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The role of meat in the European diet: current state of knowledge on dietary recommendations, intakes and contribution to energy and nutrient intakes and status

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Abstract

The role of meat in the diet has come under scrutiny recently due to an increased public emphasis on providing healthy diets from sustainable food systems and due to health concerns relating to the consumption of red and processed meat. The present review aimed to summarise dietary guidelines relating to meat, actual meat intakes and the contribution of meat to energy and nutrient intakes of children, teenagers and adults in Europe. The available literature has shown that food-based dietary guidelines for most countries recommend consuming lean meat in moderation and many recommend limiting red and processed meat consumption. Mean intakes of total meat in Europe range from 40 to 160 g/d in children and teenagers and from 75 to 233 g/d in adults. Meat contributes to important nutrients such as protein, PUFA, B vitamins, vitamin D and essential minerals such as Fe and Zn; however, processed meat contributes to significant proportions of saturated fat and Na across population groups. While few data are available on diaggregated intakes of red and processed meat, where data are available, mean intakes in adults are higher than the upper limits recommended by the UK Scientific Advisory Committee on Nutrition (70 g/d) and the World Cancer Research Fund (500 g/week). While there are no recommendations for red and processed meat consumption in children and teenagers, intakes currently range from 30 to 76 g/d. The present review provides a comprehensive overview of the role of meat in the European diet which may be of use to stakeholders including researchers, policy makers and the agri-food sector.

Key words: **Meat: Europe: Diet: Dietary recommendations: Intakes: Energy: Nutrients: Status: Health**

Introduction

The role of meat in the diet has come under scrutiny in recent times with an increased public emphasis on providing healthy diets from sustainable food systems which includes limiting/reducing the consumption of animal products[1]. Furthermore, recent studies have linked red and processed meat consumption with an increased risk of certain cancers which has brought attention to the types and quantities of meat that are being consumed[2,3]. The World Cancer Research Fund (WCRF) recommends consuming less than 500 g of red meat per week and very little if any processed meat[4] and the UK Scientific Advisory Committee on Nutrition (SACN) recommends limiting red and processed meat consumption to no more than 70 g/d[2].

Meat is a valuable source of high-biological value protein and a range of micronutrients including riboflavin, niacin, vitamin B_6, vitamin B_{12}, Fe and Zn; however, processed meats can also contain high amounts of nutrients of public health concern such as saturated fat and Na[5]. For many countries, meat is a key component of the food-based dietary guidelines (FBDG) and is often the central food around which meals are based; however, with health concerns related to red and processed meat consumption and trends towards a more plant-based diet, there is a need to understand the current role of meat in the diet including compliance with guidelines and the contribution of meat to nutrient intakes.

The present review aims to summarise dietary guidelines relating to meat, actual meat intakes and the contribution of meat to energy and nutrient intakes of children, teenagers and adults in Europe. Data are included from nationally representative dietary surveys published as reports, online web pages or peer-reviewed journal articles. For inclusion in the present review, the surveys must be published in English, must have been undertaken post-2000, and have used a food diary or 24 h recall as the dietary assessment method. The data for the present review were collected between January and June 2019; Table 1 outlines the ten European countries for which data within the above criteria were available including the years the studies were carried out, the age groups examined, the number of participants and the categories of meat reported within each study.

Abbreviations: FBDG, food-based dietary guidelines; NDNS, National Diet and Nutrition Survey; SACN, Scientific Advisory Committee on Nutrition; WCRF, World Cancer Research Fund.

