Meta Science 98 (2014) 452–460

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Inclusion of red meat in healthful dietary patterns

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ARTICLE INFO

Article history:
Received 15 April 2014
Received in revised form 19 June 2014
Accepted 20 June 2014
Available online 28 June 2014

Keywords:
Red meat
Beef
Health
Nutrition guidance
Dietary patterns

ABSTRACT

Dietary patterns are an important concept in dietary recommendations. The Western pattern is most commonly defined as a diet characterized by high intakes of refined grains, sugar and red meat, and has been shown to be associated with increased risks for certain types of cancer, coronary heart disease, diabetes, and obesity. However, isolating the independent effects of individual foods on health outcomes is central to helping individuals choose foods to build healthier dietary patterns to which they can adhere. Red meat is a popular source of high quality protein and provides a variety of essential nutrients that improve overall diet quality. It is also a source of saturated fatty acids, which observational evidence suggests are associated with heart disease, although recent data challenge this. Several studies have shown that lean red meat can be successfully included in recommended heart-healthy dietary patterns without detriment to blood lipids. Furthermore, increased dietary protein has been shown to promote healthy body weight and composition, in part by increasing satiety, and to improve vitality and stamina.

1. Introduction

The U.S. Department of Health and Human Services and the U.S. Department of Agriculture (USDA) have jointly issued Dietary Guidelines at an interval of every 5 years since 1980. The next Dietary Guidelines are slated for publication in 2015 (U.S. Department of Health and Human Services, 2014). The current Dietary Guidelines Advisory Committee (DGAC) recommends limiting saturated fatty acid [SFA] intake to <10% of kcal (emphasizing replacement with monounsaturated fatty acids [MUFA] and polyunsaturated fatty acids [PUFA]) and limiting dietary cholesterol to <300 mg per day, supporting a whole diet or dietary pattern approach to achieve these targets (U.S. Department of Health and Human Services, 2010). The Western dietary pattern is typically described as a diet characterized by high intakes of refined grains, sugar, red meat and other animal products, and fat, and has frequently been shown to be associated with negative health outcomes such as increased risk for certain types of cancer (Abid, Cross, & Sinha, 2014; Alexander, Mink, Cushing, & Sceurman, 2010; Alexander, Morimoto, Mink, & Cushing, 2010; Alexander, Weed, Cushing, & Lowe, 2011; Fung et al., 2003; Michaud et al., 2001), coronary heart disease (Bernstein, Sun, Hu, Stampfer, Manson, & Willet 2010; Clifton, 2011; Hu et al., 2000), diabetes (Aune, Ursin, & Veierod, 2009; Fung, Schulze, Manson, Willett, & Hu, 2004; Lutsey, Steffen, & Stevens, 2008; Pan et al., 2011; Song, Manson, Buring, & Liu, 2004), and obesity (O'Keefe & Abuannadi, 2010). The World Cancer Research Fund/American Institute for Cancer Research Project stated that there was convincing evidence of a causal relationship between red meat and processed meat consumption and colorectal cancer (World Cancer Research Fund & American Institute for Cancer Research, 2011). However, that conclusion has been controversial. The association is relatively modest and in a range where it is difficult to rule out bias and confounding as alternate explanations. These issues led to the decision by the 2010 DGAC to conduct another review that included only prospective cohort studies in humans published since 2000 (U.S. Department of Health and Human Services, 2010). The DGAC reported inconsistent positive associations between colorectal cancer and certain animal protein products, mainly red and processed meat, and concluded that, in general, studies showed no consistent findings with regard to the quantity and type of meat or meat product and colorectal cancer. Furthermore the report stated that the studies examined often had little information on other factors, such as the way meat is cooked, which might be expected to affect the association. It is also important to consider that observational studies cannot reliably separate the relationships of the disease under study with individual components of a dietary pattern because of interrelationships among correlated dietary variables (Maki, Slavin, Rains, & Kris-Etherton, 2014). The contribution that red meat has toward SFA intake and possible adverse effects on health outcomes are also often misunderstood, particularly as the availability and consumption of lean cuts of red meat have increased. Furthermore, the contribution made by lean red meat as a source of high quality protein and essential nutrients is frequently overlooked (McAfee et al., 2010). It is therefore important to

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http://dx.doi.org/10.1016/j.meatsci.2014.06.028

disentangle the effects on health outcomes of the individual foods, such as red meat, from that of the other components of a Western dietary pattern in order to identify more healthful dietary patterns. This review presents the case for the benefits of lean red meat, with an emphasis on lean beef, as a high-protein, nutrient-rich, popular food, which can be incorporated into dietary patterns recommended for improved health.

2. Consumer preferences for red meat

The definition of red meat vs. white meat is not universal, but beef, pork, mutton, and veal are generally classified as red meat. Beef is the predominate red meat consumed in several developed nations (e.g., U.S., Canada and Australia) (McNeill & Van Elswyk, 2012). Overall meat consumption is on the rise in developed nations worldwide (Daniel, Cross, Koebnick, & Sinha, 2011). While there has been a shift toward increased poultry consumption in the U.S., red meat still represents the largest proportion of meat consumed (Daniel et al., 2011), but it is anticipated that this may change in coming years. Research from the Mintel Group indicates that 90% of U.S. consumers report eating some kind of red meat at least once per month, but that ~39% of beef and other red meat consumers ate less in 2013 than they did in 2012, and 25% of pork consumers claimed to have eaten less pork in 2013 than in 2012. In contrast, only 10% of beef and other red meat eaters reported eating more, and only 13% of pork consumers are eating more (Mintel Group, 2014). Global food analysts note that trends motivating consumers to cut fat and cholesterol intake are the dominant factors affecting the red meat market (Mintel Group, 2014).

