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Impact of disaggregation of composite foods on estimates of intakes of meat and meat products in Irish adults

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Abstract

Objective: To evaluate the impact of the disaggregation of composite foods on intake estimates of meat and individual meat categories and on the contribution of meat to nutrient intakes in Irish adults.
Design: Data were analysed from the North/South Ireland Food Consumption Survey, which used a 7-day food diary to estimate food intake. Of 742 food codes that contained meat, 320 were codes for meat consumed as an individual portion and 422 were composite foods and were disaggregated to estimate the meat content.
Subjects: A nationally representative sample of 475 men and 483 women (not pregnant or lactating) from the Republic of Ireland aged 18–64 years.
Results: The mean intake of meat was $134\,g\,day^{-1}$ in consumers (98.5%) and men ($168\,g\,day^{-1}$) consumed significantly more ($P < 0.001$) than women ($102\,g\,day^{-1}$). Mean intakes of meat were higher in subjects with manual skilled occupations ($P < 0.01$) and lower in those with third-level educational qualifications ($P < 0.05$). Without disaggregating meat from composite foods, meat intake was overestimated by 43% ($57\,g\,day^{-1}$) and varied widely by meat category. Meat disaggregated from composite foods contributed 25% of meat intake. The contribution meat made to nutrient intakes ranged from 29% for protein, vitamin B_{12}, zinc and niacin to 20% for vitamin D, 16% for vitamin B_6, 15% for thiamine and 14% for iron.
Conclusions: Failure to disaggregate meat from composite foods substantially overestimates meat intake, with a large variation between meat categories. This has important implications for estimates of meat intakes in nutritional epidemiological studies and for food safety purposes.

Keywords
Meat and meat products
Composite foods
Nutrient contribution
Adults
Ireland

Traditionally, meat has been considered a highly nutritious food, greatly valued, and associated with well-being and prosperity[1]. It has been observed that increasing affluence in society is associated with a gradual increase in meat consumption[2,3]. Public confidence in meat, especially beef, has decreased substantially since the bovine spongiform encephalopathy (BSE) outbreak in 1996[4]. Meat consumption has been negatively linked with increased risk of colorectal cancers[5–10] and in only a very limited number of epidemiological studies to osteoporosis[11], diabetes[12,13] and obesity[14,15]. However, evidence for causality is lacking with regard to cancer risk because there is no agreement as to whether it is the type of meat, its fat content and fatty acid profiles, protein content or the formation of carcinogens (e.g. heterocyclic amines) during cooking that are potential risk factors[16–20].

On the other hand, meat and meat products are important sources of protein. In response to concerns about dietary fat, the lipid content in lean meat today is less than 5%[21]. The key micronutrients present in meat in abundant and bioavailable forms are iron, zinc, and vitamins A and D[22–25]. Meat is also an important source of B vitamins, especially thiamine, riboflavin and vitamin B_{12}[26,27]. The only consumption estimates of meat and meat products in the Republic of Ireland are based on the Irish National Nutrition Survey, which was published 14 years ago[28], and estimates from the North/South Ireland Food Consumption Survey (NSIFCS), which did not take disaggregation of composite meat dishes into account[29].

There is a need for precise quantitative data on intakes of key foods, including those commonly used in composite foods, in population subgroups, for example for epidemiological studies, for the development of food-based dietary guidelines[30,31] or for food safety purposes. The importance of disaggregating composite foods in order to estimate the intake of individual foods accurately has been highlighted[32–34]. This is particularly true of meat, which is used in a wide variety of products and composite foods, and dietary assessment methods that do not take this into account can lead to significant over- or underestimation of meat intakes[35–37]. Furthermore, the effect of disaggregation of composite foods on intake

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estimates could vary between different meat categories. The estimation of meat intakes requires detailed information on intakes of individual foods as well as recipe information for composite foods/dishes. Data of this type have been collected in the NSIFCS[29], which established a database of habitual food consumption in a representative sample of Irish adults aged 18–64 years.

The aims of the current study were to evaluate the impact of the disaggregation of composite foods on estimates of intake of total meat and individual meat categories and on the contribution of meat to nutrient intakes in Irish adults.

