Greener Pastures

How grass-fed beef and milk contribute to healthy eating

Union of Concerned Scientists
Citizens and Scientists for Environmental Solutions

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Union of Concerned Scientists

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UCS is a nonprofit partnership of scientists and citizens combining rigorous scientific analysis, innovative policy development, and effective citizen advocacy to achieve practical environmental solutions.

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Executive Summary


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The production, sale, and consumption of beef and dairy products represent a significant segment of the American food system. In fact, the United States produces more beef than any other nation.

Conventional U.S. dairy and beef production relies heavily on the feeding of grain, primarily corn. More than 50 percent of the corn grown in this country goes to animal feed. Not only does grain production cause water and air pollution, but feeding it to cattle can reduce the levels of certain fats in beef and milk that may be beneficial to human health.

Conventional beef and dairy production also confines large numbers of animals in relatively small spaces, a practice that has serious consequences for the environment and the health of both animals and humans. Manure produced in feedlots, for example, pollutes the air and combines with the runoff from fertilizers and pesticides used in cornfields to contaminate ground and surface water. Furthermore, the practice of feeding cattle antibiotics to promote growth increases the risk of antibiotic resistance in humans, leading to potential complications from bacteria-caused diseases.

An alternative to conventional production systems allows cattle to roam on pastures, eating grass and other forages rather than grain. Pasture feeding can reduce environmental damage, improve animal health, and increase profits for beef and dairy producers. It may also improve human nutrition.

Meat from pasture-raised cattle, for example, contains less total fat than meat from conventionally raised animals, and both meat and milk from pasture-raised animals contain higher levels of certain fats that appear to provide health benefits. These nutrition differences arise from the chemical differences between forage and grains, and the complex ways in which ruminant animals such as cattle process these feeds.

The Union of Concerned Scientists (UCS) has reviewed and analyzed the scientific literature that compares differences in fat content between pasture-raised/grass-fed and conventionally raised dairy and beef cattle. The fats in which we were interested are:

- total fat
- saturated fat

- the omega-3 fatty acids alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA)
- conjugated linoleic acid (CLA)

The latter two fatty acid groups are the subject of intense interest in nutrition research. The three omega-3 fatty acids—the so-called beneficial fatty acids—have been shown in many studies to improve health and prevent disease in humans. CLA has attracted attention because it has demonstrated many beneficial effects in animal studies. We have focused on the levels of these fats in milk and meat from pasture-raised cattle because, beyond their intrinsic value, widespread interest in these substances among health-conscious consumers could help shift American agriculture from conventional to pasture-based feeding systems.

This report examines the scientific basis for health benefits associated with the fatty acids listed above and determines where the evidence is strong and where additional research is needed. We also explain how federal dietary recommendations would be established for these fats and what standards would have to be met before food purveyors could make a nutrient or health claim about these fats on product labels or in advertising. Based on the existing literature, certain claims could be made now and others might be permitted after additional research has been completed.

Health Benefits of Milk and Meat from Pasture-raised Cattle

We reviewed all the studies published in English we could find that compare levels of fatty acids in pasture-raised milk and meat with levels in conventionally produced milk and meat, and converted these levels into amounts per serving of milk, steak, and ground beef. The resulting analysis found statistically significant differences in fat content between pasture-raised and conventional products. Specifically:

- Steak and ground beef from grass-fed cattle are almost always lower in total fat than steak and ground beef from conventionally raised cattle.
- Steak from grass-fed cattle tends to have higher levels of the omega-3 fatty acid ALA.
- Steak from grass-fed cattle sometimes has higher levels of the omega-3 fatty acids EPA and DHA.
- Ground beef from grass-fed cattle usually has higher levels of CLA.
- Milk from pasture-raised cattle tends to have higher levels of ALA.
- Milk from pasture-raised cattle has consistently higher levels of CLA.

At this point, the evidence supporting the health benefits of omega-3 fatty acids and CLA is mixed; the data are stronger for some fatty acids than for others. The strongest evidence, encompassing animal studies as well as experimental and observational studies of humans, supports the effects of EPA/DHA on reducing the risk of heart disease. ALA also appears to reduce the risk of fatal and acute heart attacks, but no other beneficial effects have been shown conclusively. Finally, animal research on CLA has shown many positive effects on heart disease, cancer, and the immune system, but these results have yet to be duplicated in human studies.

Implications for Dietary Recommendations and Nutrient and Health Claims

Consumers get useful information about the nutrient content and health benefits of foods in the form of claims made on product labels and in advertising. The fact that studies of the health benefits of omega-3 fatty acids and CLA have had mixed results is reflected in the limited number of claims that can be made for pasture-raised dairy and beef products. Until scientists agree on the role fatty acids play in maintaining health, the Food and Nutrition Board of the Institute of Medicine cannot recommend a specific dietary intake. And until such a recommendation is made, the U.S. Food and Drug Administration and U.S. Department of Agriculture (USDA) cannot propose standards governing whether a nutrient content claim can be made.

Claims that can be made today. Based on existing standards, our analysis found sufficient evidence for some claims about the health benefits of grass-fed beef that could be made now:

- Steak and ground beef from grass-fed cattle can be labeled “lean” or “extra lean.”
- Some steak from grass-fed cattle can be labeled “lower in total fat” than steak from conventionally raised cattle.
- Steak from grass-fed cattle can carry the health claim that foods low in total fat may reduce the risk of cancer.
- Steak and ground beef from grass-fed cattle can carry the “qualified” health claim that foods containing the omega-3 fatty acids EPA or DHA may reduce the risk of heart disease.

Claims that might be made in the future. No nutrient content claims about the omega-3 fatty acids or CLA can be made today. However, as more is learned about the health effects of these substances, new standards may be issued that would allow food purveyors to make labeling and advertising claims:

- Steak from grass-fed cattle might be labeled a “source” or “good source” of EPA/DHA.
- Some milk and cheese from pasture-raised cattle might be labeled a “source” of ALA.

Environmental Benefits of Pasture-based Production Systems

The nutrition advantage that pasture-raised meat and milk may have over conventional products is only one reason to support this emerging industry. Our review of the relevant literature finds general agreement among scientists that raising cattle on well-managed pastures will provide significant environmental and other benefits:

- Decreased soil erosion and increased soil fertility
- Improved water quality (due to decreased pollution)
- Improved human health (due to reduced antibiotic use)
- Improved farmer and farm worker health
- Improved animal health and welfare
- More profit per animal for producers

Challenges for Pasture-based Dairy and Beef Producers

Research shows that well-managed pasture-based production systems can be profitable. But implementing such systems will not be easy in the United States, which lags behind Argentina, Ireland, and New Zealand.

The literature shows that U.S. pasture-based dairy producers are still figuring out what feeding regimens will maintain good body condition and adequate milk yields. They are also learning (along with grass-fed beef producers) how to produce and manage the best mix of grasses and legumes in terms of a cow’s nutrition and the potential to produce the highest possible levels of beneficial fatty acids and CLA. The most serious questions facing U.S. producers are what to feed in the winter (when cows are not kept on pasture) and in seasons when cows can graze but the pasture is not high-quality.

Recommendations

Existing data on the possible health benefits of the omega-3 fatty acids and CLA are promising and important. Nevertheless, UCS recognizes the need for more research before pasture-based dairy and beef production systems can be widely adopted and economically viable in the United States. Specifically, we recommend:

- Beef and dairy producers interested in optimizing levels of omega-3 fatty acids and CLA should strive for pasture-based feeding regimens that maximize the number of days their cows spend on grass.
- Pasture-based beef and dairy producers might consider seasonal production as a way of improving profits and ensuring higher nutrient levels in areas where high-quality pasture cannot be produced year-round.

In addition, we recommend the following research to help advance this promising new agricultural sector:

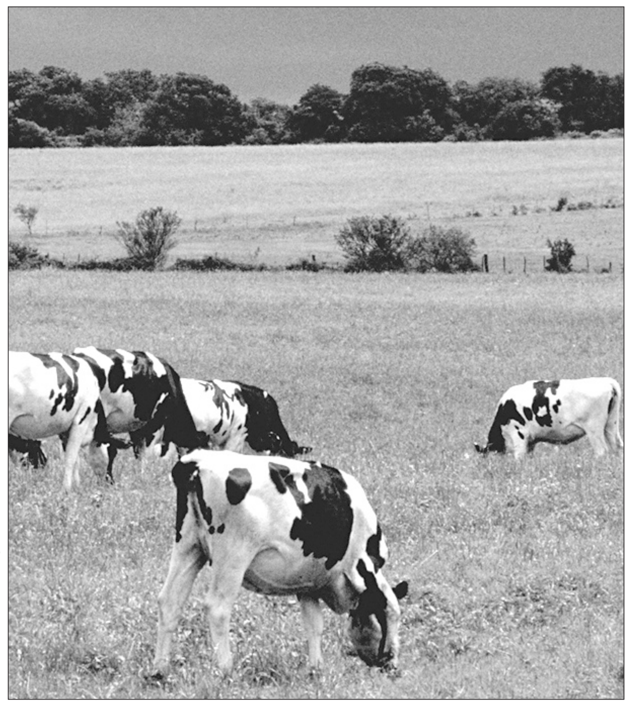
- In line with the recommendations of the Dietary Guidelines Advisory Committee, we believe the National Institutes of Health, the National Science Foundation, and other appropriate organizations should support increased basic, clinical, and epidemiological research on the health effects of omega-3 fatty acids and CLA.
    - More epidemiological research is needed on the effect of these fat substances on the incidence of heart disease, cancer, and immune system disorders.
    - More clinical research should be conducted on the human health effects of the CLA isomer (c9,t11) most prevalent in ruminant milk and meat.
- Government and industry should provide funding for scientists to conduct extensive sampling of pasture-raised dairy and beef products and analyze the content of fatty acids such as ALA, EPA/DHA, CLA, and vaccenic acid (a precursor to CLA).
- The USDA should support more research to identify pasture management strategies that will produce an optimal fat composition in milk and meat from different regions of the United States.
- The USDA (through the Agricultural Research Service, the Sustainable Agriculture Research and Education grants program, and the competitive grants program called the National Research Initiative) should fund more research on different types of U.S. pasture systems and their effects on nutrient levels.
    - This should include studies comparing fully pasture-raised cattle and cattle fed pasture/supplement mixtures with conventionally raised cattle.
- The USDA and the Environmental Protection Agency should encourage and fund more research on the environmental benefits of pasture-based production systems.

Chapter 1

Introduction

Because the livestock sector accounts for more than 50 percent of all sales of agricultural commodities in the United States (ERS 2005e) and because a high percentage of U.S. crop production is devoted to animal agriculture, animal production systems play a major role in determining the structure of American agriculture. Changing from grain-based confinement systems to pasture-based systems would therefore drive a transformation of agriculture that, in our view, would be better for the environment, animals, and humans alike. The Union of Concerned Scientists (UCS) supports and wants to accelerate this change because of the many benefits that would result, only one of which is the focus of this study: the nutrition advantages of beef and dairy products from pasture-raised cattle. We have focused on nutrition because this benefit could help attract broad-based support among health-conscious consumers for a major transformation of American agriculture.

This report examines the scientific basis for the health benefits of beef and dairy products from pasture-raised cattle, and determines where the science is strong and where additional data are needed. In this way, we can identify needed research and urge that it be undertaken. We also look at the potential claims that producers could make about their pasture-raised products. By assessing the validity of various claims, we can minimize the risk of overstatement.



Study Design and Scope

This study comprised two major tasks:

1. Reviewing and analyzing the relevant nutrition literature to determine the differences, if any, in the amounts of selected fats in pasture-raised/grass-fed dairy and beef cattle compared with conventionally fed dairy and beef cattle.
2. Discussing the significance of these differences in terms of human nutrition.

To determine whether the amounts of fat-related nutrients were different in pasture-raised and conventionally fed cattle, we conducted a thorough (although not exhaustive) review of published and unpublished research literature. The substances we studied were:

- total fat
- saturated fat
- omega-3 fatty acids (alpha-linolenic acid, eicosapentaenoic acid, and docosahexaenoic acid)
- conjugated linoleic acid
- ratio of omega-6 fatty acids to omega-3 fatty acids

As will be discussed below, we selected studies that compared the amounts of these fats in fully grass-fed animals with animals that were not fed on pasture.

We also considered the nutrition significance of different levels of fats in foods from pasture-raised animals. This discussion requires an understanding of the content of these substances in various foods, as well as current research on their health effects and expert opinion on the recommended intake of these substances. In general, once the case for nutrition significance is accepted within the scientific community, food purveyors are legally allowed to make claims about their retail products' nutrition benefits. We will discuss the strength of the case for pasture-raised cattle's nutrition benefits within the context of the food producers' ability to make claims about their products.

This study is limited to comparisons of levels of different fats in beef and dairy cattle, which represent by far the largest proportion of the research literature on pasture-raised animals. We have not included bison, sheep, goats, or non-ruminants such as swine and poultry (UCS will publish another report soon on the latter). We also present a brief discussion of fat-soluble vitamins.

Report Outline

- Chapter 2 provides background on U.S. dairy and beef production. It looks at the benefits and drawbacks of the dominant conventional system, and the positive outcomes that can be expected from the adoption of alternative, pasture-based systems by a large number of producers.
- Chapter 3 provides background on fats and describes the reasons we chose the nutrients being studied. The chapter also explains how nutritionists determine the significance of the levels of nutrients and other components found in foods, and the regulatory system that governs the claims that may be made on retail food products.
- Chapter 4 describes the methodology we followed in selecting and interpreting the studies comparing conventional and pasture-based/grass-fed animal production systems. We briefly explain some of the complexities in the literature, then present the study results.
- Chapter 5 discusses the implications of the comparison studies, including the nutrition significance of the differences noted. We also assess the ability of producers and processors to support nutrition claims under current regulations.
- Chapter 6 summarizes our conclusions and recommendations.

Chapter 2

Background on U.S. Dairy and Beef Production

Animal agriculture in the United States is such a huge industry that its practices have effects that ripple throughout our economy, our natural environment, and our nation's health.

Beef and dairy products are staples of the American diet. In fact, the United States is the world's largest beef producer (ERS 2004a), and although total beef and milk consumption have been declining in this country since 1977 (beef) and 1945 (milk), beef and dairy products (including cheese) still contribute about six and eight percent of our total calories respectively, about 12 and 21 percent of our saturated fat, and about four and seven percent of the dollars we spend on food at home (Table 2-1). Beef represents 55 percent of all the red meat consumed in the country (AMI 2005), and 30 percent of all meat (including poultry).

Both dairy and beef products have been in the news in recent years as people have begun

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considering the toll that modern modes of beef and dairy production take on the environment and on animal and human health. As a result, we decided to examine a small but growing segment of the dairy and beef industry referred to as grass-fed or pasture-raised. We will be using both terms in this report for two reasons: the scientists who have done the research on which we report

Table 2-1: Contributions of Beef, Milk, and Cheese to the U.S. Diet

Food	Kilocalories[a]		Total Fat[a]		Saturated Fat[a]		Percent of Dollars Spent on Food at Home[b]
	Rank among All Foods	% of Total Diet	Rank among All Foods	% of Total Diet	Rank among All Foods	% of Total Diet	
Beef	2	6.2	1	10.1	2	11.7	4
Milk	5	4.2	8	4.2	3	7.8	4 (including yogurt and cream)
Cheese	7	3.5	4	7.0	1	13.1	3

Source: [a] Cotton et al. 2004.
[b] Blisard, Variyam, and Cromartie 2003.

use different terms, and a segment of consumers has already seen the phrase "grass-fed" on labels (although no standard has yet been adopted). Most of the time we will use "grass-fed" when discussing beef and "pasture-raised" when discussing milk. When there is no clear context we will use the terms interchangeably.

The focus of this report is nutrition issues related to grass-fed milk and meat, but we also consider the environmental benefits of these alternative production systems as well.

Concentrated Animal Feeding Operations (CAFOs)

Cattle are the basis of two very different but equally important U.S. industries: the dairy industry (milk, cheese, yogurt, etc.) and the beef industry (steaks, roasts, ground beef, etc.). Each employs distinct breeds of cattle and raises the animals differently. However, cattle raising for both milk and meat in the United States has been characterized for the past 50 years—and especially today—by production systems that concentrate large numbers of animals in confined spaces and feed them grains, particularly corn.

Beef cattle are confined at the end of their lives in feedlots (most of which are found on the Central Plains) that may hold up to 100,000 animals. Dairy operations may have up to 4,500 animals on a single farm. Dairies are also becoming concentrated geographically, especially in the San Joaquin Valley of Southern California, where six counties now account for half of the state's total milk production (Bedgar 2005).

These concentrated animal feeding operations (CAFOs)[1] substitute significant amounts of grains such as corn for grasses or other plants on which cattle forage. Because corn is a high-starch, high-energy food that can shorten the time needed to fatten beef cattle and increase milk yield in dairy cows (Grant 1996), its use in animal feeding is quite extensive. Dairy cattle, for example, are fed about 600 million bushels of corn every year and beef cattle are fed about 1.7 billion bushels (GIPSA 2002). Dairy and cattle operations together use almost 50 percent of the corn currently produced in this country (White 2004).

Large operations offer dairy and beef producers the benefits that come with economies of scale. In the dairy industry, for instance, technological innovations have brought time savings and efficiencies that have allowed farms to expand their operations. Large farms purchase most of their feed rather than grow it themselves, specializing in cow management (Blayney 2002; Eastridge et al. n.d.) rather than grain and forage production. Purchased grains also allow for larger and more concentrated dairies, as acreage is freed up that would otherwise be needed for pasture.

These efficiencies are not always reflected in the retail price of milk because the connection between dairy production efficiencies and consumer prices depends on many factors. These factors include the total supply of and demand for milk, the number of farms and cows on those farms, energy costs, and federal and state dairy programs (GAO 2004). In 2004, after record-low milk prices had pushed many dairy farmers into bankruptcy, the price of a gallon of milk rebounded to an all-time high. A year later, the price had dropped again (deSilver 2005).

Problems Associated with Concentrated Feeding Operations

Despite their advantages for producers, CAFOs are also associated with a host of environmental

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[1] CAFOs are defined by the U.S. Department of Agriculture as livestock operations that contain more than 1,140 beef cattle or 740 dairy cattle (Gollehon et al. 2001).

A Primer on Dairy Production


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Most U.S. dairy cows today are a single breed (APHIS 2003), Holsteins, favored for their high production and milk fat content (ERS 2004a). Though the United States has fewer dairy cows than in the past, these cows are concentrated in larger herds and produce more milk than their predecessors.

To be more specific, there are about nine million U.S. dairy cows (ERS 2005a), down from 22 million in 1950 (Blayney 2002). In 2004 cows were found on approximately 81,000 American farms (NASS 2005d), about 67,000 of which (82 percent) were licensed to sell milk. Since 1970, the average number of cows per dairy operation has increased from 20 to about 100 (Blayney 2002), and the amount of milk that each cow produces has doubled from 9,700 to 19,000 pounds per year (ERS 2004a). Over 75 percent of herds comprise more than 100 cows (NASS 2005h)—3,000 farms have more than 500 cows (NASS 2005b), and in 2004 these large herds accounted for 47 percent of all milk produced (NASS 2005c).

