Food Styles and the Dynamics of the Mediterranean Adequacy Index

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Abstract

Medical longitudinal surveys demonstrated that the Mediterranean diet is inversely connected with mortality due to Coronary Heart Disease (CHD). To evaluate this phenomenon, the Mediterranean Adequacy Index (MAI) was launched in 2004, calculated as the ratio of the energy derived from Mediterranean-style foods to the energy from foods that do not characterize Mediterranean eating. According to one of the most cited research works, carried out on 16 samples from seven countries worldwide, in two Italian cohorts (Crevalcore and Montegiorgio) mortality from CHD was reduced by 26% in 20 years and by 21% in 40 years of follow-up with an index growth of 1 logarithmic unit (Fidanza et al., 2004). Fifteen years after that publication, this study aims to assess, in the six countries surveyed (Finland, USA, Netherlands, Italy, Greece, Japan and Croatia and Serbia, the former Yugoslavia), the MAI index dynamics extended universally, using the Food balance sheets data provided by FAO for the period 1961-2011. The objectives of this study are the following: a) determine the MAI trend over the past 50 years in order to check continuity or non-continuity of the Mediterranean nutritional style in the above countries; b) identify, using the latest data, the clusters of different countries which have similar eating habits and determine the convergence or divergence with respect to one prevailing style.; c) bring together, through the dual problem solution, the products that make up the predominant diet in the 28 EU member countries

Keywords: *Mediterranean Adequacy Index, diet, food styles, cluster analysis, EU-28.*

Résumé

Des enquêtes médicales de type longitudinal ont démontré que le régime méditerranéen est inversement lié à la mortalité due à la coronaropathie (CHD). Afin d'évaluer ce phénomène, l'Index d'adéquation à l'alimentation méditerranéenne (IAM) a été lancé en 2004. Il est calculé comme le rapport de l'énergie alimentaire apportée par les groupes alimentaires méditerranéens sur l'énergie apportée par les groupes non méditerranéens. Une étude parmi les plus citées, qui a fait usage d'une enquête longitudinale effectuée sur 16 échantillons provenant de sept différents pays à l'échelle mondiale, a montré que la mortalité dans les deux cohortes italiennes (Crevalcore et Montegiorgio) a été réduite de 26% en 20 ans et de 21% en 40 ans de suivi, avec une croissance de cet index de 1 unité log (Fidanza *et al.*, 2004). Cette étude a pour objectifs : a) d'établir la dynamique de l'index d'adéquation à l'alimentation méditerranéenne étendue universellement au cours des 50 dernières années pour vérifier la continuité ou non du régime méditerranéen dans les sept pays retenus (Finlande, États-Unis, Pays-Bas, Italie, Grèce, Japon, Croatie et Serbie, ex-Yougoslavie), en utilisant les données des bilans alimentaires de la période 1961-2011 fournies par la FAO; b) identifier, à partir des données les plus récentes, les groupes de pays qui ont des habitudes alimentaires similaires et déterminer la convergence ou la divergence par rapport à un modèle dominant; c) rassembler, à travers la solution du problème dual, les produits qui composent le régime prédominant dans les pays de l'UE-28.

Mots-clés : Index d'adéquation à l'alimentation méditerranéenne, régime alimentaire, styles alimentaires, analyse de clusters, UE-28

1. Introduction

The Mediterranean adequacy index (MAI) is the ratio of the energy derived from Mediterranean-style foods to the energy from foods that do not characterize Mediterranean eating. According to the most cited research work on this topic, which made use of a longitudinal survey carried out on 16 samples from seven countries of the world, the Authors found that in two Italian cohorts (Crevalcore and Montegiorgio) mortality was reduced by 26% in 20 years and by 21% in 40 years of follow-up with an index growth of 1 logarithmic unit (Fidanza et *al.*, 2004). Fifteen years after that publication, this study aims to verify, in seven countries surveyed (Finland, USA, Netherlands, Italy, Greece, Japan, Croatia and Serbia, the former Yugoslavia[1]), the index dynamics, extended to the universe, using the data of the Food balance sheets provided by FAO for the period 1961-2011.

In a recent white paper titled "Mediterranean Food Consumption Patterns – Diet, Environment, Society, Economy and Health", FAO, in collaboration with CIHEAM (CIHEAM/FAO 2015), highlighted a paradox that must lead to serious reflection. In view of the recognition of the multiple benefits of the Mediterranean diet, the Mediterranean habits and traditional eating styles have changed inducing an increased incidence of chronic degenerative diseases. This study demonstrates that the Mediterranean Adequacy Index (MAI) has been greatly reduced from the post-war period until the beginning of the 80s in most EU countries and has reached now stable values which prove a lower Mediterranean characterization of the diet. This has exacerbated the health and economic problems related to obesity, diabetes and cardiovascular disease (Bacon, 2011) with negative impacts on health care budgets.

After World War II, the growth of per capita income has led to a change in life style leading to new food patterns more and more distant from the Mediterranean one, such as those that characterize the agro-industrial period and later, the consumption pattern of the "Society of satiety" (Malassis, 1979; Padilla and Thiombiano 1996, p. 71). Considering the results of several scientific studies that praise the Mediterranean diet, now included on the World Heritage list for its benefits on health, landscape and finances of national health systems, it clearly appears that we missed an opportunity we should look for

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[1] The longitudinal analysis was performed in different areas of current Croatia and Serbia.

again. In fact, according to FAO, some Mediterranean countries have abandoned this diet for a long time to adopt the typical Northern European dietary habits.

The aim of this study is two-fold: a) establish the MAI trend over the past 50 years to verify the continuity or not of the Mediterranean nutritional style in the above countries; b) identify, using the latest data, the clusters of different countries which display similar eating habits and determine the convergence or divergence with respect to one prevailing style; c) bring together, through the dual problem solution, the products that make up the predominant diet in the EU-28 countries.

2. State of the Arts

Over the years, the concept of "Diet" and "Mediterranean Diet" (MD) has taken different meanings that have very often been misinterpreted. The term 'diet' indicates the quantity and quality of food usually consumed and all practices linked to the introduction of food and its utilization. The "Mediterranean Diet" we are exploring in in this study is the diet described by a survey conducted in 1960 on some families of Nicotera, a rural town of Calabria (South Italy), in the framework of a pilot research, called Seven countries studies (SCS) (Fidanza, 2006; Keys, 1980, 1995; Kromhout *et al.*, 1989).

