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Consumption of red meat, white meat and processed meat in Irish adults in relation to dietary quality

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The aim of the present study was to examine the association of red meat, white meat and processed meat consumption in Irish adults with dietary quality. A cross-sectional study of subjects, randomly selected using the electoral register, estimated habitual food intakes using a 7 d food diary in a nationally representative sample of 662 men and 717 women (not pregnant or lactating) aged 18–64 years. Consumers were classified into thirds, based on the distribution of mean daily intakes for red meat, white meat and processed meat. The mean intakes of red meat, white meat and processed meat were 51, 33 and 26 g/d respectively, and men consumed significantly more ($P < 0·001$) than women for all meat types. In men, red meat consumption was associated with lower ($P < 0·001$) prevalence of inadequacy for Zn, riboflavin and vitamin C intakes. Increasing processed meat intake was associated with a lower ($P < 0·01$) level of compliance with dietary recommendations for fat, carbohydrate and fibre in men. Increasing processed meat consumption was associated with lower ($P < 0·01$) wholemeal bread, vegetables, fruit and fish intakes in men and women. Managerial occupations were associated with lower processed meat intakes. It is important to distinguish between meat groups, as there was a large variation between the dietary quality in consumers of red meat, white meat and processed meat. Processed meat consumption is negatively associated with dietary quality and might therefore be a dietary indicator of poor dietary quality. This has important implications in nutritional epidemiological studies and for the development of food-based dietary guidelines.

Red meat: White meat: Processed meat: Dietary recommendations: Micronutrient adequacy

Meat is a nutrient-dense food and meat and meat products are an important source of a wide range of nutrients. However, meat is not a homogeneous food group and the composition of meat varies widely by meat category. The fat content of red meats such as beef (3·5–9·3 %), lamb (7·5–13·3 %) and pork (3·7–10·1 %) is higher than that of chicken (1·1–9·7 %) and turkey (2·0–6·6 %), with processed meat such as burgers and sausages generally having the highest fat content (up to 25 %; Chan *et al.* 1995, 1996). Usually, red meats such as beef and the dark meat of chicken and turkey are better sources of Fe than are white meats such as the light meat of poultry (Chan *et al.* 1995).

Meat and meat constituents such as its fat profile, protein and Fe content have been identified as dietary risk factors for CHD (Denke, 1994; Hu *et al.* 1999), obesity (Lahti-Koski *et al.* 2002; Schulz *et al.* 2002) and colorectal cancer (Willett *et al.* 1990; Giovannucci *et al.* 1994; World Cancer Research Fund/American Institute for Cancer Research, 1997; Sesink *et al.* 1999; Key *et al.* 2004). Recent research, however, highlights that not all meat categories make similar impacts in the development of poor health outcomes. Specifically, red meat and processed meat, but not white meat, have been shown to increase the risk for colon cancer (Willett *et al.* 1990; Giovannucci *et al.* 1994; Goldbohm *et al.* 1994; Navarro *et al.* 2003).

Evolving trends in nutrition research show that examining dietary patterns rather than individual components of the diet is important in nutritional epidemiology (Pryer *et al.* 2001; Hu, 2002; Quatromoni *et al.* 2002). Dietary patterns that include processed meat and red meat have been shown to be associated with overall increased risk of disease including CVD (Hu *et al.* 2000; Fung *et al.* 2001; van Dam *et al.* 2003), colon cancer (Fung *et al.* 2003), oesophageal cancer (Chen *et al.* 2002) and type 2 diabetes (van Dam *et al.* 2002), compared with dietary patterns including poultry.

Meat is a key food group encompassing several important individual meat categories. It is important to study dietary quality for distinct meat categories in nutritional epidemiological studies and for the development of food-based dietary guidelines (Food and Agriculture Organization/World Health Organization, 1998). Previous analysis of meat intake in the Republic of Ireland has shown that there are distinct consumer habits in relation to beef, poultry, burger and sausage intakes (Cosgrove *et al*. 2005). Few studies have examined dietary quality of subgroups of the population in terms of consumption of individual meat categories. Elmstahl *et al.* (1999) observed higher intakes of protein, monounsaturated fat, Zn and thiamine but lower intakes of carbohydrates, vitamin C and fibre with increasing meat intake. No study to date has examined dietary quality in relation to individual meat categories. The aim of the present study was to examine red meat, white meat and processed meat consumption Irish adults aged 18–64 years in relation to dietary quality.

Abbreviation: AR, average requirement.

