Diet impacts on health and the environment: Exploring possible tools for improving sustainability

Food production and consumption, especially meat, are between the main sources of human pressure on the environment. This pressure is highly unsustainable in most European countries, as it affects crucial non-renewable resources, food security and human health, also. The direct cause is the huge growth of intensive animal production during the 20th century, which made animal products rather than cereals the chief protein source in most developed countries. As many people in developing Eastern countries use their growing income to follow this trend, the pressure will continue to increase. This makes it vital that people in most developed countries choose to eat smaller quantities of meat and more environmentally-friendly proteins, such as plant-based options or other novel protein sources. A change in individual behaviors and lifestyles is generally considered to be of vital importance for making the transition to a sustainable society. However, as research and practice over several decades have shown, lifestyles are generally not becoming more sustainable, nor are changes in that direction easily made. The adoption of a healthy dietary strategy is a win-win policy thanks to its benefits for both human health and environmental pollution

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Food consumption in Europe

Diets in most developed countries are characterised by high intakes of animal products, which lead to an intake of saturated fat intake well above dietary guidelines. Consumption of meat and dairy products are increasing worldwide in the last 4 decades (FAO, 2006; Kerney, 2010), which will probably aggravate the impact of livestock production on the environment (Godfrey et al, 2010; Thornton, 2010 Bowman et al, 2011). Concerns about animal welfare, reactive nitrogen and greenhouse gas emissions have stimulated public debate in Europe on eating less meat and dairy products (Deckers, 2010; Garnett 2011; Deemer and Lobao, 2011, Kristallis et al, 2012). Changing western diets may have positive outcomes for both human health and the environment (Friel et al., 2009; Hawkesworth et al, 2010). There have been numerous life-cycle analyses (de Vries and de Boer, 2010; Nijdam et al, 2012; Weiss and Leip, 2012), broad input-output analysis (Tukker et al, 2011) and global studies (Popp et al, 2010; Stehfest et al, 2009; 2013), but these studies all lack the actual implications for the regional agriculture.

There are some differences between old and new Member States in the EU. France, Denmark, Portugal, Sweden and Spain have the highest consumption of animal protein. Much lower consumption of animal proteins is generally found in the new Member States, where vegetable proteins consumption is higher than the Eu-

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ropean average. The difference between old and new Member States in total protein consumption – including vegetable protein – is therefore slightly less.
In particular, the Mediterranean diet was characterized historically by low meat consumption and a considerable fresh vegetable and fruits consumption. Recently, the Mediterranean diet has been partially abandoned in the Mediterranean countries (De Marco et al, 2014). In fact, the level of meat consumption in these countries is currently even higher than the European average. The southern Member States (including France) now are currently responsible for half the total meat consumption in the EU27, while their share of the EU population is only 38%. The highest meat consumption is found in Spain, followed by Austria and Cyprus. In these countries, the consumption of meat is around 65 kilograms, per capita per year. This is almost 25% higher than the European average (intake of 52 kilograms, per capita, corresponding to 86 kilograms in carcass weight). Pig meat is the most consumed type of meat in Europe, as it constitutes half of all the meat consumed. The most pig meat is consumed in countries with the highest levels of meat consumption, namely Austria and Spain.
Accounting for a quarter of the meat consumption, the share of chicken is currently greater than that of beef. Per-capita consumption is the highest in Cyprus, the United Kingdom and Hungary. France and Denmark have the highest beef consumption. Sheep and goat meat are not much consumed in Europe, and their consumption is mainly attributed to southern Europe and the United Kingdom. Prosperity is the main driver for increasing consumption of animal products.
In general, higher the income higher the consumption of animal proteins. The relationship between prosperity and levels of consumption of all animal products is generally clear although the different Member States show distinct consumption preferences. Looking at the individual products, for example pig meat or dairy products, the consumption seems less related to prosperity. However, rich countries with a relatively low meat consumption – such as Sweden, the Netherlands and Finland – show higher consumption levels of dairy products. In general, cultural aspects and the supply of nationally produced foods together determine the choice of the products.

The Mediterranean diet and the Mediterranean Adequacy Index

The Mediterranean diet has been recently inscribed on the Representative List of the Intangible Cultural Heritage of Humanity (Reguant 2009), after Barcelona Process in 1995, aimed at building a multilateral framework for ingoing dialogue and cooperation between the EU and its Mediterranean partners, with the objective of achieving a common area of stability and prosperity in the Mediterranean region (Dernini 2006). The Mediterranean diet is characterized by a nutritional model consisting mainly of cereals, fresh or dried fruit and vegetables, olive oil as the principal fat source, a moderate amount of fish, dairy products, meat and wine, all accompanied by spices. From the nutritional point of view, the Mediterranean diet has eight main components: high monounsaturated-saturated fat ratio, moderate ethanol consumption, high legumes consumption, high cereals consumption, high fruits consumption, high vegetables consumption, low meat and meat products consumption, and moderate milk and dairy products consumption (Trichopoulou et al. 1995a). Olive oil undoubtedly is the distinctive dietary element. Meat intake is sporadic, only a few times per month, with greater consumption of lamb, poultry, rabbit or fish. Eggs are included in the diet a few times per week. Yoghurt and cheese intakes are abundant in some countries (i.e. Greece, Cyprus and Turkey), primarily derived from goats and sheep, and milk consumption is less than current intakes. Moreover, moderate wine consumption, combined with an active lifestyle linked to work and transport patterns, completes the characteristic Mediterranean diet model (Serra Majem and Ribas 1995).
Adherence to a Mediterranean diet was defined through scores that estimated the conformity of the dietary pattern of the studied population with the traditional Mediterranean dietary pattern (Sofi et al., 2008). The adherence to the Mediterranean diet can be calculated by the Mediterranean Adequacy Index (MAI), as the ratio between the energy provided by Mediterranean and Non-Mediterranean food (Alberti-Fidanza et al. 1999; Alberti-Fidanza and Fidanza 2004; Fidanza et al. 2004; Alberti et al. 2009). As a consequence, high

values of MAI determine high adherence of alimentary habits to the Mediterranean dietary. We calculated the trend over time (from 1960 up to 2007) for MAI and another index, linked to Mediterranean habits, that is Mediterranean Fat Index (MFI), calculated as the ratio of fats intake by Mediterranean foods and non-Mediterranean ones. Trends for both indices are shown in figure 1. A clear declining trend is highlighted by the figure for the cluster representing Mediterranean countries for both indices, while only MAI is decreasing for eastern countries, and MFI is quite stable. Both indices are stable for north-European countries. The MAI trend in Mediterranean countries well describes the "westernization" of dietary habits occurred. Actually, even though starting from different values (3 for med countries and 0.8 for north countries, respectively) the MAI values are converging for both clusters. The declining of MAI in eastern countries can be related to the increased economic availability.