Methodology

Survey sample and design

The food intake data used in the current analysis were from the NSIFCS, a cross-sectional study that was carried out from 1997 to 1999[29]. Adults were randomly selected using the electoral register as the sampling frame and an information leaflet and letter were posted to each selected individual. This was followed shortly after by a visit from one of the survey team, and participation in the survey was invited. Sixty-three per cent of the eligible sample (aged between 18 and 64 years, not pregnant or lactating) responded to the survey. Analysis of the survey sample ($n = 1379$: 662 men, 717 women) in terms of sex, age, social class occupations 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 and age, was found to be unbiased[38]. The current analysis is based on the survey database of 958 adults (475 men, 483 women) from the Republic of Ireland. Table 1 shows the characteristics of the survey sample in terms of age, social class occupation and education level, compared with sociodemographic statistics from the Republic of Ireland Census '96[39,40].

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

	Current 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 & 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[39,40].

The current sample shows an 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 persons over 65 years old, of whom a smaller percentage have 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-day food diary, and precise details on the methods used are available[41]. Briefly, the research nutritionist made four visits to the respondent during the 7-day 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 and to encourage completion of the study.

In the food diary, respondents were asked to provide detailed information regarding the type of meat consumed, a description of the cut/joint, the cooking method, brand names (where relevant), and to include details of trimming and leftovers. Respondents were also asked to provide detailed recipe information, recording detailed meat information as above, labels from meat packages, and the weight and price of meat purchased where available. 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.).

A hierarchical approach to meat quantification was used as follows. (1) Thirty-eight per cent of meat and meat products were quantified using a dataset of average portions collected from delicatessen counters and takeaway restaurants. (2) Twenty-one per cent were quantified using 12 colour photographs of meat and meat dishes, in a food atlas of commonly consumed foods in Ireland[42]. (3) Eighteen per cent were quantified using average portion sizes[43]. (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-day diaries using WISP© (Tinuviel Software, Warrington, UK), which included *McCance & Widdowson's The Composition of Foods*, fifth edition[44] and supplemental volumes[23,45–52]. An additional 993 food codes 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.

The food consumption database generated from the survey listed each individual food item as consumed by each respondent, together with the nutrient composition for the quantity of each food consumed. Overall, 3060 different food codes were recorded and 742 food codes contained meat, of which 320 were codes for meat consumed as individual portions and 422 were composite food codes. Composite foods that contained meat were predominantly pasta dishes (e.g. bolognaise and lasagne), stews, cottage/shepherd's pies, burger sandwiches (i.e. in a bun), sausage rolls and rice dishes (e.g. curry, stir-fry, 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). In the current analysis, meat intakes were estimated from the database with and without disaggregating meat from composite foods.

Meat intakes from composite foods

For estimating meat intakes from composite foods, the weight of the meat only in each meat-containing 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 & Widdowson's The Composition of Foods*, fifth edition[44] and its supplement *Meat Products and Dishes*[51] 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 data collected by fieldworkers from independent takeaway restaurants, and 1% were estimated based on similar composite foods consumed. The weights of 40 individual portions of meat were adjusted to exclude the weight of bone[43].

The contributions of meat-containing composite foods to nutrient intakes were calculated for the meat component only, to exclude the contribution of non-meat components, using nutrient data from corresponding meat codes in *McCance & Widdowson's The Composition of Foods*, fifth edition[44] and *Meat Products and Dishes*[51].

The following meats were recorded either as an individual portion or as part of a composite food: bacon (including rashers), ham, beef (including veal), lamb, pork, chicken, turkey, other poultry (including duck and pheasant), venison, rabbit, liver, kidney, other offal (including trotter, tripe, heart, tongue and oxtail), beef burger, pork sausage, continental style sausage (including salami, frankfurter, garlic sausage and chorizo) and meat products (including white pudding, black pudding, pâté, luncheon meat, doner kebab, corned beef, pastrami and rissoles). Respondents who consumed any of the 742 food codes that included meat at any time over the 7 days of recording were classified as meat consumers.

Effect of energy underreporting

Evidence of misreporting of energy intakes has been shown in this survey sample[53]. The impact of individuals with questionably low energy intakes was assessed in this sample using the Goldberg cut-off for energy intake over basal metabolic rate (EI/BMR) of less than 1.05[54]. The proportion of individuals with EI/BMR < 1.05 was 18%.