Annual U.S. milk production totals more than 170 billion pounds (ERS 2005b), about one-third of which is consumed in fluid form; one-half goes into cheese and the remainder goes into foods such as butter and ice cream (ERS 2004a). Milk is produced in every state, but the top 10 states produce 70 percent of the total (ERS 2004a).[2] California alone is home to about 20 percent of the nation's herd (Blayney 2002), or 1.7 million cows (CDRF 2004).

Most dairy cows are fed corn or other grains along with hay or silage of various kinds, including corn silage (The Small Farm Resource 2005). In a significant change from the past, only about 25 percent of U.S. dairy cows currently have access to pastures. The larger the herd size, the more likely it is that cows will be confined indoors, fed mixtures of corn and other grains plus supplements, and spend less time eating forage (APHIS 2002).[3] In addition, about 22 percent of cows on farms with herds larger than 500 are injected with a synthetic hormone called bovine somatotrophin (bST) to promote lactation (Short 2004).

The life of a dairy cow begins when a two-year-old cow produces a calf. The calf is moved from its mother after several hours and the cow soon enters the lactation stage of milk production, which lasts 12 to 14 months. Cows are inseminated on a schedule that will produce a calf every year, and allowed to stop producing milk two months before calving (EPA 2004a). And although they have life spans of about 20 years, cows are often culled from herds after only two or three lactation cycles and sold to processors to be made into hamburger. About one-third of U.S. dairy cows are culled every year (Sonnenberg, Boyles, and Looper n.d.) and some 2.5 million are slaughtered (NASS 2005g).

[2] The 10 states, in descending order, are California, Wisconsin, New York, Pennsylvania, Minnesota, Idaho, Texas, Michigan, Washington, and New Mexico.

[3] Forage is the edible portion of plants, other than separated grain, that can provide feed for grazing animals (Leep et al. 2005). This feed can be fresh, stored, or fermented (silage), or in the form of dried grasses and legumes (hay).

A Primer on Beef Production

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Out of approximately 95 million head of U.S. beef cattle (NASS 2005f), about 26 million were slaughtered in 2004 (Plain and Grimes 2005). Cash receipts from the marketing of cows and calves in the same year amounted to $47.3 billion (NASS 2005d). These numbers are down from past years for several reasons, but the most significant change in the industry has been the reduction in "cow-calf operations" (where beef cattle are born) from more than one million in 1986 to 830,000 in 2004 (EPA 2004b). These numbers reflect both the departure of producers from the industry and more concentration in feeding operations.

There are more than 95,000 U.S. feedlots, and although 98 percent have capacities of fewer than 1,000 head (APHIS 2004),[4] the other two percent account for such a large percentage of the country's total beef production (Ward and Schroeder 2001) that the U.S. Department of Agriculture (USDA) stopped collecting data on a regular basis on the smaller operations in 1995. Currently, the larger feedlots account for about 80 to 90 percent of total beef production (ERS 2004b). About 12 million cattle reside in feedlots at any given time, and a typical feedlot turns over its herd two to three times per year.

Conventional beef production consists of three main stages and venues. In the first, cows in a cow-calf operation produce a calf about every 12 months; the calf stays with the cow on pasture until it can be weaned (about seven months). Calves are then kept in a "backgrounding" or "stocker" stage until they reach a weight of 600 to 900 pounds. They are mainly pasture-fed during this stage, along with wheat or oats, and gain up to three pounds a day (EPA 2004b). Finally, they are shipped to feedlots where they consume approximately 1,800 pounds of corn and 1,200 pounds of sorghum along with other feeds (as well as growth-promoting hormones and antibiotics) over a period of 90 to 120 days (Kuhl, Marston, and Jones 2002). When they reach a weight of about 1,400 pounds they are slaughtered (EPA 2004b).

and health problems, many of which stem from the mountains of manure produced in such operations. Many of the risks to the environment, public health, and animal welfare described below have not received the study they deserve; more research is therefore needed to document the full scope and extent of the problem.

Water pollution. Animal manure contains nutrients that can be valuable fertilizers if applied to land under the proper conditions and in correct amounts. But manure is heavy and expensive to haul, so CAFOs often apply manure to nearby land in amounts that plants and soil cannot absorb. The result is runoff of nutrients

[4] Although the National Agricultural Statistics Service stopped collecting data on a regular basis on the number of cattle feedlots with fewer than 1,000 head, the Small Business Administration does maintain a count (APHIS 2004).

A Primer on Corn Production

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About 10 billion bushels of corn are produced for animal feed every year in the United States—close to 90 percent of all feed grain produced (ERS 2005d). The crop is grown on almost 80 million acres, or 25 percent of total U.S. farmland (Christensen 2002), a great increase from the 66 million acres used in 1970 for the same purpose. Yields have increased as well due to plant breeding, fertilizer and pesticide use, irrigation, and machinery improvements (ERS 2005c).

Nearly 75 percent of all corn used domestically takes the form of animal feed (GIPSA 2002), and about 50 percent of all feed corn produced domestically is genetically engineered (NASS 2005a).

such as nitrogen and phosphorus into surface waterways. Between 1982 and 1997 manure in excess of what could be fully absorbed by the soil increased by 64 percent in the United States (ERS 2002).

Manure runoff into water can cause many problems:

1. *Fish kills.* Ammonia in manure is highly toxic to fish, and nitrogen and phosphorous cause algal blooms that block waterways and deplete oxygen as they decompose (EPA 2005). As a result, 200 manure-related fish kills between 1995 and 1998 destroyed more than 13 million fish in 10 states (Frey, Hopper, and Fredregill 2000).
2. *Contaminated wells.* High levels of nitrate that originate in manure and seep into groundwater and wells pose a hazard to animal and human health (EPA 2005).
3. *Disease.* High levels of disease-causing microorganisms such as *Cryptosporidium* are carried by manure into water (ERS 2001; Kirk 2003).
4. *Antibiotics and hormones.* Antibiotics and hormones fed to cattle in feedlots are excreted unchanged in manure and can pollute surface and ground water (Nierenberg 2005).
5. *Reduced biodiversity.* Changing the balance of flora in aquatic ecosystems can reduce biodiversity by allowing some plants to become dominant and causing other plants to die from exposure to contaminants (Carpenter et al. 1998).

Air pollution. CAFOs emit hazardous compounds such as nitrogen gases, fine particulates, and pesticides into the air, posing health hazards for workers, cattle, and nearby communities (Ribaudo and Weinberg 2005). To date, empirical studies of human health risks from open cattle feedlots have not appeared in the peer-reviewed literature (Auvermann 2001); most research has centered on confined swine operations, which are indoor systems (Iowa State University 2002). That does not mean problems do not exist, however.

Cattle feedlot operators recognize that air pollution-related health hazards for animals can end up decreasing the overall profitability of an operation (Auvermann 2001), and California now requires producers to reduce emissions (Ribaudo and Weinberg 2005). Concerns about emissions from feedlots and dairies have become so widespread recently that some states and the federal government have started to measure emissions of hazardous substances such as ammonia, hydrogen sulfide, and dust particles that can carry pathogenic organisms (Iowa State University 2002). The extent of potential damage from open-air feedlots depends on weather patterns and the moisture content of a feedlot's surface, so these are being studied in detail (e.g., Sweeten et al. 2004).

The greenhouse gases methane and ammonia (see discussion below under greenhouse gases) also cause air pollution. In fact, a recent California report suggests that air quality in the San Joaquin Valley may be the worst in the country in large part because the gases released by cows react with other pollutants to form smog (Bustillo 2005).

Odors. Manure-related odors are another serious problem associated with CAFOs. In one representative study, land application of manure caused the greatest number of complaints from local residents, followed by manure storage facilities and animal buildings (Hardwick 1985 in Jacobson et al. 2001). Odors are not just a nuisance—they can cause tissue irritation and transmit toxic compounds (Schiffman 2005).

Unfortunately, air pollution and odors occurring at the same time pose a problem. Because more dust occurs at low moisture levels, and more odor at high moisture levels, decreasing them simultaneously is not possible (Auvermann 2001). It is therefore difficult to conceive a solution other than reducing the size of feedlots or using the manure for purposes other than land application. So far, however, an alternative market for manure has not developed.

Greenhouse gases. In addition to their adverse health effects, the ammonia and methane produced by feedlots contribute to global warming by trapping heat in the atmosphere (Auvermann 2001). The amount of methane released by cows in pastures is the same as that released by cows eating grain (Fredeen et al. 2004), but if more land is devoted to permanent pasture, a higher percentage of the methane's heat-trapping carbon atoms will be absorbed by plant matter rather than escaping into the atmosphere (a process called carbon sequestration). As less fertilizer is used to produce pasture, heat-trapping emissions from fertilizer production and application would also be reduced. The fact that the nutrient content of manure is preserved in pastures helps to cut methane and nitrous oxide emissions as well (Canadian Cattlemen's Association 2003).

Inhumane treatment of animals. Cattle are generally hearty animals, but when confined in small spaces under stressful conditions, they routinely become ill and are often treated with large quantities of antibiotics. Although problems can arise even in pasture systems, feedlot cattle suffer both morbidity and mortality from diseases including dust-related respiratory conditions, metabolic diseases, and other ailments that can be directly attributed to their confined conditions (Smith 1998).

Corn-based diets also contribute to health problems such as liver abscesses, and some feeds have been linked to bovine spongiform encephalopathy (BSE), or "mad cow" disease. In general, the administration of bovine somatotrophin to feedlot cows, grain-based diets, and breeding practices designed to maximize milk production have shortened cows' life spans and caused reproductive problems (Broom 2001). One specialist observed that pasture-based feeding appeared to increase the number of years a dairy cow produces milk from four (the average of conventionally raised cows) to seven (Nichols 2002).

Antibiotic resistance. Antibiotics are extensively used by the beef industry to promote growth and prevent disease (perhaps by killing particular bacteria in the cows' guts). UCS estimates that in 1998 beef cattle were fed almost 1.5 million pounds of antibiotics used in human medicine for these non-therapeutic purposes (Mellon, Benbrook, and Benbrook 2001). Non-therapeutic antibiotic use in animals, combined with the overuse of antibiotics in human medicine, has contributed to the serious problem of antibiotic resistance around the world (IOM 1998).

Energy use. Feedlots consume large amounts of energy in the form of fuels used to transport feed from distant places to the feedlot and to monitor and move animals around the lot (Brown and Elliott 2005). Scientists in Missouri and Maryland also have noted that confinement-based dairies tend to need more fuel than pasture-based systems because grain production requires the use of fertilizer that is produced from natural gas and the operation of machinery (Davis et al. 2005; Weil and Gilker 2003).

Problems Associated with Corn-based Feeding Operations

Cattle are ruminant animals that naturally eat grass and forage. As mentioned above, a corn-based diet contributes to health problems in cattle, which lead first to the unnecessary use of antibiotics important to human medicine and, second, to the development of antibiotic resistance. Because corn is low in fiber, a corn-based diet allows fermentation acids to accumulate in cows' stomachs. This acid buildup can cause ulcers, through which infectious bacteria can enter the digestive tract and eventually produce abscesses in the liver. Some cattle are fed "total mixed rations" that are formulated to contain adequate amounts of fiber, but other total mixed rations are low in fiber, and acidosis is a prevalent problem for commercial dairies (Shaver 2001).

Grain-based diets can also promote virulent strains of *E. coli* in the digestive tract. Cattle switched from corn to hay for even brief periods before slaughter are less likely to contaminate beef products with harmful *E. coli* during processing (Russell and Rychlik 2001).

Long before the corn gets to the dairy and beef cattle, its production has also had negative environmental effects. Corn production demands inordinately high levels of fertilizer (i.e., biologically usable nitrogen), and corn grown for cattle feed accounts for more than 40 percent of all the commercial fertilizer and herbicides applied to U.S. crops (Christensen 2002). Fertilizer runoff from fields contributes to the problems of high nitrate levels mentioned above (Heimlich 2003) and the depletion of oxygen that produces "dead zones" in the Gulf of Mexico (CEC 1999). The same movement of nitrates from fertilizer into groundwater carries toxic pollutants including atrazine, an herbicide used on corn (CEC 1999). And because almost half of all corn acres are irrigated, and most of these acres are in the rain-deficient states of Kansas, Nebraska, and Texas (ERS 2000), this practice has contributed to the depletion of the Ogallala aquifer (McGuire 2004).

It should also be noted that corn production is subsidized by taxpayers in the form of government payments to producers (ERS 2005a). These subsidies have tended to promote increased production, which can lower feed prices. Because feed costs are such a high percentage (85 percent) of feedlot operating costs, a high ratio of beef prices to corn prices acts as a strong incentive to produce more beef (Norton 2005), compounding the problems associated with corn-based feeding operations.

Benefits of Pasture-based Systems

As more people come to understand the far-reaching and often negative ramifications of the conventional corn- and confinement-based system of animal agriculture, a number of producers have begun to question whether corn and other grains are the best feed for dairy and beef cattle, and whether crowded feedlots are the only way to raise them. Over the past 20 years or so, this pioneering group of farmers and ranchers has moved to contemporary versions of "grass farming" or grazing to produce milk and meat (i.e., feeding cows on pasture throughout their entire lives). Although pasture-raised animals are currently only a small proportion of beef and dairy operations,[5] early experience with these systems is encouraging, and the move by even a small percentage of producers from conventional to pasture-based production would help address the problems outlined above.

There are two types of pasture-based systems. **Traditional or continuous grazing** involves releasing livestock to roam in a large open pasture for the duration of the growing season (FoodRoutes 2004). **Rotational or management-intensive grazing** entails moving cows to a fresh portion of pasture (a paddock) once or twice a day. In either case, grazed forage becomes the cows' primary source of protein and energy, and no machines are needed to harvest feed or spread fertilizer over the land—the cows do this themselves (Weil and Gilker 2003).

Environmental benefits. The environmental benefits of carefully managed grazing systems utilizing permanent pastures are potentially significant, but it should be kept in mind that pastures that are not well managed can cause pollution. One set of analyses, based on scenarios developed with farmer and community input, has predicted that the adoption of pasture systems would greatly reduce emissions of heat-trapping or greenhouse gases (40 percent), decrease soil erosion (50 to 80 percent), decrease fuel use, and improve water quality (Boody et al. 2005). This study also demonstrated the benefits of carbon sequestration, less soil nutrient loss, and decreased sediment in waterways. Of much interest to wildlife lovers and hunters are the animal habitats that can be restored in the form of pasture lands. Populations of deer, turkey, quail, and other birds could increase by a factor of five (Boody et al. 2005).

Good management of pastures and adjacent riparian areas (water edges) can offer these environmental benefits and more, while improving the situation for animals and the beef or dairy producer's bottom line (Driscoll and Vondracek 2002).

Farmers' profits. Not only are pasture-based systems better for the environment, they are more profitable for farmers (although there may be significant differences between various parts of the country and among individual farmers).[6] A national Agricultural Resource Management Survey (ARMS 2005) comparing dairies using rotational grazing[7] with those using non-grazing systems found that the value of production less operating costs was five percent higher for the grazing farms. Another study comparing a large number of grazing farms with large confinement farms (more than 100 cows) in the Great Lakes states also found grazing farms to be economically competitive (Kriegl and McNair 2005).

[5] USDA data from 2001 estimated that about nine percent of dairy producers were using rotational grazing systems (USDA 2002). One researcher has "guesstimated" that there are about 500 U.S. producers of grass-fed cattle (Clayton 2005).

[6] Most studies on this subject have looked at dairy production; there are few comparable studies of beef production.

[7] It is not possible to tell from any of the studies what percentage of forage and grain a farm's cows were fed, but almost all the grazing farms appeared to feed their cows some amount of grain.

Unpaid family labor costs account for a large part of the cost advantage, but not all. Veterinary and medicine costs are consistently lower for grazing farms because their cows are healthier (Olsen 2004). Furthermore, farmers can often get premium prices for milk and meat produced without antibiotics and growth hormones and in a way that protects water and other natural resources (Dhar and Foltz 2003).

Nutrition benefits. Along with improvements in farmers' profits and the environment, grass-fed animals reportedly produce milk and meat with nutritionally beneficial fat profiles. We will examine the data that suggest pasture-raised products are lower in fat and higher in biologically active fatty acids than products from animals raised in confinement.

In general, these changes have been attributed to high-starch, low-fiber grains being replaced in cows' diets with the low-starch, high-fiber plants found in pastures. Many of these grasses and other plants contain high levels of alpha-linolenic and other fatty acids, which bacteria help convert into beneficial fatty acids in cows' stomachs. These beneficial fatty acids eventually find their way into milk and muscle (see Chapter 3 for details).

Chapter 3

Fats in Beef and Dairy Products

Foods are composed of carbohydrates, proteins, and lipids (or fats), and this report focuses on the latter category. The most important function of fats in the body is energy storage, but they also transport fat-soluble vitamins, serve as building blocks of membranes, and regulate a number of biological functions important to health and disease prevention.

The scientific and lay literature on the positive and negative effects of fats on human health is voluminous, and far beyond the scope of this report. Our interest lies in several categories of fats—total and saturated fat, and four polyunsaturated fatty acids—in which dairy and meat products from pasture-raised cattle may differ from products from conventionally raised cattle.

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Types of Fat

The total fat category encompasses fats and oils, sterols, phospholipids, and waxes, but we will only consider the first two substances. Table 3-1 summarizes some basic information on the fatty acids (the basic chemical units of fat),

Table 3-1: Three Categories of Fat: Fatty Acids, Cholesterol, and Lipoproteins

Fatty Acids	**Molecules commonly composed of chains of 4-30 carbon molecules.**
Saturated	No double bonds
Monounsaturated	One double bond
Polyunsaturated	Two or more double bonds
Cis	Hydrogen atoms on the same side of the chain
Trans	Hydrogen atoms on opposite sides of the chain
Cholesterol	**A molecule composed of several connected rings of carbon.**
Lipoproteins	**Molecules that transport cholesterol in the blood.**
HDL	High-density lipoproteins ("good" cholesterol)
LDL	Low-density lipoproteins ("bad" cholesterol)
(and others)	

Source: Carter n.d.

cholesterol, and lipoproteins that are discussed more fully below.

Fatty acids. These fairly simple chemical structures are composed of chains of 4 to 30 carbon atoms[8] with hydrogen atoms attached. (Three fatty acids attached to a glycerol backbone are called triglycerides or, more recently, triacylglycerols). There are several hundred fatty acids that differ from one another in number of carbon atoms, placement of hydrogen atoms, and number and types of bonds between carbon atoms. These elements/differences determine the properties of different fatty acids and the effects they have on the human body.

