

## Food sources of carbohydrates in a European cohort of adults

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### Abstract

**Objective:** To describe the average consumption of carbohydrate-providing food groups among study centres of the European Prospective Investigation into Cancer and Nutrition (EPIC).

**Methods:** Of the 27 redefined EPIC study centres, 19 contributed subjects of both genders and eight centres female participants only (men,  $n = 13\,031$ ; women,  $n = 22\,924$ , after exclusion of subjects under 35 and over 74 years of age from the original 36 900 total). Dietary data were obtained using the 24-hour recall methodology using the EPIC-SOFT software. The major sources of dietary carbohydrate were identified, and 16 food groups were examined.

**Results:** The 10 food groups contributing most carbohydrate were bread; fruit; milk and milk products; sweet buns, cakes and pies; potato; sugar and jam; pasta and rice; vegetables and legumes; crispbread; and fruit and vegetable juices. Consumption of fruits as well as vegetables and legumes was higher in southern compared with northern centres, while soft drinks consumption was higher in the north. Italian centres had high pasta and rice consumption, but breakfast cereal, potato, and sweet buns, cakes and pies were higher in northern centres. In Sweden, lower bread consumption was balanced with a higher consumption of crispbread, and with sweet buns, cakes and pies. Overall, men consumed higher amounts of vegetables and legumes, bread, soft drinks, potatoes, pasta and rice, breakfast cereal and sugar and jam than women, but fruit consumption appeared more frequent in women.

**Conclusion:** The study supports the established idea that carbohydrate-rich foods chosen in northern Europe are different from those in the Mediterranean region. When comparing and interpreting diet–disease relationships across populations, researchers need to consider all types of foods.

**Keywords**  
Foods  
Carbohydrates  
Descriptive epidemiology  
EPIC study  
Cancer  
24-Hour dietary recall  
Europe

Carbohydrates contribute a major proportion of dietary energy in most populations<sup>1,2</sup>. The influences of carbohydrate-rich diets on health and disease may, however, diverge substantially depending on the specific types and food sources of carbohydrate. Dietary carbo-

hydrates are defined as naturally occurring sugars, added sugars, starch, resistant starch and dietary fibre/non-starch polysaccharides (NSP). Plant foods contribute not only dietary carbohydrates, but also a whole array of essential micronutrients and food components, generally identified

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as protective agents with respect to cancer risk<sup>2,3</sup>. For instance, soy products, legumes, whole grains and flax, with a high content of isoflavones and lignans<sup>4,5</sup>, have been related to decreased cancer risk, especially breast cancer<sup>6</sup>. Most refined food products that contribute carbohydrates will provide only negligible amounts of these food components.

The evidence linking carbohydrates to the risk of disease is inconsistent. Several factors influence the physiological response after carbohydrate ingestion and these factors may explain some inconsistencies. Experimental studies indicate that both the type of carbohydrate and the physical properties of the specific food item<sup>7,8</sup> influence the postprandial glucose and insulin response (i.e. the Glycaemic Index (GI) and Insulin Index). Thus

not only the type of carbohydrate ingested<sup>7,9</sup>, but also factors such as the refinement of foods and the physical and chemical properties of carbohydrates at the moment of consumption, could potentially influence the development of disease<sup>8</sup>. For instance, observational studies indicate that high-GI diets are related to increased risk of non-insulin-dependent diabetes mellitus (NIDDM) both in men and women<sup>10,11</sup>, and clinical trials show that low-GI energy-restricted diets, compared with similar high-GI diets, favour long-term weight reduction<sup>12</sup>. It has been hypothesised that chronic hyperinsulinaemia may be a link between dietary factors (other than simply a sum of nutrients) and the development of high-risk steroid hormone profiles and increased breast cancer incidence<sup>13</sup>. Case-control studies<sup>14,15</sup>, and two large prospective

**Table 1** Food groups contributing carbohydrates in the European Prospective Investigation into Cancer and Nutrition (EPIC) study populations

Food groups in EPIC-SOFT	Final food groups	Average amount of food (g day <sup>-1</sup> )		Contribution by each food group, % of total carbohydrate	
		Men	Women		
Potatoes	Potatoes	99	66	6.8	
Vegetables Legumes	Vegetables & legumes	187	176	4.1	
Fruits		Fruits	225	230	12.9
Milk, milk beverages Yoghurt Fromage blanc Cream desserts, etc. Dairy and non-dairy creams Milk for coffee and creamers Ice cream & water ice	Milk & milk products	266	260	8.4	
Flour, etc.		–			
Pasta, rice		Pasta & rice	65	44	6.0
Bread		Bread	148	100	26.6
Crispbread, rusks		Crispbread	10	8	2.9
Breakfast cereals		Breakfast cereals	15	10	2.0
Dough, pastry, pizza		–			
Cakes, pies, pastries	Sweet buns, cakes & pies	44	43	7.3	
Dry cakes, biscuits	Sweet biscuits	8	9	2.5	
Salty biscuits Miscellaneous, snacks	Salty biscuits & snacks	5	5	1.1	
Processed meats		–			
Fish products	–				
Sugar, honey, jam, syrup	Sugar & jam	23	16	6.2	
Chocolate, candy bars	Chocolates	6	7	1.6	
Confectionery, non-chocolate	Sweets	4	4	1.2	
Dessert sauces	–				
Non-alcoholic beverages	–				
Fruit and vegetable juices	Fruit & vegetable juices	65	68	2.8	
Soft drinks	Soft drinks	105	66	2.5	
Coffee, tea and herbal teas	–				
Soups	–				
Sauces	–				

**Table 2a** Mean consumption of bread and crispbread by men ( $n = 13031$ ) in 19 European Prospective Investigation into Cancer and Nutrition (EPIC) centres

Country and centre	Total $n$	Bread ( $\text{g day}^{-1}$ )			Crispbread ( $\text{g day}^{-1}$ )		
		Crude mean	Adjusted*		Crude mean	Adjusted*	
			Mean	SEM		Mean	SEM
<b>Greece</b>							
Greece	1312	181.6	173.6	3.0	12.6	14.2	0.6
<b>Spain</b>							
Granada	214	149.6	148.8	7.4	4.0	3.8	1.5
Murcia	243	156.3	156.3	6.9	5.8	6.5	1.4
Navarra	444	179.2	178.8	5.1	2.6	2.7	1.1
San Sebastian	490	150.9	147.4	4.9	4.3	5.1	1.0
Asturias	386	139.6	137.1	5.5	6.2	6.8	1.1
<b>Italy</b>							
Ragusa	168	184.0	185.3	8.3	7.4	7.6	1.7
Florence	271	164.8	165.2	6.6	7.3	7.3	1.3
Turin	677	156.4	154.8	4.2	20.3	20.4	0.9
Varese	328	138.3	144.3	6.0	6.7	7.4	1.2
<b>Germany</b>							
Heidelberg	1033	147.5	141.0	3.4	1.3	1.5	0.7
Potsdam	1235	161.6	159.1	3.1	2.7	2.7	0.6
<b>The Netherlands</b>							
Bilthoven	1024	173.6	167.7	3.5	2.9	3.9	0.7
<b>United Kingdom</b>							
General population	404	122.8	124.6	5.4	3.4	3.4	1.1
'Health-conscious'	114	145.9	144.0	10.1	3.0	2.9	2.1
<b>Denmark</b>							
Copenhagen	1356	174.8	177.4	2.9	2.5	2.2	0.6
Aarhus	567	190.7	195.2	4.5	1.9	2.2	0.9
<b>Sweden</b>							
Malmö	1421	105.0	112.6	3.0	9.9	8.6	0.6
Umeå	1344	74.8	77.0	3.0	40.7	41.1	0.6

SEM – standard error of the mean.

\*Adjusted for age and standardised for day of the week and season.

studies that have related NIDDM to colon cancer incidence<sup>16,17</sup>, imply that insulin resistance is a putative risk factor for colon cancers. Furthermore, it has been hypothesised that the intestinal flora in the colon uses, in addition to NSP, some component of starch as a substrate. In fact, the consumption of resistant starch leads to an increase in faecal bulk and butyrate production as well as a decrease in secondary bile acids in faeces<sup>18–20</sup>. These factors are all potentially related to a decrease in colon cancer risk<sup>20</sup>.

In addition, studies suggest that added sucrose may have specific disadvantageous effects. An experimental study in rats recently found that high intakes of sucrose were associated with a higher frequency of GC to AT mutations in the *cII* transgene of the colonic epithelium<sup>21</sup>. Also, an epidemiological study has observed similar mutations in individuals with colon cancer and high-GI diets<sup>22</sup>. Moreover, fibre-rich diets, especially those high in cereal fibre, prevent constipation and may help control energy intake and body weight by promoting satiety by slowing gastric emptying<sup>23</sup>. Obesity and positive energy balance have been identified as potential risk factors for many cancers<sup>24,25</sup>. Some researchers argue that there is sufficient evidence to link the dietary proportions of macronutrients to the development of obesity (especially

high intakes of saturated fat and low intakes of fibre-rich foods), but others only agree that excess of energy intake over expenditure is important<sup>2</sup>.

Information about the distribution of different types of carbohydrate-rich foods across European populations would therefore not only illustrate how dietary habits differ in Europe, but also could assist in the further development of hypotheses on the relationships between diet, cancer and other chronic diseases. The primary aim of this paper is to describe, separately for men and women, the average consumption of carbohydrate-providing food groups across study centres of the European Prospective Investigation into Cancer and Nutrition (EPIC).

