British Journal of Nutrition (2003), **89**, 105–114
DOI: 10.1079/BJN2002754

Food sources of nutrients in the diet of Spanish children: the Four Provinces Study

M. A. Royo-Bordonada[1]*, L. Gorgojo[1], M. de Oya[2], C. Garcés[2], F. Rodríguez-Artalejo[3], R. Rubio[2], J. L. del Barrio[2] and J. M. Martín-Moreno[1,3]†

[1]*Institute of Health Carlos III, Ministry of Health & Consumer Affairs, Madrid, Spain*
[2]*Lipids Laboratory, Jiménez Díaz Foundation, Madrid, Spain*
[3]*Department of Preventive Medicine and Public Health, Autonomous University of Madrid, Madrid, Spain*

(Received 4 February 2002 – Revised 15 July 2002 – Accepted 6 September 2002)

The aim of the present study was to assess the principal food sources of energy and nutrients among Spanish children. We used a cross-sectional study design, based on results obtained from a food-frequency questionnaire. The sample included 1112 children, aged 6–7 years, from Cadiz, Madrid, Orense and Murcia, Spain. Children were selected through random cluster-sampling in schools. We analysed the percentage contributed by each food item to total energy and nutrient intake. The most important food sources were: white bread in the case of carbohydrate (13·4 %); olive oil in the case of total lipids (18·3 %) and monounsaturated fatty acids (29·2 %); whole milk in the case of protein (10·2 %) and saturated fatty acids (14·9 %); chips (French fried potatoes) in the case of polyunsaturated fatty acids (30·4 %). The greatest proportion of Na, consumed in excess, came from salt added to meals. Ham ranked second as a source of saturated fats. Fruits and green leafy vegetables proved to have great relevance as sources of fibre and vitamins, though with regard to the latter, it was observed that fortified foods (breakfast cereals, dairy products, fruit juices, etc.) had come to play a relevant role in many cases. In conclusion, the nutritional profile of Spanish school-aged children aged 6–7 years could be improved by nutritional policies targeted at limiting their consumption of ham (cured or cooked) and of salt added to meals, replacing whole milk with semi-skimmed milk, encouraging the consumption of products rich in complex carbohydrates already present in children's diets (bread, pasta, rice) and promoting less fatty ways of cooking food.

Food sources: Children: Nutrients: Diet: Food surveys

The concept of important nutrient sources was introduced two decades ago by Batcher & Nichols (1984) as a means of identifying foods that make a relatively greater contribution to the overall intake of any given nutrient. Knowledge of such sources, together with the information about the degree to which children meet recommended nutrient intakes, is of great interest to decision-makers and planners in the field of public health, to the food industry, and to professionals engaged in health promotion and education, or clinical practice and research in the field of nutrition. On the one hand, it can prove useful when recommending changes in the intake of foods having maximum potential effectiveness for the purpose of pursuing a designated nutritional goal (Thompson *et al.* 1992), an approach only rendered possible by knowing the way in which population levels of any given nutrient may be affected by the addition or withdrawal of a set amount of a specific food. On the other hand, it can help in designing instruments for the assessment of dietary intake, by enabling lists of foods better suited to the nutritional reality of the target population to be drawn up (Block *et al.* 1985*a*,*b*, 1986).

As far as we are aware, no previous study has ever undertaken a comprehensive analysis of the food sources of nutrients among the Spanish school-age population. Not only have such studies been local or regional in

Abbreviations: FFQ, food-frequency questionnaire.

* **Corresponding author:** Dr Miguel A. Royo-Bordonada, fax +34 91 3877862, email mroyo@isciii.es

† On behalf of the investigators of the Four Provinces Study: M. Benavente and A. Studer (Jiménez Díaz Foundation, Madrid), M. A. Lasunción and H. Ortega (Ramón y Cajal Hospital, Madrid), O. Fernández (Cristal Piñol Hospital, Orense), J. Fernández Pardo (Red Cross Hospital, Murcia), A. Macías and A. Mangas (Cadiz University).

nature, but they seldom furnish information on nutrient sources. Furthermore, they present the information in an aggregate fashion, according to the food group under review, and restrict themselves to analysing the sources of energy and some nutrient in particular (Moreno-Sueskun, 1993; Fernández *et al.* 1996; Vázquez *et al.* 1996), thus limiting their potential usefulness as a tool for drawing up food guidelines (Gibney *et al.* 2000).

This present study has the widest geographical coverage of any conducted in Spain on food and nutrition in schoolchildren in the last 20 years (Gorgojo *et al.* 1999), and is the first to systematically assess the principal food sources of energy and of macro- and micronutrients among children in four Spanish cities with different demographic and socio-cultural characteristics.

Methods

Study subjects

The methods have been described in detail elsewhere (Rodríguez-Artalejo *et al.* 1999, 2002). We selected representative samples of schoolchildren, aged 6–7 years, in four cities in Spain (Cadiz, Madrid, Orense and Murcia) over the period 1998–9. Children were selected by means of random cluster-sampling in schools, and stratified by sex and type of school (i.e. public *v.* private). Sampling was carried out in two stages: in the first, schools were selected from lists supplied by the regional educational authorities; in the second, classrooms and pupils were selected. All children reported by parents to be suffering from metabolic, endocrine, liver or kidney disorders were excluded so as to rule out the possibility of the values of any of the variables of interest being altered.

The study protocol complied with Helsinki Declaration guidelines and Spanish statutory provisions governing clinical research on humans subjects (Boletín Oficial del Estado, 1993) and was formally approved by the Clinical Research Ethics Committee of the Jiménez Díaz Foundation in Madrid.

Data collection and study variables

The study design was presented orally to the Board of Governors (Consejo Escolar) of each of the schools. Following this, a letter was circulated to the parents of all children invited to participate in the study, outlining the study goals and procedures, and securing their written authorisation. In addition, this same letter urged all parents to seek the necessary consent from their children. Children were given the opportunity to refuse prior to the day of the survey.

At each school, data were collected by a field team, comprising a physician, a nurse and a group of interviewers trained in the use of a food-frequency questionnaire (FFQ), who conducted the survey and obtained the information from the children's mothers. The interviewers were given precise instructions about how to carry out the interview, how to express the questions, and how to take positive breaks in order to avoid deficiencies in the information gathered that could be due to tiredness of the interviewee.

