European Journal of Clinical Nutrition (2006) 60, 181–190
 0954-3007/06 $30.00
www.nature.com/ejcn

ORIGINAL ARTICLE

Dietary patterns and their socio-demographic determinants in 10 European countries: data from the DAFNE databank

A Naska[1], D Fouskakis[2], E Oikonomou[1], MDV Almeida[3], MA Berg[4], K Gedrich[5], O Moreiras[6], M Nelson[7], K Trygg[8], A Turrini[9], AM Remaut[10], JL Volatier[11], A Trichopoulou[1] and DAFNE participants[12]

[1]*Department of Hygiene and Epidemiology, School of Medicine, University of Athens, Athens, Greece;* [2]*Department of Mathematics, National Technical University of Athens, Athens, Greece;* [3]*Faculty of Food and Nutrition Sciences, Porto University, Porto, Portugal;* [4]*Statistics Finland, Helsinki, Finland;* [5]*Lehrstuhl für Wirtschaftslehre des Haushalts – Konsumforschung und Verbraucherpolitik, Technische Universität München, Munich, Germany;* [6]*Departamento de Nutrición, Facultad de Farmacia, Universidade Complutense de Madrid, Madrid, Spain;* [7]*King's College London, Department of Nutrition and Dietetics, London, UK;* [8]*Institute for Nutrition Research, University of Oslo, Oslo, Norway;* [9]*Istituto Nazionale di ricerca per gli Alimenti e la Nutrizione (INRAN), Rome, Italy;* [10]*Department of Food Technology and Nutrition, University of Gent, Gent, Belgium and* [11]*Unité Observatoire des Consommations Alimentaires, AFSSA, Paris, France*

Objective: To describe the dietary patterns of 10 European countries and their socio-demographic determinants, using the comparable between-countries DAFNE data.
Design: Analysis of standardized and postharmonized data collected through the national household budget surveys.
Setting: Nationally representative surveys undertaken in 10 European countries, generally in the second half of the 1990s.
Results: The differences in the fruit and vegetable consumption previously identified between Mediterranean and Northern European countries seem to be leveling out, particularly in relation to fruit consumption. Pulses, however, still characterize the diet of the Mediterraneans. Straying from their traditional food choices, Mediterraneans recorded high availability of unprocessed red meat, while Central and Northern Europeans preferably consumed meat products. The household availability of beverages (alcoholic and non-alcoholic) is generally higher among Central and Northern European populations. Principal component (PC) analysis led to the identification of two dietary patterns in each of the 10 countries. The first was similar in all countries and indicated 'wide-range' food buyers. The second was slightly more varied and described 'beverage and convenience' food buyers. PC1 was common among households of retired and elderly members, while PC2 was common among households located in urban or semi-urban areas and among adult Scandinavians living alone.
Conclusions: The dietary patterns identified point towards a progressive narrowing of dietary differences between North and South European countries. The comparable between-countries DAFNE data could prove useful in ecological studies, in the formulation of dietary guidelines and public health initiatives addressing specific population groups.
Sponsorship: European Commission.
European Journal of Clinical Nutrition (2006) **60,** 181–190. doi:10.1038/sj.ejcn.1602284; published online 9 November 2005

Keywords: household budget surveys; DAFNE; dietary patterns; disparities

Correspondence: Dr A Trichopoulou, Department of Hygiene and Epidemiology, School of Medicine, University of Athens, 75 Mikras Asias Str., GR-115 27 Athens, Greece. E-mail: antonia@nut.uoa.gr
[12]DAFNE participants
BE: AP. Cueto Eulert; FIN: A. Pajunen, T. Hirvonen; ES: C. Cuadrado, M.L. Boned, P. Seoane Spiegelberg; FR: J. Maffre; GE: G. Karg, K. Wagner; GR: Y Chloptsios, V. Foukas. K Tsiotas, E. Kritsellis; ITA: S. Barcherini, S. Martines; NW: E. Mork, K. Lund-Iversen; PT: S. Rodrigues; UK: D. Rimmer, S. Burr.
Guarantor: A Trichopoulou.
Contributors: AT is the overall coordinator of the DAFNE project, which she implemented in collaboration with AN and EO and the main investigators of the participating centres; MDVA, MAB, KG, OM, MN, KT, AT, AMR and JLV. DF was the principal statistician in this study. AN wrote the report taking into account the comments and suggestions made by the co-authors.
Received 4 February 2005; revised 20 July 2005; accepted 12 August 2005; published online 9 November 2005

Introduction

Publications derived from food consumption surveys focus mainly on presenting dietary intake in terms of individual foods and/or nutrients consumed. Because of the potential implication of nutrients to the causal pathway of disease, nutrients dominate most of the literature on nutrition research, and early dietary guidance was almost solely based on recommendations for the intake of specific nutrients (World Health Organization, 1990). Diet, however, is multidimensional and shaped by various factors, including physiological, agricultural, historical, religious, socio-economic and psychological ones (Gedrich, 2003). As diet comprises a number of nutrient and non-nutrient constituents that are often interacting, nutrition research has recently shifted towards studying inclusive food-based approaches that focus on dietary patterns. It is often suggested that pattern analysis may enhance interpretation of the diet–disease associations and may advance the translation of study outcomes into dietary guidelines (Greenwood *et al*., 2000). The formulation of food-based dietary recommendations for the general public is becoming the leading choice, and scientific societies and other stakeholders who issue dietary advice addressing groups of patients have recently endorsed recommendations formulated on the basis of dietary patterns (Krauss *et al*., 2000; Chobanian *et al*., 2003).

A dietary pattern approach is more relevant to actual eating habits, aggregates the simultaneous exposure to several food items consumed together and thus allows integration of nutritional interaction by the dietary components. Such interactions are left unconsidered in the single 'silver bullet' approaches of studying specific foods or nutrients. Furthermore, a proper understanding of overall food choices is necessary for providing nutrition guidance. Consumers rarely consider the nutrient content when choosing food. The dietary advice needs to take into account the combinations of different food items that people naturally choose to eat together.