Consumer preferences for leaner cuts of red meat, driven by dietary guidance in recent decades instructing the increased consumption of lean meats and trimming excess fat from meats, have resulted in changes in meat production and merchandising that produce meats with 80% less external fat (McNeill, Harris, Field, & Van Elswyk, 2012; Savell et al., 2005). Currently, approximately two-thirds of the beef sold retail in the U.S. meets the government guidelines for lean (McNeill et al., 2012). Despite the increased availability of lean cuts, there continue to be misconceptions among consumers and nutrition professionals about the fat content and healthfulness of red meat. A high proportion of U.S. dietitians were reported to regard beef as a greater source of SFA than pork, poultry, and dairy products (McNeill et al., 2012), despite the fact that dairy products are the largest contributor to SFA intake in the American diet (U.S. Department of Health and Human Services, 2010). The perception of the healthiness of beef among European consumers appears to be more favorable (Van Wezemael, Verbeke, de Barcellos, Scholderer, & Perez-Cueto, 2010).

The versatility of red meat as an entree or an ingredient in recipes, coupled with the wide variety of types of red meat available, increases the ease with which people following different dietary patterns, including those currently recommended by health organizations, can include red meat (Eckel et al., 2013; U.S. Department of Health and Human Services, 2010). The flexibility that this variety offers as well as the large number of people who already report enjoying red meat as part of their regular diets, would be expected to enhance compliance with healthful dietary patterns that incorporate lean red meat, compared to dietary advice that discourages consumption of red meat. Epidemiologic studies have shown that individuals attempting to follow a predominantly plant-based diet have improved compliance when incorporating lean beef (Fung et al., 2010; Jenkins et al., 2009). Clinical trial evidence also supports the usefulness of lean red meat for improving long-term dietary compliance as demonstrated in a 76-week crossover study of subjects with mild-to-moderate hypercholesterolemia who consumed lean red meat (beef, veal and pork) or lean white meat (poultry and fish) (Davidson, Hunninghake, Maki, Kwiterovich, & Kafonek, 1999; Hunninghake et al., 2000). When consuming the lean red meat diet, subjects more consistently achieved their weekly meat intake goals (6 oz of lean meat per day, 5–7 days per week, consuming at least 80% of their meat from the assigned meat category) compared with when consuming lean white meat (Hunninghake et al., 2000).

3. Red meat and cardiovascular health

The root of most of the restrictions proposed for red meat consumption stems from red meat as a source of SFA, which has historically been believed to increase the risk for heart disease (Keys et al., 1966). However, the relationship between SFA intake and risk for heart disease is complex, and recent evidence challenges earlier conclusions (Astrup et al., 2011; Baum et al., 2012; Chowdhury et al., 2014; Siri-Tarino, Sun, Hu, & Krauss, 2010a, 2010b). A meta-analysis demonstrated that in 20 observational studies, relative risk for coronary disease with SFA was 1.03 (95% confidence interval 0.98 to 1.07) when the top and bottom tertiles of consumption were compared (Chowdhury et al., 2014). Not only does the observational evidence regarding the association between SFA and heart disease appear to be inconsistent, but also the methods for evaluating evidence and the reliance on certain types of evidence for making dietary recommendations have been called into question (McAfee et al., 2010). A review of evidence-based dietary guidance suggested that advisory committees have often excluded valid evidence and ignored key outcome variables when examining the association between SFA intake and cardiovascular disease such that many current conclusions and recommendations do not reflect the full body of available evidence (Hoenselaar, 2012). Another recent review explained the limitations of observational data, such as imprecise exposure quantification, collinearity among dietary exposures, displacement/substitution effects, healthy/unconsumer bias, residual confounding, and effect modification, and made the argument that dietary recommendations should not be supported solely, or primarily, by data from prospective cohort studies (Maki et al., 2014).

When considered in its totality, the science reflects that red meat is not a unique contributor to SFA, and further that other dietary risk factors may play an even larger role in diet-related disease risk. The relationship between SFA and heart disease depends to a large degree on the comparator. Replacing SFA with MUFA or PUFA may be beneficial, but replacing SFA with some other dietary components, such as refined carbohydrates, may increase the risk (Baum et al., 2012). Research suggests that *trans* fatty acid intake (Hoenselaar, 2012; Mozaffarian, Aro, & Willett, 2009), diets with a high glycemic index (Jakobsen et al., 2010), and high dietary salt may be more significant risk factors for heart disease than dietary SFA (Aaron & Sanders, 2013; Mozaffarian et al., 2009). Furthermore, recent investigations suggest that increased consumption of refined carbohydrates is associated with cardiovascular risk (Baum et al., 2012; Flock, Fleming, & Kris-Etherton, 2014; Siri-Tarino et al., 2010a, 2010b). Results from a recent pooled analysis of cohort studies suggested that, when compared calorie-for-calorie, there was a significantly greater relative risk for coronary heart disease with intake of carbohydrate than SFA (Jakobsen et al., 2009). An examination of the dietary intakes of Americans since the inception of the Dietary Guidelines shows that intakes of refined grains and sugars have increased, and that there has been a shift away from beef consumption, perceived to be less healthy, and toward increased poultry consumption, while total caloric intake from protein has remained relatively constant (Fig. 1) (U.S. Department of Health and Human Services, 2010). Although the intent of the Dietary Guidelines was not to achieve a reduction in SFA by increasing carbohydrate intake, particularly refined carbohydrates, this has been the unfortunate result of the implementation of these recommendations.