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Methodology

Survey sample and design

A detailed account of the sampling procedure and design of this study has been published elsewhere (Kiely *et al.* 2001). Briefly, the current data were collected as part of the North/South Ireland Food Consumption Survey, a cross-sectional study that was carried out from 1997 to 1999 (Irish Universities Nutrition Alliance, 2001). Men and women were selected at random using the electoral register as the sampling frame and an information leaflet and letter were posted to each individual. This was followed by a visit from a member of the survey team and participation was invited. Food intake was measured in 63 % of the eligible sample (aged between 18 and 64 years, not pregnant or lactating). Analysis of the survey sample (*n* 1379: 662 men, 717 women) in terms of sex, age, socio-economic status and education level showed it to be representative of both the Irish and Northern Irish adult populations at that time. Moreover, non-response, investigated in terms of sex, age and geographical location, was found to be unbiased (Kiely *et al.* 2001). The present analysis is based on the survey database of 958 adults (475 men, 483 women) from the Republic of Ireland only. Table 1 shows the characteristics of the survey sample in terms of sex, age, socio-economic status and education level, compared with sociodemographic statistics from the Republic of Ireland Census '96 (Central Statistics Office, 1997, 1998). The current sample shows under-representation of the 18–35-year age group as a higher proportion of 18–35-year-olds were not contactable compared with older adults. The sample also had an over-representation of people with tertiary education compared with the census; however, the census also includes >65-year-olds, of whom a smaller percentage has tertiary education. Furthermore, the current survey included a broader range of tertiary qualifications including technical college and city and guilds qualifications.

Food and nutrient intakes

Food and beverage intake data were collected using a 7 d estimated food diary, and precise details on the methods used are available (Harrington *et al.* 2001*b*). Briefly, the research nutritionist made four visits to the respondent during the 7 d period: to train the respondent in keeping the diary; to check for completeness in recording food and drink consumption; to clarify details regarding specific food descriptors and quantities; to encourage completion of the study.

In the food diary, respondents were asked to provide detailed information regarding the types and amounts of all foods. For meat specifically, a description of the cut/joint, the cooking method and brand names (where relevant) and details of trimming and leftovers were included. Respondents were also asked to provide detailed recipe information, where they recorded details of meat included in recipes. Data were also collected on the time of each eating/drinking occasion, the respondent's definition of each eating/drinking occasion (e.g. morning snack, lunch, etc.) and the location of the preparation or source of the meal or snack consumed (e.g. home, work, takeaway, etc.). Self-administered questionnaire data were also obtained on sociodemographic factors and health and lifestyle parameters.

On the basis that different foods are best quantified using different methods and that some methods of quantification are more precise than others, a hierarchical approach to quantify meat among other foods and drinks was developed. Meat and meat products were quantified using specific methods according to a quantification protocol (Harrington *et al.* 2001*b*). If it was not possible to quantify meat with a method on the first level of hierarchy, a subsequent method was used.

(1) Thirty-eight per cent of meat and meat products were quantified using a data set of average portions collected from deli counters and takeaway restaurants.
(2) Twenty-one per cent were quantified using twelve colour photographs of fresh meat and meat dishes, in a food atlas of commonly consumed foods in Ireland (J. Robson, un publish data).
(3) Eighteen per cent were quantified using average portion sizes (Ministry of Agriculture, Fisheries and Food, 1997).
(4) Ten per cent were estimated by the researcher based on her knowledge of the respondent's eating patterns.
(5) Six per cent were quantified from average portion sizes recommended by the manufacturer on the label, including franchised fast foods and chilled and frozen foods.
(6) Six per cent were quantified by the researcher weighing a typical portion of meat consumed by the respondent.

Nutrient intakes were calculated from the 7 d diaries using WISP© (Tinuviel Software, Warrington, UK), which included *McCance and Widdowson's The Composition of Foods*, fifth edition (Holland *et al.* 1995) and supplemental volumes (Holland *et al.* 1988, 1989, 1991, 1992, 1993, 1996; Chan *et al.* 1994, 1995, 1996. Some 993 foods were added to this database to include new food products, recipes (of which 230 contained meat), nutritional supplements and manufacturer's data for generic Irish foods that were commonly consumed. Overall, 3060 different food codes were recorded, of which 742 were meat codes, including 422 composite food codes and 320 codes for meats consumed as individual portions.

Meat intakes

In the present analysis, meat intakes were estimated from the database using disaggregated composite foods to exclude the contributions from non-meat components. Previously, analysis of meat intakes has shown that failure to disaggregate composite

Table 1. Age, social class occupations and education levels of adults from the Republic of Ireland

	Present sample (*n* 958)	Census '96*
Age category (%)		
18–35 years	35·1	46·0
36–50 years	39·6	33·0
51–64 years	25·4	20·0
Social class occupations (%)		
Professional, managerial and technical	42·7	37·9
Non-manual	17·6	22·9
Skilled manual	19·4	20·1
Semi-skilled and unskilled	15·3	19·1
Education level attained (%)		
Primary	18·5	22·6
Intermediate	20·4	22·0
Secondary	23·2	31·2
Tertiary	35·3	23·7

* Republic of Ireland Census '96 (Central Statistics Office, 1997, 1998).
For details of survey samples and design, see p. 934–935.

foods substantially overestimates meat intakes by approximately 40 % (Cosgrove *et al.* 2000).

Composite foods that contained meat were predominantly pasta dishes (e.g. bolognaise and lasagne), stews, cottage/shepherds pies, burger sandwiches (i.e. in a bun), sausage rolls, rice dishes (e.g. curry, stir-fry and sweet and sour), and a small number of composite foods that normally contain a small amount of meat but are typically excluded from meat intake analysis (e.g. quiche lorraine, pizza). The weight of the meat only in each composite food was calculated. Meat was quantified in the majority of composite foods (75 %) using recipe details. Any weight losses during cooking were accounted for. *McCance and Widdowson's The Composition of Foods*, fifth edition (Holland *et al.* 1995) and *Meat Products and Dishes* (Chan *et al.* 1996) were used to quantify the meat in 13·5 % of composite foods, 8·5 % were quantified using manufacturer's weights, 2 % were quantified from product information from fast-food franchises (e.g. McDonalds, Burger King) and extra data collected by fieldworkers from independent takeaway restaurants, and 1 % were estimated based on similar composite foods consumed.

