Croatian Journal of Food Science and Technology
journal homepage: www.ptfos.unios.hr/cjfst/

Review paper *DOI: 10.17508/CJFST.2018.10.2.12*

Shifting modern dietary patterns towards sustainable diets: challenges and perspectives

KARLA FERK, MATKO GRUJIĆ, GRETA KREŠIĆ*

University of Rijeka, Faculty of Tourism and Hospitality Management, Department of Food and Nutrition, Primorska 42, P.O. Box 97, 51410 Opatija, Croatia

ARTICLE INFO

Article history:
Received: May 9, 2018
Accepted: June 5, 2018

Keywords:
sustainable diet,
greenhouse gas emission,
water use,
land use,
food waste,
organic food

ABSTRACT

The current food system contributes significantly to global greenhouse gas emissions, water consumption, and land use, which are negatively affecting the environment and contributing to climate change. With the anticipated population growth, these practices are expected to deplete the natural resources and undermine food security for future generations. The modern Western diet is unsustainable on many levels. First of all, being high in energy and animal products, it is detrimental for the planet's well-being. Secondly, it has been linked to obesity and chronic diseases, which reduce the quality of life and generate high healthcare expenses. Another major problem is food wastage that represents a needless waste of natural resources and the pollution of the environment. Conversely, a sustainable diet is expected to have a low environmental impact, maintain health and well-being, and preserve resources for future generations. Therefore, changes in dietary habits can significantly help reduce the negative environmental impacts of the food system. The aim of this paper was to critically evaluate the current data on the sustainability of different dietary patterns and food production. Research suggests that following healthy eating guidelines, adopting a Mediterranean, vegetarian, or vegan diet, or simply reducing the intake of meat and animal products can result in a more sustainable diet in comparison to current average dietary patterns. Moreover, whether organic food represents a more sustainable alternative to conventionally grown food still remains a subject of debate: Although there is no doubt about its small pollution potential, due to its lower yields, more land is needed to produce the same amount of food. Although changes in food consumption and production may lead to a reduction in dietary environmental impact, research results are controversial, and a firm definition of a sustainable diet, which would distinguish it from a diet that is not environmentally acceptable, is still lacking.

Introduction

About 7.6 billion people live on the planet today, which is three times more than in the 1950s. It is estimated that by 2050 there will be 9.8 billion people on Earth, with a growth up to 11.2 billion by 2100 (UN, 2017). Food and water requirements will increase with the growing population, making it necessary to achieve the sustainable development "that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987). However, human activity has led to air, water, and land pollution, with a reduction in biodiversity, soil degradation, deforestation, freshwater scarcity, and climate change (Garnett, 2014; Whitmee et al., 2015). Furthermore, global warming and the rise of surface temperatures in the last decades are considered a result of increased anthropogenic greenhouse gas (GHG) emissions (IPCC, 2014). It is estimated that food production alone is responsible for 26% of the total GHG emissions (FAO, 2017), with livestock having

*Corresponding author E-mail:
greta.kresic@fthm.hr

the highest impact and plant food having the lowest (Tubiello et al., 2014). Moreover, agriculture uses 70% of water withdrawn from aquifers, streams, and lakes, and 11% of the world's total land surface for crop production (FAO, 2011a).

Despite all the resources used, the Food and Agriculture Organisation estimates that 1.3 billion tonnes of food produced for human consumption, roughly one third of the food produced globally, is wasted on a yearly basis (FAO, 2011b). In addition, it has recently been suggested that food consumed above the physiological needs, leading to excessive weight gain, could also be considered food waste (Serafini and Toti, 2016). Furthermore, it has been shown that some dietary patterns, rich in animal fat and protein, refined grains, and added sugar, can contribute to developing obesity and non-communicable diseases, leading to increased healthcare expenses and premature death (Malik et al., 2013). These types of diets also have a negative influence on the environment, suggesting there’s a tight link between human health and planet health (Tilman and Clark, 2014; van Doreen et al., 2014).

The current food system and modern dietary patterns are unsustainable, with low-cost foods that come with a high cost to the environment (Lacirignola et al., 2014). Further deterioration of environmental conditions is most likely to negatively influence agriculture in the future, undermining global food security (IPCC, 2014). For that reason, one of the main challenges of our times is to prevent the degradation of natural resources and limit global warming, while providing the growing population with adequate nutrition.

The aim of this paper is to critically evaluate the environmental impact of current food consumption patterns and identify possible changes, not just in food consumption, but also in food production, with special emphasis on organic food production that can contribute to global sustainability.

Environmental indicators of the food system

Every type of food is produced at a certain environmental cost, but some foods have a higher impact on the environment than others. To approach this issue, the Barilla Centre for Food and Nutrition has developed the so-called Double Pyramid which compares the Environmental Pyramid to a healthy eating Food Pyramid (BCFN, 2015). The Environmental Pyramid is shown upside down, indicating that the foods the intake of which should be limited (mainly animal products) often have the largest environmental impact, while foods that have the most health benefits and should be consumed in higher quantities (mainly fruit and vegetables) come at a lower cost for the environment (Ruini et al., 2015). This impact can be observed through GHG emissions produced across the entire food production chain, water requirements for crops and livestock, and total land surface needed for agriculture. These values are expressed by three environmental indicators: carbon footprint, water footprint, and ecological footprint (BCFN, 2015).