A broader understanding of the fatty acid profile of lean red meat is important to understand its relationship with cardiovascular health. Fifty-four percent of the fatty acids in beef are MUFA or PUFA. Of the SFA in beef, nearly one-third are stearic acid (18:0) which has a neutral effect on total cholesterol (−C) and low-density lipoprotein (LDL)-C (Denke, 1994; Hunter, Zhang, & Kris-Etherton, 2010; U.S. Department

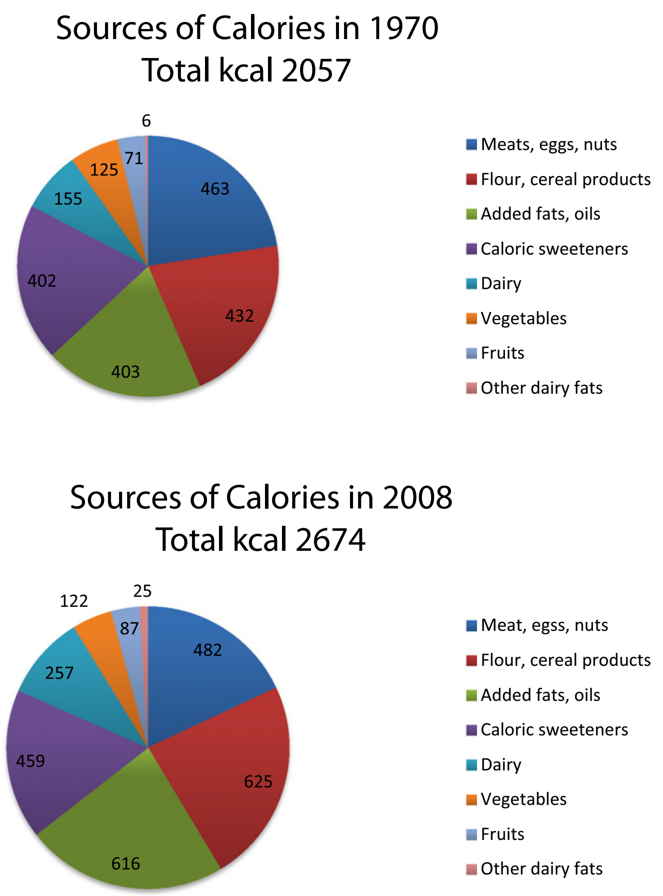

Fig. 1. Shifts in calorie sources in the United States*. *Values reported on figures are kcal. Adapted from 2010 Dietary Guidelines for Advisory Committee Report.

of Health and Human Services, 2010). The 2010 DGAC report defined cholesterol-raising fatty acids as SFAs minus stearic acid (U.S. Department of Health and Human Services, 2010).

In several studies, when incorporated into low-fat, "heart-healthy" diets, lean red meat has been shown to be equal to lean white meat for lowering total-C and LDL-C (Davidson et al., 1999; Hunninghake et al., 2000; Li, Siriamornpun, Wahlqvist, Mann, & Sinclair, 2005; Scott, Ellison, Wittels, et al., 1991; Scott et al., 1994). A systematic review by Li et al. in 2005 concluded that, in diets with ≤10% SFA, fresh red meat consumed by healthy and mildly hypercholesterolemic persons was associated with reduced LDL-C (Li et al., 2005). Regarding beef specifically, a meta-analysis of eight randomized clinical trials comparing conventionally reared beef to lean white meat in a variety of diets found beef to be equally effective to white meat for reducing total-C, LDL-C, and triglycerides (Fig. 2) (Maki et al., 2012). Roussell et al. recently reported results from the Beef in Optimal Lean Diet (BOLD) study in which a Dietary Approaches to Stop Hypertension (DASH)-type diet, which traditionally limits beef to 28.3 g/d, was modified to include up to 141 g of lean beef per day (Table 1) (Roussell et al., 2012). The increased beef diet was equally effective for reducing total-C, LDL-C, and non-high-density lipoprotein (non-HDL)-C, and was more effective for reducing apolipoprotein B (data not shown), than the traditional red meat-limiting DASH diet (Table 2). With regard to other cardiovascular health effects, randomized clinical trial evidence supports the conclusion that neither red meat, nor beef specifically, adversely affects blood pressure and may even improve blood pressure and vascular reactivity when replacing refined carbohydrate (Hodgson, Burke, Beilin, & Puddey, 2006; Nowson, Wattanapenpaiboon, & Pachett, 2009).

4. Recommended heart-healthy dietary patterns with inclusion of red meat

4.1. Current intakes

Due to its high popularity with consumers, there is a common misconception that red meat, and beef in particular, is consumed in amounts that exceed recommended levels. Dietary recommendations in developed countries recommend intakes of meat and "meat alternatives" (i.e., nuts, seeds) ranging from ~65 to 250 g/d for adults (McNeill & Van Elswyk, 2012). The 2010 U.S. Dietary Guidelines recommend consumption of ~5.5 oz/d (~150 g/d, depending on age and gender) of protein foods (meat, poultry, seafood, eggs, beans and peas, soy, nuts and seeds) (U.S. Department of Health and Human Services, 2010). The average consumption of beef in the U.S. has been estimated to be 1.7 oz (~57 g) per day (Zanovec, O'Neil, Keast, Fulgoni, & Nicklas, 2010). Contrary to popular belief, Americans appear to be consuming moderate amounts of red meat, well within the recommended healthy eating patterns recommended by Dietary Guidelines.