The demitarian diet

Demitarianism is the practice of making a conscious effort to reduce meat consumption largely for environmental reasons (Wikipedia). The term was devised in October 2009 in Barsac, France at the combined workshop of Nitrogen in Europe (NinE) and Biodiversity in European Grasslands: Impacts of Nitrogen (BEGIN) where they developed "The Barsac Declaration: Environmental Sustainability and the Demitarian Diet".

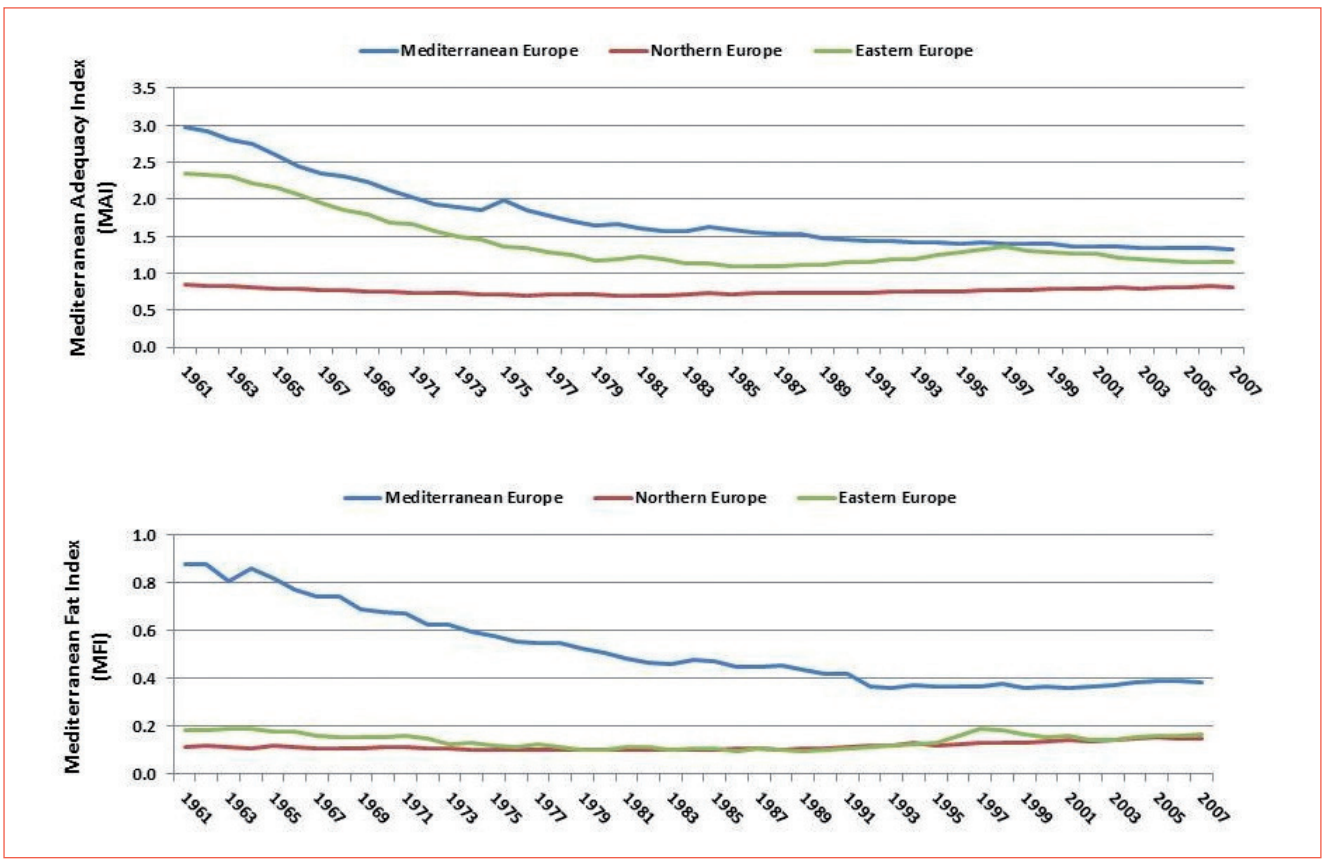

FIGURE 1 Trend of Mediterranean Adequacy Index (MAI) and Mediterranean Fat Index (MFI) from 1961 to 2007 for Mediterranean countries (blue line), eastern countries (green line) and northern countries (red line) in Europe
Source: FAOSTAT database, personal elaboration

The declaration was developed due to the implication of large scale animal farming as a primary contributor to disruptions in the nitrogen cycle and the subsequent effects on air, land, water, climate and biodiversity.
The term *demi* is from the Latin *dimedius* meaning half. The Demitarian diet is to literally "half" the standard portion of meat products that would be consumed in a regular meal. This portion is to be replaced with a correspondingly larger portion of vegetables or other food products.

