

## Mediterranean diet and longevity

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Mortality statistics from the WHO database covering the period 1960 to 1990 have provided intriguing evidence that something unusual has been affecting in a beneficial way the health of the Mediterranean population. In recent papers, which evaluated the evidence accumulated over the last three decades, it was concluded that the traditional Mediterranean diet meets several important criteria for a healthy diet. Direct evidence in support of the beneficial properties of the Mediterranean diet has also become available. These data were derived from three studies, which have used a diet score, devised *a priori* on the basis of eight desirable key features of the traditional common diet in the Mediterranean region. The conclusion of these studies is that a diet that adheres to the principles of the traditional Mediterranean one is associated with longer survival. The Greek version of the Mediterranean diet is dominated by the consumption of olive oil and by high consumption of vegetables and fruits. Antioxidants represent a common element in these foods and an antioxidant action provides a plausible explanation for the apparent benefits. Wild edible greens frequently eaten in rural Greece in the form of salads and pies contain very high quantities of flavonoids — considerably higher than those found in red wine or black tea. While there is no direct evidence that these antioxidants are central to the benefits of the Mediterranean Diet, indirect evidence from epidemiological data and the increasing understanding of their mechanisms of action suggest that antioxidants may play a major role.

### Mediterranean diet: Longevity: Antioxidants

Mortality statistics from the WHO database (WHO, 1993) covering the period 1960 to 1990 have provided intriguing evidence that something unusual has been affecting in a beneficial way the health of the Mediterranean populations, and in particular, with respect to coronary heart disease (CHD). Even though health care for many of these populations was inferior to that available to people in northern Europe and North America, and the prevalence of smoking was unusually high, death rates in the Mediterranean region were generally lower and adult life expectancy generally higher in comparison to the economically more developed countries of northern Europe and North America, particularly among men (Dalla-Vorgia *et al.* 1990; Willet, 1994), see Table 1.

### Mediterranean diet and longevity

Keys and his colleagues (1986) have hypothesized that the traditional Mediterranean diet (MD) has beneficial effects on a range of diseases, and they provided ecological evidence in support of their hypothesis with respect to CHD.

In recent papers, which evaluated the evidence accumulated over the last three decades, it was concluded that the traditional Mediterranean diet meets several important criteria for a healthy diet. Direct evidence in support of the beneficial properties of the Mediterranean diet has also become available. These data were derived from three studies (Trichopoulou *et al.* 1995a; Osler & Schroll, 1997; Kouris-Blazos *et al.* 1999) which have used a diet score, devised *a priori* on the basis of eight desirable key features of the traditional common diet in the Mediterranean region.

The traditional Mediterranean diet, may be thought of as having eight components: (1) high monounsaturated-to-saturated fat ratio, (2) moderate ethanol consumption, (3) high consumption of legumes, (4) high consumption of cereals (including bread), (5) high consumption of fruits, (6) high consumption of vegetables, (7) low consumption of meat and meat products, and (8) moderate consumption of milk and dairy products (Trichopoulou *et al.* 1995b).

In these studies it was hypothesized that a diet with more of these components has beneficial effects, whereas a diet with fewer of these components would be less healthy. These assumptions were based on the collective

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**Table 1.** Dietary characteristics and disease rates in US, Greece and Japan, in the 1960s

Dietary characteristics		US	Greece	Japan
Fat (% energy)		39	37	11
Saturated fat (% energy)		18	8	3
Vegetables (g/day)		171	191	198
Fruits (g/day)		233	463	34
Legumes (g/day)		1	30	91
Breads/cereals (g/day)		123	453	481
Potatoes (g/day)		124	170	65
Meat* (g/day)		273	35	8
Fish (g/day)		3	39	150
Eggs (g/day)		40	15	29
Alcohol (g/day)		6	23	22
Life expectancy/disease rates				
Life expectancy at age 45 in years	Males	27	31	27
	Females	33	34	32
Coronary heart disease	Males	189	33	34
	Females	54	14	21
Cerebrovascular diseases	Males	30	26	102
	Females	24	23	57
Breast cancer	Females	22	8	4
Stomach cancer	Males	6	10	48
	Females	3	6	26
Colon, rectal cancer	Males	11	3	5
	Females	10	3	5
Total cancer	Males	102	83	98
	Females	87	61	77

\* Poultry included.  
Source: Willet, 1994.

epidemiological and biological evidence as summarized in the report of the USA National Academy of Science (National Research Council, 1989) and other critical overviews (Willet, 1994).

