specialised in these matters.

Time, years and memories will confirm the timeliness and accuracy of this publication, which is destined to become a reference for its amazing dedication, rigour and professionalism, and for being strongly oriented to development, to the dignity of the people who live here and to peace through knowledge.

I reiterate my sincere gratitude for the exemplary work of the researchers Noelia Betoret and Ester Betoret.

Vicente Domingo González
CEMAS Director

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The Mediterranean diet has long been acknowledged as one of the healthiest in the world. The Dietary pattern of the Mediterranean diet cannot stand alone without considering its social characteristics, including practices and traditions related to food processing, preparation, preservation and consumption; therefore, Mediterranean diet was also recognized as an Intangible Cultural Heritage by UNESCO.

In the present chapter we discuss Mediterranean diet in terms of 'a sustainable diet' that promotes local consumption and seasonality, improves nutrient intake through food diversity, and plant genetic diversity, including crop wild relatives, contributes to sustainable rural development, and finally fits with low energy use and environment and biodiversity protection.

Aspects of the lifestyle, dietary, sociocultural, environmental and health challenges that the current Mediterranean population is facing, are also touched upon in view of the erosion of the local culture and traditional food systems and the need of their revival.

Market of fruits and vegetables. By Tomas Le. Unsplash License

Chapter 8. Mediterranean habits and patterns of consumption; interrelation with sustainability aspects

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KEY POINTS

- ***Mediterranean diet is a sustainable diet that promotes local consumption and seasonality of the foods consumed.***
- ***Mediterranean diet promotes high consumption of fruits and vegetables and low consumption of meats and has low environmental impact.***
- ***Consumed foods are fresh, minimally processed, and high in nutritive and healthy compounds content.***
- ***The adherence to Mediterranean diet is limited and influenced by many aspects like education, social status, convenience and marketing.***

1. The concept of the Mediterranean diet

Figure 8.1. Mediterranean diet concept includes food and societal elements that have direct influence on environment and sustainability.

From the research and the first definition of the Mediterranean diet by Ancel Keys back in the late 50s (Keys, 1980) to the modern Mediterranean dietary pyramid adjusted to the lifestyle of today (Bach-Faig et al., 2011) and further on to the most updated version where the concept of Double Pyramid Model of the traditional food pyramid based on the Mediterranean diet was introduced (Ruini et al, 2015) in order to assess the simultaneous impact that food has on human health and the environment, they all agree that this frugal diet is being one of the healthiest in the world. Key components involve high intake of extra virgin olive oil as the primary source of added fat, leafy green vegetables, seasonal or dried fruits, cereals -mainly wholegrain-, pulses, legumes and nuts, moderate intake of fish, dairy products, and red wine, while suggesting low intake of red meat and refined sugars. However, the dietary pattern of the Mediterranean diet cannot stand alone. This is the reason why the 'concept' of the Mediterranean diet is introduced that encompasses social characteristics, practices and traditions related to food preparation, processing, preservation, and consumption patterns as inseparable components (Figure 8.1). In 2010 the Mediterranean diet was recognized as Intangible Cultural Heritage of the United Nations by proposal of a set of Mediterranean countries (Croatia, Cyprus, Greece, Italy, Morocco, Portugal, Spain), but refers to eating habits common to people around the Mediterranean Sea. Although sharing some common features, the Mediterranean dietary patterns can differ according to age or gender, ethnicity and culture, as well as to other lifestyle factors (Park et al., 2005; Barrea et al., 2018)including the conservation of skeletal muscle. Frailty is a major geriatric syndrome characterized by low muscle strength. The Hand Grip Strength (HGS). Geography, climate, history, traditions, religion, economy, social factors, hardship, and poverty shaped the "traditional" Mediterranean diet. The following can be considered as the main elements of Mediterranean diet concept (Bach-Faig et al., 2011):

- Moderation, in terms of serving sizes.
- Socialization i.e., social interaction with family and friends during meals.
- Culinary activities e.g., maximum performance with minimal resources and a large diversity of dishes with the same products prepared either for everyday meals, or celebrations and religious festivals.
- Physical activity involving not only sports but also walking, gardening, house works etc. and mainly practicing leisure activities outdoors.
- Adequate rest such as napping after lunch.
- Seasonality; preference is towards seasonal, fresh and minimally processed foods which as a result, optimize the content and impact of health protective nutrients i.e. specific dishes are eaten when products are in abundance and have the highest nutritive value.
- Traditional, local, eco-friendly, and biodiverse products; Mediterranean diet is based on respect for the territory and on activities performed by local communities.
- The last two elements of the above list are directly associated with sustainability aspects of the Mediterranean diet which are going to be discussed further in this chapter.