## Methods and materials

The EPIC multi-centre cohort study is investigating the relationship between diet and cancer in 10 Western European countries: Denmark, France, Germany, Greece, Italy, Norway, Spain, Sweden, The Netherlands and the UK<sup>26</sup>. The study population consists of 519978 mainly middle-aged men and women. Of the 27 study centres examined in this paper, 19 centres contributed subjects of both genders and eight centres female participants only. In

**Table 2b** Mean consumption of sweet buns, cakes and pies, and sweet biscuits by men ( $n = 13\,031$ ) in 19 European Prospective Investigation into Cancer and Nutrition (EPIC) centres

Country and centre	Total $n$	Sweet buns, cakes & pies ( $\text{g day}^{-1}$ )			Sweet biscuits ( $\text{g day}^{-1}$ )		
		Crude mean	Adjusted*		Crude mean	Adjusted*	
			Mean	SEM		Mean	SEM
<b>Greece</b>							
Greece	1312	14.5	15.4	2.3	7.4	6.7	0.6
<b>Spain</b>							
Granada	214	21.3	25.8	5.7	7.6	6.5	1.4
Murcia	243	43.1	41.6	5.4	11.0	11.3	1.3
Navarra	444	19.2	19.3	4.0	10.8	10.5	0.9
San Sebastian	490	24.6	24.2	3.8	9.7	9.9	0.9
Asturias	386	27.3	27.7	4.3	9.6	9.4	1.0
<b>Italy</b>							
Ragusa	168	30.1	37.8	6.5	16.3	12.0	1.5
Florence	271	47.7	47.4	5.1	13.1	13.4	1.2
Turin	677	33.8	35.5	3.2	13.4	13.5	0.8
Varese	328	40.6	36.9	4.6	19.6	21.4	1.1
<b>Germany</b>							
Heidelberg	1033	53.1	63.2	2.6	4.2	4.6	0.6
Potsdam	1235	50.3	57.4	2.4	5.1	5.6	0.6
<b>The Netherlands</b>							
Bilthoven	1024	36.6	36.5	2.7	11.1	11.1	0.6
<b>United Kingdom</b>							
General population	404	69.7	69.0	4.2	12.7	12.6	1.0
'Health-conscious'	114	59.3	59.2	7.8	10.6	10.2	1.7
<b>Denmark</b>							
Copenhagen	1356	33.8	36.7	2.3	5.8	6.3	0.5
Aarhus	567	44.2	46.8	3.5	9.0	8.4	0.8
<b>Sweden</b>							
Malmö	1421	51.8	54.1	2.3	5.9	5.6	0.6
Umeå	1344	69.0	69.8	2.3	5.6	5.8	0.5

SEM – standard error of the mean.

\* Adjusted for age and standardised for day of the week and season.

order to standardise habitual dietary intakes reported across the EPIC study centres, a calibration study using 24-hour dietary recall interviews among sub-samples of each study population was implemented. Individuals of the calibration population were randomly selected from each national cohort in proportion to the expected number of cumulative cancer cases by gender and 5-year age strata, and completed a single 24-hour dietary recall interview ( $n = 36\,900$ ). The final calibration samples represent 5–12% of the population of each study centre. Over all EPIC centres, a total of 22 924 women and 13 031 men were considered in the analysis, after exclusion of subjects under the age of 35 and over the age of 74 years. The sampling procedure was defined to control for possible day-to-day and seasonal variations in diet. Specific details about the calibration studies in each country and the main characteristics of the calibration populations are described elsewhere in this supplement<sup>27</sup>.

### Dietary data

Details of the computerised 24-hour dietary recall interview software (EPIC-SOFT) developed for the calibration study are given elsewhere<sup>28,29</sup>. During the 24-hour dietary recall interview, the EPIC-SOFT system collected information about all food and beverage items

consumed. Common rules for describing, quantifying and checking the 1500–2200 foods and 150–350 mixed recipes per country were pre-entered into the system. The 24-hour diet recalls were collected by a total of 90 interviewers. Almost all centres used face-to-face interviews, except in Norway where telephone interviews were used. During the calibration study, preliminary and country-specific national food composition tables were used together with the EPIC-SOFT system to calculate crude intakes of total energy and macronutrients. These estimates were used for quality control purposes and in this paper for the preliminary descriptive and methodological analyses.

A total of 33 food groups were initially identified as potential major contributors of carbohydrates in the EPIC countries (see Table 1). The relative carbohydrate contribution and the number of recalls reporting zero consumption of these food groups were examined in a preliminary project across study centres and countries. However, since current European food composition tables compute carbohydrates differently and a common European food composition table is not available<sup>30</sup>, the relative contribution of specific food groups was not examined in the final project. The number of food groups was reduced to 16, because some (e.g. dessert sauce,

**Table 2c** Mean consumption of breakfast cereal, pasta and rice, and salty snacks by men ( $n = 13031$ ) in 19 European Prospective Investigation into Cancer and Nutrition (EPIC) centres

Country and centre	Total $n$	Breakfast cereal (g day <sup>-1</sup> )			Pasta & rice (g day <sup>-1</sup> )			Salty snacks (g day <sup>-1</sup> )		
		Crude mean	Adjusted*		Crude mean	Adjusted*		Crude mean	Adjusted*	
			Mean	SEM		Mean	SEM		Mean	SEM
Greece										
Greece	1312	1.1	0.5	1.3	72.1	81.3	3.0	0.9	2.0	0.6
Spain										
Granada	214	0.1	-0.3	3.2	54.0	63.1	7.4	2.1	1.9	1.5
Murcia	243	0.7	1.0	3.0	58.2	53.3	7.0	1.3	1.1	1.4
Navarra	444	0.3	0.3	2.2	30.4	30.3	5.2	0.3	0.2	1.0
San Sebastian	490	0.8	1.8	2.1	36.8	29.5	5.0	0.4	0	1.0
Asturias	386	1.4	1.7	2.4	47.5	47.9	5.5	0.5	0.5	1.1
Italy										
Ragusa	168	1.3	1.5	3.6	222.1	228.7	8.4	13.3	8.9	1.7
Florence	271	2.2	2.6	2.8	239.2	234.4	6.6	15.7	16.5	1.3
Turin	677	0.8	1.3	1.8	202.4	202.2	4.2	8.4	8.4	0.8
Varese	328	1.2	0.5	2.6	266.8	268.3	6.0	4.7	6.0	1.2
Germany										
Heidelberg	1033	6.4	6.5	1.5	73.2	68.5	3.4	5.2	4.9	0.7
Potsdam	1235	3.2	3.0	1.3	23.5	22.1	3.1	2.7	2.5	0.6
The Netherlands										
Bilthoven	1024	3.3	4.6	1.5	53.2	43.9	3.5	12.5	11.4	0.7
United Kingdom										
General population	404	34.8	33.3	2.3	29.8	32.1	5.4	15.0	15.4	1.1
'Health-conscious'	114	61.1	62.5	4.4	59.1	44.3	10.2	8.1	12.0	2.0
Denmark										
Copenhagen	1356	23.0	21.3	1.3	38.1	36.8	3.0	3.2	3.1	0.6
Aarhus	567	24.6	22.4	2.0	32.0	30.5	4.6	3.9	3.1	0.9
Sweden										
Malmö	1421	29.9	28.0	1.3	27.8	36.4	3.0	2.5	3.9	0.6
Umeå	1344	50.6	50.0	1.3	41.7	42.0	3.0	3.7	4.0	0.6

SEM – standard error of the mean.

\* Adjusted for age and standardised for day of the week and season.

pastry) had a very low frequency of consumption (less than 10% of recalls contained items from the food group) and others (e.g. sauce, flour, meat and fish products, non-alcoholic beverages) contributed less than 1% to total carbohydrate intake in most centres. Foods contributing small amounts of carbohydrates were either combined into broader food groups (e.g. vegetables and legumes, milk and milk products) or excluded from further examination (e.g. meat and fish products). The current paper examines the following food groups: bread; crispbread; pasta and rice; breakfast cereal; sweet buns, cakes and pies; sweet biscuits; salty biscuits and snacks; potato; vegetables and legumes; fruits; fruit and vegetable juices; sugar and jam; sweets; chocolates; soft drinks; and milk and milk products.

### Analysis

Analysis was conducted separately for men and women. The SPSS statistical package was used for all statistical procedures<sup>31</sup>. The percentage of 24-hour dietary recalls reporting consumption of a food group and the crude mean food group intakes are described for each EPIC centre. Preliminary analysis indicated that the distribution of participants across seasons and days of the week was not equal across study centres. Therefore a standardisation procedure to control for day-to-day and seasonal

differences across centres was used in the multivariate analysis. Thus the age-adjusted mean food group intakes were computed for each EPIC centre with centre-specific weights for season and day of the week, using the General Linear Model. The computation of adjusted mean intakes was also repeated including total energy in the model, using the crude macronutrient data of EPIC-SOFT.

### Results

As reported in Table 1, the 10 food groups contributing the most carbohydrates in the EPIC population were: bread (27% of total carbohydrate intake); fruit (13%); milk and milk products (8%); sweet buns, cakes and pies (7%); potato (7%); sugar and jam (6%); pasta and rice (6%); vegetables and legumes (4%); crispbread (3%); and fruit and vegetable juices (3%). Table 1 also suggests that men overall have higher absolute intakes of vegetables and legumes, bread, soft drinks, potatoes, pasta and rice, breakfast cereal, and sugar and jam than women. Data shown are not adjusted for energy, because only crude energy data were available.

The percentage of 24-hour dietary recalls that include a particular food group depends both on the proportion of regular consumers in the population and on how often these individuals select a food item from the food group.