In order to evaluate how a diet can approach or depart from the reference Mediterranean diet, in 1999 the Mediterranean Adequacy Index – MAI – was developed (Alberti-Fidanza *et al.*, 1999; Fidanza, 2004). The MAI is obtained by dividing the percentage of energy in kilocalories (kcals) provided by Food groups characterizing a Mediterranean Diet (bread, cereals, potatoes, legumes, vegetables, fresh and dried fruit, fishery products, virgin olive oil, red wine) by the percentage of the energy supplied by food groups that characterize a less Mediterranean diet (meat, milk, cheese, eggs, animal fats and margarine, cakes, sugary drinks, sugar):

$$MAI = \frac{\%\ energy\ from\ Carboydrates + Protective}{\%\ energy\ from\ Animal\ Derivatives + Sweets}$$

"*The MAI has been tested in the Seven Countries Study (Finland, Japan, Greece, Italy, ex-Yugoslavia, Netherlands and USA), using the 16 cohorts of the study as statistical units, showing a strong inverse relationship between the natural log of MAI and CHD mortality in 25 years*" (Fidanza *et al*., 2004; Bach *et al.*, 2006; for criticism see D'Alessandro and De Pergola 2015; for the association between the Mediterranean diet and biomarkers of diet and diseases see Bach-Faig *et al*., 2006).

An analysis of death rate for various reasons in relation to the diet consumed in 1965 (Farchi *et al.*, 1989) by the male population of the two Italian cohorts of SCS Crevalcore (Emilia) and Montegiorgio (Marches) for the period 1960-1991, demonstrates that after 20 years and 40 years, the death rate from cardiovascular disease was reduced by 26% and 21% of follow-up, respectively. The MAI has instead increased by 1 log unit, equal to 2.7 units of MAI. A further result, which allows to evaluate the positive effects of such a diet, is the inverse correlation found between infarction and the Mediterranean Diet (Menotti *et al*., 2012).

In this paper, MAI is calculated based on kcal per capita/day of Food Balance Sheets (FBS) provided by FAO. This approach was previously used in other papers for different periods, countries and different food groups (Balanza *et al.*, 2006; da Silva *et al.*, 2009; Palma e Padilla, 2012). MAI trend from 1961 to 2007, but only for aggregate data (according to their geographical location assembled in Mediterranean European, Other Mediterranean, Northern European and Eastern European), has also been analyzed (De Marco *et al.*, 2014).

One problem encountered in MAI calculation, using the food balance sheet, is to decide whether certain foods may be considered characteristic of a Mediterranean Diet (MD) or not. This is even more true for vegetable oils and alcoholic beverages except wine. Regarding vegetable oils, Nicotera's MD is known to include only the use of olive oil. The problem was solved by the MAI's proponents in an article (Fidanza, 2004) which referred to "vegetal oils" in general, and included them among the foods that characterize the MD. The classification of beer is instead more delicate because its incidence in kcals is substantial and often higher compared to wine. Given that, unfortunately, beer is not mentioned in the main publications concerning the calculation of MAI index, it was finally considered, along with other alcoholic drinks, among the foods that do not characterize the MD, because it is not included in the customary consumption of Nicotera population.

Longitudinal studies investigating eating habits, conducted by Fidanza and his collaborators (Fidanza, 1994), clearly pointed out a reduction from the initial MAI values not only in the Italian cohorts of the rural areas included in the Seven Country Study, Nicotera, Crevalcore and Montegiorgio, but also in the groups of elderly people in the city of Perugia and in the families of Pollica and Rofrano towns in the area of Cilento (Alberti-Fidanza *et al*., 1999). This trend was also emphasized by further studies, see for example Garcia-Closas *et al*., 2005, Schmidhuber and Traill, 2005, Schmidhuber, 2009, da Silva *et al.*, 2009 and Padilla and Palma, 2015; for an exhaustive summary see Castro-Quezada, 2014.

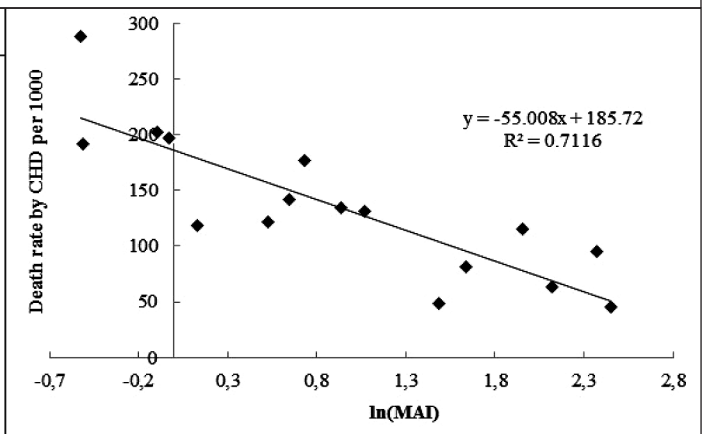
Figure 1 reports the experiment of Fidanza's article (2004) in order to highlight some of the critical issues observed when applying MAI to predict the mortality rates from cardiac ischemia (CHD). The table in Figure 1 reports MAI values and natural logarithms and mortality rates per 1000 inhabitants after 25 years of follow-up of 16 cohorts in the Seven Country Study.

The Graph in Figure 1 reproduces the regression line between the MAI natural logarithm and the number of deaths due to cardiac ischemia per thousand inhabitants.

Despite the good data regression ($R^2 = 0.7116$), with very similar values of MAI logarithms, such as -0.53 for East Finland, and -0.51 for West Finland, mortality rates vary con-

Figure 1. *Left) MAI values and natural logarithms; mortality rates from CHD per 1000 inhabitants in 16 cohorts. Source: Fidanza 2004; right) correlation between logaritm of MAI and death rates by ischemic heart disease (CHD). Source: reconstruction from Fidanza 2004.*

Locality	MAI	Log of MAI	Mortality rates from CHD per 1000 inhabitants
Railwaymen USA	0.91	-0.09	202
East Finland	0.59	-0.53	288
West Finland	0.60	-0.51	192
Zutphen-Holland	0.97	-0.03	197
Crevalcore-Italy	2.55	0.94	134
Montegiorgio-Italy	7.08	1.96	115
Railwaymen Rome-Italy	2.91	1.07	131
Dalmatia, Croatia	5.15	1.64	81
Croatia-Slavonia	1.91	0.65	142
Velika Krsna and Serbia	1.69	0.52	122
Zrenjanin-Serbia	2.08	0.73	177
Belgrade-Serbia	1.14	0.13	119
Crete-Greece	4.43	1.49	49
Corfu-Greece	10.69	2.37	95
Tanuscimaru-Japan	11.58	2.45	45
Ushibuka-Japan	8.33	2.12	63



siderably, i.e. 288 in the first case and 192 in the second, respectively. Similarly, close mortality rates, for example Tanuscimaru-Japan with 45 and Crete-Greece 49, rise also when MAI logarithm is very different: 2.45 in the first case and 1.49 in the second case. A similar paradox was highlighted, using FAO data, between France and Finland, by other authors (Artaud-Wild *et al*., 1993). In fact, their analysis proves that France and Finland, despite a similar consumption of high cholesterol foods and saturated fats, display very different mortality rates, higher for Finland compared to France. This paradox has been justified by the authors maintaining that France has a high consumption of foods (antioxidants) of plant origin (except for vegetable oils consumption, that is low) while Finland has a large consumption of milk, and fats derived from milk.