Saturated and unsaturated. The fatty acids have been subdivided into well-defined families. Fatty acids are said to be saturated when each carbon atom in the chain is attached to (saturated with) hydrogen atoms. These carbons are linked by single bonds. Unsaturated fatty acids contain at least one double bond that results from the attachment of only a single hydrogen atom to some carbons on the chain.

Saturated fatty acids are usually solid at room temperature, while unsaturated fatty acids are usually liquid oils. This means that when the fatty acid composition of a food such as butter is changed by supplementing cows' diets with oilseed, the properties of the food change as well (e.g., the butter is more spreadable).

Figure 3-1 illustrates the structures and the degree of saturation of three fatty acids:

- palmitic acid (the most common *saturated* fatty acid in plants and animals), a 16-carbon fatty acid saturated with a full complement of hydrogen atoms
- oleic acid, an 18-carbon *monounsaturated* fatty acid with one double bond
- linoleic acid, an 18-carbon *polyunsaturated* fatty acid with two double bonds

Figure 3-1: Molecular Structures of Selected Fatty Acids

Saturated fatty acid: Palmitic acid (16:0)

$COOH\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

↑ Carboxyl (COOH) or alpha end

↑ Methyl (CH_3) or omega end

Monounsaturated fatty acid: Oleic acid (18:1 omega-9)

$COOH\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH{=}CH\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$

1 2 3 4 5 6 7 8 9 ↑ 10 11 12 13 14 15 16 17 18

Double bond is nine carbons from the omega end.

Polyunsaturated fatty acid: Linoleic acid (18:2 omega-6)

$COOH\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH{=}CH\text{-}CH_2\text{-}CH{=}CH\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$

1 2 3 4 5 6 7 8 9 10 11 12 ↑ 13 14 15 16 17 18

The first of two double bonds is six carbons from the omega end.

Source: O'Fallon, Busboom, and Gaskins 2003.

[8] Some rare fatty acids are longer than 30 carbon atoms.

Omega designations. Omega designations describe the position of double bonds along the carbon chain. At the opposite ends of fatty acids are a methyl (CH_3) group and a carboxyl (COOH) group (Figure 3-1). The designations omega-3, omega-6, omega-7, and omega-9 refer to the number of carbon atoms from the omega end of the chain to the first double bond.[9]

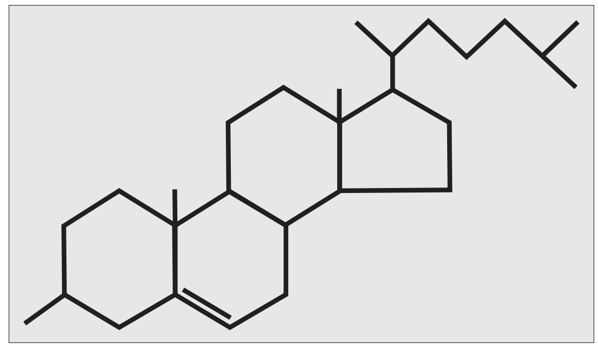
***Cis* versus *trans*.** In fatty acids with double bonds, the two hydrogen atoms around the double bond can be on either side of the carbon atoms. When the hydrogen atoms are on the same side as the carbon atoms, the structure has a *cis* configuration; when they are on opposite sides of the carbon atoms, the structure has a cross or *trans* configuration.

Although there are many fatty acids in nature, only a small subset occurs commonly—about 10 in plants and perhaps 20 in animals (Cyberlipid Center n.d.[a]). Linoleic acid (18:2 omega-6) and linolenic acid (18:3 omega-3), two of the fatty acids on which this report focuses, are vital for human health but are not produced in humans or animals. Thus, they are considered "essential" and must be consumed in the diet.

Cholesterol. The carbon molecules in cholesterol are not arranged in a chain but connected to other molecules to form several rings (Figure 3-2). This type of lipid molecule is called a sterol. Cholesterol is found mainly in animal tissues but also in some plant tissues (Cyberlipid Center n.d.[b]). It is an important constituent of cellular membranes, and tends to circulate in the body while connected to lipoproteins (GuruNet Corporation n.d.).

This report does not detail the amounts of cholesterol in foods because milk is naturally low in cholesterol and different cattle feeding regimens have little effect on the levels of cholesterol in meat and dairy products (*Wellness Letter* 2003). Some information about cholesterol is useful, however, in understanding the health implications of fatty acids.

Figure 3-2: Molecular Structure of Cholesterol



Source: Carter n.d.

Cholesterol travels in the blood in packets called lipoproteins, which are classified by their density. **Low-density lipoproteins (LDL)** carry about 75 percent of total blood cholesterol and are called "bad" cholesterol because a high level of LDL in the blood reflects an increased risk of heart disease. **High-density lipoproteins (HDL)** carry about 25 to 30 percent of total blood cholesterol and are called "good" cholesterol because high levels seem to protect against heart disease.

Bioactive food components. Nutritionists, consumers, and the food industry are also interested in this category of substances,[10] which, though found mainly in plant foods, also includes omega-3 fatty acids (OPHS-HHS 2004). These substances are not essential to prevent disease but may provide health benefits such as enhanced immune function, decreased proliferation of tumor cells, and decreased serum cholesterol (Bloch and Thomson 1995).

There is no accepted definition for bioactive food components, nor commonly accepted

[9] The correct technical designation is now n-3, n-6, etc., but we have chosen to emphasize the terminology widely familiar to the general public.

[10] Substances such as plant sterols, carotenoids, indoles, flavonoids, and others (Pennington 2002; OPHS-HHS 2004).

approaches for evaluating their health effects. In 2004 an ad hoc federal working group was asked to establish a definition (OPHS-HHS 2004). The group, composed of representatives from the National Institutes of Health (NIH), the Centers for Disease Control and Prevention (CDC), the U.S. Food and Drug Administration (FDA), and the USDA, has received written comments on what categories of compounds should or should not be considered bioactive food components and will be developing approaches to research and how to assess their health effects.

Fats of Interest to This Report

In looking for studies that have compared products from grass-fed cattle with those from conventionally raised cattle, we had to decide which nutrients to consider. Because of their impact on human health and the resulting level of public interest, we decided to focus on total fat, saturated fat, and three biologically active groups of fatty acid molecules: linoleic acid, the omega-3 fatty acids, and conjugated linoleic acid. In general, total fat and saturated fat have a negative correlation with good health, while the fatty acids have more positive associations that we describe below.

Total fat. Research over the last 10 years has begun to challenge the notion that the total fat content of diets should be reduced to lower the risk of heart disease (Hu, Manson, and Willett 2001). However, we are concerned with the total fat content of beef and dairy products for several reasons.

First, all fats are packed with energy—more than twice the caloric content of carbohydrates and proteins. This makes fat intake an important contributor to weight gain. Second, there is a strong correlation in American diets between total fat and saturated fat, and high levels of saturated fat correlate strongly with heart disease and other conditions. Since saturated fat is not likely to fall unless total fat is decreased in the diet (DHHS-USDA 2005), the amount of both total fat and saturated fat remains an important determinant of health. Third, in the case of beef, claims for lean and extra lean meat are based partly on its total fat content (see p. 34 for details). Finally, information on total fat is necessary to calculate the amount of a fatty acid in a serving of food.

Saturated fat. Decades of research have shown that high amounts of saturated fat in the diet increase the risk of coronary heart disease. The association is not always strong, but it is quite consistent across research studies. The mechanism appears to involve an increase in LDL cholesterol, which leads to atherosclerosis, a forerunner of coronary heart disease (IOM 2002). Not all saturated fatty acids found in foods add to the risk of heart disease; four (caproic, caprylic, capric, and stearic) appear to have a neutral effect on LDL cholesterol, and three (lauric, myristic, and palmitic) actually have LDL-increasing potential (German and Dillard 2004).

Heart disease has many causes, but animal and human research have both consistently shown a positive relationship between the three latter fatty acids and blood cholesterol levels. The data are strong enough to have influenced the dietary recommendation to decrease saturated fat in the diet. As mentioned earlier, the major sources of saturated fat in the U.S. diet are cheese, beef, and milk, although low-fat versions of each can significantly decrease saturated fat intake if eaten in moderation.

The "beneficial" fatty acids.[11] Linoleic acid and the omega-3 fatty acids have been extensively studied either because they are essential or are

[11] "Beneficial" is a descriptor applied to several food substances including some of the fatty acids discussed in this report.

believed to enhance human health in some way. They are also sometimes referred to as *beneficial* fatty acids. More recently, research on conjugated linoleic acid has suggested that this fatty acid might reduce the risk of certain diseases. At some point the evidence supporting the benefits of conjugated linoleic acid may be strong enough that it too can be included among the beneficial fatty acids.

We begin this section by providing some information on linoleic acid. Although we did not compare levels of linoleic acid or other omega-6 fatty acids in pasture-raised and conventional milk and beef, we did compare the ratio of omega-6 to omega-3 fatty acids for reasons discussed below. The following information is therefore provided as background for that discussion.

Omega-6 fatty acids. **Linoleic acid or LA** (18:2 n-6) is the most common polyunsaturated fatty acid in both plant and animal tissues. Because it is vital for human health and can only be produced by plants, it is considered an "essential" fatty acid that animals must find in foodstuffs. The most significant sources of LA are plant seeds and oils such as corn, peanut, safflower, soy, and walnut.

When researchers discovered that polyunsaturated fatty acids including LA had a positive effect on cholesterol levels and heart health, the public was encouraged to increase its intake of these oils. At present, LA provides about 85 percent of Americans' energy intake from polyunsaturated fatty acids (Kris-Etherton et al. 2000).

Omega-3 fatty acids. This family of fatty acids includes three fats of interest to this report (Table 3-2). One is **alpha-linolenic acid or ALA** (18:3 n-3), an essential fatty acid that cannot be synthesized by animals. It is found in plant foods including grasses, and the major sources in the U.S. diet are flaxseed and flaxseed oil, canola and soybean oils, and English walnuts. ALA contributes about 10 percent of Americans' energy intake from polyunsaturated fatty acids.

Eicosapentaenoic acid or EPA (20:5 n-3) and **docosahexaenoic acid or DHA** (22:6 n-3) are found predominantly in fish and fish oils

Table 3-2: Selected Dietary Sources of Fatty Acids

Omega-6 fatty acids	
LA	Corn, peanut, safflower, soy, and other oils Various nuts
Omega-3 fatty acids	
ALA	Grass Flaxseed Flaxseed, canola, soybean, wheat germ, and walnut oils English walnuts Tofu
EPA and DHA	Fish (fatty), fish oils, caviar
Conjugated linoleic acid (CLA)	
	Whole milk and dairy products Ruminant meats

Source: MacLean et al. 2004; Fritsche and Steinhart 1998b.

Table 3-3: Pathways of Omega-6 and Omega-3 Metabolism in Humans

Dietary Omega-6	Common Enzymes	Dietary Omega-3
linoleic acid 18:2 (LA)		alpha-linolenic acid 18:3 (ALA)
↓	delta-6-desaturase	↓
gamma-linolenic acid 18:3		octadecatetranoic acid
↓	elongase	↓
dihomo-gamma-linolenic acid		eicosatetranoic acid
↓	delta-5-desaturase	↓
arachidonic acid 20:4		eicosapentaenoic acid 20:5 (EPA)
↓	elongase	↓
adrenic acid		docosapentaenoic acid 22:5
↓	beta-oxidation	↓
docosapentaenoic acid 20:5		docosahexaenoic acid 22:6 (DHA)

Source: Williams 2000.

because fish consume marine algae that contain high levels of these substances. ALA is a precursor of EPA and DHA, but the conversion to those compounds in the liver (Table 3-3) is modest and fairly inefficient. Because ALA-to-DHA conversion is particularly poor, a group of European scientists has concluded that DHA is likely an essential fatty acid (Muskiet et al. 2004). If it is eventually designated as such, producers and purveyors of foods high in DHA will find it much easier to make a nutrient or health claim (see pp. 31, 34).

Conjugated linoleic acid. **Conjugated linoleic acid or CLA** is a collective term for more than 20 close relatives (isomers[12]) of LA. The term "conjugated" refers to the fact that the double bonds along the chain are separated by only a single carbon-to-carbon bond, whereas most polyunsaturated fatty acids have two carbons between double bonds (Figure 3-3). The double bonds in conjugated molecules are in either a *cis* or *trans* configuration. Among the 20 isomers, only two have been intensively studied: *cis*-9, *trans*-11 (CLA n-7, the predominant isomer in ruminant foods), and *trans*-10, *cis*-12 (CLA n-6).

The primary sources of CLA in the human diet are meat and dairy products from ruminant animals. About 75 percent of CLA intake in most countries comes from milk and other dairy products; most of the remainder comes from meat (Fritsche and Steinhart 1998a).[13] U.S. researchers have reported a similar breakdown (Ritzenthaler et al. 2001). CLA is also found in fish products, but the amounts are negligible compared with dairy products (Fritsche and Steinhart 1998b).

CLA is produced in the stomach (rumen) and mammary glands of dairy cows by converting the polyunsaturated fatty acids found in grasses and other feeds. Bacteria convert most, but not all, of the polyunsaturated fatty acids into saturated fatty acids. This is why the polyunsaturated fatty acid content of milk is only two to three percent of total fat (Demeyer and Doreau 1999). The major unsaturated fatty acid leaving the stomach and entering the intestine is

[12] Isomers are molecular structures that contain the same elements in the same order, but oriented differently in space and often possessing different properties. *Cis* and *trans*, when applied to a molecule name, describe different isomers.

[13] The 75 percent figure is our calculation based on data in Fritsche and Steinhart 1998a.

Figure 3-3: Molecular Structure of CLA (18:2 c9,t11)

$$COOH\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH{=}CH\text{-}CH{=}CH\text{-}\ CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$$

1 2 3 4 5 6 7 8 9 10 11 ↑ 12 13 14 15 16 17 18

The two double bonds are close to each other and the first double bond is seven carbons from the omega end.

Source: Fallon, Busboom, and Gaskins 2003.

vaccenic acid or VA (18:1 t), a monounsaturated fat. From the intestine, VA is absorbed into the bloodstream and transported via lipoproteins to the mammary glands and muscles (Demeyer and Doreau 1999).

There are two pathways by which CLA is produced (Griinari and Bauman 1999). One starts with LA; the other starts with ALA and leads through VA. About 70 to 90 percent of CLA is formed via this second pathway (Lock and Bauman 2004), which is important for two reasons. First, this pathway opens the possibility of giving cattle different feeds and fat compounds to increase the amounts of CLA in milk and meat. Second, because approximately 20 to 30 percent of VA can be converted to CLA in humans (Turpeinen et al. 2002), VA from milk or meat can make a significant contribution to the total CLA in the diet (Bauman et al. n.d.).

Effects of Beneficial Fatty Acids on Human Health

To produce evidence of different food components' health benefits, scientists employ three types of studies: laboratory animal studies, clinical studies, and epidemiological studies. Although tests on lab animals are a good starting point from which to ascertain nutritional benefits, scientists are generally not convinced of such benefits until they have been observed in either clinical or epidemiological studies of human populations. But studies of humans are difficult to conduct.

Before describing the known effects of fatty acids in humans, it may be useful to briefly review the methodology of clinical and epidemiological studies. **Clinical studies** involve controlled trials in which participants are either assigned to a control group or a treatment group. Members of the treatment group are given a set amount of the substance under observation (for example, a diet high in foods containing ALA). In some clinical studies, scientists know which individuals are in the treatment group(s), and in others they do not. Clinical studies are important because they help establish cause-and-effect relationships between a particular compound and a disease.

In **epidemiological studies**, scientists assess the factors that affect disease risk by observing disease outcomes in selected populations without any intervention. Such research can be divided into **case-control studies**, which look for differences in behavior (e.g., the amount of milk consumed) between a group of people with a disease and a group that doesn't have the disease, and **cohort studies**, which follow a single group of people over time to see what differences in behavior might affect an individual's condition. A variety of factors can affect the validity of any given study (Morse 2005), and it is a challenge to control for as many of these factors as possible.

Effects of LA. A large body of evidence from animal and human studies indicates that LA at appropriate levels is important for the prevention of heart disease. However, recent clinical research has suggested that high intakes of omega-6 fatty acids including LA (greater than 10 percent of calories) may also have adverse effects, such as a slower inflammatory response (Kris-Etherton, Hecker, and Binkoski 2004).

Effects of EPA and DHA. A large body of evidence suggests that these two long-chain omega-3 fatty acids, which are found primarily in fish, have a number of beneficial effects on human health, although some findings are still inconclusive. Some of the strongest evidence supports the effect of these compounds on coronary heart disease.

Interestingly, the first evidence of the importance of EPA and DHA was epidemiological studies of Eskimo/Inuit populations who consume large amounts of fat—most of it from fish—but have low rates of coronary heart disease. These fatty acids, especially EPA, have an anti-arrhythmic effect as well as an anti-thrombosis effect (de Longeril, Renard, and Mamelle 1994). Both have been shown to decrease triglyceride levels, which would reduce the risk of coronary heart disease (Harris 1997). They also appear to reduce blood pressure, although the research has employed large doses of the fatty acids (Kris-Etherton, Harris, and Appel 2003).

A recent exhaustive study of research assessing the effects of omega-3 fatty acids on cardiovascular disease (Wang et al. 2004) concludes that the intake of fish or omega-3 fatty acids, including supplements, reduces coronary heart disease-related sudden death, cardiac death, and heart attacks. The strongest evidence is for fish and fish oil. The same analysis concluded that omega-3 fatty acids reduce triglycerides in patients with Type II diabetes.

Omega-3 fatty acids from fish appear to have beneficial effects on inflammation and immune reactions (de Deckere et al. 1998), such as those involved in rheumatoid arthritis. ALA, however, does not appear to have the same effects (see below). Finally, EPA and especially DHA play a key role in building the cellular structures of the brain and are particularly important in infancy (Connor 2000).

Effects of ALA. Both clinical and epidemiological evidence indicates that ALA, like EPA and DHA, reduces the risk of coronary heart disease and the incidence of fatal heart attacks, probably due to an anti-arrhythmic effect (Wang et al. 2004; Hu et al. 1999). An exhaustive study of research linking omega-3 fatty acids to cancer outcomes, however, led the authors to conclude that "the evidence does not support a significant association between omega-3 fatty acids and cancer incidence" (MacLean et al. 2005).

Effects of the omega-6/omega-3 ratio. Omega-6 and omega-3 fatty acids often have opposing physiological functions (Simopoulos 1999), and evidence is emerging that their ratio in the diet may be an important factor in human health. This line of inquiry was prompted by studies that concluded the diets of early humans (Table 3-4) contained roughly equal amounts of omega-6 and omega-3 fatty acids—a ratio between 1:1 and 2:1 (Kris-Etherton et al. 2000).

In contrast, Americans' consumption of omega-6 fatty acids has increased enormously over the past 150 years (particularly in the form of vegetable oils) while our intake of omega-3 fatty acids from fish, meat, and dairy foods has declined. Recent studies suggest that the average U.S. omega-6/omega-3 ratio is now about 10:1 (Kris-Etherton et al. 2000). Individual foods, of course, have different ratios.