The *carbon footprint* (CF) quantifies the food-related GHG emissions, mainly including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), expressed in a mass of equivalent CO_2 (kg CO_2 eq). Agriculture, forestry and other land use are, with a yearly GHG emission higher than 12.3 Gt of CO_2 eq, the second leading source of total GHG emissions, after energy production (FAO, 2017). Within the different sectors of the food industry, livestock contributes to nearly two-thirds of total GHG emissions related to food production, with ruminant enteric fermentation alone contributing up to 40% (FAO, 2014). Aside from agriculture itself, the entire life cycle of foods, from harvest to processing, packaging, storing, transport, home preparation, and disposal, contributes indirectly to GHG emissions through its energy requirements. Although fruit and vegetable cultivation generally has a low impact on the environment, adding the latter to the equation elevates their environmental cost (BCFN, 2015). Seasonal and locally produced fruit and vegetables are likely to have a lower GHG emission, but considering their demand throughout the year, together with shipping, refrigerating, freezing, and greenhouse production, the issue becomes more complex and it’s difficult to say which has a less detrimental effect (Garnett, 2014; Stoessel et al., 2012). Another problem is the increasing number of large international supermarkets, which are not only repressing farmers’ markets with local and seasonal foods but are also offering a large variety of processed and energy-dense products (Malik et al., 2013).

The *water footprint* (WF) measures the volume (litres or m^3) of water used throughout the food production chain, but also the water polluted during this process. It consists of green water (rainwater stored in soil), blue water (surface water and groundwater), and grey water, which measures the volume of water required to assimilate pollutants entering freshwater bodies (Hoekstra, 2017). With the increasing demand for fresh water, the world is dealing with increasing water scarcity. Furthermore, the problem is expected to deteriorate as the population grows, together with climate changes and global warming interfering with the water cycle (FAO, 2012a). In some regions of the world, as much as 80-90% of blue water is used for agricultural purposes (FAO, 2017). Livestock is responsible for up to 29% of agriculture's total WF, which is almost exclusively attributed to feed crops and grazing (Mekonnen and Hoekstra, 2010). Furthermore, up to 40% of the total WF of the food supply in high-income countries can be attributed to meat alone (Capone et al., 2013; Lacirignola et al., 2014).

The *ecological footprint* (EF) refers to the area of land (m^2 or ha) and water required for agriculture and aquaculture. This concept includes land needed for crop growth, livestock grazing, fishing, infrastructure, and construction, and forests used for wood, but also for CO_2 absorption (WWF, 2016). Food production's requirements for land are the leading cause of deforestation, resulting in significant GHG emissions, habitat destruction, loss of species and biodiversity, together with increasing natural disasters (FAO, 2017). Up to 80% of the total land used for agriculture is dedicated to livestock production (FAO, 2009), with 33% of all croplands meant for feed (FAO, 2012b).

Dietary patterns with a negative health and environmental impact

Despite the desperate need to reduce the environmental impact of food production, the current consumption patterns are moving in the opposite direction. In Europe alone, in the last 50 years, the annual *per capita* supply has increased by a total of 63% for all meat (of which by 407% for poultry and by 60% for pork), 57% for fish and seafood, and 26% for milk and butter (EUPHA, 2017). In the last few decades, the global population is shifting towards a so-called Western diet, high in animal products, fats, sugar, and refined carbohydrates, while being deficient in fruit, vegetables, legumes and whole grains, leading to an obesity epidemic and the associated co-morbidities (Popkin et al., 2012). Diets high in industrially produced *trans*-fatty acids are associated with an increased risk of coronary heart disease (de Souza et al., 2015), while those high in red and processed meat were recently linked to an increased risk of colon and rectum cancer (Bouvard et al., 2015), obesity and larger waist circumference (Rouhani et al., 2014), diabetes type 2 (Pan et al., 2011), and stroke (Chen et al., 2013).

Tilman and Clark (2014) showed that meat and calorie intakes correlated with the annual income (GDP) and, as a result, high-income countries have a higher intake and *vice versa*. They estimated that, continuing at this rate, by 2050 the *per capita* income-dependent diet will contain 23% more pork and poultry, 31% more ruminant meat, 58% more dairy and eggs, and 82% more fish and seafood, while the intake of fruit and vegetables, and plant protein will decline by 18% and 2.7%, respectively. This scenario would lead to an 80% increase of global GHG emissions from food production and would demand an additional 540 million hectares of land. Considering the possible adverse effect of climate change on total yield production, land requirements might even increase above 800 million hectares. Moreover, water usage is forecasted to increase by 60% (Muller et al., 2017). Livestock production heavily depends on resources that are being depleted in an attempt to support a growing population (Pimentel and Pimentel, 2003).

Besides unsustainable dietary choices, food wastage also has its share in the deterioration of the environment. Food produced never to be consumed creates a total of 3.3 billion Gt of CO_2 eq (37% of which is attributed to the consumption phase) and requires 1.4 billion hectares of land (28% of the global agricultural land area) and 250 km^3 of water globally per year. Although individual behaviour changes cannot influence production phase food loss, they can reduce food waste at the consumer level, which is estimated to be as high as 31-39% in middle-income and high-income countries (FAO, 2013). In the EU, it is estimated that around 53% of total food wastage occurs in households (Stenmarck et al., 2016), giving even more power to the consumer to initiate positive changes. The lack of planning and management of purchase, storage, preparation, and reuse of food and meals is one of the main drivers of food waste. Furthermore, in a culture of abundance where food comes at a low price, consumers tend to buy too much food without worrying about the consequences of wastage (Aschemann-Witzel et al., 2015).