Although publications appear depicting dietary patterns in specific studies, few attempts have been made to describe dietary patterns on an international basis (Slimani *et al*., 2002a). The limited comparability of the samples and the methods used in the various studies have hindered international comparisons (Beer-Borst *et al*., 2000). Making use of the databank developed in the context of the Data Food Networking (DAFNE) project, this paper aims to describe the dietary patterns prevailing in 10 European countries in recent years, and their socio-economic and demographic determinants. The DAFNE databank allows the central combination and postharmonization of food data collected from nationally representative population samples of European countries, using a standardized methodology (Trichopoulou *et al*., 2003a).

Methods

The DAFNE databank comprises data collected in the context of the country representative and the standardized household budget surveys (HBS), which are systematically conducted by the National Statistical Offices and aim at collecting information on all goods and services available to household members during a reference period. Thus, through the HBS, data are collected on the availability of foods and beverages at the household level, taking into consideration the households' purchases, contributions from own production and food items offered to members as gifts (Trichopoulou, 1992). The data retrieved for the purpose of the present analysis were generally collected in the second half of the 1990s in the following 10 European countries (the recording period of the respective HBS is in parenthesis): Belgium (1 month), France (1 week), Finland (2 weeks), Germany (1 month), Greece (2 weeks), Italy (10 days), Norway (2 weeks), Portugal (2 weeks), Spain (1 week) and the United Kingdom (1 week). With the exception of Norway, where the survey extended over a period of 3 years, the data collection was accomplished within 1 year with due attention paid to capturing seasonal variation and bulk purchases (Table 1). Information was also collected on the socio-demographic characteristics of the household members, thus allowing linkage of dietary habits to explanatory demographic and socio-economic factors (Trichopoulou *et al*., 2002).

The food and socio-demographic HBS data of the 10 European countries were postharmonized according to the DAFNE methodology, described elsewhere (Lagiou *et al*., 2001; Trichopoulou *et al*., 2003a). Between-countries comparisons are feasible at the level of 56 detailed food groups, which can be further aggregated (European Commission, DG-SANCO, in press). The process of harmonization included the establishment of operational qualitative and quantitative criteria for the classification of foods, iterative cross-coding, as well as several working group meetings and bilateral sessions to address specific problems.

The food quantities available for consumption in the household were estimated without making allowances for

Table 1 Characteristics of the household budget surveys that were utilized in the present study

Country	*Year of survey*	*Number of households*
Belgium	1999	3745
Finland	1998	4359
France	1991	6353
Germany	1998	12 680
Greece	1998–1999	6258
Italy	1996	22 740
Norway	1996–1998	3792
Portugal	1995	10 554
Spain	1998–1999	14 644
United Kingdom	1999	9439

Table 2 Age and gender-specific consumption units calculated on the basis of the respective average energy requirements

Age groups (years)	*Consumption units*	
	Males	*Females*
0–1.9	0.23	0.21
2–4.9	0.42	0.40
5–9.9	0.59	0.54
10–14.9	0.73	0.62
15–17.9	0.88	0.67
18–29.9	1.00	0.72
30–59.9	0.90	0.69
60–74.9	0.75	0.63
>75	0.68	0.62

Consumption units were calculated using the average energy requirements of males 18–29.9 years of age as the reference unit.

inedible parts, preparation losses, spoilage on the plate, or food offered to domestic pets and under the assumption of equal distribution of food during the survey period. Individual food availability was estimated as a calibrated average, taking into account the size of the household, as well as the gender and the age of the household members. Based on age- and gender-specific average energy requirements retrieved from the literature (Commission of the European Communities, 1992), *consumption units* were estimated for nine age groups, and separately for males and females. The energy requirements of males aged 18–29 years old were set as the reference unit and consumption units were calculated for the remaining groups as fractions of the reference unit. In Table 2, the calculated consumption units are presented for all age and gender groups. The consumption units corresponding to the members of each household, according to their age and gender, were added to estimate the *household values*. The recorded food quantities were then divided by the corresponding household values, in order to approximate the individual food availability.

Dietary patterns are illustrated using 'radar' graphic presentations of the relative food availability values by country. The daily individual food availability is presented relative to the overall average DAFNE food availability, which was calculated for each food group as the unweighted arithmetic mean of the country-specific mean availability values. These DAFNE means, one for each food group, were used as the common denominator to calculate the deviation of the mean food availability recorded in a particular country from the average DAFNE food availability. Deviations are expressed as percentages and illustrate the variation in the national mean food availability, in comparison to the overall DAFNE mean.

Statistical methods

The distributions of the recorded food quantities were right skewed, with a large number of zero values. In order to make data look more symmetrical, log transformations were applied. Specifically the $x' = \log(x/\text{mean}(x) + k)$ transformation was used, where k is a small constant, in order to address the limitation of zero values and to respect the shape of the distribution.

National dietary patterns were identified by means of principal components (PCs), extracted from principal component analysis (PCA), using the correlation matrix. To identify the number of PCs to be retained, two commonly applied criteria were used: (a) the eigenvalue >1.0 criterion, according to which each component should explain a larger amount of variance than a single standardized variable in order to be retained and (b) the interpretability of each component. Food groups with absolute scoring coefficients greater than 0.2 were considered as important contributors to a pattern; scoring coefficients can be regarded as correlation coefficients between the original variables (daily individual food availability) and the PCs extracted. A positive scoring coefficient indicates that the original dietary variable is positively associated with the respective PC, while a negative scoring coefficient implies an inverse association.

Each of the extracted PCs was regressed on socio-demographic categories: *locality*, categorized on the basis of the urbanization of the residence area (rural, semi-urban and urban); *education of the household head,* categorized according to the educational level attained (elementary, secondary and higher education); *occupation of the household head*, reflecting both the working status and the profession (grouped as manual, non-manual, retired and other); and six types of household composition (single adult households, two adult households, lone parent households, households with adults and children, households with a single elderly member and households with two elderly members). Out of the 94 564 households of the ten countries under study, 15 251 households whose composition did not fit in any of the predefined categories were excluded (percentages of households excluded per country are the following: Belgium 8%, Finland 11%, France 8%, Germany 13%, Greece 14%, Italy 16%, Norway 9%, Portugal 14%, Spain 18% and the UK 32%). Statistical analyses were performed using the STATA 8 Software (Stata Corporation. Stata statistical software, release 8.0, College Station, Texas: Stata Corporation 2003).