Environmental impacts of food

Dietary habits affect the environment, also. In the context of this debate, the central question is: what would be the consequences for the environment and human health if consumers in an affluent world region were to reduce their meat and dairy intake? We here explore this question with a focus on the European Union (EU), a region that illustrates a high per-capita intake of animal protein compared with many other parts of the world. Recently, many works have been carried out regarding the potentiality of the diet to reduce greenhouse gases emissions, water consumption and ecological footprint. Anthropogenic emissions of greenhouse gases (GHGs) related to food production accounts for about 15% at a world level. Other studies (Carlsson-Kanyama 1998; Carlsson-Kanyama et al. 2003; Engstrom et al. 2007) have shown that food choices and diet can influence the energy requirements for the provision of human nutrition and the associated GHG emissions. Meals similar in caloric content may differ by a factor lasting from 2 to 9 in GHG emissions (Carlsson-Kanyama 1998; Engstrom et al. 2007). An analysis of the energy inputs showed that meals with similar nutritional value had a difference in GHG emissions of up to a factor of 4, depending on the items chosen (Carlsson-Kanyama et al. 2003). All of these studies identified certain foods as more resource demanding/polluting, including animal products and certain vegetable-intensive ways produced.
Concerning the high use of water resources for food production and consumption, a detailed analysis has been performed (Mekonnen and Hoekstra 2011). The authors found that the water footprint of the global average consumer in the period 1996-2005 was 1385 m^3/yr. About 92% of that water footprint is related to the consumption of farming, 5% to the consumption of industry and 4% to domestic water use. Literature evidence (Duchin 2005), studying diets from multiple viewpoints of sustainability, showed that the predominantly plant-based Mediterranean-type diet has a lower environmental effect than the current average US diet. The nitrogen footprint of meat and dairy products was much higher than that from plant-based food.
Recently Westhoek et al, 2014, demonstrated that if everyone in the European Union halved their meat and dairy consumption, this would cut GHGs from agriculture by 25 to 40%. One of the major barriers to action is the international trade in food commodities. The result is that countries fear that tackling nitrogen pollution will reduce their international competitiveness. The present study shows that there is huge power for pollution control in simply reducing our meat and dairy consumption. The authors expect widespread environmental gains from a switch towards a more plant-based diet. In fact agriculture is the major source of nitrogen pollution.
They expect the reductions in nitrogen emissions will benefit not only the EU but the entire European continent and the world. Both atmospheric ammonia and water-borne nitrates cross national frontiers, so altering European diets could help significantly to reduce international pollution, while cutting emissions of methane, nitrous oxide and carbon dioxide (all GHGs) is globally important. In the presented scenarios the EU would become a net exporter of cereals, and the use of soymeal would be reduced by 75%. The nitrogen use efficiency of the food system would increase from its current 18% to between 41% and 47%, depending on choices over land use.
For each country, four food consumption footprints have been calculated (water, nitrogen, carbon and ecological footprint, respectively). Figure 2 shows the graphs concerning the four footprints per geographic position. Since, for the year 2006, the agriculture sector accounts for 84% and 52% of CH_4 and N_2O emissions, we have analysed the carbon footprint for food consumption in EU countries. Figure 2 shows the differences among clusters: the food production and consumption car-

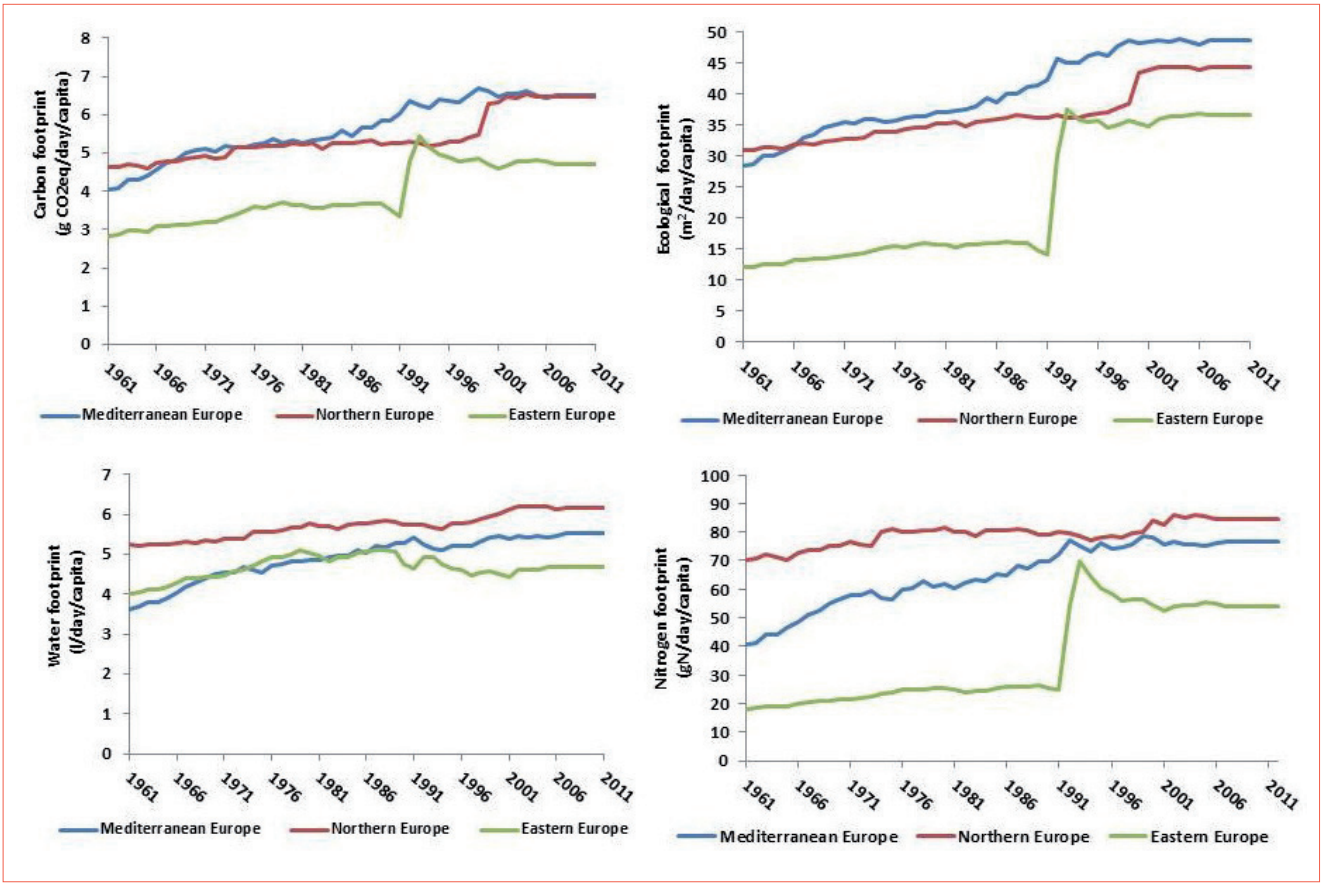

FIGURE 2 Trend for carbon, water, ecological and nitrogen footprints for food consumption for Mediterranean countries (blue line), eastern countries (green line) and northern countries (red line) from 1961 up to 2011
Source: FAOSTAT data, personal elaboration

bon footprints are lower in eastern and Mediterranean countries, compared to Northern ones.

Finally, as the agriculture accounts for almost all of the consumptive water use attributed to humans, the ratio between the total exploitable water is the most important resource indicator when dealing with food consumption.

The change in the commodities consumption is the result of changes in agricultural practices over the past 50 years, which have increased the capacity to provide food for people through increasing productivity, greater diversity of foods and less seasonal dependence. Food availability has also increased, as a consequence of rising income levels. In Eastern European countries almost all the commodities show a sudden rising trend in coincidence with the Berlin Wall fall: maybe this is due to an enhanced food availability or to a different system in collecting statistical data. The trends observed in the commodities consumption in the period 1961-2007 show a sort of "westernization" of dietary habits from Eastern and Mediterranean countries to Northern ones.

