Estimated carbon dioxide equivalents emissions in Greece following different types of diet

K. Anagnostopoulos, V. Costarelli & K. Abeliotis
Harokopio University, Department of Home Economics & Ecology, El. Venizelou 70, 17671, Athens, Greece

Abstract

Purpose: There is great interest worldwide on the effect of diet and its modification, on greenhouse gases emissions. The current paper aims at estimating the carbon footprint of the diet of the Greek consumers in 2004, following different dietary modifications.
Methods: Based on the per capita food items consumption data and the equivalent CO_2 emission factors, the associated total carbon footprint following different types of diet, was calculated. Data for this task were retrieved from readily available resources of existent literature. In addition, three alternative diet scenarios were proposed, their individual carbon footprint was calculated and suggestions were made for possible sustainable dietary changes.
Results: The results indicate that the transition from the existent diet to a lacto-ovo-vegetarian diet constitutes a drastic positive change towards mitigating greenhouse gases, followed by the substitution of beef by mainly pork, as a second, less drastic alternative diet modification The need for the estimation of CO_2 emission factors of different foods, specific for the southern Mediterranean area, is also indentified in this study,
Conclusions: These results could serve as a yardstick for possible policy interventions aiming at reducing GHG emissions via diet modifications in Greece.

Keywords: carbon footprint, diet, Greece

1 Introduction

Dietary habits and specific food choices can have a direct impact not only to our health and wellbeing but also to the environment. More specifically, there is good evidence that the most environmentally damaging form of human consumption is eating [1], mainly due to the contribution that food and dietary choices make to global warming [2-5]. It is estimated that approximately one-third of the total household burden on the environment is derived from the eating habits of humans [6]. Food, through its life cycle from production to its final consumption, impacts adversely on numerous natural resources. Land is needed for its cultivation; water is required for its production and processing while energy and its associated greenhouse gases (GHG) emissions are resulting from production, transportation, processing, preservation and cooking of food [7]. The calculation of the GHG emissions is mainly based on Life Cycle Assessment, a well established methodology for assessing the environmental impacts of produced goods and services throughout their life cycle [8]. Different food items pose varying degrees of adverse burdens on the natural environment with meat production often requiring more energy than the production of fruits or vegetables [6, 9].

Most worryingly, given the progressively increasing world population and the increased consumption of animal products, the impact of food related emissions is projected to increase significant in the forthcoming years [2]. Thus, the identification and adoption of more sustainable diets, particularly in the developed counties, is considered of paramount important. Sustainable diets are defined by the Food and Agriculture Organization [10] as "…those with low environmental impacts which contribute to food and nutrition security and to healthy life for the present and future generations."

It is important to note that consumers are frequently faced with contradictory messages regarding the environmental impact of their food choices. Whereas it is well documented that beef is one of the major methane emitters, due to the enteric fermentation associated with the cattle breeding [6], there is a major contradiction of the possible effect of local food production in heated greenhouses in comparison to food transported from overseas which is produced without the use of heating greenhouses. Regarding the environmental and dietary information data, there are plenty of data available from various sources. However, there is no unique standard of presenting the information for the various food items. In addition, most of the data for carbon footprint originate from the northern Europe; therefore there is a lack of data for the southern European regions, where Greece is located. Another source of uncertainty is that the diet of the population can drastically change in a country during the course of the years. For instance, Geeraert (2013) examined the implications of the Swedish consumption patterns on the sustainability of the planet between 1960 and 2006 [2]. During this period, the author reports an overall increase of 31% in the emissions of GHG.

Finally, there is evidence that a growing number of consumers would like to make environmentally friendly consumer choices and that local governments of countries in different parts of the world are interested in placing policy measures that increase consumers' opportunities and motives for eating in a sustainable manner [11, 12].