3. Materials and Methods

Materials will be first described below and then the methods adopted: a) for MAI calculation; and b) for the cluster analysis, direct and dual.

Concerning the Materials, data from the "Food Balance Sheets" (FBS) provided by FAO are taken into account. They are internationally harmonized and comparable both geographically and temporally. These data are widely used for different purposes and cited by scholars and researchers in economics and in other disciplines, as well as by public health officials and development agencies. These research works have also significantly contributed to the analysis for the food policy choices. The database includes more than 180 countries and geographical areas and about 100 different food items in a span of fifty years (1961-2011).

The FBS data include: 1) the total availability of food in metric tons for countries and clusters of countries, estimated as the sum of the production, the balance of imports minus exports, the balance of the inventories from the beginning to end of the year or of the period; 2) distribution in tonnes of the availabilities referred to 1) between the human food use and other uses (feed, seed for agricultural use, losses during transport of food, storage, and processing waste); 3) food availability in tonnes and per capita daily for human consumption in grams and kilocalories of macronutrients of the different food products, achieved by applying appropriate food composition factors for all primary and processed products. The total amount can be easily determined by multiplying the per capita/day data by the reference population, statistic that is also provided.

The macro-nutrients included are: cereals, starchy tubers, sugars and sweeteners, legumes, nuts, seeds, vegetable oils, vegetables, fruit, stimulants, spices, alcoholic beverages, meat, meat offal, animal fats, eggs, milk and fish (for a detailed list of all the individual foods, see FAO 2011). In this analysis, the per capita figures of daily energy consumed derived from the various foods measured in kilocalories (kcals) will be mainly used.

It is well known that the FBS data can only give an estimate of the average national food consumption. The amount of food available for human consumption itself simply refers to the one that can reach the consumer, not to the actual amount of food consumed. Although in FBS data the firm's wastes inherent with distribution and processing are taken into account, household food waste (from storage, kitchen and cafeteria), food for pets, and everything that is not used. expired or not consumed, are not be considered. Thus, the amount of actually consumed foods tends to be lower than that theoretically available. The magnitude of this difference varies depending on the food considered. Nonetheless, FBS data are recognized to be the most comprehensive database and valid for comparison in time and space. The same objection can be made to most of the database related to consumption of any kind and the problem of accounting for scraps and waste is long-standing and should be solved within the framework of the national accounts, of the international guide-systems as well as in other accounting contexts.

As regards the methodology used to identify the EU food styles, a 20×28 matrix has been created: the columns report the per capita kcals consumed per day for 20 groups of products (derived from a database of 73 products) whereas the rows indicate the 28 EU countries where these groups of products are consumed. The database obtained was analyzed

by cluster analysis. Indeed, the cluster analysis is a special case of multivariate analysis, which aims to redistribute the statistical universe in a predetermined number of groups, called clusters, based on greater internal consistency and greater dissimilarity between different groups. In the literature, and in the applications, there are several variations related to the use of different metrics and the introduction of any dimensional constraints (limits upward and downward). Since a rectangular matrix, where the rows represent the statistical universe elements and the columns represent the intensity of the attributes, is at the basis of this method, it is possible also to resort, by putting the question in a very innovative manner, to the dual problem by applying the cluster analysis to the transposed matrix. In general, the number of clusters suitable to solve this dual problem will be different from that of the original problem (Chang, 2011). To clarify the meaning of the dual cluster analysis in this context, an example is proposed that also allows for a geometrical representation, using a 3x3 matrix with 2 clusters in each phase. Suppose that the attributes x, y, and z represent respectively the consumption of 3 types of foods such as cereals, vegetable oils, meat. Suppose also that the countries considered in this example are 3: A, B, C, then the following matrix is obtained:

	x	y	z
A	1	1	2
B	1	0	3
C	2	4	0

Apply first the normal clustering of locations in two clusters. See Graph 1 left side.

One may notice that the axes represent the food values and that the countries are represented as points in the space (three-dimensional in this case). The first cluster consists of A and B and has the center at the point (1, 0.5, 2.5), while the second cluster, consisting only of C, has the center at the point (2, 4, 0). If one assumes now that attributes have been properly normalized, the coordinates of the cluster centers have the same meaning as the coordinates of individual countries. One might suppose that the total food of each country would be allocated in proportional parts, and that they represent the percentage in the diet of each individual country. Now, examine instead the transposed matrix below

	A	B	C
x	1	1	2
y	1	0	4
z	2	3	0

represented in the hyper-quadrants of Graph 1 right side.

In this case, the axes represent the countries, while foods are the points of the space generated by the countries themselves. Note that two foods are neighbors if they clearly exhibit similar values in different countries. Values can be both high and low. This means that the two foods are difficult to separate. Each country that contains one of the twos, contains also the other; if a country does not contain one of the twos, it will not contain the other. The clusterization at this point separates those blocks of foods that mostly differ from one another.

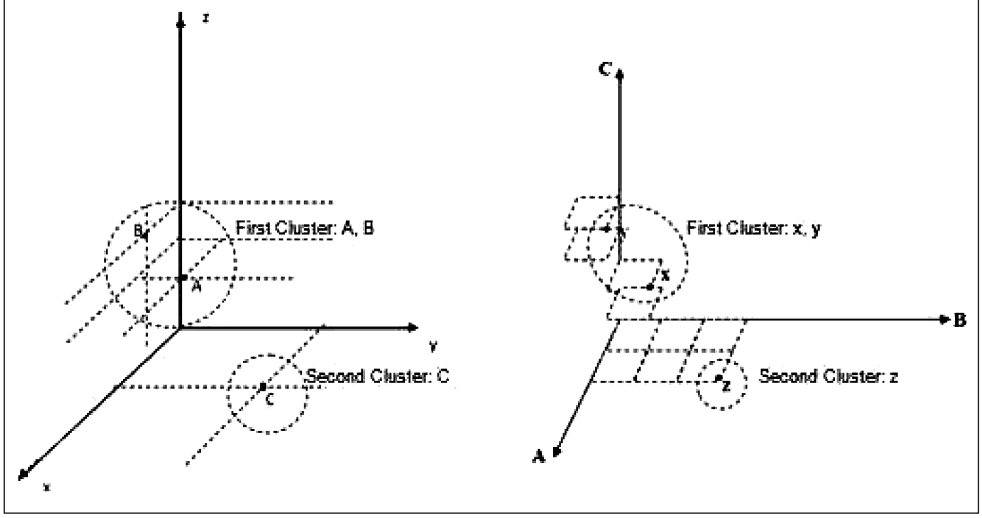
In this specific case study, first the 28 EU countries were grouped into four clusters of affinity in diet composition following the direct clustering method, then 20 food groups that make up the diet of the EU-28 countries were subjected to the cluster analysis applying dual clustering on the transposed matrix 20×28.