**Table 2d** Mean consumption of potatoes, vegetables and legumes, and fruits by men ( $n = 13\,031$ ) in 19 European Prospective Investigation into Cancer and Nutrition (EPIC) centres

Country and centre	Total $n$	Potatoes ( $\text{g day}^{-1}$ )			Vegetables & legumes ( $\text{g day}^{-1}$ )			Fruits ( $\text{g day}^{-1}$ )		
		Crude mean	Adjusted*		Crude mean	Adjusted*		Crude mean	Adjusted*	
			Mean	SEM		Mean	SEM		Mean	SEM
Greece										
Greece	1312	46.3	43.1	3.5	299.0	302.2	4.5	236.2	272.1	6.6
Spain										
Granada	214	81.1	79.2	8.5	269.7	254.6	11.0	382.4	353.0	16.3
Murcia	243	84.6	85.1	8.0	301.0	306.4	10.3	438.2	453.8	15.3
Navarra	444	69.9	70.4	5.9	296.5	292.5	7.6	315.2	312.5	11.3
San Sebastian	490	86.5	89.5	5.7	290.7	291.4	7.3	369.4	381.5	10.9
Asturias	386	99.1	98.5	6.3	210.2	213.0	8.2	337.3	339.8	12.1
Italy										
Ragusa	168	59.0	57.5	9.6	189.1	187.2	12.4	391.3	438.6	18.4
Florence	271	50.8	50.6	7.5	229.3	234.9	9.8	373.8	404.0	14.5
Turin	677	49.6	51.9	4.8	261.6	255.1	6.2	410.4	418.5	9.2
Varese	328	49.7	45.1	6.9	188.0	215.5	8.9	343.4	345.9	13.2
Germany										
Heidelberg	1033	79.6	87.9	3.9	177.2	175.9	5.0	173.2	166.6	7.5
Potsdam	1235	109.5	114.9	3.5	151.9	157.9	4.6	236.8	239.0	6.8
The Netherlands										
Bilthoven	1024	120.9	127.4	4.0	141.4	142.1	5.2	155.8	166.4	7.7
United Kingdom										
General population	404	111.2	110.7	6.2	166.6	169.1	8.0	148.7	152.2	11.9
'Health-conscious'	114	92.9	105.5	11.6	248.2	255.5	15.1	261.0	255.0	22.3
Denmark										
Copenhagen	1356	100.7	105.3	3.4	142.3	150.5	4.4	140.6	143.2	6.5
Aarhus	567	115.5	117.0	5.2	131.4	135.8	6.8	180.4	178.2	10.0
Sweden										
Malmö	1421	131.7	128.2	3.5	125.2	127.6	4.5	135.3	120.8	6.7
Umeå	1344	147.6	148.7	3.4	106.7	105.4	4.4	124.9	120.7	6.5

SEM – standard error of the mean.

\* Adjusted for age and standardised for day of the week and season.

The percentage of recalls that included bread, vegetables and legumes, fruit, and sugar and jam was high in all centres. The percentage of 24-hour dietary recalls including bread ranged from 91% to 98% in men and from 83% to 94% in women. In Umeå (Sweden), however, only 79% of recalls (both genders) included bread. Vegetables and legumes were found in at least 81% of recalls in men and in 84% in women. Fruit was included more commonly in recalls of women (72%), compared with men (58%). The corresponding numbers for sugar and jam were 59% in men and 52% in women and for milk products, 52% and 62%, respectively.

The percentage of recalls including pasta and rice was low in most centres, but high in Italian centres, where the range was from 69% to 80% in women, and from 79% to 90% in men. The number of recalls including potatoes was lowest in Italian and Greek centres (less than 38%) and similar for men and women. In French centres (women only) the percentage of recalls that included potato varied from 28% to 44%. In other centres, the percentage ranged from 41% to 73% (both men and women). Although few recalls in most centres included sweet biscuits, sweet buns, cakes and pies, crispbread, breakfast cereal and juice, there were some distinct exceptions. Among women

in Utrecht (The Netherlands), 56% of recalls included sweet biscuit consumption. Also, the percentage of recalls including sweet buns, cakes and pies was high in the Swedish centres (Umeå, 59% in men, 58% in women; Malmö, 49% in men, 56% in women) and in women in Utrecht, The Netherlands (50%). Crispbread consumption appeared particularly common among participants in Umeå (Sweden). Breakfast cereal consumption was most common in the UK and in Umeå (Sweden). The percentage of recalls including fruit and vegetable juices was highest in Murcia, Spain (men, 61%; women, 60%), but it was also high in the 'health-conscious' UK population, in Greece, Germany and The Netherlands. Few recalls overall included soft drinks, sweets, chocolates, and salty biscuits and snacks. Soft drinks consumption appeared uncommon among French women (7–9% of recalls). The highest percentages were seen among men in Bilthoven, The Netherlands (38%) and among women in the North & West of Norway (38%).

### Mean intakes

Crude and age-adjusted (standardised on day of the week and season) mean intakes are displayed in Tables 2a–2f and 3a–3f; age-adjusted mean intakes are presented in

**Table 2e** Mean consumption of fruit and vegetable juices, soft drinks, and milk and milk products by men ( $n = 13\,031$ ) in 19 European Prospective Investigation into Cancer and Nutrition (EPIC) centres

Country and centre	Total $n$	Fruit & vegetable juices ( $\text{g day}^{-1}$ )			Soft drinks ( $\text{g day}^{-1}$ )			Milk & milk products ( $\text{g day}^{-1}$ )		
		Crude mean	Adjusted*		Crude mean	Adjusted*		Crude mean	Adjusted*	
			Mean	SEM		Mean	SEM		Mean	SEM
Greece										
Greece	1312	31.6	34.4	4.7	45.9	47.3	7.5	134.9	129.1	7.5
Spain										
Granada	214	46.9	50.7	11.6	106.5	98.5	18.5	355.5	352.9	18.5
Murcia	243	43.0	42.3	10.9	99.7	101.1	17.4	230.3	228.6	17.4
Navarra	444	28.6	27.8	8.1	52.7	52.2	12.9	270.4	269.6	12.9
San Sebastian	490	23.2	17.7	7.8	46.5	33.1	12.4	314.9	314.4	12.4
Asturias	386	38.5	35.6	8.7	77.3	80.5	13.8	394.9	391.1	13.8
Italy										
Ragusa	168	11.9	6.9	13.1	59.3	31.7	21.0	117.6	107.2	20.9
Florence	271	22.7	20.3	10.3	29.3	25.0	16.5	170.8	168.9	16.5
Turin	677	24.6	23.2	6.6	38.7	34.3	10.4	142.7	140.2	10.4
Varese	328	23.3	22.2	9.4	43.9	48.7	15.0	199.9	223.8	15.0
Germany										
Heidelberg	1033	186.7	182.5	5.3	149.4	141.7	8.5	190.8	177.8	8.5
Potsdam	1235	145.6	140.6	4.9	79.8	81.1	7.7	188.8	188.6	7.7
The Netherlands										
Bilthoven	1024	70.3	62.0	5.5	183.8	168.8	8.8	324.6	318.9	8.7
United Kingdom										
General population	404	69.4	71.8	8.5	124.1	130.2	13.5	380.3	376.5	13.5
'Health-conscious'	114	111.4	123.6	15.9	97.7	107.2	25.4	180.9	195.7	25.4
Denmark										
Copenhagen	1356	58.0	60.5	4.6	177.5	173.7	7.4	300.7	292.7	7.4
Aarhus	567	56.7	56.7	7.2	150.4	147.8	11.4	318.6	316.7	11.4
Sweden										
Malmö	1421	42.7	50.3	4.8	81.3	100.5	7.6	300.4	301.8	7.6
Umeå	1344	40.4	41.8	4.7	139.8	145.4	7.4	433.9	437.2	7.4

SEM – standard error of the mean.

\* Adjusted for age and standardised for day of the week and season.

Figs. 1a, 1b and 2a, 2b. Energy adjustment influenced the relative ranking of a few centres, but had virtually no influence on the north–south consumption gradients observed. Therefore energy-adjusted data are not shown. The means were computed for the population as a whole (consumers *and* non-consumers).

#### *Bread, crispbread, sweet buns, cakes and pies, and sweet biscuits*

Bread was a major food in all of the EPIC centres, and specific consumption gradients were difficult to distinguish. In men, the highest consumption was observed in Aarhus, Denmark (195 g) and the lowest in Umeå, Sweden (77 g). In women, the highest consumption levels were seen in Denmark (Aarhus, 160 g; Copenhagen, 142 g) and Norway (131 g), and the lowest in Sweden (Umeå, 58 g).

Crispbread consumption was low and even across most centres. Umeå (Sweden) stands out, however, with high consumption levels, both in men (41 g) and in women (26 g). The lowest levels were found in Heidelberg, Germany (men, 1.5 g) and in Aarhus, Denmark (women, 2.7 g).

Consumption of sweet buns, cakes and pies appeared

higher in most northern centres. The highest consumption levels were seen in Umeå, Sweden (men, 79 g; women, 59 g). Centres in the south and in The Netherlands and Denmark had lower levels; the lowest was in Greece, both in men (15 g) and women (19 g). Sweet biscuit consumption was low overall. Varese, Italy had the highest consumption (men and women, 21 g). The lowest levels were seen in Heidelberg, Germany (men, 4.6 g) and in South & East Norway (women, 2.4 g).

#### *Breakfast cereal, pasta and rice, and salty biscuits and snacks*

Breakfast cereal consumption varied between centres. In men, the UK 'health-conscious' population had the highest consumption (63 g), but Swedish and Danish centres also had high consumption levels. Similarly, in women consumption was highest in Umeå, Sweden (42 g), followed by centres in the UK, Sweden, Denmark and Norway. Other centres had, overall, very low consumption levels, with the lowest being in Spanish centres (less than 1 g).

