

# Importance of functional foods in the Mediterranean diet

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## Abstract

*Objective:* Analyse the importance of components of Mediterranean diet in functional feeding.

*Design:* We have based the study in a bibliographic review.

*Results:* Many of the characteristic components of the traditional Mediterranean diet (MD) are known to have positive effects on health, capacity and well-being, and can be used to design functional foods. Vegetables, fruits and nuts are all rich in phenols, flavonoids, isoflavonoids, phytosterols and phytic acid—essential bioactive compounds providing health benefits. The polyunsaturated fatty acids found in fish effectively regulate haemostatic factors, protect against cardiac arrhythmias, cancer and hypertension, and play a vital role in the maintenance of neural functions and the prevention of certain psychiatric disorders. Accumulating evidence suggests that olive oil, an integral component of the MD, may have health benefits, including the reduction of the risk of coronary heart disease, the prevention of several types of cancer and the modification of the immune and inflammatory responses. Olive oil is known for its high levels of monounsaturated fatty acids and is a good source of phytochemicals, such as polyphenolic compounds, squalene and  $\alpha$ -tocopherol. In the context of the MD, the benefits associated with the consumption of several functional components may be intensified by certain forms of food preparation. In addition, the practice of more physical activity (once common among Mediterranean populations) and the following of other healthy lifestyle habits may have additive effects.

*Conclusions:* The identification of the active constituents of the MD is crucial in the formulation of appropriate dietary guidelines. Research into the pharmacological properties of the minor components of this diet (vitamins, sterols, polyphenols, etc.) is very active and could lead to the formulation of functional foods and nutraceuticals.

**Keywords**  
 Functional foods  
 Mediterranean diet  
 Fruits  
 Vegetables  
 Cardiovascular disease  
 Cancer  
 Degenerative diseases  
 Antioxidant capacity

## Introduction

The Mediterranean diet (MD), a dietary pattern detected in the olive-growing areas of the Mediterranean (mainly Greece, Spain, Italy and France) in the late 1950s and early 1960s, is a very healthy dietary model. Numerous epidemiological studies have shown that the people of Mediterranean countries have a longer life expectancy and a lower risk of suffering certain chronic diseases<sup>1–3</sup>, including cardiovascular disease, metabolic disorders and certain types of cancer<sup>4–8</sup>. Many authors have underlined the beneficial role of the MD on lipid metabolism, blood pressure<sup>6,9</sup>, body mass index<sup>6,7</sup>, inflammation and coagulation<sup>8</sup>.

## Importance of functional components in the Mediterranean diet

The traditional MD is characterised by an abundance of vegetable foods, such as bread, pasta, vegetables, legumes, fruits and nuts. Olive oil is the main source of fat, and the intake of fish, poultry, dairy products and eggs

is moderate. In addition, variable amounts of wine are usually consumed with meals<sup>3</sup>. Many of the characteristic components of the MD are functional components with positive effects on health, capacity and well-being; these may be responsible for the advantages associated with this diet<sup>10–13</sup>.

- Nuts in particular are rich in phenols, flavonoids, isoflavonoids, phytosterols and phytic acid, and have been linked to reductions in plasma lipids and protection against cardiovascular disease<sup>3</sup>.
- Vegetables are the most important sources of phenolic compounds in the MD. Flavonoids in particular are thought to be essential bioactive compounds that provide health benefits<sup>14,15</sup>.
- Several carefully studied Mediterranean and Asian populations, whose traditional diets consist largely of foods of vegetable origin, show low incidences of certain chronic diseases and enjoy long life expectancies<sup>13</sup>. Many case-control and prospective studies have provided evidence that a high consumption of plant foods confers numerous health benefits. There

is evidence to support links between increased vegetable, fruit and fibre consumption and a lower incidence of certain cancers, coronary heart disease, neural tube defects and cataracts. Although the mechanisms are not fully understood, carotenoids, folic acid and fibre, all of which are abundant in the MD, appear to play important roles in the prevention of coronary artery disease<sup>13</sup>.