Results

Figures 1a–c presents the relative daily individual food availability by country, in terms of deviation (%) of the average food availability in each country from the overall average DAFNE availability. Countries are grouped as Mediterranean (Figure 1a: Greece, Italy, Portugal and Spain), Central/North European (Figure 1b: Belgium, France, Germany and the UK) and Scandinavian (Figure 1c: Finland and Norway). The reference circle of radius 100% indicated in each figure corresponds to the overall average DAFNE availability, which is the arithmetic mean of the average food availability values of the 10 countries. A 'dent' below 100%

indicates that the country recorded lower availability of that food group in comparison to the reference DAFNE average, and a 'dent' above 100% indicates higher than average availability. Results are presented for 25 food groups, common between countries, defined according to the DAFNE food classification scheme (European Commission, DG-SANCO, in press). The overall DAFNE average availability for each food group under study is indicated in parenthesis next to each group.

In the Mediterranean region (Figure 1a), food choices are characterized by the consumption of vegetable oils and particularly olive oil, pulses, red meat, poultry, fish and seafood. In terms of added lipids, the Central/North European (Figure 1b) and the Scandinavian populations (Figure 1c) recorded higher values of vegetable and animal fats, when compared to the overall DAFNE mean. An exception is France, where the population seemed to favor the consumption of butter and vegetable oils other than olive oil. The large differences in the fruit and vegetable consumption identified in the 1960s between the Mediterranean and the Northern European countries seem to be leveling out. Pulses, however, still characterize the diet of the Mediterraneans, with South European countries recording higher than the DAFNE mean availability values. Another aspect illustrating the departure of Mediterranean populations from their traditional dietary patterns in the 1960s is the increased availability of red meat. Poultry meat, fish and seafood are also widely consumed in the Mediterranean region, particularly by the Spaniards and the Portuguese. In Central and North Europe and in the Scandinavian countries under study, the mean availability of meat products is well above the overall DAFNE mean, while that of unprocessed meat (red or poultry) is below the DAFNE mean.

Disparities in food choices are also observed among countries of the same region. Among the Mediterranean

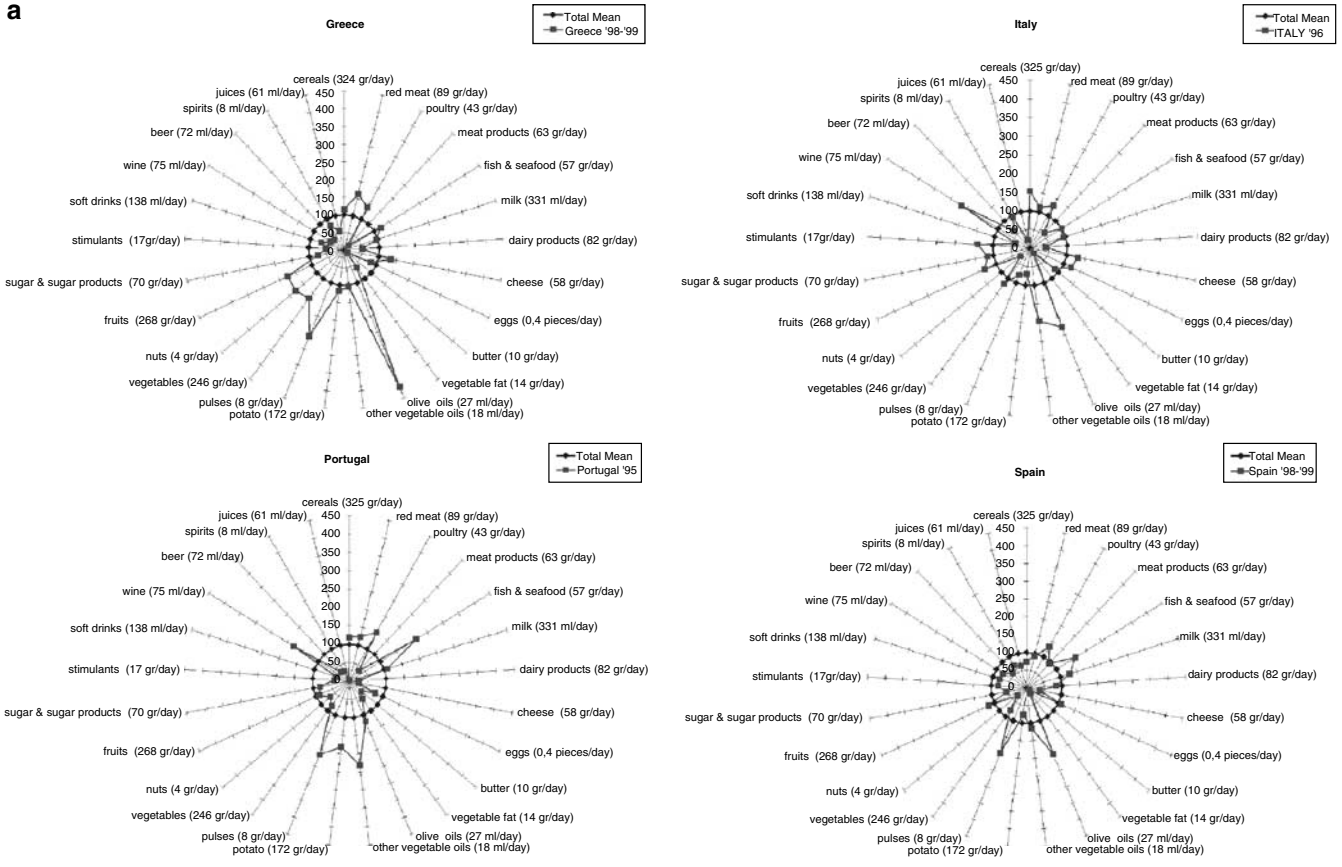

Figure 1 (**a**) Deviation (%) of the daily individual food availability from the overall DAFNE mean in Mediterranean countries. The reference circle of radius 100% indicated in the figure corresponds to the total DAFNE mean and the 'dents' indicate the deviation of specific food group means from the reference DAFNE mean. (**b**) Deviation (%) of the daily individual food availability from the overall DAFNE mean in Central/North European countries. The reference circle of radius 100% indicated in the figure corresponds to the total DAFNE mean and the 'dents' indicate the deviation of specific food group means from the reference DAFNE mean. (No data are available on the mean daily availability of pulses in Belgium.) (**c**) Deviation (%) of the daily individual food availability from the overall DAFNE mean in Scandinavian countries. The reference circle of radius 100% indicated in the figure corresponds to the total DAFNE mean and the 'dents' indicate the deviation of specific food group means from the reference DAFNE mean.