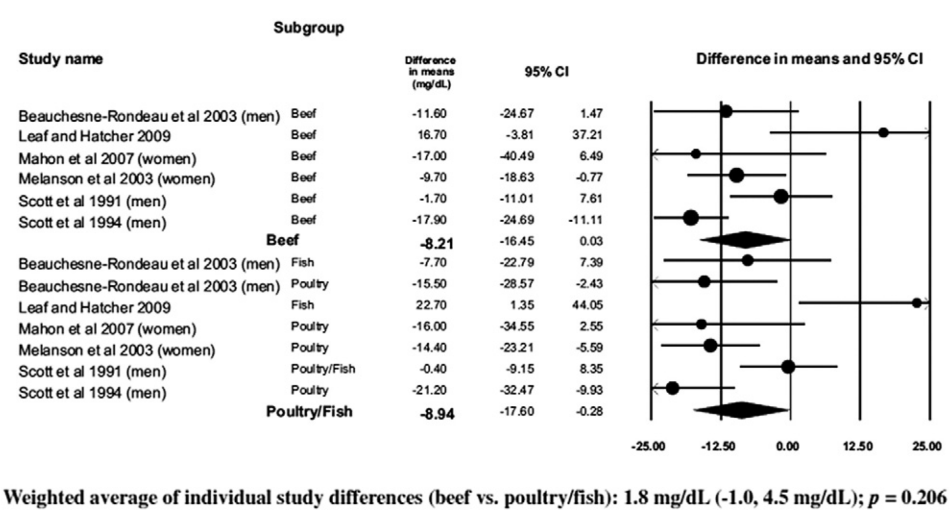

Fig. 2. Meta-analysis results of the effects of beef or poultry/fish consumption on LDL-C*. *Circle sizes are proportional to the weights used in the meta-analysis, and the lines indicate 95% confidence intervals (CI). The diamond represents the summary measure (mean and 95% CI) for the lipoprotein lipid impacts of beef or poultry/fish consumption. I^2 (beef) = 42.0%, p = 0.01; I^2 (poultry and/or fish) = 36.9%, p = 0.003.
Taken from: Maki 2012. Permission granted for re-use.

Table 1
The Healthy American Diet, Dietary Approaches to Stop Hypertension (DASH) diet, Beef in an Optimal Lean Diet (BOLD), and BOLD plus additional protein diet in the BOLD study. Adapted from Roussell et al., 2012.

	Healthy American Diet	DASH Diet	BOLD Diet	BOLD + protein Diet
Nutrients				
Total calories, kcal	2097	2106	2100	2104
Protein, % of kcal	17	18	19	27
Carbohydrate, % of kcal	50	55	54	45
Fat, % of kcal	33	27	28	28
SFA, % of kcal	12	6	6	6
PUFA, % of kcal	7	8	7	7
MUFA, % of kcal	11	9	11	12
Cholesterol, mg	287	188	168	193
Fiber, g	24	36	32	38
Sodium, mg	3243	2983	2712	3344
Potassium, mg	3259	4247	3998	4417
Calcium, mg	993	1140	936	1060
Magnesium, mg	308	403	392	429
Food groups, servings/d				
Fruit and juice, cups	3.1	4.1	4.5	3.4
Vegetables, cups	3.2	4.3	3.9	4.6
Grains, oz	8.3	4.5	5.6	5.3
Low-fat dairy, cups	1.2	2.3	1.8	4.7
High-fat dairy, cups	0.7	0.1	0.0	0.0
Legumes/nuts/seeds/other vegetable protein, oz	0.6	2.1	1.3	4.2
Beef, oz	0.7	1.0	4.0	5.4
Poultry/pork/fish, oz	3.7	3.7	1.0	1.0
Egg/egg-product substitutes, oz	0.2	0.2	0.1	0.9
Fats/oils, g	5.4	4.0	4.3	1.4

Abbreviations: MUFA = monounsaturated fatty acids, PUFA = polyunsaturated fatty acids, SFA = saturated fatty acids.

4.2. Recommended dietary patterns

The recent American College of Cardiology/American Heart Association (AHA) 2013 Guideline on Lifestyle Management to Reduce Cardiovascular Risk recommended consumption of a dietary pattern that emphasizes intake of vegetables, fruits, and whole grains; includes low-fat dairy products, poultry, fish, legumes, non-tropical vegetable oils and nuts; and limits intake of sweets, sugar-sweetened beverages and red meats (Eckel et al., 2013). Plans such as the DASH dietary pattern, the USDA Food Pattern, or the AHA diet were suggested in order to achieve these goals. As described previously, the BOLD study demonstrated the successful incorporation of lean beef into the DASH diet, without adverse effects on blood lipids (Roussell et al., 2012). Similarly, in a study by Scott et al. (1991) lean beef was successfully incorporated into a diet consistent with the USDA Food Pattern (U.S. Department of Health and Human Services, 2010). Lean beef has also been shown to be effective for reducing total-C and LDL-C levels when incorporated into an AHA diet (Beauchesne-Rondeau, Gascon, Bergeron, & Jacques, 2003; Kestin, Rouse, Correll, & Nestel, 1989) and the National Cholesterol Education Program Step I diet (Davidson et al., 1999; Hunninghake et al., 2000; Wolmarans et al., 1999). An analysis of U.S. National Health and Nutrition Examination Survey (NHANES) data found that, among healthy women ≥50 years of age, those who adhered most closely to a dietary pattern with beef as a primary source of protein had an overall diet that conformed most closely with the 2005 U.S. dietary guidelines, as well as the lowest probability of being overweight or obese, and a greater likelihood of having normal blood pressure (Lopez, Rice, Weddle, & Rahill, 2008). Thus, lean red meat consumption is clearly compatible with a variety of dietary patterns that have been suggested to lower cardiovascular risk factors.