Changes toward a more plant-based diet could help substantially in mitigating emissions of GHGs, because the 24% of GHGs emissions (an average for all the selected countries) is due to food consumption. Unfortunately, this is a largely unexplored area of climate policy. Few authors have proposed changes that lower

meat consumption. For example, it has been suggested (Smil 2002) that because a large percentage of beef is consumed ground in hamburgers or sausages, the inclusion of protein extenders from plant origin would be a practical way to replace red meats. Recently (McMichael et al 2007) a 10% reduction in the current global average meat consumption of 100 g/person/day has been estimated as a working global target.

All the beneficial effects for the environment are associated with co-benefits for public health.

Concerning the ecological footprint, a change in dietary habits toward a Mediterranean (or more plant-based) diet is suitable, mostly for those countries having a food consumption footprint exceeding their biocapacities. More realistically, a change in food habits could results in a benefit for the environment, and this could lead to a reduction of the ecological footprint below the threshold linked to the biocapacity of a specific country. This is supported by the evidence that a return to the past food consumption, provided that the diet is nutritionally adequate, could result in an ecological footprint below the biocapacity. The production of fruits and vegetables and other plant-based foods is less resource-intensive than the production of meat and the former offer protection from the risk of cardiovascular diseases and some cancers. Production and consumption of fresh and unprocessed fruits and vegetables require less energy than production and consumption of processed foods, and confer additional health benefits (Duchin 2005).

Effects of food on human health

Food consumption is a very important factor in determining human health. In fact, comparing the cancer risk associated with many driver factors we can see that food is the most relevant parameter, with higher risk level than the smoking habit (Table 1).

The relationship between red meat consumption and colorectal cancer incidence is supporting this idea (De Marco et al., 2014). Furthermore, an increase in the consumption of Mediterranean food (olive oil, particularly) is very important for epidemiological evidence, because the negative effects of meat consumption could be balanced or deleted by introducing healthy food in the diet.

This concept is also supported by the evidence that colorectal cancer incidence is linked to animal protein intake, and not only in general protein intake, thus underlining the protective effects of vegetal protein consumption (De Marco et al., 2014).

From our analysis we did not find relationship between body mass index and Mediterranean Adequacy Index (unpublished observations), that is instead suggested from bibliographic evidences as one of the co-benefits of a healthy diet (Trichopoulou et al. 2007; Kastorini et al. 2011; Esposito et al. 2006; Toobert et al. 2007; Buckland et al. 2008). This result could be linked to other parameters affecting the body mass index, that do not allow to generalize our observation. The body mass index seems to be linked to differences in race, education, attitude to physical activity, culture, prevention, medical information and income availability of the country.

Meat and dairy product are rich sources of vitamins, vitamin B12 in particular, iron, calcium, zinc, and other compounds. In the EU, these products are also primary sources of energy and protein. The energy-intake is higher than necessary as many Europeans are overweight. Protein consumption is as much as 70% higher (Westhoek et al, 2011) than recommended in the WHO guidelines (threshold set to 18.5 kg/capita/year). Although there are differences in protein consumption levels among Member States, consumption levels in all are higher than it would be necessary.

Furthermore, there are some risks related to eating too

Type of exposition	Cancer risk
Food	35
Tobacco	30
Infections	10
Reproduction factors	7
Working activity	4
Geophysical factors	3
Environmental pollution	2
Drugs	1
Unknown	?

TABLE 1 Cancer risk associated with different pressure

many animal products. Although excessive consumption of red meat is related to an increase in cancer, the consumption of red meat in Europe is still twice as high as that recommended by the World Cancer Research Fund. Beef, pig, sheep, goat and horse meat are all red meats. The World Cancer Research Fund recommends that the average consumption of red meat should be no more than 16 kilograms per year, of which little to none should be processed meats (WCRF & AICR 2007).

Many people in Europe, however, eat much more than the recommended limit of 16 kilograms per year. On average, Europeans consume about 37 kilograms per capita of pig meat and beef. In the EU15 this is even as much as 39 kilograms. Austria leads with 50 kilograms per year, and Bulgaria consumes the least with 14 kilograms per year.

In addition, consumption of saturated fats should be limited according to WHO because of the increased risk of cardiovascular diseases. However, the consumption of saturated fats in Europe is currently 42% higher than the recommended maximum amount. The difference in the consumption of animal fats between EU countries is more than a factor of two. The per-capita consumption of animal saturated fatty acids is highest in Denmark and France. Only in Estonia and Bulgaria the consumption is less than the maximum recommended intake. Overall, the consumption of saturated fatty acids is more than the recommended maximum intake in most European countries. As 80% of saturated fats originate from animal products, a reduction in animal products is favourable to health. A shift in the consumption of proteins from animal products – which generally also contain high amounts of saturated fats – to vegetal products would be healthier.

A very large amount of papers has been published which evaluated the evidence accumulated over the last three decades and they conclude that the traditional Mediterranean diet meets several important criteria for a healthy diet (Keys 1980; Trichopoulou et al. 1995b; Osler and Schroll 1997; Kouris-Blazos et al. 1999; Corbalan MD et al. 2009). Direct evidence in support of the beneficial properties of the Mediterranean diet has also become available (Trichopoulou et al. 2007). Different Mediterranean-style diets have been shown as a safe strategy for the treatment of the metabolic syndrome (Kastorini et al. 2011), and for helping to reduce associated cardiovascular risk (Esposito et al. 2006; Goulet et al. 2007; Toobert et al. 2007; Buckland et al. 2008), also in children (Lazarou 2009). Indeed, greater adherence to the Mediterranean diet has been associated with a lower prevalence of abdominal obesity (Panagiotakos 2006), and recently it was proposed that the Mediterranean diet is particularly effective for glycaemic control (Shai et al. 2008). Moreover, results suggest that promoting eating habits consistent with Mediterranean diet patterns may be a useful part of efforts to combat obesity (Corbalan MD et al. 2009, Mendez et al. 2006). All the beneficial effects of the Mediterranean diet are linked to the high content of antioxidant and antitumor molecules in the Mediterranean food. For example, tomato has a very high content in lycopene (Agarwal et al. 2001), limonene is present in citrus (Wang et al. 1996), curcuma is abundantly present in turmeric (Egan et al. 2004). A special mention is due to grapes and olive oil. Grapes contain a very large amount of antioxidant molecules, like resveratrol (Costant 1997), quercetin (Fenech et al. 1997), and a lot of recent literature has been focused on antioxidant and beneficial effects of olive oil (Trichopoulou et al. 2007). Resveratrol in particular, a polyphenol present in red wine, has been thought to be responsible for the cardiovascular benefits associated with moderate wine consumption (Costant 1997; Fenech et al. 1997; Iacopini et al. 2008). The alleged beneficial effects of extra virgin olive oil have been linked to both its monosaturated fatty acids (MUFA, namely oleic acid) and its antioxidant components, e.g., hydroxytyrosol and oleuropein, most of which phenolic in nature. Several data show that olive oil phenolic exert in vitro and in vivo antioxidant and potentially cardio protective activities (reviewed in Visioli et al. 2002; Tripoli et al. 2005; Covas 2007; Bogani et al. 2007; Rotondi and Lapucci 2010).