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Classification of meat

Meat is a nutrient-dense food eaten in a variety of different forms, often being the central food around which meals are based[6]. It is defined as the flesh of animals used as food, but this definition is often widened to include organs such as liver, kidney, brains and other edible tissues[7]. Meat can be broadly categorised into red and white meat, with red meat typically having a higher proportion of type I oxidative (red) muscle fibres than type IIb glycolytic (white) muscle fibres[8]. Both red and white meat are then further categorised as either processed or unprocessed. However, there is lack of consistency between public health bodies and individual studies on the definitions of red, white and processed meat. The WCRF defines red meat as beef, pork, lamb and goat from domesticated animals including that contained in processed foods[4]. The International Agency for Research on Cancer (IARC) refers to red meat as unprocessed mammalian muscle meat (including minced or frozen meat), for example, beef, veal, pork, lamb, mutton, horse, or goat meat[3] and processed meat refers to meat that has been transformed through salting, curing, fermentation, smoking, or other processes to enhance flavour or improve preservation[3]. The UK SACN defines processed meat as meat (usually red) that has been treated with preservatives, excluding salt, but including some cured meats[2]. The European Prospective Investigation into Cancer and Nutrition (EPIC) has defined white meat as poultry (including chicken, hen, turkey, duck, goose, and unclassified poultry)[9] and domestic rabbit, while other epidemological studies include fish in their definition of white meat[10]. Not withstanding the variations in definitions from public health bodies, variations between individual studies can make it difficult to compare intakes between countries; for example, the UK National Diet and Nutrition Survey (NDNS) reported intakes of total red meat including processed meat[11] while the Dutch National Food Consumption Survey 2012–2016[12] reported intakes of 'domestic mammals' (including beef, veal, pork, mutton/lamb, and horse) in line with the International Agency for Research on Cancer (IARC) definition of red meat as unprocessed mammalian muscle meat (including minced or frozen meat)[3] (Table 1). This highlights a need for standardised definitions of red and processed meat both from a public guidance perspective and to allow for uniform estimation of meat intakes and compliance with guidelines. Table 1 highlights the variations of subcategories reported within 'total meat' between studies which can make it difficult to compare intakes between countries.

Dietary guidelines for meat consumption

The FAO has compiled a comprehensive database of all FBDG worldwide[13]. Countries in the WHO European Region which include meat as part of their FBDG are outlined in Table 2. While most FBDG recommend eating meat in some form, guidelines differ between countries in terms of types and quantities of meat in their recommendations. In Austria, for example, the recommendation is to 'Eat up to 3 servings of lean meat or low-fat sausages per week (300–450 g)'[14], while in Latvia the recommended weekly amount of lean meat is 300–600 g[15]. Recommended portion sizes also vary between countries, for example according to the Albanian guidelines one portion of meat equates to 100–120 g[16] while the Turkish guidelines state that 50–60 g equates to 1 serving[17]. Furthermore, certain countries do not distinguish meat from other foods when providing quantitative recommendations on consumption limits, for example, Belgium, 'Do not eat more than 75–100 g per day of meat, fish, eggs or products made with these foods'[18] and Greece, 'Consumption of poultry, eggs and red meat should not exceed on the average 1 serving per day' (1 serving of cooked lean meat = 60 g)[19].

The WCRF recommends that adults limit consumption of red meat to less than 500 g/week to provide a balance between the advantages of eating red meat (as a source of essential macro- and micronutrients) and the disadvantages (an increased risk of colorectal cancer and other non-communicable diseases) and to consume very little, if any, processed meat[4]. The following countries provided a quantitative consumption limit for red and/or processed meat: Bulgaria, 'Consume poultry meat without the skin and lean red meats up to three times per week' (100 g/serving)[20]; Finland, 'Limit the amount of red meat and meat products to <500 g per week'[21]; France, 'Limit red meat consumption to no more than 500 g per week and processed meat consumption to 25 g per day'[22]; Iceland, 'Limit the consumption of red meat to <500 g per week'[23]; Malta, 'Limit consumption of red meat to <2 servings twice weekly' (1 serving = 90 g)[24]; Sweden, 'Eat less red and processed meat, no more than 500 g per week, only a small amount of this should be processed meat'[25]; and the UK, 'If you eat more than 90 g of red or processed meat per day, try to cut down to no more than 70 g per day'[26]. Furthermore, a number of countries provide non-quantitative recommendations limiting red and processed meat consumption, such as the Irish guidelines which state to limit processed meats'[27], the Austrian guidelines recommend to 'Eat red meat and sausages in moderation'[14] and the Estonian guidelines which state 'Eat less red meat, prefer fish and poultry'[28]. Despite variations in dietary guidance for meat consumption across European countries, overall, most countries recommend limiting red meat and to consume little, if any, red and processed meat.