Table 3-4: Change in Omega-6/Omega-3 Ratios over Time

Human Population	Ratio	Diet Features
Hunter-gatherers (400,000 to 45,000 years ago)	1:1	Wild plants, animals, and fish
Western cultures at onset of Industrial Revolution (150 years ago)	8.4:1	Greatly increased vegetable oils along with animals raised on cereal grains
Present-day Western cultures (70 years ago)	10.3:1	Increased fats, oils, vegetables, and nuts

Source: Kris-Etherton et al. 2000.

Based on epidemiological and clinical studies that show a correlation between lower omega-6/omega-3 ratios and higher bone density in men and women aged 45 to 90 (Weiss, Barrett-Connor, and von Muhlen 2005a), as well as epidemiological studies that have shown "near significant" associations between lower ratios and reduced coronary heart disease and mortality (Wang et al. 2004), suggestions have been made to bring the ratio more in line with humans' earlier diet composition. One way to establish a lower ratio is to increase the consumption of pasture-raised products and fish in the diet and decrease the consumption of LA-rich vegetable oils.

Effects of CLA. CLA has been associated in animal and laboratory studies with an impressive array of health benefits. Interest in this omega-7 fatty acid was first triggered by the finding that CLA had anti-carcinogenic properties in mice (Ha, Grimm, and Pariza 1987). Since then, other animal studies have shown CLA to have positive effects on atherosclerosis, diabetes, immune function, and body composition.

The c9,t11 isomer is predominant in ruminant products but many studies have also used the t10,c12 isomer. Since each isomer has different effects on various conditions, interpreting research studies can be somewhat difficult. For example, the t10,c12 isomer greatly reduces the synthesis of milk fat in cows (Bauman, Corl, and Peterson 2003), and reduces body fat mass and increases lean body mass in mice (Pariza, Park, and Cook 2001). Both isomers have shown anti-carcinogenic effects at all three key stages of cancer development (Belury 2002), and both appear to have a protective effect in animal models against the inflammatory responses induced by various substances. Also, rabbits fed an isomer mixture of CLA experienced a reduction in aortic plaque formation and a decrease in cholesterol, LDL cholesterol, and triglycerides (Lee, Kritchevsky, and Pariza 1994).

Disappointingly, most of these positive effects have not been duplicated in human studies. This may be due to a variety of factors. First, most clinical research has involved fairly high doses of CLA and a 50/50 combination of the two major isomers. Because the isomers have different effects on the body, results can be contradictory and ambiguous. Second, humans do not react to many substances in the same way as many animals, so animals other than rats, mice, and rabbits would be better models for what effects CLA might have on humans.

Up to this point, the available clinical studies are too few and their results too confusing for scientists to have a good understanding of the effects of CLA on human disease conditions. Most research has focused on weight loss and cancer, but other diseases such as diabetes have also been studied.

With regard to concerns about obesity and its relationship to heart disease and cancer, a recent review of all the studies documenting the effects of CLA on human body composition and plasma lipids showed no significant effect on body weight or weight regain (Terpstra 2004). In the two studies that recorded a beneficial effect on body fat mass, it was difficult to disentangle the simultaneous effects of physical exercise. The review found no significant effect on plasma cholesterol or LDL cholesterol, both of which increase the risk of heart disease, and there also seemed to be no effect on plasma triglycerides. Although there have been a number of ways proposed by which both CLA isomers might reduce inflammation responses and enhance immune function, the few human studies to date have shown mixed results (Wahle, Heys, and Rotondo 2004). Clinical studies of CLA's effects on insulin resistance have shown apparently adverse effects, probably due to the t10,c12 isomer (Aminot-Gilchrist and Anderson 2004).

Clinical studies are only one part of the evidence needed to determine the role of a food component in human health. So far there have been very few epidemiological studies of CLA, and only on its relationship to cancer. One inherent problem in any such study is that the major dietary sources of CLA are milk and cheese, and it is difficult to separate the effect of CLA from the effect of the dairy products themselves.[14]

In two case-control studies and one cohort study of the relationship between breast cancer and CLA intake, reduced risk was seen in one (Aro et al. 2000), no association in another (McCann et al. 2004), and a slightly increased risk in the third (Voorrips et al. 2002). Other studies have shown no consistent evidence for an association between consumption of dairy products in general and breast cancer risk (Moorman and Terry 2004).

A recent meta-analysis (Norat and Riboli 2003) of the relationship between dairy consumption and colorectal cancer risk showed no association in case-control studies and a reduced risk with higher total dairy consumption in cohort studies (but not cheese or yogurt when analyzed separately). One other just-published study concludes that high consumption of high-fat dairy foods may lower the risk of colorectal cancer in women, which may in part be due to CLA intake (Larsson, Bergkvist, and Wolk 2005).

Summary of the Evidence

Table 3-5 provides an overview of the evidence for beneficial health effects of omega-3 fatty acids and CLA. Rather than attempting to present a thorough review of the enormous literature on this topic, the table represents judgments made by UCS on the strength of the evidence from animal tests and clinical and epidemiological studies in human populations.

Check marks indicate a substantial body of evidence supporting the link between the fatty acid or CLA and a positive health outcome or, in the case of clinical and epidemiological studies, that either research failed to detect a link or showed evidence of a negative association. Empty cells indicate that data have not been found or studies have not been done. In almost all cases, the studies have involved levels of fatty acids far higher than would be found in typical diets.

As the table shows, the strongest evidence of beneficial health effects is for EPA and DHA.

[14] Of course, it would not be ethical to conduct human clinical trials until there is clear evidence that CLA might be beneficial in treatment (and then it would be given at fairly high levels).

Table 3-5: Summary of the Evidence for Health Effects of EPA/DHA, ALA, and CLA

	Animal studies[a]	Clinical studies		Epidemiological studies	
	Positive association	Positive association	No or negative association	Positive association	No or negative association
EPA/DHA					
Arrhythmias	✓	✓		✓ (supplements and fish)	
Blood pressure				✓ (fish)	
Cancer	✓		✓		✓
Coronary heart disease	✓	✓		✓ (supplements and fish)	
Diabetes	✓		✓		
Immune/Inflammatory	✓	✓ (some cases of rheumatoid arthritis)			
Mental health		✓ (very high doses)			
Neural development	✓	✓			
Stroke				✓ (fish)	✓ (supplements)
Triglyceride levels	✓	✓ (high doses)		✓	
ALA					
Arrhythmias	no				✓
Blood pressure					✓
Cancer		✓ (maybe)			✓
Coronary heart disease		✓ (fatal & acute heart attack)		✓ (only long-duration studies)	
Immune/Inflammatory			✓		✓
Triglyceride levels			✓		
CLA					
Cancer	✓	✓ (*in vitro*)		conflicting (breast cancer)	
Coronary heart disease	✓		✓		
Diabetes	variable	✓	✓		✓
Immune/Inflammatory	✓	✓ (limited)			
Lean body mass	✓ (very high doses)		✓		
Weight gain	✓ (very high doses)		✓		

[a] Clinical and epidemiological studies are rarely conducted in humans unless animal studies show positive results.

Sources: AHA Conference Proceedings 2001; Allison et al. 1999; Angel 2003; Ascherio, Stampfer, and Willett 1999; Bauman, Corl, and Peterson 2003; Brewer 1994; Connor 2000; de Deckere et al. 1998; EFSA 2004; Ha, Grimm, and Pariza 1987; Jordan et al. 2004; Kris-Etherton, Harris, and Appel 2002; Lee, Kritchevsky, and Pariza 1994; MacLean et al. 2005; MacLean et al. 2004; Pariza, Park, and Cook 2001; Roche et al. 2001; Schacter et al. 2005; Tricon et al. 2004; Wahle, Heys, and Rotondo 2004; Wang et al. 2004; Weggemans, Rudrum, and Trautwein 2004; Willett et al. 1993; Williams 2000.

Research on ALA shows a beneficial effect on fatal and acute heart attacks but not on other conditions. Animal research on CLA has shown many positive effects on heart, cancer, and immune conditions, but these results have not been borne out by the relatively small number of human studies. The sources for Table 3-5 are listed in alphabetical order; the findings are not matched with individual reports.

A Note on Trans Fats

CLA and VA are *trans* fatty acids. Trans fats have received a good deal of attention as a result of their negative health effects and so deserve a special discussion in the context of this report. There are two dietary sources of trans fats: solid fats produced from oils that have had hydrogen added to them, which makes them more saturated, and ruminant milk and meat. The major U.S. food sources of the former category of trans fats, often referred to as industrial trans fatty acids, are shortening, margarine, fast foods, and commercial baked goods. In many European countries animal foods are now a larger contributor to total trans fat intake (80 to 90 percent) than industrial sources (Weggemans, Rudrum, and Trautwein 2004), but in the United States, where removal of trans fats from processed foods has lagged behind Europe, only about 20 to 25 percent may come from animal foods (Allison et al. 1999).

Scientists are concerned about trans fats because studies show a link not only with increased LDL cholesterol but also decreased HDL cholesterol, which has a doubly negative effect on heart disease (Ascherio, Stampfer, and Willett 1999). One study estimated that replacing just two percent of the calories received from trans fats with unhydrogenated, unsaturated fats would reduce the risk of coronary heart disease 50 percent (Hu et al. 1999).

Because the evidence of trans fats' negative effect on coronary heart disease is so strong, most countries have adopted policies that require food labels to provide the amount of trans fatty acids in a serving. The FDA requires such labeling as of January 1, 2006 (FDA 2003), which has raised the question of whether the trans fatty acids in ruminant foods differ from those in industrial sources. There are many reasons to think the answer is yes.

First, the isomer profile is very different: the main trans fatty acid in hydrogenated oils is elaidic acid, while the main trans fatty acid in ruminant foods is VA. Second, trans fats in general are present in small amounts in animal foods (0.3 gram per cup of milk) compared with the large amounts found in baked goods: three grams in a doughnut, 1.5 grams in an ounce of corn chips, 0.6 gram in a teaspoon of margarine, etc. (Brewer 1994). Third, an increased risk of heart disease has been linked with trans fats from hydrogenated vegetable oils, but not from fatty acids that occur in meat and dairy products from cattle (Willett et al. 1993; Bauman et al. n.d.). Because no human intervention studies have been conducted on the effects of trans fats in ruminant foods, it is not yet possible to determine whether these substances differ from hydrogenated vegetable oils in increasing the risk of coronary heart disease (EFSA 2004).

Once there is more clarity about the role of CLA in human diet and disease, it will be easier to sort out the contributions of trans fatty acids from animal and industrial sources.

Dietary Recommendations and Food Labeling

For more than 100 years, people have been interested in the relationship between diet and health, and the optimum levels of dietary intake. The USDA suggested in 1905 that eating a high-fat diet was not a good idea, but it was only after the discovery of the essential nutrients and research linking nutrient levels with an absence of disease symptoms that the Food and Nutrition Board of the National Academy of Sciences set the first nutrient allowances. This eventually led the USDA to recommend consumption of food groups that would furnish the needed nutrients. Later, the U.S. Senate's Dietary Goals (U.S. Senate Select Committee 1977) and the DHHS-USDA Dietary Guidelines (DHHS-USDA 1980) suggested foods or food substances that should be eaten in smaller or larger quantities as part of a healthy diet and as a way to lower the risk of certain diseases.

With the advent of nutrition labels for processed foods in 1973, it became clear that better regulation of nutrition claims was needed, so in 1990 Congress passed the Nutrition Labeling and Education Act (PL No. 101-535 1990), establishing a standard for nutrition claims and allowing comparisons between foods to be made on retail food labels. The act also recognized the manufacturer's or producer's right to make health claims backed by science, such as "a diet low in total fat may reduce the risk of some cancers" (CFSAN 2002). This ability represents a significant advantage for retailers seeking to attract health-conscious consumers.

Now, as evidence of the potential health benefits of fatty acids in milk and meat continues to accumulate, nutritionists, consumers, and retailers are beginning to focus on the levels of these compounds in food and their significance in the diet. Whether producers and retailers will be able to make claims about these food components in their advertising and labeling, however, is a subject of much debate.

We will consider this issue later, but it is important to first present some background information on the government agencies, laws, and regulations involved in the setting of standards and the ability of beef and dairy producers to make nutrient and health claims about their products.

There are different types of dietary recommendations, standards, and claims relevant to the food substances covered in this report. In this section, we first identify the institution that sets U.S. nutrient requirement standards and those that develop the U.S. government's dietary recommendations; we then review the recommendations relevant to this report. Next, we identify the institutions that regulate nutrition claims made on food labels and in advertising. The section ends with a review of the specific standards for nutrients and other substances found in milk and meat.

Organizations that set dietary standards

Food and Nutrition Board. For almost 65 years this group has used the best available scientific evidence to recommend the dietary intake of specific nutrients needed to maintain good health. These standards were first prompted by the need to feed troops adequately during World War II, and have been revisited every six or seven years.

In 1994 the board developed a more sophisticated system of classifying dietary allowances that included the familiar U.S. Recommended Dietary Allowance. Several components of the resulting Dietary Reference Intake system (IOM 2002) are relevant to the nutrients in which we are interested. These recommendations (as defined by the Food and Nutrition Board below) reflect differences in the nutrients (vitamins, minerals, and energy sources) and the level of sophistication and consistency in the results of the scientific research behind the recommendations.

- **Recommended Dietary Allowance (RDA):** the average daily dietary nutrient intake level determined to be sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) of healthy individuals in a particular life stage and gender group.

- **Adequate Intake (AI)**: the recommended average daily intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate—used when an RDA cannot be determined.
- **Acceptable Macronutrient Distribution Range (AMDR)**: the range of intake for a particular energy source that is associated with reduced risk of chronic disease while providing intakes of essential nutrients (IOM 2002).

In 2002 the Food and Nutrition Board released its report on the Dietary Reference Intake system for fat and fatty acids (IOM 2002), including total fat, LA, and the omega-3 fatty acids. Since there is no known requirement in the diet for saturated fatty acids, trans fatty acids, and dietary cholesterol, the board made no recommendations for these substances.

As mentioned earlier, "essential" nutrients are required for normal body function and cannot be synthesized by the body. The absence of such a nutrient in the diet will result in the development of a disease that only the nutrient can cure. This category of substances includes vitamins, minerals, essential amino acids, and essential fatty acids.

There are a variety of other compounds found in food that, although not required, can have a beneficial effect on health or in treating a disease. In adults the omega-3 fatty acids EPA and DHA are examples of beneficial nutrients that are not essential (because they can be formed from ALA). Research on these fatty acids is not as extensive as on other nutrients, but much attention is now being given to them (see the discussion of bioactive food components on p. 19).

The U.S. Department of Health and Human Services (DHHS) and USDA. The Dietary Guidelines disseminated by the DHHS and USDA and drawn from the recommendations of a non-federal Dietary Advisory Committee are the formal source of diet and food recommendations in this country. They were developed as a way to translate nutrient requirements into food choices consumers could and should make, and are based on extensive research. The guidelines have been released every five years starting in 1980; the most recent were released in January 2005 (DHHS-USDA 2005). These were accompanied soon after by an updated Food Guide Pyramid, which serves to visualize the Dietary Guidelines and what the federal government considers a healthy diet (USDA 2005).

Specific dietary recommendations. U.S. standards for total and saturated fat are different from those that might be set for fatty acids. In general, nutritionists are concerned about moderating the intake of total fat and saturated fat, but where the evidence supports it, they encourage the intake of beneficial fatty acids. Currently, the scientific evidence on the health effects of total and saturated fat (primarily detrimental effects) is much more robust than the evidence on the health effects of some of the beneficial fatty acids.

The recommendations for total fat, saturated fat, and the beneficial fatty acids (reviewed below) reflect both our current knowledge about fats in the diet and the confused and preliminary nature of the data needed to support specific dietary recommendations. Considering the many kinds of fats and the complexities of their interrelationships, the tentative nature of these recommendations is not surprising.

Total fat. The Food and Nutrition Board's Acceptable Macronutrient Distribution Range for fat in the adult diet is 20 to 35 percent of calories. The DHHS/USDA Dietary Guidelines make the same recommendation, and further suggest that most dietary fats should come from sources of polyunsaturated and monounsaturated fatty acids.

Saturated fat. As noted above, the Food and Nutrition Board does not suggest a necessary level of saturated fat in the diet,[15] but the Dietary Guidelines recommend that less than 10 percent of calories (or about one-third of fat intake) come from these kinds of fats. In a typical 2,000-calorie diet this translates into just over 20 grams of saturated fat per day. Only about 40 percent of individuals in the United States currently meet this guideline (Basiotis et al. 2002).

LA. The Adequate Intake for LA set by the Food and Nutrition Board is 17 grams per day for men and 12 grams per day for women. The World Health Organization has essentially the same recommendation. The International Society for the Study of Fatty Acids and Lipids, a non-governmental body composed of scientists studying beneficial fatty acids, in contrast, because of concern about the possible ill effects discussed in Chapter 2 of high-LA diets and omega-6/omega-3 ratios, recommends a lower intake of 4.4 grams for every 2,000 calories per day, or about two percent of total calories (Cunnane et al. 2004).

Aside from suggesting that most sources of fat should be polyunsaturated and monounsaturated, the Dietary Guidelines make no specific recommendation on sources or types of fats. In the technical report accompanying the guidelines, the Dietary Guidelines Advisory Committee concludes that an intake of omega-6 fatty acids such as LA to constitute between 5 and 10 percent of total calories may confer beneficial effects on coronary heart disease-related mortality (Dietary Guidelines Advisory Committee 2004).

ALA. The Food and Nutrition Board's Adequate Intake for this omega-3 fatty acid is 1.6 grams per day for men and 1.1 grams per day for women (close to the current average intake of the U.S. population). As with LA, the Dietary Guidelines do not make a specific recommendation for ALA, but the technical report concludes that an intake between 0.6 and 1.2 percent of calories is appropriate (Dietary Guidelines Advisory Committee 2004). This would be 1.2 grams per day for someone consuming 2,000 calories per day.

EPA/DHA. The Food and Nutrition Board has not set an Adequate Intake for EPA/DHA because, in contrast to ALA, it believes there are not enough data showing these omega-3 fatty acids to be essential in the diet. However, the committee that set the Adequate Intake for ALA did suggest that 10 percent of the Adequate Intake amount for ALA (130 milligrams per day) "can come from" EPA and DHA. A lack of agreement on this standard is evident in the fact that the International Society for the Study of Fatty Acids and Lipids recommends a minimum 500 milligrams per day and the United Kingdom's Scientific Advisory Committee on Nutrition recommends 200 milligrams per day (Horner 2005). The Dietary Guidelines recommend the consumption of about two servings of fish per week to meet EPA/DHA needs.[16]

Omega-6/omega-3 ratio. There is no clear agreement among U.S. or international nutrition experts on the optimum ratio of omega-6 to omega-3 fatty acids. Suggestions range from 2:1 (Japan) to 5:1 (Sweden) and 10:1 at the upper end of the range suggested by the World Health

[15] It has been recently suggested that "steps to decrease SFAs [saturated fatty acids] to as low as agriculturally possible should wait until research shows which amounts and types of SFA are optimal" (German and Dillard 2004), but it is not clear how much of the nutrition research community agrees.