Epidemiological effects of protein intake

In the last few decades a massive interest has been focused on protein consumption and its effects on health (Westhoek et al. 2011). In 2014 De Marco et al. found a significant relationship between animal protein intake per capita and one of the most accepted epidemiological evidence linked to protein intake, the colorec-

Country	Vegetable	Animal	Total	WHO	% surplus
Austria	12.73	18.80	31.53	18.25	172.77
Belgium	10.88	17.32	28.20	18.25	154.54
Bulgaria	11.60	10.48	22.08	18.25	120.99
Cyprus	10.91	17.46	28.36	18.25	155.42
Czech Republic	11.57	15.97	27.54	18.25	150.91
Denmark	10.91	21.02	31.93	18.25	174.98
Estonia	12.37	14.56	26.94	18.25	147.60
Finland	12.09	19.35	31.44	18.25	172.27
France	11.62	21.34	32.96	18.25	180.61
Germany	11.69	17.79	29.48	18.25	161.55
Greece	16.03	18.74	34.78	18.25	190.56
Hungary	12.16	13.67	25.84	18.25	141.57
Ireland	12.61	18.86	31.47	18.25	172.43
Italy	14.74	17.80	32.54	18.25	178.30
Latvia	10.84	14.94	25.79	18.25	141.30
Lithuania	13.85	20.46	34.31	18.25	188.02
Luxembourg	10.88	17.32	28.20	18.25	154.54
Malta	16.76	18.50	35.26	18.25	193.23
Netherlands	10.65	19.93	30.58	18.25	167.55
Poland	14.46	15.52	29.98	18.25	164.27
Portugal	12.83	20.77	33.60	18.25	184.11
Romania	15.91	16.19	32.10	18.25	175.90
Slovakia	11.21	9.80	21.01	18.25	115.14
Slovenia	12.87	16.72	29.59	18.25	162.13
Spain	11.49	20.54	32.02	18.25	175.47
Sweden	10.49	20.62	31.11	18.25	170.45
United Kingdom	13.12	17.40	30.51	18.25	167.20

TABLE 2 Intake of vegetable and animal protein in European countries in comparison with WHO suggested levels and percentage of surplus respect to total protein intake

tal cancer. The intake of animal proteins is increasing from Southern to Northern countries, whilst the intake of the vegetal proteins is decreasing in the same gradient. ANOVA confirms this geographical trend linked to animal protein intake, pointing out an homogeneous group between Mediterranean and Eastern countries and another group constituted by Northern countries. Taking into account the overall data, a good correlation exists between animal proteins consumption and colorectal cancer risk ($r= 0.61$, $p<0.01$), and with vegetal proteins consumption ($r=-0.64$, $p<0.01$), according to literature evidence (Bogani et al. 2007; Rotondi and Lapucci 2010; Owen et al. 2000; Galeone et al. 2006). In the same way, the distribution of red meat consumption and colorectal cancer is strictly related as supported by many bibliographic evidence (Larsson and Wolk 2006; Gingras and Béliveau 2011; Chan et al. 2011; De Marco et al., 2014).

In Table 2, intake of vegetable, animal and total protein intake are expressed per country. The surplus is

the percentage of exceedance respect to total level protein intake, as suggested by WHO (WHO, 2008). It is clear that Europe is characterized by an overconsumption of total protein intake, that is largely due to the very high level of animal protein consumption. Reducing the intake of animal consumption would be a possible solution to reach a safer value for human health protection.

Conclusions

The findings illustrated in the previous paragraphs show that policies aimed at changing the dietary habits of citizens for public health purposes would result in a more efficient use of the environmental resources involved in food production. Accordingly, a reduction of the ecological, carbon, nitrogen and water footprints due to food consumption would be achieved. This means that public health policies could also benefit the environment, allowing to achieve a double dividend. That is very interesting in a time of extended economic and environmental crisis, characterized by limited public resources. Despite the huge amount of evidences showing that the Mediterranean diet is healthy both for people (Trichopoulou et al. 2007; Kastorini et al. 2011; Esposito et al. 2006; Toobert et al. 2007; Buckland et al. 2008; Trichopoulou and Lagiou 2009) and the environment, dietary changes are not yet properly taken into account for the contribution they could give to the improvement of public health, to sustainability and climate policy (Carlsson-Kanyama and Gonzalez 2009).

So far, there are several examples of behavioural taxation in the EU and US, which have produced discordant outcomes. The classic behavioural taxation about cigarettes and alcohol consumption have had the desired effect over time.

In 2011, Denmark was the first country to introduce a tax on saturated fats equivalent to 2.15 euro per kg of saturated fat (EPHA, 2012). One year later, tax on sugar and energizing drinks consumption have been introduced in France, the so-called "tax soda" (Harles, 2012). In 2011, the USDA and the U.S. Department of Health and Human Services' FDA and Centers for Disease Control and Prevention (CDC) sponsored a public meeting, "Approaches to Reducing Sodium Consumption" (Federal Register, 2011) to provide an opportunity to comment on current and emerging approaches to reducing sodium intake. The results of these initiatives have highlighted some controversial aspects of measures. On the one hand, the policy maker thinks about new fiscal instruments able to contribute in a structural way to finance social spending, triggered by wrong eating habits. On the other hand it is necessary to take into account the elasticity, namely the substitution degree of food consumption, which limits the effectiveness of the fiscal measure. It is also important to consider that these measures are fiscally regressive and that aspect limits their social acceptability.

Recently, the French Senate has conducted a survey on "taxation and public health" and pointed out that in order not to create distortions, it is necessary that behavioral taxation has to give time both to consumers to change their habits and to manufacturers to align their production methods.