Meat consumption in Europe

Comparison of studies

Data from nationally representative nutrition surveys in ten European countries are presented in the present review. For comparison of meat intakes, data were available from the Czech Republic[29], Denmark[30], Finland[31], Germany[32], Ireland[33–36], Italy[37,38], Lithuania[39,40], the Netherlands[12,41,42], Sweden[43] and the UK[11] while data on the contribution of meat to energy and nutrient intake were available from Denmark[30], Finland[31], Ireland[33–36], the Netherlands[41] and the UK[11].

Due to the previously mentioned lack of internationally accepted standard definitions for red, white and processed meat there are variations in definitions between studies which report intakes of these meat categories. Additionally, as meat is often consumed as part of a composite dish, total weight of the dish

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Table 1. European countries from which data were available for the present review, including study years, age groups examined, number of participants and categories of meat reported

Country	Study years	Age group (years)	*n*	Meat categories reported
Czech Republic[29]	2003–2004	16–64	1751	Meat and meat products, offal; of which: 'meat & meat products & substitutes', 'edible offal & offal products' and 'meat-based preparations'
Denmark[30]	2011–2013	4–9	421	Meat and meat products (excluding poultry) and poultry & poultry products
	2011–2013	10–17	509	
	2011–2013	18–75	3016	
Finland[31]	2012	25–64	1295	Meat dishes; of which: 'cold cuts & sausages', 'minced meat dishes', 'poultry dishes', 'meat soups', 'meat casseroles', 'meat stews', 'sausage dishes', 'steaks & chops' and 'offal dishes'
	2012	65–74	413	
Germany[32]	2005–2006	14–18	1412	Meat, meat products & sausages; of which: 'meat & meat products' and 'sausages'
	2005–2006	19–64	10 928	
	2005–2006	65–80	3031	
Ireland[33–36,45,48]	2010–2011	1–4	500	1. Total meat; of which: 'red meat', 'processed meat' and 'poultry & game'
	2003–2004	5–12	594	2. Total meat; of which: 'bacon & ham', 'beef & veal', 'lamb', 'pork', 'chicken, turkey & game', 'offal & offal dishes', 'beef & veal dishes', 'lamb, pork & bacon dishes', 'poultry & game dishes', 'burgers', 'sausages', 'meat pies & pastries' and 'meat products'
	2004–2005	13–17	441	
	2008–2010	18–64	1274	
	2008–2010	65–90	226	
Italy[37,38]	2005–2006	0–3	52	Meat & meat products; of which: 'mammals & birds meat', 'processed whole meat products', 'sausages', 'animal mechanically separated meat' and 'animal offal'
	2005–2006	3–10	193	
	2005–2006	10–18	247	
	2010–2013	18–65	6070	
	2010–2013	66–96	2874	
Lithuania[39,40]	2007	19–65	1936	Meat & meat products, offal; of which: 'meat & meat products & substitutes', 'edible offal & offal products' and 'meat based preparations'
	2013–2014	65–75	300	
Netherlands[12,41,42]	2005–2006	0–3	52	Meat, meat products & substitutes; of which: 'unclassified & combined meat & meat products', domestic mammals', 'poultry', 'game', 'processed meat', 'offals' and 'meat substitutes'
	2005–2006	3–10	193	
	2005–2006	10–18	247	
	2007–2010	19–69	2106	
	2010–2012	≥70	739	
Sweden[43]	2010–2011	18–64	1430	Meat (including offal and blood products) and poultry
	2010–2011	65–80	367	
UK[11]	2008/09–2011/12	1·5–3	604	1. Total meat; of which: 'red meat' and 'white meat'
	2008/09–2011/12	4–10	1277	2. Total meat; of which: 'bacon & ham', 'beef, veal & dishes', 'lamb & dishes', 'pork & dishes', 'coated chicken & turkey', 'chicken, turkey & dishes', 'liver & dishes', 'burgers & kebabs', 'sausages', 'meat pies & pastries' and 'other meat, meat products & dishes'
	2008/09–2011/12	11–18	1497	
	2008/09–2011/12	19–64	2697	
	2008/09–2011/12	≥65	753	

is typically reported; hence, intakes of meat can be overestimated. It has previously been reported that failing to disaggregate the meat component of composite dishes may overestimate meat intakes by >40 %[44]. The German, Italian, Dutch, Irish and UK national food consumption surveys have disaggregated meat from composite dishes; however, compliance with upper limitations of meat intake may be underestimated in other countries.