2. Biodiversity in the Mediterranean area

The Mediterranean Basic is the third richest hotspot in the world in terms of its plant biodiversity with approximately 25,000 species and one of the most important areas on Earth for endemic plants (13,000 endemic species) (Mittermeier, Myers, & Mittermeier, 2005; Derneği, 2010). The presence of more than 5000 unique islands on various sizes and topography contribute to this high biodiversity since the level for endemism for Mediterranean islands ranges from 9.7% in Sardinia to 12.4% in the Balearics (Vogiatzakis, Mannion, & Sarris, 2016). Moreover, in terms of water biodiversity, the Mediterranean Basin with 26 freshwater ecoregions, harbors high numbers of freshwater species and high levels of endemism, particularly in the Balkans and Turkey. It can be declared that approximately 7% of the world's marine fish species are found in the Mediterranean Sea, with a wide range of both temperate and tropical species (Derneği, 2010). Without doubt this biodiversity has played a significant role in global nutritional and gastronomical habits since about one third of used foodstuff comes from the Mediterranean climatic region if not solely by the basin (Harlan, 1995). Barley, oat, wheat, grapes, olives, almonds, figs, dates and various other vegetables, fruits and herbs are derived from wild plants located in the Mediterranean region. This large biodiversity is also depicted in the Mediterranean diet since the habits between the different countriesor even within the same countries are great. Interestingly, this polymorphism partially reflects the religious and cultural differences (Aboussaleh, Capone, & Bilali, 2017).

challenge

Mediterranean region has large plant and water biodiversity.

Biodiversity contributes towards consuming varied and nutritionally rich foods.

3. Typical products of the Mediterranean diet

3.1 Olive oil

Without doubt, olive oil (Olea europaea) can be considered as one of the most vital nutritional components that are linked with the health benefits of the Mediterranean diet (Martinez-Gonzalez & Martin-Calvo, 2016) (Figure 8.2). It is an excellent source of lipids, being associated not only with the primary and secondary prevention of cardiovascular disease outcomes, but also with the improvement of the lipid profile and insulin sensitivity, increased oxidative stability, improvement of inflammatory markers, and control of arterial pressure (Marcelino, Hiane, Freitas, Santana, Pott, Donadon, et al., 2019). These benefits can be mostly attributed to the composition of the triacylglycerols where monounsaturated fatty acids (MUFAs) dominate with oleic acid (C18:1) being the fraction representing 55% to 83%, followed by polyunsaturated fatty acids (PUFAs), representing 4% to 20%, and saturated fatty acids (SFA), representing only 8% to 14% (Covas, De La Torre, & Fitó, 2015). Among other minor compounds that can be found in olive oil phenols like oleuropein and hydroxytyrosol have gained great attention lately due to their nutritional importance (Fernandes, Fialho, Santos, Peixoto-Plácido, Madeira, Sousa-Santos, et al., 2020). This fact is so crucial that led to the establishment of a Health Claim by the European Food Safety Authority (EFSA) in 2012 stating that "Olive oil polyphenols contribute to the protection of blood lipids from oxidative stress. The claim may be used only for olive oil, containing at least 5 mg of hydroxytyrosol and its derivatives (e.g. oleuropein complex and tyrosol) per 20 g of olive oil. In order to bear the claim information shall be given to the consumer that the beneficial effect is obtained with a daily intake of 20 g of olive oil" (EU, 2012) .

Figure 8.2. Olive oil is an important ingredient in the Mediterranean diet. By Roberta Sorge Unsplash License.

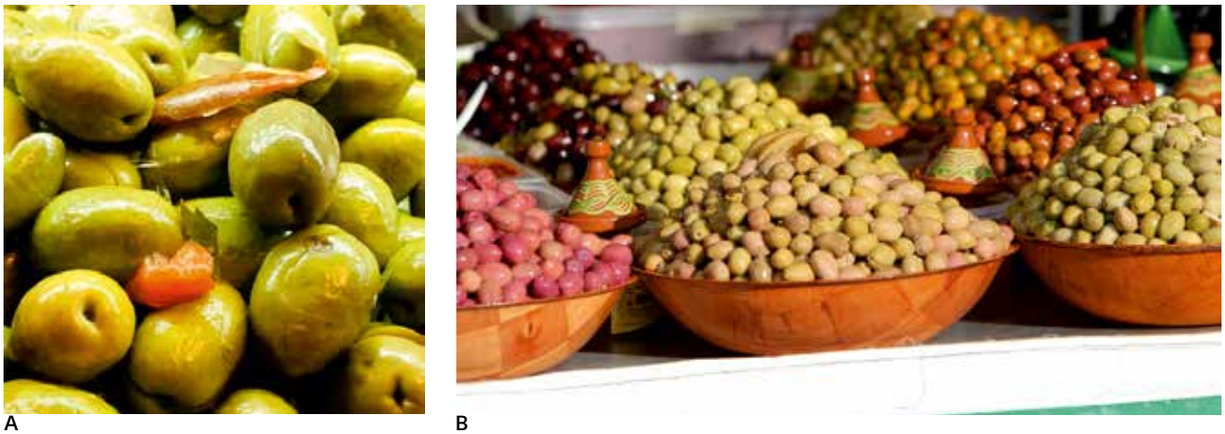
Interestingly, it has been recently demonstrated that the consumption of Extra Virgin Olive Oil can be associated with the enhancement of intestinal health by favoring a higher biodiversity of gut microbiota. More specifically it has been shown that the consumption of Extra Virgin Olive Oil was related to the increase of the genus Clostridium XIVa, one of the main strict anaerobic groups of the intestine that is responsible for the production of butyrate. This short chain fatty acid plays a vital role in the reduction of total cholesterol and anti-inflammatory activity (Hidalgo, Prieto, Abriouel, Villarejo, Ramírez-Sánchez, Cobo, et al., 2018). Additionally, polyphenols can have an effect on the microbial composition by acting as prebiotics; inhibiting the growth of pathogens and stimulating the probiotic bacteria such as Bifidobacterium (Mitsou, Kakali, Antonopoulou, Mountzouris, Yannakoulia, Panagiotakos, et al., 2017).