In addition to food being literally thrown away, it was suggested that an energy intake surplus causing excessive weight and obesity can also be considered a type of waste, defined as metabolic food waste. Serafini and Toti (2016) estimated that the amount of food leading to excessive body weight in overweight and obese people was 63.1 kg and 127.2 kg *per capita*, respectively. An additional concern is that animal products contribute the most to metabolic food waste, with 57% of the total CF, 57% of the total WF, and 71% of the total EF. Given that more than 1.9 billion adults around the world are overweight, of which over 650 million obese (WHO, 2017a), the environmental impact of food intake above physiological need is remarkable.

Overeating is unsustainable, both in terms of health and ecological balance: Not only does it cause damage to the environment through the needless waste of resources, but it also leads to poor health.

Obesity and excessive weight significantly increase the risk of non-communicable diseases, such as cardiovascular diseases, diabetes type 2, some types of cancer, osteoarthrosis, together with gallbladder disease, asthma, and chronic back pain (Guh et al., 2009). Non-communicable diseases cause 70% of deaths globally, with cardiovascular diseases being the number one killer. In high-income countries, diabetes and colon, rectum, and breast cancer are among the top 10 causes of death (WHO, 2017b). Furthermore, excessive weight and obesity decrease the quality of life, at the same time producing immense economic losses reaching billions of euros, not only through health care costs but also through a loss of productivity (Dee et al., 2014).

Sustainable dietary patterns

In 2010, the FAO acknowledged the close link between human health and the ecosystem's well-being, highlighting the importance of adopting a sustainable diet. Considering this, a dietary pattern can be considered sustainable if it: a) has a low environmental impact, b) is nutritionally adequate, safe, and healthy, c) is affordable, d) is culturally acceptable, e) enables a healthy life for present and future generations, d) does not decrease biodiversity, and e) contributes to food and nutrition security (FAO, 2010). Consequently, some governments, health and dietetic institutions, and organisations across Europe have embedded this idea into their dietary guidelines, advising the population to embrace a more sustainable diet in order to safeguard their health and that of the planet. These dietary recommendations primarily highlight limiting the intake of animal products and eating plenty of plant foods, while choosing those that are local, organic, and in season (BCFN, 2015; EUPHA, 2017; German Council for Sustainable Development, 2013; Health Council of the Netherlands, 2011; Public Health England, 2016; Swedish National Food Agency, 2015).

There is no definition of a sustainable diet strictly determining the upper limits for its CF, WF, and EF. Therefore, researchers try to identify which diets have a lower impact on the environment, compared to the dietary patterns in the population. Results vary depending on the baseline dietary pattern to which more sustainable options are being compared. Currently, there is growing scientific evidence, summarized in a few literature reviews, suggesting that shifting towards a more plant-based diet can significantly reduce diet-related GHG emissions, water use, and land requirement (Aleksandrowicz et al., 2016; Hallström et al., 2015, Joyce et al., 2014).

National dietary guidelines from various countries are designed to help the population make healthy dietary choices and achieve or maintain well-being. Besides focusing on the content of macro- and micronutrients, the recommendations also include local foods and traditional meals. Some research has shown that, in comparison to modern dietary patterns, national recommendations can also provide a sustainable alternative (Reynolds et al., 2014). In Italy, following dietary guidelines would enable a 70% reduction in water use (Capone et al., 2013). The Dutch population could lower its CF by 12% and its EF by 37% by following the national guidelines, which would require a reduction of meat intake and an increased fruit, vegetables, legumes, and grain consumption (van Doreen et al., 2014). In Germany, a yearly reduction in GHG emissions (14%), land requirements (15%), and water use (26%) could be achieved if dietary guidelines were adopted by the population and less meat was consumed (Meier and Christen, 2012). In Australia, following dietary recommendations would lead to a 25% reduction of the daily *per capita* GHG emissions attributed to the average 1995 diet (Hendrie et al., 2014).

The Mediterranean diet is generally recognized as a healthy and sustainable dietary pattern developed in the millennia of exchange between different cultures, cuisines, foods, and people throughout the Mediterranean basin (Burlingame and Dernini, 2011). It is a predominantly plant-based diet, and because it's low in meat and rich in fruit, vegetables, nuts, legumes, whole grains, olive oil, and fish, it contributes to optimal health and longevity while lowering the risk of modern chronic diseases and all causes of mortality (Tilman and Clark, 2014; Trichopoulou et al., 2014). Besides the promotion of human well-being, it has also shown to be beneficial for the environment in comparison to many other dietary patterns. For example, Germani et al. (2014) estimated that the shift from a modern Italian diet to a Mediterranean one would reduce the CF by 30%, the EF by 24%, and the WF by 18% *per capita* and per week, without additional burden on the family budget. Sáez-Almendros et al. (2013) found that Spain's CF, EF, and WF could be reduced by 51%, 32% and 1.5%, respectively, if the population were to follow a Mediterranean dietary pattern, while the Dutch could reduce their daily *per capita* CF and EF by 17% and 48%, respectively, with the same dietary change (van Doreen et al., 2014).