The present analysis is based on the consumption of three independent meat groups: (i) red meat (40 % of all meat), including beef (including veal), lamb and pork; (ii) white meat (21 % of all meat), including chicken and turkey; (iii) processed meat (16 % of all meat), including beefburger, pork sausage, continental-style sausage (including salami and frankfurter) and minced beef. The remaining 23 % of all meat recorded included bacon, duck, pheasant, rabbit, venison, liver, kidney, white and black pudding, ham, luncheon meat and corned beef, and was not included in the current analysis.

Adequacy of micronutrient intakes

The average requirement (AR), as estimated by the Scientific Committee for Food (1993), was used as a cut-point to estimate the proportion of population subgroups with inadequate micronutrient intakes for men and women separately. The AR is the daily intake value estimated to meet the requirement, as defined by a specified indicator of adequacy, in 50 % of a life-stage or gender group (Food and Nutrition Board, 1997). The percentage of the population with a mean daily nutrient intake below the AR was taken as an estimate of the percentage of the population with inadequate intakes. This cut-point approach using AR has been used previously and was demonstrated favourably under specified conditions (Carriquiry, 1999), most of which were met in this population (Hannon *et al.* 2001).

Compliance with dietary recommendations

The Wearne & Day (1999) method of evaluating population compliance with dietary guidelines of 50 % or more of food energy from carbohydrate, 35 % or less of food energy from fat, 11 % or less of food energy from saturated fat, 13 % or more of food energy from monounsaturated fat and 18 g or more of NSP, as recommended by the Committee on Medical Aspects of Food Policy (Department of Health, 1991), was used. The maximum size of a subgroup of the population, whose mean intake meets the population dietary recommendations, was calculated. These subgroups are referred to as 'compliers'. To identify the compliers with the fat and saturated recommendation, the mean intake for each individual was ranked in ascending order, the mean intake was calculated by starting with the individual with the lowest mean fat intake and successive individuals were added until the addition of the next individual caused the group mean to exceed the target. For carbohydrate, monounsaturated fat and fibre the same approach was used except that mean intakes for each individual were ranked in descending order, then starting with the highest mean intake successive individuals were added until the addition of the next individual caused the group mean to fall below the target.

Statistical analysis

Meat intakes were examined by dividing men and women separately into thirds of the distribution, based on the mean daily intake of each meat group in consumers. Thus, the lowest third (for each meat group) represents the low consumers while the highest third represents the high consumers. Data manipulation and statistical analysis were carried out using the Statistical Package for Social Sciences Version 10.0 for Windows™ (SPSS Inc., Chicago, IL, USA) and Microsoft Excel™ 2000 (Microsoft Corporation, Redmond, WA, USA).

Differences in meat intakes between men and women were compared using independent *t* tests, and between age groups using one-way ANOVA. Differences in nutrient and food intakes were compared between thirds using analysis of covariance, with age as a covariate. Differences across categorical variables were compared using Pearson's χ^2 test. Values of $P<0·01$ were reported as statistically significant (two-tailed).

The effect of under-reporting

Mean energy intakes increased significantly with increasing red meat and processed meat intakes. Therefore, nutrient and food intakes across thirds of meat intake were examined after adjusting for energy intake (excluding energy from alcohol). As with all dietary surveys, evidence of misreporting of energy intakes has been shown in this survey sample (McGowan *et al.* 2001). Using the Goldberg cut-off for energy intake:BMR of $<1·05$ (Goldberg *et al.* 1991), the impact of individuals with questionably low energy intakes was assessed in this sample. The proportion of individuals with energy intake:BMR $<1·05$ was 18 % and this was higher in non-consumers (20, 17 and 25 %) compared with consumers (18, 18 and 16 %) of red meat, white meat and processed meat, respectively. In this sample the removal of individuals with very low energy intakes did not change the overall dietary trends associated with red meat, white meat or processed meat consumption. Therefore, the classification of low and high meat consumers includes the entire sample.