Meat intakes in adults

In European countries for which data have been reported on meat consumption, 95–99 % of adults were identified as meat consumers. The mean intake (g/d) of total meat in European adults is reported in Table 3. Mean intakes of total meat ranged from 75 g/d in Swedish adults[43] to 211 g/d in Finnish adults[31]. Where data have been reported by population subgroups such as age group or sex, mean intakes of total meat in Italy, Sweden, Finland, Denmark, the Netherlands, Germany, Ireland and the UK were higher in younger adults aged 18–69 years (range 93–233 g/d) compared with older adults aged over 65 years (range 75–191 g/d)[11,12,30–32,35,37,41–43]. Mean intakes of total meat across Europe were higher in men (84–218 g/d) compared with women (64–163 g/d).

Intakes of poultry have been reported in the Netherlands, Sweden, Finland, Denmark and Ireland while the UK has reported the intake of 'total white meat'[11,12,30,31,35,41,43]. Mean intakes of poultry ranged from 11 to 46 g/d, with the highest intakes observed in Irish adults (55 g/d among males aged 18–64 years, 39 g/d among females aged 18–64 years and 32 g/d among older adults ≥65 years)[35] and intakes in the Netherlands and Sweden ranged from 15 to 23 g/d for younger adults and from 11 to 16 g/d for older adults[12,41].

Consumption of offal across all European countries was relatively low compared with consumption of other meat groups. Offal intakes have been reported in Italy, Lithuania, the Czech Republic, Finland, the Netherlands and Ireland. Mean intakes of offal among adults in Italy, Lithuania, the Netherlands and Ireland were 0–2 g/d[12,35,38–41] while intakes in the Czech Republic and Finland were higher (4 and 3 g/d, respectively)[29,31].

Intakes of red and processed meat in adults have been reported in the Netherlands[12], Ireland[45] and the UK[11]. Mean intakes of red and processed meat in younger adults were 93 g/d in the Netherlands, 86 g/d in Ireland and 71 g/d in the UK which is above the UK SACN recommendation of <70 g/d, with adults in the Netherlands and Ireland also exceeding the WCRF

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Table 2. Meat consumption guidelines in Europe