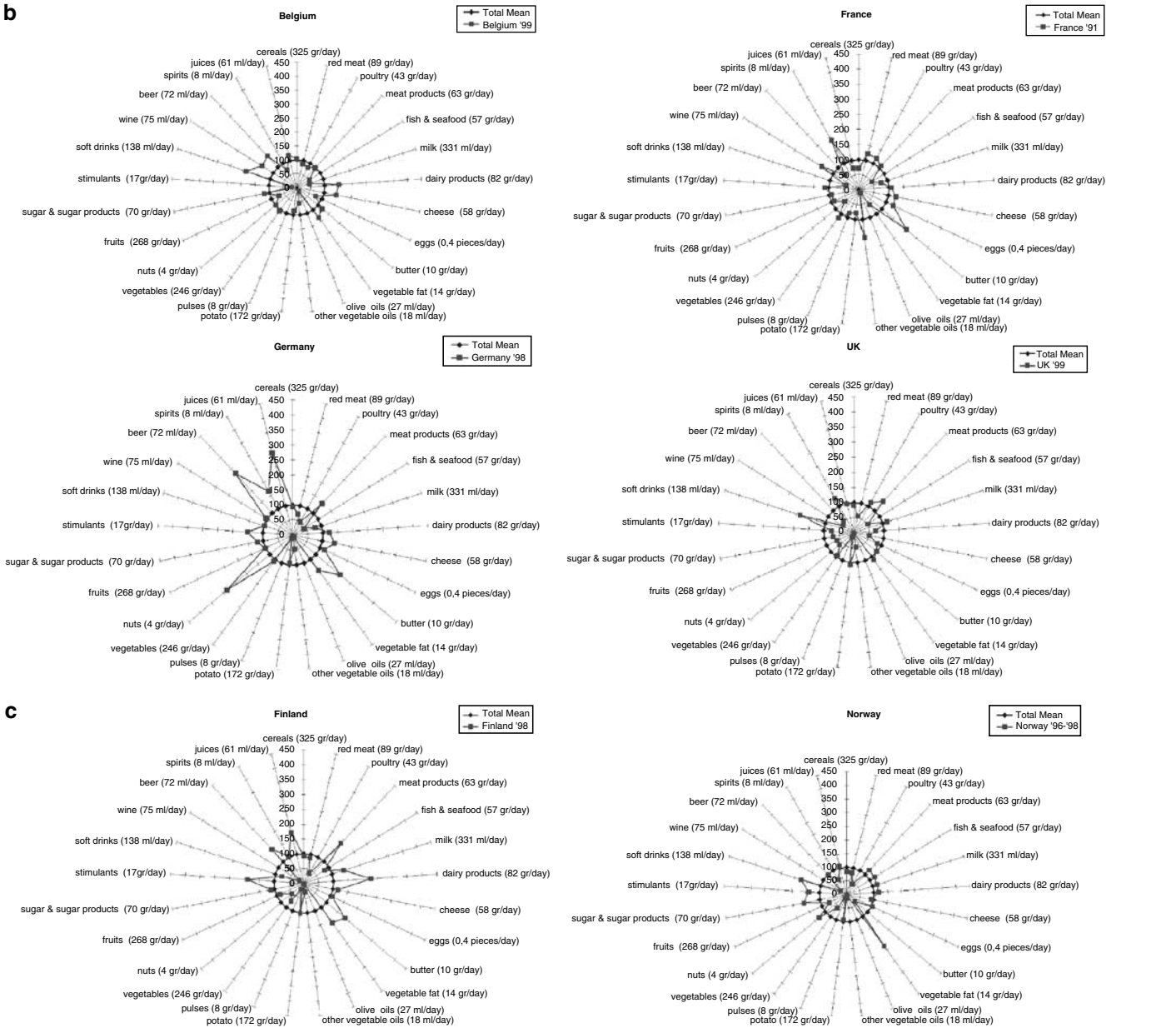

Figure 1 Continued.

countries (Figure 1a) Portugal, for example, recorded the highest availability of vegetable oils other than olive oil. Italy is the only Mediterranean country, where the daily availability of wine and stimulants (notably coffee and tea) in the household is above the overall DAFNE mean. The daily availability of beverages (alcoholic and/or non alcoholic) among the household premises was above the overall DAFNE mean in the Central and Northern European countries (Figure 1b and c), with country-specific particularities again being present. Thus, wine is preferred in Belgium and France, while the household consumption of beer is higher than the DAFNE mean in Germany, Finland and, again, Belgium. In Germany, the high beer availability seems to be accompanied by a high availability of nuts. In Norway and the UK, the availability of alcoholic drinks was generally below the DAFNE mean, probably indicating a strong component of out-of-home alcohol intake. These two countries, however, recorded availability values above the DAFNE mean for soft drinks (excluding fruit juices). With respect to fruit and vegetable juices, the largest deviation from the DAFNE mean availability was recorded in Germany and Finland.

Two PCs were retained in each of the 10 countries. The first component was remarkably similar in all countries, with positive loadings for a wide range of foods, from fruits, vegetables and cereals to meat, fish and dairy products, and rarely a negative loading. This PC explained between 15–20% of variation and was interpreted as indicating households with a wide variety of food purchasing. The second PC was slightly more varied among the 10 countries explaining between 6–8% of total variance and was generally characterized by positive loadings for beverages (alcoholic and non-alcoholic) and foods that could be consumed without elaborate preparation and negative loadings for plant foods and foods requiring laborious kitchen work. In short, we designated the first PC as 'wide-range' food buyers and the

Table 3 Multiple regression-derived coefficients β (and 95% CIs) linking, alternatively, the two major principal components indicating dietary patterns among Mediterranean populations to specified predictors