The vegetarian diet excludes all meat, poultry, and fish but not eggs and dairy, while the vegan diet excludes all foods of animal origin. Despite these restrictions, both dietary patterns have been evaluated to be safe and healthy for all stages of life if carefully planned. A high intake of fruit, vegetables, nuts, whole grains, soy products, and thus fibre and phytochemicals, with a low intake of saturated fat may explain the health benefits of these plant-based diets. In comparison to omnivores, vegetarians seem to have a lower body mass index, and a lower risk of chronic diseases, such as cancer, type 2 diabetes, and cardiovascular diseases (Craig et al., 2009). Meat avoidance contributes highly to these dietary patterns' low environmental footprint. In fact, the vegan diet, with zero animal products, seems to have the lowest impact on the environment of all the diets observed in the literature (Aleksandrowicz et al., 2016). Van Doreen et al. (2014) estimated that the vegetarian and the vegan diet had a 22% and a 35% lower daily CF, with a 51% and a 59% lower daily EF, respectively, in comparison to the modern Dutch diet. In their study, they estimated that both vegetarian and vegan diets had a lower environmental impact than the recommended Dutch diet, the Mediterranean diet, and the semi-vegetarian diet. Similarly, compared to the average UK diet, the reduction in GHG emission can be seen for both vegetarian (22%) and vegan (26%) diets (Sabaté and Soret, 2014). Ruini et al. (2015) designed and compared weekly omnivorous, vegetarian, and vegan menus. In their calculations, the plant-based menus showed an impressive reduction of all three environmental footprints by 60-74% in comparison to the meat menus, with the vegan menu having the lowest impact. Interestingly, despite showing benefits in regards to CF and EF, Meier and Christen (2012) estimated that water use was higher for vegetarian and vegan diets in comparison to the current German dietary pattern. This increase was attributed to a high intake of nuts and seeds which have one of the highest WF among plant foods.

Surely, other dietary patterns, such as the pescetarian diet and the semi-vegetarian diet, and dietary changes, such as partial meat reduction or substitution with plant-based foods, substitution of beef with poultry and pork, and reduction of energy intake, have all shown, in different scales, to have a positive impact on the GHG emissions (Ruini et al., 2015; Scarborough et al., 2012; Scarborough et al.; 2014 Soret et al., 2014), water use (Jalava et al., 2014; Tom et al., 2016; Vanham et al., 2013), and land requirements (Tilman and Clark, 2014; van Doreen et al., 2014).

Taking into consideration the anticipated population growth, some analyses have pointed out that, if by 2050 the Mediterranean diet was the global average, an additional 130 million hectares of land would be required in comparison to the 2009 situation. Similarly, the pescetarian diet would require 26 million more hectares of land, while the vegetarian would require 16 million less hectares of land compared to the 2009 requirements. Those estimations are still much lower than those for the 2050 global average diet which would require 540 million hectares of land more than in 2009. Interestingly, there would be no increase in GHG emissions from food production if the future global average diets were similar to the three aforementioned alternative diets. In fact, in comparison to the 2050 global average diet, the Mediterranean, the pescetarian, and the vegetarian diet have a 30%, 45%, and 55% lower CF *per capita*, respectively (Tilman and Clark, 2014).

Nonetheless, it must be noted that all these scenarios are hypothetical, and being based on fictional and ideally designed diets, they do not necessarily represent real-life settings. Dietary patterns differ vastly among individuals and a one-size fits-all approach may not produce trustworthy results. Rosi et al. (2017) studied the environmental impact of omnivorous, ovo-lacto-vegetarian, and vegan diets based on 7-day weighed food records. As expected, it was confirmed that the omnivorous diet had the highest environmental impact, with more than half of its total environmental impacts being attributed to animal products. However, no significant differences were observed between the ovo-lacto-vegetarian and vegan diet, whose CF, WF, and EF were lower by 34-41%, 22-27%, and 38-44%, respectively, in comparison to the omnivorous diet. The absence of the previously observed additional environmental benefits of a vegan diet may be explained in two ways. Firstly, the vegan diet relies on low energy food items, resulting in a larger quantity of food consumed. Secondly, the intake of highly processed plant-based substitutes for meat and dairy has a higher environmental impact than unprocessed plant foods appearing in hypothetical vegan diets. Another study using data from food frequency questionnaires (FFQ) collected in the Adventist Health Study 2 estimated that vegetarians and semi-vegetarians had a 22% and 29% lower CF compared to non-vegetarian diets, while the energy intake was similar (Soret et al., 2014). Scarborough et al. (2014) used FFQ data from the EPIC-Oxford cohort study to calculate GHG emissions of different dietary patterns and showed that the high-meat diet had the highest CF, followed by medium- and low-meat, pescetarian, vegetarian, and vegan diets. Meat-eaters' CF in this study was twice as high as that for vegans. In summary, it seems that the less animal products a diet has, the lower its burden on the planet (Aleksandrowicz et al., 2016; Garnett, 2014).

It should be noted that, although there is a link between human health and planet health, a sustainable diet doesn't necessarily equal a healthy diet and *vice versa*. For example, a high intake of products loaded with sugar, fat, and carbohydrates can have a low environmental impact, but be unhealthy in the long term (Tilman and Clark, 2014). At the same time, olive oil has a very high WF, but offers many health benefits, manifested primarily in decreasing the risk of cardiovascular diseases (BCFN, 2015, Covas et al., 2015). Moreover, it is well known that fish is also good for human health, especially because it's a great source of long chained unsaturated fatty acids, but many fish stocks have been depleted. Unsustainable fishing practices harm the marine ecosystem and lead to a reduction in species number and diversity. If people ate as much as recommended in the Mediterranean diet (two times per week), the world's oceans and seas would run out of fish (Garnett, 2014).