Based on the principles of the traditional Mediterranean diet, the Supreme Scientific Health Council of the Ministry of Health and Welfare of Greece recently issued official dietary guidelines for adults in Greece (Supreme Scientific Health Council, 1999), see Fig. 1.

#### *The Greek study*

In the first study, data collected in three Greek villages provided the opportunity to evaluate prospectively the role of diet in the survival of elderly Greeks. The data was collected from 182 elderly residents as part of an international cross-cultural study of food habits in later life. Diet was assessed with a validated extensive semiquantitative questionnaire on food intake. A one-unit increase of the score, devised *a priori* on the basis of the eight component characteristics of the traditional diet common in the Mediterranean region, was associated with a significant 17 % reduction in overall mortality. This study provided the first direct evidence that MD favorably affects life expectancy among elderly people (Trichopoulou *et al.* 1995a)

#### *The Danish study*

Results of studies of Mediterranean diet in Mediterranean populations, however, may be confounded by the likely

association of adult diet with early life nutritional patterns and culture-specific psychosocial variables like social support. But a similar study performed in Denmark provided similar results.

This study examined the association of a Mediterranean dietary pattern with total mortality in a cohort of elderly people living in a North European Community. Diet and nutritional status were studied among 202 elderly men and women born between 1914 and 1918 and living in a Danish Municipality in 1988. They were followed for 6 years. A diet score, with seven dietary characteristics of the Mediterranean diet, was associated with a significant reduction in overall mortality. A one-unit increase in the diet score predicted a 21 % (95 % confidence interval 2–36 %) reduction in mortality. The authors agreed with us that a Mediterranean diet score predicts survival in a North European population (Osler & Schroll, 1997).

#### *The Australian study*

We have also undertaken a study in Australia among elderly Anglo-Celts and Greek-Australians with two objectives: (1) to examine whether the results from the studies in rural Greece and Denmark could be replicated in an urban setting in Australia, and (2) to examine whether the apparent benefits of the Mediterranean diet are transferable to population groups with very different dietary habits.