Predictor characteristics	*Greece*		*Italy*	
	Principal component 1	*Principal component 2*	*Principal component 1*	*Principal component 2*
Education				
Elementary	Referent	Referent	Referent	Referent
Secondary	−0.04 (−0.17, 0.08)	0.62 (0.53, 0.70)	−0.22 (−0.30, −0.14)	0.21 (0.16, 0.25)
Higher	−0.03 (−0.20, 0.14)	0.95 (0.83, 1.06)	−0.40 (−0.55, −0.25)	0.24 (0.15, 0.32)
Locality				
Rural			Referent	Referent
Semi-urban			0.14 (0.05, 0.24)	0.01 (−0.04, 0.06)
Urban			0.34 (0.25, 0.43)	−0.17 (−0.22, −0.12)
Occupation				
Manual	Referent	Referent	Referent	Referent
Non-manual	−0.03 (−0.19, 0.12)	−0.23 (−0.34, −0.13)	−0.08 (−0.17, 0.01)	0.09 (0.04, 0.14)
Retired	0.36 (0.17, 0.56)	−0.32 (−0.45, −0.19)	0.49 (0.38, 0.60)	−0.16 (−0.23, −0.10)
Other	0.10 (−0.10, 0.31)	−0.11 (−0.25, 0.02)	0.41 (0.29, 0.53)	−0.25 (−0.32, −0.19)
Household composition				
Adult household (single)	Referent	Referent	Referent	Referent
Adult household (2 members)	1.00 (0.78, 1.22)	−0.27 (−0.42, −0.13)	0.08 (−0.04, 0.21)	0.22 (0.15, 0.29)
Adult + children (lone parents)	0.66 (0.25, 1.06)	0.26 (−0.01, 0.53)	0.29 (0.02, 0.57)	0.41 (0.26, 0.56)
Adult + children	0.73 (0.53, 0.93)	0.18 (0.04, 0.31)	0.09 (−0.02, 0.20)	0.46 (0.40, 0.52)
Elderly household (single)	0.73 (0.47, 0.99)	−0.59 (−0.76, −0.42)	0.33 (0.18, 0.47)	−0.26 (−0.34, −0.18)
Elderly household (2 members)	1.03 (0.76, 1.30)	−0.62 (−0.79, −0.44)	0.33 (0.17, 0.50)	−0.17 (−0.27, −0.08)
	Portugal		*Spain*	
	Principal component 1	*Principal component 2*	*Principal component 1*	*Principal component 2*
Education				
Elementary	Referent	Referent	Referent	Referent
Secondary	0.05 (−0.09, 0.20)	0.69 (0.61, 0.78)	−0.05 (−0.14, 0.04)	0.18 (0.12, 0.23)
Higher	0.25 (0.02, 0.48)	0.96 (0.82, 1.09)	−0.11 (−0.24, 0.10)	0.18 (0.11, 0.26)
Locality				
Rural	Referent	Referent	Referent	Referent
Semi-urban	0.15 (0.04, 0.27)	0.12 (0.06, 0.19)	0.10 (−0.04, 0.24)	0.19 (0.10, 0.27)
Urban	−0.06 (−0.16, 0.05)	0.63 (0.57, 0.70)	0.01 (−0.09, 0.09)	0.24 (0.18, 0.29)
Occupation				
Manual	Referent	Referent		
Non-manual	−0.24 (−0.38, −0.10)	0.27 (0.18, 0.35)		
Retired	0.05 (−0.08, 0.19)	−0.06 (−0.14, 0.01)		
Other	−0.10 (−0.26, 0.06)	−0.07 (−0.16, 0.03)		
Household composition				
Adult household (single)	Referent	Referent	Referent	Referent
Adult household (2 members)	1.11 (0.89, 1.33)	−0.03 (−0.16, 0.10)	0.63 (0.44, 0.83)	0.07 (−0.05, 0.19)
Adult + children (lone parents)	0.41 (0.02, 0.80)	0.76 (0.53, 0.99)	0.47 (0.11, 0.83)	0.50 (0.28, 0.72)
Adult + children	0.56 (0.37, 0.76)	0.65 (0.54, 0.77)	0.75 (0.58, 0.92)	0.50 (0.39, 0.60)
Elderly household (single)	0.01 (−0.22, 0.24)	−0.28 (−0.42, −0.15)	0.43 (0.22, 0.64)	−0.56 (−0.69, −0.43)
Elderly household (2 members)	0.73 (0.50, 0.96)	−0.44 (−0.58, −0.30)	0.98 (0.77, 1.18)	−0.32 (−0.44, −0.19)

Table 4 Multiple regression-derived coefficients β (and 95% CIs) linking, alternatively, the two major principal components indicating dietary patterns among Central/North European populations to specified predictors