2 Purpose of the study

The current paper aims at estimating the carbon footprint of the diet of the Greek consumers in 2004, following different dietary modifications. In order to calculate the aforementioned footprint, the following methodological steps were followed:

1. Data for the per capita food consumption in 2004 in Greece were derived from the Hellenic Statistical Authority (2013) [13].
2. Based on published literature data [4, 14], emission factors for CO_2 equivalents were derived for each food item included in the diet of Greeks in 2004. This was a key step since relevant data are not available for Greece.
3. Consumption data, CO_2 emission factors and the CO_2 equivalents associated with the Greek diet patterns in 2004 were calculated, using a spreadsheet computer application. This constituted the reference scenario.
4. Three alternative scenarios were developed based on the recommendations by Nilsson and Sonesson (2010) [15]. These scenarios were based on the substitution of certain food items included in the

reference scenario. The substitute items have a lower carbon footprint but they are nutritionally equivalent (in terms of calories and proteins) compared to the items in the reference scenario.

3 Materials and Methods

3.1 Assumptions and data sources

Scenario building is a well established approach when tackling the impacts of diets on climate [3, 16, 17]. The main underlying assumption when building the scenarios was that, as it is generally accepted, animal based foods tend to have higher emissions than plant-based foods, by weight of food [17]. In our case, for each scenario, the total annual carbon footprint per capita was calculated as the sum of the per capita consumption of each food item multiplied by the respective emission factor of the food item expressed in CO_2 equivalents. For each alternative scenario (see Tables 2 to 4) only the per capita consumption of food items that were substituted, is presented. The consumption for all other food items remained unaltered, as presented in the reference scenario (see Table 1). Also, for each alternative scenario, the calorific value and the protein content for the food items that participated in the substitution was calculated and presented in order to ensure that the alternative scenarios had similar nutritional contents. Or, as Saxe et al. (2013) phrase it, “it is easy to design a climate friendly diet if it is low in energy and protein” [3].

The modeling approach was quite complex due to the fact that there were no available Greek data related to the carbon footprint of the different food items. In order to form a consistent baseline, the carbon footprint data of the research center of Barilla (2010) [14] were utilized based on the fact that they were readily available and also because Italy is a Mediterranean country, sharing a lot of common in food culture with Greece [14]. Whenever data from Barilla (2010) were not available, data from Wallen et al. (2004) were utilized [4].

Data for the consumption of food items in Greece were obtained from the Hellenic Statistical Authority (2013) [13]. Only the consumption of soy “meat” products was taken from Keinan-Boker et. al. (2002) [18]. Food consumption data in this manuscript were reported as kg of food item/capita/y. The carbon footprint of each scenario for the year 2004 was expressed in g of CO_2 equivalents/capita/y. For each scenario, the g of CO_2 eq. per kcal of food item and the g of CO_2 eq. per g of protein was also calculated.

The key prerequisite for a fair comparison among the alternative proposed diets was to ensure their nutritional equivalence. The nutritional equivalence was defined in terms of their calorific and protein intake values. These data were taken from McCance and Widdowson (1991) [19] for raw, not cooked, food items since cooking alters the nutritional characteristic of the food items. Food item substitution among scenarios was carefully performed in order to account for the requirements of the Greek food culture. Currently, there are no complete food composition tables of Greek foods; hence the McCance and Widdowson values were used. A final assumption was that the estimation of the carbon footprint of each food item did not include refrigeration at home, cooking, or resources necessary for waste disposal.

3.2 Outline of the reference scenario

The reference scenario refers to the carbon footprint, expressed in g of CO_2 equivalents, resulting from the sum of the quantities of each food item consumed in Greece in 2004 multiplied by the emission factors for each food item. The reference scenario is presented in Table 1.

3.3 Outline of the 1st alternative scenario

The first scenario describes the transition from a conventional diet to a lacto-ovo-vegetarian. It is important to note that Wallen et al. (2004) [4] report a value of 6,250 g CO_2 eq./kg of product, while the respective Barilla (2010) value was 30,400 g CO_2 eq./kg. The difference was quite significant, however explainable: beef production is a very complex agricultural system that poses considerable challenges for environmental assessment [6].In brief, the value of Barilla (2010) [14] was selected to be included in the calculation, because it was assumed to be more representative for Greece because of its dietary proximity to Italy, which was also supported by Tukker et al. (2009) [20].In order to achieve a nutritional equivalency with the baseline diet, we used dairy products, we kept the consumption of butter constant, we added fruits and vegetables following the recommendations by Plaisted and Adams (2002) [21] and Winston and Ann (2009) [22] for increased intake of natural fibers, vitamins, antioxidants, etc. Also, rice, potatoes, pasta, breakfast cereals, bread and non-sweet bread products were added in order to account for the recommendations for amino acids from Lappe (1991) [23]. Finally, wine and olive oil were added because of their health benefits.