Italian centres had the highest mean levels of consumption of pasta and rice, with the highest in Varese (men, 268 g; women, 151 g). Other centres had much

**Table 2f** Mean consumption of sugar and jam, sweets, and chocolates by men ( $n = 13031$ ) in 19 European Prospective Investigation into Cancer and Nutrition (EPIC) centres

Country and centre	Total $n$	Sugar & jam (g day <sup>-1</sup> )			Sweets (g day <sup>-1</sup> )			Chocolates (g day <sup>-1</sup> )		
		Crude mean	Adjusted*		Crude mean	Adjusted*		Crude mean	Adjusted*	
			Mean	SEM		Mean	SEM		Mean	SEM
Greece										
Greece	1312	11.3	10.9	0.8	3.2	2.8	0.6	1.3	1.5	0.5
Spain										
Granada	214	15.3	15.2	2.1	3.3	3.4	1.5	2.0	2.1	1.3
Murcia	243	15.4	15.1	1.9	2.7	2.6	1.4	2.8	2.6	1.2
Navarra	444	15.0	15.1	1.4	4.1	4.0	1.0	2.3	2.3	0.9
San Sebastian	490	18.1	18.6	1.4	5.2	4.5	1.0	2.8	2.1	0.9
Asturias	386	18.7	18.9	1.5	4.4	4.2	1.1	4.7	4.7	1.0
Italy										
Ragusa	168	17.3	16.9	2.3	0.3	0.0	1.7	1.1	0.4	1.4
Florence	271	14.1	13.8	1.8	1.5	1.4	1.3	2.6	2.5	1.1
Turin	677	18.0	17.9	1.2	2.6	2.5	0.8	3.0	2.8	0.7
Varese	328	24.0	25.7	1.7	4.6	3.2	1.2	3.4	3.2	1.0
Germany										
Heidelberg	1033	19.8	20.0	1.0	3.1	2.3	0.7	7.3	7.3	0.6
Potsdam	1235	19.5	19.9	0.9	2.0	1.7	0.6	7.1	7.3	0.5
The Netherlands										
Bilthoven	1024	31.8	32.9	1.0	8.9	8.4	0.7	8.3	7.6	0.6
United Kingdom										
General population	404	28.2	28.0	1.5	2.4	2.6	1.1	11.3	12.0	0.9
'Health-conscious'	114	18.2	16.8	2.8	2.6	1.7	2.0	3.8	3.2	1.8
Denmark										
Copenhagen	1356	25.8	26.2	0.8	3.9	4.0	0.6	7.3	7.6	0.5
Aarhus	567	23.5	23.2	1.3	5.3	5.0	0.9	8.1	7.4	0.8
Sweden										
Malmö	1421	27.7	26.0	0.9	6.8	7.8	0.6	6.8	7.8	0.5
Umeå	1344	35.3	35.4	0.8	5.2	5.6	0.5	6.0	6.5	0.5

SEM – standard error of the mean.

\* Adjusted for age and standardised for day of the week and season.

lower levels; the lowest in women was in North & West Norway (15 g) and in men in Potsdam, Germany (22 g).

Consumption of salty snacks was low overall. The highest levels were seen in Italy (men, 17 g in Florence; women, 16 g in Naples) and the UK 'general population' (men, 15 g; women, 12 g). Spanish centres had the lowest levels, 1 g or less for both genders.

#### Potato, and vegetables and legumes

Potato consumption also varied between EPIC centres. Umeå, Sweden had the highest consumption (men, 149 g; women, 92 g), followed by other centres in northern Europe. Consumption was lowest in Ragusa, Italy (women, 26 g; men, 43 g). The amounts of vegetables and legumes eaten varied across EPIC centres. In men, vegetable and legume consumption was highest in Murcia, Spain (306 g), followed by centres in Greece, the 'health-conscious' group in the UK and Italy, while Umeå, Sweden (105 g) had the lowest mean consumption. In women, vegetable consumption was highest among women in France (South coast, 275 g), followed by centres in Spain and Greece, the 'health-conscious' group in the UK and most Italian centres. Consumption was lowest in North & West Norway (120 g). Clear north–south gradients were observed in both men and women for potatoes and also for vegetables and legumes, although less pronounced.

#### Fruits, and fruit and vegetable juices

Fruits were commonly consumed in all EPIC centres, but the amounts varied considerably. High levels of consumption were seen in the Italian and Spanish centres, with the highest in Murcia, Spain (men, 454 g) and in Ragusa, Italy (women, 397 g). Consumption was moderately high in the 'health-conscious' group in the UK, Greece, Germany and Aarhus (Denmark) and lowest in Sweden (men, 121 g; women, 151 g). Fruit and vegetable juice consumption was highest in Heidelberg, Germany (men, 183 g; women, 165 g), followed by The Netherlands, the UK and Norway (women). Ragusa, Italy had the lowest mean consumption (men, 6.9 g; women, 4.4 g). Thus fruit as well as fruit and vegetable juices clearly show opposing north–south gradients.

#### Soft drinks, sugar and jam, sweets, and chocolates

Soft drinks consumption varied considerably across EPIC centres with clear north–south gradients. In men, Copenhagen (Denmark) had the highest mean consumption of soft drinks (174 g) and Florence (Italy) had the lowest consumption (25 g). In women, South & East (163 g) and North & West (159 g) Norway had the highest mean consumption levels of soft drinks, while the South coast of France (12 g) had the lowest.

The consumption of sugar and jam, sweets, and



**Table 3a** Mean consumption of bread and crispbread by women ( $n = 22\,924$ ) in 27 European Prospective Investigation into Cancer and Nutrition (EPIC) centres

Country and centre	Total $n$	Bread ( $\text{g day}^{-1}$ )			Crispbread ( $\text{g day}^{-1}$ )		
		Crude mean	Adjusted*		Crude mean	Adjusted*	
			Mean	SEM		Mean	SEM
<b>Greece</b>							
Greece	1374	109.6	102.6	2.1	10.9	11.5	0.4
<b>Spain</b>							
Granada	300	90.9	96.7	4.4	3.9	4.9	0.9
Murcia	304	76.3	76.2	4.4	6.2	6.7	0.9
Navarra	271	88.8	88.4	4.7	6.9	6.9	1.0
San Sebastian	244	80.8	79.6	4.9	8.9	9.8	1.0
Asturias	324	74.2	74.2	4.3	10.4	10.2	0.9
<b>Italy</b>							
Ragusa	138	102.5	93.4	6.5	6.3	5.8	1.3
Naples	403	103.6	97.1	3.8	7.6	8.1	0.8
Florence	785	97.6	97.8	2.7	7.9	8.0	0.6
Turin	392	84.0	85.3	3.9	17.1	16.6	0.8
Varese	794	75.9	77.6	2.7	7.5	7.3	0.6
<b>France</b>							
South coast	612	85.0	92.9	3.1	8.1	7.4	0.6
South	1396	100.8	100.7	2.1	7.8	7.3	0.4
North-west	622	96.7	99.3	3.1	3.9	3.2	0.6
North-east	2009	92.7	94.5	1.7	5.1	4.8	0.4
<b>Germany</b>							
Heidelberg	1087	101.1	102.5	2.4	2.8	2.9	0.5
Potsdam	1063	106.4	104.7	2.4	3.8	4.4	0.5
<b>The Netherlands</b>							
Bilthoven	1086	116.5	114.8	2.4	4.2	4.8	0.5
Utrecht	1874	110.1	111.0	1.8	6.3	6.0	0.4
<b>United Kingdom</b>							
General population	571	83.2	83.9	3.2	3.2	3.2	0.7
'Health-conscious'	197	93.2	99.8	5.5	6.2	6.5	1.1
<b>Denmark</b>							
Copenhagen	1485	140.1	141.9	2.0	3.4	3.1	0.4
Aarhus	510	154.3	159.7	3.4	3.1	2.7	0.7
<b>Sweden</b>							
Malmö	1711	69.4	71.1	1.9	9.4	8.9	0.4
Umeå	1574	57.3	57.6	1.9	25.6	25.5	0.4
<b>Norway</b>							
South & East	1136	135.7	131.4	2.3	7.4	7.8	0.5
North & West	662	133.1	131.0	3.0	7.8	7.9	0.6

SEM – standard error of the mean.

\* Adjusted for age and standardised for day of the week and season.

chocolates was low overall and specific trends were difficult to discern. Sugar and jam consumption was highest among men in Umeå, Sweden (35 g) and in Bilthoven, The Netherlands (33 g) and among women in North & West Norway (22 g) and Umeå, Sweden (21 g). Consumption was lowest in Greece (men, 11 g) and in Florence, Italy (women, 10 g). The consumption of sweets ranked high in The Netherlands, Denmark and Sweden, and lowest in Ragusa in Italy. Chocolate consumption was highest in the UK general population, but overall higher in northern centres. Men in Ragusa (Italy) and women in Granada (Spain) had the lowest mean consumption of chocolates.

#### *Milk and milk products*

The consumption of milk and milk products varied substantially across EPIC centres. In men, Umeå, Sweden (437 g) had the highest mean consumption of milk and

milk products, followed by the UK general population, Spanish centres, Bilthoven (The Netherlands), Malmö (Sweden) and Danish centres. In women, consumption was highest in Asturias, Spain (462 g), followed by other Spanish centres, Utrecht (The Netherlands), Umeå (Sweden) and the UK general population. The lowest levels were seen both for men (107 g) and women (116 g) in Ragusa (Italy).

#### **Discussion**

This study indicates that several major sources of carbohydrates differ between northern and southern EPIC centres. Fruit consumption is high in most southern centres. A similar pattern, although less pronounced, is observed for vegetables and legumes, with a higher consumption of these foods in southern Europe. Soft drinks consumption is higher in the north, and fruit and

**Table 3b** Mean consumption of sweet buns, cakes and pies, and sweet biscuits by women ( $n = 22\,924$ ) in 27 European Prospective Investigation into Cancer and Nutrition (EPIC) centres

Country and centre	Total $n$	Sweet buns, cakes & pies (g day <sup>-1</sup> )			Sweet biscuits (g day <sup>-1</sup> )		
		Crude mean	Adjusted*		Crude mean	Adjusted*	
			Mean	SEM		Mean	SEM
Greece							
Greece	1374	17.8	19.2	1.9	11.0	10.5	0.5
Spain							
Granada	300	19.4	21.9	4.1	6.2	5.7	1.1
Murcia	304	43.7	43.0	4.1	9.9	9.9	1.1
Navarra	271	29.6	30.4	4.4	14.0	14.3	1.2
San Sebastian	244	26.3	28.7	4.6	10.4	9.4	1.2
Asturias	324	28.4	30.2	4.0	10.7	11.0	1.1
Italy							
Ragusa	138	35.3	38.1	6.1	16.4	13.9	1.7
Naples	403	39.6	37.4	3.6	9.9	9.6	1.0
Florence	785	38.0	37.9	2.6	12.3	12.2	0.7
Turin	392	29.8	29.9	3.6	13.7	14.4	1.0
Varese	794	31.6	34.7	2.5	19.8	20.6	0.7
France							
South coast	612	35.6	36.9	2.9	5.9	6.5	0.8
South	1396	39.6	41.3	1.9	6.3	6.2	0.5
North-west	622	44.7	45.1	2.9	4.2	4.2	0.8
North-east	2009	47.3	50.3	1.6	6.5	6.4	0.4
Germany							
Heidelberg	1087	45.5	51.9	2.2	7.4	7.7	0.6
Potsdam	1063	48.9	50.9	2.2	4.6	4.9	0.6
The Netherlands							
Bilthoven	1086	41.1	42.2	2.2	13.0	12.9	0.6
Utrecht	1874	39.0	39.6	1.7	15.9	16.4	0.5
United Kingdom							
General population	571	48.4	51.0	3.0	10.5	10.4	0.8
'Health-conscious'	197	50.4	54.3	5.1	8.9	8.2	1.4
Denmark							
Copenhagen	1485	30.5	33.1	1.7	5.67	5.8	0.5
Aarhus	510	45.6	49.2	3.2	8.67	8.2	0.9
Sweden							
Malmö	1711	52.5	52.6	1.8	5.4	5.4	0.5
Umeå	1574	58.3	59.1	1.8	5.3	5.6	0.5
Norway							
South & East	1136	48.1	49.1	2.2	2.7	2.4	0.6
North & West	662	54.6	55.1	2.8	2.9	2.7	0.8

SEM – standard error of the mean.