Predictor characteristics	*Belgium*		*France*	
	Principal component 1	*Principal component 2*	*Principal component 1*	*Principal component 2*
Education				
Elementary	Referent	Referent	Referent	Referent
Secondary	−0.23 (−0.43, −0.04)	0.09 (−0.04, 0.21)	−0.15 (−0.27, −0.02)	0.17 (0.10, 0.25)
Higher	−0.27 (−0.47, −0.07)	0.01 (−0.13, 0.13)	−0.34 (−0.51, −0.16)	0.22 (0.12, 0.33)
Locality				
Rural	Referent	Referent	Referent	Referent
Semi-urban	0.15 (−0.19, 0.48)	−0.12 (−0.34, 0.10)	−0.02 (−0.18, 0.14)	0.11 (0.01, 0.20)
Urban	0.15 (−0.17, 0.47)	0.02 (−0.19, 0.23)	−0.02 (−0.14, 0.10)	0.14 (0.07, 0.21)
Occupation				
Manual	Referent	Referent	Referent	Referent
Non-manual	0.46 (0.30, 0.63)	−0.06 (−0.17, 0.05)	−0.01 (−0.14, 0.14)	−0.12 (−0.20, −0.04)
Retired	1.73 (1.47, 1.98)	−0.21 (−0.38, −0.04)	0.72 (0.53, 0.92)	−0.42 (−0.54, −0.31)
Other	0.08 (−0.16, 0.32)	−0.12 (−0.28, 0.04)	0.03 (−0.22, 0.28)	−0.18 (−0.32, −0.03)
Household composition				
Adult household (single)	Referent	Referent	Referent	Referent
Adult household (2 members)	0.79 (0.59, 0.99)	0.28 (0.15, 0.42)	0.77 (0.59, 0.95)	−0.09 (−0.19, 0.01)
Adult + children (lone parents)	−0.05 (−0.40, 0.29)	−0.24 (−0.47, −0.10)	0.32 (0.02, 0.63)	0.27 (0.09, 0.44)
Adult + children	0.92 (0.74, 1.10)	−0.08 (−0.20, 0.04)	0.94 (0.78, 1.11)	0.21 (0.12, 0.31)
Elderly household (single)	−0.05 (−0.36, 0.25)	−0.10 (−0.30, 0.11)	−0.01 (−0.26, 0.23)	−0.38 (−0.52, −0.24)
Elderly household (2 members)	0.52 (0.17, 0.87)	0.30 (0.07, 0.53)	0.77 (0.50, 1.04)	−0.38 (−0.54, −0.23)
	Germany		*United Kingdom*	
	Principal component 1	*Principal component 2*	*Principal component 1*	*Principal component 2*
Education				
Elementary	Referent	Referent		
Secondary	−0.02 (−0.19, 0.24)	−0.02 (−0.16, 0.13)		
Higher	0.21 (−0.01, 0.42)	−0.29 (−0.44, −0.14)		
Locality				
Rural	Referent	Referent	Referent	Referent
Semi-urban	0.01 (−0.08, 0.10)	−0.20 (−0.26, −0.13)	−0.04 (−0.17, 0.09)	0.20 (0.13, 0.27)
Urban	0.01 (−0.09, 0.11)	−0.18 (−0.25, −0.11)	−0.15 (−0.29, −0.02)	0.14 (0.07, 0.21)
Occupation				
Manual	Referent	Referent	Referent	Referent
Non-manual	−0.13 (−0.24, −0.02)	−0.32 (−0.40, −0.25)	0.20 (0.07, 0.34)	0.46 (0.38, 0.53)
Retired	1.20 (1.06, 1.34)	−0.20 (−0.30, −0.10)	0.83 (0.61, 1.04)	−0.14 (−0.26, −0.02)
Other	0.22 (0.05, 0.39)	−0.06 (−0.17, 0.06)	0.27 (0.10, 0.45)	−0.35 (−0.44, −0.25)
Household composition				
Adult household (single)	Referent	Referent	Referent	Referent
Adult household (2 members)	1.06 (0.95, 1.16)	0.63 (0.56, 0.71)	0.99 (0.82, 1.16)	0.03 (−0.07, 0.12)
Adult + children (lone parents)	0.60 (0.40, 0.79)	0.01 (−0.13, 0.14)	0.73 (0.49, 0.97)	−0.24 (−0.37, −0.11)
Adult + children	0.74 (0.64, 0.85)	0.45 (0.37, 0.52)	1.11 (0.95, 1.27)	−0.04 (−0.13, 0.05)
Elderly household (single)	0.21 (0.03, 0.39)	−0.37 (−0.49, −0.24)	0.20 (−0.05, 0.46)	−0.36 (−0.50, −0.22)
Elderly household (2 members)	0.75 (0.56, 0.93)	0.44 (0.31, 0.56)	0.96 (0.67, 1.24)	−0.21 (−0.36, −0.05)

second PC as 'beverage and convenience' food buyers. Detailed loading factors by country and PC can be found at www.nut.uoa.gr.

Tables 3–5 show multiple regression-derived, mutually adjusted, partial regression coefficients and corresponding confidence intervals of PCs 1 and 2 regressed, on socio-demographic variables, for Mediterranean, Central/ North European and Scandinavian countries.

Among the Mediterranean populations (Table 3), individuals scoring higher in PC1 were more likely to be retired and less likely to be adults living alone. The PC2 that indicates a possible departure from traditional eating choices

Table 5 Multiple regression-derived coefficients β (and 95% CIs) linking, alternatively, the two major principal components indicating dietary patterns among Scandinavian populations to specified predictors

Predictor characteristics	*Finland*		*Norway*	
	Principal component 1	*Principal component 2*	*Principal component 1*	*Principal component 2*
Education				
Elementary	Referent	Referent	Referent	Referent
Secondary	−0.11 (−0.28, 0.06)	0.18 (0.08, 0.28)	0.06 (−0.13, 0.26)	0.41 (0.28, 0.54)
Higher	0.08 (−0.13, 0.27)	0.50 (0.38, 0.61)	0.15 (−0.07, 0.38)	0.69 (0.54, 0.84)
Locality				
Rural	Referent	Referent	Referent	Referent
Semi-urban	−0.03 (−0.24, 0.17)	0.25 (0.13, 0.37)	0.27 (0.12, 0.42)	0.32 (0.22, 0.42)
Urban	−0.33 (−0.49, 0.17)	0.54 (0.44, 0.63)	0.25 (0.05, 0.45)	0.67 (0.54, 0.81)
Occupation				
Manual	Referent	Referent	Referent	Referent
Non-manual	−0.13 (−0.32, 0.05)	0.17 (0.07, 0.28)	−0.11 (−0.26, 0.05)	−0.28 (−0.38, −0.17)
Retired	0.50 (0.23, 0.76)	−0.10 (−0.25, 0.05)	0.19 (−0.08, 0.47)	−0.38 (−0.56, −0.20)
Other	−0.27 (−0.59, 0.06)	−0.04 (−0.23, 0.15)	−0.71 (−1.03, −0.40)	−0.31 (−0.52, −0.10)
Household composition				
Adult household (single)	Referent	Referent	Referent	Referent
Adult household (2 members)	1.41 (1.18, 1.63)	0.25 (0.12, 0.38)	1.63 (1.37, 1.88)	0.20 (0.03, 0.37)
Adult + children (lone parents)	1.17 (0.72, 1.63)	0.13 (−0.14, 0.39)	1.15 (0.80, 1.50)	−0.22 (−0.45, 0.01)
Adult + children	1.38 (1.16, 1.60)	0.18 (0.05, 0.31)	1.61 (1.39, 1.84)	−0.19 (−0.34, −0.04)
Elderly household (single)	0.73 (0.37, 1.09)	−0.74 (−0.95, −0.554)	1.12 (0.66, 1.57)	−0.12 (−0.42, 0.18)
Elderly household (2 members)	1.37 (1.01, 1.72)	−0.60 (−0.80, −0.44)	2.35 (1.96, 2.74)	−0.21 (−0.47, 0.04)

was positively associated with higher educational attainment and with households including children, and was negatively associated with households including retired members.

Results are less consistent among the Central/North European countries (Table 4), where greater variation on the effect of socio-demographic factors to food choices was noted. Some common observations can be made, however. PC1 was positively associated with being retired and inversely associated with manual work in all countries and with higher education in Belgium and France. The PC2 was negatively associated with being retired or with being an elderly person living alone.