Results

Meat consumption

Red meat was consumed by 88 % of the population (92 % of men and 84 % of women), white meat by 79 % (77 % of men and 81 % of women) and processed meat by 79 % (82 % of men and 75 % of women). The majority (83 %) of eating occasions that included red meat, white meat or processed meat occurred in the respondent's home. The main source of red meat, white meat and processed meat throughout the day was at the main meal (as defined by the subject),

Table 2. Mean daily intakes (g) of red meat, white meat and processed meat in consumers by sex and age group

	Age (years)	Red meat				Percentile		White meat				Percentile		Processed meat				Percentile	
		%	Mean	SD	Median	5	95	%	Mean	SD	Median	5	95	%	Mean	SD	Median	5	95
All	18–64	88	51·2	38	43·6	8	120	79	32·9	23	27·4	7	82	78	25·6	20	20·6	5	63
Men	18–64	92	63·9*	44	54·6	11	158	77	36·5*	25	30·2	9	93	82	30·9*	23	26·1	6	75
	18–35	91	53·6a*	35	47·4	11	117	81	38·5*	25	32·1	9	87	91	36·4a*	25	35·7	6	94
	36–50	91	67·6b*	48	59·3	7	169	80	37·1	27	29·2	9	99	83	29·8b*	22	24·7	6	77
	51–64	95	71·9b*	48	60·8	22	171	67	32·5	20	28·5	7	72	68	23·2b*	17	19·4	3	60
Women	18–64	84	37·5	24	33·4	7	82	81	29·6	21	25·3	7	68	75	19·9	15	16·6	4	49
	18–35	75	35·9	22	33·4	6	79	84	28·9	21	24·7	6	69	78	21·7a	16	19·2	3	52
	36–50	86	36·5	24	31·6	7	84	82	31·4	21	26·7	6	74	80	20·0a	14	17·1	4	46
	51–64	94	41·0	25	37·2	9	85	77	27·2	17	23·7	7	63	62	16·1b	13	11·4	3	39

Mean values between men and women in corresponding age groups were significantly different (independent *t* test): *$P<0·001$.
[a,b]Mean values with unlike superscript letters between age group for men and women separately were significantly different (ANOVA): $P<0·01$.
For details of survey samples and design, see p. 934–935.

either at dinner (127·2, 101·4 and 78 g, respectively) or at lunch (129·2, 94·7 and 66·4 g, respectively).

Table 2 shows the mean daily intakes of red meat, white meat and processed meat in consumers. Men consumed significantly more ($P<0·001$) red meat, white meat and processed meat than women. In men, 18–35-year-olds consumed significantly less ($P<0·01$) red meat than >35-year-olds and the percentage of consumers was highest in 51–64-year-olds. The percentage of consumers of white meat was lowest in 51–64-year-olds. In men, 18–35-year-olds consumed significantly more ($P<0·01$) processed meat than >35-year-olds, and had the highest percentage of consumers.

Nutrient intakes

Table 3 compares the nutrient density of the diets of non-consumers and consumers across the three levels of red meat intake. When expressed as a percentage of food energy, the intake of protein was significantly highest ($P<0·001$) and the intake of carbohydrate was significantly lowest ($P<0·001$) in high consumers of red meat in men and women. In men, the mean intakes (g/10 MJ) of NSP were significantly higher ($P<0·001$) for non-consumers. The mean intakes (mg/10 MJ) of Ca were significantly higher ($P<0·001$) in non-consumers, whereas the intakes of Zn were significantly higher in high consumers for men and women. In men the intake of vitamin B_{12} was significantly higher in high consumers.

Overall, the nutrient densities of the diets of non-consumers and consumers across the three levels of white meat intake were similar. The intake of protein was significantly higher ($P<0·001$) for men and women, and the intake of carbohydrate was significantly lower ($P<0·01$) for men, in high consumers of white meat. The mean intake of niacin was significantly higher ($P<0·01$) for men and women in high consumers (data not shown).

Table 4 compares the nutrient density of the diets of non-consumers and consumers across the three levels of processed meat intake. The intakes of protein, carbohydrate and NSP were significantly lower ($P<0·01$) and the intakes of fat were significantly higher ($P<0·001$) in high consumers of processed meat compared with non-consumers for both men and women. The intakes (unit/10 MJ) of Ca (women only), Mg and vitamin D were significantly lower ($P<0·001$) in high consumers, while the intakes of thiamine, niacin (women only), vitamin B_6 (women only) and folate (men only) were significantly higher ($P<0·01$) in non-consumers.

Compliance with population goals and adequacy of micronutrient intakes

The proportions of compliers with population goals for macronutrient and fibre intakes in non-consumers and across thirds of red meat and processed meat intakes are shown in Table 5. In men increased red meat consumption was associated with a significant decrease ($P<0·01$) in the proportion of compliers with the carbohydrate goal. There was also a significant decrease in the proportion of compliers with the carbohydrate goal with an increase in white meat intake in men and women (data not shown). Increased processed meat consumption was associated with significant decreases ($P<0·01$) in the proportion of compliers with the total fat, saturated fat, monounsaturated fat, carbohydrate and fibre goals in men, and saturated and monounsaturated fat goals in women.

