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Contribution of meat to vitamin B_{12}, iron and zinc intakes in five ethnic groups in the USA: implications for developing food-based dietary guidelines

S. Sharma,* T. Sheehy† & L. N. Kolonel*

*Epidemiology Program, Cancer Research Center of Hawaii, University of Hawaii, Honolulu, HI, USA
†School of Food and Nutritional Sciences, University College Cork, Cork, Ireland

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Correspondence
S. Sharma, Department of Medicine, University of Alberta, 5-10 University Terrace, 8301 112 Street, Edmonton, AB T6G 2E1, Canada.
Tel.: +1 780 248 1610
Fax: +1 780 248 1611
E-mail: gita.sharma@ualberta.ca

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Abstract

Background: To describe the sources of meat and their contributions to vitamin B_{12}, iron and zinc in five ethnic groups in the USA.
Methods: Dietary data for the Multiethnic Cohort, established in Hawaii and Los Angeles, were collected using a quantitative food frequency questionnaire from more than 215 000 subjects, aged 45–75 years at baseline (1993–1996). Participants included African American, Latino, Japanese American, Native Hawaiian and Caucasian men and women. Servings of meat items were calculated based on the US Department of Agriculture recommendations and their contributions to intakes of total meat, red meat, vitamin B_{12}, iron and zinc were determined.
Results: Of all types of meat, poultry contributed the most to meat consumption, followed by red meat and fish among all ethnicities, except for Latino (born in Mexico and Central/South America) men who consumed more beef. Lean beef was the most commonly consumed red meat for all ethnic-sex groups (9.3–14.3%), except for Native Hawaiian and Japanese American men, and Japanese American women whose top contributor was stew/curry with beef/lamb and stir-fried beef/pork with vegetables, respectively. The contribution of meat was most substantial for zinc (11.1–29.3%) and vitamin B_{12} (19.7–40%) and, to a lesser extent, for iron (4.3–14.2%).
Conclusions: This is the first large multiethnic cohort study to describe meat sources and their contributions to selected nutrients among ethnic minorities in the USA. These findings may be used to develop ethnic-specific recommendations for meat consumption aiming to improve dietary quality among these groups.

Introduction

Chronic diseases, including cancer, cardiovascular disease (CVD) and diabetes, are the leading causes of death for men and women of all races and ethnicities in the USA (National Center for Health Statistics, 2009). However, mortality and morbidity rates from these diseases differ by race and ethnicity. African Americans are more affected by death from CVD and cancer than Latinos, Asians or Caucasians in the USA (National Center for Health Statistics, 2009). Age-adjusted prevalences of CVD among men and women were 9.7% and 10.8% among African Americans, 9.0% and 7.6% for Latino Americans, and 14.0% and 11.8% for Caucasians, respectively (National Center for Health Statistics, 2009). Furthermore, age-adjusted cancer mortality rates for men and women, respectively, were 322 and 189 per 100 000 for African Americans, 235 and 161 for Caucasians, 142 and 97 for Asians and 162 and 107 for Latinos in 2008 (American Cancer Society, 2008). More information on the aetiology and the disparities in rates of chronic diseases among these ethnic/racial groups is urgently needed.

Substantial evidence indicates that the consumption of meat, in particular red meat and processed meat, is associated with several chronic diseases, including CVD (Sinha *et al.*, 2009; Wang & Beydoun, 2009), diabetes (Vang *et al.*, 2008) and cancer (Lee *et al.*, 2009; Sinha *et al.*, 2009). Carcinogenic compounds are formed when red meat is cooked at high temperature (Tasevska *et al.*, 2009). Red meats are also energy-dense and high in total fat and saturated fat, which have been linked to a high risk of obesity and associated co-morbidities, such as diabetes, CVD and cancer (Leitzmann, 2005; Wang & Beydoun, 2009). By contrast, a higher intake of white meat (poultry and fish) has been associated with a decreased risk for total death, as well as death from cancer (Sinha *et al.*, 2009). Fish contains high levels of omega-3-fatty acids, which are considered to have a positive effect on cholesterol levels and to be preventative against heart disease and cancer (Mozaffarian, 2009; Pot *et al.*, 2009).

Conversely, in most cases, meats are good sources of essential micronutrients, such as iron, zinc and vitamin B_{12}, which have important functions in many metabolic and physiological processes (Vaes *et al.*, 2009; Welch *et al.*, 2009). Zinc is involved in immune system function and has been associated with the prevention of atherosclerosis and prostate cancer (Prasad, 2009; Lobo *et al.*, 2010). Iron is required in the formation of haemoglobin and inadequate iron intake can result in anaemia, decreased intellectual and work performance, and functional alterations of the small bowel (Clark, 2008). In addition, animal-based sources of several micronutrients such as iron, zinc and vitamin B_{12} have better bioavailability compared to plant-based food sources (Allen, 2008). Muscle tissue is a source of high quality protein and contains little carbohydrate; some studies have advocated that a high protein and low-carbohydrate diet promotes weight loss and prevents obesity (Atkins, 2004; Gardner *et al.*, 2007; Halkjaer *et al.*, 2009).

The USA has the highest *per capita* consumption of meat in the world. Americans consumed 200 pounds (boneless weight) of beef, pork, chicken and fish per person in 2005 (US Department of Agriculture, Economic Research Service, 2010; Wang *et al.*, 2010). The debate over the health risks versus nutritional benefits of animal products in the diet raises the need to more closely investigate the contributions of meat to the diet, as well as the relationship between different meat sources and chronic disease. Unfortunately, to our knowledge, no studies have provided information regarding meat sources relative to micronutrient intake among ethnic minorities in the USA using a standardised dietary assessment methodology. The objective of the present study was to describe consumption of different meat sources and their relative contributions to vitamin B_{12}, iron and zinc in five main ethnic groups in the USA.