In the two Scandinavian populations (Table 5), single adults were more likely to score lower in PC1 than all other types of household composition. In both countries, households with an educated household head, located in urban areas and composed of two adult members were likely to score higher in the PC2, possibly because of higher availability of drinks.

Discussion

The dietary patterns identified through the use of the DAFNE databank point towards a progressive narrowing of differences in the food choices of Northern and Southern European countries. Some disparities, however, remain. Greece, Italy and Spain still follow a Mediterranean pattern of lipid intake, which can be clearly differentiated from the pattern found in the Nordic countries. Considerable disparities between the North and the South were also identified in the case of pulses, which, together with olive oil, seem to be the only two food items that still show a clear North/South gradient in their consumption. It is worth noting that several of the Central/Northern European countries recorded values for daily vegetable and fruit availability that are close to those of the Mediterranean region. In addition, the consumption of fruit juices was identified as a characteristic of the Northern diet, particularly in Germany and Finland. Over the years, Mediterranean countries have increased their meat consumption (Serra-Majem *et al*., 1993; Noah and Truswell, 2003; Tur *et al*., 2004) and now appear to surpass the Nordic countries in the availability of red meat, with Greece recording the highest daily availability values of all the participating countries. Similar results have been derived from analyses focused on food balance sheets (Trichopoulos and Lagiou, 2004).

These observations also agree with those reported from cross-sectional analyses of dietary patterns recorded in several European countries, in the context of the European Prospective Investigation into Cancer and nutrition (the EPIC project) (Riboli and Kaaks, 1997; Slimani *et al*., 2002b). In the EPIC data, as in the DAFNE data, the diet of the Greek, Italian and Spanish participants is characterized by plant foods and oils of vegetable origin. A preference for meat products among Spaniards is also noted. In both the EPIC and the DAFNE data, Nordic cohorts report a higher consumption of meat products and juices and the German

participants are singled out as high juice consumers. The EPIC investigators also reported that pulses were not typical of the Nordic diet. The dietary patterns of the EPIC cohorts, however, did not reveal an increased consumption of unprocessed meat in the Mediterranean countries and did not clearly suggest a narrowing of the gap between the South and the North diet, possibly because the EPIC participants have to be volunteers and, at least, largely health conscious. The westernization of the food habits experienced by the European Mediterranean countries has been recognized, particularly in relation to increasing intake of animal products, and concern has been expressed on how contemporary diets could take away the reputed Mediterranean advantage in longevity. (Alberti-Fidanza *et al*., 1999; De Lorenzo *et al*., 2001; Sanchez-Villegas *et al*., 2003; Trichopoulou *et al*., 2003b).

Two major dietary patterns emerged using the PCA analysis. The PC1, indicating 'wide- range' food buyers, was more common among households whose head was retired and elderly, possibly indicating infrequent out-of-home consumption. In addition, elderly individuals, particularly women living alone, have often been reported to overpurchase during the survey period and the extra purchasing was occurring throughout the range of foodstuffs (Nelson *et al*., 1985; Chesher 1997). Higher scores in PC2, which indicated 'beverage and convenience' food buyers, were more common among households located in urban or semiurban areas and among adult Scandinavians living alone.

The data used in the present analysis were collected through the national HBS and cover all food items available for consumption to the household members for a specified period of time. Nevertheless, food consumed outside the household (in canteens, cafeterias restaurants etc) was not considered. The lack of information on eating out is an important limitation of the HBS data and it is likely to affect estimations of food intake to a different extent in each country. The identification of dietary patterns, however, is not expected to be seriously affected, since the type of food people choose to eat in their households is not remarkably different from the food they choose when they are eating out. A second limitation of the HBS data relates to different recording periods used in some of the countries. However, this inherent weakness will not affect within-country comparisons and no major bias is expected to be introduced when comparisons between countries are made.

The HBS data is the collected data that refer to aggregate household consumption, and a process of individualization is required. There are different ways to estimate the per person food availability based on the HBS data and methods range from a simple division by the number of household members to the application of sophisticated statistical modeling (Chesher, 1997; Vasdekis *et al*., 2001). In our approach, we individualized the HBS data by taking into consideration the energy requirements of the household members, according to their age and gender. Based on these energy requirements, a composite index was computed that reduced the household to 'young adult male equivalents', even if there were no young adult males present in the household.

The present approach for allotting food shares to each household member is based on the assumption that energy requirements are being met, which is usually the case in the Western world. This approach, however, fails to consider factors such as the occupation and the physical activity, as well as personal taste and related preferences, which also affect the food quantity consumed. Our approach also does not differentiate the type of food preferred by males, females and children (Wheeler, 1991). Ideally, *consumption units* should be differentiated with respect to specific food items. A child's consumption of milk, for example, is expected to be higher than that of a young adult male, while the consumption of alcoholic beverages is expected to be zero. Nevertheless, our aim is not to present food availability by age and gender, but to compare average food choices among different European households.

From methods applied to identify dietary patterns, we used the explorative PCA, which has selected factors that explain as much variation in food availability as possible and is thus appropriate for identifying patterns of food consumption. The main reservations concerning PCA are the arbitrariness in determining the number of components extracted and the interpretation of components in the absence of health outcome information. (Hoffmann *et al*., 2004). In our study, two components were retained for each country, because of the lack of any meaningful interpretation in the remaining ones.

Among the advantages of the present study are the nationally representative population samples, the standardized data collection and the postharmonization of the available information in order to allow for inter-country comparisons. Variability in the national sample sizes exists and may affect the power of the study, which is already considerable, but it is unlikely to affect validity. An additional asset of the HBS-derived food data is their collection in regular time intervals, allowing for analysis of time trends in food choices. Nutrition monitoring is an important aspect of public health, given the increasing pace of change in food choices. Hence, the HBS data can be used for identifying variable and changing dietary choices. This information could prove useful in ecological studies, particularly when no other type of comparable data are available, in the formulation of dietary guidelines, and in public health initiatives involving nutrition policies and their implementation.

