



## Conference on ‘Nutrition dynamics in Africa: opportunities and challenges for meeting the sustainable development goals’

# Mediterranean food consumption patterns: low environmental impacts and significant health–nutrition benefits

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The Mediterranean dietary patterns comply better with recommended nutrient and micro-nutrient intakes. The Mediterranean diet (MD) was associated with reduced mortality and lower risk for metabolic chronic diseases. It has also low ecological, carbon and water footprints due to its high share of plant-based foods. In fact, the share of plant-based dietary energy is higher in the Mediterranean than in Northern Europe. The Mediterranean hotspot is a major centre of plant and crop diversity. Mediterranean people gather and consume about 2300 plant species. This review paper aims at highlighting the nutrition–health benefits of the MD and analysing the main environmental impacts of the Mediterranean food consumption patterns. There is a growing body of scientific evidence that the MD has significant health–nutrition benefits and low environmental footprints, so there is urgent need to reverse the ongoing erosion of the MD heritage and to promote it as a sustainable diets model.

### Mediterranean: Food: Consumption: Nutrition: Health

Since ancient times, nutrition has always played an integral part in the pursuit of human health (cf. Hippocrates, Plato, Galen)<sup>(1)</sup>. Nutrition is central in the prevention of food-related non-communicable diseases representing an important health risk factor and an enormous socio-economic burden for Mediterranean societies. Nevertheless, assessment of food systems and diets sustainability should take into account not only their health benefits but also their environmental impacts. According to the FAO<sup>(2)</sup>: ‘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...’. The Mediterranean diet (MD) was first presented by Ancel Keys in the 1960s<sup>(3)</sup>. The MD includes lots of olives and olive oil, fruit, vegetables and wholegrain cereals, low-fat dairy, fish, nuts, and legumes but relatively little red meat<sup>(4)</sup>. The MD was inscribed, in November 2010, on the Representative List of the Intangible Cultural Heritage of UNESCO. The nomination was

supported by Italy, Spain, Greece and Morocco. Cyprus, Croatia and Portugal joined in 2013. Nevertheless, the MD is a common and shared cultural heritage of all Mediterranean people and countries.

The way food is produced, processed, distributed and consumed determines its environmental impacts or footprints. Environmental impacts refer to the ecological footprint (EF)<sup>(5–8)</sup>, carbon footprint<sup>(9)</sup> and water footprint<sup>(10,11)</sup>.

This review paper provides insights about the nutrition–health benefits of the MD and highlights its low environmental footprints, thus making the case for the urgency of its promotion among the Mediterranean population.

### Mediterranean food consumption patterns

According to FAO<sup>(12)</sup>, dietary energy in the Mediterranean ranges from 2176 in Palestine to 3694 energy/d

**Abbreviations:** EF, ecological footprint; MD, Mediterranean diet; MDP, Mediterranean dietary pattern.

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**Table 1.** Nutritional benefits of adherence to the Mediterranean diet. Percentages (%) of participants who did not comply with recommended nutrient intakes according to quintiles (Q) of adherence to the Mediterranean (MDP) and Western (WDP) dietary patterns calculated through the probabilistic approach

Micro nutrients	Zn	Iodine	Vitamin E	P	Mg	Fe	Vitamin B <sub>12</sub>	Vitamin B <sub>6</sub>	Vitamin B <sub>3</sub>	Vitamin b <sub>2</sub>	Vitamin B <sub>1</sub>	Vitamin A	Se	Vitamin C	Folic acid
<b>MDP</b>															
Q1	8	9	94	0	21	20	1	2	0	1	2	23	4	8	19
Q2	4	8	93	0	12	13	1	0	0	1	1	15	2	4	16
Q3	3	9	92	0	8	12	1	0	0	1	1	11	2	3	15
Q4	2	7	90	0	5	8	1	0	0	0	0	7	1	2	12
Q5	1	7	89	0	2	3	1	0	0	0	0	4	2	1	10
<b>WDP</b>															
Q1	3	4	91	0	3	8	1	0	0	0	0	4	2	1	13
Q2	2	6	92	0	5	11	0	0	0	0	0	6	1	1	11
Q3	3	8	92	0	8	12	1	0	0	1	1	10	2	2	13
Q4	4	9	92	0	11	14	1	1	0	1	1	13	2	4	16
Q5	5	14	92	0	21	13	1	1	0	1	2	27	4	10	20