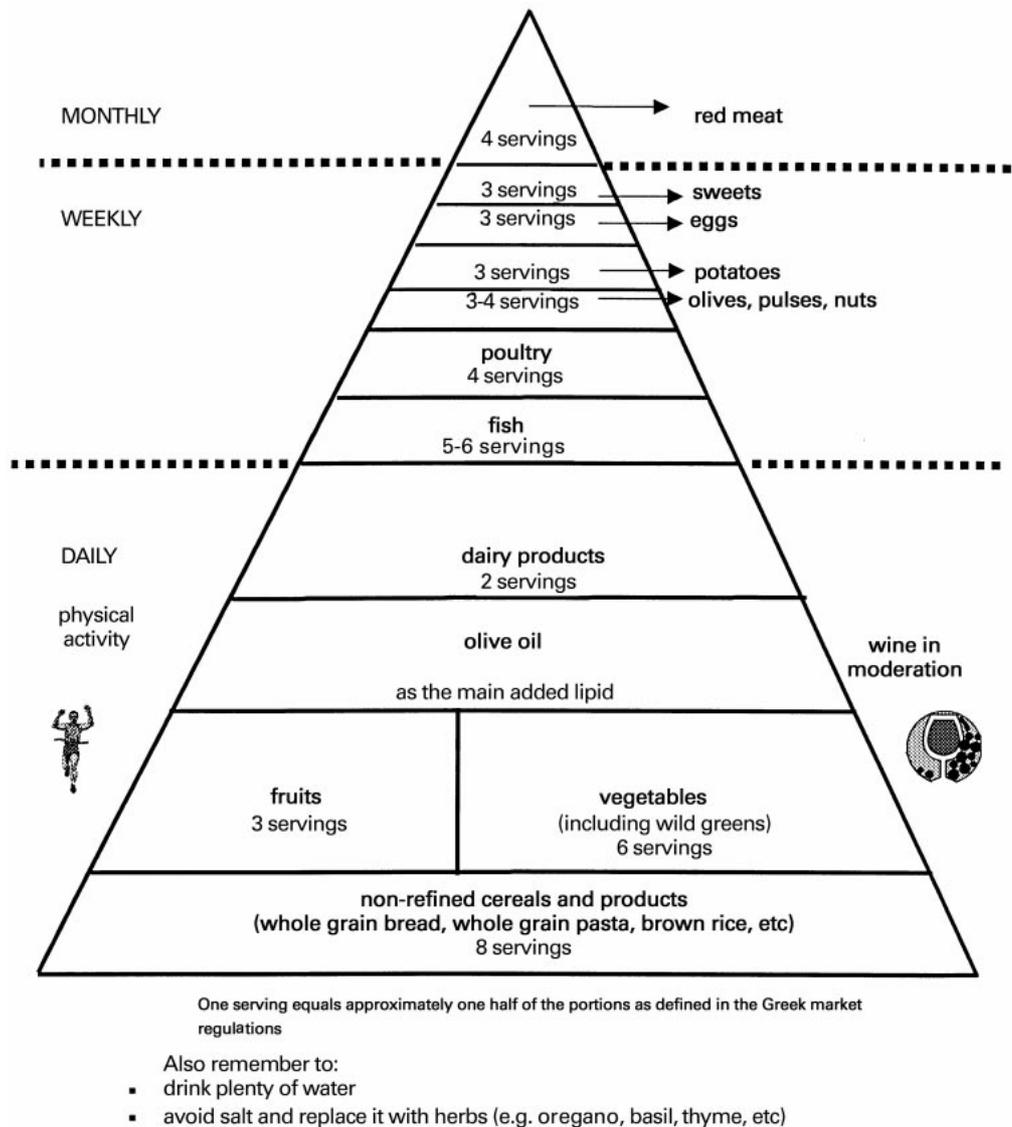
This study was undertaken in Melbourne, Australia and involved 141 Anglo-Celts and 189 Greek-Australians of both sexes aged 70 years or more. The objective was again to evaluate whether adherence to the principles of Mediterranean diet affects survival of elderly people in a non-Mediterranean country. A one unit increase in the diet score, was again associated with a 17 % reduction in overall mortality (two-tailed *P*-value 0.07). Mortality reduction with increasing diet score was at least as evident among Anglo-Celts as among Greek-Australians (Kouris-Blazos *et al.* 1999).

So we can conclude that a diet that adheres to the principles of the traditional Mediterranean one is associated with longer survival.

#### *Beneficial components of the Mediterranean diet*

It might be convenient, if not wholly accurate, to define the Mediterranean diet as the dietary pattern found in the olive growing areas of the Mediterranean region, in the late 1950s and early 1960s, when the consequences of World War II were overcome, but the fast-food culture had not yet invaded the area.

The traditional diets of Mediterranean countries are based on fruits, vegetables, seafoods, legumes and cereals and, of course, olive oil. Total fat may be high, around or in excess of 40 % of total energy intake in Greece. It should be remembered that consumption of added lipids in Greece is higher than the total fat intake in the United States (Byrd-Bredbenner *et al.* 2000), yet the incidence of heart disease and as well as colorectal, breast and prostate cancer is higher in the United States, suggesting that these



Source: Supreme Scientific Health Council, 1999

Fig. 1. The traditional Mediterranean diet pyramid depicting dietary guidelines for adults in Greece.

differences are not due to the amount of fat consumed but rather the type of fat and other components of the diet (Mattson & Grundy, 1985; Mensink & Katan, 1987; Trichopoulou, 1992).

The lasting, but only partly correct, conclusion, of the early studies launched by Keys (1980) in the 1950s, was that Mediterraneans were privileged by having low rates of coronary heart disease, simply because they consumed diets with low saturated fat content. The argument of several scientists from Mediterranean countries, that the diet of their region is more than a low saturated fat diet and has implications for diseases other than CHD, was lost in the wider scientific community (Trichopoulou, 1988). Olive oil remained in the shadow of the polyunsaturated fat-cholesterol debate.