\* Adjusted for age and standardised for day of the week and season.

vegetable juices higher in north-west and central Europe. Potato consumption is high in northern centres and low in the south of Europe. Breakfast cereals are consumed more in the northern centres and Italian centres have high pasta and rice consumption. Consumption of sweet buns, cakes and pies is higher in northern compared with southern centres, but consumption of sweet biscuits is more evenly distributed. The consumption of bread and crispbread shows an opposing gradient to that of sweet buns, cakes and pies and sweet biscuits, although not so clearly along a north–south axis. In Sweden, lower bread consumption is balanced by a higher consumption of crispbread. Consumption of milk and milk products is higher in most northern centres and in Spain. Thus the consumption levels of fruits, vegetables and legumes, and pasta and rice are not only lower in northern compared with southern centres, but the levels of consumption of potatoes,

breakfast cereals (in some centres), soft drinks, sweet buns, cakes and pies, and juice (in some centres) are also higher, and therefore constitute a larger part of the diet. Although there are reports that food practices in the Mediterranean region are incorporating Westernised food styles<sup>32,33</sup>, this study shows that the foods providing carbohydrates are still quite different in southern compared with northern Europe.

Differences between food habits of populations depend on factors such as culture, climate and geography, and agricultural, economic and technical development. The traditional diets of the Mediterranean region were high in vegetables, fruits and pulses, with cereals (wheat) contributing a large part of the energy content. In traditional northern European diets, a smaller proportion of energy came from cereals (rye, oats and barley rather than wheat) and potatoes were commonly eaten. Animal

**Table 3c** Mean consumption of breakfast cereal, pasta and rice, and salty snacks by women ( $n = 22\,924$ ) in 27 European Prospective Investigation into Cancer and Nutrition (EPIC) centres

Country and centre	Total $n$	Breakfast cereal ( $\text{g day}^{-1}$ )			Pasta & rice ( $\text{g day}^{-1}$ )			Salty snacks ( $\text{g day}^{-1}$ )		
		Crude mean	Adjusted*		Crude mean	Adjusted*		Crude mean	Adjusted*	
			Mean	SEM		Mean	SEM		Mean	SEM
Greece										
Greece	1374	1.2	1.2	1.0	51.7	53.2	2.1	1.2	1.8	0.6
Spain										
Granada	300	0.6	0.6	2.0	24.0	23.3	4.5	1.5	1.2	1.2
Murcia	304	0.4	0.8	2.0	29.7	28.9	4.5	1.3	1.2	1.2
Navarra	271	0.5	0.5	2.2	27.7	26.7	4.7	0.5	0.3	1.3
San Sebastian	244	1.7	1.9	2.3	28.9	26.7	5.0	0.5	0	1.3
Asturias	324	1.3	1.3	2.0	34.3	33.5	4.3	1.4	1.1	1.1
Italy										
Ragusa	138	0.4	0.8	3.0	125.0	101.7	6.6	3.2	2.2	1.8
Naples	403	2.0	1.5	1.8	124.7	125.1	3.9	12.1	15.5	1.0
Florence	785	1.8	1.9	1.3	125.7	126.5	2.8	10.1	10.1	0.7
Turin	392	1.4	1.5	1.8	110.8	110.1	3.9	6.7	6.8	1.0
Varese	794	2.6	2.5	1.3	147.1	150.5	2.8	5.6	5.2	0.7
France										
South coast	612	4.2	4.5	1.4	42.2	45.0	3.1	4.6	4.1	0.8
South	1396	5.0	4.4	1.0	44.0	43.2	2.1	4.1	4.4	0.6
North-west	622	4.9	4.8	1.4	36.5	37.7	3.1	5.7	5.1	0.8
North-east	2009	4.3	3.7	0.8	40.0	40.1	1.7	6.2	6.8	0.5
Germany										
Heidelberg	1087	4.7	5.3	1.1	55.3	49.8	2.4	4.5	3.9	0.6
Potsdam	1063	3.4	3.6	1.1	26.7	26.5	2.4	2.9	2.3	0.6
The Netherlands										
Bilthoven	1086	3.3	4.0	1.1	37.2	33.2	2.4	10.9	10.4	0.6
Utrecht	1874	3.6	3.2	0.8	24.1	25.5	1.8	8.8	9.4	0.5
United Kingdom										
General population	571	23.9	23.5	1.5	25.8	26.6	3.2	11.8	11.6	0.9
'Health-conscious'	197	30.5	29.3	2.5	50.5	43.8	5.5	8.4	7.9	1.5
Denmark										
Copenhagen	1485	16.3	15.6	0.9	28.3	28.5	2.0	3.5	3.4	0.5
Aarhus	510	15.7	16.0	1.6	26.5	26.2	3.4	2.3	2.1	0.9
Sweden										
Malmö	1711	19.4	18.1	0.9	23.4	27.0	1.9	3.3	4.1	0.5
Umeå	1574	42.3	42.0	0.9	30.2	29.2	2.0	3.6	3.6	0.5
Norway										
South & East	1136	13.1	14.9	1.1	20.1	16.5	2.3	4.5	4	0.6
North & West	662	11.5	11.9	1.4	18.2	14.6	3.0	5.0	3.8	0.8

SEM – standard error of the mean.

\* Adjusted for age and standardised for day of the week and season.

products provided a larger part of dietary energy and intakes of milk and milk products were high<sup>2</sup>. Traditional Mediterranean diets are generally considered to promote good health<sup>34,35</sup>; this is especially true for cardiovascular health<sup>36,37</sup>, but also for some types of cancer<sup>38,39</sup>. For instance, total mortality from malignant neoplasm was low in Mediterranean countries compared with the UK during the latter part of the last century<sup>32</sup> and lung cancer rates were low in southern Europe in spite of high rates of cigarette smoking<sup>32</sup>. In addition, the protective effects of vegetables and fruits with regard to a number of cancers<sup>2,40</sup> and cardiovascular disease<sup>41,42</sup> have been documented.

European food habits underwent drastic changes during the second half of the last century. Thus the dietary differences across European regions may have diminished substantially<sup>32,33</sup>. Most studies describing these changes either use food balance sheets<sup>32</sup> or look at trends within

single countries<sup>43</sup>. Others compare food habits of a few study centres and countries<sup>44</sup> or those of studies using dissimilar dietary methodologies<sup>45</sup>. Comparisons on food availability in 14 European countries are also feasible, using data retrieved from the DAFNE databank (the DATA Food NETWORKING initiative and DafneSoft program, <http://www.nut.uoa.gr>), which comprises comparable food and related data collected in national household budget surveys. Few studies have, however, compared dietary intake data collected from individuals in several countries simultaneously. The major advantage of the current project is that it uses dietary data from the EPIC calibration study, with standardised study design and dietary methodology in all centres. Also, it is of great importance for future analytical projects within the EPIC study that major differences in carbohydrate-containing foods could be demonstrated.

This study provided only preliminary information on

**Table 3d** Mean consumption of potatoes, vegetables and legumes, and fruits by women ( $n = 22\,924$ ) in 27 European Prospective Investigation into Cancer and Nutrition (EPIC) centres

Country and centre	Total $n$	Potatoes ( $\text{g day}^{-1}$ )			Vegetables & legumes ( $\text{g day}^{-1}$ )			Fruits ( $\text{g day}^{-1}$ )		
		Crude mean	Adjusted*		Crude mean	Adjusted*		Crude mean	Adjusted*	
			Mean	SEM		Mean	SEM		Mean	SEM
Greece										
Greece	1374	34.0	32.4	2.4	229.7	225.5	4.0	219.6	238.8	5.7
Spain										
Granada	300	54.0	55.0	5.2	248.6	220.3	8.6	352.4	338.4	12.1
Murcia	304	67.6	68.1	5.1	272.9	268.2	8.5	372.6	379.3	12.1
Navarra	271	51.5	54.0	5.4	219.4	219.2	9.0	320.3	330.1	12.7
San Sebastian	244	60.5	64.4	5.7	257.1	250.5	9.5	370.0	365.4	13.4
Asturias	324	70.3	71.5	5.0	140.3	138.6	8.2	325.5	335.9	11.7
Italy										
Ragusa	138	25.4	26.2	7.6	160.1	149.4	12.6	362.9	397.0	17.9
Naples	403	29.0	31.3	4.5	181.7	181.5	7.4	289.9	284.5	10.5
Florence	785	31.7	31.6	3.2	207.5	206.9	5.3	321.5	320.8	7.5
Turin	392	32.0	31.8	4.5	237.7	237.7	7.5	357.6	359.6	10.6
Varese	794	34.6	36.6	3.2	173.8	166.0	5.3	334.7	333.6	7.4
France										
South coast	612	37.8	30.9	3.6	235.9	274.8	6.0	231.0	245.7	8.5
South	1396	50.9	49.2	2.4	228.4	226.0	4.0	256.8	259.3	5.6
North-west	622	68.8	68.8	3.6	199.3	213.8	6.0	237.5	249.7	8.4
North-east	2009	55.3	56.5	2.0	222.9	220.8	3.3	244.8	248.8	4.7
Germany										
Heidelberg	1087	62.1	69.3	2.8	173.4	170.1	4.6	202.1	211.3	6.4
Potsdam	1063	81.9	82.7	2.8	177.0	171.5	4.6	247.8	260.2	6.5
The Netherlands										
Bilthoven	1086	81.9	84.8	2.8	135.5	132.0	4.6	157.2	168.1	6.5
Utrecht	1874	87.2	84.4	2.1	136.5	136.1	3.5	222.2	212.8	4.9
United Kingdom										
General population	571	73.2	71.1	3.7	173.1	173.9	6.2	172.9	172.6	8.8
'Health-conscious'	197	75.7	85.5	6.4	240.9	246.2	10.6	261.7	273.0	14.9
Denmark										
Copenhagen	1485	66.8	70.6	2.3	148.2	152.9	3.9	186.6	180.1	5.5
Aarhus	510	72.6	71.1	4.0	145.9	148.4	6.6	239.2	233.6	9.3
Sweden										
Malmö	1711	86.8	82.5	2.2	128.3	133.9	3.7	162.5	150.9	5.2
Umeå	1574	90.8	91.8	2.3	125.5	125.8	3.7	164.5	159.1	5.3
Norway										
South & East	1136	69.7	72.6	2.7	132.2	132.4	4.5	163.3	173.1	6.3
North & West	662	85.0	89.7	3.5	120.1	119.9	5.8	147.0	162.1	8.2