Food and nutritional data

Information on children's dietary and nutrient intakes was obtained by means of an FFQ, initially developed for use on adults and previously validated in Spain (Martín-Moreno *et al.* 1993). For the purpose of the present study, the FFQ was adapted for a primary-school population by amending and downscaling the list of foods and portion-sizes consumed, eliminating alcoholic beverages and including some foods frequently found in children's diet (e.g. pizzas, hamburgers, etc.). These amendments were based on a recent, systematic, in-depth review of child-population food surveys in Spain (Gorgojo *et al.* 1999). Although some of those studies used different FFQ, the reliability of those instruments was unknown as they were not previously assessed or validated in children or in adults. Hence, we adapted the FFQ (previously validated in the Spanish adult population by our team, see Martín-Moreno *et al*. 1993) for the present study. The final version of the FFQ included a total of seventy-seven food items grouped under eleven headers by affinity of nutrient content. A detailed list of food items covered by the FFQ is given in Table 1. For each food, the usual size of the serving eaten was defined (e.g. one cup of milk, 170 ml; a dish of lentils, 60 g dry weight) and the mean frequency of consumption of such servings over the previous year ascertained. The FFQ included five consumption frequency scales (never, once per year, once per month, once per week and once per day), and respondents provided the number of times the food was consumed according to the most appropriate frequency scale (once per week, once per day, etc.). In cases where it was difficult to translate the interviewee's answer immediately into mean frequency of consumption, the interviewer registered the answer literally, and once the interview was finished, he/she calculated the corresponding value without being under pressure of time. For conversion of foods into nutrients (main macronutrients and vitamins) and total energy intake, the frequency of consumption was multiplied by the nutrient content of a specified portion, according to standard Spanish food composition tables (Mataix *et al.* 1998; Moreiras-Varela *et al.* 1999*b*) and summed for all foods. A food-frequency conversion programme was designed that furnished a database with the annual food consumption and daily nutrient intake frequencies for each individual surveyed.

Food sources of nutrients

The structure of the FFQ dictated the way in which foods were grouped for the purpose of obtaining nutrient sources. For instance, the oil used to cook any given food was included as a source of energy and nutrients along with the food in question; hence, all energy and lipids furnished by oil used to fry potatoes were assigned to the 'chips' (French fried potatoes) item. Although the nature of the food listing and subsequent nutrient analysis introduces error, this is commonly done in order to reduce the length of the food list.

Food mixtures were not broken down into their

Table 1. List of items on the school children's food-frequency questionnaire

Dairy products	**Legumes and cereals**	**Fruit**
Whole milk	Legumes	Citrus fruit
Semi-skimmed milk	White bread	Bananas
Yoghurt	Wholemeal bread	Apples and similar¶¶
Petit Suisse*	Breakfast cereals	Strawberries and similar***
Processed cheese	White rice	Water- and other melons
Hard and semi-soft matured cheese	Pasta	Canned fruit
Ice-cream (excluding sherbets)	Pizza	Dried fruits†††
Flavoured milk drinks	**Oils and fats**	Nuts‡‡‡
Other dairy products†	Olive oil	Olives
Eggs, poultry, meat and fish	Maize oil	**Beverages**
Eggs	Sunflower oil	Carbonated soft drinks
Poultry (chicken and turkey)	Soyabean oil	Non-carbonated soft drinks
Meat‡	Mixed oils	Natural fruit juices
Cured or cooked ham	Margarine	Other fruit juices
Sausage or processed meats§	Butter or lard	Other beverages
Liver and other offal	**Pre-cooked foods**	**Miscellaneous**
White fish	Croquettes and similar††	Mayonnaise
Blue fish	Breaded fish‡‡	Tomato sauce or ketchup
Salted or smoked fish	Breaded chicken§§	Mustard
Shellfish	Consommé and cream soups	Added salt (table and/or cooking)
Greens and vegetables	**Bakery products**	Sugar
Green leafy vegetables‖	Plain (Marie-type) biscuits	Honey
Cabbage, cauliflower and broccoli	Chocolate biscuits	Jams and marmalades
Raw tomatoes	Buns‖‖	
Green beans	Cakes and pastries	
Vegetables¶	Churros (an oil-fried pastry) and similar	
Roast or boiled potatoes	Instant drinking chocolate	
Chips (French fried potatoes)	Chocolate	
Button or wild mushrooms	Pastas (assorted biscuits, including shortbread) and similar	
Andalusian gazpacho**		

* A sweetened, soft dessert cheese.
† Custard, cream caramel, milk puddings and cuajada (rennet pudding).
‡ Veal, beef, pork and lamb.
§ Chorizo (a spicy red Spanish sausage), salchichón (a salami-style sausage), mortadela (boloney), sausages, sobrasada (a spicy Balearic sausage spread) and hamburgers.
‖ Lettuce, endives (chicory), escarole, chard and spinach.
¶ Egg-plant, courgettes (zucchini), cucumbers, carrots, pumpkin, and green and red peppers.
** Cold soup of diced tomatoes, cucumber and green peppers in olive oil, vinegar and garlic.
†† Includes buñuelos (a type of fritter) and empanadillas (small meat- or fish-filled pasties).
‡‡ Includes hake fish-fingers.
§§ Includes filetes de san jacobo (breaded ham and cheese).
‖‖ Ensaimada (a turban-shaped bun), doughnuts, croissants and bollicao (a chocolate-filled roll).
¶¶ Includes pears, peaches, apricots and nectarines.
*** Includes cherries.
††† Dates, dried figs, raisins and sultanas and prunes.
‡‡‡ Peanuts, chestnuts, hazelnuts and almonds.

constituent components, because the same food item included mixtures with different compositions. For instance, there was a single food item for croquettes, buñuelos (a type of fritter) and empanadillas (small meat- or fish-filled pasties), and the 'pizza' food item included all types of pizza consumed by the individual, regardless of their composition. This type of approach allows one to ascertain the importance of food mixtures as a source of nutrients, a relevant aspect in view of the growing presence of food mixtures in the diets of preschool and school-aged children (Popkin *et al.* 2001).

The contribution made by any one food to the intake of a given nutrient was obtained by means of the following fraction: target nutrient contributed by a specific food for all individuals in the sample (g) : target nutrient contributed by all foods for all individuals in the sample (g) (Krebs-Smith *et al.* 1989). All statistical analyses were performed using the Statistical Analysis System computer software package (SAS System for Windows, version 6.11, 1996; SAS Institute Inc., Cary, NC, USA).