Statistical analysis

Data manipulation and statistical analysis were carried out using SPSS® Version 10.0 (SPSS Inc., Chicago, IL, USA) for Windows™ and Microsoft Excel™ 2000 (Microsoft Corporation, Redmond, WA, USA). Differences in intakes and contributions between men and women were compared using independent *t*-tests or the Mann–Whitney test for non-parametric data, and between age groups using one-way analysis of variance (ANOVA). Differences in intakes across social class occupations were compared using ANOVA with the Tukey *post hoc* test, and across education levels using analysis of covariance, with age as a covariate. A value of $P < 0.05$ was taken as statistically significant.

Results

Meat intakes

The mean daily intake of meat increased by 5% when the underreporters were excluded while the removal of these individuals did not change the overall meat intake findings. Therefore the results presented in this study include the entire sample. Meat was consumed by 98.5% of the population (98% of men and 99% of women) on at least one eating occasion during the recording week. The majority (75%) of eating occasions of meat occurred in the respondent's home. Forty per cent of all meals that included meat throughout the day were at dinner (as defined by the respondents). Table 2 shows the mean daily intakes of meat in Irish men and women consumers. Bacon and ham were consumed by the largest proportion of respondents (93% of men and 90% of women), followed by poultry (87% and 91%) and beef (86% and 74%). Significantly more men than women consumed beef, pork, burgers, sausages and meat products, while significantly fewer men than women consumed poultry ($P < 0.01$). The mean daily intake of meat among consumers was 134 g (150 g/10 MJ) and men (168 g or 162 g/10 MJ) consumed significantly more ($P < 0.001$) than women (102 g or 140 g/10 MJ). Sixty per cent of the population (35% of men and 85% of women) had mean meat intakes < 140 g, as recommended by the UK Department of Health[9]. Similarly, 60% of the population (41% of men and 79% of women) had mean red meat intakes ≤ 80 g, as recommended by the World Cancer

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Table 2 Mean daily intakes (g) of meat† in Irish men and women consumers

	Total population ($n = 958$)						Men ($n = 475$)						Women ($n = 483$)						
				Percentile						Percentile						Percentile			
	%	Mean	SD	5	50	95	%	Mean	SD	5	50	95	%	Mean	SD	5	50	95	
Bacon and ham	92	33.0	27	5	26	87	93	42.1	32	6	35	104	90	23.7	18	3	19	59	**
Beef	80	39.1	32	6	31	91	86	46.8	38	7	37	116	74	30.5	22	6	25	73	**
Lamb	38	22.8	19	6	16	60	41	28.1	22	6	21	72	36	16.9	13	6	13	39	**
Pork	42	26.9	20	6	24	66	46	30.6	24	7	24	73	39	22.7	15	5	20	52	**
Poultry	89	36.7	27	6	31	88	87	41.3	30	7	36	99	91	32.4	22	6	29	74	**
Offal	8	13.6	11	3	11	46	7	15.3	14	3	10	55	9	12.2	9	2	11	32	NS
Burger	27	12.7	9	4	10	32	32	14.0	10	5	11	34	22	10.8	7	4	9	25	*
Sausage	64	16.1	13	4	11	41	71	19.6	14	4	15	49	57	11.7	9	3	9	29	**
Meat products	30	10.0	9	1	8	30	35	12.0	10	2	9	36	25	7.4	6	1	5	18	**
Total meat	99	134.3	65	50	121	256	98	167.9	69	76	159	295	99	101.6	41	40	98	180	**

SD – standard deviation.
† Includes only the meat components of composite foods that contained meat.
Differences between men and women using independent t-tests: *, $P < 0.01$; **, $P < 0.001$; NS, not significant.

Research Fund[8]. Compared with 51–64-year-olds, 18–35-year-olds consumed significantly ($P < 0.05$) more poultry and sausage and less beef (data not shown). The mean serving size of meat consumed per eating occasion was 77 g, being significantly higher ($P < 0.001$) in men (85 g) than in women (68 g). The mean serving sizes of beef (121 g), lamb (105 g) and pork (127 g) were higher than the serving sizes of poultry (87 g), bacon and ham (52 g) and processed meat (37 g).