SEM – standard error of the mean.

\* Adjusted for age and standardised for day of the week and season.

the relative carbohydrate contribution of different food groups. Since a uniform food composition table is not available for Europe and current European food composition tables compute carbohydrates differently<sup>30</sup>, the relative contribution of specific food groups in each EPIC centre could not be examined. Similarly, preliminary information on total energy intake was used when adjusting for energy (energy-adjusted data are not presented). Also, some food groups (e.g. coffee and tea, soups) were not examined in the final analysis, because of their apparent low contribution to carbohydrates. The importance of these foods as carbohydrate sources may be underestimated. Future studies need to examine different types of carbohydrates, as well as the relative contribution of carbohydrates, from various food products across EPIC centres.

The broader food groups in this study may reduce the actual diversity of European food habits, because each

food group incorporates a range of foods and food products. For example, 'crispbread' in Nordic countries is commonly based on whole-grain rye<sup>46</sup>, while wheat flour is preferred in southern European countries. Also, salty biscuits and snacks in Italian centres are not only crackers, but also bread dipped in salt and olive oil. The apparent balances, in some centres, between bread and sweet buns, cakes and pies, potatoes, crispbread and breakfast cereal indicate that the food sources of fibre may vary considerably across EPIC centres. No conclusion on differences in fibre sources can be made in this study, because the fibre content of bread and cereal products was not examined. The food group sweet buns, cakes and pies includes cereal- or flour-based items with added sugar, but the relative proportions of sugar, starch, fibre and fat could vary substantially between study centres, depending on the customary use. Similarly, bread is in reality a composite of many kinds made with different

**Table 3e** Mean consumption of fruit and vegetable juices, soft drinks, and milk and milk products by women ( $n = 22\,924$ ) in 27 European Prospective Investigation into Cancer and Nutrition (EPIC) centres

Country and centre	Total $n$	Fruit & vegetable juices (g day <sup>-1</sup> )			Soft drinks (g day <sup>-1</sup> )			Milk & milk products (g day <sup>-1</sup> )		
		Crude mean	Adjusted*		Crude mean	Adjusted*		Crude mean	Adjusted*	
			Mean	SEM		Mean	SEM		Mean	SEM
Greece										
Greece	1374	41.6	49.2	4.1	28.1	35.2	4.8	151.0	146.1	6.2
Spain										
Granada	300	36.2	37.8	8.8	67.7	77.9	10.3	363.5	366.3	13.3
Murcia	304	37.6	32.4	8.7	49.7	45.3	10.3	316.0	314.1	13.2
Navarra	271	28.2	26.5	9.2	22.9	20.3	10.9	380.6	378.4	14.0
San Sebastian	244	23.1	18.3	9.7	29.5	22.4	11.5	386.9	388.2	14.7
Asturias	324	39.4	35.6	8.5	41.3	38.2	10.0	462.5	461.6	12.8
Italy										
Ragusa	138	9.9	4.4	13.0	43.8	28.6	15.3	117.3	116.2	19.6
Naples	403	21.6	19.0	7.6	22.3	17.6	8.9	145.0	150.7	11.4
Florence	785	24.3	23.8	5.4	12.2	12.9	6.4	174.8	175.9	8.2
Turin	392	28.8	26.9	7.7	27.1	28.0	9.0	154.5	152.8	11.6
Varese	794	18.5	18.9	5.4	21.9	22.5	6.4	204.2	203.7	8.2
France										
South coast	612	48.2	47.8	6.2	9.3	11.9	7.3	233.7	241.4	9.3
South	1396	51.6	54.1	4.1	14.5	18.9	4.8	237.9	232.8	6.2
North-west	622	56.6	63.5	6.1	8.4	12.4	7.2	238.3	235.3	9.2
North-east	2009	55.7	60.1	3.4	14.5	18.6	4.0	242.1	240.4	5.1
Germany										
Heidelberg	1087	175.7	164.7	4.7	68.4	57.2	5.5	205.3	207.7	7.1
Potsdam	1063	158.2	156.0	4.7	30.4	28.5	5.5	210.8	204.0	7.1
The Netherlands										
Bilthoven	1086	104.1	97.7	4.7	103.8	92.4	5.5	296.5	297.8	7.1
Utrecht	1874	100.3	104.9	3.5	68.5	73.0	4.2	390.8	386.7	5.4
United Kingdom										
General population	571	65.5	69.8	6.4	141.1	140.6	7.5	350.4	346.1	9.6
'Health-conscious'	197	94.7	82.4	10.8	103.3	101.1	12.8	220.5	195.6	16.4
Denmark										
Copenhagen	1485	52.8	55.2	4.0	123.5	129.2	4.6	253.5	252.1	6.0
Aarhus	510	59.0	54.7	6.7	93.2	96.0	7.9	276.1	268.7	10.2
Sweden										
Malmö	1711	46.9	53.4	3.8	63.3	75.9	4.4	276.2	273.3	5.7
Umeå	1574	42.8	43.0	3.8	114.6	121.9	4.5	334.5	334.3	5.8
Norway										
South & East	1136	93.8	96.6	4.6	167.9	163.1	5.4	246.8	245.7	6.9
North & West	662	89.2	83.5	6.0	167.7	159.1	7.0	243.4	247.6	9.0

SEM – standard error of the mean.

\* Adjusted for age and standardised for day of the week and season.

cereals, types of flour and bread-making procedures. However, if all differences were accounted for, a huge amount of data and many models would be required, which is beyond the scope of this paper.

Other researchers have also reported higher intakes of sugar-rich food products in northern compared with southern Europe<sup>44</sup>. Such observations may have important implications for cross-cultural comparisons and the interpretation of diet–disease relationships. When the percentage of dietary fat is reduced, intakes of foods with low micronutrient density and rich in added sugars tend to increase, rather than foods rich in starch and dietary fibre, i.e. the so-called fat and sugar seesaw<sup>47–51</sup>. Populations of southern Europe, where vegetables and fruits are traditionally consumed in larger amounts, may be less vulnerable to such seesaw patterns. However, a French study indicates that individuals with high sugar intakes

(compared with those with low intakes) are younger, leaner and have more varied diets, but also have low intakes of fruits and vegetables<sup>51</sup>.

The consumption gradient of milk among adults across European populations is believed to result from genetic adaptation<sup>52,53</sup>, related to the prevalence of lactose maldigestion being very low in northern Europe (i.e. 1–3% in Denmark and Sweden), moderate in central Europe (i.e. 8–22% in Germany) and high in the south (i.e. 50–72% in Italy)<sup>52</sup>. However, milk consumption is high in the Spanish centres in this study. Other studies indicate that milk consumption has increased in Spain during the last three decades<sup>43</sup> and it may be that lactose maldigestion is less common in Spain than in other southern European populations<sup>52</sup>. Also, moderate amounts of milk may be tolerated well by individuals with lactose maldigestion<sup>53</sup>. Cheese is not included in the milk group because of its

**Table 3f** Mean consumption of sugar and jam, sweets, and chocolates by women ( $n = 22\,924$ ) in 27 European Prospective Investigation into Cancer and Nutrition (EPIC) centres