Results

Among the mothers contacted, there was an overall response rate of 85 %, which proved similar for all four cities. The valid sample totalled 1112 individuals, 557 (50·1 %) boys and 555 (49·9 %) girls. Mean age was 6.7 years, with no substantial differences between cities.

The ten most important food sources of each nutrient are listed in Tables 2–6. As the most important sources of energy and nutrients were practically identical and of very similar magnitude (results not shown) for both boys and girls, unless otherwise specified, the results reported later are given jointly for the two sexes.

Energy

Mean energy intake was 8·907 MJ (2129 kcal)/d. Table 2 shows the principal food sources of energy. Chips proved the most important source, accounting for 10·2 % total

energy intake. Other important sources were white bread, whole milk and olive oil, which provided 8·0, 7·3 and 7·1 % total energy intake respectively. Dairy products as a whole accounted for 19·9 % total energy intake. Sugar added domestically accounted for 0·85 % total energy intake (results not shown).

Macronutrients and cholesterol

The food sources of the principal macronutrients and cholesterol are shown in Tables 2 and 3. Whole milk and chips ranked among the principal food sources of carbohydrates, lipids and proteins. Other important (i.e. among the top four) sources of these macronutrients were olive and sunflower oil for lipid, and white bread and yoghurt for carbohydrate and protein.

Separate analyses of the various types of fatty acids revealed that the profiles of the food sources of total lipids and saturated and monounsaturated fatty acids were very similar. Indeed, nine out of the ten most important sources of these nutrients coincided. Moreover, the three most important sources of total lipids and monounsaturated fatty acids (olive oil, chips and whole milk) ranked in the same order of importance: (1) olive oil, 18·3 % lipid and 29·2 % monounsaturated fatty acids; (2) chips, 10·2 and 7·4 % respectively; (3) whole milk, 9·7 and 7·0 % respectively. The principal source of saturated fatty acids was whole milk (14·9 %), followed by ham (cured or cooked) (8·2 %), olive oil (6·7 %), dried fruits and nuts (6·4 %) and red meat (5·7 %). Consumption of chips alone accounted for 30·4 % polyunsaturated fatty acid intake; the other three most important sources of this nutrient (sunflower oil, olive oil and margarine) accounted for 35·2 % total intake.

The principal source of cholesterol was eggs, with 24·5 % total intake, a value that does not include the contribution made by eggs forming part of the ingredients of other food items (e.g. buns and pastries, dairy products such as custard, puddings etc.). Other important sources of cholesterol were whole milk (11·2 %), red meat (6·3 %), bakery products (6·1 %), chicken or turkey (5·9 %) and white fish (5·5 %).

Fibre, minerals and vitamins

Table 4 shows legumes to be the principal source of fibre, with a contribution of 16·2 %, followed by white bread and bananas, both accounting for approximately 11·0 %. Green leafy vegetables ranked fifth, with 7·0 %. Fruits as a whole contributed over 30 % of the study population's fibre intake.

The principal food sources of Ca were dairy products, and milk in particular, with whole milk accounting for 24·7 and semi-skimmed milk 7·8 % Ca. The top six sources of Ca belonged to the dairy food group and together represented 70·0 % Ca intake. Other relatively important sources of Ca were pizzas, green leafy vegetables and plain (Marie-type) biscuits, with 2·7, 2·6 and 2·3 % respectively.

With a value of 21·2 %, salt added to meals (at the table or in cooking) proved to be the principal source of Na. Among the foods accounting for major amounts of Na were chips, white bread and ham (cured or cooked), with 12·1, 11·3 and 6·3 % respectively (Table 4).

Among the seven most important sources of vitamin A were foods from the main food groups (cereals, fruit, vegetables, dairy products and meat), according to national and international guidelines (Mataix & Puigdueta, 1999; US Department of Agriculture and US Department of Health and Human Services, 2000*b*). Green leafy vegetables and whole milk were the two most important sources of vitamin A, accounting for 18·0 and 16·8 % respectively. Fatty foods were the most important sources of vitamins D and E. The principal source of vitamin D was blue fish

Table 2. Food sources of energy, carbohydrates and proteins*
(Mean values for 1112 schoolchildren)

		Carbohydrates		Proteins	
	Energy (%)	Order	%	Order	%
Chips (French friend potatoes)	10·2	2	12·3	9	4·2
White bread	8·0	1	13·4	3	6·5
Whole milk	7·3	5	4·6	1	10·2
Olive oil	7·1	–	–	–	–
Plain (Marie-type) biscuits	5·5	3	7·2	–	–
Yoghurt	4·1	4	5·7	2	6·9
Meat	3·0	–	–	4	6·3
Instant drinking chocolate	2·9	7	4·4	–	–
Pasta	2·4	6	4·4	–	–
Sausage or processed meats	2·4	–	–	–	–
Bananas	–	8	3·8	–	–
Breakfast cereals	–	9	3·6	–	–
Natural fruit juices	–	10	3·2	–	–
Cured and cooked ham	–	–	–	5	5·4
Poultry (chicken and turkey)	–	–	–	6	4·5
Hard and semi-soft matured cheese	–	–	–	7	4·3
White fish	–	–	–	8	4·3
Legumes	–	–	–	10	3·9

* For details of subjects and procedures, see p. 106.