The procedure utilized for clustering is first Ward's method as follows:

$$\sum_{s=1}^{p}\sum_{i=1}^{n}(x_{is}-\overline{x_s})^2=\sum_{s=1}^{p}\sum_{i=1}^{n}(\overline{x_{sk}}-\overline{x_s})^2\cdot n_k+\sum_{k=1}^{g}\sum_{s=1}^{p}\sum_{i=1}^{n}(x_{is}-\overline{x_s})^2$$

For each step of the sequential construction of the dendrogram, the joined groups are those that create the minimum possible increase of deviance "within", or, alternatively, the greatest decrease of deviance "between". Then the K-means method is applied to identify the affinities between the clusters and their relative distances.

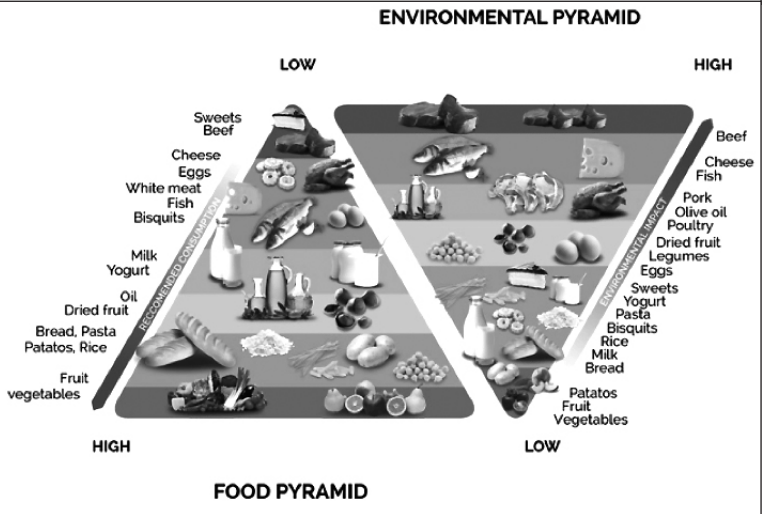
Graph 1 - *Left) clustering of locations; right) clustering of groups of products.*



4. Results and Discussion

The food styles of developed countries, including the Mediterranean Diet, result in energy expenditure. For example, in the USA the energy needed for agricultural production alone is equal to a quarter of the total energy input consumed by the entire food chain, which also includes processing, distribution, handling and domestic conservation (Leonardi, 2015). According to specialized studies, to produce a calorie of food, 7.3

Figure 2. *Food and Environmental Pyramids compared.*



Source: http://www.sport100.it/sport/images/stories/alimentazione/Piramide%20alimentare%20 invertita.jpg

calories of energy are needed, derived predominantly from fossil fuels (Heinberg, Bomford, 2009). This suggests that in developed countries, the current food production system is no longer sustainable from an energetic and environmental point of view and, therefore, it is necessary to follow new eating patterns which typically allow for energy saving.

Figure 2 shows that the Mediterranean diet is likely to be an example of a diet that not only has positive effects on human health, but also allows to reduce environmental impact. At the foundation of the Mediterranean Diet, in fact, lie foods which require a limited energy input for their production.

The observed increase in available energy resulting from the global food has been accompanied by changes in the diet composition. The process underlying this change seems to follow a model that involves two main steps. In the first stage, the main change consists in the expansion of energy consumption, with an excess of calories from less expensive foods of vegetable origin (Smil, 2001, 2002). In the second phase, there is a shift in the consumption of foods from the basic carbohydrates like cereals, roots, tubers towards vegetable oils, animal products (meat and dairy products) and sugar, giving rise to an increase in the energy introduced into the diet. The first phase has caused mainly an "expansion" effect, while the second a "substitution effect". The first phase has occurred in both developed and developing countries, while the second phase has mainly affected the rich countries leading, in some cases, to a certain worsening of the diet quality (more sugar or saturated fats), and in others to an improvement due to the substitution effect of animal products with the vegetable ones.

(Kearney, 2010). This different behavior is ascribable to the cultural specificity, beliefs and religious traditions as well as to a change occurring at income, price, and technology level (Dernini *et al.*, 2013). Globalization, population growth and other socio-demographic changes, such as urbanization and the increase in the rate of female participation in the workforce, are other factors that have influenced the change in dietary patterns (Mazzocchi *et al.,* 2012). Moreover, the importance of visual perception in food choice cannot be overestimated (Rizzato, 2016).

A study proves that foods, with high energy density (fats, sugary foods, fast foods, desserts etc.), cause weight gain and obesity and are associated with a lower cost; conversely those with lower energy intake (vegetables and fruit) has a higher cost for the consumer, comparatively (Darmon *et al.*, 2004).

In this paper MAI is calculated to verify the continuity or not of the Mediterranean nutritional style in the countries of the Seven Country Study from 1961 to 2011 compared to the aggregate data of "World" and "Europe" (Graph 2).

Regarding the MAI trend in the aggregate "World", in the early 1970s values are higher than in Europe and the countries surveyed, due to the inclusion of countries with less advanced economies, where the diet mainly consists of cereals. In contrast, in the 1960s, Japan and Greece (EL) exhibited much higher MAI values than the same aggregate "World".

The "Europe" aggregated data, instead, presents a lower MAI during all the 50 years under investigation with respect to both Japan and the Mediterranean countries (Greece, Italy and the former Yugoslavia), from 1.63 in 1961 to 1.35 in 2011 and scored the lowest value of 1.21 in 1983. Its position

Graph 2 - *MAI trend in 7 countries from 1961 to 2011. Source: own elaboration based on FAO data.*

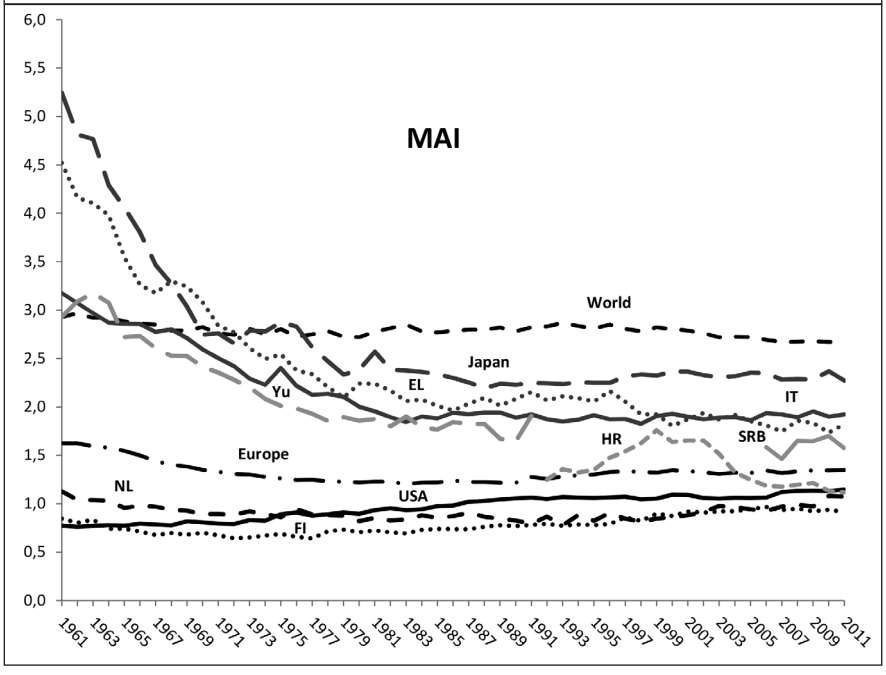


Table 1 - *MAI indexes for 4 periods. Source: own elaboration based on FAO data.*