#### *The role of antioxidants in the traditional Mediterranean diet*

The Mediterranean diet and, in particular the traditional Greek diet, is currently attracting considerable interest because of its likely health benefits. Olive oil is central to this diet but several authors have hypothesized (Willet, 1994; Trichopoulou & Lagiou, 1997a; Trichopoulou *et al.* 1998) that antioxidants may also be important mediators of the apparent health effects of this diet. Lionis and his colleagues (1998) have recently provided evidence in support of the antioxidant theory, by demonstrating that herb extracts in the island of Crete have high antioxidant capacity, as documented by decreased lipid peroxidation.

According to the legend, Aristeo, son of Apollo, was the

**Table 2.** Mean availability of olive oil and vegetables in ten European countries, circa 1990

	Belgium	Germany	Greece	Hungary	Ireland	Luxembourg	Norway	Poland	Spain	UK
Olive oil ml/person/day	0.58	N/A*	70	N/A*	0.06	1.6	0.15	N/A*	42	0.33
Vegetables g/person/day	162	141	267	201	130	180	102	202	180	158

\* N/A = not available.

Source: Trichopoulou & Lagiou, 1997b, 1998.

first to press olives. In fact, although most vegetable oils are extracted from seeds by solvents, olive oil is obtained from the whole fruit by means of physical pressure without the use of chemicals. During this procedure, all of the components of the drupe are transferred to the oil as opposed to seed-oils that are deprived of this important group during the various stages of refining. Thus, in addition to its high oleic acid content, olive oil contains a variety of other components that may have beneficial effects (Visioli & Galli, 1998). Especially, extra virgin olive oil contains a variety of minor components that produce its particular aroma and taste. Several of these components have antioxidative properties and amount to 50–800 mg/kg, depending on several key factors, such as the soil, degree of ripeness of the drupes, and the way the oil is produced and stored.

The Greek version of the Mediterranean diet is dominated by the consumption of olive oil and by high consumption of vegetables and fruits (Trichopoulou & Lagiou, 1997b; Trichopoulou & Lagiou, 1998), see Table 2. The data in Table 2 has been retrieved from the DAFNE food data bank (DAta Food NETworking) and they present the disparity in olive oil and vegetable consumption among ten European countries. It is evident that Greece and Spain are the two countries where the consumption of olive oil and vegetables is high.

In Greece, the consumption of vegetables includes the various wild greens, which are traditionally collected throughout Greece and consumed in various ways. They are usually prepared with virgin olive oil. The wild edible

greens frequently eaten in rural Greece in the form of salads and pies contain very high quantities of flavonoids, which are generally considered one of the most important categories of antioxidants in the human diet. (Trichopoulou *et al.* 1998, 2000), see Table 3.

Table 3 presents the flavonoid content of several edible wild greens of Greece and green pies (Trichopoulou *et al.* 2000) as well as, for comparative purposes, previously published results concerning the flavonoid content of selected fresh vegetables, fruits and beverages commonly consumed in Europe (Hertog *et al.* 1992; Hertog *et al.* 1993; Crozier *et al.* 1997; Justesen *et al.* 1998). It is clear that the edible wild greens have a considerably higher flavonoid content than an equal quantity of red wine or black tea, which are considered principle sources of flavonoids for North European countries.

### Conclusion

Until recently the valuation of the Mediterranean diet focused on the low content of saturated fatty acids and the high content of composite carbohydrates and dietary fiber. Recent studies imply that other compounds of the Mediterranean diet, the antioxidants, which exist in abundance in vegetables, fruit, beverages and also virgin olive oil, may contribute to the prevention of heart diseases and possibly several forms of cancer and other diseases, thus providing a plausible explanation for its apparent benefits.

As already indicated, fruits, vegetables and beverages

**Table 3.** Flavonoid content of Greek edible wild greens and green pies (in bold) and published data concerning selected fresh vegetables, fruits and beverages commonly consumed in Europe