3.4 Outline of the 2nd alternative scenario

The 2nd scenario aims at mitigating the release of GHG by the substitution of beef by pork and chicken. This scenario was, again, closely following the recommendations by Nilsson and Sonesson (2010) [15]. The only improvement was that in order to achieve a calorific equivalency with the reference scenario, the per capita consumption numbers have been increased. Again, the carbon footprint from beef has been extracted from Barilla (2010) [14]. One more issues related to protein intake and GHG emissions arises with the protein intake, because after the substitution of beef the protein intake is reduced by 1.1 kg/capita/y. or by 3 g/capita/d.

3.5 Outline of the 3rd alternative scenario

The third alternative scenario deals with the substitution of rice by potatoes. It aims at mitigating the emissions of GHG based on the fact that the cultivation of rice releases considerable amounts of methane [5, 24]. The developed scenario is very close to the recommendations by Nilsson and Sonesson (2010) [15]. In order to achieve the nutritional equivalence, the per capita consumption of potato was increased compared to the substituted rice.

Results and discussion

4.1 Reference scenario

Table 5 shows the carbon footprint resulting from the diet of one person in Greece in 2004 (reference scenario). Each food group is included along with its relative contribution to the overall carbon footprint. The per capita carbon footprint resulting from the consumption of food items in Greece in 2004 for the reference scenario was calculated to be approximately 1,167 kg CO_2/y. (see Table 1). The breakdown of the carbon footprint per food group category is presented in Table 6. The contribution of meat is dominant (54.4%), followed by dairy products and eggs (17.9%) and flour-bread-cereals (9%).

Compared to the results of Wallen (2004) [4], referring to Swedish data of 1999, there are two major differences identified in the relative contribution of each food item category: the first one is in the meat product group while the second is in the vegetables product group. The Swedish GHG emissions associated with meat reported by Wallen et al. (2004) [4] are half of the respective Greek, despite the fact that the consumption of meat in Sweden is much higher, almost double, compared with the respective in Greece. This is due to the differences in the feed provided to the productive animals in addition to the genetic background of the animal itself and the management of the manure [6]. Interestingly enough, both Sweden and Greece import a great share of their consumed meat products [15, 25]. A similar trend is identified in the GHG emissions associated with dairy products and eggs. They correspond to 15% and 18% of the total GHG emissions in Sweden and Greece respectively, but the consumption of dairy products and eggs in Sweden is 2.5 times higher compared to Greece.

In the case of vegetables, the difference between in Greece and Sweden is more easily explainable. Most of the vegetables consumed in Sweden are cultivated in heated greenhouses while on the same time most of the vegetables in Greece keep their seasonal identity. In addition, the consumption of vegetables in Greece is much higher in Greece compared to Sweden. A similar trend is observed for fruits: in Greece and Sweden account from 1% and 6% of the total GHG emissions respectively; in the same time, the consumption of fruits in Greece is overwhelmingly higher compared to the respective Swedish consumption. The effect of heated greenhouses in global climate change is well identified [5,7]. However, in today's globalised world where a lot of food items are imported, things are much more complicated than the operation of a heated greenhouse. Transportation, especially via airplanes, also contributes to the overall carbon footprint of a food product. As Wallen et al. (2004) state, in Sweden tomatoes, lettuces, cucumbers and peppers are cultivated in heated greenhouses while

80% of apples and 75% of oranges are imported. This situation, i.e., the combination of heated greenhouses and imports, puts a heavy GHG burden on vegetables and fruits in Sweden [4].