Table 6 shows the prevalence of inadequate micronutrient intakes in non-consumers and cross thirds of red meat and processed meat

Table 3. Mean daily intakes of macronutrients (as a percentage of food energy), fibre, minerals and vitamins (per 10 MJ food energy) in non-consumers and across thirds of red meat intake in men and women

	Men								Women							
	Non-consumers (*n* 38)		Low (*n* 145)		Medium (*n* 146)		High (*n* 146)		Non-consumers (*n* 77)		Low (*n* 135)		Medium (*n* 136)		High (*n* 135)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Protein (%)	14·4^{a}	2	15·8^{b}	3	16·6^{b}	3	17·7^{c}	3**	15·2^{a}	3	16·2^{ab}	3	16·8^{bc}	3	17·7^{c}	3**
Fat (%)	37·2	7	37·3	6	36·8	5	37·5	5	37·4	7	36·8	6	37·2	6	37·8	5
Saturated fat (%)	13·6	4	14·7	3	14·4	3	14·7	3	14·2	3	14·3	3	14·3	3	14·7	3
Monosaturated fat (%)	12·3	3	12·6	2	12·3	2	12·7	2	12·2	3	12·0	2	12·3	2	12·8	2
Polyunsaturated fat (%)	8·4	3	7·3	2	7·1	2	7·1	2	8·0	3	8·0	3	7·7	2	7·4	2
Carbohydrate (%)	48·2^{a}	6	46·6^{a}	5	46·6^{a}	6	44·8^{b}	5**	47·7^{a}	6	47·7^{a}	6	46·1^{ab}	6	44·9^{b}	5**
Fibre (NSP) (g)	20·3^{a}	11	16·0^{b}	5	16·4^{b}	6	16·8^{b}	5**	19·2	8	18·5	6	17·9	5	17·8	6
Na (mg)	3882	1209	3571	710	3435	616	3423	651	3595	654	3552	835	3487	673	3299	656
Ca (mg)	1053^{a}	240	956^{b}	278	890^{b}	195	812^{c}	177**	1164^{a}	623	1017^{b}	274	1002^{b}	357	939^{b}	285**
P (mg)	1600	253	1576	296	1591	316	1619	285	1592	336	1592	294	1580	257	1616	307
Fe (mg)	15·8^{a}	6	13·1^{b}	4	14·5^{a}	5	14·5^{a}	3*	22·6	22	15·8	9	20·2	28	16·7	19
Zn (mg)	10·3^{a}	4	10·2^{a}	3	11·3^{b}	3	12·9^{c}	3**	10·3^{a}	6	10·6^{a}	4	11·9^{a}	4	13·3^{b}	7**
Vitamin A (μg)	998	632	870	514	1113	983	1097	1118	1424	1079	1267	1006	1357	1418	1332	1034
Vitamin D (μg)	3·7	3	3·5	3	3·8	4	3·9	3	5·4	6	4·4	4	5·2	7	5·5	6
Vitamin E (μg)	9·3	5	16·9	74	9·0	30	8·3	18	11·8	7	12·3	22	14·2	31	16·3	38
Thiamine (mg)	2·7	3	2·1	1	2·3	1	2·2	1	3·4	6	2·9	6	3·6	8	2·5	2
Riboflavin (mg)	2·7	3	2·1	1	2·1	1	2·0	1	3·4	5	3·0	6	3·1	5	2·3	1
Niacin (mg)	25·3	10	26·8	10	28·3	11	28·7	10	30·2	15	27·4	12	28·1	13	28·3	11
Vitamin B_6 (mg)	3·6	4	3·4	2	3·4	2	3·6	1	5·0^{a}	8	4·0^{a}	7	6·3^{a}	14	3·5^{b}	2*
Vitamin B_{12} (μg)	4·4^{a}	3	4·7^{a}	2	5·3^{ab}	4	6·0^{b}	4*	5·3	5	5·1	5	6·5	6	6·0	4
Folate (μg)	375	171	319	113	330	123	328	106	388	176	351	164	362	200	348	139
Vitamin D (mg)	145	209	148	487	109	145	101	155	183	276	153	345	136	183	145	245

Men: low consumers, $<$41·0 g/d; medium consumers, 41·0–72·1 g/d; high consumers, $>$ 72·1 g/d. Women: low consumers, $<$24·2 g/d; medium consumers, 24·2–45·5 g/d; high consumers, $>$45·5 g/d.

[a,b,c]Mean values with unlike superscript letters between thirds for men and women separately were significantly different (analysis of covariance with age as covariable): * $P<0·01$, ** $P<0·001$.

For details of procedures, see page 934.

Table 4. Mean daily intakes of macronutrients (as a percentage of food energy), fibre, minerals and vitamins (per 10 MJ food energy) in non-consumers and across thirds of processed meat intake in men and women