Food 100 g	Myricetin mg	Quercetin mg	Kaempferol mg	Isorhamnetin mg	Luteolin mg	Apigenin mg
Contents are expressed as mg/100 g for solid foods, and as mg/100 ml for beverages						
<b>Fennel<sup>a</sup></b> ( <i>Foeniculum vulgare</i> Mill)	<b>19,8</b>	<b>46,8</b>	<b>6,5</b>	<b>9,3</b>	<b>0,1</b>	<b>&lt;0,07</b>
<b>Chive<sup>a</sup></b> ( <i>Allium schoenoprasum</i> )	<b>&lt;0,03</b>	<b>10,4</b>	<b>12,5</b>	<b>8,5</b>	<b>0,3</b>	<b>&lt;0,07</b>
<b>Annual saw-thistle<sup>a</sup></b> ( <i>Sonchus oleraceus</i> L.)	<b>3,6</b>	<b>16,0</b>	<b>3,8</b>	<b>0,7</b>	<b>6,5</b>	<b>3,8</b>
<b>Hartwort<sup>a</sup></b> ( <i>Tordylium apulum</i> )	<b>1,6</b>	<b>29,3</b>	<b>2,9</b>	<b>5,1</b>	<b>0,6</b>	<b>&lt;0,08</b>
<b>Corn poppy<sup>a</sup></b> ( <i>Papaver rhoeas</i> L.)	<b>1,1</b>	<b>26,3</b>	<b>2,3</b>	<b>1,1</b>	<b>0,2</b>	<b>0,1</b>
<b>Broad leaf dock<sup>a</sup></b> ( <i>Rumex obtusifolius</i> L.)	<b>5,7</b>	<b>86,2</b>	<b>10,3</b>	<b>&lt;0,03</b>	<b>&lt;0,02</b>	<b>&lt;0,05</b>
<b>Queen Anne's lace<sup>a</sup></b> ( <i>Daucus carota</i> )	<b>0,4</b>	<b>1,1</b>	<b>0,2</b>	<b>&lt;0,06</b>	<b>34,1</b>	<b>12,6</b>
<b>Cretan green pie<sup>a</sup></b>	<b>1,4</b>	<b>12,4</b>	<b>4,3</b>	<b>1,8</b>	<b>6,6</b>	<b>&lt;0,3</b>
Lettuce <sup>b</sup> ( <i>Lactuca Sativa</i> L. cv. <i>capitata</i> L.)	<0.1	1.4	<0.2	N/A*	<0.1	<0.2
Onion <sup>b</sup> ( <i>Allium cepa</i> L.)	<0.1	34.7	<0.2	N/A*	<0.1	<0.2
Endive <sup>b</sup> ( <i>Chicorium endiva</i> L.)	<0.1	<0.1	4.6	N/A*	<0.1	<0.2
Broad beans <sup>b</sup> ( <i>Vicia Faba</i> L.)	2.5	2	<0.2	N/A*	<0.1	<0.2
Celery <sup>b</sup> ( <i>Apium graveolens</i> var. <i>dulce</i> Pers.)	<0.1	<0.1	<0.2	N/A*	2.2	10.8
Apple <sup>b</sup> ( <i>Malus pumila</i> Mill.)	<0.1	3.6	<0.2	N/A*	<0.1	<0.2
Red wine <sup>b</sup>	0.9	1.1	<0.1	N/A*	<0.05	<0.1
Black tea <sup>b</sup>	0.25	2	1.4	N/A*	<0.05	<0.1
Apple juice <sup>b</sup>	<0.05	0.3	<0.1	N/A*	<0.05	<0.1

\* N/A = Not Available.

Sources: <sup>a</sup>(Trichopoulou *et al.* 2000). <sup>b</sup>(Hertog *et al.* 1992; Hertog *et al.* 1993; Crozier *et al.* 1997; Justesen *et al.* 1998).

Average values reported in these papers are given. Whenever average values of two or more papers were available, the lowest and highest averages are given.

contain a significant amount of flavonoids whereas the main polyphenolic compounds of virgin olive oil, which is the basis of the Mediterranean diet, also have antioxidant properties.

While there is no direct evidence that these antioxidants are central to the benefits of the Mediterranean Diet, indirect evidence from epidemiological data and the increasing understanding of their mechanisms of action suggest that antioxidants may play a major role. Ongoing research will help elucidate the role of antioxidants in the significant benefits of the traditional Mediterranean diet.

The Mediterranean diet and life-style were shaped by climatic conditions, poverty and hardship, rather than by intellectual insight or wisdom. Nevertheless, results from methodologically superior nutritional investigations have provided strong support to the dramatic ecological evidence represented by the Mediterranean natural experiment. The current momentum towards the Mediterranean diet has solid biological foundation and does not represent a transient fashion. We are now well under way to understand and explain what nature has been trying to tell us through the otherwise unexplained good health of the Mediterranean people.

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