- Vegetables are also an important source of phytoosterols, the intake of which is associated with a reduction in serum cholesterol levels and of cardiovascular risk. This could be of great importance in developed societies in which cardiovascular disease is the main cause of death<sup>16</sup>.
- Fruits also provide fibre, as well as vitamins, minerals, flavonoids and terpenes, many of which provide protection against oxidative processes<sup>3</sup>. Due to the phytoestrogenic substances they contain, an increased consumption of fruits, vegetables, whole grains and pulses (common in the MD) may offer an alternative to hormone replacement therapy in menopausal women. In the intestine, these compounds turn into oestrogen and help counteract the hormonal deprivation suffered at menopause. Several types of flavone and isoflavone purified from habitually consumed Mediterranean vegetables have been shown to possess this oestrogenic activity<sup>17</sup>.
- The polyunsaturated fatty acids found in fish (eicosapentaenoic and docosahexaenoic acids) effectively regulate haemostatic factors, and provide protection against cardiac arrhythmias, cancer and hypertension. They also play a vital role in the maintenance of neural functions and the prevention of certain psychiatric disorders<sup>3,18</sup>.
- Accumulating evidence suggests that olive oil, an integral component of the MD, may have health benefits, including the reduction of coronary heart disease risk, the prevention of several types of cancers and the modification of the immune and inflammatory responses<sup>19</sup>. It also appears to have a role in bone mineralisation (thus reducing the risk of osteoporosis). Olive oil is known for its high levels of monounsaturated fatty acids and it is a good source of phytochemicals, such as polyphenolic compounds, squalene and  $\alpha$ -tocopherol. This food therefore has several components that contribute to its overall protective effect<sup>19</sup>.
- Phenolic compounds have been shown to inhibit LDL oxidation *in vitro* and *ex vivo*<sup>20</sup>. In a dietary intervention involving volunteers, foods rich in phenolic compounds affected LDL composition. No changes were observed in the short term, but after 1 week of olive oil consumption and following the MD, changes in the LDL composition became apparent<sup>20</sup>.
- The dairy products characteristic of the MD, such as cheese and yoghurt, are better tolerated by lactose-

intolerant individuals. In addition, lactic acid bacteria confer probiotic benefits, including improvements in gastrointestinal health and of the immune response<sup>21</sup>. The consumption of yoghurt might induce favourable changes in the faecal bacterial flora and have a positive effect on colon cancer risk indices. It may also help regulate mouth to caecum transit time<sup>21,22</sup>.

- Garlic, onions, herbs and spices are used as condiments in the MD, and may increase the nutritional value of food. Some also contain large quantities of flavonoids (fennel, chives, etc.) or allicin (raw garlic and onion); the latter may have cardiovascular benefits and help improve cognitive function<sup>3</sup>. The caper, *Capparis spinosa* L., which is found all over the Mediterranean basin and is consumed in salads or on pizzas, etc. has been used in traditional medicine for its diuretic and anti-hypertensive effects, and to treat certain conditions related to uncontrolled lipid peroxidation<sup>15</sup>. Caper extract contains flavonoids (kaempferol and quercetin derivatives) and hydrocinnamic acids with known anti-inflammatory and antioxidant effects. Panico *et al.*<sup>15</sup> concluded capers to have a chondroprotective effect; they might therefore be of use in the management of cartilage damage during the inflammatory phase.
- Some of the beneficial effects of the MD with respect to human disease have been attributed to the polyphenols in red wine. The antioxidant activity of these compounds may also be responsible for the cytoprotective action of red wine reported in some papers<sup>23,24</sup>. Wine exerts its protective effect *via* the induction of changes in the lipoprotein profile, coagulation and fibrinolytic cascades, platelet aggregation, oxidative mechanisms and endothelial function. The endothelium regulates vascular tone by delicately balancing vasorelaxation (nitric oxide, NO) and vasoconstriction (endothelins) factors (produced by the endothelium itself) in response to different stimuli. Wine and other grape derivatives exert an endothelium-dependent vasorelaxatory effect *via* the NO-stimulating activity of their polyphenol components. Under experimental conditions, resveratrol (a stilbene polyphenol) was found to protect the heart and the kidneys from ischaemia-reperfusion injury *via* its antioxidant activity and the upregulation of NO production. Red wine, dealcoholised wine extract and even purple grape juice have all been reported to have positive effects on endothelial function<sup>24</sup>. It is likely that regular and prolonged moderate wine drinking positively affects endothelial function. The beneficial effects of wine on cardiovascular health would, of course, be greater if associated with a healthy diet. The most recent nutritional and epidemiological studies show that the ideal diet closely resembles the MD<sup>24</sup>.

### Health benefits of Mediterranean diet

Greater adherence to the MD has been associated with a lower incidence of degenerative disease, in particular cardiovascular disease and cancer<sup>11,25,26</sup>. Pitsavos *et al.*<sup>11</sup> studied the effect of the MD on total antioxidant capacity (TAC) in 3042 subjects who had no clinical evidence of cardiovascular disease. Adherence to the MD was found to be positively correlated with TAC. The subjects in the highest dietary score tertile had, on average, 11% higher TAC levels than those in the lowest tertile, even after adjustment for confounding factors. Additional analysis showed that TAC was positively correlated with the consumption of olive oil, and of fruit and vegetables, and inversely associated with the consumption of red meat<sup>11</sup>. In another study, a nutritional intervention programme promoting the MD food pattern was effective in modifying the food habits of healthy women, and after 6 weeks resulted in small but significant benefits with respect to certain cardiovascular risks (lower total cholesterol and apolipoprotein B levels, and lower body mass index)<sup>2</sup>.