5.2 1st alternative scenario

The lacto-ovo-vegetarian diet had almost identical calorific intake compared to the conventional one (661,610.6 kcal/capita/y. for the conventional diet vs. 661,759 kcal/capita/y. for the lacto-ovo-vegetarian diet) and efforts were made to also retain the nutritional intake of the lacto-ovo-vegetarian diet in terms of vitamin B_{12}, uptake of iron, complement amino acids, and substitution of saturated fats.

Moreover, the substitution of animal protein with the plant equivalent reduces the environmental burden since 2/3 of the proteins in the lacto-ovo-vegetarian diet originate from plant sources. In this case, the GHG emissions of the lacto-ovo-vegetarian diet is 47.8% lower compared to the reference scenario (see Table 2). Thus, this scenario is in agreement with what is reported by Reijnders and Soret (2003) [26], i.e., that the environmental impacts of a non-vegetarian diet are expected to be 1.5-2 times higher compared to a vegetarian. Regarding the relative contribution of the various food groups in the total carbon footprint (see Table 6), dairy products and eggs contribute now 47.8% followed by flour, bread and cereals (20.2%) and oils and fats (12.6%).

Despite that, this scenario does not negate completely animal husbandry: dairy products and eggs require the existence of productive animals. However, with a lacto-ovo-vegetarian diet we have a quality shift towards a more climate friendly pattern: the CO_2 equivalents per g of protein and per kcal are reduced drastically, while the total GHG emissions are reduced by 48%. However, Pimentel and Pimentel (2003) [27] mention that both diets, the conventional and the lacto-ovo-vegetarian, are not sustainable in the long run. However, it is evident that the latter diet is environmentally preferable over the conventional. Moreover, Nilsson and Sonesson (2010) [15] also mention that the transition to a lacto-ovo-vegetarian diet can have the reverse effects: productive animals also produce dung that can be used as organic fertilizer. Thus, the reduction in the numbers of productive animals can yield to the increased use of synthetic fertilisers.

5.3 2nd alternative scenario

In the 2nd scenario, meat consumption is by 4 kg/y. less compared to the baseline scenario. By ensuring the calorific equivalence, 470 kg CO_2eq./capita/y were saved by this substitution, mainly from beef. This corresponds to a reduction of 40.4% compared to the carbon footprint of the reference scenario (see Table 3). Nilsson and Sonesson (2010) [15], report a reduction of 58% resulting from the respective substitution is Sweden. The difference between the percentages in Greece and Sweden can be attributed to the differences among the diets, and the different carbon footprint of the corresponding food items in the two countries.

Overall, it is evident that the substitution of beef by pork and chicken reduces the carbon footprint of the diet. However, the scenario still depends on meat. According to Nilsson and Sonesson (2010) [15], this scenario is an easy way for those who wish to be fed on meat but also want to reduce their carbon footprint. Moreover, chicken offers a very good alternative compared to beef and pork. Overall, this 2nd alternative scenario seems to be a very realistic approach in trying to mitigate the GHG emissions resulting from the Greek diet. Regarding the contribution of the various food groups in the total carbon footprint, meat is again ranked first (23.5%), followed by flour, bread and cereals (15.2%) and oils and fats (9.3%). In this alternative scenario, the contribution of fish and seafood becomes relatively significant (6.9%).By the substitution of meat proposed in the 2nd scenario, the percentage of the contribution of the meat food category to the overall diet footprint is reduced to 24% compared to the original 53% of the reference scenario. In terms of externalities, the adoption of this scenario will reduce the imports of beef in Greece but probably it will increase the imports of pork and chicken.

5.4 3rd alternative scenario

The average Greek consumer prefers potatoes over rice, since the per capita consumption of potatoes in 2004 was approximately seven times higher compared to the respective for rice (see Table 1). So this scenario demonstrates that the local nutritional conditions and culture should be taken into account. The relative contribution of each food group in the overall carbon footprint resembles that of the reference scenario (see Table 6).