Country/organisation	Guidance on meat consumption	Additional comments
Albania[16]	Adults should consume 1 portion of meat, fish, egg or cheese alternatively every day (1 portion of meat = 100–120 g)	Guidance also available for children and adolescents
Austria[14]	Eat up to 3 servings of lean meat or low-fat sausages per week (300–450 g)	Eat red meat and sausages in moderation
Belgium[18]	Do not eat more than 75–100 g/d of meat, fish, eggs or products made with these foods	Not applicable
Bosnia and Herzegovina[56]	Eat meat, poultry, eggs and legumes several times per week	Not applicable
Bulgaria[20]	Consume poultry meat without the skin and lean red meats up to 3 times per week (100 g/serving)	Replace meat and meat products often with fish, poultry or pulses
Croatia[57]	Choose lean meats (for example, poultry, rabbit) and fish over red meat	Not applicable
Denmark[58]	Choose lean meats and cold meats	Not applicable
Estonia[28]	Eat less red meat, prefer fish and poultry	Not applicable
Finland[21]	When eating meat, choose low-fat, low-salt products and limit the amount of red meat and meat products to <500 g/week	Not applicable
France[22]	Eat meat, fish, other seafood and eggs alternating 1 or 2 times per d	Limit red meat to <500 g/week and processed meat to <25 g/d
Georgia[59]	Eat 1–3 portions per d of cooked lean meat, poultry, fish, eggs or legumes (1 portion of meat = 80 g)	Replace fatty meat and meat products by legumes, fish and chicken and low-fat meat
Germany[60]	Eat meat, sausages and eggs in moderation	Not applicable
Greece[19]	Consumption of poultry, eggs and red meat should not exceed on the average 1 serving per d (1 serving of cooked lean meat = 60 g)	Poultry is much preferred over red meat
Hungary[61,62]	Eat lean meats prepared with small amounts of fat regularly	Look for lean cold cuts
Iceland[23]	Meat in moderation (limit the consumption of red meat to 500 g/week, especially limit the consumption of processed meat)	Not applicable
Ireland[27]	Consume two servings of lean meat, poultry, fish, eggs, beans or nuts per d	Limit the consumption of processed meat
Latvia[15]	Eat legumes, fish or lean meat. The recommended weekly amount of lean meat is 300–600 g	Guidance also available for children, adolescents and the elderly
Macedonia[63]	Choose lean meats. Substitute meat and meat products with fish, poultry, beans and bean-based products	Not applicable
Malta[24]	Eat 2 servings per d of lean white meat (1 serving = 100 g). Limit consumption of red meat to <2 servings twice weekly (1 serving = 90 g)	If desired, occasionally consume small quantities of processed meat
Netherlands[64,65]	Limit the consumption of red meat, particularly processed meat	Not applicable
Norway[66]	Choose lean meat and lean meat products. Limit the amount of processed meat and red meat you consume	Not applicable
Poland[67]	Eat meat in moderation	Not applicable
Slovenia[68]	Eat lean meat. Limit consumption of meat products	Not applicable
Sweden[25]	Eat less red and processed meat, no more than 500 g/week. Only a small amount of this should be processed meat	Four meals containing meat equates to approximately 500 g
Switzerland[69]	1 portion of meat/fish/eggs/tofu/cheese per d (1 portion of meat/poultry = 100–120 g)	Not applicable
Turkey[17]	2 daily servings of meat/poultry/fish/eggs/legumes (1 serving of meat = 50–60 g)	Not applicable
UK[26]	If you eat more than 90 g of red or processed meat per d, try to cut down to no more than 70 g per d	Choose lean cuts of meat and grill meat instead of frying
World Cancer Research Fund[4]	Limit red meat consumption to <500 g/week	Eat very little, if any, processed meat

recommendation of <500 g per week. For older adults, the mean intakes of red and processed meat were 77 g/d in the Netherlands, 85 g/d in Ireland and 63 g/d in the UK, with older adults in the UK only having meat intakes below the upper daily consumption limits recommended by the WCRF and the UK SACN. It is important, however, to continue to monitor meat intakes, particularly in light of changing food consumption patterns. Recent time-trend analysis from the NDNS over a 9-year period (2008/2009 to 2016/2017) has reported a downward trend in intake of red and processed meat in adults and older adults with little change in the intake of total meat, indicating a change in the types of meats consumed[46].

The contribution of meat to energy and nutrient intakes in adults has been reported in Denmark[30], Finland[31], Ireland[35,45], the Netherlands[41] and the UK[11] (Table 4). Overall, meat contributed 12–17 % of energy intake in adults across Europe. Meat also contributed to large proportions of key nutrients such as protein (29–41 %), MUFA (23–28 %), PUFA (11–21 %), B vitamins (4–38 %), vitamin D (5–30 %), Fe (16–23 %), K (13–19 %) and Zn (27–36 %); however, it also

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Table 3. Mean intake (g/d) of total meat in European adults by age group and sex

Country	Disaggregation of meat from composite dishes	Study years	Age group (years)	All		Males		Females	
				n	Mean intake (g/d)	*n*	Mean intake (g/d)	*n*	Mean intake (g/d)
Czech Republic[29]	Not specified	2003–2004	16–64	1751	187	–	–	–	–
Denmark[30]	Not specified	2011–2013	18–75	3016	160	1464	201	1552	123
Finland[31]	Not specified	2012	25–64	1295	211	585	258	710	163
		2012	65–74	413	191	210	231	203	150
Germany[32]	Yes	2005–2006	19–64	10 928	233	4912	154	6016	79
		2005–2006	65–80	3031	85	1469	105	1562	64
Ireland[35,45,48]	Yes	2008–2010	18–64	1274	134	634	165	640	102
		2008–2010	65–90	226	117	106	133	120	101
Italy[37]	Yes	2010–2013	18–65	6070	161	2775	178	3295	144
		2010–2013	66–96	2874	139	1401	156	1473	121
Lithuania[39,40]	Not specified	2007	19–65	1936	180	849	207	1087	159
		2013–2014	65–75	300	129	–	–	–	–
Netherlands[41,42]	Yes	2007–2010	19–69	2106	110	1055	133	1051	88
		2010–2012	≥70	739	89	373	99	366	81
Sweden[43]	Not specified	2010–2011	18–64	1430	93	623	111	807	75
		2010–2011	65–80	367	75	169	84	198	65
UK[11]	Yes	2008/09–2011/12	19–64	2697	190	1126	218	1571	163
		2008/09–2011/12	≥65	753	153	317	178	436	133