Country and centre	Total $n$	Sugar & jam ( $\text{g day}^{-1}$ )			Sweets ( $\text{g day}^{-1}$ )			Chocolates ( $\text{g day}^{-1}$ )		
		Crude mean	Adjusted* Mean	SEM	Crude mean	Adjusted* Mean	SEM	Crude mean	Adjusted* Mean	SEM
Greece										
Greece	1374	9.8	10.2	0.6	3.1	3.1	0.5	2.3	2.5	0.5
Spain										
Granada	300	12.2	12.4	1.4	2.3	3.1	1.1	2.1	1.4	1.1
Murcia	304	12.0	12.2	1.4	2.3	2.2	1.1	2.0	1.6	1.0
Navarra	271	14.6	14.5	1.4	3.5	3.5	1.1	2.3	2.1	1.1
San Sebastian	244	18.9	19.2	1.5	3.9	3.7	1.2	3.2	3.1	1.2
Asturias	324	15.7	16.1	1.3	3.1	2.8	1.0	4.0	4.2	1.0
Italy										
Ragusa	138	8.9	11.8	2.0	0.2	0	1.6	4.2	8.1	1.6
Naples	403	14.0	13.5	1.2	2.2	1.4	0.9	3.6	3.1	0.9
Florence	785	10.2	9.9	0.8	0.6	0.6	0.7	2.8	2.6	0.7
Turin	392	14.1	14.2	1.2	2.2	2.2	0.9	2.6	2.7	0.9
Varese	794	15.0	14.9	0.8	2.2	2.6	0.7	2.5	2.6	0.6
France										
South coast	612	19.5	18.1	1.0	2.4	2.8	0.8	7.6	7.4	0.7
South	1396	21.0	20.7	0.6	2.8	2.7	0.5	6.1	5.9	0.5
North-west	622	20.4	19.5	0.9	1.8	2.6	0.7	6.3	6.5	0.7
North-east	2009	19.0	19.0	0.5	3.0	3.3	0.4	8.1	7.8	0.4
Germany										
Heidelberg	1087	15.4	16.2	0.7	3.3	2.8	0.6	8.6	8.0	0.6
Potsdam	1063	14.3	14.8	0.7	3.1	3.1	0.6	7.4	7.6	0.6
The Netherlands										
Bilthoven	1086	17.3	17.7	0.7	8.8	8.3	0.6	10.1	9.3	0.6
Utrecht	1874	15.3	15.0	0.6	9.1	9.4	0.4	7.8	8.4	0.4
United Kingdom										
General population	571	13.5	13.9	1.0	3.0	3.2	0.8	10.6	9.9	0.8
'Health-conscious'	197	15.1	14.1	1.7	4.3	4.2	1.3	9.8	8.2	1.3
Denmark										
Copenhagen	1485	14.5	15.1	0.6	3.9	3.8	0.5	7.0	7.5	0.4
Aarhus	510	14.2	14.0	1.0	8.7	9.0	0.8	8.2	7.8	0.8
Sweden										
Malmö	1711	16.5	16.1	0.6	7.6	8.3	0.5	7.7	8.5	0.5
Umeå	1574	21.6	21.4	0.6	6.0	6.0	0.5	4.8	4.9	0.5
Norway										
South & East	1136	17.6	18.7	0.7	3.0	2.6	0.6	10.7	9.8	0.6
North & West	662	21.2	21.6	0.9	2.7	2.5	0.7	8.8	8.4	0.7

SEM – standard error of the mean.

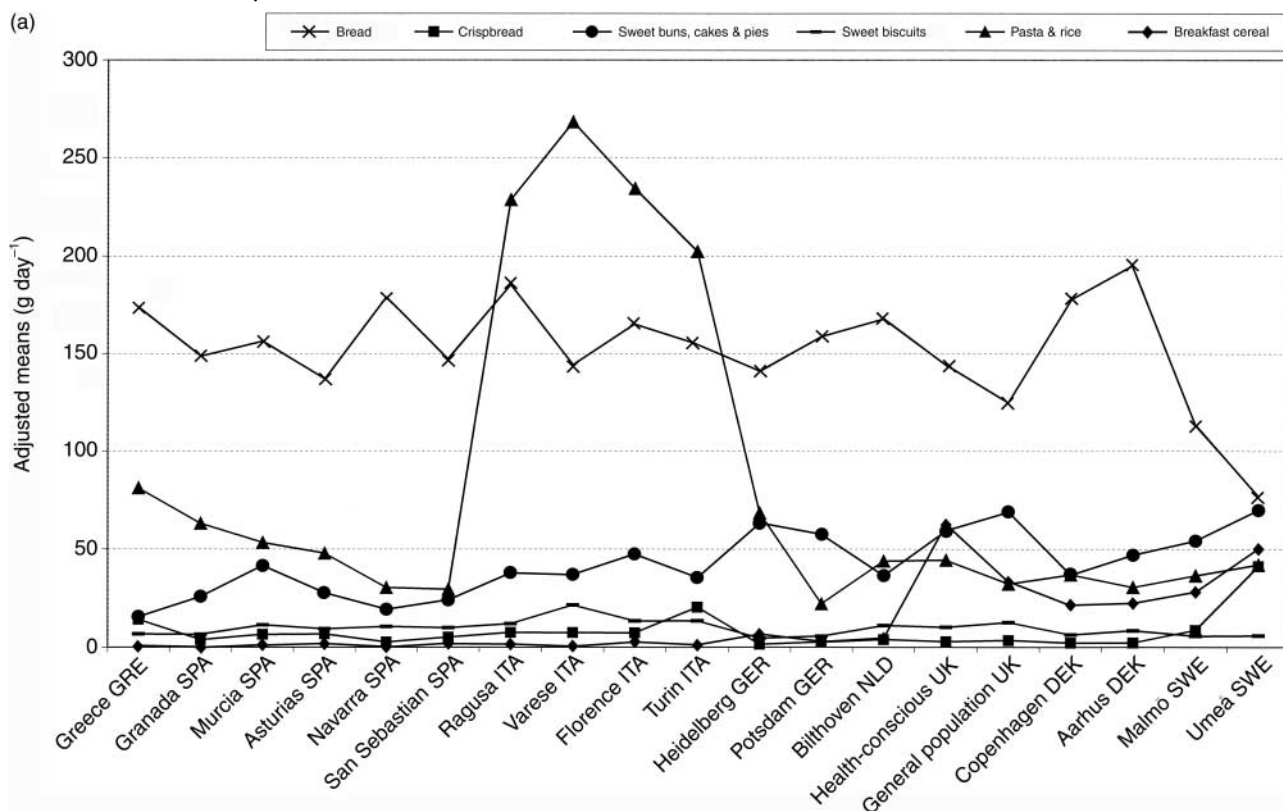
\* Adjusted for age and standardised for day of the week and season.

negligible carbohydrate content. In Norwegian diets, however, 1% of total carbohydrate intake comes from cheese<sup>54</sup>, because 'brown' cheese (made from whey and with a high content of lactose) is commonly eaten. But the percentage is not high enough to count as a major carbohydrate source in this study.

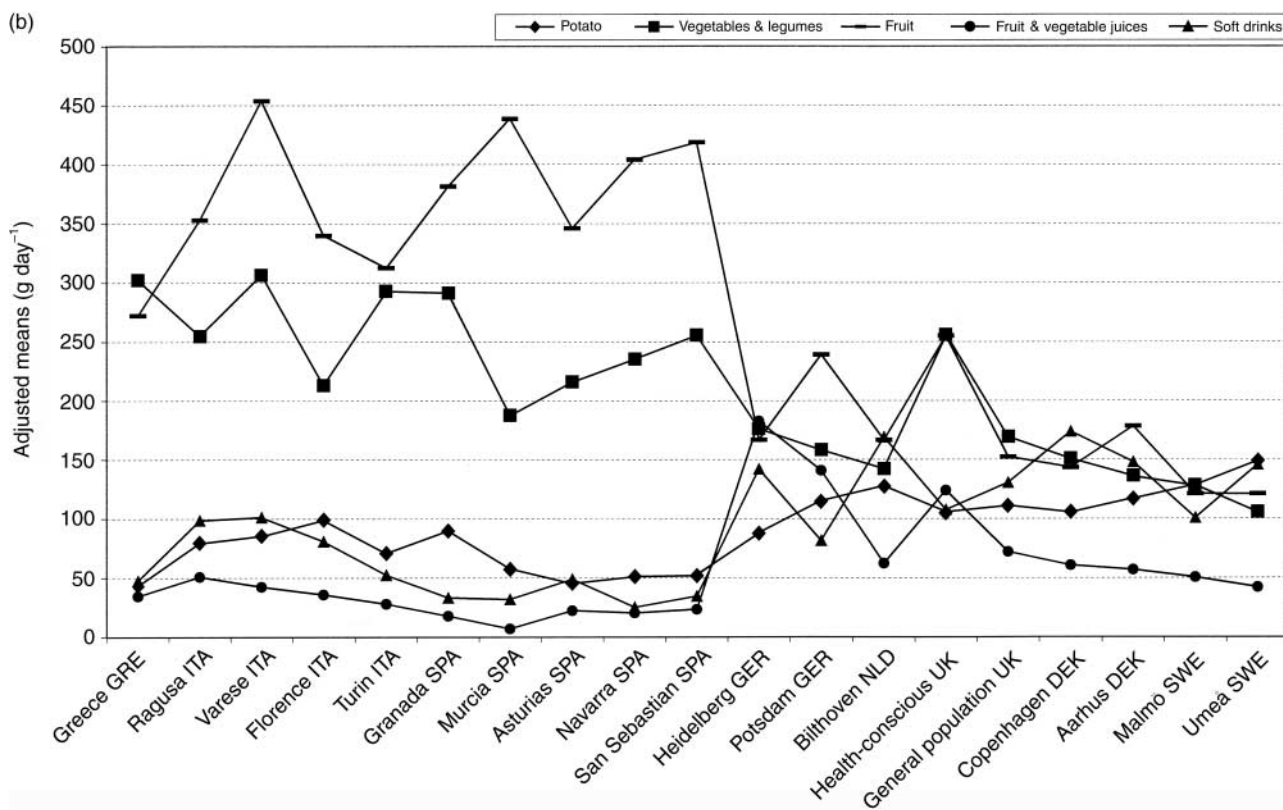
Men consume, overall, higher amounts of vegetables and legumes, bread, soft drinks, potatoes, pasta and rice, breakfast cereal, and sugar and jam. Since no adjustment was made for energy intake differences between gender groups (but analysis was stratified by gender), the higher intakes of these foods are most likely explained by higher energy needs in men. Both gender groups consume sweet buns, cakes and pies, sweet biscuits, crispbread, salty biscuits and snacks, chocolates, sweets, milk and milk products, and fruit and vegetable juices in equal amounts. This suggests that these foods take up larger proportions

of the diets of women. In addition, fruit consumption is reported in a larger percentage of dietary recalls in women. Other studies report similar gender differences both in food preferences<sup>55</sup> and intakes<sup>56</sup>.