Patients and methods

The Multiethnic Cohort (MEC) and dietary assessment methods have been described elsewhere (Kolonel *et al.*, 2000; Stram *et al.*, 2000). Briefly, the MEC includes representative population samples of more than 215 000 men and women of five ethnic/racial groups: African Americans (AfAm), Latinos – born in Mexico and Central/South America (Latino-Mexico) and born in the USA (Latino-USA), Japanese Americans (JpAm), Native Hawaiians (NH) and Caucasians. Participants aged 45–75 years completed a 26-page, self-administered mailed questionnaire at baseline in 1993–1996, which included sections on anthropometric and demographic information (including migrant status), physical activity, medical and reproductive history, and a validated quantitative food frequency questionnaire (QFFQ; Kolonel *et al.*, 2000). The QFFQ was developed specifically for the study population based on 3-day measured food records from approximately 60 men and 60 women from each ethnic/racial group. Ethnic-specific food items were added to the QFFQ irrespective of their contribution to nutrient intake (Kolonel *et al.*, 2000). Acceptable correspondence between the questionnaire and multiple 24-h recalls for the ethnic-sex groups was shown in a calibration sub-study (Stram *et al.*, 2000).

Participants outside the range of mean (3 SD) for energy and mean (3.5 SD) for fat, protein and carbohydrate values were excluded (n = 9854). Similarly, individuals from mixed ethnic background (n = 13 994) and Latinos born in the Caribbean (n = 4487) were not included in this analysis. Latino-Mexico, Latino-USA and Latinos born elsewhere were separated because food consumption patterns have been shown to differ substantially between Latinos by birthplace (Sharma *et al.*, 2004). The present analysis included 31 852 AfAm, 13 629 NH, 51 248 JpAm, 42 951 Latinos (21 083 Latino-Mexico and 21 868 Latino-USA) and 47 236 Caucasians.

The QFFQ included eight frequency categories for foods and nine for beverages, together with three choices of portion size. As an additional aid for quantification, photographs depicting selected foods and representative portion sizes were provided. The portion size options were based on typical serving sizes for each single food or grouping of foods as reflected in the original 3-day measured food records (Kolonel *et al.*, 2000). The detailed methods of developing and calculating servings of food groups for the MEC have been described previously (Sharma *et al.*, 2003). Servings of different types of meat consumed were determined using the US Department of

Agriculture (USDA) Pyramid serving's database file. Each individual's servings for each food group were computed by summing the daily servings across the food items on the QFFQ. Composite dishes were disaggregated into their individual components. Nutrient intakes were analysed based on the unique food composition table, which was extended and adapted from the USDA Food Composition Database (Sharma *et al.*, 2003). In the present study, the average number of types of meat was calculated by ethnic-sex group and ranked.

The following meats were recorded either as an individual portion or as part of composite food: beef, pork, lamb, chicken, turkey and fish. Red meat was the sum of beef, pork and lamb. Poultry included chicken and turkey. Fish included baked/broiled/raw fish, canned tuna fish and shrimp/shellfish. Total meat constituted all of the above mentioned meats. In the present study, we report the types of meat contributing to total meat and red meat as a result of their association with chronic disease. Similar foods were combined to calculate the percentage contributions of commonly consumed meats and other food items to daily vitamin B_{12}, iron and zinc intakes.

All participants provided their informed consent. The study protocol was approved by the institutional review boards of the University of Hawaii and the University of Southern California.

Results

The mean ages of 86 320 men and 100 596 women included in the analysis of the present study ranged from 56 to 62 years among the ethnic-sex groups. Among the ethnic-sex groups, NH men (28.5 kg m^{-2}) and AfAm women (28.4 kg m^{-2}) had the highest mean body mass index (Table 1). NH had the highest energy intakes for men [11 547 kJ day^{-1} (2760 kcal day^{-1})] and women [9916 kJ day^{-1} (2370 kcal day^{-1})], whereas AfAm men [9179 kJ day^{-1} (2194 kcal day^{-1})] and JpAm women [7564 kJ day^{-1} (1808 kcal day^{-1})] reported the lowest energy intake by ethnic-sex group.

Sources of meat intake

Table 2 lists the top 10 most commonly consumed types of meat and their contribution to total meat intake. Of the top 10 contributors, poultry products contributed the most (15.2–39.3%; Table 2 subtotals) to meat consumption, followed by red meat or fish in all ethnic-sex groups, except for Latino-Mexico men who consumed more red meat than poultry. The top meat dish (i.e. the first row of Table 2) that contributed to total meat intake was chicken (either chicken wings or roasted/baked; 5.2–12.2%) in all ethnic-sex groups, except for NH men and women and JpAm men for whom fish (canned tuna fish and baked/broiled/raw fish, respectively) was the most commonly consumed type of meat (5.0–5.4%), and for Latino-Mexico men and women for whom broth with noodles or rice was the top contributor (6.0% and 7.5%, respectively). Among AfAm, seven of the top 10 contributors were poultry products. Red meat was reported most commonly among Latinos (12.2–23.5%) and the least among AfAm (2.5–3.3%). Fish was one of the 10 major sources of total meat among AfAm, NH, JpAm, Latino-USA and Caucasians; however, it was not among the top 10 for Latino-Mexico individuals.