Table 4. Contribution (%) of total meat to energy and nutrient intakes in European adults

	Denmark[30]	Ireland[45,70,71]	Netherlands[41]	UK[11]	Finland[31]
Age (years)	4–75	18–64	19–69	19–69	25–64
n	3946	1274	2106	2697	1295
Contribution (%) to intakes					
Energy	14	17	12	17	16
Protein	33	41	29	38	31
Total fat	23	23	19	24	22
Saturated fat	21	22	19	24	19
MUFA	28	27	23	–	26
PUFA	14	20	11	–	21
Thiamin	35	20	24	22	31
Riboflavin	19	16	21	17	16
Niacin	34	38	–	36	33
Vitamin B_6	26	24	22	24	29
Folate/folate equivalents	9	7	4	9	12
Vitamin B_{12}	37	31	30	29	31
Vitamin A	40	10	–	16	27
Vitamin D	17	27	20	30	5
Vitamin E	4	9	7	13	12
Na	15	27	18	27	28
K	13	19	13	18	14
Mg	9	15	9	15	11
Fe	22	18	16	21	23
P	18	24	18	–	16
Zn	36	36	28	35	27

contributed to high proportions of total fat (19–24 %), saturated fat (19–24 %) and Na (15–28 %).

While some national nutrition surveys in Europe have collected biochemical data to explore the nutritional status of population groups, there are few studies which examine the impact of meat consumption on nutritional status. A recent study from the UK NDNS has shown that among females aged 11–64 years those who consumed less than 40 g/d of total red meat were more likely to have micronutrient intakes below the lower reference nutrient intake (LRNI) for vitamin D, vitamin B_{12}, Zn, Fe and K; however, there were no significant differences observed for blood biomarkers[47].

Meat intakes in children and teenagers

The mean intake (g/d) of total meat in European children and teenagers is reported in Table 5. Mean intakes of total meat in Irish children and teenagers (1–4, 5–12 and 13–17 years)[33,34,36] and Danish children and teenagers (4–9 and 10–17 years)[30] were higher than those observed in children and teenagers in

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Table 5. Mean intake (g/d) of total meat in European children and teenagers by age group and sex

Country	Disaggregation of meat from composite dishes	Study years	Age group (years)	All		Boys		Girls	
				n	Mean intake (g/d)	*n*	Mean intake (g/d)	*n*	Mean intake (g/d)
Denmark[30]	Not specified	2011–2013	4–9	421	103	216	109	205	96
		2011–2013	10–17	509	147	251	176	258	117
Germany[32]	Yes	2005–2006	14–18	1412	118	712	152	700	84
Ireland[33,34,36,48]	No	2010–2011	1–4	500	78	–	–	–	–
		2003–2004	5–12	594	104	293	111	301	100
		2004–2005	13–17	441	160	224	186	217	132
Italy[38]	Yes	2005–2006	0–3	52	55	–	–	–	–
		2005–2006	3–10	193	100	–	–	–	–
		2005–2006	10–18	247	126	108	145	139	107
Netherlands[12]	Yes	2012–2014	1–3	362	40	–	–	–	–
		2012–2014	4–8	296	61	–	–	–	–
		2012–2014	9–18	532	96	259	111	273	80
UK[11]	Yes	2008/09–2011/12	1·5–3	604	42	–	–	–	–
		2008/09–2011/12	4–10	1277	67	665	71	612	63
		2008/09–2011/12	11–18	1497	97	744	114	753	80