Table 3 compares the mean intakes of meat across age, social class occupation and education level. Individuals with manual skilled occupations consumed significantly more ($P < 0.01$) meat than the other social class occupations. Compared with professional, managerial and technical occupations, individuals with manual skilled occupations consumed significantly more bacon and ham, lamb, sausage and meat products. The mean intakes of meat among individuals with second- and third-level educational qualifications were significantly lower ($P < 0.05$) than among individuals with no formal educational qualifications. Individuals with no formal educational qualifications had significantly higher ($P < 0.01$) intakes of bacon and ham, beef, lamb and offal, and significantly lower ($P < 0.001$) intakes of poultry, than individuals with third-level qualifications.

Impact of composite foods on meat intake estimates

The impact of disaggregating composite foods on meat intake estimates is shown in Table 4. The mean intakes of meat with and without the disaggregation of composite foods were 134 and 192 g day^{-1}, respectively. There was a difference of 57 g day^{-1} between the two methods, resulting in a 43% overestimation of meat intake without disaggregating composite foods. Similarly, the intakes of meat products were overestimated by 207% (21 g day^{-1}), burgers by 89% (11 g day^{-1}), beef by 74% (29 g day^{-1}) and poultry by 47% (17 g day^{-1}). The impact of composite foods on intake estimates was much less for bacon and ham and sausage, where the intakes increased only slightly by including composite foods (e.g. pizza) that contain small amounts of these meats.

Sources of meat intake

The relative proportions of meat consumed as an individual portion and as part of a composite food are shown in Figs 1–3. The mean intake of meat consumed as an individual portion was 100 g day^{-1} while the mean intake of meat consumed as part of a composite food was only 38 g day^{-1}. Bacon and ham (97%), sausages (92%) and meat products (91%) were almost exclusively consumed as an individual portion. The largest contributions made by composite foods to intakes were for burgers (63%), beef (41%), poultry (39%) and offal (38%) (Fig. 1). The majority of burgers consumed as part of a composite food were either fried or grilled, and many were eaten from takeaway restaurants. The contribution of composite foods to meat intake was significantly higher ($P < 0.001$) in women (29%) than in men (23%). With the exception of burger, the contributions of composite foods to all meat intakes were higher in women than men, particularly beef (Fig. 2). In 18–35-year-olds, 31% of meat was consumed as part of a composite food compared with 19% in 51–64-year-olds. The relative proportion of meat consumed as part of a composite food was highest in 18–35-year-olds for beef (46%), lamb (27%), pork (22%), poultry (45%) and meat products (17%) compared with 51–64-year-olds (Fig. 3).

Contribution of meat to nutrient intakes

Meat (with and without disaggregation, respectively) contributed significantly to the mean daily intakes of energy (12 and 17%), protein (29 and 42%), fat (17 and 25%), zinc (29 and 41%), vitamin B_{12} (29 and 41%), niacin (28 and 39%), vitamin D (20 and 29%), pantothenic acid (19 and 27%), vitamin B_6 (16 and 23%) and thiamine (15 and 22%) in consumers. Table 5 shows the percentage contribution of meat (with and without disaggregation) to nutrient intakes in men and women. Meat made a

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Table 3 Mean daily intakes (g) of meat† in Irish men and women by age group, and by social class occupations and education level