Table 3 presents the top 10 types of red meat consumed in each ethnic-sex group. The primary sources of red meat (i.e. top row of Table 3) were lean beef steak/

Table 1 Characteristics of the participants by ethnicity and sex

	African Americans	Native Hawaiians	Japanese Americans	Latino-Mexico	Latinos-USA	Caucasians
Men						
n	11 722	5979	25 893	10 180	10 613	21 933
Age (years), mean (SD)	62 (8.9)	57 (8.7)	61 (9.2)	59 (7.7)	61 (7.6)	59 (9.1)
Body mass index (kg m^{-2}), mean (SD)	26.7 (4.3)	28.5 (5.1)	24.7 (3.3)	26.7 (3.7)	26.7 (4.1)	26.0 (4.0)
Energy [kJ day^{-1} (kcal day^{-1})], mean (SD)	9179 (4878) [2194 (1166)]	11 547 (5485) [2760 (1311)]	9434 (3485) [2255 (833)]	11 363 (5861) [2716 (1401)]	10 326 (5276) [2468 (1261)]	9552 (3761) [2283 (899)]
Women						
n	20 130	7650	25 355	10 903	11 255	25 303
Age (years), mean (SD)	61 (9.0)	56 (8.7)	61 (8.9)	58 (7.6)	60 (7.9)	59 (9.0)
Body mass index (kg m^{-2}), mean (SD)	28.4 (5.8)	28.0 (6.1)	23.1 (3.8)	27.0 (4.8)	27.6 (5.4)	25.2 (5.2)
Energy [kJ day^{-1} (kcal day^{-1})], mean (SD)	7861 (4154) [1879 (993)]	9916 (5284) [2370 (1263)]	7564 (2836) [1808 (678)]	9690 (5179) [2316 (1238)]	8602 (4619) [2056 (1104)]	7552 (2941) [1805 (703)]

Table 2 Top 10 sources of meat and relative contributions (%) to total meat consumption by ethnicity and sex

	African Americans		Native Hawaiians		Japanese Americans		Latino-Mexico		Latino-USA		Caucasians	
	Food items	%	Foods items	%	Foods items	%	Foods items	%	Foods items	%	Foods items	%
Men	Chicken wings (with skin)	5.3	Canned tuna fish	5.0	Baked/broiled/raw fish	5.4	Broth with noodles or rice	6.0	Roasted/baked chicken*	5.2	Roasted/baked chicken*	7.3
	Chicken wings*	4.7	Baked/broiled/raw fish	4.6	Stew/curry (with beef/lamb)	4.8	Mexican meat soup or stew	4.5	Beef steak/roast (lean only)	4.9	Beef steak/roast (lean only)	4.6
	Roasted/baked chicken*	4.6	Stew/curry (with beef/lamb)	4.5	Canned tuna fish	4.5	Beef steak/Roast (lean only)	4.2	Chili	4.7	Canned tuna fish	4.3
	Roasted/baked chicken (with skin)	4.4	Broth with noodles or rice	3.9	Stir-fried beef/pork†	4.1	Arroz Con Pollo	4.0	Mexican meat soup or stew	3.8	Baked/broiled/ raw fish	4.1
	Fried chicken (with skin)	4.2	Stir-fried beef/pork†	3.6	Stir-fried chicken†	4.0	Chili	3.9	Meat burritos	3.8	Roasted/baked chicken (with skin)	3.4
	Beef steak/roast (lean only)	3.3	Stir-fried chicken†	3.0	Broth with noodles or rice	4.0	Roasted/baked chicken*	3.9	Broth with noodles or rice	3.5	Broth with noodles or rice	3.0
	Broth with noodles or rice	3.2	Fried fish	3.0	Fried fish	4.0	Dried bean or pea soup	3.8	Chicken wings*	3.1	Turkey*	2.9
	Chicken/turkey hot dogs	3.1	Roasted/baked chicken*	3.0	Roasted/baked chicken*	3.7	Stew/curry (with beef/lamb)	3.6	Chicken/turkey hot dogs	2.9	Chicken/turkey hot dogs	2.8
	Fried chicken*	2.9	Fried chicken (with skin)	2.9	Fried chicken*	3.3	Stir-fried beef/pork†	3.5	Canned tuna fish	2.7	Stew/curry (with beef/lamb)	2.8
	Canned tuna fish	2.6	Roasted/baked chicken (with skin)	2.8	Fried chicken (with skin)	2.9	Fried chicken*	3.5	Fried chicken*	2.7	Fried chicken*	2.6
Total (%)		38.3		36.3		40.7		40.9		37.3		37.8
Poultry subtotal‡		32.4		15.6		17.9		17.4		17.4		22.0
Fish subtotal		2.6		12.6		13.9		0		2.7		8.4
Red meat subtotal§		3.3		8.1		8.9		19.0		9.6		7.4
Women	Chicken wings*	7.2	Canned tuna fish	5.4	Roasted/baked chicken*	6.2	Broth with noodles or rice	7.5	Roasted/baked chicken*	8.1	Roasted/baked chicken*	12.2
	Roasted/baked chicken*	7.0	Baked/broiled/ raw fish	4.3	Stir-fried chicken†	5.5	Roasted/baked chicken*	5.9	Chicken wings*	5.3	Canned tuna fish	5.0