Table 3. Food sources of lipids, fatty acids and cholesterol*
(Mean values for 1112 schoolchildren)

		SFA		MFA		PFA		Cholesterol	
	Lipids (%)	Order	%	Order	%	Order	%	Order	%
Olive oil	18·3	3	6·7	1	29·2	3	12·0	–	–
Chips (French fried potatoes)	10·2	9	3·4	2	7·4	1	30·4	–	–
Whole milk	9·7	1	14·9	3	7·0	–	–	2	11·2
Sunflower oil	5·9	–	–	7	4·3	2	17·7	–	–
Meat	5·3	5	5·7	5	5·2	9	1·8	3	6·3
Sausage or processed meats	4·8	8	4·9	6	4·8	8	2·3	9	3·6
Plain (Marie-type) biscuits	4·4	7	5·2	9	2·9	–	–	7	5·3
Hard and semi-soft matured cheese	3·5	6	5·2	–	–	–	–	–	–
Nuts and dried fruit	2·3	4	6·4	8	3·4	5	2·5	–	–
Cured and cooked harm	2·2	2	8·2	10	2·7	–	–	10	3·2
Petit suisse	–	10	3·2	–	–	–	–	–	–
Poultry (chicken and turkey)	–	–	–	4	6·7	–	–	5	5·9
Margarine	–	–	–	–	–	4	5·5	–	–
White bread	–	–	–	–	–	6	2·5	–	–
Bakery products	–	–	–	–	–	7	2·4	4	6·1
Breaded fish	–	–	–	–	–	10	1·7	–	–
Eggs	–	–	–	–	–	–	–	1	24·5
White fish	–	–	–	–	–	–	–	6	5·5
Pasta and similar	–	–	–	–	–	–	–	8	5·3

SFA, saturated fatty acid; MFA, monounsaturated fatty acid; PFA, polyunsaturated fatty acid.
* For details of subjects and procedures, see p. 106.

(43·3 %), much greater than bottled or canned fruit juices, breakfast cereals, plain (Marie-type) biscuits or eggs, with 16·7, 8·7, 7·7 and 6·8 % respectively. Blue fish had a greater weight as a source of vitamin D in girls (45·1 %) than in boys (41·7 %), a result that was inverted in the case of fruit juices (15·4 and 17·8 % respectively). The most important source of vitamin E, sunflower oil, accounted for 35·2 % of this nutrient among the children in the present study. This was followed by olive oil (11·4 %), and nuts and dried fruit (8·6 %). Other important sources of vitamin E were raw tomatoes, green leafy vegetables, plain (Marie-type) biscuits and whole milk, which together accounted for approximately 17·0 % of this nutrient (Table 5).

Table 4. Food sources of fibre, calcium and sodium*
(Mean values for 1112 schoolchildren)

		Calcium		Sodium	
	Fibre (%)	Order	%	Order	%
Legumes	16·2	–	–	–	–
White bread	11·2	–	–	3	11·3
Bananas	11·1	–	–	–	–
Apples and similar	7·6	–	–	–	–
Green leafy vegetables	7·0	8	2·6	–	–
Citrus fruit	6·9	10	1·7	–	–
Plain (Marie-type) biscuits	5·5	9	2·3	9	3·3
Roast or boiled potatoes	4·3	–	–	–	–
Green beans	3·9	–	–	–	–
Chips (French fried potatoes)	3·1	–	–	2	12·1
Whole milk	–	1	26·5	7	4·2
Yoghurt	–	2	17·5	–	–
Hard and semi-soft matured cheese	–	3	11·1	–	–
Semi-skimmed milk	–	4	7·8	–	–
Flavoured milk drinks	–	5	3·6	–	–
Other dairy products	–	6	3·5	10	3·3
Pizza	–	7	2·7	–	–
Added salt (at table or in cooking)	–	–	–	1	21·3
Cured and cooked ham	–	–	–	4	6·3
Instant drinking chocolate	–	–	–	5	5·6
Sausage or processed meats	–	–	–	6	5·2
Breakfast cereals	–	–	–	10	3·3

* For details of subjects and procedures, see p. 106.

Table 5. Food sources of vitamins A, D and E*
(Mean values for 1112 schoolchildren)

		Vitamin D		Vitamin E	
	Vitamin A (%)	Order	%	Order	%
Green leafy vegetables	18·0	–	–	5	4·7
Whole milk	16·8	8	1·9	7	3·2
Raw tomatoes	9·9	–	–	4	5·0
Plain (Marie-type) biscuits	9·2	4	7·7	6	4·3
Watermelons and other melons	5·9	–	–	–	–
Hard and semi-soft matured cheese	5·2	10	0·6	–	–
Eggs	3·1	5	6·8	8	3·1
Citrus fruit	3·1	–	–	–	–
Bananas	2·5	–	–	–	–
Apples and similar	2·3	–	–	–	–
Blue fish	–	1	43·3	–	–
Other fruit juices	–	2	16·7	–	–
Breakfast cereals	–	3	8·7	–	–
Ice cream (excluding sherbets)	–	6	6·8	–	–
Margarine	–	7	3·4	10	2·3
Bakery products	–	9	1·5	–	–
Sunflower oil	–	–	–	1	35·2
Olive oil	–	–	–	2	11·4
Nuts and dried fruit	–	–	–	3	8·6
Pasta and similar	–	–	–	9	2·3

* For details of subjects and procedures, see p. 106.

Table 6. Food sources of vitamins C and B_6 and folic acid*
(Mean values for 1112 schoolchildren)

		Vitamin B_6		Folic Acid	
	Vitamin C (%)	Order	%	Order	%
Natural fruit juices	19·2	–	–	–	–
Citrus fruit	16·4	–	–	3	7·8
Other fruit juices	7·2	–	–	–	–
Pizza	6·7	–	–	–	–
Green leafy vegetables	6·2	–	–	2	11·9
Raw tomatoes	6·0	–	–	8	4·3
Cabbage, cauliflower and broccoli	5·1	–	–	10	3·9
Roast or boiled potatoes	4·3	5	5	–	–
Vegetables	4·1	–	–	9	4·1
Bananas	3·6	1	15·6	7	5·4
Breakfast cereals	–	2	11·7	1	12·4
Whole milk	–	3	5·9	5	5·9
Chips (French fried potatoes)	–	4	5·3	–	–
Meat	–	6	4·8	–	–
Poultry (chicken and turkey)	–	7	4·8	–	–
Blue fish	–	8	3·9	–	–
Sausage or processed meats	–	9	3·6	–	–
Legumes	–	10	3·2	6	5·9
Green beans	–	–	–	4	6·0

* For details of subjects and procedures, see p. 106.

From Table 6 it will be seen that fruit juices and citrus fruit were the principal sources of vitamin C (43·0 %). Other leading sources of vitamin C were pizzas, green leafy vegetables and raw tomatoes (6·7, 6·2 and 6·0 % respectively). In the case of vitamin B_6, the most important sources were bananas, breakfast cereals and whole milk (15·6, 11·7 and 5·9 respectively). Potatoes as a whole accounted for over 10 % and meat (red and white) 9·0 % of this same nutrient. The three most important sources of folic acid were breakfast cereals, green leafy vegetables and citrus fruits (12·4, 11·9 and 7·7 % respectively). This was the only nutrient for which the most important food source was not the same in both sexes (breakfast cereals in boys *v.* green leafy vegetables in girls), although the differences were small (results not shown).