	Bacon & ham		Beef		Lamb		Pork		Poultry		Offal		Burger		Sausage		Meat products		Total meat	
	n	Mean	*n*	Mean	*n*	Mean	*n*	Mean	*n*	Mean	*n*	Mean	*n*	Mean	*n*	Mean	*n*	Mean	*n*	Mean
Men																				
18–35 years	157	39.8	130	36.8[a]	63	25.4	73	28.7	157	45.8[a]	9	14.8	83	15.0	127	22.2[a]	68	12.4	166	170.7
36–50 years	165	43.8	134	46.6[ab]	71	29.4	82	32.4	158	41.2[a]	11	14.7	52	13.4	130	18.8[ab]	61	11.2	174	171.7
51–64 years	121	42.8	104	48.9[b]	60	29.4	64	30.5	98	34.1[b]	15	16.1	19	11.3	79	16.7[b]	36	12.5	126	159.0
Women																				
18–35 years	142	18.3[a]	88	26.4	38	14.1	63	25.4	155	34.6	15	8.9	51	11.8	100	11.9	38	6.6	162	96.5[a]
36–50 years	188	26.1[b]	135	25.4	75	17.3	80	21.7	189	32.8	17	14.4	48	9.7	122	12.5	56	8.0	201	106.6[b]
51–64 years	107	26.5[b]	83	30.3	59	18.1	45	20.7	97	28.1	11	13.1	8	11.5	52	9.8	25	7.0	115	100.0[b]
Education level attained																				
Primary	170	37.8[a]	131	43.6[a]	73	27.3[a]	76	28.3	151	29.7[a]	14	18.3[a]	39	10.8	114	14.6	51	10.8	175	139.2[a]
Intermediate	177	35.5[ab]	144	39.4[ab]	81	20.3[ab]	82	28.5	171	39.7[b]	18	18.9[a]	59	15.4	137	17.6	60	9.4	194	144.6[a]
Secondary	205	29.9[b]	163	31.7[b]	89	25.2[ab]	96	25.0	197	38.1[b]	19	10.0[b]	60	12.4	142	16.5	66	10.0	221	129.9[b]
Tertiary	304	29.7[b]	218	32.9[b]	109	19.8[b]	140	26.3	313	38.1[b]	25	8.6[b]	98	12.1	198	15.3	101	10.0	328	127.5[b]
Social class occupations																				
Professional, managerial & technical	375	30.7[a]	270	38.7	164	20.9[a]	178	28.1	374	36.6	42	12.7	83	11.4	232	13.8[a]	111	9.0[a]	405	128.4[a]
Non-manual	158	29.7[a]	117	30.6	53	20.6[a]	63	25.2	150	36.0	7	10.6	58	12.0	105	15.0[ab]	47	9.2[a]	166	122.2[a]
Skilled manual	176	39.6[b]	155	38.5	75	29.5[b]	85	28.3	166	38.6	12	18.0	53	14.7	131	17.9[b]	65	12.5[b]	184	159.3[b]
Semi-skilled and unskilled	132	34.9[ab]	105	32.4	58	20.7[a]	61	25.0	128	37.4	15	15.0	50	13.9	109	18.9[b]	50	8.9[a]	145	123.0[a]

† Includes only the meat components of composite foods that contained meat.
[a,b] Differences between categories using analysis of variance: $P < 0.01$.

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Table 4 Comparison of meat intakes (g day^{-1}) with and without disaggregating composite foods in Irish consumers

	Composite foods†			Disaggregated‡			Difference	
	%	Mean	SD	%	Mean	SD	g day^{-1}	%
Bacon and ham	85.0	31.0	28	91.9	33.0	27	−2.0	−6.1
Beef	77.8	68.1	55	79.9	39.1	32	28.9	73.9
Lamb	35.2	34.4	31	38.2	22.8	19	11.6	50.6
Pork	40.0	36.1	28	42.5	26.9	20	9.1	33.9
Poultry	79.7	53.8	45	89.1	36.7	27	17.1	46.6
Offal	4.4	20.0	15	8.1	13.6	11	6.4	47.1
Burger	27.2	24.0	20	27.2	12.7	9	11.3	88.6
Sausage	62.0	15.8	13	63.7	16.1	13	−0.3	−1.9
Meat products	72.1	30.8	29	29.6	10.0	9	20.8	206.9
Total meat	98.3	191.5	95	98.5	134.3	65	57.2	42.6

SD – standard deviation.
† Includes intakes of non-meat components from composite foods including vegetables, sauce, etc.
‡ Includes only the meat components of composite foods that contained meat.

significantly greater contribution ($P < 0.001$) to the diet of men than women for energy, protein, fat and micronutrient intakes except for vitamins A and B_6.

Discussion

Despite the growing popularity of vegetarianism[55] and the impact of the BSE crisis[4], the majority of Irish adults were consumers of meat and meat products (98% of men and 99% of women), and this is consistent with observations from the UK[56], Switzerland[57] and the USA[58]. Compared with the meat intakes reported in the Irish National Nutrition Survey[28], the intakes of beef and meat products are lower in the current estimates. Comparing current meat intake estimates with other European countries, intakes are higher than in the Mediterranean countries[36], Holland[59] and Sweden[35]. Compared with the UK national study[56], beef, lamb, pork, burger and sausage intakes appear lower in Ireland. Direct comparisons are difficult due to differences in food group aggregation together with an inconsistency and sometimes a lack of clarity on the definition of meat groups.