Several unmodified MD foods with functional properties may protect against type 2 diabetes, including polyunsaturated fat products, vegetables, fruit, whole-grain foods and low glycaemic index starchy foods<sup>12</sup>.

Obesity and excess body weight are frequently addressed with diets that reduce calorie intake but which are unbalanced. Usually, these diets involve increasing the consumption of fats and proteins and reducing the intake of carbohydrates<sup>27</sup>. Approximating the diet to the MD profile could, however, help in weight control as well as provide nutritional and health improvements<sup>28,29</sup>.

Recurrent myocardial infarction, total cardiovascular events, and cardiac and overall death are significantly reduced in patients recovering from myocardial infarction, who habitually follow the MD. It is also known that fruits and legumes (which have a pivotal role in the MD), reduce serum homocysteine concentrations (tHcy) in men<sup>26</sup>, and consequently the risk of coronary events, especially in high-risk individuals. Dedoussis *et al.*<sup>1</sup> report, however, that the effect of the methylenetetrahydrofolate reductase gene–MD interaction on tHcy concentrations is independent of fruit and vegetable consumption. This implies that other foods in the MD may play a role in tHcy reduction.

Adherence to the MD is inversely associated with both systolic and diastolic blood pressure. Vegetables, fruit and olive oil (which induce a high ratio of monounsaturated to saturated lipids) appear to be chiefly responsible for the apparent protection offered by the MD against hypertension. Plant foods have high potassium, magnesium and calcium contents which tend to reduce arterial blood pressure. The high antioxidant content of plant foods and olive oil may also contribute to the health of the vascular system. In addition, the relatively high intake of fish and seafood in the MD is associated with reduced systolic blood pressure<sup>18</sup>.

Some components of the MD diet may also help improve cognitive function and mood. In particular, some flavonoids (which are frequently found in vegetables and fruits) have anti-depressant activity<sup>30</sup>.

### The effect of preparation methods

How the components of the MD diet are prepared may be important from a health and functional point of view. For example, the addition of olive oil to tomatoes during cooking greatly increases the absorption of lycopene (a carotenoid that reduces the risk of certain cancers and heart disease)<sup>31</sup>.

The results highlight the importance of cuisine (i.e. how a food is prepared and consumed) in determining the bioavailability of dietary carotenoids, such as lycopene<sup>31</sup>.

Ninfali *et al.* investigated the antioxidant capacity of different salads, and salads to which aromatic herbs had been added. Lemon balm and marjoram at a concentration of 1.5% (w/w) increased the antioxidant capacity of salad portions by 150 and 200%, respectively. Olive oils and wine or apple vinegars were the salad dressings that afforded the greatest increase in antioxidant capacity<sup>14</sup>.

### Importance of monitoring the whole diet

Recently, Martínez-González and Estruch<sup>32</sup> underlined the need for randomised trials that investigate the whole diet rather than its components or supplements when evaluating the role of the diet in human health. In a recent review, Martínez-González and Sanchez-Villegas<sup>5</sup> indicated that not all components of the MD are protective, or at least may not provide equal levels of protection. Thus, since food items and nutrients could have a synergistic and antagonistic effect on health outcomes, the study of overall dietary patterns rather than single nutrients would appear appropriate. In a recent editorial, Trichopoulos and Lagiou<sup>4</sup> suggested that the evaluation of whole-diet patterns and the use of dietary scores would capture the extremes of dietary habits, pre-empt nutritional confounding, and avoid bias. Many of the health benefits associated with the intake of several MD functional foods are greater if these components are part of a healthy diet<sup>24</sup>.

### Importance of physical exercise

Finally, the original description of the MD involved the idea of extensive physical activity (mainly related to work and outdoor leisure activities)—something quite common among Mediterranean populations until the 1960s. Recovering a higher level of physical activity may provide benefits in addition to those associated with the regular consumption of functional ingredients<sup>33</sup>.

## Conclusion

In conclusion, adherence to a Mediterranean-style diet affords protection from degenerative diseases such as cardiovascular disorders and cancer. The identification of the active constituents of the MD is crucial to the formulation of appropriate dietary guidelines. Research into the pharmacological properties of the minor components of this diet (vitamins, sterols, polyphenols, etc.) is very active and might lead to the formulation of functional foods and nutraceuticals<sup>34</sup>. To achieve nutritional and health improvements in a population, it would seem a priority to improve the global diet, approximating it to the theoretical ideal of the MD. This should be coupled with an increase in physical activity. The foods showing the biggest gaps in terms of habitual and recommended intake (e.g. the intake of vegetables and whole-grain foods) deserve special correctional attention.

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