Acknowledgements

The DAFNE initiative has been supported by the following EU projects: Cooperation in Science and Technology with Central and Eastern European Countries, the COST Action 99 – Food Consumption and Composition Data, the

Agriculture and Agro-Industry, including fisheries (AIR), the Agriculture and Fisheries (FAIR) Programmes and the Health Monitoring Programme of DG-SANCO. Thanks are due to the Statistical Offices of all countries of the DAFNE network for supplying their national household budget survey data and supporting documentation, and for their unreserved collaboration.

References

Alberti-Fidanza A, Fidanza F, Chiuchiu MP, Verducci G, Fruttini D (1999). Dietary studies on two rural Italian populations groups of the Seven Countries Study. 3. Trends of food and nutrient intake from 1960 to 1991. *Eur J Clin Nutr* **53** (11), 854–860.

Beer-Borst S, Hercberg S, Morabia A, Bernstein MS, Galan P, Galasso R *et al.* (2000). Dietary patterns in six European populations: results from EURALIM, a collaborative European data harmonization and information campaign. *Eur J Clin Nutr* **54**, 253–262.

Chesher A (1997). Diet revealed? Semiparametric estimation of nutrient intake–age relationships. *J Royal Stat Soc A* **160**, 389–428.

Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo Jr JL, *et al.*, National Heart, Lung, and Blood Institute Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure; National High Blood Pressure Education Program Coordinating Committee (2003). The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA* **289**, 2560–2572.

Commission of the European Communities (1992). Reports of the Scientific Committee for food: 31st series. Nutrition Chapter 2: Energy. Luxembourg: Office for Official Publications of the European Communities.

De Lorenzo A, Alberti A, Andreoli A, Iacopino L, Serrano P, Perriello G (2001). Food habits in a southern Italian town (Nicotera) in 1960 and 1996: still a reference Italian Mediterranean diet? *Diab Nutr Metab* **14** (3), 119–120.

European Commission, DG-SANCO (2005). The DAFNE food classification system. Operationalisation in 16 European countries. Luxembourg: Services of the European Commission.

Gedrich K (2003). Determinants of nutritional behavior – a multitude of levers for successful intervention? *Appetite* **41** (3), 231–238.

Greenwood DC, Cade JE, Draper A, Barrett JH, Calvert C, Greenhalgh A (2000). Seven unique food consumption patterns identified among women in the UK Women's Cohort Study. *Eur J Clin Nutr* **54**, 314–320.

Hoffmann K, Schulze MB, Schienkiewitz A, Nothlings U, Boeing H (2004). Application of a new statistical method to derive dietary patterns in nutritional epidemiology. *Am J Epidemiol* **159** (10), 935–944.

Krauss RM, Eckel RH, Howard B, Appel LJ, Daniels SR, Deckelbaum RJ *et al.* (2000). AHA dietary guidelines revision 2000: a statement for healthcare professionals from the nutrition committee of the American Heart Association. *Circulation* **102**, 2284–2299.

Lagiou P, Trichopoulou A, DAFNE contributors. Data Food Networking (2001). The DAFNE initiative: the methodology for assessing dietary patterns across Europe using household budget survey data. *Public Health Nutr* **4** (5B), 1135–1141.

Nelson M, Dyson PA, Paul AA (1985). Family food purchases and home food consumption: comparison of nutrient contents. *Br J Nutr* **54** (2), 373–387.

Noah A, Truswell S (2003). Commodities consumed in Italy, Greece and other Mediterranean countries compared with Australia in 1960s and 1990s. *Asia Pac J Clin Nutr* **12** (1), 23–29.

Riboli E, Kaaks R (1997). The EPIC project: rationale and study design. *Int. J. Epidemiol* **26**, S6–S14.

Sanchez-Villegas A, Delgado-Rodriguez M, Martinez-Gonzalez MA, De Irala-Estevez J, Seguimiento Universidad de Navarra group (2003). Gender, age, socio-demographic and lifestyle factors associated with major dietary patterns in the Spanish Project SUN (Seguimiento Universidad de Navarra). *Eur J Clin Nutr* **57** (2), 285–292.

Serra-Majem L, La Vecchia C, Ribas-Barba L, Prieto-Ramos F, Lucchini F, Ramon JM *et al.* (1993). Changes in diet and mortality from selected cancers in southern Mediterranean countries, 1960–1989. *Eur J Clin Nutr* **47** (Suppl 1), S25–S34.

Slimani N, Fahey M, Welch AA, Wirfalt E, Stripp C, Bergstrom E *et al.* (2002a). Diversity of dietary patterns observed in the European Prospective Investigation into Cancer and Nutrition (EPIC) project. *Public Health Nutr* **5**, 1311–1328.

Slimani N, Kaaks R, Ferrari P, Casagrande C, Clavel-Chapelon F, Lotze G *et al.* (2002b). European Prospective Investigation into Cancer and Nutrition (EPIC) calibration study: rationale, design and population characteristics. *Public Health Nutr* **5**, 1125–1145.

Trichopoulos D, Lagiou P (2004). Mediterranean diet and overall mortality differences in the European Union. *Public Health Nutr* **7** (7), 949–951.

Trichopoulou A (1992). Monitoring food intake in Europe: a food data bank based on household budget surveys. *Eur J Clin Nutr* **46** (Suppl 5), S3–S8.

Trichopoulou A, Naska A, Costacou T, DAFNE III Group (2002). Disparities in food habits across Europe. *Proc Nutr Soc* **61**, 553–558.

Trichopoulou A, Naska A, DAFNE III Group (2003a). European food availability databank based on household budget surveys: the Data Food Networking initiative. *Eur J Public Health* **13** (Suppl 3), 24–28.

Trichopoulou A, Costacou T, Bamia C, Trichopoulos D (2003b). Adherence to a Mediterranean diet and survival in a Greek population. *N Engl J Med* **26** (348), 2599–2608.

Tur JA, Romaguera D, Pons A (2004). Food consumption patterns in a Mediterranean region: does the Mediterranean diet still exist? *Ann Nutr Metab* **48**, 193–201.

Vasdekis VG, Stylianou S, Naska A (2001). Estimation of age- and gender-specific food availability from household budget survey data. *Public Health Nutr* **4** (5B), 1149–1151.

Wheeler EF (1991). Intra-household food and nutrient allocation. *Nutr Res Rev* **4**, 69–81.

World Health Organization (1990). *Diet, nutrition, and the prevention of chronic diseases*. World Health Organization: Geneva. World Health Organization Technical Report Series 797.