Countries	1961-63			1978-80			1992-94			2009-11		
	kcal/day average per capita											
	Med	Not Med	MAI	Med	Not Med	MAI	Med	Not Med	MAI	Med	Not Med	MAI
Finland	1437	1726	**0.83**	1279	1770	**0.72**	1371	1719	**0.79**	1572	1692	**0.93**
US	1248	1618	**0.77**	1510	1672	**0.90**	1861	1749	**1.06**	1945	1705	**1.14**
Netherlands	1574	1468	**1.07**	1435	1661	**0.86**	1509	1782	**0.85**	1632	1561	**1.05**
Italy	2279	742	**3.08**	2413	1159	**2.08**	2278	1220	**1.87**	2344	1215	**1.93**
Greece	2267	532	**4.27**	2258	1034	**2.19**	2420	1156	**2.09**	2241	1244	**1.80**
Japan	2136	433	**4.95**	1976	823	**2.40**	2031	903	**2.25**	1881	814	**2.31**
Yugoslavia	2376	774	**3.07**	2366	1262	**1.87**	/	/	/	/	/	/
Croatia	/	/	/	/	/	/	1309	997	**1.31**	1653	1426	**1.16**
Serbia	/	/	/	/	/	/	/	/	/	1694	1032	**1.64**

is closer to that of northern European countries and the US with respect to the Mediterranean countries while it is still higher as regards the effect of the presence of the Mediterranean countries on the average.

Like in almost all countries, MAI declined until the early 1980s, apart from Finland (FI), whose maximum value is, however, 0.97, and the US. Here again the maximum value reached is relatively low and equal to 1.16. The US, Finland and the Netherlands (NL), however, recorded over time parallel MAI values in a range between 0.65 and 1.15, which finally converged around almost the same value in the late 1990s.

Japan has always had the highest MAI in the sample seven countries, but has shown a significant reduction over time from 5.25 in 1961 to 2.28 in 2011. The collapse of Japan took place mainly in the period 1961-1972 and has been attributed to improvements in the population living conditions due to the increase in per capita income. In the whole period 1961-2011, the calories derived from wheat have increased enormously whereas those from the rice have nearly halved (from 1170 kcals/daily to 576) and also those from potatoes, without however compensating the calories lost by lower rice consumption. At the same time, in Japan there has been an increase in kcals from meat with special emphasis on poultry, pork and dairy. Kcals from vegetable oils and in particular from rapeseed oil and mustard, which have a strong content of highly positive monounsaturated fat, have had a four-fold increase. The energy derived from sugars has not increased much, while that from sweeteners has significantly increased. The Japan food style has come closer to that of continental Europe while the fish quota has remained high, providing 138 kcal per capita/day. As for the total contribution of proteins, there was an increase due to the replacement of vegetal with animal proteins and a sharp rise of meat proteins compared to those derived from fish. For Greece, Italy (IT) and the former Yugoslavia (Yu) the evolution of MAI over time has been quite similar. Greece scored a MAI higher than the two other countries until 2005 when Italy recorded higher values, even if only slightly. However, a certain MAI convergence between Italy and Greece around the value 2 can be noticed, besides the overtaking (Piccinini *et al.*, 2014; 2016) of Italy with respect to Greece since 2005. Furthermore, the analysis of data in Serbia and Croatia, starting from 2006 and from 1992 respectively, with values higher than the index of the former Yugoslavia in 1991, showed a different trend. Over time, Serbia (SRB) has come closer to Greece and Italy, while Croatia (HR) has moved away going towards the typical dietary habits of the US, Finland and the Netherlands.

Tab. 1 summarizes MAI values for 4 periods of time. An average of 3 years was chosen to limit any oscillations that can be recorded in consecutive years. A more detailed analysis of the reasons which have led to significant MAI changes results from an examination of the three-year average of the amounts of food kcals characterizing at most (Med) and at least (Not Med) the Mediterranean diet, that is the numerator and the denominator of the MAI index.

In brief, among the European countries, Finland recorded the lowest MAI followed by the Netherlands and Croatia. Italy was marked, instead, by the highest MAI followed by Greece and Serbia. In the period 1961-2011, there was also a sharp MAI collapse in Greece (more than halved). In more detail in Italy, compared to a small change in kcals due to the consumption of Mediterranean foods, the calories of non-Mediterranean foods have increased significantly from 742 kcal in the period 1961-63 to 1215 kcal in 2009-11. This is also true for Greece where the consumption of non-Mediterranean food has more than doubled (from 532 to 1244 kcals). Japan has also almost doubled the energy deriving from non-Mediterranean food (from 433 to 814 kcals), besides a significant decrease in the use of Mediterranean food (from 2136 to 1881 kcals) as mentioned earlier. The US has, instead, considerably increased the kcals of Mediterranean food from 1248 to 1945 kcals whereas the kcals of non-Mediterranean foods have increased slightly (from 1618 to 1705 kcals). Concerning Finland, the kcal of Mediterranean foods have increased (from 1437 to 1572 kcals), while those from other foods have decreased (from 1726 to 1692) although not much. Finally, the Netherlands, have increased kcals of both Mediterranean foods (from 1574 to 1632 kcals), and non-Mediterranean ones (from 1468 to 1561 kcals), but changes were quite limited. Furthermore, although the MAI value has been drastically reduced compared to 1961, in Italy (-1.15), Greece (-2.47) and Japan (-2.64) in the last period 2009-2011, a modest recovery has occurred in five out of the seven countries studied except Greece and Serbia (in the last case the MAI value for 2006-2008 was 1.57). Just Finland (+0.1) and the United States (+0.37) increased their MAI from 1961-1963. Some authors observed a MAI decreasing in all the countries of the SCS, except a slight rise for the United Kingdom (Palma and Padilla 2012; 2015 and de Silva *et al.*, 2009) and the US (de Silva *et al.*, 2009).