The sustainability of organic food production

Taking into consideration the path that humanity is on, there have been ongoing debates on whether organic food is the key to feeding the world while conserving the environment (Connor, 2013; Seufert et al., 2012). The main idea behind organic agriculture is to combine traditional farming with modern technologies while decreasing reliance on non-renewable resources. It consists of promoting crop rotation, soil fertility, usage of green and animal manure, natural pest and weed management, animal welfare, and biodiversity. At the same time, organic agriculture excludes synthetic pesticide and fertilizer usage, genetic engineering, and unjustified antibiotic application. This type of farming has been shown to be more environmentally friendly than conventional agriculture, safeguarding the water and soil quality against agrochemical pollution (Gomiero et al., 2011; Reganold and Wachter, 2016). From the environmental footprint point of view however, the CF of organic agriculture appears to be lower for certain foods, but higher for others, in comparison to the same, conventionally produced, items (Tuomisto et al., 2012), suggesting that there is no overall difference in GHG emissions. Another issue is land requirement: Given that the organic production yield is generally lower than the conventional one, a larger area is needed to produce the same amount of crops (Seufert et al., 2012). In a recent study by Muller et al. (2017), it has been estimated that if by 2050 the entire food production relied on organic agriculture, the requirement of arable area would increase from 16%, at best, to 81%, if adverse impacts of climate change and a high yield gap are considered. This worst case scenario would demand more than 1 billion hectares of additional land compared to today, leading to increased deforestation and soil erosion as a consequence. On the other hand, these circumstances would also reduce other negative factors, such as pesticide pollution and nitrogen surplus from synthetic fertilizers that lead to the nitrogen cycle disruption. It is clear that a 100% global conversion to an organic agriculture would therefore not be sustainable if dietary patterns do not change. Muller et al. (2017) suggest that there is a possibility for organic food to feed the world, providing that food waste, competitive animal feed, animal numbers, and, consequently, animal consumption are reduced. However, if these dietary habit changes were applied in the conventional food production system, environmental benefits could be observed as well.

Conclusion

With the expected population growth and with natural resources being exhausted, it is clear that action needs to be taken in order to achieve a more sustainable lifestyle and a secure future for generations to come. Individuals can tackle environmental degradation and climate change through more sustainable dietary choices. These include adopting a plant-based diet, emphasized by various national dietary guidelines, such as the Mediterranean, vegetarian, and vegan diets that have a reduced intake of meat and animal products. At the same time, attention needs to be drawn to food waste reduction, considering its current high levels, and adequate food intake that will prevent excessive weight gain. Whether organic foods represent a more sustainable choice over conventional products still remains a subject of debate. While organic food does reduce pesticide exposure and agrochemical pollution, it does not seem to have an advantage over conventional food when CF, WF, and EF are compared.

Although many dietary changes have been shown to reduce a diet's impact on the environment, and have therefore been considered sustainable, taking into account the growing population, it is yet to be seen if that is enough to prevent the exploitation of natural resources and the loss of global food security. Future research is needed to determine the highest level of GHG emissions, land use, and water requirements that a diet can have in order to be considered sustainable.

References

Aleksandrowicz, L., Green, R., Joy, E. J. M., Smith, P., Haines, A. (2016): The Impact of Dietary Change on Greenhouse Gas Emissions, Land Use, Water Use, and Health: A Systematic Review. PLOS ONE 11 (11), doi: 10.1371/journal.pone.0165797.

Aschemann-Witzel, J., de Hooge, I., Amani, P., Bech-Larsen, T., Oostindjer, M. (2015): Consumer-Related Food Waste: Causes and Potential for Action. Sustainability 7, 6457-6477, doi: 10.3390/su7066457.

BCFN - Barilla Center for Food and Nutrition (2015): Double pyramid 2015 Recommendations for a sustainable diet, Parma, Italy: Barilla Center for Food and Nutrition, pp. 44-69.

Bouvard, V., Loomis, D., Guyton, K. Z., Grosse, Y., El Ghissassi, F., Benbrahim-Talla, L., Guha, N., Mattock, H., Straif, K. (2015): Carcinogenicity of consumption of red and processed meat. The Lancet 16 (16), 1599-1600, doi: 10.1016/S1470-2045(15)00444-1.

Burlingame, B., Dernini, S. (2011): Sustainable diets: the Mediterranean diet as an example. Public Health Nutr. 14 (12A), 2285-2287, doi: 10.1017/S1368980011002527.

Capone, R., Iannetta, M., El Bilali, H., Colonna, N., Debs, P., Dernini, S., Maiani, G., Intorre, F., Polito, A., Turrini, A., Cardone, G., Lorusso, F., Belsani, V. (2013): A preliminary assessment of the environmental sustainability of the current italian dietary pattern: water footprint related to food consumption. J. Food. Nutr. Res. 1 (4), 59-67, doi: 10.12691/jfnr-1-4-5.

Chen, G. C., Lv, D. B., Pang, Z., Liu, Q. F. (2013): Red and processed meat consumption and risk of stroke: a meta-analysis of prospective cohort studies. Eur. J. Clin. Nutr. 67 (1), 91-95, doi: 10.1038/ejcn.2012.180.

Connor, D. (2013): Organically grown crops do not a cropping system make and nor

can organic agriculture nearly feed the world. Field Crops Res. 144, 145–147, doi: 10.1016/j.fcr.2012.12.013.