Thus, in Greece, the substitution of rice by potatoes results to comparable intake of proteins and calories (see Table 4) but does not reduce drastically the carbon footprint value (approximately 1%, see Table 4). The results reported by Nilsson and Sonesson (2010) [15], referring to Sweden, reveal a reduction of the GHG emissions of 48%. This means that either the carbon footprint of potatoes is too low, since in Sweden the consumption of potatoes is ten times higher compared to that of rice, or the carbon footprint of rice is too high. Comparing the data by Carlsson-Kanyama (1998) [5] and Wallen et. al. (2004)[4] to those of Barilla (2010)[14], it seems that the potatoes' footprint is comparable; however the carbon footprint data for rice differ significantly. More specifically, Barilla (2010) refers to 2,750 g CO_2, equivalents while the respective value from Carlsson-Kanyama (1998) is 6,400 g CO_2 equivalents [4]. Trying to explain this huge difference, we refer to Manjunath et al. (2011) [24] who mention that methane emissions from rice cultivation, are not the result from only on the anaerobic conditions but also depend on soil typology, irrigation, etc. Thus, the differences of the emissions of the current scenario compared to the reference, are easily explained by the high carbon footprint of rice reported by Carlsson-Kanyama (1998) [5].

6 Conclusions

In conclusion, there is evidence that the transition from the existent diet to a lacto-ovo-vegetarian diet constitutes a positive change towards mitigating greenhouse gases, followed by the substitution of beef by mainly pork, as a second, less drastic alternative diet modification. The main limitations of the study were that the carbon footprints for the alternative scenarios were calculated based on databases which include data that are not originating from Greece. More research is required towards this direction for the compilation of a database which reflects the local conditions in Greece. Also, since dietary habits change over time a new estimation which reflects the current situation in Greece should be compiled. Moreover, since the impact of food includes almost all aspects of natural resources, a more spherical approach is required which includes more environmental impacts than just climate change, in order to assess the real impact of food consumption in Greece.

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Table 1. Reference scenario.

	Carbon footprint (g CO_2 -eq/kg product/y.)	Consumption in Greece (kg product/capita/y.)	Carbon footprint (g CO_2 -eq/capita/y.)
Flour - Bread - Cereals			
Rice[1]	2,750	5.612	15,433.483
Bread and non-sweet bakery products[1]	983	56.521	55,559.721
Sweet bakery products[1]	2,300	3.174	7,299.642
Pasta[1]	1,564	9.578	14,979.820
Bakery products[1]	3,700	0.971	3,592.493
Flour (all types)[2]	990	7.544	7,468.255
Breakfast cereals[2]	1,000	0.826	826.330
Other cereals[2]	1,000	0.299	299.120
Sub-Total			**105,458.9**
Meat			
Beef[1]	30,400	17.005	516,949.653
Pork[1]	4,359	9.675	42,174.042
Fresh chicken[1]	3,110	10.371	32,253.533
Frozen chicken[1]	3,290	0.290	954.962
Other poultry[1]	3,830	1.822	6,978.393
Other meats[2]	2,360	5.611	13,241.104
Meat products[1,2]	4,623	4.952	22,893.844
Sub-Total			**635,445.6**
Fish - Seafood			
Fresh fish or plain refrigerated[2]	2,600	10.457	27,189.256
Frozen fish[2]	6,530	1.835	11,979.316
Cod (fillet)[1]	2,700	0.539	1,454.556
Fresh seafood, plain refrigerated or frozen[2]	2,590	1.966	5,092.794
Processed fish and seafood[2]	2,010	1.047	2,104.270
Sub-Total			**47,820.2**

Dairy - Eggs			
Fresh Milk[1]	1,138	40.119	45,655.059
Yoghurt[1]	1,138	8.274	9,416.336
Cheese[1]	8,784	15.618	137,187.152
Cream[2]	1,138	0.370	420.885
Organic eggs[1]	4,919	0.343	1,686.513
Non organic eggs[1]	4,600	3.086	14,194.277
Sub-Total			**208,560.2**
Oils - Fats			
Olive oil[1]	3,897	14.840	57,829.765
Butter[1]	8,800	0.293	2,581.202
Margarine[2]	2,120	2.177	4,615.821
Sub-Total			**65,026.8**
Fruits			
Apples[1]	70	16.146	1,130.218
Pears[1]	70	4.644	325.098
Oranges[1,2]	73	17.510	1,277.175
Bananas[2]	450	8.907	4,008.204
Lemons[1,2]	73	6.465	471.555
Tangerines[,2]	73	3.894	284.014
Sub-Total			**7,496.3**
Vegetables			
Tomatoes[1]	154	23.296	3,587.509
Lettuce[1]	450	3.326	1,496.709
Potatoes[1]	164	41.358	6,782.773
Cucumbers[2]	154	5.187	801.251
Greens[2]	500	5.652	2,826.220
Parsley, mint, celery, fennel[2]	500	1.344	672.065
Spinach[2]	500	2.538	1,268.989
Onions (fresh and dry)[2]	500	9.710	4,854.813