It is suggested to replace the expression behavioural tax with "contribution to public health" to define the set of fiscal measures related to health issues. This change would break with the moral aspect associated with the term "behavioural", highlighting the objective goal of these taxes. Also, it would establish a clear link between taxation and the cost of health care likely to be linked to consumption. Furthermore, the introduction of these measures requires an adaptation of the indirect tax system involved. For example, taxed foods should not benefit from a reduced Value Added Tax. It is also necessary to design an effective taxation system of advertising the need for foodstuffs to discourage consumption. In any case, the target of the initiatives so far decided and implemented in the EU and U.S. has been public health, only. The environmental impact has not been considered yet, although the ecological food footprint in developed countries represents almost a third of the total ecological footprint. Instead, the environment should be taken into account, especially through integrated informative and educational campaigns targeted to the general public and schools. An international initiative taking into account the environmental effects of food consumption is the Demitarian Diet described above, consisting in the practice of making a conscious effort to halve meat consumption

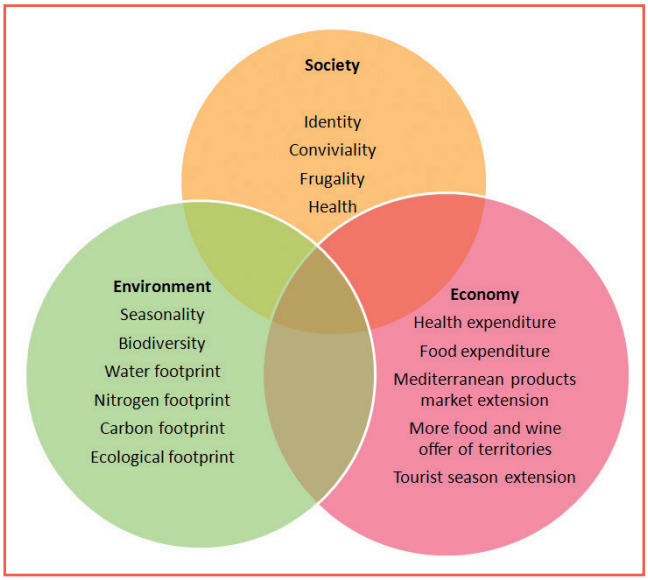

FIGURE 3 Sustainability scheme for Mediterranean diet. A healthy diet is sustainable, since it answers all the requests for a sustainable policy

for environmental reasons. Demitarians are committed not only to the environment but to a healthy diet, also. Concerning Italy and all the Mediterranean countries, in order to improve the epidemiological status of the population and the environmental impact of food consumption, they should just get back to Mediterranean Diet, recently inscribed in the UNESCO list of intangible heritage of humanity (Reguant, 2009). An increased adherence to the Mediterranean diet lifestyle will produce the same effects as a set of sustainable policies. In fact, the diet affects the three principal aspects of sustainability: environment, economy and society, as shown in Figure 3.

A major spreading of Mediterranean diet principles can lead to a less water consumption, due to the reduced irrigation needs of Mediterranean species, that are known to be resistant to environmental stresses, also because of their content of antioxidant molecules (Parejo et al. 2002; Conforti et al. 2009). Furthermore, the improvement of dietary habits can carry out a reduction in GHGs emissions, a reduction of biodiversity loss, and it allows a more sustainable use of natural resources. A diet composed of locally and regionally produced foods reduces the energy costs and the atmospheric pollution associated with foodstuff transportation and is less expensive, and therefore more affordable to a large public. Informative campaigns have demonstrated that sharp changes in lifestyles can be achieved relatively quickly (Duchin 2005). Dietary habits can be changed, recurring to food education initiatives in schools and addressed to families, labelling requirements on food items and mass communication of scientific evidences of the wrong dietary habits on health and the environment.

Finally, considering further economic and social indexes, notably the reduction of the national health expenditure, the household food expenditure and the economic growth, Mediterranean diet can be suggested to be suitable not only as a win-win policy for health and the environment, but as a global sustainable development policy also, generating benefits in the economic context as well.

Moreover, more work is required to quantify the potential beneficial environmental impacts obtained by the change of dietary habits.

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References

Agarwal, A., Shen, H., Agarwal, S., Rao, A.V., 2001. Lycopene content of tomato products: its stability, bioavailability and in vivo antioxidant properties. Journal of Medicinal Food 4(1):9-15.

Alberti, A., Fruttini, D., Fidanza, F., 2009. The Mediterranean adequacy index: further confirming results of validity. Nutrition, Metabolism and Cardiovascular Diseases 19:61–66.

Alberti-Fidanza, A., Fidanza, F., 2004. Mediterranean adequacy index of Italian diets. Public Health Nutrition 7:37–941.

Alberti-Fidanza, A., Fidanza, F., Chiuchiu, M.P., Verducci, G., Fruttini, D., 1999. Dietary studies on two rural Italian population groups of the Seven Countries Study. 3. Trend of food and nutrient intake from 1960 to 1991. European Journal of Clinical Nutrition 53:854–860.

Bogani, P., Galli, C., Villa, M., Visioli, F., 2007. Postprandial anti-inflammatory and antioxidant effects of extra virgin olive oil, Atherosclerosis 190(1):181-186.

Bouwman L. et al., Exploring global changes in nitrogen and phosphorus cycles in agriculture induced by livestock production over the 1900–2050 period. Proc. Natl. Acad. Sci. U.S.A., (May 16, 2011).

References

Buckland, G., Bach, A., Serra-Majem, L., 2008. Obesity and the Mediterranean diet: a systematic review of observational and intervention studies. Obesity Reviews 9:582–93.

Carlsson-Kanyama, A., 1998. Climate change and dietary choices: how can emissions of greenhouse gases from food consumption be reduced? Food Policy 23:277–293.

Carlsson-Kanyama, A., Ekstrom, M.P., Shanahan, H., 2003. Food and life cycle energy inputs: consequences of diet and ways to increase efficiency. Ecological Economics 44:293–307.

Carlsson-Kanyama, A., Gonzalez, A.D., 2009. Potential contributions of food consumption patterns to climate change. The American Journal of clinical nutrition 89(suppl):1704S–9S.

Centers for Disease Control and Prevention, 2011. Hyattsville, MD: National Center for Health Statistics Available: http://www.cdc.gov/tobacco/data_statistics/fact_sheets/adult_data/cig_smoking/index.htm [accessed 12 September 2011].

Chan, D.S., Lau, R., Aune, D., Veira, R., Greenwood, D.C., Kampman, E., et al., 2011. Red and processed meat and colorectal cancer incidence: meta-analysis of prospective studies. PLoS One 6(6):e20456.

Conforti, F., Sosa, S., Marrelli, M., Menichini, F., Statti, G.A., Uzunov, D., et al., 2009. The protective ability of Mediterranean dietary plants against the oxidative damage: the role of radical oxygen species in inflammation and the polyphenol, flavonoid and sterol contents. Food Chemistry 112(3):587-594.