Table 2 *(Continued)*

	African Americans		Native Hawaiians		Japanese Americans		Latino-Mexico		Latino-USA		Caucasians	
	Food items	%	Foods items	%	Foods items	%	Foods items	%	Foods items	%	Foods items	%
	Chicken wings (with skin)	6.8	Roasted/baked chicken*	4.2	Baked/broiled/raw fish	5.3	Mexican meat soup or stew	4.3	Chili	4.5	Beef steak/ roast – (lean only)	4.7
	Roasted/baked Chicken (with skin)	5.7	Broth with noodles or rice	4.2	Stir-fried beef/pork†	4.9	Arroz Con Pollo	4.3	Beef steak/roast (lean only)	4.4	Baked/broiled/ raw Fish	4.3
	Fried chicken (with skin)	3.7	Stew/curry (with beef/lamb)	3.9	Canned tuna fish	4.8	Chicken wings*	4.2	Mexican meat soup or stew	4.2	Turkey*	4.0
	Broth with noodles or rice	3.1	Stir-fried beef/pork†	3.9	Broth with noodles or rice	4.7	Dried bean or pea soup	4.0	Broth with noodles or Rice	3.8	Roasted/baked chicken (with skin)	3.4
	Canned tuna fish	3.1	Stir-fried chicken†	3.6	Stew/curry (with beef/lamb)	4.1	Beef steak/roast (lean only)	3.9	Canned tuna fish	3.4	Chicken wings*	3.2
	Turkey (no skin)	3.1	Chicken wings*	3.2	Fried fish	3.8	Fried chicken*	3.9	Meat burritos	3.0	Broth with noodles or rice	3.1
	Fried chicken *	2.7	Fried fish	2.8	Fried chicken*	3.6	Stir-fried chicken†	3.7	Fried chicken*	2.9	Stir-fried chicken†	2.9
	Beef steak/roast (lean only)	2.5	Meat loaf/ meatballs/patties	2.7	Chicken wings*	3.6	Tomato or vegetables soup	3.5	Arroz Con Pollo	2.8	Meat loaf/ meatballs/patties	2.6
Total (%)		44.9		38.2		46.5		45.2		42.4		45.4
Poultry subtotal‡		39.3		15.2		23.6		29.5		22.9		28.8
Fish subtotal		3.1		12.5		13.9		0		3.4		9.3
Red meat subtotal§		0		10.5		9.0		7.9		11.9		7.3

*Without skin.
†Including vegetables.
‡Includes broth with noodles or rice.
§Includes chili and meat burritos.

Table 3 Top 10 sources of red meat and relative contributions (%) to total red meat consumption by ethnicity and sex

	African Americans		Native Hawaiians		Japanese Americans		Latino-Mexico		Latino-USA		Caucasians	
	Food items	%	Foods items	%	Foods items	%	Foods items	%	Foods items	%	Foods items	%
Men	Beef steak/roast (lean only)	9.8	Stew/curry (with beef/lamb)	11.5	Stew/curry (with beef/lamb)	13.1	Beef steak/roast (lean only)	10.4	Beef steak/roast (lean only)	11.9	Beef steak/roast (lean only)	12.2
	Meatloaf/meat-balls/Patties	6.5	Stir-fried Beef/pork*	9.2	Stir-fried beef/pork*	11.3	Chili	9.5	Chili	11.1	Stew/curry with beef/lamb	7.4
	Spare ribs	5.6	Beef steak/roast (regular)	6.3	Beef steak/roast (lean only)	7.8	Stew/curry (with beef/lamb)	8.9	Meat burritos	7.0	Meat loaf/meat-balls/patties	6.6
	Pork chops/roast (lean only)	5.4	Meat loaf/meat-balls/patties	6.1	Meat loaf/meat-balls/patties	6.1	Stir-fried beef/Pork*	8.8	Tacos/tostadas (beef/pork)	5.3	Stir-fried beef/pork*	6.3
	Stew/curry (with beef/lamb)	5.4	Beef steak/roast (lean only)	5.4	Beef steak/roast (Regular)	4.6	Dried bean or pea soup	6.1	Pork chops/roast (lean only)	5.1	Beef steak/roast (regular)	5.7
	Stir-fried beef/pork*	4.4	Pork chops/roasts (regular)	4.5	Hamburgers	4.1	Meat burritos	5.7	Stir-fried beef/ pork/vegetables	5.0	Hamburgers	5.1
	Beef steak/roast (regular)	4.4	Spare ribs	4.1	Spare ribs	4.1	Tacos/Tosdadas (beef/pork)	5.1	Meat loaf/meat-balls/patties	5.0	Chili	5.0
	Hamburgers	4.1	Pork and greens or laulaus	3.8	Pork chops/roasts (lean only)	4.0	Beef steak/roast (regular)	4.8	Beef steak/roast (regular)	4.8	Pork chops/roast (lean only)	4.9
	Chili	3.9	Pork chops/roast (lean only)	3.7	Chili	3.7	Meat loaf/meat-balls/patties	3.6	Stew/curry (with beef/lamb)	4.3	Cheeseburgers	3.2
	Pork and greens or laulaus	3.3	Chili	3.6	Corned beef (lean only)	3.3	Pork chops/roast (lean only)	3.4	Hamburgers	3.6	Spare ribs	3.0
Total (%)		52.8		58.2		62.1		66.3		63.1		59.4
Women	Beef steak/roast (lean only)	9.3	Stew/curry (with beef/lamb)	10.5	Stir-fried beef/pork*	14.5	Beef steak/roast (lean only)	11.3	Beef steak/roast (lean only)	12.0	Beef steak/roast (lean only)	14.3
	Meat loaf/meat-balls/patties	7.6	Stir-fried beef/pork*	10.4	Stew/curry (with beef/lamb)	12.1	Chili	9.2	Chili	12.0	Meat loaf/meat-balls/patties	8.0
	Spare ribs	5.5	Meat loaf/meat-balls/patties	7.2	Beef steak/roast (lean only)	9.0	Stir-fried beef/pork*	8.3	Meat burritos	6.2	Stir-fried beef/pork*	7.1
	Pork chops/roast (lean only)	5.4	Beef steak/roast (lean only)	6.0	Meat loaf/meat-balls/patties	7.1	Stew/curry (with beef/lamb)	7.8	Meat loaf/meat-balls/patties	6.2	Stew/curry (with beef/lamb)	6.5
	Stir-fried Beef/pork*	5.1	Beef steak/roast (regular)	4.4	Pork chops/roasts (lean only)	4.6	Dried bean or pea soup	7.3	Tacos/tostadas (beef/pork)	6.1	Pork chops/roast (lean only)	6.1
	Stew/curry (with beef/lamb)	4.7	Pork chops/roasts (lean only)	4.4	Spare ribs	3.8	Tacos/tosdadas (beef/pork)	5.4	Stir-fried beef/ pork*	5.6	Chili	4.7
	Pork and greens or laulaus	4.5	Pork and greens or laulaus	3.9	Corned beef (lean only)	3.5	Meat loaf/meat-balls/patties	5.1	Pork chops/ roasts (lean only)	5.5	Hamburgers	3.8
	Tacos/tosdadas (beef/pork)	4.2	Spare ribs	3.9	Chow mein/chow fun/yakisoba	3.2	Tomato or vegetable soup	4.3	Stew/curry (with beef/lamb)	4.0	Taco/tostadas (beef/pork)	3.8
	Chili	3.7	Chili	3.5	Chili	3.2	Meat burritos	4.1	Beef steak/roast (regular)	3.6	Beef steak/roast (regular)	3.8
	Beef steak/roast (regular)	3.4	Hamburgers	3.4	Hamburgers	2.7	Beef steak/roast (regular)	4.0	Mexican meat soup or stew	3.3	Spaghetti/ravioli/ lasagna	3.8
Total (%)		53.4		57.6		63.7		66.8		64.5		61.9