It is important to mention that there is a growing commercial interest for Protected Designation of Origin and Protected Geographical Indication quality labels and currently there are a total of 126 Protected Designation of Origin and Protected Geographical Indication extra virgin olive oils that are divided among Italy (46), Spain (34), Greece (28), France (7), Portugal (6), Croatia (4) and Slovenia (1) (European Commission, e-ambrosia). This fact pinpoints the variability found in those natural products that derives from the presence of different olive varieties all over the Mediterranean Basin.

3.2 Table olives

Table olives are the products prepared from sound fruits of the cultivated olive tree (Olea europaea L.) and have been a component of the Mediterranean diet for centuries (Figure 8.3). Lately, there is a profound increase in table olive consumption due to their nutritional and palatable characteristics. Most of the production is located in Mediterranean countries of the European Union (Spain, Greece, Italy and Portugal) while other producing countries of importance include Egypt, Turkey and Morocco (Rocha, Borges, & Pinho, 2020). All over the world numerous processing methods are applied. However, only some of them or economically important from an international standpoint as determined by the International Olive Council (IOC, 2004). According to most processing method the most common commercial products are classified as treated olives, natural olives and olives darkened by oxidation. Treated olives, such as Spanish-style olives are fruits that undergo alkaline treatment, followed by complete or partial fermentation. Natural olives, for example, Greek olives, are placed directly in brines where they undergo a complete or partial fermentation. In this case the oleuropein removal, the compound responsible for the bitter taste, is slow and partial (Pires-Cabral, Barros, Nunes, & Quintas, 2018).

The nutritional value of table olive consumption has been demonstrated in numerous studies and has been associated with the presence of several phenolic compounds (Malheiro, Sousa, Casal, Bento, & Pereira, 2011) as well as triterpenoids, a group of secondary metabolites derived from the cyclization of squalene, oxidosqualene or bis-oxidosqualene (Alexandraki, Georgalaki, Papadimitriou, Anastasiou, Zoumpopoulou, Chatzipavlidis, et al., 2014). However, the concentration of all these bioactives is highly dependent on various factors and most importantly the processing method. Last but not least, fermented table olives can be an excellent source of probiotics that have been shown to have anti-pathogenic, anti-diabetes, anti-obesity, anti-inflammatory, anti-cancer, anti-allergic properties (Perpetuini, Prete, Garcia-Gonzalez, Alam, & Corsetti, 2020). The only drawback in the restless consumption of table olives is the relatively high salt content that is why the substitution of NaCl with other salts namely potassium chloride (KCl), calcium chloride ($CaCl_2$) and zinc chloride ($ZnCL_2$) has been studied (Campus, Degirmencioglu, & Comunian, 2018).



A B

Figure 8.3. Table olives of different types in a local market. (A) By Molin and (B) Timothy Newman, Unsplash License.

3.3 Whole grain cereals and legumes

Legumes (including lupins, green beans and peas, peanuts, soybeans, dry beans, broad beans, dry peas, chickpeas, and lentils) still represent an important component of the human diet in several areas of the world, especially in the developing countries. Legumes are foods rich in proteins and fibers and have a low glycemic index. Moreover, they contain sizeable amounts of B vitamins, especially folate, as well as important minerals such as, calcium, magnesium and potassium. All these attributes result in their recommendation by several diabetes guidelines (Becerra-Tomás, Babio, Martínez-González, Corella, Estruch, Ros, et al., 2016). Additionally, whole grains and legumes contain a complex mixture of phytochemicals possessing potent antioxidants. Lately, their high nutritional value is gaining great interest in developed countries as well due to the elevating demand for healthy food and plant-based proteins (Bouchenak & Lamri-Senhadji, 2013). As far as Europe is concerned, legume consumption has increased in the last decade to 3.9 kg per capita/year. However, there are large differences between countries with Greece, Portugal, and Spain holding the highest annual consumption of approximately 6 kg per capita. It has been demonstrated that frequent legume consumption (four or more times weekly compared with less than once a week) can been associated with 22% and 11% lower risk of coronary heart disease and cardio vascular disease, respectively (Bouchenak & Lamri-Senhadji, 2013). In recent studies, consumption of legumes has been linked with a decreased risk of colorectal cancer that is globally recognized as the second most common type of cancer both in men and women. The two group of substances that are responsible for this effect are proteins and fibers and their mechanism of action is probably mediated by the intestinal microbiota composition (Aranda-Olmedo & Rubio, 2020). Grains constitute a common source of proteins; energy from the carbohydrates; dietary fiber; B-group vitamins, vitamin E; minerals such as iron, zinc, magnesium, phosphorus; as well as phytoestrogens, lignans, phenolic compounds and phytic acid. However, the concentration of many these compounds is decreased during the milling process. Consequently, the consumption of carbohydrate-rich foods produced from whole grains is recommended (Gaesser, 2019. In a previous review on a number of studies regarding the effect of whole grain consumption in lowering cardiovascular risk it was demonstrated that the overall risk reduction ranged from 20% to 40% (Jacobs Jr & Gallaher, 2004). Moreover, studies have shown that whole grain foods consume less water, provide more food and less waste, and sustain better land use and healthy soil. An excellent example of products made from whole grain flour is the Creatan rusks, known as 'Dakos'. These are bakery items traditionally made in the Greek island of Crete and have been recognized by the European Union (EU) as Protected Geographical Indication products. 'Dakos' consists of whole barley (40–60%), whole wheat (20–30%) and refined wheat (20–30%) flour and in this context it can be an important source of barley β-glucans (Lazaridou, Marinopoulou, Matsoukas, & Biliaderis, 2014). To this end 'The Whole Grain Initiative' arose in 2017, aiming to increase consumption of whole grains (Figure 8.4) (http://www.wholegraininitiative.org/en/#).