[16] This recommendation was accompanied by an advisory about the potential health risks associated with methylmercury contamination of fish (DHHS-USDA 2005).

Organization (Davis and Kris-Etherton 2003). Neither the Food and Nutrition Board nor the Dietary Guidelines Advisory Committee has offered a recommendation.

Scientists have disagreed about the usefulness of the omega-6/omega-3 ratio in characterizing diets for several reasons. First, not all omega-3 fatty acids are the same. As noted above, plant and marine omega-3 fatty acids (ALA in plants, EPA/DHA in fish) have different effects (Finnegan et al. 2003; de Deckere et al. 1998). Second, a decrease in intake of the omega-6 fatty acid LA "does not produce the same effects as an increase in omega-3 fatty acid intake" because omega-6 and omega-3 fatty acids function in different metabolic pathways and have different effects on disease risk (de Deckere et al. 1998). Third, the same ratio can exist for low and high intake levels. For example, even at a ratio of 4:1, saturated fat, trans fats, and cholesterol could be above recommended levels (Kris-Etherton, Hecker, and Binkoski 2004).

Nevertheless, the ratio remains a subject of interest in the nutrition community. We offer data on the ratio because of this interest and as a way to understand one of the ways in which the nutrient content of milk and meat samples from animals raised in different systems can vary.

CLA. Because research into the specific effects of CLA on human health continues, no effort has been made to offer dietary recommendations. The lack of a nationally established database of CLA content in various foods complicates matters. The USDA Nutrient Data Laboratory, for example, maintains data on the amounts of 115 components in 8,000 foods (Dwyer, Picciano, and Raiten 2003), but CLA content is only noted for a few ruminant foods in the trans fatty acid table (Exler, Lemar, and Smith 2001). Without such data for a wide variety of foods, current and recommended levels of CLA in the diet cannot be calculated. These data will probably come from many sources, but the laboratories that perform the analyses must use an appropriate method (e.g., Aldai et al. 2005).

Trans fatty acids. The Dietary Guidelines suggest that trans fat intake be kept as low as possible. No distinctions are currently made between natural trans fats such as CLA and industrial trans fats such as hydrogenated vegetable oils.

Agencies that regulate nutrient claims. Food manufacturers and producers translate dietary recommendations into useful information for consumers by making claims on their product labels or in advertising about the presence of healthful substances (or the absence of detrimental substances). Such claims are regulated by the FDA, USDA, and the Federal Trade Commission (FTC) to protect consumers from premature, inaccurate, or misleading assertions.

The FDA and USDA have primary responsibility for food labeling and the FTC for food advertising (FTC 1994). The USDA specifically regulates the labeling of all fresh meat sold at the wholesale level (but not direct sales from producers to consumers), all sausage sold at retail, and processed meat products sold at retail that contain greater than three percent raw meat. This constitutes about 20 percent of the U.S. food supply (Robinson 2005). The FDA regulates all other foods with labeling requirements, including single-ingredient raw meat sold directly to consumers. Nutrient labeling is voluntary for fresh raw meat, but mandatory for all other meat products (CFR 317.300).

While the USDA approves labeling content prior to sale, the FDA enforces its regulations through complaints made after the food is on the market. Both agencies, however, have coordinated requirements for labeling claims in order to have consistency in the marketplace (FNB 2003).

Table 3-6: Nutrients and Food Components That May Appear on a Nutrition Label

*Total fat	*Iron	Pantothenic acid
*Saturated fat	Vitamin D	Phosphorus
*Cholesterol	Vitamin E	Iodine
*Sodium	Vitamin K	Magnesium
Potassium	Thiamin	Zinc
*Total carbohydrates	Riboflavin	Selenium
*Fiber	Niacin	Copper
*Protein	Vitamin B_6	Manganese
*Vitamin A	Folate	Chromium
*Vitamin C	Vitamin B_{12}	Molybdenum
*Calcium	Biotin	Chloride

* Must appear on nutrition labels.
Source: CFSAN 1999.

The nutrition information on food labels (called the Nutrition Facts Panel[17]) is expressed as a percentage of the so-called Daily Value that is present in the food for:

- 25 nutrients,[18] not all of which are required (Table 3-6)
- Eight food components for which there are no established Recommended Dietary Allowances, including total fat and saturated fat (Table 3-6)[19]
- Trans fatty acids (FR 2003) (as of January 1, 2006)

For labeling purposes the FDA does not include conjugated trans fatty acids, but does include trans vaccenic acid because it fits the chemical structure definition used by the agency rather than a metabolic or functional definition (FR 2003).[20] The percent Daily Value (%DV) was developed to meet the Nutrition Labeling and Education Act's requirement that the nutrition label be designed so the public could "readily observe and comprehend" nutrition information and its significance in the diet (104 Stat. 2353, 2356). These values, finalized by the FDA in 1993 (FNB 2003), are based on the 1968 Recommended Dietary Allowances and a number of reports released in the 1980s (FNB 2003).

Producers and manufacturers can state the amount of a substance for which there is no Daily Reference Value as long as all other labeling requirements are met. These requirements include, among other things, the minimum number of food units that must be sampled from each lot for nutrient analysis, the methods that must be used, and the extent of record keeping.

[17] Small businesses with annual sales of not more than $500,000 are exempt from food labeling as long as they make no claims (Nutrition Labeling and Education Act in FNB 2003), except for trans fat labeling.

[18] Derived from the Recommended Dietary Allowances.

[19] Derived from the Daily Reference Values established for nutrients for which there are no Recommended Dietary Allowances (FDA 1993).

[20] Therefore, VA but not CLA must appear on labels unless the amount is less than 500 milligrams. When that is the case the content will be expressed as zero.

If producers don't have nutrient data on their own products they can use representative values from the USDA Nutrient Data Bank, but this point is moot for the time being since the Data Bank does not contain values for pasture-raised products.

Specific nutrient claims. Food manufacturers are allowed to make specific claims about the nutrient composition of a food if the claims meet certain standards (21 CFR Part 101 Subpart D). Producers of pasture-raised meat and milk, for example, might make a claim that their products are "lean," "low in fat," or have "less total fat" than a conventional product. Such claims cannot be made unless the food bears a Nutrition Facts Panel.

The claim "low in fat" can be made for a food that contains three grams or less of fat in a serving of at least 30 grams. The claim "low in saturated fat" can be made if the food contains one gram or less of saturated fatty acids per serving, and saturated fat accounts for no more than 15 percent of the total calories in a serving.

In order to claim that a food has "less total or saturated fat," it must contain at least 25 percent less total or saturated fat per serving than the product being compared. The identity of that product and the percentage difference between the two foods must be declared in immediate proximity to the claim, and the amount of saturated fat in both foods must be stated on the label.

"Lean" refers to seafood or meats that contain fewer than 10 grams of total fat, 4.5 grams of saturated fat, and 95 milligrams of cholesterol per serving (and per 100 grams). "Extra lean" refers to seafood or meats that contain fewer than five grams of total fat, two grams of saturated fat, and 95 milligrams of cholesterol per serving (and per 100 grams).

The FDA and USDA also establish the standards that allow a producer to claim that a food "contains" or "is a good source of" a specific nutrient. In that case, the nutrient must have a Daily Reference Value and one serving of a food must contain 10 to 19 percent of the Daily Value. Food purveyors cannot claim a food "contains" or "is a good source of" ALA or EPA/DHA because neither has a Daily Reference Value. Claims that a food has more of a certain component than another food are limited to protein, vitamins, minerals, dietary fiber, and potassium (21 CFR 101 (54) (e)).

Specific health claims. According to guidance implementing the Nutrition Labeling and Education Act, the FDA is authorized "to allow statements that describe the relationship between a nutrient and a disease condition to appear in the labeling of foods" (CFSAN 2005). There are currently 12 FDA-approved health claims that have met a number of technical requirements and are supported by "significant scientific agreement," including: "A diet low in total fat may reduce the risk of some cancers" and "Diets low in saturated fat and cholesterol may reduce the risk of coronary heart disease."

The FDA also recently began allowing food producers to make 12 "qualified health claims" based on "somewhat settled science." To ensure that these claims do not mislead consumers, they must be accompanied by a qualifying statement and undergo pre-market review by the FDA (CFSAN 2003; CFSAN 2005). For example, the claim "omega-3 fatty acids EPA and DHA may reduce the risk of coronary heart disease"[21] must include the fact that this statement is based on supportive but not conclusive research.

[21] This is the only qualified health claim that would apply to the foods in this report.

Other labeling claims and standards

Claims about grass-fed beef. At the moment, there are no voluntary federal standards for marketing claims related to livestock production practices (AMS 2002). In contrast, organic meat production is verified through third-party certification. In 2002, the USDA's Agricultural Marketing Service proposed minimum requirements for production-related claims about grass feeding, antibiotic use, and other related items,[22] but public outcry over flaws in the proposed requirements sent the agency back to the drawing board (AMS 2003).

Many people feared that the USDA's proposal would limit the ability of small and mid-sized farms and ranches to benefit from the markets for grass-fed meat, and that consumers would be confused and misled by producers' claims. For example, the proposal would have allowed a grass-fed animal to be given feeds other than grass or forage for up to 20 percent of its life. Because many farmers already raise cattle on a diet of 100 percent grass and other plants or close to it, and because (as will be discussed later) some differences in nutrient content would be lost with an 80 percent standard, this was not seen as an acceptable compromise between producers who would prefer a lax standard and those who could meet a more stringent requirement.

The USDA proposal suggested one claim that would prove valuable to purveyors of grass-fed products: "Livestock have never received antibiotics." On the other hand, the antibiotics-related claim "no sub-therapeutic antibiotics added" would confuse consumers because neither the USDA nor the FDA has defined the term "sub-therapeutic" (SAC 2003).

The federal organic label. This label can be used on food produced in compliance with methods and practices defined by the Organic Food Production Act as implemented by the USDA and the National Organic Standards Board (7 CFR 6501 et seq. 1990). Periodic on-farm inspections ensure that food bearing the organic label meets the federal standard, which does not require that animals be grass-fed.[23]

Cattle may be fed corn or other grains as long as the feed has been certified organic, and though the animals must have access to pasture at some point in their lives, beef cattle may be confined to outdoor feedlots for several months prior to slaughter. Livestock are also exempt from pasture access during "stages of life" such as birthing, the first six months of life, and illnesses. This exemption recently became controversial when some large-scale dairy operations argued that lactation is a "stage of life" (Martin 2005). Such an interpretation would allow the milk of dairy cows that have been confined and fed organic grain for most of their lives to be considered organic.

The National Organic Standards Board responded in March 2005, proposing to limit the time dairy cows could be confined by requiring that grazed feed provide more than 30 percent of dry-matter intake during the growing season (but not less than 120 days per year) and that temporary confinement be allowed only during severe weather, when the health of the animal could be jeopardized, or to protect local soil and water quality (NOSB 2005). These proposed changes were approved by the board in August, but finalization of a new rule was postponed (SAC 2005).

Use of the word "natural." Because there is no FDA standard governing the use of this word, it can mean almost anything—which is why it appears frequently on food labels and in advertising. An administrative decision made by the USDA more than 20 years ago (Hibbert 1982) allows products

[22] Note that these standards apply only to beef, not dairy, cattle.

[23] Because pastures often are treated with fertilizer and pesticides, pasture-raised meat and milk may not be organic.

to be labeled "natural" if they are minimally processed and contain no artificial ingredients, colors, or chemical preservatives (FSIS 1999).

All fresh meat qualifies as natural by this definition, but some alternative meat producers started using the term to describe meat from animals raised without antibiotics and growth hormones. Producers are permitted to make claims about antibiotics and hormones if they are true, but such claims are independent of the term "natural."

Chapter 4

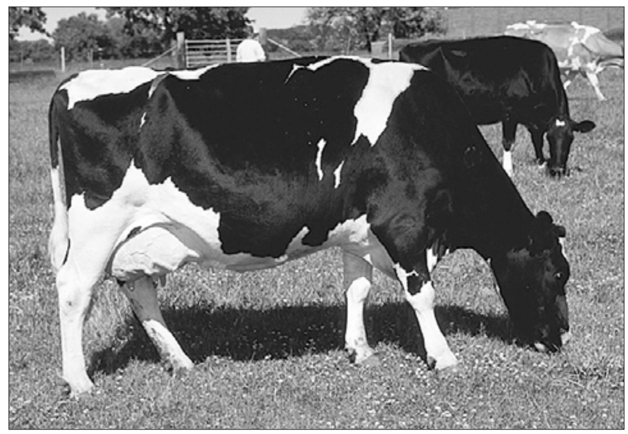
Methodology and Results of the Comparison Studies

The scientific literature is filled with studies that compare food products from cattle raised on pastures with those raised in conventional systems. We were only concerned with those studies that addressed the most important nutrients and other food substances and provided the most useful information on the impact of grass/pasture feeding. To that end, in order to build our major tables of results (Tables 4-2, p. 41, and 4-4, p. 44), we collected all the published and unpublished English-language research studies we could locate that met two criteria:

- contains an analysis of total fat, saturated fat, and omega-3 fatty acids or CLA, and
- is based on a controlled study of fully pasture-raised dairy and beef cattle compared with cattle that were not fully pasture-raised.

We define "fully pasture-raised" as research systems in which the cows' nutrition is derived entirely from grazing, without oil supplements or hay, silage, grain, or similar feeds. Isolating pasture feeding from supplements is the only way to accurately assess its nutrition effects on milk and meat.

Because we also wanted to calculate the content of each relevant substance in a given serving of milk, cheese, steak, or ground beef—information that is meaningful to nutritionists and consumers—we needed the percent of the total fatty acids in each food sample. Unfortunately, some



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researchers did not report these data, and studies that did not meet this third criterion were not included in the report.

Researchers in many different disciplines, from nutrition science to agronomy, have an interest in some aspect of this topic. The animal scientist wants to know whether the content of specific fatty acids differs as a percentage of total fat, while the human nutritionist wants information on amounts of fatty acids per serving of food. The oncology researcher is interested in knowing whether a fatty acid is anti-carcinogenic in laboratory studies, but the epidemiologist waits to see whether human population studies demonstrate the same effect.

The time frames over which scientists have researched particular fats are quite different. Saturated fat, for example, has been the subject of scientific study for more than 80 years but CLA has only been studied during the last three decades, so there is much more information about saturated fat in terms of its role in human health and appropriate amounts in the diet. Nevertheless, because new scientific research often necessitates the revision of old dietary recommendations, it is not surprising that there is considerable debate and uncertainty about the substances covered in this report. Many of these concerns were mentioned in Chapter 2 and others are described below.

Cattle Feeding Practices Considered

At one end of the spectrum of dairy and beef cattle feeding practices are "pure pasture" systems (i.e., cattle grazing exclusively on pastures). At the other end are indoor systems totally reliant on prepared feeds, often called total mixed rations.[24] In between these extremes are production systems that combine pasture grazing with stored forages such as grass silage or hay, supplements such as sugar beet pulp, or varying amounts of grains (e.g., corn, barley, wheat).

In general, most milk in the United States is produced by cows fed total mixed rations throughout their lives, while conventional beef operations allow cows and calves to graze on pastures for the first two-thirds of their lives before "finishing" the animals on grain-rich rations in a feedlot. Although the major emphasis of this report is fully pasture-raised production systems, we also offer the results of a few studies of systems that supplemented pasture with various forage or grain supplements (see Chapter 5) because this is such a frequent practice.

We did not review any experimental studies in which cattle were fed supplements of oil or oilseeds to raise levels of omega-3 fatty acids and CLA. Many researchers and commercial interests want to increase the level of these fatty acids in milk and meat even higher than the levels currently reached in pasture-raised cattle, and supplements can be used without changes in production methods (e.g., Mir et al. 2004; Lock and Bauman 2004; Noci et al. 2005). Doing so, however, makes it impossible to assess the impact of pasture feeding alone on the nutrient content of meat and dairy products. Other reasons why we did not include these studies are discussed on pp. 55-56.

Challenges in Interpreting the Results

A number of factors affect the fatty acid content of milk and meat (Table 4-1). One of these variables, the season of the year, is discussed in Chapter 5. Two others, altitude and fatty acid analysis methods, are discussed below.

Altitude. Swiss researchers have conducted many studies on the differences in fatty acid composition between milk produced in cows at low (1,970 to 2,100 feet), medium (2,950 to 3,970 feet), and high altitudes (4,180 to 6,950 feet). The most comprehensive studies sampled milk produced at all three altitudes from June to September (when grass is most plentiful). The low-altitude cows were fed corn silage along with grass; medium- and high-altitude cows were fully pasture-fed. This study showed that the ALA content of milk produced at high altitude was significantly higher than that of milk produced on the plains or at medium altitude (Collomb et al. 2001, 2002a, 2002b).

In a more recent Swiss experiment, a single group of cows was moved to different altitudes and studied for differences in ALA and CLA (Leiber et al. 2005). CLA levels proved to be twice as high in the milk of pasture-fed cows compared with grain-fed cows in the lowlands,

[24] Dairy cattle consume total mixed rations composed of ingredients such as alfalfa hay, corn silage, shelled corn, and soybean meal with a supplement of vitamins and minerals (Dunham and Call 1989). Total mixed rations for beef cattle typically contain sorghum silage, alfalfa hay, corn, and grain sorghum plus a supplement of vitamins and minerals (Kuhl, Marston, and Jones 2002).

Table 4-1: Variables That Can Affect Fatty Acid Levels in Milk and Meat

Animal	Research Methodology
Breed	Length of study
Lactation stage (days producing milk)	Sampling frequency
Lactation number	Fatty acid analysis methodology
Weight at slaughter	Sample size
Large intra-animal variation	Confounding variables
Large inter-animal variation	How fatty acids are reported
Feed	**Production Environment**
Energy balance	Altitude
Amount of time on pasture	Season of year
Amount of pasture grazed	
Plant species in pasture	
Type of confinement ration	
Type of supplement	
Amount of supplement	
Time on supplement	

but the difference was smaller in the mountains. ALA levels were also higher in the milk of pasture-raised cows compared with grain-fed cows in the lowlands, and even higher in the mountains. This occurred even though the ALA content of the alpine grass was lower than the lowlands grass.

These findings confirm those of Collomb et al., and lead Leiber et al. to suggest several hypotheses. Chemicals in high-altitude pasture forages may influence ALA production in cattle. Or, ALA production could be affected by the fact that high altitudes cause cold stress and hypoxia, greatly increasing cows' energy requirements. These stresses also induce a number of metabolic responses including increased plasma fatty acid levels (Berry et al. 2001).