	Men								Women							
	Non-consumers (*n* 86)		Low (*n* 129)		Medium (*n* 131)		High (*n* 129)		Non-consumers (*n* 120)		Low (*n* 121)		Medium (*n* 122)		High (*n* 120)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Protein (%)	16·8^{a}	4	17·0^{a}	3	16·4^{ab}	3	15·9^{b}	2*	17·1^{a}	4	16·9^{ab}	3	16·7^{ab}	3	16·0^{b}	3*
Fat (%)	34·2^{a}	6	36·8^{b}	5	37·8^{bc}	5	39·0^{c}	5**	34.9^{a}	7	37·7^{b}	6	38·1^{b}	5	38·5^{b}	6**
Saturated fat (%)	12·8^{a}	4	14·5^{b}	3	14·9^{b}	3	15·2^{b}	3**	13.2^{a}	4	14·5^{b}	3	14·8^{b}	3	15·0^{b}	3**
Monounsaturated fat (%)	11·1^{a}	2	12·3^{b}	2	12·6^{b}	2	13·6^{c}	2**	11.4^{a}	3	12·3^{b}	2	12·6^{b}	2	13·0^{b}	2**
Polyunsaturated fat (%)	7·4	3	7·1	2	7·4	2	7·4	2	7.4	2	7·9	2	7·7	2	7·6	2
Carbohydrate (%)	48·9^{a}	5	46·2^{b}	5	45·6^{b}	5	45·0^{b}	5**	48.3^{a}	6	45·8^{b}	5	45·5^{b}	5	45·6^{b}	5**
Fibre (NSP) (g)	21·2^{a}	9	16·8^{b}	5	15·9^{bc}	5	14·4^{c}	4**	21.4^{a}	7	18·2^{b}	6	17·4^{b}	5	16·0^{c}	4**
Na (mg)	3602	1012	3420	655	3503	602	3540	684	3351	712	3583	846	3539	706	3405	578
Ca (mg)	938	254	912	241	867	182	895	254	1094^{a}	520	1069^{a}	406	1013^{a}	262	881^{b}	234**
Mg (mg)	399^{a}	169	359^{b}	97	346^{bc}	106	318^{c}	64**	384^{a}	97	355^{ab}	90	352^{b}	83	324^{c}	88**
Fe (mg)	15·6^{a}	6	14·2^{ab}	4	14·2^{ab}	4	13·3^{b}	4*	19.4	23	17·1	15	17·2	20	19·7	24
Zn (mg)	11·4	3	11·9	4	11·3	3	10·9	3	10.9	4	11·7	4	12·2	6	11·9	8
Vitamin A (μg)	1211	1153	1103	868	916	592	932	961	1354	920	1321	1084	1498	1505	1167	996
Vitamin D (μg)	4·9^{a}	5	3·8^{ab}	3	3·5^{b}	3	3·2^{b}	2*	6.7^{a}	8	5·4^{ab}	7	4·4^{b}	4	3·9^{b}	3**
Vitamin E (μg)	13·6	55	8·2	17	11·0	36	12·8	63	17.7	42	14·1	26	13·0	18	10·7	23
Thiamine (mg)	2·6^{a}	2	2·2^{ab}	1	2·2^{ab}	1	2·0^{b}	1*	4.7^{a}	10	2·8^{ab}	5	2·5^{b}	2	2·3^{b}	2*
Riboflavin (mg)	2·4	2	2·1	1	2·1	1	2·0	1	3.9	7	2·8	5	2·5	1	2·3^{a}	3
Niacin (mg)	29·0	13	27·5	9	28·8	11	25·9	8	32.4^{a}	17	26·8^{b}	10	27·7^{b}	11	26.3^{b}	10**
Vitamin B_6 (mg)	3·8	3	3·4	1	3·5	2	3·2	2	6.9^{a}	14	4·5^{ab}	8	3·9^{a}	6	3·5^{a}	5*
Vitamin B_{12} (μg)	6·0	5	5·3	3	5·0	2	5·1	4	5.6	5	5·8	5	6·0	5	5·6	5
Folate (μg)	370^{a}	136	330^{ab}	118	331^{ab}	118	300^{b}	104**	391	208	359	164	359	149	328	152
Vitamin C (mg)	158	295	128	182	87	93	124	480	190	345	142	241	160	270	111	186

Men: low consumers, <173·36.3 g/d; medium consumers, 17·3–36·3 g/d; high consumers, >36·3 g/d. Women: low consumers, <11·1 g/d; medium consumers, 11·1–22.4 g/d; high consumers, >22·4 g/d.

^{a,b,c}Mean valves with unlike superscript letters between thirds for men and women separately were significantly different (analysis of covariance with age as covariate): *$P<0·01$, **$P<0·001$.

For details of procedures, see page 934.

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Table 5. Percentage of compliers with population goals† for macronutrients in non-consumers and across thirds of red meat and processed meat intake

		Red meat								Processed meat							
		Men				Women				Men				Women			
	Goat†	Non (38)	L (145)	M (146)	H (145)	Non (77)	L (135)	M (136)	H (135)	Non (86)	L (129)	M (131)	H (129)	Non (120)	L (121)	M (122)	H (120)
% Food enery from fat	35 %	74	81	82	77	71	74	76	78	91	83	77	71*	83	74	74	73
% Food enery from saturated fat	11 %	39	30	36	27	35	32	35	31	58	31	27	19**	44	29	31	28*
% Food energy from monounsaturated fat	13 %	89	87	89	92	79	85	87	92	76	90	92	95**	72	88	93	94
% Food energy from carbohydrate)	50 %	71	61	62	48*	60	61	58	48	77	57	56	48**	63	57	54	52
Fibre (NSP)	18 g/d	87	77	75	86	53	55	63	64	92	77	75	80*	69	55	56	58

Non, non-consumers; L, low consumers; M, medium consumers; H, high consumers. Values in parentheses are numbers of subjects.
Percentages between thirds for men and women separately were significantly different (Pearson's χ^2 test): $*P<0{\cdot}01$, $**P<0{\cdot}001$.
† Dietary Reference Values (Department of Health, 1991).
For details of procedures, see page 934.