A B

Figure 8.4. Traditional breads, cereal grains, and legumes are typical in the Mediterranean Diet. (A) By Mae Mu (B) V2osk, Unsplash License.

3.4 Wine

Figure 8.5. Moderate wine consumption in meals is common in Mediterranean countries. By Julia Kuzenkov, Unsplash License.

Among other products, wine (Figure 8.5) can be considered as one of the typical components of the Mediterranean diet (with the exception of muslim countries). Moderate consumption of alcohol has been associated with the reduction of cardiovascular diseases and the consumption of wine by the french has been proposed as the explanation for the low cardio vascular disease mortality rates (Muñoz-Bernal, Coria-Oliveros, de la Rosa, Rodrigo-García, del Rocío Martínez-Ruiz, Sayago-Ayerdi, et al., 2021). The beneficial effects of wine consumption on prevention of vascular disease have been considered to be partly attributed to the effects of ethanol on HLD-cholesterol, platelets and coagulation. However, there is clear evidence that the protective effects of red wine are not exclusively due to alcohol but mostly due to the high levels of polyphenols that exhibit potent antioxidant properties and scavenging of hyperoxides (Román, Jackson, Gadhia, Román, & Reis, 2019).

3.5 Fruits, vegetables and wild edible plants

It is apparent that regular consumption of fruit and vegetables (Figure 8.6) is one of the cornerstones of a healthy diet and has been recommended to the general public to reduce the risk of cardiovascular diseases and cancer (Aune, Giovannucci, Boffetta, Fadnes, Keum, Norat, et al., 2017). In a previous review that included 95 epidemiological conducted in 18 countries across seven world regions it was showed that moderate consumption (3–4 servings per day) of fruits, vegetables, and legumes was associated with reduced risk of 27% to 39% of cardiovascular events, stroke and 35% reduction of mortality. The comparison was made to low consumption of less than 1 serving/day (Miller V, Mente A, Dehghan M, & al., 2017). Moreover, the high fiber content of the Mediterranean diet contributes to long-lasting feeling of satiety and as a result to a lower energy intake and better weight control (Diekmann, Wagner, Huber, Preuß, Preuß, Predel, et al., 2019). Recently, wild edible species have gained a lot of attention due to their long documented therapetic uses. The Mediterranean basin can be characterised by amassive abudance of such species and among the most promising ones for cultivation, Sinapis arvensis L., known as charlock mustard and Allium ampeloprasum, known as broad leaf wild leek are included. However, concerns about safety issues, yield, and the phytochemical profiles of these species, makes it crucially important to establish a large-scale methodology of cultivation (Ceccanti, Landi, Benvenuti, Pardossi, & Guidi, 2018).

A

B

Figure 8.6. Mediterranean area is plenty of fruits diversity and wild plants. By (A) Markus Spiske (B) Alexander Schimmeck, Unsplash License.

3.6 Fish

Another basic characteristic of the Mediterranean diet is the low consumption of meat and meat products and increased consumption of fish. At the same time, the Mediterranean sea is characterized by a variety of fish and it has been demonstrated that Mediterranean seafood species are an excellent source of omega-3 fatty acids (Figure 8.7). This applies particularly to the pelagic fish species such as sardine, anchovy, mackerel, and bluefin tuna; and crustaceans such as lobsters and crabs. The muscle (i.e. the edible part) of these pelagic fishes and crustaceans can contain up to 10 times more of total lipids and omega-3 fatty acids than that of demersal fish species (Simopoulos, 2016). Since certain important diseases such as depression and Cardio vascular disease share similar underlying biological risk factors such as inflammation and low levels of omega-3 PUFAs, it is apparent that the consumption of fish as recommended by the Mediterranean diet can be beneficial (Parletta, Zarnowiecki, Cho, Wilson, Bogomolova, Villani, et al., 2019).

A B

Figure 8.7. Mediterranean sea contains high varieties of fishes and crustaceans. (A) Pau Casals (B) Diane Helentjaris, Unsplash License.

strength

Typical Mediterranean diet foods are high in healthy compounds.

Seasonal foods contain the highest content in nutritive and healthy compounds.

4. Mediterranean diet and sustainability

Because eating is essential for human survival, the production of food to meet the needs of the increasing world population is an imminent challenge (Armanda et al., 2019; Guiné, et al., 2020b). The global population is constantly increasing and, according to estimates, from 7.7 billion people worldwide in 2019 it could rise to around 8.5 billion by 2030 and up to 9.7 billion by 2050. Indubitably, providing sufficientand healthy food to the global population will be a growing concern for all governments.