Covas, M. I., de la Torre, R., Fitó M. (2015): Virgin olive oil: a key food for cardiovascular risk protection. Br. J. Nutr. 113, S19-S28, doi: 10.1017/S0007114515000136.

Craig, W. J., Mangels, A. R., American Dietetic Association (2009): Position of the American Dietetic Association: vegetarian diets. J. Am. Diet. Assoc. 109 (7), 1266-1282, https://doi.org/10.1016/j.jada.2009.05.027.

de Souza, R., Mente, A., Maroleanu, A., Cozma, A., Ha, V., Kishibe, T., Uleryk, E., Budylowski, P., Schunemann, H., Beyene, J., Anand, S. S. (2015): Intake of saturated and trans unsaturated fatty acids and risk of all cause mortality, cardiovascular disease, and type 2 diabetes: Systematic review and meta-analysis of observational studies. BMJ 351, doi: h3978. 10.1136/bmj.h3978.

Dee, A., Kearns, K., O'Neill, C., Sharp, L., Staines, A., O'Dwyer, V., Fitzgerald, S., Perry, I. J. (2014): The direct and indirect costs of both overweight and obesity: a systematic review. BMC Res. Notes. 7 (242), doi: 10.1186/1756-0500-7-242.

EUPHA- European Public Health Association. 2017. Healthy and sustainable diets for European countries. https://eupha.org/repository/advocacy/EUPHA_report_on_healthy_and_sustainable_diets_20-05-2017.pdf., Accessed January 25, 2018.

FAO - Food and Agriculture Organisation of the United Nations (2009): The state of food and agriculture. Livestock in balance, Rome, Italy: Food and Agriculture Organisation of the United Nations, pp. 54.

FAO - Food and Agriculture Organisation of the United Nations (2010): Sustainable diets and biodiversity, Directions and solutions for policy, research and action, Rome, Italy: Food and Agriculture Organisation of the United Nations, pp. 7.

FAO - Food and Agriculture Organisation of the United Nations (2011a): Summary Report: The State of the World's Land and Water Resources. Managing Systems at Risk, Rome, Italy: Food and Agriculture Organisation of the United Nations, pp. 13.

FAO - Food and Agriculture Organisation of the United Nations (2011b): Global Food Losses and Food Waste – Extent Causes and Prevention, Rome, Italy: Food and Agriculture Organisation of the United Nations, pp. 5.

FAO - Food and Agriculture Organisation of the United Nations (2012a): Coping with water scarcity. An action framework for agriculture and food security, Rome, Italy: Food and Agriculture Organisation of the United Nations, pp. 13.

FAO - Food and Agriculture Organisation of the United Nations. 2012b. Livestock and landscapes. http://www.fao.org/docrep/018/ar591e/ar591e.pdf. Accessed January 22, 2018.

FAO - Food and Agriculture Organisation of the United Nations (2013): Summary report: Food wastage footprint. Impact on natural resources, Rome, Italy: Food and Agriculture Organisation of the United Nations, pp. 6-12.

FAO - Food and Agriculture Organisation of the United Nations. 2014. Greenhouse gas emissions from agriculture, forestry and land use. http://www.fao.org/assets/infographics/FAO-Infographic-GHG-en.pdf. Accessed January 20, 2018.

FAO - Food and Agriculture Organisation of the United Nations (2017): The future of food and agriculture – Trends and challenges, Rome, Italy: Food and Agriculture Organisation of the United Nations, pp. 5-36.

Garnett, T. 2014. What is a sustainable healthy diet? A discussion paper. https://www.fcrn.org.uk/sites/default/files/fcrn_what_is_a_sustainable_healthy_diet_final.pdfAccessed January 20, 2018.

German Council for Sustainable Development. 2013. The sustainable shopping basket, http://www.nachhaltigkeitsrat.de/en/projects/projects-of-the-council/the-sustainableshopping-basket/. Accessed January 25, 2018.

Germani, A., Vitiello, V., Giusti, A. M., Pinto, A., Donini, L. M., del Balzo, V. (2014): Environmental and economic sustainability of the Mediterranean Diet. Int. J. Food Sci. Nutr. 65 (8), 1008-1012, doi: 10.3109/09637486.2014.945152.

Gomiero, T., Pimentel, D., Paoletti, M. G. (2011): Environmental Impact of Different Agricultural Management Practices: Conventional vs. Organic Agriculture. Crit. Rev. Plant Sci. 30 (1-2), 95-124, https://doi.org/10.1080/07352689.2011.554355.

Guh, D. P., Zhang, W., Bansback, N., Amarsi, Z., Birmingham, C. L., Anis, A. H. (2009): The incidence of co-morbidities related to obesity and overweight: A systematic review and meta-analysis. BMC Public Health 9 (88), doi: 10.1186/1471-2458-9-88.

Hallström, E, Carlsson-Kanyama, E., Borjessön, P. (2015): Environmental impact of dietary change: a systematic review. J. Clean. Prod. 91, 1-11, https://doi.org/10.1016/j.jclepro.2014.12.008.

Health Council of the Netherlands. 2011. Guidelines for a healthy diet: the ecological perspective, https://www.gezondheidsraad.nl/sites/default/files/201108E.pdf. Accessed January 25, 2018.

Hendrie, G. A., Ridoutt, B. G., Wiedmann, T. O., Noakes, M. (2014): Greenhouse Gas Emissions and the Australian Diet - Comparing Dietary Recommendations with Average Intakes. Nutrients 6, 289-303, doi: 10.3390/nu6010289.