The estimates of meat intake were obtained in a relatively small ($n = 958$) but representative sample of 18–64-year-old adults from the Republic of Ireland, using the NSIFCS[29]. Furthermore, non-response, investigated in terms of sex and age, was found to be unbiased[38]. Interpretation of results from food consumption databases is prone to potential sources of bias[60]. However, the duration of NSIFCS dietary assessment was 7 days, which reduced inter-individual variability that occurs in shorter surveys[61]. 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[41]. Excluding energy underreporters from the analysis did not significantly affect the outcomes.

This current analysis highlights the bias introduced in meat intake estimates when composite foods, such as meat dishes, are not disaggregated to exclude non-meat components. Meat is a diverse food group encompassing fresh meat, processed meat and composite foods. The structure of the 7-day food diary used in this study provided detailed recipe information to facilitate complete disaggregation of meat from composite foods. Other dietary assessments (e.g. food-frequency questionnaires) are typically based on aggregated data, where meat from composite foods cannot be disaggregated. The importance of disaggregating composite foods has been highlighted

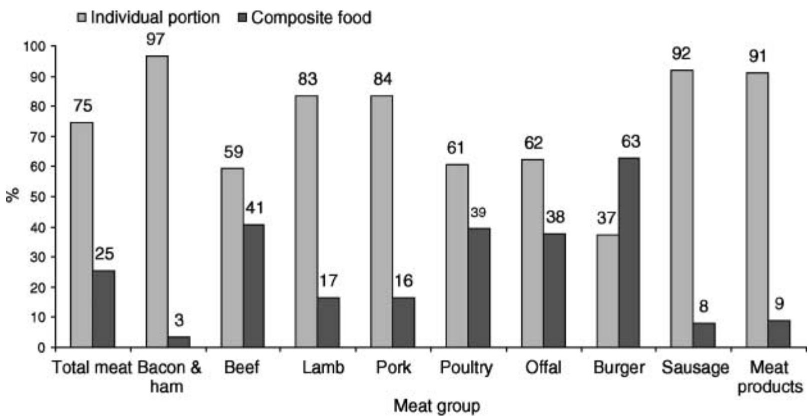

Fig. 1 Percentage of meat consumed as an individual portion and as part of a composite food

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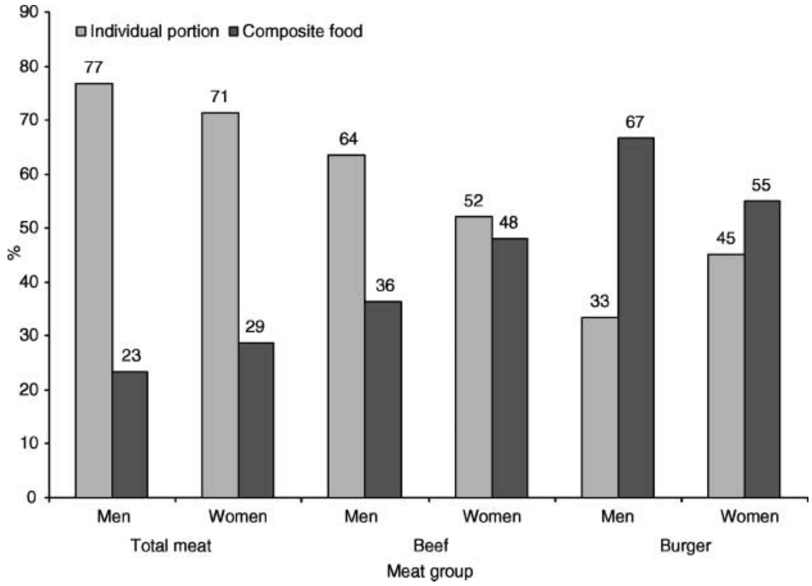

Fig. 2 Percentage of meat consumed as an individual portion and as part of a composite food in Irish men and women