Nowadays, food systems around the world are far from sustainable, having high impact on the environment and society. Agriculture occupies about 40% of global land, food production contributes to climate change (is responsible for about 30% of global greenhouse gasemissions), and 70% of freshwater use, highly impacts land, water and energy usage (accounts for 70-80% of all human withdrawals) and is an important cause of water pollution and loss of biodiversity (Garnett, 2013; Hoek et al., 2017; Tilman& Clark, 2014)

Therefore, changes in food production and consumption to a more sustainable approach are required in order to achieve food and nutrition security (Serra-Majem, Tomaino, Dernini, Berry, Lairon, de la Cruz, et al., 2020). Other important aspects to have in mind when analyzing the sustainability of food supply chains is the inequality at global scale, characterized by

insufficient food intake in underdeveloped countries and excessive food in developed countries (Waterlander et al., 2018). Food waste is also an important concern that needs urgent intervention, since about 1/3 of the world food production is wasted (1.3 billion tons/year) (FAO, 2011). In Europe, approximately 88 million tons/year of food are wasted, with losses occurring along the entire food supply chain including the final intervenients (families generate 47 million tons/year of food waste) (European Food Information Council, 2017). Hence, it is pivotal to adopt more sustainable food systems and dietary patterns.

Indeed, there is a growing interest on a shift towards more sustainable food systems and dietsand in that respect the interest in Mediterranean diet as a model of a sustainable dietary pattern has increased (Truzzi, Puviani, Tripodi, Toni, Farinetti, Nasi, et al., 2020). According to the definition by the Food and Agriculture Organization (FAO) "Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources (FAO, 2010).

Therefore, food policy, dietary guidelines and food security strategies need to evolve from the limited historical approach, to a new one where other factors such as the environmental, socio-economic and cultural impact are considered. The environmental impact of a large number of food products has been estimated by using three indexes: i) the Carbon Footprint that measures the amount of greenhouse gases that are released during the whole life cycle assessment of the product ii) the Water Footprint index that is defined as the quantity of water sent during the life cycle of a product and iii) the Ecological Footprint index that estimates the quantity of production area employed by an entity to generate the resources consumed and to absorb the created wastes (Behrens, Kiefte-De Jong, Bosker, Rodrigues, De Koning, & Tukker, 2017). Based on such findings the model of the double pyramid has been proposed as shown in Figure 8.8.

It is pretty apparent that the Mediterranean diet by promoting the high consumption of fruits and vegetables and low consumption of meat fits perfectly to this double pyramid model. Previous studies have showed that shifting to a Mediterranean dietary pattern in Spain could reduce the environmental impact; -72% land use, -58% energy, -52% water and -33% consumption (Berry, 2019). Meat production has a higher environmental impact than fruit and vegetables production. Meat and dairy products are responsible for 14% of the total amount of Greenhouse gases produced by human activities. To be more precise seasonal vegetables produce 815 g/kg of CO_2 while poultry meat produces 4000 gr of CO_2 for the same amount. Similar trends are observed regarding water consumption and ecological footprint. Other attributes of Mediterranean diet such as the seasonal consumption of local products, the biodiversity, the minimal food preservation-processing techniques, the methods of cooking, moderation in portion sizes, and the small amount of waste due to frugality positively contribute towards this. Moreover, the production of many fresh and/or specialized local delicacies produced in certain areas by small usually family owned businesses contribute to the sustainability of the rural areas (Vasilopoulou, Dilis, & Trichopoulou, 2013). These actions support locally produced foodstuffs that are grown and processed relatively nearby to where they are sold thus saving transportation resources while fullfiling the term "local" that has been trendy for more than a decade. Consequently, it can be affirmed that Mediterranean diet can meet both nutritional and environmental requirements for a growing world population while reducing the pressure of food and agricultural systems on the environment.

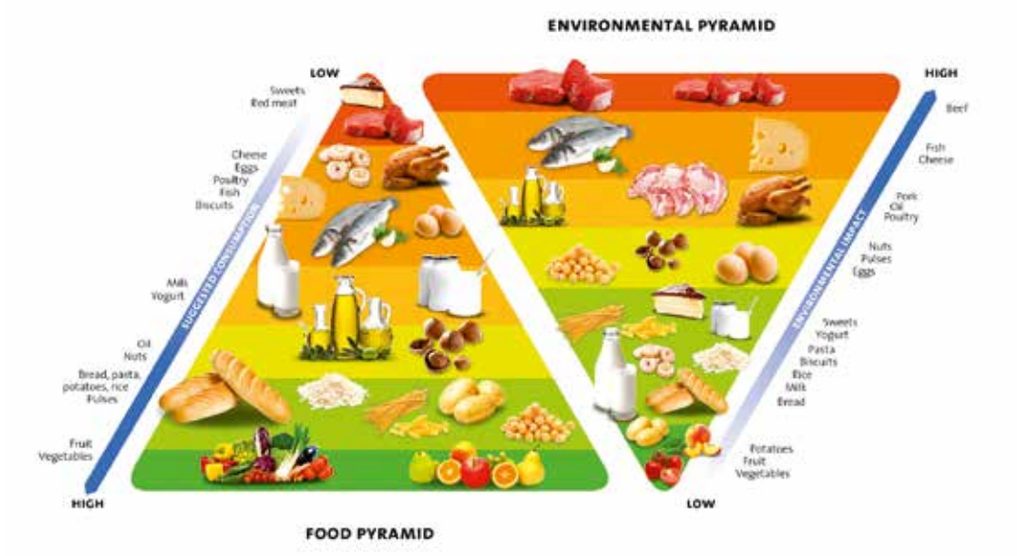


Figure 8.8. The double food and environmental pyramid model developed by the Barilla Center for Food and Nutrition (Lin & Krochta, 2005)(https://www.barillacfn.com/).