Table 2
Lipid results from the Beef in Optimal Lean Diet (BOLD) study. Adapted from Roussell et al., 2012.

	Healthy American Diet	DASH Diet	BOLD Diet	BOLD + protein Diet
	Mean (SEM)			
Total-C, mg/dL	203 (3.5)	192 (3.5)	193 (3.5)	192 (3.5)
LDL-C, mg/dL	133 (3.1)	124 (2.7)	125 (2.7)	125 (2.7)
HDL-C, mg/dL	51 (1.9)	47 (1.5)	48 (1.5)	48 (1.5)
Non-HDL-C, mg/dL	150 (2.7)	143 (3.1)	143 (3.1)	141 (2.7)
Triglycerides, mg/dL	94 (5.3)	96 (5.3)	93 (6.2)	88 (4.4)

Abbreviations: DASH = Dietary Approaches to Stop Hypertension; HDL-C = high-density lipoprotein cholesterol; LDL-C = low-density lipoprotein cholesterol; Non-HDL-C = non-high-density lipoprotein cholesterol; SEM = standard error of the mean; Total-C = total cholesterol; TG = triglycerides.

Plant-based diet regimens that encourage consumption of whole, plant-based foods, and discourage consumption of meats, dairy products and eggs, are the current trend of many dietary recommendations (Eckel et al., 2013; Tuso, Ismail, Ha, & Bartolotto, 2013). The potential health benefits associated with plant-based diets are often claimed to be due to the exclusion of animal protein sources, particularly red meat (McNeill, Lofgren, & Van Elswyk, 2013). However, studies comparing plant protein-based diets (excluding those that emphasized soy protein) to equivalent amounts of animal protein have shown similar effects of these dietary patterns on blood lipids and body weight and composition (Campbell et al., 1999; Wiebe, Bruce, & McDonald, 1984; Yamashita, Sasahara, Pomeroy, Collier, & Nestel, 1998). Of note is that even in diets reported to be "plant-based," beef and other red meats contribute substantially to the daily protein intake, while maintaining the overall health benefits. For example, Fung et al. found that subjects with the highest consumption of vegetables as part of a vegetable protein-based low carbohydrate diet still consumed nearly a full serving of red or processed meat daily (0.8 serving per day) which was, on average, only a half serving less of red or processed meat per day than those consuming an animal protein-based low carbohydrate diet (Fung et al., 2010). Studies examining diet optimization indicate that partial replacement (often <5 foods) of less healthful food choices with foods having a more favorable nutrient profile, e.g., substitution of higher fat red meats with lean red meats, is compatible with the creation of diets meeting current recommendations (Maillot, Drewnowski, Vieux, & Darmon, 2011; Maillot, Vieux, Amiot, & Darmon, 2010). Moreover, even foods with unfavorable nutrient profiles do not need to be excluded completely in order to achieve dietary goals (Maillot et al., 2011). Rather than severely restricting or eliminating red meat from plant protein-based dietary patterns, which would be expected to have negative consequences with respect to compliance as well as reduce intakes of high quality protein and essential nutrients, the message should be to select lean cuts of red meat and a wide variety of nutrient-rich foods should be encouraged (Huth, Fulgoni, Keast, Park, & Auestad, 2013).

5. Protein and healthy body weight and body composition

Proteins, and the amino acids they are comprised of, are often called the building blocks of life. The body uses them during growth and development, and throughout life, to repair and maintain itself. An expanding area of research is the ability of high quality protein to promote weight loss and/or prevent weight gain or regain in adults, reduce fat mass, and protect against reductions in lean body mass (Bopp et al., 2008; Brehm & D'Alessio, 2008; Halton & Hu, 2004; Keller, 2011; Kushner & Doerfler, 2008; Weigle et al., 2005; Westerterp-Plantenga, Nieuwenhuizen, Tome, Soenen, & Westerterp, 2009; Wycherley, Moran, Clifton, Noakes, & Brinkworth, 2012). Weight loss diets containing higher amounts of protein have been shown to be more effective compared to standard protein (higher carbohydrate) diets. The quantity of protein necessary to promote improved weight management lies somewhere between 1.2 and 1.6 g protein$\cdot$kg$^{-1}\cdot$d^{-1} (~89–119 g protein/d for females or ~104–138 g protein/d for males) (Layman et al., 2005; Layman et al., 2009; Leidy, Carnell, Mattes, & Campbell, 2007; Soenen, Martens, Hochstenbach-Waelen, Lemmens, & Westerterp-Plantenga, 2013). Results from several studies indicate that subjects report greater overall satisfaction (i.e., greater palatability, pleasure, enjoyment) and/or motivation with higher vs. lower protein diets (Layman et al., 2005; Layman et al., 2009; Leidy et al., 2007; McConnon et al., 2013). Furthermore, because of the improved long-term compliance with red meat versus white meat diets (Hunninghake et al., 2000), inclusion of lean red meat as a means to increase protein intake would be expected to enhance dietary compliance.