Fatty acid analysis methods. Another challenge arises from the use of different reporting measurements for fatty acids. Most of the studies we selected report fatty acids as a percentage of fatty acid methyl esters, but the FDA has determined that such a measurement in oils will overestimate the amount of the fatty acid by about 10 percent because it fails to account for other fat components in the oil (VSP n.d.). The same is true of such measurements in meat (Duckett 2005).[25] We have not adjusted any of the figures we report, but this possible overestimation of fatty acid levels should be kept in mind.

In addition, the analytical methodologies for identifying amounts of different CLA isomers in foods have greatly improved over time. Because different isomers have different health effects, this can be a source of confusion in the older literature, but we have opted to include studies in which older methodologies were employed.

[25] We therefore assume this would also be the case in milk.

Comparing Milk from Pasture-raised and Conventional Dairy Cows

Our search produced 12 published and unpublished studies of dairy cows that met our requirements for a fully pasture-raised control group and sufficient data to complete a per serving analysis.[26] More specifically, the selected studies included data on the percentage of total fat in the milk, pure pasture feeding compared with another treatment, and animals that were both raised and finished on pure pasture (not silage or hay). The selected research appeared in the literature or was completed between 1997 and 2005, and was carried out in seven different countries.

Table 4-2 summarizes the information comparing eight-ounce servings of milk from pasture-based and conventional dairy systems on five nutrient parameters:

- percentage of total fat
- per serving level of saturated fat
- per serving level of ALA
- per serving level of CLA
- ratio of omega-6 to omega-3 fatty acids[27]

Milk contains very low amounts of the omega-3 fatty acids EPA and DHA so they are not usually measured by researchers (Lock and Bauman 2004).

Several points should be made about the calculations. First, researchers have reported on a varying number of the saturated fatty acids, from C4 to C20. To ensure the greatest degree of comparability we have presented saturated fat as the total of the C10 to C18 fats for dairy and the C14 to C18 fats for beef, except when noted. Second, researchers may have reported on all the omega-6 and omega-3 fatty acids, or just LA and ALA. Since the latter practice was by far the more common, especially for milk, we have calculated the ratio of only 18:2 n-6 to 18:3 n-3 except where the total was reported (as noted).

Given the small number of studies, none of the data have been adjusted for breed, altitude, season of year, fatty acid measurement methodology, type of pasture, type of ration feeding, time of measurement, or any other variable. Conventional feeding regimens considered include total mixed rations (various grasses and forages plus corn or corn/maize), silage, and barley/wheat concentrate.

Summary of the results

Total fat per serving of milk. Of the 16 experiments, only four (including the alpine pasture study) show a significant difference in percentage of total fat between pasture-raised and conventionally fed cows. The grass-fed cows had higher levels in three of these, and the conventionally raised cows had a higher level in one. We conclude that milk from pasture-raised and conventionally raised cows does not differ appreciably in total fat.

Saturated fat per serving of milk. In two of the 14 experiments that reported saturated fat, milk from pasture-raised cows was significantly lower on a per serving basis than milk from conventionally raised cows. In three others there was no difference. Statistical significance could not be calculated for the remaining experiments, but the differences tended to be small and inconsistent across studies. We conclude that milk from pasture-raised and conventionally raised cows does not differ appreciably in levels of saturated fat, although when there is a difference, the levels tend to be lower in milk from pasture-raised animals.

ALA per serving of milk. In seven of the 15 studies reporting these data, milk from pasture-raised animals was significantly higher in ALA than milk from conventionally raised cows. In five studies there was no difference, and in the remaining three studies the significance could

[26] One report contained three different experiments that met our criteria, and two others (including Leiber et al.) contained two such experiments.

[27] Not all the studies measured all the fats of interest.

Table 4-2: Comparisons of Milk from Pasture- and Conventionally Raised Dairy Cows*

Study and Feeding Regimen	% Total Fat	Saturated Fat (g/8 oz serving)	ALA (mg/8 oz serving)	CLA (mg/8 oz serving)	Omega-6/Omega-3 Ratio
Dhiman et al. 1999					
Pasture	3.37	4.1	155[a]	160[a]	0.7
Pasture (2/3) + alfalfa/corn concentrate	3.64	4.3[#]	121[b]	114[b]	1.8[†]
Pasture (1/3) + alfalfa/corn concentrate	3.51	4.1	64[c]	68[c]	5.3
Elgersma et al. 2004		◊			
Pasture	4.37	4.2[a]	100	251[a]	1.0
Grass/maize silage	5.49	6.9	137	55	1.0
Friest et al. 2004					
Grass/clover	4.66		108	81	
Grass/clover + corn	4.36		88	66	
Kay et al. 2005					
Pasture	4.50	5.6[†]	97[a]	189[a]	0.8[a]
Total mixed rations	3.81	5.0	28	62	5.2
Kelly et al. 1998					
Pasture	3.72	4.1[†]	80[a]	91[a]	2.8[†]
Total mixed rations	3.48	4.8	23	41	7.4
Khanal, Dhiman, and Boman 2003					
Ryegrass	4.0			231[a]	
Total mixed rations	3.4			34	
Leiber et al. 2005					
Lowland pasture	4.13	5.2[†]	66[a]	160[a]	1.3[a]
Ryegrass/maize silage + concentrate	4.11	5.7	47	50	2.8
Alpine pasture	4.70[a]	5.4[†]	123[a]	144[a]	1.4[a]
Ryegrass/maize silage + concentrate in lowlands	4.01	5.5	49	50	2.4
Lock and Garnsworthy 2003					
Pasture (June)	3.7	4.5[†]	84	160[a]	2.8
Total mixed rations (December)	3.3	4.4	75	59	3.1
Mackle et al. 1997					
Ryegrass/white clover	4.88[a]	7.0[†]	79[‡]	75	0.9[‡]
Ryegrass/white clover + corn	4.63	6.8	61	74	1.2
Schroeder et al. 2005					
Pasture	3.22[a]	3.9[‡]	37[‡]	104[‡]	2.7[‡]
Total mixed rations	3.55	4.7	14	44	12.9
Stockdale et al. 2003					
Experiment 1		€			
Low pasture: 20 kg dry matter/day	3.53	4.9	48	113	2.3
High pasture: 70 kg dry matter/day	3.66	5.4	50	117	2.3
Experiment 3 (pasture)	3.79	5.5	52	130[a]	2.2[a]
Pasture + barley/wheat concentrate	3.69	5.7	50	101	2.7
Experiment 4 (pasture)	3.62	5.2	50[a]	99[a]	2.0[a]
Pasture + barley/wheat concentrate	3.66	5.7	42	75	2.8
Wijesundera et al. 2003					
Experiment 1					
Ryegrass/white clover: 20 kg dry matter/day	3.80	4.7	55[a]	124[a]	1.2
Ryegrass/white clover: 40 kg dry matter/day	3.68	4.6[#]	50[a]	138[a]	1.1[†]
Low pasture with barley	3.57	4.8	39[b]	89[b]	2.0
Experiment 2					
Ryegrass: 30 kg dry matter/day	4.2[a]	5.2[#]	87[‡]	116[‡]	0.6[†]
Low pasture with barley	3.8	4.9	60	136	1.3

* All studies contained at least one fully pasture-raised group.

[a,b,c] Mean values with unlike superscripts are significantly different from each other at $p \leq 0.05$.

◊ Only C14, C16, C18.

€ C6-C18.

† Significance cannot be calculated because this number was computed by the author of this report.

‡ Significance of the difference between values cannot be calculated because statistics in the original study are based on fatty acid percentage (not on a per serving basis) and the percentage of total fat is significantly different.

Significance of the difference between values cannot be calculated because on a per serving basis the amounts are changed (although on a per fatty acid basis the difference was significant).

Table 4-3: Comparisons of Milk from Dairy Cows Raised Conventionally and on Pasture Supplemented with Various Feeds

Study and Feeding Regimen	% Total Fat	Saturated Fat (g/8 oz serving)	ALA (mg/8 oz serving)	CLA (mg/8 oz serving)	Omega-6/Omega-3 Ratio
Agenas et al. 2002		◊			
Pasture + concentrate + hay (day 29)	4.53	7.1	62	72[a]	2.5
Grass silage + concentrate (day 1)	4.53	7.1	62	41	2.7
Lawless et al. 1998					
Pasture + beet pulp	3.89	5.3**	63**	147	3.3**
Pasture + soybeans	3.69	4.6	87	166	4.8
Schroeder et al. 2003					
Winter oats + corn	3.45[a]	4.6‡	45‡	88‡	3.7‡
Total mixed rations	3.91	4.7	6	36	32
White et al. 2001					
Pasture + corn/soy concentrate	3.23[a]	4.4‡	52‡	53‡	2.6‡
Total mixed rations	3.33	4.6	29	31	6.5

** Significance was not reported.

[a] Mean values with an unlike superscript are significantly different from each other at $p \leq 0.05$.

◊ Only C4-C18.

‡ Significance of the difference between values cannot be calculated because statistics in the original study are based on fatty acid percentage (not on a per serving basis) and the percentage of total fat is significantly different.

not be calculated. We conclude that milk from pasture-raised cows tends to be higher in ALA than milk from conventionally raised cows.

CLA per serving of milk. In 11 of the 16 studies there was a significantly higher level of CLA in milk from pasture-raised cattle compared with milk from conventionally fed cattle. In three there was no significant difference. We conclude that pasture-raised cows produce milk that is consistently higher in CLA compared with milk from conventionally fed cows.

Omega-6/omega-3 ratio. In five of the 14 studies reporting these data, the ratio of omega-6 to omega-3 fatty acids was significantly lower in milk from pasture-raised cows than in milk from conventionally raised cows. In three studies there was no difference, and in the remaining studies there was a trend toward lower ratios in the milk of pasture-raised cows, but these ratios were all close to 2:1, the preferred ratio. We conclude that there is no significant difference in omega-6/omega-3 ratio between pasture-raised and conventional milk.

Comparing Cheese from Pasture-raised and Conventional Dairy Cows

We identified only one study that met our criteria and compared the fat content of dairy products other than milk. In this report, an "alpine" cheese produced from alpine pasture-raised milk showed an ALA level (208 milligrams per serving) more than four times higher than a commercial cheddar cheese (48 milligrams per serving). The fact that the alpine cheese ALA level was also nearly one and a half times as high as the level in cheese made from the milk of cows fed corn silage at the same high altitude (Hauswirth, Scheeder, and Beer 2004) suggests that both pasture feeding and altitude could play a significant role in increasing ALA levels in milk and cheese.

Comparing Milk from Dairy Cows Raised on Mixed Feeds

Table 4-3 presents the amounts of fats and fatty acids found in a small selection of studies that focused not on fully pasture-raised cows but on cows raised on pasture plus a supplementary feed. Here, conventional feeds include total mixed rations, grass silage, soybeans, and barley/wheat concentrate.

Summary of the results. As with the milk from fully pasture-raised cattle, results for milk from cattle raised on pasture plus supplements varied. Two studies show a significant difference in the percentage of fat and two do not. The statistical significance of most of the other differences cannot be calculated, but in the two studies comparing fully pasture-raised cows with cows fed pasture plus corn or pasture plus concentrate, the milk from the purely pasture-fed cows was slightly lower in saturated fat, higher in ALA and CLA, and had a much lower omega-6/omega-3 ratio.

These results are generally consistent with pure pasture feeding, but suggest that partial pasture feeding may not consistently deliver significantly higher levels of beneficial fatty acids. It must be acknowledged that such generalized conclusions are difficult to make because of the variety of supplements used in the studies.

Comparing Steak from Pasture-raised and Conventional Cattle

Although consumers have a wide variety of beef products from which to choose, almost all the research literature has focused on steaks and ground beef. We review the research on steaks first.

Table 4-4 (p. 44) presents the results of 14 experiments comparing 100-gram servings of steak from grass-fed cattle with steak from cattle fed a concentrate[25] or total mixed rations. Steaks were compared on six nutrient parameters:

- percentage of total fat
- per serving level of saturated fat
- per serving level of ALA
- per serving level of EPA/DHA
- per serving level of CLA
- ratio of omega-6 to omega-3 fatty acids

Interpretation of the results is hampered by variations in the fat composition of different breeds, cattle at different life stages, male and female cattle, and herds raised under identical conditions. For example, Charolais and Limousin cattle have significantly lower fat levels than Angus breeds (Cundiff et al. 2004). The studies that met our criteria included examples of all of these variables.

Fat content can also differ between cuts of meat taken from the same animal. For example, round steak and ribeye steak contain different amounts of total fat and fatty acids. We have presented data on the *longissimus dorsi* muscle (the source of most steaks) when possible to make our comparisons consistent, but there are still differences in fat content between steaks taken from this one muscle. Steak samples have been closely trimmed so that the total fat and fatty

[25] Concentrate in this context can be barley meal, a barley-soybean mix, "corn-based," or not specified.

Table 4-4: Comparisons of Steak from Grass-fed and Conventionally Raised Cattle*

Study and Feeding Regimen	% Total Fat	Saturated Fat (g/100 g serving)	ALA (mg/100 g serving)	EPA/DHA (mg/100 g serving)	CLA (mg/100 g serving)	Omega-6/ Omega-3 Ratio
Descalzo et al. 2005						
Pasture	2.7[a]	1.2†	38‡			3.8[a]
Grain	4.7	2.2	33			6.7
Dhiman et al. 2005						
Pasture	3.3**		16**		72**	
Total mixed rations	5.6		17		22	
Duckett n.d.* **						
Pasture	2.34[a]	1.0‡	25‡	10‡	18‡	1.8[a]
Corn silage concentrate	4.03	1.7	16	5	14	4.8
Duckett et al. 1993						
Pasture	2.52[a]	1.2‡	23‡	31‡		7.1†
140 days on concentrate	9.73	4.7	8	14		55.0
Duynisveld, Charmley, and Mir n.d.* **						
Pasture	4.89	1.84	50[a]		22[a]	2.52
Total mixed rations	5.77	2.53	43		17	2.65
Enser et al. 1998						
Steers (pasture)	2.86[a]	1.2‡	33[a]			2.0†
Bulls (barley/soy concentrate)	2.07	0.8	10			11.2
French et al. 2000						
Grazed grass	4.36	1.8	49[a]		47[a]	1.9[a]
6 kg grazed grass + 5 kg concentrate	4.49	2.0	39[b]		24[b]	3.0[b]
Grass silage + 4 kg concentrate	4.08	1.9	28[c]		19[b]	3.8[b]
Ponnampalam et al. n.d.* **						
Grass		0.8[a]	32[b]		14[b]	3.4
Short-term barley/soy concentrate		0.6[a]	10[a]		7[a]	11.5**
Long-term barley/soy concentrate		1.4[b]	15[a]		16[b]	11.2
Rule et al. 2002						
Range	1.07[a]	0.4‡	16‡	31‡	4‡	2.7[a]
Feedlot	2.88	1.3	6	18	7	14.9
Scollan et al. 2003						
Grass/white clover	3.4**	1.4**	66**	31**		1.5**
Purchased	3.8	1.6	26	12		2.2
Sinclair et al. 2002						◊
Grass		1.5[a]			26[a]	1.8†
Short-term grain		1.1			9	3.8
Steen et al. 2003						◊
Experiment 1 (heifers)				L		
Ryegrass	3.9	1.8	77	49		1.7
Ad lib 70% barley/soy concentrate	4.3	1.9	29[a]	30[a]		5.0[a]
Ad lib 95% barley/soy concentrate	5.0	2.4	26	27		5.2
Experiment 2 (steers)				L		
Ryegrass	2.7	1.1	90	70		1.5
Ad lib 70% barley/soy concentrate	2.4	1.0[a]	20[a]	30[a]		6.6[a]
Ad lib 95% barley/soy concentrate	3.4	1.5	20	40		6.1
Yang et al. 2002						
Pasture	1.71[a]	0.7‡	31‡	22‡	4‡	3.6‡
Sorghum-based concentrate	3.63	1.7	14	12	2	9.4

* All studies contained at least one group raised on pure pasture.

[a,b,c] Mean values with unlike superscripts are significantly different from each other at $p \leq 0.05$.

L Long-chain omega-3 polyunsaturated fatty acids.

** Significance was not reported.

*** No date (study not yet published).

† Significance cannot be calculated because this number was computed by the author of this report.

‡ Significance of the difference between values cannot be calculated because statistics in the original study are based on fatty acid percentage (not on a per serving basis) and the percentage of total fat is significantly different.

◊ Ratio calculated from total omega-6 and omega-3 fatty acids.

acids reported are those found inside the muscle (intramuscular fat) and not in the visible fat.

It is also important to remember that the fatter the animal, the more fatty acids per serving. Since pasture-raised animals have a lower energy intake than cattle fed concentrates or total mixed rations, they take longer to reach the same slaughter weight. Therefore, if grass-fed cattle are slaughtered at an earlier age and lower slaughter weight than cattle raised on grain, the total fat and fatty acid content of the grass-fed meat will be lower.

The total number of studies meeting our criteria was small, so the data have not been corrected for breed, methodology, type of pasture, length of experiment, number of animals, etc. Conventional feeds in these studies include total mixed rations, corn silage concentrate, barley/soy concentrate, and sorghum-based concentrate.

Summary of the results

Percent total fat per serving. In six of the 12 experiments reporting these data, total fat was significantly lower in the grass-fed animals than the conventionally raised animals (two of the studies simultaneously compared steers with bulls). In three experiments there was no difference in total fat. We conclude that steaks from grass-fed animals are likely to be lower in total fat than steaks from conventionally raised animals.

Saturated fat per serving. Three of the 13 experiments reporting these data show significant differences in saturated fat between grass-fed and conventionally produced meat (one can be attributed to the differences between steers and bulls), but the differences tend to be small. In three other studies there was no difference, and in those in which the significance cannot be calculated, saturated fat was consistently (if slightly) lower in the grass-fed steak on a per serving basis. We conclude that levels of saturated fat are likely to be similar in conventionally fed and grass-fed animals.

ALA per serving. In six of the 13 studies reporting these data, ALA was significantly higher per serving in the grass-fed meat. The trend is the same in the other experiments, but the significance has not been reported or cannot be calculated. We conclude that steaks from grass-fed cattle are likely to contain higher levels of ALA than those from conventionally raised cattle.

EPA/DHA per serving. Levels of these omega-3 fatty acids were higher in the pasture-raised steaks in two experiments, but their levels were not measured in five studies and the significance was not calculated or reported in five others. We conclude that levels of EPA/DHA may differ sometimes.

CLA per serving. Steak contains only a small amount of CLA, and the differences between grass-fed and conventionally raised meat were significant in only four comparisons (three of which showed a higher level of CLA in the grass-fed meat). We conclude that CLA levels do not differ.

Omega-6/omega-3 ratio. This ratio is consistently and significantly lower in steaks from grass-fed cattle.

Comparing Steak from Cattle Raised on Mixed Feeds

Table 4-5 (p. 46) presents the results of two studies that looked at representative mixed feeding systems (pasture plus a concentrate).