5. The Food Styles in the European Union (1961-2011)

A well-known study demonstrates that, as income increases, the diet undergoes an evolution mainly from an energy-intensive content towards another highly nutrition-intensive diet in a broad meaning, i.e. the diet is modified in its composition with the replacement of carbohydrates with proteins and other foods rich in vitamins and pro-vitamins (Malassis and Padilla, 1986). In this process, the "social laws of food consumption" are acting as follows: a) for the effect of the Law of energy consumption, consumption, expressed in final calories, increases with income; b) due to the Law of substitution of nutritional consumption, the structure turns out to be modified by categories of products; c) according to Engel's Law, this means that as income increases, the absolute value of food spending increases, while it decreases in a relative sense. The economic processes that took place in the industrialized countries enabled the establishment of a consumer style that can be called "agro-industrial". This style has recently been replaced by that of the so-called "society of satiety".

The agro-industrial consumption style is characterized by: 1) a high percentage of calories coming from animal products; 2) higher losses and waste that occur along the supply chain; 3) the availability of a large amount of products with standard features; 4) an increasing value added resulting from secondary and tertiary activities; 5) the emergence of globalization in the trade of food products resulting from the increasing power assumed by multinationals; 6) the expansion of the consumption of energy-using food, whose production requires 5/10 kcal as input to obtain an output of 1 kcal of food.

This consumption pattern or nutritional style has evolved with time or has turned into an eating style concerning the so-called "society of satiety". The salient feature is represented by the fact that the income level and trend in an affluent society is no longer an explanatory variable of food consumption (Galbraith, 1998, Coderoni *et al.*, 2017). This is confirmed by a value of the income elasticity of food demand (at very high income levels) that is practically zero. Therefore, in his food choice behavior the consumer is not driven by energy needs because these have reached now a saturation level. The choices are instead guided primarily by psychological, social or cultural reasons. A condition, that of saturation in consumption, which is not reflected in much of the world population. In fact, according to FAO estimates, 795 million people in the period 2012-14 have suffered from chronic malnutrition.

In the literature there are several scientific papers that use the cluster analysis techniques to investigate eating habits. These studies will be cited in the comments on the four major food styles which will be identified below.

This research aims to analyze whether the EU countries selected in the Seven Countries Study are still or not representative of different food styles.

Starting from the Cluster analysis with the direct method, after identifying 4 clusters applying the Ward method (see graph 3 left side) – using the data on the distribution of spending for energy sources of food consumed in the EU-28 countries in 2011 – the K-means method is applied to identify affinities between the clusters and their relative distances. Four major food styles have been identified: 1- Mediterranean; 2- Balkan; 3- North-Eastern; 4- Central-North-Western (Table 2, Graph 3 left side, Figure 3).

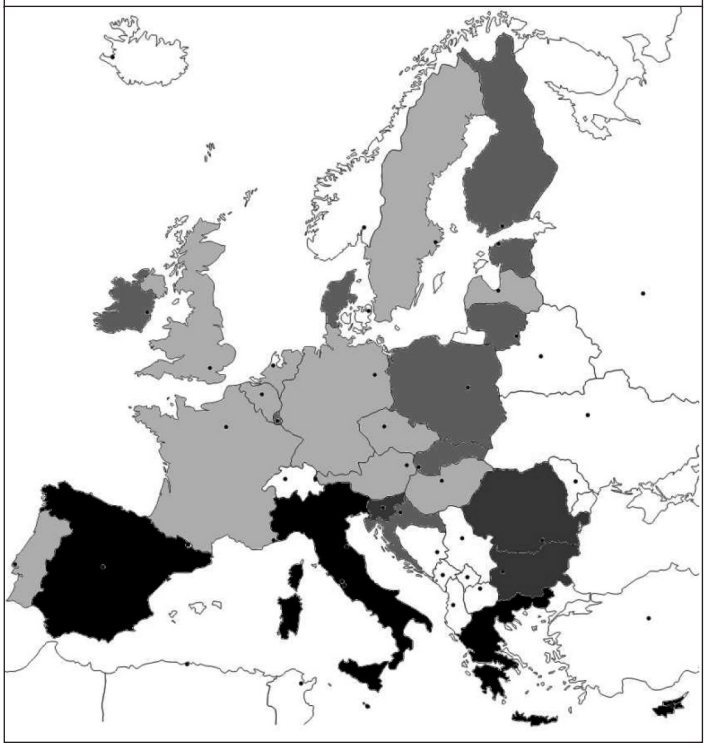
Cluster 1 - The Mediterranean Style (S_MED_EU) is present in Italy, Cyprus, Spain, Greece (black colored Fig. 3), countries that follow a diet

Table 2 - *Percentage distribution of calories among the product groups of the main EU food Styles (2011). Source: own elaboration based on FAO data.*

Consumer Products Groups	% of Diet Distribution of Cluster Centers				Diet cluster distribution differentials (%) versus the Mediterranean style			Others Differentials (%)		
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 1 vs Cluster 2	Cluster 1 vs Cluster 3	Cluster 1 vs Cluster 4	Cluster 2 vs Cluster 3	Cluster 2 vs Cluster 4	Cluster 3 vs Cluster 4
Cereals	26.7	39.1	30.2	25.6	-12.4	-3.5	1.2	8.9	13.6	4.6
Tubers	2.6	3.4	4.0	4.0	-0.9	-1.4	-1.4	-0.6	-0.5	0.0
Sugar	8.3	7.7	12.3	11.7	0.7	-3.9	-3.3	-4.6	-4.0	0.6
Pulses	1.5	0.6	0.7	0.5	0.9	0.9	1.0	-0.1	0.1	0.1
Shell Fruit	1.4	0.5	0.6	0.7	0.9	0.8	0.7	-0.1	-0.3	-0.1
Oilseeds	1.3	0.8	0.7	0.8	0.5	0.5	0.5	0.1	0.0	0.0
Vegetal Oils	19.8	10.0	7.7	13.4	9.8	12.1	6.4	2.3	-3.3	-5.7
Vegetables	3.1	2.3	2.5	2.3	0.8	0.5	0.8	-0.3	0.0	0.2
Fruit	3.8	3.4	3.0	3.2	0.4	0.8	0.6	0.4	0.2	-0.2
Grapes	0.4	0.9	0.4	0.4	-0.4	0.0	0.0	0.4	0.5	0.0
Tea, coffee and stimulants	1.1	1.2	1.6	0.9	-0.1	-0.5	0.2	-0.4	0.2	0.7
Spices	0.1	0.5	0.2	0.2	-0.4	-0.1	-0.1	0.3	0.3	0.0
Alcoholic beverages	3.5	5.1	6.6	5.6	-1.6	-3.0	-2.1	-1.5	-0.5	1.0
Meat	10.9	8.3	10.7	10.8	2.6	0.2	0.1	-2.4	-2.5	-0.1
Offal	0.3	0.4	0.3	0.3	-0.1	0.0	0.0	0.1	0.1	0.0
Animal fats	2.2	3.9	5.6	7.2	-1.7	-3.4	-5.0	-1.7	-3.3	-1.5
Eggs	1.3	1.3	1.3	1.5	0.0	0.0	-0.2	0.0	-0.2	-0.2
Milk	9.4	9.9	9.7	9.4	-0.5	-0.3	0.0	0.2	0.5	0.3
Fish	1.6	0.5	1.5	1.4	1.1	0.1	0.3	-1.0	-0.9	0.2
Miscellany	0.5	0.2	0.2	0.2	0.3	0.3	0.4	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0