There are several mechanisms whereby increased protein intake may lead to weight loss and changes in body composition (Leidy, 2014; Veldhorst et al., 2008). One key factor in the effectiveness of higher protein meals/diets to decrease body weight is the improvement in appetite control and satiety, which may lead to decreased food consumption at later meals (Barkeling, Rossner, & Bjorvell, 1990; Brennan et al., 2012; Leidy, Armstrong, Tang, Mattes, & Campbell, 2010; Leidy et al., 2007). Dietary protein increases satiety to a greater extent than dietary carbohydrate or fat (Stubbs, Ferres, & Horgan, 2000). Protein also increases thermogenesis, which changes substrate oxidation and may, in turn, influence the appetitive signals that control food intake (Halton & Hu, 2004). A high protein diet has been hypothesized to modulate the release of hormones and neurochemicals in the gastrointestinal tract, which alters appetite and satiety, and ultimately regulates energy intake (Leidy & Racki, 2010; Leidy et al., 2007, 2010; van der Klaauw et al., 2013). These effects include decreasing levels of ghrelin (a hormone which stimulates hunger) and increasing the secretion of peptide YY and glucagon-like peptide-1 (hormones which reduce hunger) (Batterham et al., 2006; Belza et al., 2013; Blom et al., 2006). Imaging technology has identified regions of the brain that are involved with food motivation and reward (Carnell, Gibson, Benson, Ochner, & Geliebter, 2012; Journel, Chaumontet, Darcel, Fromentin, & Tome, 2012). An emerging area of research is investigating the role of dietary protein with respect to hedonic, reward-driven control of appetite, by examining these brain regions following high protein meals (Leidy, Ortinau, Douglas, & Hoertel, 2013).

In addition to the total amount and quality of protein consumed, new research suggests that the timing of protein consumption is also relevant with regard to its effects on satiety and directly on muscle tissue (Paddon-Jones & Rasmussen, 2009). Most adults in the United States have an unbalanced distribution of protein throughout the day; >60% is consumed during a single evening meal (Berner, Becker, Wise, & Doi, 2013). The satiating effects of protein are particularly evident when it is consumed at breakfast compared with later in the day, and often results in reduced energy intake at subsequent meals (Clegg & Shafat, 2010; Fallaize, Wilson, Gray, Morgan, & Griffin, 2013; Leidy & Racki, 2010; Leidy et al., 2010; Ratliff et al., 2010). Leidy et al. reported that higher protein (egg and beef) intake at breakfast (35 vs. 13 g) was associated not only with greater satiety and less hunger throughout the morning, but also with reduced energy intake from snacks in the evening hours, particularly high-fat snacks (Leidy et al., 2013). This, combined with evidence from brain imaging, suggests that a breakfast rich in protein has potential hedonic effects associated with reduced food motivation and reward. The level of protein necessary to heighten satiety and decrease food consumption has generally been ≥20 g of protein per meal (Clegg & Shafat, 2010; Fallaize et al., 2013; Layman, 2009; Leidy et al., 2007, 2010, 2013; Ratliff et al., 2010). The satiating effects of protein have been demonstrated with a variety of sources, including beef, pork, and eggs (Fallaize et al., 2013; Holt, Miller, Petocz, & Farmakalidis, 1995; Leidy et al., 2013; Meinert, Kehlet, & Aaslyng, 2012; Ratliff et al., 2010).

6. Red meat consumption for improving vitality and stamina

Research regarding red meat as a source of high quality protein and highly bioavailable iron and other nutrients for improving vitality and stamina is emerging. Aging adults often suffer from sarcopenia (degenerative loss of skeletal muscle mass) and sarcopenic obesity (replacement of lost skeletal muscle with fat) (Paddon-Jones & Leidy, 2014; Paddon-Jones & Rasmussen, 2009; Paddon-Jones, Short, Campbell, Volpi, & Wolfe, 2008). Increased consumption of high quality protein during middle age and beyond is necessary to maintain the quality of life associated with adequate muscle mass and strength. Protein maintains or increases fat-free mass by favoring a stimulatory effect on muscle protein anabolism (Churchward-Venne, Murphy, Longland, & Phillips, 2013; Paddon-Jones & Leidy, 2014; Paddon-Jones & Rasmussen, 2009; Paddon-Jones et al., 2008). The branched chain amino acids (leucine, isoleucine, and valine) are the essential amino acids needed for protein synthesis. Leucine supplementation has been shown to increase muscle protein synthesis in older adults (Casperson, Sheffield-Moore, Hewlings, & Paddon-Jones, 2012; Wall et al., 2013). Branched-chain amino acids are generally higher in animal proteins than plant proteins, and are highest in red meat. Yang and co-workers have reported a reduced ability of soy protein isolate to stimulate myofibrillar protein synthesis both at rest and post-resistance exercise as compared to whey protein isolate in elderly men (71 years of age) fed a bolus 20 g dose of protein (Yang et al., 2012). Although much of the protein and muscle mass research conducted to date has examined the effects of isolated amino acids or soy and whey protein supplements, more recent studies have examined the role of protein-rich foods such as lean beef in protein anabolism (Asp, Richardson, Collene, Droll, & Belury, 2012; Daly et al., 2014; Robinson et al., 2013; Symons et al., 2007). An examination of elderly women showed that resistance training combined with lean red meat consumption resulted in greater gains in total body lean tissue mass, leg lean tissue mass, and muscle strength compared to a control diet (pasta/rice) combined with resistance training (Daly et al., 2014). Comparing beef versus soy, Phillips found greater myofibrillar protein synthesis at rest and after performance of resistance exercise with beef (Phillips, 2012).