Table 6. Proportion of men and women with inadequate† micronutrient intakes in non-consumers and across thirds of red meat and processed meat intake

	Average requirement†		Red meat								Processed meat							
			Men				Women				Men				Women			
	Men	Women	Non (38)	L (145)	M (146)	H (145)	Non (77)	L (135)	M (136)	H (135)	Non (86)	L (129)	M (131)	H (129)	Non (120)	L (121)	M (122)	H (120)
Ca	550 mg	550 mg	8	9	10	14	19	24	20	27	14	11	11	9	24	22	17	28
Fe	7 mg	10 (6) mg	3	3	1	1	38	41	36	33	2	2	2	1	29	46	38	34*
Zn	7·5 mg	5·5 mg	32	18	9	1**	32	18	9	2**	17	7	14	8*	23	20	4	6*
Total vitamin A	500 μg	400 μg	16	26	16	16	19	6	13	11	19	17	22	19	16	15	10	17
Riboflavin	1·3 mg	1·1 mg	16	17	9	5**	19	21	15	15	13	10	15	5	15	28	11	16
Vitamin B_{12}	1 μg	1 μg	8	0	0	0	3	3	1	0	3	0	0	0	2	2	2	1
Folate	140 μg	140 μg	3	2	3	1	6	10	7	6	2	4	1	1	5	11	5	8*
Vitamin C	30 mg	30 mg	5	10	8	1**	8	8	9	9	2	9	8	5	7	12	6	10*

Non, non-consumers; L, low consumers; M, medium consumers; H, high consumers. Values in parentheses are numbers of subjects.
Percentages between thirds for men and women separately were significantly different (Pearson's χ^2 test): $*P<0{\cdot}01$, $**P<0{\cdot}001$.
† Reports of the Scientific Committee for Food (1993); value in parentheses in recommendation for post menopausal women (>50 years).
For details of procedures, see page 934.

intakes. Increased red meat consumption was associated with a significantly ($P<0.001$) lower prevalence of inadequate intakes of Zn in men and women and of riboflavin and vitamin C in men. Increased consumption of white meat was associated with a significantly lower ($P<0.01$) prevalence of inadequate Cu intakes in women (data not shown). Increased processed meat consumption was associated with a significantly lower ($P<0.01$) prevalence of inadequate Zn intakes. In women, low compared with high consumers of processed meat had a significantly higher ($P<0.01$) prevalence of inadequate Fe intakes.

The influence of meat on food intake

In men and women, there was an increase ($P<0.01$) in potato and a decrease in processed meat intake with increasing red meat intakes, while in men there were also increases in vegetable and alcoholic beverage intakes with increasing red meat intakes ($P<0.01$; data not shown). High white meat intake was associated with significantly lower ($P<0.01$) intakes of white bread, potatoes and red meat in men, and lower ($P<0.01$) intakes of cheese, butter and red meat in women, compared with low and non-consumers (data not shown). High consumers of processed meat had significantly lower ($P<0.001$) intakes of wholemeal bread, vegetables, fruit and fish, and significantly higher ($P<0.001$) intakes of carbonated beverages, compared with low and non-consumers. In men, the intakes of biscuits, cakes and pastries, and red meat were significantly lower in high consumers compared with non-consumers. In women the intakes of ready-to-eat breakfast cereals, yoghurts and white meat were significantly lower in high consumers compared with non-consumers.

Sociodemographic, health and lifestyle factors

Over half of men (58 %) and women (52 %) who did not consume red meat had tertiary-level educational qualifications compared with only a quarter of high consumers ($P<0.001$). A higher proportion of non-consumers (55 and 61 %) than of high consumers (25 and 41 %) of processed meat had professional, managerial and technical occupations in men and women, respectively ($P<0.001$). In women, a higher proportion of high consumers compared with non-consumers of processed meat were smokers ($P<0.01$).

Discussion

The present paper examines the habitual intakes of meat and meat products in Irish adults as three individual meat groups. Red meat, white meat and processed meat are examined at upper and lower ends of the distribution of intakes in relation to nutrient profiles and concurrent food intakes. Investigating current patterns of meat intake is important in epidemiological studies and is an important step in the development of food-based dietary guidelines. Relative to total meat intake, red meat was consumed in the largest (51 g/d or 118 g/eating occasion) and processed meat in the smallest quantity (26 g/d or 56 g/eating occasion). In studies of dietary intake and nutritional epidemiology, meat and meat products are generally examined as one homogeneous food group. However, the present report has shown that this approach may not be appropriate due to the diverse dietary trends and variation across different indicators of dietary quality observed in consumers at different levels of intake of red meat, white meat and processed meat.

The estimates of meat intake were obtained in a representative sample of 18–64-year-old adults from the Republic of Ireland, using the North/South Ireland Food Consumption Survey (Irish Universities Nutrition Alliance, 2001). Furthermore, non-response, investigated in terms of sex, age and geographical location, was found to be unbiased (Kiely *et al.* 2001). Interpretation of results from food consumption databases is prone to potential sources of bias (Leclercq & Arcella, 2001). However, the duration of dietary assessment in the North/South Ireland Food Consumption Survey was 7 d, which reduced inter-individual variability that occurs in shorter surveys (Lambe & Kearney, 1999). A hierarchical approach to food and drink quantification was developed and the food composition database was extended to include generic Irish foods and new foods on the market (Harrington *et al.* 2001*a*). Excluding energy under-reporters from the analysis did not significantly affect the outcomes. Therefore, it is valid to extrapolate conclusions from this analysis to the population as a whole and use the data for the development of national food-based dietary guidelines.