Cabbage[2]	500	4.708	2,353.846
Soy beans[1]	1,000	0.387	386.900
Peas[1]	890	0.275	244.622
Fava bean[1]	1,000	0.275	274.856
Sub-Total			**25,550.6**
Sweeteners - Marmalade - Chocolate – Ice creams			
Sugar[1]	470	8.573	4,029.274
Honey, grape syrup και glucose[2]	470	1.068	501.960
Marmalade[2]	810	0.374	303.100
Chocolates[2]	1,800	1.214	2,185.950
Ice creams[2]	640	1.608	1,029.401
Sub-Total			**8,049.7**
Non alcoholic drinks			
Coffee, tea and cocoa[2]	7,960	2.048	16,300.679
Mineral water[1]	200	22.809	4,561.758
Soft drinks[2]	560	23.138	12,957.538
Fruit juices[2]	990	12.624	12,497.933
Sub-Total			**46,317.9**
Alcoholic drinks			
Wine[1]	2,240	7.837	17,555.691
Sub-Total			**17,555.7**
Total emissions **(g CO_2/capita/year)**			**1,167,281.7**

[1] Carbon footprint from Barrila (2010) [2] Carbon footprint from Wallen et. al. (2004)

Table 2. Lacto-ovo-vegetarian diet (alternative scenario 1): Main diet components, total GHG emissions, energy and proteins of substituted food items.

	Consumption in Greece (kg product/capita/y.)	
	Conventional diet	**Lacto-ovo-vegetarian diet**
Fresh milk	40.119	68.202
Yoghurt	8.274	10.757
Cheese	15.618	20.303
Organic eggs	0.343	0.480
Non organic eggs	3.086	4.320
Butter	0.293	0.293
Margarine	2.177	2.177
Olive oil	14.840	17.807
Soybeans	0.387	7.738
Peas	0.275	3.298
Rice	5.612	6.735
Pasta	9.578	11.493
Bread and non-sweet bakery products	56.521	67.825
Breakfast cereals	0.826	0.992
Apples	16.146	17.761
Pears	4.644	5.109
Oranges	17.510	22.763
Bananas	8.907	9.798
Tomatoes	23.296	27.955
Lettuce	3.326	3.991
Potatoes	41.358	49.630
Sugar	8.573	8.573
Wine	7.837	7.837
Beef	17.005	0
Pork	9.675	0
Fresh chicken	10.371	0

Frozen chicken	0.290	0
Other poultry	1.822	0
Other meat	5.611	0
Meat products	4.952	0
Fresh fish or plain refrigerated	10.457	0
Frozen fish	1.835	0
Cod (fillet)	0.539	0
Fresh seafood, plain refrigerated or frozen	1.966	0
Processed fish and seafood	1.047	0
Total emissions (g CO_2 -eq/capita/y.)	**1,167,281.7**	**608,826.5**
Energy of substituted items (kcal/capita/y.)	**661,610.6**	**661,759.0**
Proteins of substituted items (g protein/capita/y.**)**	**23,669.5**	**18,820.7**

Table 3. Substitution of beef by pork and chicken (alternative scenario 2): Main diet components, total GHG emissions, energy and proteins of substituted food items.