Summary of the results. No conclusions can be drawn by comparing two studies so different in design. There was no significant difference in percentage of fat, but there was a significant (though small) difference in saturated fat per serving of bull meat. In all three experiments

Table 4-5: Comparisons of Steak from Cattle Raised Conventionally and on Pasture Supplemented with Various Feeds

Study and Feeding Regimen	% Total Fat	Saturated Fat (g/100 g serving)	ALA (mg/100 g serving)	EPA/DHA (mg/100 g serving)	CLA (mg/100 g serving)	Omega-6/ Omega-3 Ratio
Nuernberg et al. 2002						
Experiment 1 (steers)						
Summer pasture +						
silage/barley/linseed	3.94	1.7	35[a]	50[a]	22	1.6[a]
Barley/soy concentrate	4.54	1.9	9	17	27	18.7
Experiment 2 (bulls)						
Summer pasture +						
silage/barley/linseed	1.98	0.9[a]	48[a]	61[a]	10	1.8[a]
Barley/soy concentrate	1.70	0.7	5	19	9	43.8
Rosmann et al. 2004						
High pasture + corn/soy concentrate	4.02	2.0[†]	32[a]		18[a]	4.7[a]
High corn/soy concentrate	3.45	1.7	21		6	7.9

[a] Mean values with unlike superscripts are significantly different from each other at $p \leq 0.05$.
[†] Significance of the difference between values cannot be calculated because this number was computed by the author of this report.

the ALA content of the grass-fed steak was higher than the conventionally raised steak, which was also the case for EPA/DHA content in the two experiments that considered this component. The omega-6/omega-3 ratio was significantly lower for pasture-raised steak in all three experiments. CLA content was higher in the grass-fed steak in one study, but there was no difference in the other. Overall there were no notable differences in nutrient content between meat samples.

Comparing Ground Beef from Pasture-raised and Conventional Cattle

Ground beef is a special case with regard to the nutrients being discussed here. As noted above, researchers closely trim steaks of fat so the data isolate the content of intramuscular fat (or "marbling"). The meat used to produce ground beef, however, is not necessarily trimmed, and extra fat can be added—up to 30 percent of the product's total weight—if the ground beef is produced in a supermarket or butcher's shop (Hopkins Technology n.d.). Ground beef produced in a USDA- or state-inspected plant cannot contain more fat than was present in the original cut of meat (Midland County Department of Public Health n.d.).

In Chapter 3 we stated that claims about a meat's leanness are regulated by the FDA. To receive an "extra lean" designation, for instance, the meat cannot contain more than 16 percent fat; for "lean" the maximum is 22 percent fat.

We present the data in Table 4-6 because, although the fat content is variable and arbitrary, ground beef is one of the best-selling forms of grass-fed meat. All data are for raw meat unless otherwise noted. Unlike the data reported in Tables 4-2, 4-3, 4-4, and 4-5, none of the data in this table come from a controlled study. For comparison purposes we have included a few reports on the CLA content of ground beef purchased at retail, where the type of feeding is unknown but presumed to be conventional.

Summary of the results. Differences in percentage of total fat were noted in the one study that compared samples of ground beef from six different farms—three of which employed a full pasture system and three of which fed grains along with pasture (Martz et al. 2004). Only one regimen, however, produced ground beef with total fat comparable to ground beef purchased at retail and presumed to be conventionally raised. We conclude that despite the limitations in these studies, the total fat in ground beef from grass-fed beef is likely to be lower than that from conventionally fed cattle.

The data also show that all the ground beef samples from pasture-raised animals had higher levels of CLA than ground beef of unknown but presumed conventional origin. These levels are higher than those in the same amount of steak (Table 4-4, p. 44) because the amount of fat in the ground meat is so much higher.

Comparing Vitamin Levels in Pasture-raised and Conventional Cattle

Reports that levels of fat-soluble vitamins—particularly vitamin E—are higher in milk and meat from pasture-raised animals have drawn attention for several reasons. One is that vitamin E (usually measured in its most potent form, alpha-tocopherol) is an antioxidant and a natural

Table 4-6: Comparisons of Ground Beef from Grass-fed and Conventionally Raised Cattle

Study and Feeding Regimen	% Total Fat	Saturated Fat (g/100 g serving)	ALA (mg/100 g serving)	CLA (mg/100 g serving)	Omega-6/ Omega-3 Ratio
Carr and Driskell 2002					◊
Grass-fed	13.1	7.2	120	7*	3.0[a]
Grain-fed	16.7	7.5	92	**	6.1
Martz et al. 2004					◊
Farm 1: pasture	9.0[a]			99[a]	2.4
Farm 3B: pasture	11.7[b]			166[b]	2.5
Farm 4: pasture	11.5[b]			93[a]	2.2
Martz et al. 2004					◊
Farm 6: pasture + 2 lb/day concentrate (60 days)	10.1[a]			101[a]	2.0[a]
Farm 3A: pasture + 6 lb/day corn (60 days)	13.4[b]			133[b]	6.0[b]
Farm 5: pasture + 20 lb/day corn/soy	21.9[c]			133[b]	4.3[b]
Shantha, Crum, and Decker 1994					
Retail/unknown (broiled)	18.2			71	
Ma et al. 1999					
Retail/unknown	26.0			42	
Chin et al. 1992					
Retail/unknown (broiled)	16.0[+]			48	

[a,b,c] Mean values with unlike superscripts are significantly different from each other at $p \leq 0.05$.

+ Calculated using data from the USDA Nutrient Database for Standard Reference.

* Not detected in five samples.

** Not detected.

◊ Ratio calculated from total omega-6 and omega-3 fatty acids.

preservative. In meat, vitamin E stabilizes color and maintains flavor.

Research has proven that vitamin E levels are higher in fresh forages than in preserved or dried feeds. The vitamin rapidly degrades after cutting, so levels drop 20 percent in silage and 80 percent in hay (NRC 2001). Grains contain even less vitamin E than grasses, so conventionally raised cows are routinely fed a supplement containing vitamins E, A, and D.

Despite the higher levels of vitamin E in fresh uncut pasture, the levels in pasture-raised meat and milk are not similarly high. This may be because milk is "not a major excretion route" for vitamin E (NRC 2001), or because the most significant levels of vitamin E in beef cattle are found in the liver and adipose (or fatty) tissue rather than in the muscles (NRC 2000).

Our review of a substantial number of studies that measured alpha-tocopherol showed that meat and milk from pasture-raised animals had levels of vitamin E significantly higher than meat and milk from animals fed grain, but the total amounts were still low and represented only a small portion of the Recommended Dietary Allowance: an average of three percent of the recommended 15 milligrams per day (FNB 2000). This is enough, however, to provide a color preservative effect in packaged meat (Geay et al. 2001).

Levels of beta-carotene, the plant precursor of vitamin A, follow a pattern similar to vitamin E. Forages contain substantial amounts of beta-carotene and grains contain very little (NRC 2001), but these levels decrease as forages mature. And because beta-carotene is easily oxidized, stored forages have a significantly lower concentration of the substance (NRC 2001). The major storage site for beta-carotene in cattle is the liver, though it also appears in the fat of grass-fed beef, giving it a yellow color (Daly et al. 1999). Levels of beta-carotene are higher in grass-fed steak than in conventional steak, but the average level in several studies was only two percent of the suggested daily intake of three milligrams per day (FNB 2000).

Chapter 5

Implications

Our review of the scientific literature demonstrates that, compared with conventionally raised cattle, foods from pasture-raised cattle have higher levels of several fatty acids that scientists believe are (or may be) beneficial for human health. CLA levels, for example, are almost always higher in milk from pasture-raised animals. Levels of the essential fatty acid ALA tend to be higher in grass-fed meat, and EPA/DHA levels were higher in grass-fed meat in some studies. In addition, the ratio of omega-6 to omega-3 fatty acids tends to be lower (i.e., better) in products from grass-fed cows.

Milk and beef are dissimilar in the amounts of certain fatty acids found per serving, especially in the case of CLA: the studies reviewed in Chapter 3 reported an average per serving amount of CLA eight times higher in milk from pasture-raised animals than in steak. On the other hand, grass-fed beef is lower in total and saturated fat than milk, and has a lower omega-6/omega-3 ratio.

We believe these results support the appropriateness of choosing fully pasture-raised milk and beef over conventionally produced milk and beef. When the environmental benefits of pasture feeding are considered along with the health benefits—particularly those associated with reduced antibiotic use—the case for choosing pasture-raised milk and beef is even stronger.

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Challenges in Making Nutrient and Health Claims

The fact that pasture-raised milk and meat have higher levels of potentially beneficial fatty acids does not necessarily mean that such levels are significant for human health. Where the significance of higher levels of a specific fat is unresolved, milk and meat producers will have limited opportunities to make nutrient or health claims.

As explained in Chapter 3, the ability to make a nutrient or health claim depends on several factors:

- Research on the nutrient is sufficient to set a specific Dietary Reference Intake.
- Nutrient levels in a given food meet the standards for a claim.
- Where no Dietary Reference Intake exists, the scientific evidence supporting the nutrient's

benefits is sufficiently significant or settled to allow a health claim to be made.

- Nutrient levels in a given food were measured in an appropriate way.

Not enough research has been completed on some of the food substances discussed in this report to support such claims. For CLA in particular, many years of research will be necessary to establish its significance in the human diet.

An additional challenge to nutrient claims for pasture-raised milk and meat is the fact that, unlike processed foods, nutrient levels in products from pasture-raised animals vary by season, breed, and other factors. As a result, researchers must take frequent samples to ensure the absolute amount of a nutrient is consistent enough to warrant a claim.

Based on the data presented in Chapter 4, producers of pasture-raised milk and beef could make the nutrient and health claims described below. Following this discussion is a preliminary analysis of claims that might be made on pasture-raised foods in the future if certain conditions (described in that section) are met. Keep in mind that all nutrient and health claims on food labels must be accompanied by a complete nutrient analysis and nutrition labeling.

Claims That Can Be Made Today

Lean and extra lean meat

Steak. All the grass-fed steak in the studies we reviewed could be labeled "lean" (no more than 10 grams of total fat and 4.5 grams of saturated fat per serving) or "extra lean" (no more than five grams of total fat and two grams of saturated fat). Some of the samples could also be labeled "low fat" (no more than three grams of total fat per serving), and about two-thirds could be described as lower in fat than steak from conventionally raised cattle.

Ground beef. The lean and extra lean standards for ground beef are 22 percent and 16 percent of fat content, respectively. All the samples from fully grass-finished cattle had fat levels below these thresholds. Although the sample size was small we believe it is representative and that ground beef from fully grass-fed and/or grass-finished cattle will generally qualify as lean or extra lean. Several samples from mixed feeding systems also met the criteria, suggesting that such meat could sometimes qualify as lean or extra lean.

Dietary fat and cancer. Seven of the 10 samples of grass-fed steak met the criteria for a claim associating a diet low in fat with a reduced risk of cancer.

EPA/DHA. As mentioned in Chapter 3, the FDA has approved a qualified health claim linking the EPA/DHA content of a food with a lower risk of heart disease (though the claim is targeted at fish, which contain much higher amounts of EPA/DHA than grass-fed meat). Because there appears to be no minimum requirement of EPA/DHA needed to make this claim, any food that contains these omega-3 fatty acids can be labeled accordingly.

Claims That Might Be Made in the Future

ALA in milk and cheese. ALA is an essential fatty acid that humans must obtain through their diet, and of the three omega-3 fatty acids discussed in this report, it is the only one found in milk. The average per-serving level of ALA in milk from pasture-fed cows in the studies we reviewed was 80 milligrams. The gender-averaged Adequate Intake for ALA (roughly the amount that consumers should consume in a day) is 1,350 milligrams. While any amount of ALA is welcome in the diet, for foods to be considered a "source" or "good source" of ALA they must provide at least 10 percent of the Adequate Intake. Thus, foods that contain at least 135 milligrams per serving of ALA could claim to be a "good source" of the fatty acid if such claims were allowed.

The studies selected for this report include one sample of pasture-raised milk that provided more than 135 milligrams of ALA on a per serving basis and would therefore be considered a good source. In addition, one study analyzing cheese made from milk produced at a high altitude provided 208 milligrams per serving, easily meeting the requirement. Considering all the uncontrolled factors in the studies we examined, these data suggest that at least some milk and cheese from pasture-raised dairy cows is likely to qualify as a good source of ALA, although inconsistent levels would require frequent product analysis.

EPA/DHA in meat. As mentioned earlier, evidence supporting the health benefits of these omega-3 fatty acids is mounting, but no Adequate Intake has been set by the Food and Nutrition Board. If suggested levels based on the current evidence—ranging from 160 (FNB 2002) to 500 milligrams per day (Cunnane et al. 2004)—were used to set an Adequate Intake for EPA/DHA, foods would have to contain between 16 and 50 milligrams per serving (10 percent of the Adequate Index) to be labeled as a "source" or "good source" of EPA/DHA. In the studies we reviewed, all the steak from grass-fed cattle and some of the steak from cattle raised on pasture plus concentrate would fall within this range.

In Australia and New Zealand, a food can be labeled as a source if it contains 30 milligrams of EPA/DHA per serving (FSANZ 2002). Except for one ground beef sample, all the grass-fed meat reviewed in this report would meet this standard.

CLA. As explained in Chapter 3, although animal and laboratory tests have returned promising data on this fatty acid, there are few clinical and epidemiological data showing a positive effect on human health. The federal government therefore has not formally determined that CLA is beneficial, and has not set standards for CLA-related claims. Although it appears one of the isomers of CLA (c9,t11) may be important for human nutrition, more research must be completed before this contention will be widely accepted (see Chapter 6). Only then can a determination be made as to what level in the diet is significant.

It should be noted that VA is also found in higher amounts in pasture-raised milk and meat than in conventionally produced foods. If, as some research shows, VA is converted into CLA in the human body, the amount of VA in foods could be considered in setting an appropriate intake level for CLA. For example, if the human body can convert up to 20 percent of VA into CLA, this would lower the amount of CLA itself required to confer a health benefit. The Food and Nutrition Board could therefore propose an Adequate Intake level for VA and one for CLA (or, more likely, a single Adequate Intake for VA and CLA combined). One consequence for producers of pasture-raised milk might be that the combined level of VA and CLA meets a future "good source" standard while the level of CLA alone does not.

Omega-6/omega-3 ratio. All the milk and meat samples presented in this report, except for a few from grain-fed animals, met the 10:1 omega-6/omega-3 ratio recommended by the Dietary Guidelines. A number of samples from grass-fed animals met the more stringent 2:1 ratio recommended by other groups. Because no agreement about the importance of this ratio to human health has been reached, producers will likely not be allowed to make product claims any time soon.

Nutrition-related Challenges in Promoting Pasture-raised Meat and Milk

Nutritionists face a dilemma when beneficial fatty acids occur in products that have higher-than-recommended levels of total and saturated fat (which increase the risk of disease). From one perspective, if people are going to consume high-fat milk and meat products, it is better that they consume products that also contain beneficial fatty acids. On the other hand, consumption of high-fat milk and meat products cannot be encouraged simply to obtain beneficial fatty acids. The fact that dietary saturated fat is an important factor in the development of coronary heart disease is well established, and because grass-fed milk and meat products with high levels of beneficial fatty acids generally have higher total fat as well, consumption of such products could increase total and saturated fat levels.

It may be possible to consume meat lower in fat and still ingest more beneficial fatty acids; a recent literature review suggests that lean red meat trimmed of visible fat does not raise total blood cholesterol and LDL ("bad") cholesterol levels (Li et al. 2005). On the other hand, many studies suggest that health problems can arise from excessive intake of meat and milk not because of these foods' fat content but their high protein levels. For example, high-protein diets increase the risk of kidney stones and can increase the risk of osteoporosis if calcium intake is low (Mayo Clinic 2004). Caution must therefore be exercised in suggesting that people increase their intake of even lean cuts of meat, especially if by doing so they decrease their intake of whole grains, fruits, and vegetables.

Not surprisingly, low-fat milks have much lower levels of these fatty acids than whole milk (Lin et al. 1995; Ma et al. 1999), but just as with meat, nutritionists would have to be cautious in suggesting that people increase their consumption of whole milk merely to obtain beneficial fatty acids. To illustrate this dilemma, we note that a person consuming 2,000 calories per day could satisfy his or her entire recommended intake of saturated fat (20 grams) with just three and a half glasses of either pasture-raised or conventional whole milk (based on the average of the samples we reviewed). The pasture-raised milk, however, would also supply 280 milligrams of ALA—twice the amount required of a "good source" (if such a claim were allowed). Of course, if all of the diet's saturated fat came from milk, a trade-off would definitely be required in other parts of the diet.

Production-related Challenges for Pasture-raised Meat and Milk

Maintaining body condition and milk yield in dairy cows. Pasture-raised cows generally (but not always) produce lower quantities of milk than grain-fed cows (e.g., Foltz 2003). This prospect raises two important questions.

The first is whether the U.S. dairy industry could accommodate pasture systems based on lower-yielding cows, and there are a number of reasons to think it could. For one, the U.S. milk supply far exceeds demand, as evidenced by the federal government's yearly purchases of surplus milk (which ensure farmers receive a minimum price for their milk). In addition, the USDA routinely provides incentives for dairy exports (Blayney and Manchester 2001). From the standpoint of individual farmers, many find management-intensive grazing to be more profitable per animal, and more profitable cows make up for lower production (Nichols 2002; Johnson 2002). Also, in several historically important dairy regions such as Wisconsin and the Northeast, pasture-based farmers believe the goal of dairy policy should be to keep a large number of farms operating (Nehring 2005). Maintaining the milk supply with lower overall productivity per cow would keep more dairy farms in business.

The second question is what might be done to enhance the milk yield and body condition of pasture-raised dairy cows. One option is adding low levels of grain to the cows' diet, which provides more energy and a higher percentage of non-fiber carbohydrates than forage alone (Johnson 2002).

Most pasture-based U.S. dairy farmers already do supplement their cows' diets to maintain good condition and increase milk yields. Depending on how much grain cows are fed, however, this approach can lower levels of beneficial fatty acids.

Another approach is selecting breeds better adapted to pasture systems. Under good pasture management, forage intake "is normally sufficient to meet the requirements of a medium-sized cow, but is not enough to meet the feed needs of larger cows producing high levels of milk"—cows that are characteristic of U.S. dairy herds (Kolver 2003). Many pasture-based U.S. dairy farmers have begun turning to more suitable breeds. Pasture quality can also make a difference because forage with a high rate of fiber degradation increases milk yields (Kolver 2003).

In New Zealand cows are raised almost completely on pasture and fed small amounts of grain silage or concentrates. Lower yields are acceptable here because producers have remained profitable while stocking more cows per acre. Also, and quite importantly, herds are "dried off" in the winter (discussed under "Seasonal dairying" below).