per person in Greece. In general, dietary energy is higher in northern Mediterranean countries. The share of plant-based energy in the diet; cereals, vegetable oils (including olive oil), roots and tubers, fruit and pulses, in the Mediterranean is generally higher than 50%; ranging from 80.7% in Egypt to 46.6% in Cyprus. In general, that share is higher than in northern and central Europe and North America (e.g. USA). Generally speaking, it is higher in eastern and southern Mediterranean countries rather than northern ones, while intermediate values are recorded in the Balkans. The largest share of plant-based energy is derived from cereals (from 21.5% in Spain to 63.7% in Egypt)<sup>(12)</sup>.

#### Biodiversity and diversity of plants consumed in the Mediterranean

The Mediterranean Basin Biodiversity Hotspot is the third richest hotspot in the world in terms of its plant biodiversity<sup>(13)</sup>. Approximately 30 000 plant species occur, and more than 13 000 species are endemic to the hotspot<sup>(14)</sup>. The Mediterranean Basin Biodiversity Hotspot is a centre of plant endemism, with 10% of the world's plants<sup>(15)</sup>. About one third of the foodstuff that is used by humankind comes from the Mediterranean climatic region, if not strictly from the topographic basin proper<sup>(16)</sup>. Barley, wheat, oat, olives, grapes, almonds, figs, dates, peas and other innumerable fruit, vegetables and medicinal or aromatic herbs are derived from wild plants found in the Mediterranean region<sup>(17)</sup>.

In the Mediterranean region, a diet has been created over centuries that is unique in its tremendous diversity<sup>(18)</sup>. Even within the same country, significant dietary differences can be seen. For instance, in Italy, cereals, fruit and vegetables consumption is higher in the southern part of the country<sup>(19)</sup>. Dietary polymorphism in the Mediterranean region partially reflects religious and cultural differences<sup>(20)</sup>. Local foods represent a type of mutual interaction between the availability of locally growing and edible plants, and the nutritional

requirements and needs of populations. In general, wild varieties tend to be richer in micronutrients and bioactive secondary metabolites than cultivated ones<sup>(21)</sup>. Ethnobotanical research has identified about 2300 different plant and fungi taxa that are gathered and consumed in the Mediterranean<sup>(22)</sup>.

#### Nutrition and health benefits of the Mediterranean diet

People adhering to the Mediterranean dietary pattern (MDP) comply better with recommended nutrient and micronutrient intakes (Table 1). A wide variety of foods in the MD minimises the possibility of nutrient deficiencies. A higher adherence to the MDP has been associated with a better nutrient profile, i.e. a lower prevalence of individuals showing inadequate intakes of micronutrients in comparison with other patterns such as the Western pattern<sup>(23)</sup>. Plant-origin foods represent the core of the MD and provide key nutrients, fibre and protective substances that contribute to general well-being, satiety and the maintenance of a balanced diet<sup>(24)</sup>.