	Consumption in Greece (kg product/capita/y.)	
	Conventional diet	**Beef substitution by pork and chicken**
Pork	9.675	15.480
Fresh chicken	10.371	16.593
Frozen chicken	0.290	0.464
Beef	17.005	0
Other meats	5.611	5.611
Meat products	4.952	4.952
Total emissions (g CO_2 -eq/capita/y.)	**1,167,281.7**	**695,634.2**
Energy of substituted items (kcal/capita/y.)	**115,685.0**	**112,513.4**
Proteins of substituted items (g protein/capita/y.**)**	**8,208.6**	**7,101.1**

Table 4. Rice substitution by potatoes (alternative scenario 3): Main diet components, total GHG emissions, energy and proteins of substituted food items.

	Consumption in Greece (kg product/capita/y.)	
	Conventional diet	**Rice substitution by potatoes**
Rice	5.612	0
Potatoes	41.358	66.173
Pasta	9.578	9.578
Total emissions (g CO_2 -eq/capita/y.)	**1,167,281.7**	**1,155,917.8**
Energy of substituted items (kcal/capita/y.)	**85,268.8**	**82,386.0**
Proteins of substituted items (g protein/capita/y.**)**	**2,427.5**	**2,539.0**

Table 3. Substitution of beef by pork and chicken (alternative scenario 2): Main diet components, total GHG emissions, energy and proteins of substituted food items.

	Consumption in Greece (kg product/capita/y.)	
	Conventional diet	**Beef substitution by pork and chicken**
Pork	9.675	15.480
Fresh chicken	10.371	16.593
Frozen chicken	0.290	0.464
Beef	17.005	0
Other meats	5.611	5.611
Meat products	4.952	4.952
Total emissions (g CO_2 -eq/capita/y.)	**1,167,281.7**	**695,634.2**
Energy of substituted items (kcal/capita/y.)	**115,685.0**	**112,513.4**
Proteins of substituted items (g protein/capita/y.**)**	**8,208.6**	**7,101.1**

Table 5. Overall carbon footprint per food product category for each scenario.

	Reference Scenario	**Scenario 1**	**Scenario 2**	**Scenario 3**
Flour - Bread - Cereals	105,458.865	123,066.634	105,458.865	90,025.382
Meat	635,445.531	0	163,798.036	635,445.531
Fish - Seafood	47,820.191	0	47,820.191	47,820.191
Dairy - Eggs	208,560.222	290,852.125	208,60.222	208,560.222
Oils - Fats	65,026.788	76,592.741	65,026.788	65,026.788
Fruits	7,496.264	8,425.768	7,496.264	7,496.264
Vegetables	25,550.554	37,965.897	25,550.554	29,620.120
Sweetening - Marmalade - Chocolates – Ice creams	8,049.685	8,049.685	8,049.685	8,049.685
Non alcoholic drinks	46,317.909	46,317.909	46,317.909	46,317.909
Alcoholics drinks	17,555.691	17,555.691	17,555.691	17,555.691
Total emissions (g CO_2 –eq/capita/y.)	**1,167,281.7**	**608,826.5**	**695,634.2**	**1,155,917.8**

Table 6. Contribution (%) of the various food groups in the total diet-related carbon footprint in Greece and comparison with literature.

	Reference scenario (%)	Alternative scenario 1 (%)	Alternative scenario 2 (%)	Alternative scenario 3 (%)	Wallen et al. (2004) %	Kramer et al. (1999) %
Flour-bread-cereals	9,0	20,2	15,2	7,8	10	14
Meat	54,4	0,0	23,5	55,0	28	27
Fish-seafood	4,1	0,0	6,9	4,1	7	2
Dairy-Eggs	17,9	47,8	3,0	18,0	15	24
Oils-Fats	5,6	12,6	9,3	5,6	4	3
Fruits	0,6	1,4	1,1	0,6	6	4
Vegetables	2,2	6,2	3,7	2,6	13	9
Sweetening-Marmalade -Chocolates – Ice creams	0,7	1,3	1,2	0,7	-	-
Non-alcoholic	4,0	7,6	6,7	4,0	-	-
Alcoholic	1,5	2,9	2,5	1,5	-	-
Other food groups	-	-	-	-	17	17
Total	100,0	100,0	100,0	100,0	100,0	100,0