Germany[32], Italy[38], the Netherlands[12,41] and the UK[11], which may be partly explained by the inclusion of meat from composite dishes in estimates of intakes. Mean intakes of total meat in young children aged 0–3 years in the Netherlands, the UK and Italy ranged from 40 to 55 g/d[11,12,38] and mean intakes in Irish children aged 1–4 years were 78 g/d[36,48]. Mean intakes of total meat in older children aged 3–12 years were 61 and 67 g/d in the Netherlands[12,41] and the UK[11] and ranged from 100 to 104 g/d in Italy[38], Denmark[30] and Ireland[33,36,48]. Mean intakes of total meat in older children/teenagers aged 9–18 years ranged from 96 to 97 g/d in the Netherlands[12,41] and the UK[11] and from 118 to 160 g/d in Germany[32], Italy[38], Denmark[30] and Ireland[33,34]. Where data have been reported by age group and sex, mean intakes of total meat in European children and teenagers were higher in boys (71–186 g/d) compared with girls (63–132 g/d) across all age groups examined.

Intakes of poultry and poultry dishes have been reported in the Netherlands[12,41], Denmark[30], Italy[38] and Ireland[33,34,36], while the UK[11] has reported the intake of 'total white meat'. Mean intakes of poultry ranged from 5 to 15 g/d in younger children aged 0–4 years, from 7 to 24 g/d in older children aged 3–12 years and from 14 to 44 g/d in older children/teenagers aged 9–18 years.

Mean intakes of offal in children and teenagers have been reported for children and teenagers in Italy[38], the Netherlands[12,41] and Ireland only[33,34,36]. Mean intakes of offal were 0 g/d among all children and teenagers in the Netherlands and Ireland while intakes among Italian children were <1 g/d across all age groups.

Intakes of red and processed meat in children and teenagers have been reported in the Netherlands[12,41], Ireland[48] and the UK[11]. Mean intakes of red and processed meat in the Netherlands, Ireland and the UK ranged from 30 to 41 g/d in younger children (0–4 years) and from 45 to 54 g/d in older children (4–12 years). Mean intakes of red and processed meat in older children/teenagers (9–18 years) were 60 g/d in the UK, 68 g/d in the Netherlands and 76 g/d in Ireland. There are currently no recommendations on red and processed meat intake in children and teenagers. While older children/teenagers and boys have higher intakes compared with younger children and girls, it is important to continue to monitor intakes as there is evidence from the recent NDNS time-trend analysis that intakes of red and processed meat are declining among children/teenagers aged 11–18 years[46].

The contribution of meat to energy and nutrient intakes in children and teenagers has been reported in Denmark[30], Finland[31], Ireland[33,34,36], the Netherlands[41] and the UK[11] (Table 6). Overall, meat contributed 10–17 % of energy intake in children and teenagers across Europe. Meat also contributed to large proportions of key nutrients such as protein (26–41 %), MUFA (22–26 %), PUFA (11–19 %), B vitamins (4–39 %), vitamin D (19–35 %), Fe (13–19 %), K (12–18 %) and Zn (26–34 %); however, it also contributed to high proportions of total fat (19–24 %), saturated fat (17–23 %) and Na (19–28 %). To the best of the authors' knowledge there are no data available exploring the association of meat consumption with nutritional status markers among children and teenagers in Europe.

Current research and future perspectives

Research is ongoing to explore the potential to improve the nutritional composition of meat for both macro- and micronutrients. Enhancing the fatty acid composition of meat to improve the unsaturated fat:saturated fat ratio is one area which has been investigated extensively. A recent review has shown that on a g/g fat basis, grass-fed beef has a more favourable profile for saturated fat, conjugated linoleic acid and *n*-3 fatty acid composition than grain-fed beef[49]. Moreover, the review found that grass-fed beef tends to be lower in overall fat content and is also higher in precursors for vitamins A and E. Another recent review has highlighted the potential of fish oil or microalgae in the diets of single-stomached animals such as pigs and chickens to enhance *n*-3 content of the animal meat[50]. Additionally, despite the extensive lipolysis and biohydrogenation of dietary lipids in the microbiome of ruminants, some studies have also achieved high levels of long-chain *n*-3 in lamb[51,52]. The lack of human

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Table 6. Contribution (%) of total meat to energy and nutrient intakes in European children and teenagers