*Including vegetables.

roast among AfAm, Caucasians and Latinos (9.3–14.3%), stew/curry with beef/lamb among JpAm men and NH (10.5–13.1%), and stir-fried beef or pork with vegetables for JpAm women (14.5%). Lean beef steak/roast contributed to a lesser degree among JpAm and NH (5.4–9.0%). Meat burritos appeared in the top 10 lists only for Latinos who also consumed chili in significant amounts.

Contribution of meat to nutrient intakes

Among the top 10 foods, meats contributed approximately 20% or more to vitamin B_{12} intake. Fish was the second highest contributor to vitamin B_{12} intake in all ethnic-sex groups, except in Latino-Mexico men and women and Caucasian women, among whom fish appeared in third and fourth place. Similarly, liver ranked among the top three contributors for AfAm, NH, Latino-US and Latino-Mexico women. Beef and lamb were also notable contributors to vitamin B_{12} intake, usually ranking between third and fifth place. However, cereals (11.7–25.5%) were the single top contributor to vitamin B_{12} intake in each ethnic-sex group (Table 4).

Among the 10 major dietary sources of daily iron intake, the contribution of meat varied between 4.3% in Caucasian women and 14.2% in NH men (Table 5). By comparison, the contribution of cereals to total daily iron intake ranged from 13.8% in Latino-Mexico men to 30.8% in Latino-Mexico women. Cereals were followed by rice and bread, except among AfAm women and Caucasian men for whom pasta (with tomato sauce/cheese) and, for Latino-Mexico women, beans followed cereals and bread. Overall, beans contributed 1.9–3.5% to total daily iron intake for most ethnic-sex groups, except for JpAm and NH individuals where beans did not appear among the top 10 contributors to iron intake.

Cereals were also the top contributor to total daily zinc intakes across all ethnic-sex groups (8.6–20.6%), except for JpAm men for whom rice was the highest contributor (14.6%; Table 6). However, within the top 10 dietary zinc sources (which accounted for 50.7–59.9% of dietary zinc), the contribution of meat ranged from 11.1% in Caucasian women to 29.3% in NH men. Burgers, meatballs and meat patties were the third major contributor to total daily zinc intake only for AfAm men and NH women, whereas beef and lamb or bread was the third top source of zinc intake for all other ethnic-sex groups. Interestingly, wine was the second top contributor to zinc for Caucasian women (5.9%) and it was also one of the major dietary sources of zinc for AfAm women, Latino-Mexico and Caucasian, with a contribution ranging from 2.7% to 4.1%.

Discussion

The present study examined sources of meat consumption and their respective contributions to selected mineral and vitamin intakes among five ethnic/racial groups in the USA. The results obtained indicate a clear variability in major meat sources and their contributions to vitamin B_{12}, iron and zinc intakes by ethnicity and sex. Variations could be attributed to different geographical and cultural influences (Carrera *et al.*, 2007; Talegawkar *et al.*, 2008). For example, in the present study, fish was one of the 10 major sources of total meat among Latino-USA individuals; however, it was not among the top 10 for Latino-Mexico individuals. This emphasises the importance of investigating dietary patterns in each ethnic group in the aetiology of chronic diseases.

In the present study, the contribution of poultry exceeded that of red meat and fish among all ethnic/racial groups, except for Latino-Mexico men. It has been reported that the consumption of red meat decreased from 1980 to 2004, whereas the intake of poultry increased in the USA (Ward, 2006) and similar trends were observed in the UK (Prynne *et al.*, 2009). Several factors could have been responsible for these changing trends. Substitution of poultry for red meat may be related to the increased perception of the saturated fat content of red meat being considered as unhealthy since the late 1970s (Eckel *et al.*, 2009). Over the past decade, the US government has promoted healthier eating and food manufacturers have responded by providing foods, new or reformulated, with added healthy attributes and claims. Furthermore, consumer awareness of basic food components increased after the passage of the 1990 Nutritional Label and Education Act (Yen *et al.*, 2008).