Discussion

This is, to our knowledge, the first study to provide a detailed list of the principal food sources of energy and

of the main macro- and micronutrients in the Spanish school-aged population aged 6–7 years. Chips, white bread, whole milk and olive oil played a major role as sources of energy and nutrients in the study population, with white bread being the most important source in the case of carbohydrates, olive oil in the case of total lipids and monounsaturated fatty acids, whole milk in the case of proteins and saturated fatty acids, and chips in the case of polyunsaturated fatty acids. Fruits and green leafy vegetables proved to have great importance as sources of fibre and vitamins, though insofar as vitamins were concerned, it was observed that in many cases fortified foods (breakfast cereals, dairy products, fruit juices, etc.) have also come to play an important role.

The results obtained must be interpreted carefully, given the complexity inherent in this field, including the potential limitations when assessing food and nutrient intake through a FFQ, and the fact that the principal source of information resides in and relies upon mothers' powers of recall. While some studies argue that FFQ lead to an overestimate of energy intake among children (Stein *et al.* 1992), others indicate that this type of questionnaire provides valid measures of usual intake of energy and nutrients (Treiber *et al.* 1990; Hammond *et al.* 1993). Furthermore, there is evidence to show that mothers furnish reliable information regarding meals made for children at home (Klesges *et al.* 1987; Treiber *et al.* 1990). Nevertheless, it has to be borne in mind that it is difficult to generalise about the validity and reliability of the results of different methods of dietary assessment (McPherson *et al.* 2000). Although the FFQ has not been validated for Spanish children, it has been validated for use on adults (Martín-Moreno *et al.* 1993). However, for the purpose of the present study, the questionnaire was adapted for a primary-school population, making amendments based on a recent, systematic, in-depth review of child-population food surveys in Spain (Gorgojo *et al.* 1999). Last, caution must be exercised when it comes to using these results to estimate the order of importance of the principal food sources of the nutrients studied. On the one hand, the nutrient analysis does not consider bioavailability of nutrient sources. On the other hand, the precise way in which the foods were grouped for the purpose of studying the nutrient sources (dictated by the very structure of the questionnaire used) and the decision not to break down the food mixtures into their component parts, have influenced the percentage contribution of some foods to the intake of certain nutrients. This approach has, however, made it possible to detect the enormous importance of chips as a source both of energy and nutrients in children's diets.

Two of the principal sources of energy, namely, bread and milk, are common to both the children in the USA and those studied by us in Spain (Block *et al.* 1995; Subar *et al.* 1998). With regard to the remaining leading sources of energy, however, there are few similarities, e.g. whereas in Spain fatty foods, such as chips and olive oil, tend to predominate, in the USA it is hamburgers, carbonated soft drinks and breakfast cereals that acquire importance. The contribution of sugar to total energy intake was somewhat smaller in our present study, but while we have only take into account the sugar added domestically, they have also included the sugar added in the course of the industrial preparation of foods.

Whole milk ranks first in importance as a source of saturated fatty acids, ahead of chips and olive oil, positions that are interchanged in the case of total lipids and monounsaturated fatty acids. In different samples of US children drawn from different age and racial groups, whole milk has consistently been the most important source of saturated fatty acids and total fats (Thompson & Dennison, 1994; Block *et al.* 1995; Subar *et al.* 1998). The elevated intake of total lipids among Spanish children (Gorgojo *et al.* 1999) is probably due to an excess intake of saturated fatty acids, since according to the results of our present study, the majority of children have an adequate intake of monounsaturated and polyunsaturated fatty acids (Royo-Bordonada, 2002). Although dairy products constitute the principal source of Ca for children (Block *et al.* 1995; Fernández *et al.* 1996; Subar *et al.* 1998), in our present population, the intake of this nutrient was far greater than nutritional guideline levels (Moreiras-Varela *et al.* 1999*a*); it might, therefore, be as well to consider a moderate reduction in whole-milk intake as a feasible strategy for limiting the intake of saturated fat, without in any way compromising the benefits to be derived from an adequate intake of Ca (Royo-Bordonada, 2002). However, milk is also an important source of a wide variety of minerals and vitamins (Durá, 2001*b*), as is reflected by the results of our present study with respect to folic acid and vitamins A, B_6, D and E. Furthermore, variation in milk intake is one of the factors with greatest potential for modifying children's nutrient-intake profile (Gordon & McKinney, 1995). Accordingly, nutritional policies targeted at replacing whole milk with another low-fat (e.g. semi-skimmed) variety (Basch *et al.* 1992), equally capable of acting as a vehicle for fat-soluble vitamins and folic acid, should be implemented as a key strategy for achieving recommended saturated-fat-intake levels in this age group.

A study of schoolchildren in the Madrid Autonomous Region (Vázquez *et al.* 1996) reported a dietary fat profile very similar to that observed in the present study, except for the fact that sausage meats represented the third most important source of total lipids, accounting for 18·0 % intake as opposed to the value of 4·8 % recorded for our present children. In spite of methodological differences, results of other studies, whose most important source of total lipids and saturated and mono- and polyunsaturated fatty acids was the meat and meat-products group (Durá, 2001*a*), appear to support findings of the current study, where a member of the meat group was also found to be a significant source of saturated fat. Nevertheless, differences in methodology and ways of grouping foods tend to render direct comparisons difficult. Whatever the case, however, cured and cooked ham, foods included in the groups mentioned earlier, were the second leading source of saturated fatty acids among the children in our present study. Moreover, these foods played a relevant role in the intake of Na and protein, nutrients that register a higher than desirable level of consumption among Spain's school-aged population (Rodríguez-Artalejo *et al.* 1996, 2002; Gorgojo *et al.* 1999; Royo-Bordonada, 2002). This excessive intake of Na may contribute to the

high blood-pressure values observed in Spanish children and adolescents, values comparable with those reported in other developed countries (Brotons *et al.* 1989; Grupo Cooperativo Español para el Estudio de los Factores de Riesgo Cardiovascular en la Infancia y Adolescencia, 1995). Further, intakes may also contribute to the high prevalence of hypertension among Spain's middle-aged population (Banegas *et al.* 1998). While recent years have witnessed a decline in added salt intake in Spain, there has been a parallel increase in the consumption of pre-cooked foods having a high Na content (Serra & Aranceta, 2001). Although we acknowledge that the FFQ is not the standard method to assess Na intake, we have made a particular effort to measure Na intake properly because our FFQ and food composition tables considered both the Na arising from the generic food items and that coming from salt directly added to the food. Moreover, some studies have found good correlations for Na intake between the FFQ and the urinary excretion (Willet, 1998). It would therefore seem wise to reduce the consumption of foods, like ham (cured or cooked), that furnish substantial amounts of Na and other nutrients such as fatty acids and cholesterol and whose intakes, according to current dietary recommendations (Sociedad Española de Nutrición Comunitaria, 2001), are excessive.