The health benefits of the MD came to public attention with the Seven Countries Study led by Ancel Keys. The first results of the Seven Countries Study<sup>(25)</sup>, 12 763 subjects aged 40–59 years in sixteen cohorts of seven countries (USA, Finland, The Netherlands, Italy, former Yugoslavia (Croatia and Serbia), Greece and Japan), were that overall mortality and especially mortality for chronic degenerative diseases was higher among countries consuming a typical Westernised diet, and, by contrast, countries consuming a typical MD had the lowest rates of mortality. Inhabitants of Southern European and North African regions surrounding the Mediterranean Sea have a longer life expectancy and lower risk of chronic diseases than in other regions of the world<sup>(26)</sup>. A meta-analysis of fifty studies, including half a million subjects, has confirmed that eating a MD has a wide variety of health benefits for lifestyle diseases, especially CVD and diabetes<sup>(4)</sup>. The beneficial role of the MD with regard to mortality from all causes, CVD and cancer<sup>(27)</sup>, as well as

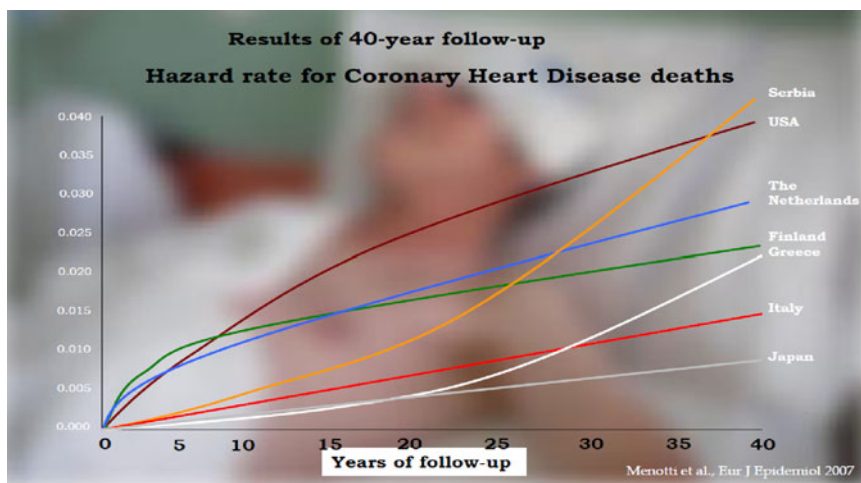


Fig. 1. Evolution of hazard rate for CHD in seven countries over a 40-year period. Source: Menotti *et al.*<sup>(41)</sup>.

obesity and type 2 diabetes<sup>(28,29)</sup> and degenerative diseases has already been reported.

Major biopathophysiological mechanisms include antioxidant and anti-inflammatory effects of the foods included in the MDP<sup>(28,30–33)</sup>. Foods eaten in the Mediterranean region have many health benefits as they are rich in antioxidants, carotenoids, monounsaturated fats, phytochemicals, etc. (Fig. 1).

A meta-analysis on MD and health status showed that adherence to a MD can significantly decrease: the risk of overall mortality; mortality from CVD; incidence of or mortality from cancer and incidence of chronic neurodegenerative diseases (i.e. Parkinson and Alzheimer)<sup>(27)</sup>.

Olives and olive oil are a key component in the MD and a key contributor to the healthy aspects attributed to it<sup>(34)</sup>. The benefits of olive oil are attributed primarily to the high level of oleic acid as well as the powerful phenolic antioxidants, which are specific to olives alone. The antioxidants and polyphenols from olive oil, in addition to vitamin E and vitamin C, have been shown to decrease incidences of disease including CHD and cancer. Virgin olive oil has a greater concentration of phenols and is a source of thirty phenolic compounds<sup>(35)</sup>. Olive oil is a crucial element of the MD, not only for its inherent nutritional effects but also the cumulative benefits of the foods that are typically prepared with olive oil (e.g. vegetables, fish)<sup>(34)</sup>.

#### Environmental footprints of Mediterranean food consumption patterns

The Mediterranean EF of consumption is always higher than the EF of production, except for Serbia. The carbon footprint alone is generally higher than the biocapacity<sup>(7)</sup> (Fig. 2).