Constant, J., 1997. Alcohol, ischemic heart disease, and the French paradox. Coronary and Artery Diseases 8:645–649.

Corbalán, M.D., Morales, E.M., Canteras, M., Espallardo, A., Hernández, T., Garaulet, M., 2009. Effectiveness of cognitive–behavioral therapy based on the Mediterranean diet for the treatment of obesity. Nutrition 25:861–869.

Covas, M.I., 2007. Olive oil and the cardiovascular system. Pharmacological Research 55(3):175-186.

de Vries M., I.J.M. de Boer, Comparing environmental impacts for livestock products: A review of life cycle assessments. Livestock Science 128, 1 (2010).

Deckers J., Should the consumption of farmed animal products be restricted, and if so, by how much? Food Policy 35, 497 (2010).

Deemer D.R., L.M. Lobao, Public concern with farm-animal welfare: religion, politics, and human disadvantage in the food sector. Rural Sociology 76, 167 (2011).

De Marco A, M Velardi, C Camporeale, A Screpanti, M Vitale, 2014: The Adherence of the Diet to Mediterranean Principle and Its Impacts on Human and Environmental Health. International Journal of Environmental Protection and Policy. 2(2):64-75.

Dernini, S., 2006. Towards the advancement of the Mediterranean food cultures. Public Health Nutrition 9(1A):103–104.

Duchin, F., 2005. Sustainable consumption of food: a framework for analyzing scenarios about changes in diets. Journal of Industrial Ecology 9:99–114.

Egan, M.E., Pearson, M., Weiner, S.A., Rajendran, V., Rubin, D., Glöckner-Pagel, J., et al., 2004. Curcumin, a Major Constituent of Turmeric, Corrects Cystic Fibrosis Defects. Science 304(5670): 600-602

Engstrom, R., Wadeskog, A., Finnveden, G., 2007. Environmental assessment of Swedish agriculture. Ecological Economics 60:550–563

Esposito, K., Ciotola, M., Giugliano, D., 2006. Mediterranean diet, endothelial function and vascular inflammatory markers. Public Health Nutrition 9:1073–1076.

European Public Health Alliance (EPHA), 2012. Food Taxationin Europe: evolution of the legislation. http://www.epha.org/a/4814.

Eurostat. (2010) Public Health statistics, Body mass index (BMI) by sex, age and activity status, Eurostat

FAO, World agriculture: towards 2030/2050 : prospects for food, nutrition, agriculture and major commodity groups. (FAO, Rome, 2006).

Federal Register 2011. Approaches to reducing sodium consumption; public meeting. Notice of public meeting; request for comments.; 76:63305 - 8. Available from: http://www.gpo.gov/fdsys/pkg/FR-2011-10-12/html/2011-26371.htm Accessed 18 April 2012.

Fenech, M., Stockley, C., Aitken, C., 1997. Moderate wine consumption protects against hydrogen peroxide-induced DNA damage. Mutagenesis 12(4):289-296.

Fidanza, F., Alberti, A., Lanti, M., Menotti, A., 2004. Mediterranean adequacy index: correlation with 25-year mortality from coronary heart disease in the Seven Countries Study. Nutrition, Metabolism and Cardiovascular Diseases 14:254–258.

Friel S. et al., Public health benefits of strategies to reduce greenhouse-gas emissions: food and agriculture. The Lancet 374, 2016 (2009).

Galeone, C., Talamini, R., Levi, F., Pelucchi, C., Negri, E., Giacosa, A., et al., 2006. Fried foods, olive oil and colorectal cancer. Annals of oncology 18(1): 36-39.

Garnett T., Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)? Food Policy 36, S23 (2011).

Gingras, D., Béliveau, R., 2011. Colorectal cancer prevention through dietary and lifestyle modifications. Cancer Microenvironment 4(2):133-139.

Godfray H.C.J. et al., Food security: The challenge of feeding 9 billion people. Science 327, 812 (2010).

Goulet, J., Lapointe, A., Lamarche, B., Lemieux, S., 2007. Effect of a nutritional intervention promoting the Mediterranean food pattern on anthropometric profile in healthy women from the Quebec city metropolitan area. European Journal of Clinical Nutrition 61:1293–1300.

Harles E., 2012. Taxes on unhealthy foods gains taxations in Europe.

Hawkesworth S. et al., Feeding the world healthily: The challenge of measuring the effects of agriculture on health. Philos. Trans. R. Soc. London Ser. B 365, 3083 (2010).

Iacopini, P., Baldi, M., Storchi, P., Sebastiani, L., 2008. Catechin, epicatechin, quercetin, rutin and resveratrol in red grape: Content, in vitro antioxidant activity and interactions. Journal of Food Composition and Analysis 21:589–598.

Kastorini, C.M., Milionis, H.J., Esposito, K., Giugliano, D., Goudevenos, J.A., Panagiotakos, D.B., 2011. The Effect of Mediterranean Diet on Metabolic Syndrome and its Components. A Meta-Analysis of 50 Studies and 534,906 Individuals. Journal of the American College of Cardiology 57(11):1299-1313.

Kearney J., Food consumption trends and drivers. Philos. Trans. R. Soc. London Ser. B 365, 2793 (2010).

Keys, A., 1980. Seven Countries: a multivariate analysis of death and coronary heart disease. London: Harvard University Press.

Kouris-Blazos, A.K,, Gnardellis, C., Wahlqvist, M.L., Trichopoulos, D., Lukito, W., Trichopoulou, A., 1999. Are the advantages of the Mediterranean diet transferable to other populations? A cohort study in Melbourne, Australia. British Journal of Nutrition 82:57-61.

Krystallis A., K.G. Grunert, M.D. de Barcellos, T. Perrea, W. Verbeke, Consumer attitudes towards sustainability aspects of food production: Insights from three continents. Journal of Marketing Management 28, 334 (2012).

Larsson, S.C., Wolk, A., 2006. Meat consumption and risk of colorectal cancer: a meta-analysis of prospective studies. International Journal of Cancer 119(11):2657-2664.

Lazarou, C., Panagiotakos, D.B., Matalas, A.L., 2009. Lifestyle factors are determinants of children's blood pressure levels: the CYKIDS study blood pressure risk factors in children. Journal of Human Hypertension 23:456-463.

McMichael, A., Powles, J.W., Butler, C.D., Uauy, R., 2007. Food, livestock production, energy, climate change, and health. Lancet 370:1253–63.

Mekonnen, M.M., Hoekstra, A.Y., 2011 in National water footprint accounts: the green, blue and grey water footprint of production and consumption, eds Value of Water Research Report Series n. 50, UNESCO-IHE Institute for Water Education (Delf, the Netherlands).