The leading source of carbohydrates proved to be white bread, followed by potato chips. It is noteworthy that pasta and rice, foods rich in complex carbohydrates and well accepted by children, accounted for $<5{\cdot}0\,\%$ of the intake of this nutrient. Among the children in our present study, intake of carbohydrates, and of complex carbohydrates in particular (Royo-Bordonada, 2002), fell far short of the nutritional objectives set for the Spanish population (Aranceta, 1995). It would therefore appear advisable to foster an increase in the intake of products rich in complex carbohydrates and already present in the diet of our children, foods such as white bread, pasta and rice. Chips are an important source of Na and lipids, particularly polyunsaturated fatty acids, thereby rendering it a food warranting special attention, with a view either to preventing any increase in intake, or even promoting a slight reduction in or partial replacement of same by less fatty cooking methods (e.g. potatoes to be roasted or boiled rather than fried).

Thanks to their high concentration of dietary fibre, legumes were the most important source of this nutrient, ahead of white bread, which was consumed in far greater amounts (Rodríguez-Artalejo *et al.* 2002). Among children in the USA, legumes accounted for $6{\cdot}7\,\%$ fibre intake (Subar *et al.* 1998), less than half the percentage contribution found in our present study ($16{\cdot}2\,\%$). In the case of bread, the values were very similar (about $14\,\%$ fibre), although in the case of US children, $50{\cdot}0\,\%$ of such fibre came from wholemeal bread, while in Spanish children this figure was $14{\cdot}5\,\%$. Overall, fruits were the principal source of fibre, accounting for approximately one-third of intake, in contrast to the moderate ($11{\cdot}3\,\%$) or insignificant role that this item played in the diets both of adolescents in a rural area of Navarre (Durá, 2001*a*) and of US children (Subar *et al.* 1998) respectively. By way of example, bananas were the third most important source of fibre in our present study, accounting for $11{\cdot}1\,\%$ total intake, while among US children this same fruit ranked eighteenth, with $1{\cdot}3\,\%$ intake.

Cereals are a poor source of folic acid and yet, thanks to fortification, breakfast cereals were the principal source of this nutrient in the present study population. Similarly, cereals not only represented the second most important food source of vitamins B_6 and D, but they also registered a considerable consumption frequency, findings that are in accordance with the results of the enKid study, which analysed the dietary breakfast habits of a representative Spanish population sample aged 2–24 years (Serra *et al.* 2000). Even so, cereal intakes did not reach the recommended level in the present population (Royo-Bordonada, 2002). Although blue fish continues to be the principal source of vitamin D (Moreiras *et al.* 1992), our present results show that food fortification is once again the explanation for the fact that, over the last decade, items such as fruit juices, margarine and dairy products have risen to rank among the leading sources of vitamin D (Durá, 2001*a*). This phenomenon had already been observed to a more marked degree in an earlier survey (1989–91) of the US population aged 2–18 years, among whom breakfast cereals were seen to rank as the most important food source of Fe, vitamin A and folic acid (Subar *et al.* 1998). In the case of this latter nutrient, breakfast cereals accounted for $30{\cdot}0$ *v.* $12{\cdot}4\,\%$ total intake observed in our present study. Unlike their US counterparts, however, our present children received an important percentage of their folic-acid intake from green leafy vegetables, in accordance with their high intake of vegetables (Royo-Bordonada, 2002). The incorporation of fortified foods into the diet, associated in principle with better dietary behaviour and nutrient intake (Serra *et al.* 2000), is particularly relevant in the case of nutrients such as vitamin B_6, where intake lies below the recommended level for a high percentage of the population (Kant & Block, 1990; Albertson *et al.* 1992; Royo-Bordonada, 2002). Then again, this might reflect a trend towards foods that are rich in nutrients in their natural state being replaced by other fortified varieties. If such a trend were to increase, it could lead to increased risk of nutrient deficiencies since fortified foods may not have the same nutrient profile as foods that are naturally rich in the nutrient in question. It therefore seems highly advisable that nutrient intake be drawn essentially from a natural and varied diet (US Department of Agriculture and US Department of Health and Human Services, 2000*a*; Sociedad Española de Nutrición Comunitaria, 2001); for instance, a very healthy alternative way of increasing vitamin B_6 intake would be to promote banana consumption.

Within the framework of its nutrition policy in Europe, the WHO recommends that dietary guidelines be drawn up, based on identification of potential target foods by analysis of current food and nutrient intake patterns (Gibney *et al.* 2000; Sociedad Española de Nutrición Comunitaria, 2001). This is the first comprehensive examination of food sources of nutrients in children and therefore would be useful in establishing guidelines for Spanish children. The earlier results show that the nutritional profile of Spanish school-children aged 6–7 years

could be potentially improved by nutritional policies targeted at limiting their consumption of ham (cured or cooked) and of salt added to meals, substituting semi-skimmed for whole milk, encouraging the consumption of products rich in complex carbohydrates already present in children's diets (bread, pasta, rice), and promoting less fatty ways of cooking food (e.g. roasting or boiling as opposed to frying potatoes).

Acknowledgements

This study was partly funded by grants from the International Olive Oil Board (Consejo Oleícola Internacional), Madrid Regional Authority (Comunidad de Madrid), Pedro Barrié de la Maza Foundation and Eugenio Rodríguez Pascual Foundation.

References

Albertson AM, Tobelmann RC, Engstrom A & Asp EH (1992) Nutrient intakes of 2- to 10-year-old American children: 10-year trends. *Journal of the American Dietetic Association* **92**, 1492–1496.