Hoekstra, A. Y. (2017): Water Footprint Assessment: Evolvement of a New Research Field. Water Resour. Manage. 31 (10), 3061–3081, doi: 10.1007/s11269-017-1618-5.

IPCC - Intergovernmental Panel on Climate Change (2014): Climate change 2014: Synthesis Report, Geneva, Switzerland: Intergovernmental Panel on Climate Change, pp. 8-13.

Jalava, M., Kummu, M., Porkka, M., Siebert, S, Varis, O. (2014): Diet change - a solution to reduce water use? Environ. Res. Lett. 9, doi: 10.1088/1748-9326/9/7/074016.

Joyce, A., Hallett, J., Hannelly, T., Carey, G. (2014): The impact of nutritional choices on global warming and policy implications: examining the link between dietary choices and greenhouse gas emissions. Energy and Emission Control Technologies 2, 33–43, https://doi.org/10.2147/EECT.S58518.

Lacirignola, C., Capone, R., Debs, P., El Bilali, H., Bottalico, F. (2014): Natural Resources – Food Nexus: Food Related Environmental Footprints in the Mediterranean Countries. Front. Nutr. 1:23, doi: 10.3389/fnut.2014.00023.

Malik, V. S., Willet, W. C., Hu, F. B. (2013): Global obesity: trends, risk factors and policy implications. Nat. Rev. Endocrinol. 9, 13–27, doi: 10.1038/nrendo.2012.199.

Meier, T., Christen, O. (2012): Environmental Impacts of Dietary Recommendations and Dietary Styles: Germany As an Example. Environ. Sci. Technol. 47, 877-888, doi: 10.1021/es302152v.

Mekonnen, M. M., Hoekstra, A. Y. (2010): The green, blue and grey water footprint of farm animals and animal products, Delft, The Netherlands: Value of Water Research Report Series 48, UNESCO-IHE, pp 30.

Muller, A., Schader, C., El-Hage Scialabba, Bruggemann, J., Isensee, A., Erb, K., Smith, P., Klocke, P., Leiber, F., Stolze, M., Niggli, U. (2017): Strategies for feeding the world more sustainably with organic agriculture. Nat. Commun. 8 (1), 1290, doi: 10.1038/s41467-017-01410-w.

Pan, A., Sun, Q., Bernstein, A. M., Schulze, M. B., Manson, J. E., Willett, W. C., Hu, F. B. (2011): Red meat consumption and risk of type 2 diabetes: 3 cohorts of US adults and an updated meta-analysis. Am. J. Clin. Nutr. 94 (4), 1088-1096, doi: 10.3945/ajcn.111.018978.

Pimentel, D., Pimentel, M. (2003): Sustainability of meat-based and plant-based diets and the environment. Am. J. Clin. Nutr. 78, 660S–663S.

Popkin, B. M., Adair, L., S., Ng, S. W. (2012): Global nutrition transition and the pandemic of obesity in developing countries. Nutr. Rev. 70 (1), 3–21, doi: 10.1111/j.1753-4887.2011.00456.x.

Public Health England. 2016. The Eatwell Guide: Helping you eat a health, balanced diet. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/551502/Eatwell_Guide_booklet.pdf. Accessed January 25, 2018.

Reganold, J. P., Wachter, J. M. (2016): Organic agriculture in the twenty-first century. Nat. Plants 2, 15221, doi: 10.1038/nplants.2015.221.

Reynolds, C. J., Buckley, J. D., Weinstein, P., Boland, J. (2014): Are the Dietary Guidelines for Meat, Fat, Fruit and Vegetable Consumption Appropriate for Environmental Sustainability? A Review of the Literature. Nutrients 6, 2251-2265, doi: 10.3390/nu6062251.

Rosi, A., Mena, P., Pellegrini, N., Turroni, S., Neviani, E., Reffocino, I., Di Cagno, R., Ruini, L., Ciati, R., Angelino, D., Maddock, J., Gobbetti, M., Brighenti, F., Del Rio, D., Scazzina, F. (2017): Environmental impact of omnivorous, ovo-lacto-vegetarian, and vegan diet. Sci. Rep. 7 (1), doi: 10.1038/s41598-017-06466-8.

Rouhani, M. H., Salehi-Abargouei, A., Surkan, P. J., Azadbakht, L. (2014): Is there a relationship between red or processed meat intake and obesity? A systematic review and meta-analysis of observational studies. Obes. Rev. 15 (9), 740-748, doi: 10.1111/obr.12172.

Ruini, L. F., Ciati, R., Pratesi, C. A., Marino, M., Principato, L., Vannuzzi, E. (2015): Working towards healthy and sustainable diets: the „Double Pyramid Model“ developed by the Barilla Center for Food and Nutrition to raise awareness about the environmental and nutritional impacts of foods. Front. Nutr. 2, doi: 10.3389/fnut.2015.00009

Sabaté, J., Soret, S. (2014): Sustainability of plant-based diets: back to the future. Am. J. Clin. Nutr. 100, 476S–482S, doi: 10.3945/ajcn.113.071522.

Sáez-Almendros, S., Obrador, B., Bach-Faig, A., Serra-Majem, L. (2013): Environmental footprints of Mediterranean versus Western dietary patterns: beyond the health benefits of the Mediterranean diet. Environ. Health 12 (118), doi: 10.1186/1476-069X-12-118.