In all ethnic-sex groups, the three red meats, beef, lamb and pork, were consumed in comparable amounts, which was similar to findings from the National Health and Nutrition Examination Survey (NHANES) based on a sample of 15 006 US adults (Wang & Beydoun, 2009). Although red meat is a good source of high-quality protein and other essential nutrients, studies have found correlations to several health risks, including a shorter life span and a higher risk of cardiovascular diseases, diabetes and cancer (Vang *et al.*, 2008; Halkjaer *et al.*, 2009; Lee *et al.*, 2009; Sinha *et al.*, 2009; Wang & Beydoun, 2009; Erber *et al.*, 2010). These associations could be attributable to several meat components, such as carcinogens formed in meat when cooked at a high temperature, as well as the high energy and saturated fat content of red meat (Tasevska *et al.*, 2009; Wang & Beydoun, 2009). In another MEC study, red meat was a

Table 4 Top 10 food sources and relative contributions (%) to daily vitamin B_{12} intakes by ethnicity and sex

	African Americans		Native Hawaiians		Japanese Americans		Latino-Mexico		Latino-USA		Caucasians	
	Food items	%	Foods items	%	Foods items	%	Foods items	%	Foods items	%	Foods items	%
Men	Cereals	21.1	Cereals	14.6	Cereals	17.1	Cereals	11.7	Cereals	17.1	Cereals	20.3
	Fish	7.7	Fish	12.9	Fish	14.2	Beef and lamb	9.3	Fish	9.3	Fish	7.6
	Liver	6.7	Liver	6.5	Beef and lamb	6.2	Fish	7.6	Liver	6.3	Pasta with TS or cheese	7.5
	Burg. MB/patties	6.6	Beef and lamb	6.3	Burg. MB/patties	5.9	Veg. soups	5.5	Beef and lamb	6.2	Burg. MB/patties	6.0
	Veg. soups	5.3	Burg. MB/patties	6.2	Shrimp/shellfish	5.1	Low-fat milk	5.2	Burg. MB/patties	6.1	Beef and lamb	5.3
	Pasta with TS or cheese	5.2	Shrimp/shellfish	5.0	Veg. soups	4.7	Burg. MB/patties	4.9	Pasta with TS or cheese	5.1	Veg. soups	4.7
	Beef and lamb	4.6	Veg. soups	4.5	Pasta with TS or cheese	4.1	Liver	4.4	Veg. soups	4.8	Low-fat milk	4.7
	Shrimp/shellfish	4.5	Pasta with TS or cheese	4.1	Liver	3.8	Meat soups/stew	4.3	Shrimp/shellfish	4.0	Liver	4.2
	Low-fat milk	3.7	Low-fat milk	3.4	Nonfat milk	3.3	Pasta with TS or cheese	4.2	Low-fat milk	3.5	Nonfat milk	3.7
	HD-spam – bologna-other	2.8	HD-spam-bologna-other	3.1	Meat soups/stew	3.2	Taco salad	4.2	HD-spam-bologna	3.0	Shrimp/shellfish	3.6
Total (%)		68.2		66.6		67.6		61.3		65.4		67.6
Women	Cereals	23.2	Cereals	16.6	Cereals	19.5	Cereals	25.5	Cereals	19.7	Cereals	21.6
	Fish	8.8	Fish	11.8	Fish	13.3	Low-fat milk	5.8	Fish	8.9	Pasta with TS or cheese	7.8
	Liver	7.6	Liver	7.6	Nonfat milk	6.1	Liver	5.8	Liver	6.2	Fish	7.5
	Pasta with TS or cheese	5.4	Burg. MB/patties	5.8	Burg. MB/patties	5.0	Fish	4.9	Pasta with TS or cheese	6.0	Nonfat milk	6.0
	Low-fat milk	4.5	Beef and lamb	5.0	Beef and lamb	4.9	Burg. MB/patties	4.7	Veg. soups	4.9	Low-fat milk	5.2
	Burg. MB/patties	4.3	Pasta with TS or cheese	4.7	Pasta with TS or cheese	4.6	Nonfat milk	4.6	Burg. MB/patties	4.9	Burg. MB/patties	4.4
	Beef and lamb	3.9	Veg. soups	4.5	Veg. soups	4.2	Pasta with TS or cheese	4.4	Beef and lamb	4.9	Beef and lamb	4.2
	Shrimp/shellfish	3.6	Shrimp/shellfish	4.2	Shrimp/shellfish	4.0	Beef and lamb	4.3	Low-fat milk	4.2	Liver	4.0
	Veg. soups	3.1	Low-fat milk	4.1	Low-fat milk	3.9	Veg. soups	4.1	Shrimp/shellfish	3.7	Veg. soups	3.9
	Yogurt	3.1	Nonfat milk	3.3	Stir-fried MT and Veg	3.0	Yogurt	3.0	Nonfat milk	3.4	Yogurt	3.5
Total (%)		67.5		67.6		68.5		67.1		66.8		68.1

Burg., burgers; HD, hot dog; MB, meat ball; MT, meat; TS, tomato sauce; Veg, vegetables.

Table 5 Top 10 food sources and relative contributions (%) to daily iron intakes by ethnicity and sex