Mendez, M.A., Popkin, B.M., Jakszyn, P., Berenguer, A., Tormo, M.J., Sanchéz, M.J., et al., 2006. Adherence to a Mediterranean diet is associated with reduced 3-year incidence of obesity. The Journal of Nutrition 136:2934–2938.

Nijdam D., T. Rood, H. Westhoek, The price of protein: Review of land use and carbon footprints from life cycle assessments of animal food products and their substitutes. Food Policy 37, 760 (2012).

References

Osler, M., Schroll, M., 1997. Diet and mortality in a cohort of elderly people in a North European community. International Journal of Epidemiology 26:155-159.

Owen, R.W., Giacosa, A., Hull, W.E., Haubner, R., Spiegelhalder, B., Bartsch, H., 2000. The antioxidant/anticancer potential of phenolic compounds isolated from olive oil. European Journal of Cancer 36(10):1235-1247.

Panagiotakos, D.B., Chrysohoou, C., Pitsavos, C., Stefanadis, C., 2006. Association between prevalence of obesity and adherence to the Mediterranean diet: the ATTICA study. Nutrition 22:449–456.

Parejo, I., Viladomat, F., Bastida, J., Rosas-Romero, A., Flerlage, N., Burillo, J., et al., 2002. Comparison between the radical scavenging activity and antioxidant activity of six distilled and non-distilled Mediterranean herbs and aromatic plants. Journal of Agricultural and food chemistry 50(23):6882-6890.

Popp A., H. Lotze-Campen, B. Bodirsky, Food consumption, diet shifts and associated non-CO2 greenhouse gases from agricultural production. Global Environ. Change 20, 451 (2010).

Reguant-Aleix, J., Arbore, M.R., Bach-Faig, A., Serra-Majem, L., 2009. Mediterranean Heritage: an intangible cultural heritage. Public Health Nutrition 12(9A):1591–1594.

Rotondi, A., Lapucci, C., 2010. Nutritional properties of extra-virgin olive oils from the Emilia-Romagna region: profiles of phenols, vitamins and fatty acids in Olives and olive oil in health and disease prevention, eds Preedy VR, Watson R (Accademy Press), pp 725-733.

Serra Majem, L., Ribas, L., 1995, in Metodos, Bases Cientıficas y Aplicaciones, eds. Nutricion y Salud Publica (Masson, Barcelona), pp: 303–10.

Shai, I., Schwarzfuchs, D., Henkin, Y., Shahar, D.R., Witkow, S., Greenberg, I., et al., 2008. Weight loss with a low-carbohydrate, Mediterranean, or low-fat diet. The New England Journal of Medicine 359:229–241.

Smil, V., 2002. Worldwide transformation of diets, burden of meat production and opportunities for novel food proteins. Enzyme and Microbial Technology 30:305–11.

Sofi F, F Cesari, R Abbate, GF Gensini, A Casini, 2008. Adherence to Mediterranean diet and health status: meta-analysis. British Medical journal, 337: 1344.

Stehfest E. et al., Climate benefits of changing diet. Clim. Change 95, 83 (2009).

Stehfest E., M. V. D. Berg, G. Woltjer, S. Msangi, H. Westhoek, Options to reduce the environmental effects of livestock production - Comparison of two economic models. Agricultural Systems 114, 38 (2013).

Thornton P.K., Livestock production: Recent trends, future prospects. Philos. Trans. R. Soc. London Ser. B 365, 2853 (2010).

Toobert, D.J., Glasgow, R.E., Strycker, L.A., Barrera, M. Jr, Ritzwoller, D.P., Weidner, G., 2007. Long-term effects of the Mediterranean lifestyle program: a randomized clinical trial for postmenopausal women with type 2 diabetes. International Journal of Behavioral Nutrition and Physical Activity 4:1.

Trichopoulou, A., Kouris-Blazos, A., Vassilakou, T., Gnardellis, C., Polychronopoulos, E., Venizelos, M., et al., 1995a. The diet and survival of elderly Greeks: a link to the past. American Journal of Clinical Nutrition 61(suppl): 1346-1350.

Trichopoulou, A., Kouris-Blazos, A., Wahlqvist, M.L., Gnardellis, C., Lagiou, P., Polychronopoulos, E., et al., 1995b. Diet and overall survival in elderly people. British Medical Journal 311:1457-1460.

Trichopoulou, A., Lagiou, P., 2009. Health traditional Mediterranean diet: an expression of culture, history and lifestyle. Nutrition Reviews 55(11):383-389.

Trichopoulou, A., Psaltopoulou, T., Orfanos, P., Hsieh, C.C., Trichopoulos, D., 2007. Low-carbohydrate-high-protein diet and long-term survival in a general population cohort. European Journal of Clinical Nutrition 61:575-581.

Tripoli, E., Giammanco, M., Tabacchi, G., Di Majo, D., Giammanco, S., La Guardia, M., 2005. The phenolic compounds of olive oil: structure, biological activity and beneficial effects on human health. Nutrition Research Review 18:98-112.

Tukker A. et al., Environmental impacts of changes to healthier diets in Europe. Ecological Economics 70, 1776 (2011).

Visioli, F., Poli, A., Galli, C., 2002. Antioxidant and other biological activities of phenols from olives and olive oil, Medicinal Research Reviews 22:65–75.

Wang, H., Cao, G., Prior, R.L., 1996. Total Antioxidant Capacity of Fruits. Journal of agricultural and food chemistry 44(3): 701–705.

Weiss F., A. Leip, Greenhouse gas emissions from the EU livestock sector: A life cycle assessment carried out with the CAPRI model. Agric. Ecosyst. Environ. 149, 124 (2012).

Westhoek, H., Lesschen, J.P., Rood, T., et al., 2014. Food choices, health and environment: Effects of cutting Europe's meat and dairy intake. Global Environmental Change, http://dx.doi.org/10.1016/j.gloenvcha.2014.02.004.

Westhoek, H., Rood, T., van de Berg, M., Janse, J., Nijdam, D., Reudink, M., et al., 2011 in The protein puzzle: the consumption and production of meat, dairy and fish in the European Union, eds PBL Netherlands Environmental Assessment Agency (The Hague, Netherland).

World Health Organization, 2008. The World Health Report 2008 - primary Health Care (Now More Than Ever), eds WHO.

WCRF, AICR. (2007) Food, nutrition, physical activity and the prevention of cancer: a global perspective. 2nd Expert Report ed. World Cancer Research Fund and American Institute for Cancer Research, Washington D.C.