7. Red meat as a source of high quality protein and essential nutrients

The current U.S. Dietary Reference Intakes (DRI) specify a recommended daily allowance (RDA) for protein of 0.8 g/kg body weight/day for adults, a value that is based largely on the minimum amount needed to avoid deficiency and to maintain growth and development (National Research Council, 2005). This is not presumed to be the "optimal" level to improve overall metabolic health. Although not necessary to prevent deficiency, higher target protein intakes than that recommended by the U.S. RDA have been advanced for improving specific health outcomes (Wolfe, 2008), such as a recent consensus position paper from the PROT-AGE Study Group that proposed a daily protein intake >1.0 g/kg to support lean body mass and functional outcomes in older adults (Bauer et al., 2013). This recommendation is within the Acceptable Macronutrient Distribution Range (AMDR), which expresses recommended macronutrient intakes as a percentage of total energy intake, of 10–35% of energy for protein in adults (National Research Council, 2005). An examination of National Health and Nutrition Examination Survey data from 2003 to 2004 reported that nearly all Americans in all age groups achieved their estimated average requirement for protein, with the exceptions of some adolescent females and older adult women (Fulgoni, 2008). However, virtually none of the population approached the highest AMDR for protein of 35%. Evidence suggests that protein intake associated with the higher end of the AMDR is more likely to benefit a variety of health outcomes as opposed to simply preventing protein deficiency, i.e., maintaining nitrogen balance. Protein intakes moderately greater than the RDA may reduce the risk for chronic diseases such as obesity, cardiovascular disease, type 2 diabetes, and osteoporosis (Bauer et al., 2013; Gaffney-Stomberg, Insogna, Rodriguez, & Kerstetter, 2009; Gannon & Nuttall, 2004; Houston et al., 2008; Meckling & Sherfey, 2007; Moughan, 2012), as well as assist with maintaining lean muscle mass which is particularly important for the elderly and those who are physically active/exercisers (Fukagawa, 2013; Paddon-Jones & Leidy, 2014).

Beef and pork are among the top food sources of protein, bioavailable iron, and a range of other key nutrients in the U.S. diet (Cotton, Subar, Friday, & Cook, 2004; Murphy, Spungen, Bi, & Barraj, 2011; Nicklas, O'Neil, Zanovec, Keast, & Fulgoni, 2012; O'Neil, Keast, Fulgoni, & Nicklas, 2012; Sharma, Sheehy, & Kolonel, 2013; U.S. Department of Agriculture, A. R. S., 2013; Zanovec et al., 2010). To list the roles of just a few of these key nutrients, vitamin B12 reduces the risk for developing megaloblastic anemia and the irreversible neurologic disease caused by its deficiency (Thomson et al., 2011), zinc is important in cell growth and replication, osteogenesis and immunity (Etcheverry, Hawthorne, Liang, Abrams, & Griffin, 2006; Hambidge & Krebs, 2007), and heme iron, the form found in animal products that is better absorbed than non-heme iron, supports cognitive development and functioning in children and adolescents (Batra & Sood, 2005; Moshe et al., 2013). On average, in an 85-g cooked serving, the 29 lean cuts of beef contribute 8% of calories, 50% of the daily value for protein, 45–62% (males–females) of the RDA for zinc, 91% for vitamin B12, 52% for selenium, 21% for phosphorous, 31–36% for niacin, 31% for vitamin B6, 27–12% for iron, and 13–15% for riboflavin (McNeill et al., 2013; U.S. Department of Agriculture, A. R. S., 2013). From U.S. NHANES 1999–2004 dietary recall data, Zanovec et al. reported that in adults ≥19 years of age, beef provided 14–15% of total protein and was a major source of nutrients including iron, zinc, niacin, vitamins B6 and B12, phosphorous and potassium, while contributing ≤5% of the total energy and ≤10% fat or SFA intakes (Tables 3 and 4) (Zanovec et al., 2010). In another examination of persons 4+ years of age, Nicklas et al., demonstrated that compared to those who did not consume beef, consumers of the highest amounts of lean beef had significantly higher intakes of protein and vitamins A, C, B6 and B12, niacin, phosphorous, magnesium, iron, zinc, and potassium, and lower intakes of total energy, total fat, SFA, MUFA, and carbohydrates (Nicklas et al., 2012). Results similar to beef were reported for pork by Murphy et al. in U.S. NHANES 2003–2006 dietary recall data showing that intakes of fresh pork and fresh lean pork products accounted for 27% and 23% of total protein, respectively, and substantially contributed to intakes of other key nutrients including selenium, thiamin, phosphorous, potassium, riboflavin, niacin, and vitamins B6 and B12, while contributing to just 10% (fresh pork) and 7% (fresh lean pork) of total energy (Murphy et al., 2011). Studies specific to U.S. children and adolescents have also shown that inclusion of meat in general (Moore, Singer, Qureshi, Bradlee, & Daniels, 2012), and red meat in particular, is significantly associated with intakes of protein and essential vitamins and minerals (O'Neil, Zanovec, Keast, Fulgoni, & Nicklas, 2011).