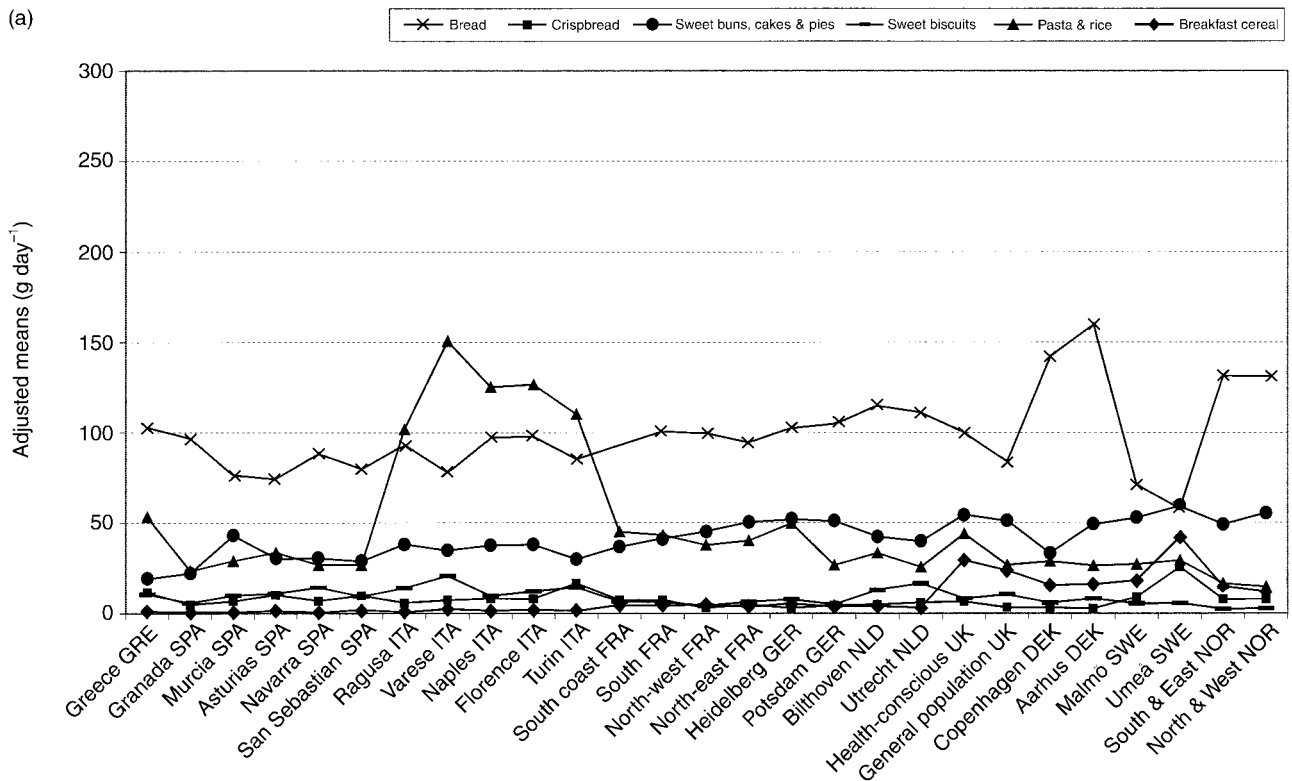
The study samples for the EPIC calibration study were selected randomly from each sub-study cohort<sup>27</sup>. However, the definition and recruitment of sub-cohorts varied by study centre (e.g. France and Norway recruited only women; some centres used specific sub-populations) and the findings should therefore not be extrapolated to the general populations of each region. In addition, since this study did not adjust for differences in socio-economic and lifestyle factors, it is plausible that food consumption differences observed between cohorts depend partly on socio-economic or lifestyle differences. Several studies have described that lifestyle behaviours and socio-demographic factors co-vary with healthy food choices



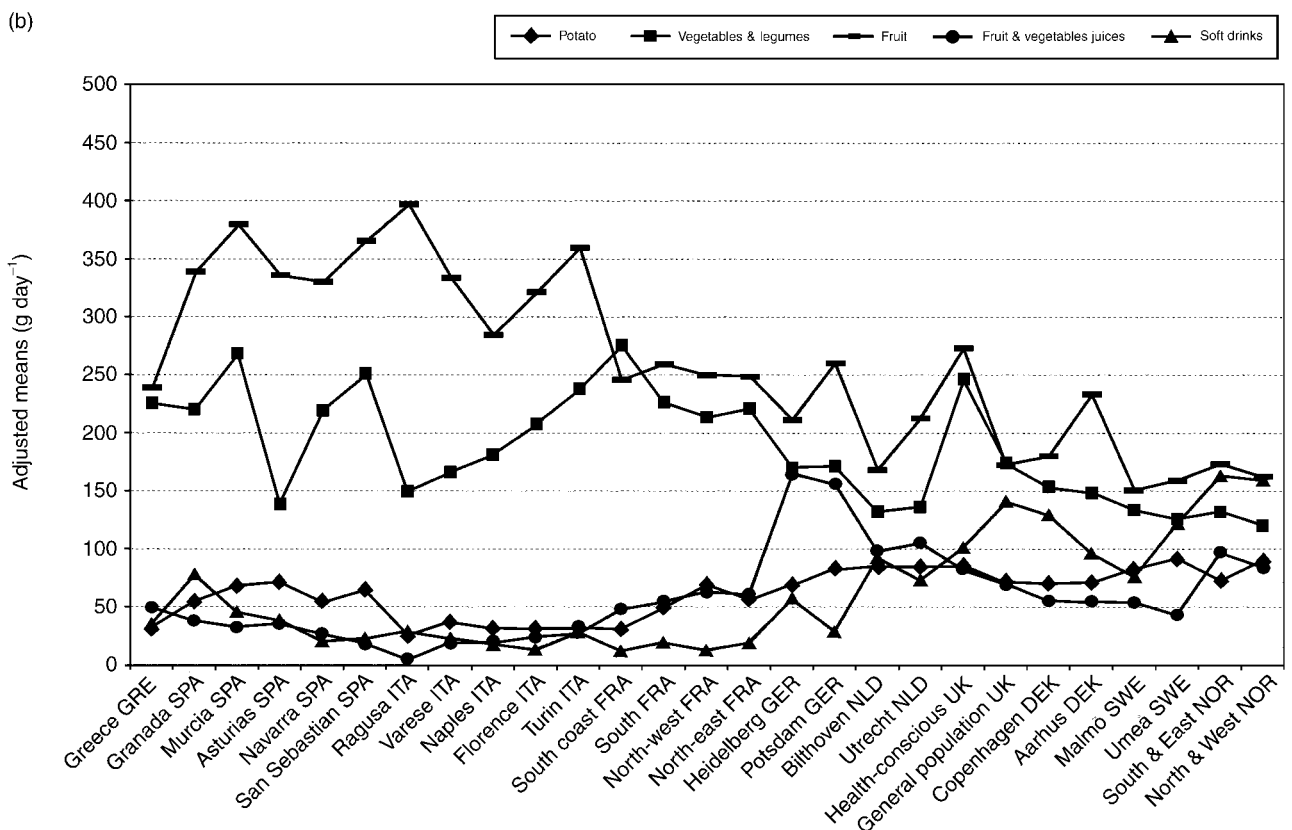
**Fig. 1a** Consumption of bread, crispbread, sweet buns, cakes and pies, sweet biscuits, pasta and rice, and breakfast cereal by men in 19 European Prospective Investigation into Cancer and Nutrition (EPIC) centres. Abbreviations: GRE – Greece; SPA – Spain; ITA – Italy; GER – Germany; NLD – The Netherlands; UK – United Kingdom; DEK – Denmark; SWE – Sweden



**Fig. 1b** Consumption of potato, vegetables and legumes, fruit, fruit and vegetable juices, and soft drinks by men in 19 European Prospective Investigation into Cancer and Nutrition (EPIC) centres. Abbreviations: GRE – Greece; SPA – Spain; ITA – Italy; GER – Germany; NLD – The Netherlands; UK – United Kingdom; DEK – Denmark; SWE – Sweden



**Fig. 2a** Consumption of bread, crispbread, sweet buns, cakes and pies, sweet biscuits, pasta and rice, and breakfast cereal by women in 27 European Prospective Investigation into Cancer and Nutrition (EPIC) centres. Abbreviations: GRE – Greece; SPA – Spain; ITA – Italy; FRA – France; GER – Germany; NLD – The Netherlands; UK – United Kingdom; DEK – Denmark; SWE – Sweden; NOR – Norway



**Fig. 2b** Consumption of potato, vegetables and legumes, fruit, fruit and vegetable juices, and soft drinks by women in 27 European Prospective Investigation into Cancer and Nutrition (EPIC) centres. Abbreviations: GRE – Greece; SPA – Spain; ITA – Italy; FRA – France; GER – Germany; NLD – The Netherlands; UK – United Kingdom; DEK – Denmark; SWE – Sweden; NOR – Norway



such as fruit and vegetable intakes<sup>57–59</sup>. For instance, reports from Denmark and Sweden indicate that alcohol use (especially wine) is positively related to fruit and vegetable consumption<sup>60,61</sup>. Such relations are not found in Italy<sup>62</sup>, however. Because clear consumption gradients are visible across EPIC centres in this study, one might speculate that the associations between food sources of carbohydrates and potential confounders are dissimilar. This notion is supported by a review of research in 15 European countries that concluded that fruit and vegetable consumption was higher in population groups with lower education in some southern European countries<sup>63</sup>. However, recent studies across EPIC centres in both Spain and Italy indicate that vegetable and fruit consumption is indeed higher among those with higher education<sup>64–66</sup>. In addition, although many regional food consumption differences have been removed by technical developments and improved communications, some still exist. For instance, fruit consumption is high in Ragusa (Italy) because Sicily is a major fruit-producing region. Also, differences in the cost of bread may explain the north–south gradient in bread consumption seen in Italy (less than €1 per kg in the south, more than €3 in the north).

To conclude, this study supports the established idea that the choice of carbohydrate-rich foods in northern Europe is different from that in the Mediterranean region. Due to potential differences in confounders across geographically and culturally diverse populations, researchers need to consider carefully the intake ranges for all food choices and non-dietary confounders when comparing and interpreting diet–disease relations across centres participating in the EPIC study.

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