Food production contributes up to 30% to greenhouse emissions.

About 1/3 of the world food production is wasted (1.3 billion tons/year)

Inequality at global scale, is characterized by insufficient food intake in underdeveloped countries and excessive food in developed countries.

Mediterranean diet has a low environmental impact.

Mediterranean diet promotes seasonal and local food contributing to the development of rural areas.

Food system needs transformation towards sustainable diets.

Environmental, socio-economic and cultural impacts needs to be considered.

5. Dietary patterns and eating habits

5.1. Human diets

Eating is a basic requirement of humans but the eating patterns are not only shaped by physiology, since many other factors have a decisive influence over what people eat. Additionally, those factors are characterized by highly complex interactions that in each person produce specific eating habits (WHO, 2018). Nevertheless, there are some groups of individuals that share common eating habits thus giving place to some recognized dietary patterns, such as for example specific diets aimed at certain health benefits or sustainable diets aimed at preserving the environmental balance (Krause et al., 2015; Moro, 2016; van Bussel et al., 2019)

Healthy diets are aimed at providing the body with the necessary macro and micro nutrients for body functioning, as well as some bioactive compounds that bear additional benefits for those who consume them. They are called healthy because they protect against many of the non-communicable diseases like diabetes, obesity, heart and cardiovascular diseases or cancer (WHO, 2018). Presently, people are increasingly concerned about the association between the quality of their diet and its effect on their health (van Buul et al., 2017)" Still, even having this knowledge, some consumers continue to make unhealthy food choices, because the knowledge about the benefits of a certain diet is less valued than the pleasure or convenience of eating less healthy options (Mai & Hoffmann, 2014; Guiné et al., 2019) Dietary patterns correspond not only to eating certain types of foods, but also relate with the amounts consumed, the relative proportions of certain food items or categories, frequency of consumption, variety and combinations. Dietary patterns can be specific from a certain cultural background or from a geographical region, like for example the Mediterranean diet, or be adopted at global scale, like for example vegetarianism. Regardless of being based on certain rules and assumptions, dietary patterns encompass everyday food choices (Papavagelis et al., 2018; Guiné et al., 2020c; Nezlek & Forestell, 2020)

5.2. Food Choices

In the course of one single day, individuals are confronted with multiple food choices that they do not even realize most of the times, since many of those choices are done at sub conscience levels. Food choice is undoubtedly a most complex system influenced by a series of diverse factors, some of them related to the product, others connected with the consumer and others associated with the consumption context (Kaya, 2016; Pelly et al., 2018; Stasi et al., 2018). People's food choices and the factors that may regulate what they select to consume are important from many perspectives, including the economic, social or health points of view (McGuire, 2016; Cabral et al., 2019; Guiné et al., 2020c).
Food choices are influenced by many different determinants, such as hunger, biology, sociodemographic factors, health status, knowledge about health or nutrition, cognitive and affective aspects, including emotions and sensory perceptions, socioeconomic aspects linked with society, culture, convenience and price, ethical or political concerns, and also environmental factors (Sleddens et al., 2015; Kullen et al., 2016; Cunha et al., 2018; Guiné et al., 2020d). Hence, decisions about food and what to eat depend on the individual's physical and psychological factors, cultural background, beliefs and values, but also on the present socioeconomic status and possible marketing influences (Köster, 2009; Rozin, 2007; Sobal&Bisogni, 2009). Nevertheless, food choices are not static and even for the same person they change according to the situation or during that person's lifetime (Guiné et al., 2020d; Monteleone et al., 2017).
Guiné et al. (2019) studied the eating motivations in some Mediterranean countries (Croatia, Egypt, Italy, Greece and Portugal), and reported that in all those countries the motivations related to health as well as environmental and political aspects were the more relevant to influence people's eating habits. On the contrary, aspects linked with price, availability, emotions, society, culture, religion, marketing or advertising campaigns were not so determinant. A similar study by Boustani & Guiné (2020) conducted in another Mediterranean country also showed that the health and the environmental and political motivations were the most important for Lebanese people. In a study conducted in France by Mathé (2009) it was reported that consumers concerned with environmental sustainability, worker's rights and animal welfare triplicated (from 7% to 20%) in about a decade (1995 to 2007).