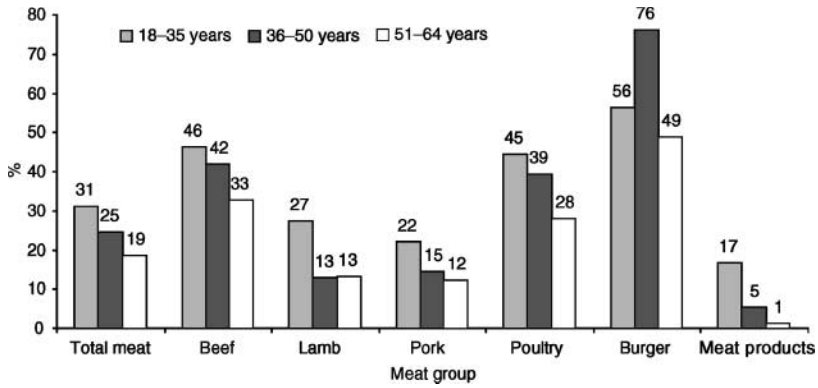

Fig. 3 Percentage of meat consumed as part of a composite food by age group

previously[32–34]. However, this current study is the first, to the authors' knowledge, reporting the quantification of meat disaggregated from composite foods. Following disaggregation, the mean meat intake in consumers was 134 g day^{-1} compared with 192 g day^{-1} without disaggregation. Thus, estimating meat intake without disaggregating composite foods results in an overestimate in meat intake of 57 g day^{-1} (43%), and this effect can vary between individual meats. Composite foods contributed 3% of bacon and ham intake, and 8% for sausage; therefore, as expected, there was very little effect with the disaggregation of composite foods on these meat intakes. For all other meats the effect on intake was much greater, i.e. 89% for burger and 74% for beef. This overestimation has serious implications in epidemiological studies of food intakes and disease patterns, in monitoring meat intake for food safety purposes and is a critical factor in the design of food consumption databases to allow for accurate food intake estimates.

Composite foods contributed about a quarter of total meat intake in the Irish diet (34 g day^{-1}). Therefore composite foods were an important source of meat, especially burgers, beef and poultry. Women were more likely to eat meat as part of a composite food (except for burgers) than men, while men were more likely to consume beef as an individual portion than women. This trend was also seen in a study in Australia where men tended to consume slightly more of their red meat as cuts than women[62]. Younger adults were more likely than older adults to consume meat as part of a composite food.

The current analysis shows that meat and meat products accounted for about 12% of energy intake but made a contribution greater than 10% to the mean daily intake of 20 nutrients for both men and women, particularly for protein, vitamin B_{12}, zinc, niacin, vitamin D, vitamin B_6, thiamine and iron. Previous analysis of the NSIFCS ($n = 1379$) based on aggregated meat data showed that no other single food group made such a comprehensive contribution to the intakes of a variety of nutrients in the Irish diet[63–66]. Meat is one of the most important dietary factors promoting iron status[67–69]. Poor iron status and anaemia have been shown to be more common among

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Table 5 Percentage contribution of meat with and without non-meat components from composite foods to mean daily nutrient intakes in Irish consumers

	Men				Women					
	Composite foods† ($n = 465$)		Disaggregated† ($n = 466$)		Composite foods† ($n = 477$)			Disaggregated‡ ($n = 478$)		
	Mean	SD	Mean	SD	Mean		SD	Mean		SD
Energy	18.3	7	12.9	5	16.2	*	7	10.7	*	5
Protein	44.0	12	31.4	11	39.6	*	12	26.9	*	11
Total fat	27.2	11	19.4	9	22.3	*	10	14.9	*	8
Saturated fat	25.6	12	18.3	10	20.8	*	11	14.0	*	9
Monounsaturated fat	30.9	12	22.3	11	24.9	*	11	16.9	*	9
Polyunsaturated fat	18.9	10	13.3	8	14.7	*	9	9.7	*	6
Sodium	30.8	13	21.6	10	25.6	*	11	17.1	*	9
Iron	22.4	10	15.8	8	17.5	*	10	11.6	*	7
Copper	17.5	12	12.0	8	15.3	*	12	10.2	*	9
Zinc	44.8	15	32.2	13	37.0	*	15	25.1	*	13
Total vitamin A	14.0	18	8.8	12	14.1	NS	20	8.6	NS	14
Vitamin D	33.4	20	23.8	16	24.6	*	19	16.6	*	14
Vitamin E	13.3	12	8.7	7	9.5	*	9	5.8	*	5
Thiamine	23.8	12	16.7	9	19.7	*	12	13.4	*	9
Riboflavin	20.6	10	14.7	8	17.3	*	11	11.8	*	9
Niacin	40.3	13	28.9	12	38.4	*	15	26.3	*	13
Vitamin B_6	23.1	9	16.3	7	21.9	NS	10	14.8	*	8
Vitamin B_{12}	45.2	20	32.4	17	37.0	*	21	25.4	*	17
Pantothenic acid	28.7	12	20.1	9	25.5	*	12	17.2	*	9