Distance between the final cluster centres				
Cluster	1	2	3	4
1		0.164	0.141	0.094
2	0.164		0.11	0.152
3	0.141	0.11		0.076
4	0.094	0.152	0.076	

Figure 3 - *Maps of the food style clusters.*



mainly characterized by consumption, below the EU average, of vegetable oils, cereals, tubers, sugar, alcohol and animal fats, while they consume, above the EU average, legumes, fruit in shell, oilseeds, vegetables, fruit and fish. Such a dietary structure is also confirmed by the study conducted by Costacou *et al.* in 2003 on a sample of 28,304 recruited volunteers from all regions of Greece. In 1961, Portugal was part of this cluster, but then in 2011 this country has approached more Cluster 4 - that of Central and Western Europe.

The centers of the clusters 1 (Tab. 2) have a distance lower than that referred to in 4). The prominent differentiation of characters consists in the relatively lower use of animal fats, sugars, alcoholic drinks including beer and tubers (especially potatoes), and in the most relevant use of vegetable oils, cereals, vegetables and fruit. The greater distances from the final cluster centers are found in comparison with the Balkan style and correspond to a greater dissimilarity.

Italy, Spain, Greece and Cyprus are also in the same cluster in a worldwide study (Sy *et al.*, 2013; Abbade *et al.*, 2015). In the EU context, just Spain and Italy are in the same cluster when different hierarchical methods are used (Petrovici *et al.*, 2005) but not confirmed with other methods.

Another study using 2005 data demonstrates how Portugal has moved towards a Central European diet, indicating that it falls in the same cluster as Germany (Finardi *et al.,* 2010).

Cluster 2 - The Balkan Style (BALKAN_EU) prevails in Romania, Bulgaria, Slovenia (dark gray colored Fig. 3), where the diet is characterized by a greater consumption of cereals (39.1% of calories) and less sugar, meat and fish. From the 1961 data, the composition of this cluster proves to be unchanged except that there is Slovenia rather than the whole Yugoslavia and Malta also included in this cluster. Compared to the centers of the other clusters, the distance of cluster 2 from cluster 1 - Mediterranean is the highest, while the Balkan style seems more akin to the grouping of countries whose eating style is close to Northeast Europe and the former Soviet Bloc countries.

In comparison to the Mediterranean style, the Balkan countries consume more cereals (much more), potatoes, alcoholic beverages and animal fats. They consume less sugar, legumes, nuts, vegetable oils (much less), meat and fish. It is not surprising if a study focusing only on meat, vegetables and sugar consumption, as well as on the number of calories consumed daily (Bradatan, 2003), shows that there are strong similarities between the diet in the Balkan countries (Greece, Romania, Albania, Bulgaria, Yugoslavia) and in other parts of Europe, in particular the Mediterranean countries (Spain, Portugal and Italy). The Principal Component Analysis confirms this structure in the diet (Balanza *et al*., 2006), Romania and Bulgaria are in the same cluster also using different cluster methods (Petrovici *et al*., 2005).

Cluster 3 - the food style of North-East Europe and of the former Soviet Bloc countries (NE_SOV_EU) characterizes the following countries (medium gray colored Fig. 3): Ireland, Lithuania, Latvia, Malta, Croatia, Poland, Slovakia, Estonia, Luxembourg, Finland and Denmark (larger distance than the Mediterranean cluster and closer to the cluster of Central and Western Europe).

The style is characterized by a very high consumption of sugar and alcoholic beverages, and by a high use of cereals and animal fats.

In 1961, Hungary was also part of this cluster with USSR, Malta and Poland, the other countries split in cluster 4. Compared to the Mediterranean countries, this cluster of countries consumes more grains (not much), potatoes, sugar, alcoholic beverages and animal fats (a lot more even than Cluster 2). The consumption of legumes and nuts is smaller while that of vegetable oils and fruit, much lower. Poland, Lithuania, Estonia and Latvia are in the same cluster also using different cluster methods (Petrovici *et al*., 2005).

Cluster 4 - The style of Central and Western Europe (MIT_W_EU) is adopted by Germany, France, Sweden, Hungary, the UK, Czech Republic, Austria, Belgium, Portugal, Netherlands (light gray colored Fig. 3), and is characterized by the lowest consumption of cereals (25.6% of kcals), by a high use of sugar and a good use of vegetable oils, but also by a strong use of animal fats (7.2% of the diet) and a high consumption of alcoholic beverages. The clustering of Germany, Austria, Belgium (with Luxembourg) and Netherlands is confirmed also when different cluster methods, with a higher number of clusters, are considered (Petrovici *et al*., 2005).

In 1961, Portugal had not adopted this style, as it turned towards it fifty years later in 2011, while this style has also been adopted by Ireland, Finland, Denmark. It is interesting

to observe that, using the K-means with 5 clusters instead of 4, just the fourth cluster split into two: Germany, Denmark, UK, Netherlands and Sweden in one; Austria, France, Ireland, Finland and Belgium with Luxembourg in the other.

This cluster represents an eating style more akin to that of North-East Europe and of the former Soviet Bloc countries, but it is dissimilar from the Balkan style. Compared with the Mediterranean style, these countries in Cluster 4 consume more potatoes, sugar, alcoholic beverages and animal fats (many more). Moreover, they consume less cereals (slightly less), legumes, nuts, vegetables, vegetable oils (much less) . The consumption of milk and meat is equivalent. In practice, this style is characterized by a much higher consumption of animal fats, although the use of vegetable oils is conspicuous, but it does not reach the typical level of the Mediterranean diet. This condition has also been verified in other works (Balanza *et al*., 2006; Finardi *et al*., 2010).

There is not a single Mediterranean diet, but different diets although there are common elements between the various diets adopted in the southern European countries, such as the large amount of fresh fruit and vegetables, whole grains, legumes, nuts and seeds, and fish seasoned with olive oil as the primary source of fat. Dairy products, especially yogurt and sheep cheese, are present and these products bring proteins. Wine consumption has become modest in terms of quantity, but it characterizes the diets of all the Mediterranean countries, except Muslim countries (Baldari *et al*., 2013).