In general, the northern Mediterranean countries have a higher EF with respect to North Africa and Middle East ones. EF of production and consumption as well as carbon footprint of North American countries are

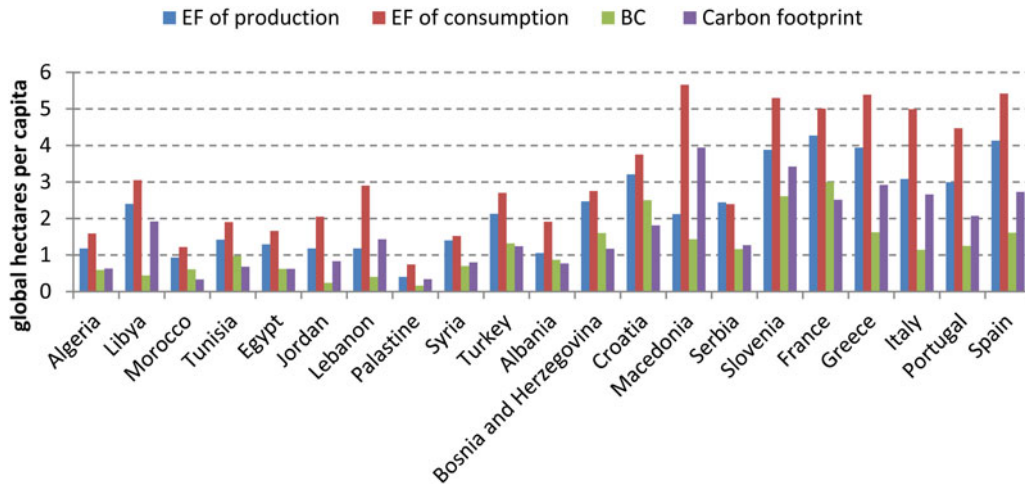
higher than in Mediterranean countries, even northern ones. The cropland EF is the highest in Mediterranean countries. In general, the EF *per capita* in the Mediterranean increased in the period 1961–2007, while the biocapacity decreased, thus the ecological deficit increased. On average, the EF has increased by 47.4%, while the biocapacity decreased by 36.4%. The Mediterranean countries have a net demand on the planet: on average, 2 years and 3 months are needed to regenerate the resources used for production, while 3 years and 4 months are needed to regenerate the resources effectively consumed<sup>(7)</sup>.

Red meat is the food with greatest ecological impact, while fruit and vegetables have a decidedly limited impact<sup>(36)</sup>. In general, lower is the animal food consumption and also lower is the environmental impact. The livestock sector is an important driver of deforestation, land degradation, pollution, climate change, erosion, etc.<sup>(37)</sup>.