	African Americans		Native Hawaiians		Japanese Americans		Latino-Mexico		Latino-USA		Caucasians	
	Food items	%	Foods items	%	Foods items	%	Foods items	%	Foods items	%	Foods items	%
Men	Cereals	26.0	Cereals	20.1	Cereals	21.1	Cereals	13.8	Cereals	22.1	Cereals	26.8
	Bread	9.7	Bread	8.9	Rice	11.0	Bread	13.4	Bread	9.3	Bread	9.8
	Rice	3.6	Rice	7.7	Bread	8.1	Rice	4.2	Rice	6.9	Pasta with TS or cheese	5.0
	Burg. MB/patties	3.6	Burg. MB/patties	3.4	Burg. MB/patties	2.8	Muffins/dough-nuts	3.6	Pasta with TS or cheese	3.5	Burg. MB/patties	3.2
	Pasta with TS or cheese	3.5	Pasta with TS or cheese	2.7	Pasta with TS or cheese	2.7	Beans	3.5	Burg. MB/patties	3.3	Rice	2.9
	Chicken/turkeys	3.3	Chicken/turkeys	2.4	Chicken/turkeys	2.6	Taco salad	3.3	Chicken/turkeys	2.6	Chicken/turkeys	2.2
	Beans	2.6	Stir-fried MT and Veg	2.2	Stir-fried MT and Veg	2.6	Meat burritos	2.9	Beans	2.2	Beans	2.0
	Veg. soups	1.7	Beef and lamb	2.2	Fish	2.1	Beef and lamb	2.8	Beef and lamb	2.1	Beef and lamb	1.8
	Crackers/chips/popcorn	1.6	Fish	2.1	Meat soups/stew	1.9	Pasta with TS or cheese	2.7	Stir-fried MT and Veg	1.9	Crackers/chips/popcorn	1.6
	Beef and lamb	1.5	Meat soups/stew	1.9	Beef and lamb	1.9	Burg. MB/patties	2.5	Meat soups/stew	1.8	Veg. soups	1.6
Total (%)		57.1		53.6		56.8		52.7		55.7		56.9
Women	Cereals	26.4	Cereals	22.5	Cereals	22.6	Cereals	30.8	Cereals	24.3	Cereals	26.6
	Bread	9.0	Bread	9.3	Bread	9.3	Bread	6.9	Bread	10.1	Bread	11.0
	Pasta with TS or cheese	4.1	Rice	5.3	Rice	8.3	Beans	3.4	Rice	5.2	Pasta with TS or cheese	5.1
	Chicken/turkeys	3.1	Pasta with TS or cheese	3.2	Pasta with TS or cheese	3.0	Pasta with TS or cheese	3.2	Pasta with TS or cheese	3.8	Rice	2.2
	Beans	2.5	Burg. MB/patties	3.0	Stir-fried MT and Veg	2.7	Rice	2.6	Chicken/turkeys	2.4	Chicken/turkeys	2.2
	Rice	2.4	Chicken/turkeys	2.2	Dark greens	2.5	Chicken/turkeys	2.5	Burg. MB/patties	2.3	Burg. MB/patties	2.1
	Crackers/chips/popcorn	2.4	Stir-fried MT and Veg	2.2	Chicken/turkeys	2.2	Fortified diet beverages	2.2	Stir-fried MT and Veg	2.2	Dark greens	2.0
	Burg. MB/patties	2.1	Dark greens	2.0	Burg. MB/patties	2.1	Burg. MB/patties	2.1	Beans	2.2	Beans	1.9
	Dark greens	2.0	Fish	1.9	Tofu	1.8	Veg. soups	1.9	Dark greens	1.9	Crackers and pretzels	1.7
	Stir-fried MT and Veg	1.8	Beef and lamb	1.7	Fish	1.7	Pizza	1.9	Veg. soups	1.8	Crackers/chips/popcorn	1.6
Total (%)		55.8		53.3		56.2		57.5		56.2		56.4

Burg., burger; MT, meat; MB, meat ball; TS, tomato sauce; Veg, vegetables.

Table 6 Top 10 food sources and relative contributions (%) to daily zinc intakes by ethnicity and sex

	African Americans		Native Hawaiians		Japanese Americans		Latino-Mexico		Latino-USA		Caucasians	
	Food items	%	Foods items	%	Foods items	%	Foods items	%	Foods items	%	Foods items	%
Men	Cereals	17.4	Cereals	12.7	Rice	14.6	Cereals	8.6	Cereals	14.0	Cereals	17.0
	Chicken/turkeys	5.7	Rice	9.9	Cereals	13.1	Beef and lamb	7.0	Rice	8.8	Burg. MB/patties	5.1
	Burg. MB/patties	5.5	Beef and lamb	5.7	Beef and lamb	4.9	Bread	5.9	Beef and lamb	5.3	Bread	4.9
	Bread	5.3	Burg. MB/patties	5.3	Chicken/turkeys	4.5	Taco salad	5.3	Burg. MB/patties	5.1	Beef and lamb	4.7
	Rice	5.0	Bread	4.4	Burg. MB/patties	4.4	Meat soups/stew	5.2	Chicken/turkeys	4.5	Pasta with TS or cheese	4.1
	Beef and lamb	3.9	Meat soups/stew	4.2	Meat soups/stew	4.4	Rice	4.4	Bread	4.5	Chicken/turkeys	4.1
	Pork and ham	3.2	Chicken/turkeys	4.1	Bread	4.1	Wine	4.1	Meat soups/stew	3.9	Rice	3.9
	Shrimp/shellfish	3.1	Pork and ham	3.4	Stir-fried MT and Veg	3.6	Meat burritos	3.8	Pork and ham	3.0	Wine	3.8
	Pasta with TS or cheese	3.0	Shrimp/shellfish	3.4	Shrimp/shellfish	3.6	Chicken/turkeys	3.7	Shrimp/shellfish	2.9	Shrimp/shellfish	2.4
	Meat soups/stew	2.2	Stir-fried MT and Veg	3.2	Pork and ham	2.7	Burg. MB/patties	3.6	Pasta with TS or cheese	2.8	Pork and ham	2.4
Total (%)		51.2		56.3		59.9		51.6		54.8		52.4
Women	Cereals	18.3	Cereals	14.6	Cereals	14.6	Cereals	20.6	Cereals	15.8	Cereals	17.3
	Chicken/turkeys	5.9	Rice	7.2	Rice	12.1	Chicken/turkeys	4.8	Rice	6.8	Wine	5.9
	Bread	4.9	Burg. MB/patties	4.9	Bread	5.1	Bread	3.8	Bread	5.3	Bread	5.7
	Pasta with TS or chee	3.6	Bread	4.8	Chicken/turkeys	4.4	Burg. MB/patties	3.7	Chicken/turkeys	4.5	Pasta with TS or cheese	4.3
	Rice	3.5	Beef and lamb	4.5	Stir-fried MT and Veg	4.1	Beef and lamb	3.5	Beef and lamb	4.0	Chicken/turkeys	4.2
	Burg. MB/patties	3.5	Chicken/turkeys	4.1	Beef and lamb	3.7	Wine	3.3	Burg. MB/patties	3.9	Burg. MB/patties	3.5
	Crackers/chips/ popcorn	3.3	Meat soups/stew	3.4	Burg. MB/patties	3.6	Rice	2.9	Pasta with TS or cheese	3.2	Beef and lamb	3.4
	Beef and lamb	3.2	Stir-fried MT and Veg	3.2	Meat soups/stew	3.3	Cheese	2.8	Meat soups/stew	3.2	Rice	3.2
	Wine	2.7	Shrimp/shellfish	2.9	Shrimp/shellfish	2.8	Pork and ham	2.7	Stir-fried MT and Veg	3.2	Cheese	2.6
	Stir-fried MT and Veg	2.6	Pork and ham	2.8	Pasta with TS or cheese	2.5	Pasta with TS or cheese	2.6	Shrimp/shellfish	2.8	Nonfat milk	2.4
Total (%)		51.5		52.4		56.2		50.7		52.7		52.5