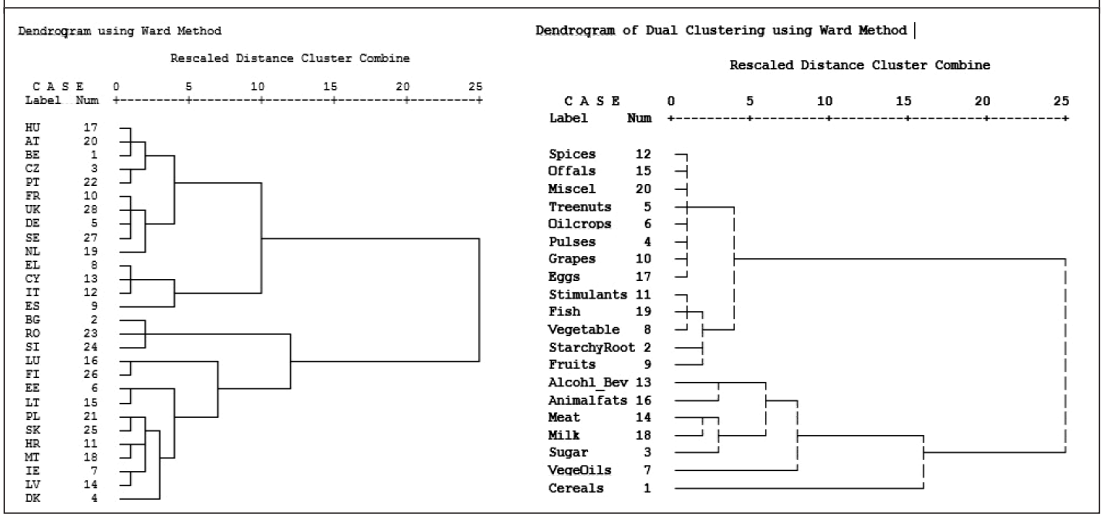
Furthermore, the results of cluster analysis of 2011 confirm the representativeness of different diet styles of selected countries across the EU in the Seven Countries study. In fact, Italy and Greece continue to follow a Mediterranean food style and Slovenia a Balkan style. In 2011 Finland and Croatia followed the style of North-East countries and the Netherlands the Central and Western Europe style. In 1961 a differentiation between the diet styles of Finland and the Netherlands is proved when a further subdivision of diets is required.

The Cluster analysis with the dual method (Graph 3 right side) highlights, on the average of the EU countries, a first partition between two large clusters: a) **Cluster 1_dual or Traditional/Rural Food habits** is characterized by the combination of a number of product groups of mainly vegetable type as fruit, vegetables, spices, pulses, tree nuts, stimulant, starchy roots, oil crops, plus some animal production groups of no great value as eggs and offal, and in addition fish; b) **Cluster 2_dual or Agro-industrial Food habits** is instead based on primarily animal products and bisects itself into two sub-clusters; the first b.1 includes Animal Fats and alcoholic beverages; and the second b.2 is formed by meat, milk and sugar (**Post-modern habits**); c) subsequently, to sub cluster b.2 are added, at a tolerable significance level, vegetable oils which characterize an evolution of Post-modern to **Satiety society habits,** and at higher levels of dissimilarity cereals (above the unification of the sub-clusters).

It is clear that the first dual cluster describes the virtuous food behavior that characterizes the Traditional societies where the prevailing style is rural, with a predominant role for custom and habit. The second dual cluster can be ascribed to the prevalent harmful behavior of industrial/post-modern society characterized by physical inactivity and alcohol consumption combined with animal fats and then by the consumption of meat, milk and sugar. As a result, the good food-healthy habits tend substantially to merge with each other and the same holds true for the harmful ones. The duality found in the dual cluster unfortunately excludes combinatorial attitudes to a mixing of the two food styles described above.

The economic crisis has led to reduced fish consumption due to very high relative prices and also that of meat, if we exclude North African countries where the consumption of packaged agro-food products, processed industrially, has increased (Chang, Iseppi, 2011; Chang *et al*., 2014). It should be stated that consumption has also held in southern Europe thanks to confectionery products such as ice cream, snacks and junk foods. Following this still enthusiastic intake of packaged foods, the nutrient profiles of the diets adopted in the Mediterranean countries mimic those of the highly industrialized markets in the north (and the south as far as Australia and New Zealand are concerned), where the high consumption of processed products such as foods and energy-dense drinks were deemed partly responsible for the spread of chronic diseases. The consumption of saturated fat is still relatively low, but in the Mediterranean countries of North Africa its quick rise is alarming. The FAO white paper indicates that the whole Mediterranean area is going through a phase of "nutrition transition", characterized by erosion of its traditional healthy models, resulting in a concomitant increase in chronic diseases.

Graph 3 - *Cluster EU-28 countries 2011: left) Food styles by countries; right) Groups of products by food styles. Source: own elaboration based on FAO data*



Conclusions

The results of this study demonstrate that, in a relatively small area of the world such as the European Union, significant differences in dietary attitudes persist, despite globalization. Following the economic evolution, the Mediterranean food style has been reducing its incidence for a long time, and this demonstrates that its original dissemination depended more on economic than on cultural reasons. During the half century examined, the trend of the Mediterranean Adequacy Index (MAI) in many EU countries has been sharply decreasing in the first phase, but this has not been the effect of a decreased (in kcal) consumption of Mediterranean goods, but rather of a strong growth in the consumption of proteins (in kcal) of the most expensive goods of animal origin following the increase of per capita income. Since the late 1970s or the early 1980s, in many EU countries the second phase has begun, in which MAI has become stable, but its stability depends mostly on cultural and health reasons given the lack of economic factors. The dual analysis has finally revealed the persistence in pairing of animal consumption goods (such as meat and milk) which remains homogeneous in the EU countries, unlike what happens in other parts of the world (e.g. China).

The Mediterranean diet is the result of a hybridization or bastardization by adopting a more organized lifestyle, typical of the industrial era in which the agri-food industry's role has become more important and the intake of meals away from home for work or pleasure is no longer an exception (Chang *et al*., 2013). With the post-industrial and the consumption pattern of the society of satiety, the Mediterranean lifestyle might return in the long run, with emphasis on health benefits, to a more physically active style (not only sportier) outdoors and to a diet mostly based on fresh foods.

It is hard not to agree with FAO conclusions and to think that sooner or later a turnaround towards the Mediterranean diet will prevail. Actually, consumers are attracted by energy-intensive products because for centuries this has been a practice carried out by the mankind to survive the recurrent famines. The precooked and pre-packaged foods are obviously not better than those homemade, but now they have become convenience goods that the food industry has made highly competitive through large-scale production (Romano, 2011). Moreover, cooking after a hard and stressful day's work cannot be attractive and may save time for other activities such as family care and leisure, for which the consumer often evaluates the alternative opportunity cost.

In conclusion, economic development and income growth have led to a shift towards more sedentary lifestyles and less need for energy-intensive diet. However, the available total calories have increased along with food waste. In developed countries, this waste is of greater extent downstream of agriculture in the food chain (food processing, food wholesale and retail), while in less developed countries the main source is upstream and in agriculture (Chang *et al.*, 2015). Clearly, to deal with a highly active food energy balance, and not turn it into pre-obesity or obesity, satiety society has focused on increasing energy consumption during leisure time, being unable to reduce physical inactivity imposed by office work in post-modern age.

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