Table 3
Mean nutrient intakes and percentage of total nutrient intake contributed by total beef and lean beef in adults 19–50 years of age (n = 7049): NHANES 1999–2004[a].
Adapted from Zanovec et al., 2010.

19–50 years	Total beef		Lean beef	
	Mean (SEM)	%	Mean (SEM)	%
Food energy, kJ	535.9 (15.1)	5.31	390.2 (11.3)	3.87
Protein, g	13.32 (0.38)	15.18	13.32 (0.38)	15.18
Carbohydrate, g	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Total fat, g	7.88 (0.23)	8.84	4.03 (0.12)	4.52
SFA, g	3.04 (0.09)	10.28	1.12 (0.03)	3.79
MUFA, g	3.43 (0.10)	10.21	1.82 (0.05)	5.42
PUFA, g	0.28 (0.01)	1.57	0.13 (0.01)	0.72
Cholesterol, mg	43.2 (1.2)	14.27	39.0 (1.1)	12.88
Micronutrient intakes that are the same in total beef and lean beef				
Vitamin A, μg RAE	0.0 (0.0)			0.00
Vitamin C, mg	0.0 (0.0)			0.00
Thiamin, mg	0.032 (0.001)			1.89
Riboflavin, mg	0.103 (0.003)			4.65
Niacin, mg	2.47 (0.07)			9.88
Vitamin B6, mg	0.178 (0.006)			9.23
Total folate, μg	4.64 (0.14)			1.13
Vitamin B12, μg	1.34 (0.04)			25.00
Calcium, mg	8.24 (0.27)			0.91
Phosphorous, mg	102.4 (2.9)			7.27
Magnesium, mg	11.5 (0.3)			3.93
Iron, mg	1.30 (0.04)			8.05
Zinc, mg	2.92 (0.08)			23.14
Sodium, mg	38.5 (1.2)			1.04
Potassium, mg	168.1 (4.9)			6.05

Abbreviations: MUFA = monounsaturated fatty acids; NHANES = National Health and Nutrition Examination Survey; PUFA = polyunsaturated fatty acids; RAE = retinol activity equivalents; SEM = standard error of the mean.
[a] Data are presented as sample-weighted means ± SEM and percentages using PROC DESCRIPT of SUDAAN. Mean total and lean beef intake was 49.3 ± 1.4 and 45.5 ± 1.3 g, respectively. Lean beef was defined by MyPyramid Equivalents Database as beef that contains no more than 9.28 g of total fat/100 g total beef (after cooking).

Table 4
Mean nutrient intakes and percentage of total nutrient intake contributed by total beef and lean beef in adults 51+ years of age (n = 6243): NHANES 1999–2004[a].
Adapted from Zanovec et al., 2010.

51+ years	Total beef		Lean beef	
	Mean (SEM)	%	Mean (SEM)	%
Food energy, kJ	395.2 (13.0)	4.98	293.5 (10.0)	3.70
Protein, g	10.05 (0.34)	13.71	10.05 (0.34)	13.71
Carbohydrate, g	0.0 (0.0)	0.00	0.0 (0.0)	0.00
Total fat, g	5.70 (0.19)	7.81	3.01 (0.10)	4.12
SFA, g	2.18 (0.07)	9.33	0.84 (0.03)	3.59
MUFA, g	2.48 (0.08)	9.16	1.35 (0.05)	4.99
PUFA, g	0.21 (0.01)	1.35	0.10 (0.01)	0.66
Cholesterol, mg	32.5 (1.1)	12.14	29.5 (1.0)	11.04
Micronutrient intakes that are the same in total beef and lean beef				
Vitamin A, μg RAE	0.0 (0.0)			0.00
Vitamin C, mg	0.0 (0.0)			0.00
Thiamin, mg	0.025 (0.001)			1.64
Riboflavin, mg	0.078 (0.003)			3.83
Niacin, mg	1.82 (0.06)			8.56
Vitamin B6, mg	0.132 (0.004)			7.49
Total folate, μg	3.37 (0.11)			0.90
Vitamin B12, μg	0.99 (0.03)			19.73
Calcium, mg	5.72 (0.18)			0.74
Phosphorous, mg	78.0 (2.6)			6.53
Magnesium, mg	8.7 (0.3)			3.24
Iron, mg	0.98 (0.03)			6.66
Zinc, mg	2.23 (0.08)			20.42
Sodium, mg	32.8 (1.9)			1.07
Potassium, mg	126.7 (4.4)			4.71

Abbreviations: MUFA = monounsaturated fatty acids; NHANES = National Health and Nutrition Examination Survey; PUFA = polyunsaturated fatty acids; RAE = retinol activity equivalents; SEM = standard error of the mean.
[a] Data are presented as sample-weighted means ± SEM and percentages using PROC DESCRIPT of SUDAAN. Mean total and lean beef intake was 37.1 ± 1.2 and 34.4 ± 1.2 g, respectively. Lean beef was defined by MyPyramid Equivalents Database as beef that contains no more than 9.28 g of total fat/100 g total beef (after cooking).

8. Conclusions

Generally, U.S. dietary guidance has implied or directly recommended reducing red meat intake, primarily citing its SFA content as a reason for doing so. However, a broader examination of the science reveals the benefits of including lean red meat, as an important source of high quality protein and essential nutrients, in a wide variety of dietary patterns for cardiovascular health, achieving and maintaining a healthy body weight and composition, and improving vitality and stamina.

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