SD – standard deviation.
† Includes contributions from non-meat components from composite foods including vegetables, sauce, etc.
‡ Includes only the meat components of composite foods that contained meat.
Differences between men and women using independent *t*-test/Mann–Whitney test: *, $P < 0.001$; NS, not significant.

non-consumers of meat, especially in women[70,71]. In the current study, meat contributed 15% and 12% to iron intakes in men and women, respectively.

The contribution of meat to nutrient intakes was examined with and without the disaggregation of composite foods. There was a decrease in the contribution of disaggregated meat to the mean daily intakes of all nutrients, particularly for vitamin A, where aggregated meat contributed 14% of the mean daily intakes in men and women compared with 9% from disaggregated meat in men and women. The contribution of vegetables in composite foods would account for this reduction. In men, the contribution of meat to fat intake decreased from 27 to 19% for disaggregated meat. Similarly, energy intake decreased from 18 to 13% for disaggregated meat in men. The consumption of burgers and processed meat as part of a composite food, especially by younger men, may partially explain the reduction in the contribution of disaggregated meat to these nutrient intakes.

The serving size of meat varied considerably between meat groups and sources. The mean serving sizes of red meats such as beef, lamb and pork were higher than the serving sizes of poultry, bacon and ham, and processed meat. The mean serving size of meat consumed as part of a composite food was higher than that of meat consumed as an individual portion. Serving sizes are important in terms of estimating intakes (e.g. food-frequency questionnaires) and in terms of public health (e.g. recommending intakes at the population level). There are no quantitative recommended intakes for meat in Ireland; however, in the USA the recommended intake of the food group including meat is 2–3 servings daily, which, for servings of 2–3 oz, is equivalent to about 110–250 g daily[72]. Our study shows that Irish adult meat intakes are towards the lower end of this recommendation. While a significant proportion of individuals, especially men, exceed the recommendations of the World Cancer Research Fund[8] for ≤80 g red meat per day and of the UK Department of Health[9] for <140 g total meat per day, the scientific basis of these recommendations has been questioned[73,74].

In this study, men consumed significantly more meat than women, which can be partly explained by the higher energy intake in men. However, when differences in energy intakes were controlled for, women consumed more poultry than men. A preference for red meat over white meat in men has also been observed in other studies[35,57]. The high mean intake of meat at the 95th percentile (256 g day^{-1}) indicates that some individuals consumed large amounts of meat, particularly men. Analysis showed that social class and educational attainment had a significant effect on meat consumption. In this population, individuals with manual occupations had the highest intakes of meat compared with the other social class occupations. This was true of all meat groups with the exception of sausages. Higher meat intakes were also associated with individuals with no formal educational qualifications, particularly sausage, pork, burger, offal and poultry. These results indicate that individuals with no formal educational qualifications or in lower social class occupations are more likely to consume more meat.

Other studies have shown similar differences in meat consumption by socio-economic status[36,57,75,76].

In conclusion, meat makes an important contribution to nutrient intakes in the Irish diet. Meat intakes are higher among men, individuals in lower socio-class occupations and with no formal education. There are distinct consumer habits in relation to meat consumption in Ireland, which is an important consideration in studies of dietary modification of disease risk. The current study shows that while composite foods are important sources of meat, failure to disaggregate meat from composite foods overestimates meat intake by over 40%, with a large variation between meat categories. This has important implications for estimates of meat intakes in nutritional epidemiological studies and for food safety purposes.

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