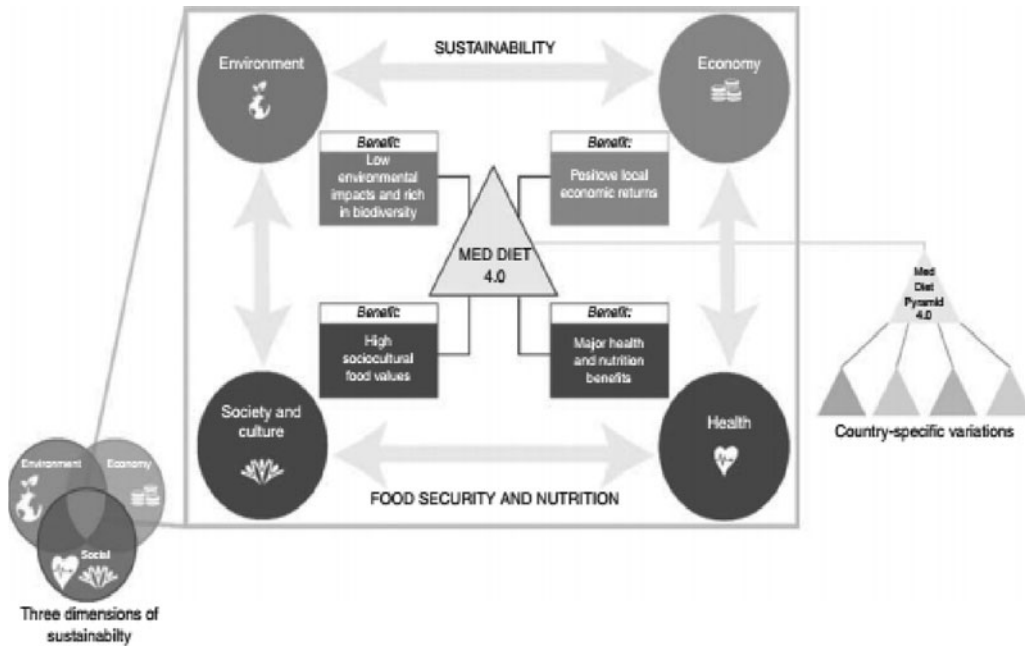
In the Mediterranean, water resources are limited and unevenly distributed. Food supply directly translates into consumptive water use. Water requirements for plant and animal products vary widely<sup>(38)</sup>. Countries of the north Mediterranean have higher water footprint of consumption per year and *per capita* (2279 m<sup>3</sup>) compared with North Africa (1892 m<sup>3</sup>), Balkans (1708 m<sup>3</sup>) and Middle East (1656 m<sup>3</sup>). Most of the water footprint of consumption is due to agricultural products consumption (average is about 91% of the total water footprint of consumption): 96% in North Africa, 93% in Middle East, 82% in Balkans and 91% in northern Mediterranean. Net virtual water flow between 1995 and 2005 in the Mediterranean is positive except in Tunisia, Syria and Serbia<sup>(10)</sup>.

#### The Mediterranean diet: beyond health and environmental benefits

The food pyramid that reflects MDP has been associated with good health<sup>(39)</sup> but also respects the environment.



**Fig. 2.** Ecological footprint (EF) of production, EF of consumption, biocapacity (BC) and carbon footprint (CF) in the Mediterranean region. Source: Adapted from Ewing *et al.*<sup>(7)</sup>.



**Fig. 3.** Med Diet 4.0 framework showing the four benefits of the Mediterranean diet. Source: Dernini *et al.*<sup>(40)</sup>.

Reclassifying foods on the basis of their negative effect on the environment produces an environmental pyramid. When the environmental pyramid is brought alongside the food pyramid, it creates a food–environmental pyramid called the double pyramid. It shows that those foods with higher recommended consumption levels in the MD are also those with lower environmental impact<sup>(37)</sup>. Dernini *et al.*<sup>(40)</sup> presented recently the Med Diet 4.0 framework (Fig. 3) in which the well-documented health and nutrition advantages of the MD are incorporated with three additional sustainable benefits: low environmental impacts and rich in biodiversity, high socio-cultural food values and positive economic return locally.

### Conclusions

The traditional MD offers considerable nutrition and health benefits, especially in the prevention of major chronic diseases. It has also lower environmental impacts (ecological, carbon and water footprints) than northern Europe and American diets. In fact, by using less meat and animal products, MD reduce health impacts of meat consumption and environmental impacts of livestock sector on biodiversity and natural resources (e.g. water, land). Therefore, adopting the MDP means reconciling personal well-being (personal ecology) with the environment (ecological context). However, there is an ecological deficit in the Mediterranean since the EF of

consumption is higher than the biocapacity. Furthermore, population increase, especially in the southern and eastern Mediterranean countries, will increase pressure on the limited and scarce Mediterranean natural resources in particular water. Therefore, actions and measures aiming at MD safeguarding and sustainability should be promoted. Moreover, the MDP should be promoted as a cornerstone in public health strategies and sustainable diets should become central in sustainable development policies.

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#### Conflicts of Interest

None.

#### Authorship

Y. A. and H. E. provided the drafts. R. C. has enriched and reviewed the paper.

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