Aranceta J (1995) Objetivos nutricionales y guías dietéticas. Propuesta de la SENC para la población española (Nutritional objectives and dietary guidelines. Spanish Community Nutrition Society proposal for the Spanish population). In *Documento de Consenso. Guías Alimentarias para la Población Española (The Consensus Document. Dietary Guidelines for the Spanish Population)*, 1st ed., pp. 127–152 [Ll Serra, J Aranceta and J Mataix, editors]. Barcelona: SG editores.

Banegas JR, Rodríguez-Artalejo F, de la Cruz JJ, Guallar P & del Rey J (1998) Blood pressure in Spain. Distribution, awareness, control, and benefits of a reduction in average pressure. *Hypertension* **32**, 998–1002.

Basch Ch, Shea S & Zybert P (1992) Food sources, dietary behavior, and the saturated fat intake of Latino children. *American Journal of Public Health* **82**, 810–815.

Batcher OM & Nichols JM (1984) Identifying important food sources of nutrients. *Journal of Nutrition Education* **16**, 177–181.

Block G, Dresser CM, Hartman AM & Carrol MD (1985*a*) Nutrient sources in the American diet: quantitative data from the NHANES II survey. I. Vitamins and minerals. *American Journal of Epidemiology* **122**, 13–26.

Block G, Dresser CM, Hartman AM & Carrol MD (1985*b*) Nutrient sources in the American diet: quantitative data from the NHANES II survey. II. Macronutriuents and fats. *American Journal of Epidemiology* **122**, 27–40.

Block G, Hartman AM, Dresser CM, Carrol MD, Gannon J & Gardner L (1986) A data-based approach to diet questionnaire design and testing. *American Journal of Epidemiology* **124**, 453–469.

Block G, Norris JC, Mandel RM & DiSogra C (1995) Sources of energy and six nutrients in diets of low-income Hispanic-American women and their children: Quantitative data from NHANES, 1982–1984. *Journal of the American Dietetic Association* **95**, 195–208.

Boletín Oficial del Estado (1993) *Real Decreto* (Royal Decree) 561/1993, 16 April: *Por el que Establecen los Requisitos para la Realización de Ensayos Clínicos con Medicamentos* (*Governing The Requirements For And Manner In Which Clinical Drug Trials Are To Be Conducted*), 12483, pp. 14346–14364.

Brotons C, Singh P, Nihsio T & Labarte DR (1989) Blood pressure by age in childhood and adolescence: a review of 129 surveys worldwide. *International Journal of Epidemiology* **18**, 824–829.

Durá T (2001*a*) Ingesta de energía y nutrientes en los alumnos de educación secundaria obligatoria (Energy and nutrient intake in secondary education students in a health district). *Anales Españoles de Pediatría* **54**, 547–554.

Durá T (2001*b*) Importancia de la variedad en la ingesta de leche y productos lácteos en adolescentes (The importance of the variety in the adolescents' milk and dairy produce intake). *Acta Pediátrica Española* **59**, 366–373.

Fernández C, López T, Martínez P, Jaunsolo MA, de Cos AI, Cilleruelo ML & Vázquez C (1996) Consumo de lácteos y su contribución al aporte de nutrientes en la dieta de los escolares de la Comunidad de Madrid (Actual intake of milk products by a population of schoolchildren in the Community of Madrid and their contribution to dietary nutrients). *Anales Españoles de Pediatría* **44**, 214–218.

Gibney MJ, Serra Ll, Kearney JM, Becker W, Löwik MRH, Wiseman M, De Henauw S, Haraldsdóttir J, Flynn MAT, Graça P, Kafatos A, Koenig J, Leclercq C, Lambe J & Ribas L, *et al.* (2000) Por una política de nutrición en Europa en el siglo XXI: desarrollo de unas guías alimentarias basadas en el consumo de alimentos (For an European nutrition policy in the 21st century: dietary guidelines development based on food intake). *Nutrición Clínica* **20**, 29–46.

Gordon A & McKinney P (1995) Sources of nutrients in students' diets. *American Journal of Clinical Nutrition* **61**, 232S–240S.

Gorgojo L, Guallar E, Martín-Moreno JM, López-Nomdedeu C, Vázquez C, Martí-Henneberg C & Serrano-Ríos M (1999) Encuestas alimentarias en los niños españoles de edad escolar: análisis del período 1984–1994 (An overview of nutritional surveys of school-age Spanish children during 1984–1994). *Medicina Clínica (Barcelona)* **112**, 368–374.

Grupo Cooperativo Español para el Estudio de los Factores de Riesgo Cardiovascular en la Infancia y Adolescencia (1995) Factores de riesgo cardiovascular en la infancia y adolescencia en España. Estudio RICARDIN II: valores de referencia (Spanish cooperative group for the study of the childhood and adolescence cardiovascular risk factors (1995). Spanish childhood and adolescence cardiovascular risk factors. The RICARDIN II study: reference values). *Anales Españoles de Pediatría* **43**, 11–17.

Hammond J, Nelson M, Chinn S & Rona RJ (1993) Validation of a food frequency questionnaire for assessing dietary intake in a study of coronary heart disease risk factors in children. *European Journal of Clinical Nutrition* **47**, 242–250.

Kant AK & Block G (1990) Dietary vitamin B-6 intake and food sources in the US population: NHANES II, 1976–1980. *American Journal of Clinical Nutrition* **52**, 707–716.

Klesges RC, Klesges LM, Brown G & Frank GC (1987) Validation of the 24-hour dietary recall in preschool children. *Journal of the American Dietetic Association* **87**, 1383–1385.

Krebs-Smith SM, Kott PS & Guenteher PM (1989) Mean proportion and population proportion: Two answers to the same question? *Journal of the American Dietetic Association* **89**, 671–676.

McPherson RS, Hoelscher DM, Alexander M, Scanlon KS & Serdula MK (2000) Dietary assessment methods among school-aged children: Validity and reliability. *Preventive Medicine* **31**, Suppl., S11–S33.

Martín-Moreno JM, Boyle P, Gorgojo L, Maisonneuve P, Fernandez-Rodriguez JC, Salvini S & Willet WC (1993) Development and validation of a food frequency questionnaire in Spain. *International Journal of Epidemiology* **22**, 512–519.

Mataix J, Mañas M, Llopis J, Martínez E, Sánchez J & Borregón A (1998) *Tabla de Composición de Alimentos Españoles*

(Spanish Food Composition Tables), 3rd ed. Granada: Editorial Universidad de Granada, Campus Universitario de Cartuja.