High consumers of red meat had higher protein intakes, lower carbohydrate intakes, lower compliance with carbohydrate intake recommendations and a less fibre-dense diet than did non-consumers. Previous studies have shown that low consumers of meat have diets higher in carbohydrate and fibre and lower in energy, fat and protein (Slattery *et al.* 1991; Nicklas *et al.* 1995; Elmstahl *et al.* 1999). Although processed meat was consumed in relatively small quantities, increased processed meat consumption was associated with an increase in the percentage of food energy from fat, a decrease in the percentage of food energy from carbohydrate and protein, and a less fibre-dense diet. Processed meat consumption was also associated with a lower level of compliance with fat, carbohydrate and fibre recommendations, particularly in men. Comparing compliance with dietary recommendations in male consumers and non-consumers of processed meat respectively, 29 % and 9 % did not comply with fat, 52 % and 23 % did not comply with carbohydrate and 22 % and 8 % did not comply with fibre goals.

The results suggest that red meat consumption is associated with a micronutrient-dense diet, as red meat consumers had higher Zn, niacin and vitamin B_{12} intakes than did non-consumers and high consumers had higher Fe intakes than low consumers. Red meat consumers also had a lower prevalence of inadequacy of micronutrient intakes particularly for Fe, Zn, vitamin A, riboflavin and vitamins B_6, B_{12} and C. There were no differences in micronutrient intakes between white meat consumers and non-consumers; however, in women, white meat consumers had a lower prevalence of inadequacy of Cu intakes. On the other hand, processed meat consumption was associated with lower micronutrient intakes and higher levels of inadequacy of Fe, folate and vitamin C intakes, particularly among women. Subar *et al.* (1998) showed that meat was among the top ten sources of twelve micronutrients and this was primarily due to beef (top five contributor to ten micronutrients).

To help explain the different associations observed with nutrient quality within subgroups of red meat, white meat and processed meat intakes, associations with other food groups were examined. The most significant food associated with red meat consumers was potatoes, where high consumers compared with low and non-consumers had significantly higher potato intakes. Compared with non-consumers, white meat consumers had lower potato and higher rice and pasta intakes, particularly in men. Differences between non-consumers and consumers of processed meat were found in the intakes of wholemeal and brown bread, ready-to-eat breakfast cereals, yoghurts, vegetables, fruit and fish. These food groups were consumed in lower quantities among processed meat consumers, particularly high consumers. Several studies have highlighted that foods such as fruit, high-fibre breakfast cereals, wholemeal bread, vegetables and fish are healthy owing to their impact on dietary quality (Galvin *et al.* 2003; Newby *et al.* 2003) and their influence on disease risk (Hu *et al.* 2000; Joshipura *et al.* 2001; Hu & Willett, 2002; Hung *et al.* 2003; Steffen *et al.* 2003). The main source of red meat, white meat and processed meat throughout the day was at the main meal. Further research is needed to identify the convergence of foods within the main meal; however, results suggest that the consumers of processed meat make consistently poor dietary choices.

Increasing intakes of red meat were associated with lower levels of educational attainment and lower social class occupations. Those with tertiary educational qualifications or with professional and managerial occupations were less likely to be high consumers of red meat. These findings are consistent with the perceived healthiness of excluding red meat from the diet (Lea & Worsley, 2002). In relation to processed meat, a smaller proportion of consumers than non-consumers had managerial, professional and technical occupations. Previous analysis of the current database has shown that there is a positive relationship between high social class occupations and consumption of health-promoting foods such as ready-to-eat breakfast cereals and vegetables (Galvin *et al.* 2003; O'Brien *et al.* 2003). Similarly, in this study there was a negative relationship between low social class occupations and consumption of nutrient-poor foods such as processed meat. These findings add more evidence to the theory that high social class groups eat more healthy foods, and thus have a higher chance of consuming a more health-promoting diet.

The present study has demonstrated clearly that not all meat types make similar contributions to the diet. While red meat consumption was associated with reduced compliance with dietary recommendations for carbohydrate, consumers had relatively high intakes of micronutrients, particularly Cu, Zn, thiamine, riboflavin, niacin, and vitamins B_6 and B_{12}. On the other hand, processed meat consumption was associated with low compliance with recommended fat, carbohydrate and fibre intakes, and poor adequacy of micronutrient intakes. Overall, consumption of processed meat at relatively moderate levels may be an indicator of poor overall dietary quality in the Irish adult population, as evidenced by the negative association of increasing processed meat intake with nutrient-dense food intakes. These results emphasise the importance of considering distinct subgroups of major food categories (e.g. dairy foods, meat and cereals) and the overall diet in studies of dietary modification of disease risk. Programmes for improving dietary quality in terms of meat intake should highlight individual meat groups and target in particular young adults (especially men), those with a lower level of educational attainment and those in lower socio-economic groups, as these groups are more likely to be high consumers of processed meat.

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