Burg., burger; MB, meatball; MT, meat; TS, tomato sauce; Veg, vegetables.

major source of energy, fat and saturated fat intake for AfAm but not other ethnic/racial groups (S. Sharma, L.R. Wilkens, L. Shen & L.N. Kolonel, unpublished data).

As a result of these health concerns, limited consumption of red meat is recommended to reduce risk of obesity, cancer and other chronic diseases (Ford *et al.*, 2009; Popkin, 2009). However, lean red meat could be a healthy alternative because it is low in saturated fat, and it is also a good source of protein, omega-3 fatty acids, vitamin B_{12}, niacin, zinc and iron (Li *et al.*, 2005; Symons *et al.*, 2009; Welch *et al.*, 2009). Evidence suggests that lean red meat alternatives have important roles in the prevention and management of chronic diseases, including heart health, cancer and weight management (Hodgson *et al.*, 2006; McAfee *et al.*, 2010). In the present study, contributions of lean red meats among the top 10 varied from 9.1% to 20.4% of total red meat intake among ethnic-sex groups, and lean beef was the top red meat source among all groups, except for NH and JpAm individuals. These findings emphasise the need for culturally appropriate nutrition education programmes promoting healthy lifestyle choices to reduce the burden of chronic diseases in these populations.

Meats contributed significantly to zinc and vitamin B_{12} intakes and, to a lesser extent, iron intakes. Other studies have demonstrated a high contribution of meats to iron, zinc and vitamin B_{12} intakes (Cosgrove *et al.*, 2005a,b; Welch *et al.*, 2009). However, in the present study, the contribution of meats to iron was lower than the contribution of cereals, rice, bread or pastas for all ethnic-sex groups, which may partly be a result of the mandatory fortification of cereal and grain foods (WHO, FAO, UNICEF, GAIN, MI, FFI, 2009; Beinner *et al.*, 2010; Tripathi & Platel, 2010). Despite this finding, it is important to consider that the bioavailability of haeme iron from red meat is greater than of non-haeme iron (Clark, 2008).

Analyses of the NHANES database have highlighted areas of public health concern with regard to micronutrient status of the general US population. Data from NHANES (1999–2000) suggested that iron intakes were generally low in females of childbearing age and young children (McClung *et al.*, 2006). The prevalence of iron deficiency is greater in non-Hispanic black and Mexican-American females (19–22%) than in non-Hispanic white females (10%; McClung *et al.*, 2006). An analysis of NHANES III data found that 35–45% of adults aged $\geq$60 years had zinc intakes below the estimated average requirement (Ervin & Kennedy-Stephenson, 2002). Meat consumption and certain minerals, including iron and zinc, have been identified as topics of interest in the aetiology of certain chronic diseases including cancer, CVD, diabetes and osteoporosis (Halkjaer *et al.*, 2009; Welch *et al.*, 2009; Yamaguchi, 2009; Chua *et al.*, 2010). The results from the present study may potentially be used to help alleviate some of these concerns through the development of food-based dietary guidelines, especially for high-risk ethnic minorities. For example, recommendations for the increased consumption of lean red meat and poultry could help to reduce chronic disease risks, and increase iron, zinc and vitamin B_{12} intakes, very likely resulting in a diet with better nutrient quality.

Thus, understanding the associations between dietary patterns and chronic disease is important for identifying strategies to decrease chronic disease incidence, especially among different ethnic groups. Comparable and detailed information on foods contributing to meat and selected nutrient intake among the five main ethnic/racial groups in the USA is useful for conducting and interpreting the results of epidemiological dietary studies. One of the strengths of the present study is the use of a QFFQ developed and validated for the multi-ethnic population to assure standardised data collection among the five ethnic/racial groups. A standardised food grouping methodology of meats and their subgroups was used and based on the national recommendations. Furthermore, the large multi-ethnic sample makes it possible to study how meat consumption patterns vary between these groups. The limitations of the present study include recall bias. Also, measurement error is known to be higher with FFQs compared to other methods (Ranka *et al.*, 2008). Another limitation is that the data available for the present study were collected over 15 years ago. If dietary patterns have changed over time, this may have impacted the generalisability of these results to the current populations. Thus, more recent data would be useful to determine if changes ethnic-specific changes in the dietary patterns have occurred over time.

In conclusion, the present study indicates that variability exists among major sources of meat and their contributions to vitamin B_{12}, iron and zinc intakes among ethnic-sex groups, which are important considerations in studies of diet and chronic disease risk. Although poultry was the most commonly consumed meat source among most ethnic-sex groups, lean red meat was also a major source consumed, although this varied by ethnic/racial group. The present study adds to the limited literature on sources of meats and nutrients among different ethnic groups, particularly minorities. It serves as a basis for nutrition researchers and dietitians to make culturally appropriate recommendations to improve dietary quality, as well as for future research investigating the association between meat intake and chronic disease and for the development of food-based dietary guidelines, especially for high-risk ethnic minorities.

Conflict of interests, source of funding and authorship

The authors declare that there are no conflicts of interest.

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