Scarborough, P., Allender, S., Clarke, D., Wickramasinghe, K., Rayner, M. (2012): Modeling the health impact of environmentally sustainable dietary scenarios in the UK. Eur. J. Clin. Nutr., 66 (6), 710–715, doi: 10.1038/ejcn.2012.34.

Scarborough, P., Appleby, P. N., Mizdrak, A., Briggs, A. D. M., Travis, R. C., Bradbury, K. E., Key, T. J. (2014): Dietary greenhouse gas emissions of meat-eaters, fish-eaters, vegetarians and vegans in the UK. Climatic Change 125 (2), 179–192, doi: 10.1007/s10584-014-1169-1.

Serafini, M., Toti, E. (2016): Unsustainability of Obesity: Metabolic Food Waste. Front. Nutr. 3, doi: 10.3389/fnut.2016.00040.

Seufert, V., Ramankutty, N., Foley, J. A. (2012): Comparing the yields of organic and conventional agriculture. Nature 485 (7397), 229-232, doi: 10.1038/nature11069.

Soret, S., Mejia, A., Batech, M., Jaceldo-Siegl, K., Harwatt, H., Sabaté, J. (2014): Climate change mitigation and health effects of varied dietary patterns in real-life settings throughout North America. Am. J. Clin. Nutr. 100, 490S-495S, doi: 10.3945/ajcn.113.071589.

Stenmarck, A., Jensen, C., Quested T., Moates (2016): Estimates of European food waste levels, Stockolm, Sweden: European Comission, pp. 26-27.

Stoessel, F., Juraske, R., Pfister, S., Hellweg, S. (2012): Life cycle inventory and carbon and water foodprint of fruits and vegetables: an application to a Swiss retailer. Environ. Sci. Technol. 16 (6), 3253-3262, https://dx.doi.org/10.1021%2Fes2030577.

Swedish National Food Agency. 2015. Find your way to eat greener, not too much and be active. https://www.livsmedelsverket.se/globalassets/english/food-habits-health-environment/dietary-guidelines/kostrad-eng.pdf?id=8140. Accessed January 25, 2018.

Tilman, D., Clark, M. (2014): Global diets link environmental sustainability and human health. Nature 515 (7528), 518-522, doi: 10.1038/nature13959.

Tom, M., S., Fischbeck, P. S., Hendrickson, C. T. (2016): Energy use, blue water footprint, and greenhouse gas emissions for current food consumption patterns and dietary recommendations in the US. Environ. Syst. Decis. 36, 92-103, doi: 10.1007/s10669-015-9577-y.

Trichopoulou, A., Martínez-González, M. A., Tong, T. Y. T, Forouhi, N. G., Khandelwal, S., Prabhakaran, D., Mozaffarian, D., de Lorgeril, M. (2014): Definitions and potential health benefits of the Mediterranean diet: views from experts around the world. BMC Med. 12 (112), https://doi.org/10.1186/1741-7015-12-112.

Tubiello, F. N., Salvatore, M., Cóndor Golec, R. D., Ferrara, A., Rossi, S., Biancalani, R., Federici, S., Jacobs, H., Flammini, A. 2014. Agriculture, Forestry and Other Land Use Emissions by Sources and Removals by Sinks, Food and Agriculture Organisation Statistics Division, http://www.fao.org/docrep/019/i3671e/i3671e.pdf. Accessed January 16, 2018.

Tuomisto, H. L., Hodge, I. D., Riordan, P., Macdonald, D. W. (2012): Does organic farming reduce environmental impacts? A meta-analysis of European research. J. Environ. Manage. 112, 309-320, doi: 10.1016/j.jenvman.2012.08.018.

UN - United Nations (2017): World Population Prospects: The 2017 Revision, Key Findings and Advance Tables, New York, USA: United Nations, pp. 23.

UN - United Nations. 1987. Our Common Future, Report of the World Commission on Environment and Development. http://www.un-documents.net/our-common-future.pdf. Accessed January 15, 2018.

van Doreen, C., Marinussen, M., Blonk, H., Aiking, H., Vellinga, P. (2014): Exploring dietary guidelines based on ecological and nutritional values: A comparison of six dietary patterns. Food Policy 44, 36-46, https://doi.org/10.1016/j.foodpol.2013.11.002.

Vanham, D., Mekonnen, M. M., Hoekstra, A. Y. (2013): The water footprint of the EU for different diets. Ecol. Indic. 32, 1-8, https://doi.org/10.1016/j.ecolind.2013.02.020.

Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A. G., Ferreira de Souza Dias, B., Ezeh, A., Frumkin, H., Gong, P., Head, P., Horton, R., Mace, G. M., Marten, R., Myers, S. S., Nishtar, S., Osofsky, S. A., Pattanayak, S. K., Pongsiri, M. J., Romanelli, C., Soucat, A., Vega, J., Yach, D. (2015): Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. The Lancet 386, 1973–2028, https://doi.org/10.1016/S0140-6736(15)60901-1.

WHO - World Health Organisation. 2017a. Obesity and overweight Fact sheet. http://www.who.int/mediacentre/factsheets/fs311/en/. Accessed January 19, 2018.

WHO - World Health Organisation. 2017b. Top 10 causes of death Fact sheet. http://www.who.int/mediacentre/factsheets/fs310/en/. Accessed January 27, 2018.

WWF - World Wildlife Fund (2016): Living Planet Report 2016. Risk and resilience in a new era, World Wildlife Fund International, Gland, Switzerland, pp 76.