	Children			Teenagers		
	Ireland[33,48,72]	UK[11]	Netherlands[41]	Ireland[48,73,74]	UK[11]	Netherlands[41]
Age (years)	5–12	4–10	7–8	13–17	11–18	14–18
n	594	1277	304	441	1497	706
Contribution (%) to intakes						
Energy	13	13	10	16	17	11
Protein	32	29	26	41	38	30
Total fat	19	19	18	22	24	19
Saturated fat	–	17	18	19	23	19
MUFA	–	–	22	26	–	23
PUFA	–	–	11	19	–	11
Thiamin	16	14	22	19	20	26
Riboflavin	10	10	11	15	16	13
Niacin	30	29	–	39	37	–
Vitamin B_6	18	16	20	23	22	23
Folate/folate equivalents	5	6	4	7	10	4
Vitamin B_{12}	20	21	29	26	29	32
Vitamin A	9	8	–	11	12	–
Vitamin D	31	25	19	35	35	25
Vitamin E	8	11	7	9	15	8
Na	24	23	20	26	28	19
K	14	12	12	18	18	15
Mg	12	11	8	15	16	10
Fe	13	13	16	17	19	17
P	19	–	16	24	–	17
Zn	28	26	26	34	34	28

intervention trials to assess the nutritional value of these compositional changes has been emphasised. While meat is already a key source of many micronutrients in the diet, there is also ongoing research aimed at investigating meat as a vehicle for other micronutrients that are not naturally present in high quantities. The biofortification of red meat with vitamin D is one such area of research. It has been shown that providing the maximum allowable level of 2000 IU vitamin D (in the form of either 25(OH)D_3 (D_3) and/or 25-hydroxvitamin D) per kg diet in pigs can increase the total vitamin D activity of pork loin meat to 0·9 to 1·7 μg per 100 g[53]. Furthermore, vitamin D_3 supplementation of heifers' diets within allowable European Union inclusion levels (4000 IU of vitamin D_3 per kg of feed) can successfully enhance the vitamin D content of beef to such an extent that a 7–9 % contribution per 100 g of beef could be made to an individual's recommended daily intake of vitamin D[54]. The Se and iodine content of meat can also be improved by fortification of animal feeds, whereas Zn and Fe contents are highly variable among different species and cannot be improved by increased feed concentrations[55]. Any changes in the nutritional profile of meat and meat products should be reflected in food composition tables to allow for ongoing and accurate estimations of the contribution of meat to nutrient intakes.

Conclusion

With the role of meat consumption under scrutiny for both health and environmental reasons, the present review aimed to provide a current picture on country-specific dietary guidelines and actual consumption of meat within Europe. The review found that FBDG for most countries recommend consuming lean meat in moderation and many recommend limiting red and processed meat consumption.

In Europe, the mean intake of total meat ranged from 40 to 104 g/d in children, from 96 to 160 g/d in teenagers and from 75 to 233 g/d in adults. While meat was shown to be a key contributor to important nutrients such as protein, PUFA, B vitamins, vitamin D and essential minerals such as Fe and Zn, it can also contribute to significant proportions of nutrients of public health concern such as saturated fat and Na across population groups, primarily due to processed meats.

While there were few data available on intakes of red and processed meat (with varying defintions), mean intakes in adults are slightly higher than the upper limits recommended by the UK SACN (70 g/d)[2] and the WCRF (500 g/week)[4]. While there are no recommendations for red and processed meat consumption in children and teenagers, intakes currently range from 30 to 76 g/d. However, it is important to continue to monitor meat intakes among all popualtion groups given recent evidence from the UK indicating a decrease in red and processed meat consumption among population groups[46]. A standardised definition of red and processed meat in relation to health is needed for a uniform estimation of meat intakes and compliance with guidelines.

Research is ongoing to show the potential effects of improving the nutritional profile of meat through reformulation and biofortification. It is important that these changes to the food supply are reflected in food composition databases to allow for accurate estimates of the contribution of meat to the diet. The present review provides a comprehensive overview of the role of meat in the European diet which may be of use to stakeholders including researchers, policy makers and the agri-food sector. In light of the global shift towards providing healthy diets from sustainable

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food systems it is important to continue to monitor the consumption of meat and its role in the diet of population groups.

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