Mataix J & Puigdueta I (1999) Guías alimentarias en España (Spanish dietary guidelines). *Revista Española de Nutrición Comunitaria* **5**, 187–192.

Moreiras O, Carbajal A, Perea I & Varela G (1992) The influence of dietary intake and sunlight exposure on the vitamin D status in an elderly Spanish group. *International Journal for Vitamin and Nutrition Research* **62**, 303–307.

Moreiras-Varela O, Carbajal A & Cabrera L (1999*a*) Tablas de ingestas recomendadas de energía and nutrientes para la población española. (Recommended energy and nutrient intake tables for the Spanish population). In *Tablas de Composición de Alimentos (Food Composition Tables)*, 2nd ed., pp. 105–110. Madrid: Ediciones Pirámide.

Moreiras-Varela O, Carbajal A & Cabrera L (1999*b*) *Tablas de Composición de Alimentos (Food Composition Tables)*, 2nd ed. Madrid: Ediciones Pirámide.

Moreno-Sueskun I (1993) *Hábitos alimentarios de la población de Navarra 1989–1990 (Dietary habits of the population of Navarra 1989–1990)*. Pamplona: Fondo de publicaciones del gobierno de Navarra.

Popkin BM, Siega-Riz AM, Haines PS & Jahns L (2001) Where's the fat? Trends in U.S. diets 1965–1996. *Preventive Medicine* **32**, 245–254.

Rodríguez-Artalejo F, Garcés C, Gil A, Lasunción MA, Martín-Moreno JM, Gorgojo L & de Oya M (1999) Estudio Cuatro Provincias: principales objetivos y diseño (Four provinces study: objectives and design). *Revista Española de Cardiología* **52**, 319–326.

Rodríguez-Artalejo F, Garcés C, Gorgojo L, López E, Martín-Moreno JM, Benavente M, del Barrio JL, Rubio R, Ortega H, Fernández O & de Oya M (2002) Dietary patterns among children aged 6–7 years in four Spanish cities with widely differing cardiovascular mortality. *European Journal of Clinical Nutrition* **56**, 1–8.

Rodríguez-Artalejo F, Graciani MA, Banegas JR, Sabaté J & Rey-Calero J (1996) El consumo de alimentos y nutrientes en España en el período 1940–1988 (y II). Un estudio comparativo de las principales fuentes de información sobre consumo alimentario (Food and nutrient composition in Spain, 1940–1948 (and II). A comparative study of the main sources of information on food composition). *Medicina Clínica (Barcelona)* **107**, 446–452.

Royo-Bordonada MA (2002) Spanish children's diet: compliance with nutrient and food intake guidelines. PhD Thesis, Autonomous University of Madrid.

Serra Ll & Aranceta J (2001) Objetivos nutricionales para la población española. Consenso de la Sociedad Española de Nutrición Comunitaria (Nutritional objectives for the Spanish population. Spanish Community Nutrition Society consensus). In *Sociedad Española de Nutrición Comunitaria. Guías Alimentarias para la Población Española. Recomendaciones para una Dieta Saludable*, (Spanish Community Nutrition Society. Dietary guidelines for the Spanish population. Recommendations for a healthy diet) pp. 345–351 [Ll Serra, J Aranceta and J Mataix, editors]. Madrid: IM&C.

Serra Ll, Ribas L, García-Closas R, Pérez C & Aranceta J (2000) Cereales del desayuno y estado nutricional: contribución de los cereales del desayuno a la nutrición de los niños y jóvenes españoles (Breakfast cereals and nutritional status: breakfast cereals contribution to the Spanish children and young population nutrition). In *Desayuno y Equilibrio Alimentario. Estudio enKid (Breakfast and food balance. The enKid study)*, pp. 75–89 [Ll Serra and J Aranceta, editors]. Barcelona: MASSON.

Sociedad Española de Nutrición Comunitaria (2001) *Guías Alimentarias para la Población Española. Recomendaciones para una Dieta Saludable (Dietary guidelines for the Spanish population. Recommendations for a healthy diet)*. Madrid: IM&C.

Stein AD, Shea S, Basch Ch, Contento IR & Zybert P (1992) Consistency of the Willet semiquantitative food frequency questionnaire and 24-hour dietary recalls in estimating nutrient intakes of preschool children. *American Journal of Epidemiology* **135**, 667–677.

Subar AF, Krebs-Smith SM, Cook A & Kahle LL (1998) Dietary sources of nutrients among US children, 1989–1991. *Pediatrics* **102**, 913–923.

Thompson FE & Dennison BA (1994) Dietary sources of fats and cholesterol in US children aged 2 through 5 years. *American Journal of Public Health* **84**, 799–806.

Thompson FE, Sowers MF, Frongillo EA & Parpia BJ (1992) Sources of fiber and fat in diets of US women aged 19 to 50: implications for nutrition education and policy. *American Journal of Public Health* **82**, 695–702.

Treiber FA, Leonard SB, Frank G, Davis H & Levy M (1990) Dietary assessment instruments for preschool children: Reliability of parental responses to the 24-hour recall and a food frequency questionnaire. *Journal of the American Dietetic Association* **90**, 814–820.

US Department of Agriculture and US Department of Health and Human Services (2000*a*) *Nutrition and Your Health: Dietary Guidelines for Americans*. Home and Garden Bulletin no. 232, 5 ed, pp. 1–39. Washington, DC: US Government Printing Office.

US Department of Agriculture and US Department of Health and Human Services (2000*b*) *The Food Guide Pyramid*. Home and Garden Bulletin no. 252, 5 ed. Washington, DC: US Government Printing Office.

Vázquez C, de Cos AI, Martínez P, Jaunsolo MA, Román E, Gómez E, López T, Hernáez I, Seijas V, Ramos V, Cilleruelo ML, Sarrión D, García JJ & López-Nomdedeu C (1996) Consumo de alimentos y nutrientes por edades y sexo en escolares de la Comunidad de Madrid (CAENPE) (Intake of foodstuffs and nutrients by age and gender in schoolchildren in the Madrid Community (CAENPE)). *Revista Clínica Española* **196**, 501–508.

Willet W (1998) *Nutritional Epidemiology*, 2nd ed. New York: Oxford University Press.