5.3 Consumer behavior towards sustainable food consumption

The impact of consumer behavior is most important in the food supply chain. Sustainable consumption or green consumer behavior is related with customers' choices towards the refusal to buy and consume products known as harmful to the environment. As alternatives, they choose to consume products that have minimal environmental impacts and that contribute positively to the global sustainability. It has been reported that an increasing number of people are taking these aspects into account when making their food choices (Asian et al., 2019; Taghikhah et al., 2019; Guiné, et al., 2020a). Guiné et al. (2020b) investigated the influence of environmental concerns in the food choices of people from 16 countries, and they found that a high number of people already shape their diets so as to minimize environmental impacts. In particular, they pay attention to aspects such as opting for foods proper from the season or that conform with sustainable processing and packaging. When it comes to food waste, consumers tend to avoid it at home but they are not yet much concerned about the food waste generated along the food chain or the surplus in the food service providers, like restaurants (Guiné, et al., 2020b). Ferrão et al. (2020) studied the sustainability motivations for food choice in Portugal and reported that these are influenced by multiple sociodemographic factors, but also by professional areas and whether people are or not responsible to purchase their food. The more sustainable consumers are those who buy their own food, of older age, more educated and with professions related to food or agriculture (Ferrão et al., 2020).
Sustainable food choices in line with the Mediterranean diet can contribute significantly to reduce the impact over the environment. As an example, changing dietary patterns so as to reduce the amount of meat and dairy products consumed can diminish greenhouse gas emissions and land use. Also, a worldwide adoption of more vegetable based diets (flexitarian, vegetarian or vegan) like the Mediterranean diet would reduce Greenhouse gases emissions related to diet by 41-74% (FAO, 2020; Sarić et al., 2020)

6. Adherence to the Mediterranean diet

The Mediterranean diet is traditionally followed by people in some countries situated around to the Mediterranean Sea and,as referred to earlier in this chapter, it is characterized by certain fundaments, not all related to the food but also related with culture and society (Trichopoulou et al., 2003; Ostan et al., 2015; Boccardi et al., 2018; Thodis et al., 2018). There is abundant scientific evidence showing that the adherence to the Mediterranean diet is associated with many diverse health benefits, like, for example, a lower incidence of diabetes (Sánchez-Hernándezetal., 2020), obesity (Tuncay&Ergoren, 2020), cancer (Schulpen & van den Brandt, 2020), cognitive diseases (Paknahad et al., 2020) or cardiovascular diseases

A B C

Figure 8.9. Different market spots in the Mediterranean countries. By (A) Victoriano Izquierdo (B) Tara Clark (C) Renate Vanaga, Unsplash License.

(Asbaghi et al., 2020). The sunny climate should not be ignored since it allows people to synthesize vitamin D that is considered to be a hormone thus affecting many cell functions by being involved in gene expression.

The review by Sánchez-Sánchez et al. (2020) highlights the major role of Mediterranean diet on some non-communicable diseases, while the review by Yannakoulia et al. (2015) focuses on the effect of Mediterranean diet on cognitive health and the reviews by Farràs et al. (2020) and Maruca et al. (2019) evidence the role of Mediterranean diet on cancer. Omega-3 fatty acids, probiotics, fibers, polyphenols and other antioxidants as well as exercise are some of the key components that contribute to a successful aging (Spencer, Korosi, Layé, Shukitt-Hale, & Barrientos, 2017). On the contrary, higher amounts of saturated fatty acids and sugars, ingredients commonly found in western diets, are associated with higher anxiety in older adults (Masana, Tyrovolas, Kolia, Chrysohoou, Skoumas, Haro, et al., 2019). Despite the plethora of research studies, the exact mechanisms of action are not yet fully understood, and various hypotheses have been proposed to explain the potential beneficial effects of the Mediterranean diet. Among them, a connection between the Mediterranean diet and the gut microbiota started gaining interest lately and is under investigation (Cani & Van Hul, 2020). Table 8.1 shows some research works developed regarding the adherence to Mediterranean diet and the health effects observed. However, despite the recognized benefits of the Mediterranean diet, some people are not following the traditional dietary patterns and they introduce unhealthier foods, such as low nutrient dense foods. Sometimes it is difficult to follow a recommended dietary pattern because the decision making process to adopt a specific dietary regimen involves different interrelated factors (Guiné et al., 2019). For these reasons, in some countries around the Mediterranean Sea the adherence to the Mediterranean diet is no longer so vast, while, on the other hand, this dietary pattern has spread to other parts of the globe due to its recognized benefits (Romanidou et al., 2020; Schulpen & van den Brandt, 2020).

Dietary scores have been reported as useful tools to measure the adherence to Mediterranean diet. Several Mediterranean Diet Scores (MDS), have been developed worldwide to quantify adherence to the Mediterranean diet. The first and most frequently used was developed by Trichopoulou et al. (1995), and was based on data obtained from a complete dietary assessment. Nevertheless, this methodology is highly resource and time consuming which led to the development and validation of alternative short screeners for rapid assessment of Mediterranean diet adherence (Abu-Saad et al., 2019). Nevertheless, the use of these MDS for different populations across countries with different cultures is questionable, since they may not entirely reflect the particular characteristics of each ethnic or social group, particularly when there is no geographical or cultural proximity. The systematic review by Zaragoza-Martí et al. (2018) revealed that the most valuable Mediterranean diet adherence scores were those presented by Panagiotakos et al. (2006), Buckland et al. (2009) and Sotos-Prieto et al. (2015).

In Spain, the PREDIMED score measures the adherence to Mediterranean diet though 14 items (Guasch-Ferré et al., 2017; Martínez-González et al., 2012), being this instrument also used in Portugal (Sousa, 2018). In Italy, an alternative score was used (aMED) based on a 9 points scale (Gnagnarella et al., 2018). In Greece, the ATTICA intervention measured adherence to Mediterranean diet with a Mediterranean Diet Score composed of 55 items (Panagiotakos et al., 2006, 2015). In Israel the I-MEDAS score was used, based on 17 items (Abu-Saad et al., 2019).

The studies about adherence to the Mediterranean diet show the usefulness of this dietary pattern, however the adoption of such dietary principles is not so vast as desired, even around the Mediterranean, from where it is original. Although it is reported that in the South of Spain, in general the population follows the Mediterranean diet (Mariscal-Arcas et al., 2010), a study undertaken in Spanish university students revealed that only 5% of them had dietary patterns corresponding to the Mediterranean diet (García-Meseguer et al., 2014). In Portugal, the study by Sousa (2018) revealed that only 9.5% of the 346 participants had a good adherence to the Mediterranean diet. Works report that in Greece there is a lower adherence of younger people to the Mediterranean diet. Papadaki and Mavrikaki(2015) reported that the adherence of

HEALTH EFFECTS STUDIED	REFERENCES
Cardio metabolic health Cardiovascular disease, Coronary heart disease, blood glucose, insulin resistance/diabetes, blood pressure, triglycerides, C-reactive protein, high-density lipoprotein-cholesterol (HDL), ratio total cholesterol/HDL	(Romanidou et al., 2020) (Hodge et al., 2018) cardiovascular disease (Park et al., 2017) (Amato et al., 2020) the scientific interest and advocacy of dietary variety as a potentially healthy eating habit gradually faded, until its complete oblivion in the latest European cardiovascular prevention guidelines. Our study aims to investigate whether dietary variety adds to the "Mediterranean-ness" of the diet in protecting against coronary heart disease (CHD) (Strengersetal., 2020) this study aimed to investigate the association between adherence to a Mediterranean-style diet, reflected by modified Mediterranean Diet Scores (mMDS) (Kouvarietal., 2020)
Cognitive health Mental health, depression, cognitive functions, Alzheimer, Parkinson,	(Parlettaetal., 2017) (Sanchez-Flacketal., 2020) (Románetal., 2019) (Paknahadetal., 2020)
Cancer Overall cancer risk, prostate, breast, head and neck, lung, gastrointestinal (esophageal, gastric, colorectal),	(Kenfieldetal., 2014) (Schulpen & van den Brandt, 2020) (Schulpenetal., 2019) (Seethaleretal., 2020) possibly due to a favorable fatty acid (FA) (Benitoetal., 2019) few studies have analyzed the relationship between Mediterranean diet and the risk of developing head and neck cancer (HNC) (Gnagnarellaetal., 2013) we invited asymptomatic volunteers, aged 50 years or more, current smokers or recent quitters, who had smoked at least 20 pack-years, to undergo annual low-dose computed tomography. We assessed participants' diet at baseline using a self-administered food frequency questionnaire and calculated their average daily food intake using an ad hoc computer program and determined their alternate Mediterranean diet (aMED) (Agnolietal., 2013)

Greek adolescents to the Mediterranean diet is low (21%), and found that the adherence was higher for participants living with both parents, residing in a smaller city and whose mother's educational level was higher, while age, hours of computer and lack of physical activity were negatively correlated with adherence to Mediterranean diet. The study by Theodoridis et al. (2018) made on 236 Greek university students revealed aMEDAS score for the whole sample equal to 6.4 ± 1.9 (on a 9 pints scale), with higher adherence for women or students from dietetics. In South Italy, the adherence to the Mediterranean diet decreased from 1985 to 2006 (Veronese et al., 2019). The study by Annunziata et al. (2019) revealed that, for a sample of 37,544 Italians, the degree of adherence to the Mediterranean diet was medium to low (average score of 1.56, on a scale from 0 to 4). In Turkey, Yalcin et al.(2018) also observed a low score for adherence to Mediterranean diet in a sample of 3,688 participants.

Due to the recognized and fully proven health benefits associated with the Mediterranean diet, this dietary pattern has spread to other regions of Europe and even the world. Nevertheless, adopting the Mediterranean diet outside the Mediterranean region bears some challenges related with established eating patterns, cultural differences, lack of education and knowledge about the Mediterranean diet and possible increased costs (Tsofliou et al., 2020). In the Netherlands, adherence to Mediterranean diet was assessed through the aMED score in the works by Schulpen et al. (2019) and Schulpen and van den Brandt (2020). The work by McClure and Villani (2019) evaluated adherence to Mediterranean diet in a sample of Australian older adults. Stradling et al. (2020) investigated the effects of a Mediterranean diet intervention in patients with HIV in the United Kingdom. In the United States, the modified Mediterranean diet score (mMDS) was constructed purposely to measure adherence to the Mediterranean diet in firefighters (Yang et al., 2014). The work by Muros et al. (2017) refers to the adherence of children to Mediterranean diet in Chile.

Conclusion

Food choices are influenced by many and diverse factors while more recently the sustainability issues have been assuming a more prominent role when it comes to choose what to eat. To follow the principles of the Mediterranean diet is among the sustainable food choices that contribute towards eliminating the impact of the food systems on the environment. The Mediterranean diet has been proven to have several health benefits while also promoting an environmentally friendly food consumption pattern. However, there are many aspects limiting the adherence to the Mediterranean diet, such as personal decision making processes linked with societal elements and lifestyle, culture, education, but also convenience or marketing in the global environment. Educational interventions could be a step towards improving adherence to the Mediterranean diet, especially among school age children and their parents.

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