Maintaining optimum levels of fatty acids through the winter months. As discussed in Chapter 3, researchers have long been aware that nutrient levels in pasture-raised milk vary between the spring/summer and winter months[29] (Auldist et al. 2002). Because levels are generally higher in spring/summer milk (Palmquist, Beaulieu, and Barbano 1992), producers in cold climates are faced with the challenge of maintaining optimum levels of beneficial fatty acids after the summer season of high-quality forage has passed. If these levels cannot be maintained, producers cannot make related nutrient or health claims (p. 34).

We discuss several aspects of the winter feeding problem below.

Switching from pasture to other feeds. More than 80 percent of the studies we reviewed—and other studies as well—show a drop in the levels of beneficial fatty acids in milk when pasture-raised cows are fed total mixed rations and concentrates rather than full pasture. This raises the question of how long the higher levels of beneficial fatty acids persist after cows are moved off full pasture. According to one study in which six dairy cows in mid-lactation were transitioned from pasture to indoor winter feeding, the decrease can occur very rapidly (Elgersma et al. 2004). Just six days after changing to a diet of mixed grass/maize silage, CLA levels fell to nearly zero (Figure 5-1, p. 54).

In a study of beef cattle transitioning from pasture to feedlots, 48 grass-fed steers were divided into eight groups, switched to a high-concentrate diet, and slaughtered at 28-day intervals (Duckett et al. 1993). Figures 5-2 through 5-4 (p. 54) show a large increase in total and saturated fat content between 84 and 112 days on the grain-based diet, and a steady drop in ALA and EPA/DHA levels over a six-month period. The largest drop occurs within the first month and plateaus after about four months.

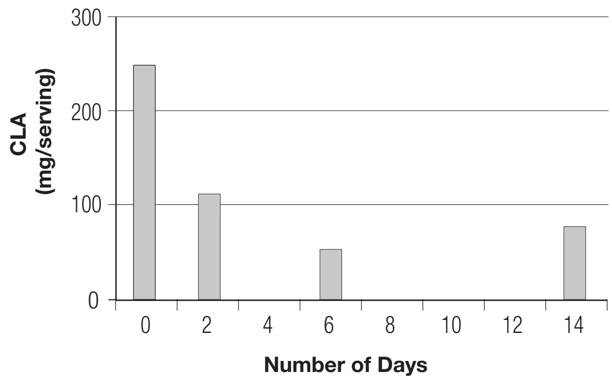
In general, fatty acids decline in both meat and milk after cattle are moved from pasture feeding to concentrates, with the declines in milk being the most precipitous.

Choice of feeds. The studies mentioned above and others suggest that the choice of feed is critical in maintaining optimal levels of fatty acids. For example, the CLA content of milk drops significantly over three weeks even when fresh pasture is replaced by grass harvested just before feeding (Leiber et al. 2005). In other studies, grass silage led to the development of more saturated fatty acids than fresh grass (Chilliard, Ferlay, and Doreau 2001),[30] and hay (dried grass) not only contained much lower concentrations of ALA

[29] In fact, this phenomenon is a factor in the FDA regulations governing the vitamin fortification of milk (CFSAN 2004).

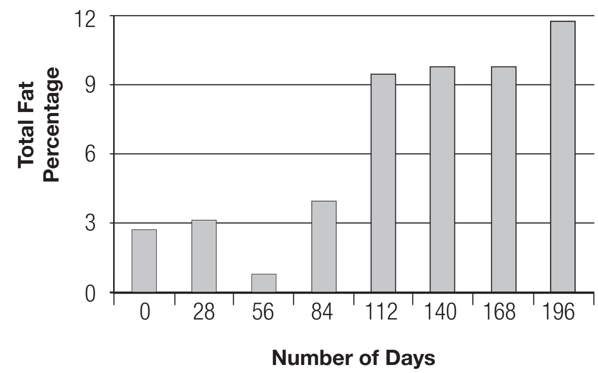
[30] Research on this topic is limited, so caution must be used in applying the results (Chilliard, Ferlay, and Doreau 2001).

Figure 5-1: CLA in Milk after Switching from Grass to Mixed Grass/Corn Silage



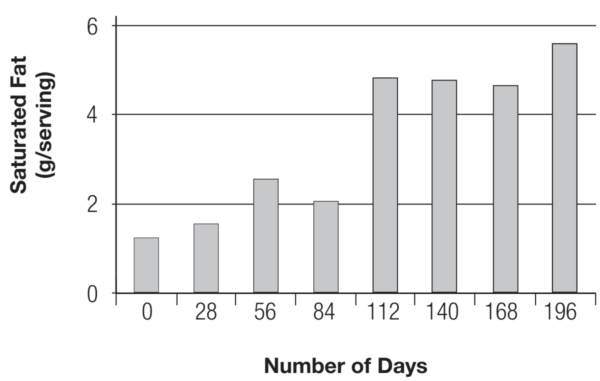
Source: Elgersma et al. 2004.

Figure 5-2: Total Fat Percentage of Beef after Switching from Grass to Concentrate



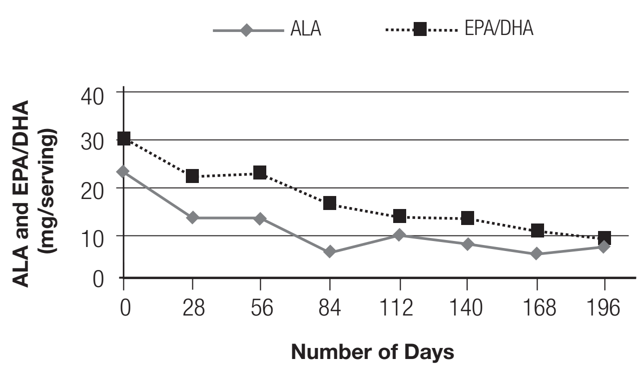
Source: Duckett et al. 1993.

Figure 5-3: Saturated Fat in Beef after Switching from Grass to Concentrate



Source: Duckett et al. 1993.

Figure 5-4: ALA and EPA/DHA in Beef after Switching from Grass to Concentrate



Source: Duckett et al. 1993.

than fresh grass (Chilliard, Ferlay, and Doreau 2001) but also decreased the amount of polyunsaturated fatty acids in meat (Steen et al. 2003). Researchers have pointed out that pasture forages are more nutritious than stored forages because the latter are harvested at a later stage of growth when the nutrient content is not as high (Amaral-Phillips et al. 1997). CLA levels in particular are higher when cows have eaten early-growth forage (Dhiman et al. 1999; Auldist et al. 2002; Lock and Bauman 2004).

In general, a summer pasture of grass and legumes with no supplements appears to produce the highest amounts of beneficial fatty acids, and hay feeding produces the lowest. The ability of other forages to maintain fatty acid levels depends on various factors including geography and grazing conditions (Table 4-1, p. 39).

Outwintering. Though it is impossible to feed cows pure pasture in some cold climates, some pasture-based producers choose to keep their dairy and beef cattle outside—even in fairly severe weather—by placing herds in wooded or lowland areas sheltered from the wind and feeding them hay and grain. Producers who do this with lactating cows make sure that the animals enter the winter with good body condition and that feed is always available. Scientists in northern states such as Minnesota and Wisconsin and southern states such as Mississippi and North Carolina (Hay and Forage Grower 2005; Poore, Capucille, and Moisan n.d.) have found that this practice, called outwintering, can keep cows cleaner and healthier (Mooney 1998; Paine and Brick 2000; Kurtz 2003).

There may be solutions to the winter feeding problem that entail feeding specific types of forages.[31] For example, legume hay and spring-cut ryegrass silage have been shown to keep energy intake up and perhaps allow levels of beneficial nutrients to remain somewhat higher over the course of the year (Nation 2005). In England, red clover silage has increased ALA (Dewhurst 2003). Further research will be needed to determine what systems would be most suited to U.S. geography and agricultural practices. In the meantime, it behooves producers to pay attention to nutrient values at different times of the year and to take this into account when considering their product marketing and labeling.

Seasonal dairying. In this production system, cows are kept on pasture as long as possible (ideally through rotational grazing), "dried off" before winter (i.e., no longer milked), fed hay and various supplements throughout the winter, and then give birth in the spring (Paine and Brick 2000; Winsten and Petrucci 2003). As a result, producers do not have milk to sell during the winter, but the practice can improve their cows' health and reproductive success, and most importantly to pasture-based dairy farmers, allow for some vacation time. Most dairy farms in New Zealand practice seasonal dairying, and studies have shown this system can also be profitable in the United States, can be a good option for small dairy farms, and can reduce the percentage of cows culled due to reproductive failure (Shoemaker, Shoemaker, and Zartman 1994; Richards 2004; Groover 2000).

Feeding oilseeds or oils to increase levels of beneficial fatty acids. Oilseeds and oils containing LA and ALA can increase the levels of these fatty acids and CLA in milk and beef. Studies have shown that soybeans and rapeseeds (canola), for example, are effective at raising levels of all three fats, and so are their oils. Fats increase energy intake and that, in turn, increases milk yields.

[31] Another possibility is moving beef cattle north in the summer and south in the winter. Such an experiment is being conducted by scientists from the USDA's Agricultural Research Service, Virginia Tech University, West Virginia University, and the University of Georgia (Comis 2004).

On the other hand, feeding high levels of unsaturated fatty acids can actually reduce the total fat content of milk, and some oils (especially fish oils) can adversely affect the taste of beef (Mir et al. 2003). Research is currently under way on what effects various oil supplements may have on taste, odor, vitamin content, and the time it takes for dairy foods and beef to become rancid (Chilliard, Ferlay and Doreau 2001; Lynch et al. 2005).

Implications for the federal organic standard. As previously discussed, organic cattle production and pure grass-fed systems have well-established benefits for the environment and the animals themselves. However, neither the current U.S. organic standard (requiring indeterminate amounts of outdoor access) nor the proposed pasture requirement of 120 days per year[32] take into account the effects that allowable feeding practices have on nutrient levels. As a result, it is unlikely that conventional milk and meat products and those bearing the U.S. organic label would differ significantly in terms of beneficial fatty acid levels.[33]

[32] The finalization of this proposal has been postponed.

[33] A grass-fed standard for beef may be proposed by the USDA's Agricultural Marketing Service.

Chapter 6

Conclusions and Recommendations

This report is the first to compile and analyze a comprehensive set of studies comparing nutrient levels in milk and meat from fully pasture-raised cattle with those in milk and meat from cattle fed grain or other forages. Our analysis encompasses virtually every study published in English that includes animals raised on pure pasture (no grain, silage, or supplements) and provides sufficient information to calculate nutrient levels on a per serving basis. Per serving data are valuable to nutritionists and consumers who want to know about amounts of substances "as eaten" in food.

Farmers have shown growing interest in pasture feeding, and numerous surveys have documented consumers' interest in purchasing animal products produced in a sustainable way (e.g., Conner n.d.; Pirog 2004; Shelquist 2002). This is not surprising given the many benefits pasture-based production systems could provide if widely adopted:

- Decreased soil erosion and increased soil fertility
- Improved water quality (due to decreased pollution)
- Improved human health (due to reduced antibiotic use)
- Improved farmer and farm worker health
- Improved animal health and welfare
- More profit per animal for producers

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UCS supports pasture-based animal agriculture for many reasons, but this report has focused on enhanced human nutrition. To provide a clearer picture of the possible health benefits of pasture-raised meat and dairy products, we examined the levels of six fats important in the diet: total fat and saturated fat (which nutritionists suggest should be decreased and moderated in the diet), the omega-3 fatty acids ALA and EPA/DHA, and CLA (a group of chemical isomers usually treated as a single substance even though different isomers appear to have different effects). ALA is known to be essential in the human diet, EPA and DHA definitely appear to reduce the risk of heart disease, and CLA shows promise in reducing the risk of certain diseases, including cancer.

The Role of Fats and Fatty Acids in Human Health

Scientists have been investigating the effects of fats and fatty acids on human health for decades, but there is still much to learn. In terms of the substances examined in this report, the science linking total fat to cancer risk, and saturated fat to heart disease risk, is considered settled. The science suggesting possible health benefits of ALA, EPA/DHA, and CLA, on the other hand, is not settled but is progressing.

The literature includes animal and clinical studies linking omega-3 fatty acids such as ALA and EPA/DHA to a number of health benefits including reduced heart disease and improved immune systems, but some of the evidence is contradictory and incomplete. The strongest evidence to date supports the role of omega-3 fatty acids in preventing heart disease, with the evidence supporting EPA/DHA stronger than that supporting ALA.

Many animal studies have connected CLA to improved immune systems and lower risk of cancer and heart disease, but these findings need to be buttressed by human clinical and epidemiological studies before they can be included in formal dietary recommendations. We expect it will take years of continued research to fully understand the complex relationship of fatty acids in the diet to human health, and to determine the levels in the diet at which fatty acids can be considered beneficial.

Nutrient Levels in Pasture-raised and Conventional Meat and Milk

In studies comparing the levels of fats and fatty acids in pasture-raised meat and milk with levels in conventionally produced meat and milk, the pasture-raised products generally had similar or lower levels of fat and saturated fat, and similar or higher levels of the omega-3 fatty acids and CLA. In particular, our review of the literature found that:

- Steak and ground beef from grass-fed cattle are almost always lower in total fat than steak and ground beef from conventionally raised cattle.
- Steak from grass-fed cattle tends to have higher levels of the omega-3 fatty acid ALA.
- Steak from grass-fed cattle sometimes has higher levels of the omega-3 fatty acids EPA and DHA.
- Ground beef from grass-fed cattle usually has higher levels of CLA.
- Milk from pasture-raised cattle tends to have higher levels of ALA.
- Milk from pasture-raised cattle has consistently higher levels of CLA.

Product Labeling and Advertising Claims

We have also described in some detail the complex multi-agency process for establishing dietary recommendations and the regulations governing what food purveyors can say on retail labels and in advertising. In general, a label or advertising claim can only be made when there is strong consensus within the scientific community about the claim's validity. Formal dietary recommendations such as an Adequate Intake level reflect agreement about the importance of that nutrient in the human diet. Where such recommendations exist, the FDA, USDA, and FTC usually permit claims on retail packaging and in advertising. But where the science is less settled and no formal dietary recommendations have been established, food producers are not allowed to make claims about nutrient content (but they may be allowed to make qualified health claims).

Claims that can be made today. We believe there is sufficient scientific evidence about the effects of some fats for purveyors of grass-fed meat products to make several claims on their labels and in their advertising as long as nutrient analyses and labeling requirements are met:

- Steak and ground beef from grass-fed cattle can be labeled "lean" or "extra lean."
- Some steak from grass-fed cattle can be labeled "lower in total fat" than steak from conventionally raised cattle.
- Steak from grass-fed cattle can carry the health claim that foods low in total fat may reduce the risk of cancer.
- Steak and ground beef from grass-fed cattle can carry the qualified health claim that foods containing the omega-3 fatty acids EPA or DHA may reduce the risk of heart disease.

Claims that might be made in the future. As more is learned about the health effects of the omega-3 fatty acids and CLA, new standards may be issued that would allow food purveyors to make other labeling and advertising claims:

- Steak from grass-fed cattle might be labeled a "source" or "good source" of EPA/DHA.
- Some milk and cheese from pasture-raised cattle might be labeled a "source" of ALA.

It remains to be seen whether CLA will be included among the substances described as "beneficial" fatty acids.

Recommendations

Based on our review of the literature, we offer the following recommendations for beef and dairy producers:

- Beef and dairy producers interested in optimizing levels of omega-3 fatty acids and CLA should strive for pasture-based feeding regimens that maximize the number of days their cows spend on pasture.
- Pasture-based beef and dairy producers might consider seasonal production as a way of improving profits and ensuring higher nutrient levels in areas where high-quality pasture cannot be grown year-round.

In addition, we recommend the following research to help advance this promising new agricultural sector:

- In line with the recommendations of the Dietary Guidelines Advisory Committee, we believe the National Institutes of Health, the National Science Foundation, and other appropriate organizations should support increased basic, clinical, and epidemiological research on the health effects of omega-3 fatty acids and CLA.
    - More epidemiological research is needed on the effect of these fat substances on the incidence of heart disease, cancer, and immune system disorders.
    - More clinical research should be conducted on the human health effects of the CLA isomer (c9,t11) most prevalent in ruminant milk and meat.
- Government and industry should provide funding for scientists to conduct extensive sampling of pasture-raised dairy and beef products and analyze the content of nutrients such as ALA, EPA/DHA, CLA, and VA (a precursor to CLA).
- The USDA should support more research to identify pasture management strategies that will produce an optimal fat composition in milk and meat from different regions of the United States.
- The USDA (through the Agricultural Research Service, the Sustainable Agriculture Research and Education grants program, and the competitive grants program called the National Research Initiative) should fund more research on different types of U.S. pasture systems and their effects on nutrient levels.

- This should include studies comparing fully pasture-raised cattle and cattle fed pasture/supplement mixtures with conventionally raised cattle.

- The USDA and the Environmental Protection Agency should encourage and fund more research on the environmental benefits of pasture-based production systems.

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Glossary

Acceptable Macronutrient Distribution Range (AMDR)
The range of intake for a particular energy source that is associated with reduced risk of disease while providing sufficient intakes of **essential nutrients**. This range is established by the **Food and Nutrition Board**.

Adequate Intake (AI)
The recommended average daily nutrient intake level based on estimates of nutrient intake that are presumed to be adequate. AIs are set by the **Food and Nutrition Board** when a **Recommended Dietary Allowance** cannot be determined.

Alpha-linolenic acid (ALA)
An **omega-3 fatty acid** found in plant foods including grasses; flaxseed; flaxseed, canola and soybean oils; and English walnuts. It is a precursor of **EPA** and **DHA** and is essential in the human diet.

Alpha-tocopherol
The most potent form of vitamin E (a fat-soluble vitamin and antioxidant found in foods).

Antibiotic resistance
The phenomenon in which bacteria acquire resistance to certain antibiotics due to repeated exposure or the transfer of resistance from other bacteria.

Beta-carotene
The plant precursor of vitamin A.

Bioactive food components
Food substances that seem to have a beneficial effect on health but are not classified as **essential nutrients**.

Bovine somatotrophin (bST)
A synthetic, genetically engineered hormone injected into dairy cattle to promote lactation. Also referred to as bovine growth hormone (BGH).

Calorie
A measure of the energy supplied by food. Also called a kilocalorie (kcal).

Carbon sequestration
Absorption of carbon atoms into soil, trees, and other life forms, delaying release of the carbon into the atmosphere (where its heat-trapping effect contributes to global warming).

Case-control study
A scientific study comparing one group of individuals who have been diagnosed with a disease or are subjected to a particular treatment (the case group) with a second group of individuals who are treated with a placebo, receive no treatment, or have not been diagnosed with a disease (the control group).

Cholesterol
A fatty compound in the sterol class of **lipids**, it is composed of several carbon rings and is an important constituent of cellular membranes.

Cis
A chemical configuration in which the two pieces of the carbon chain on either side of a double bond are on the same side of the molecule.

Cohort study
A scientific study observing a group of individuals over time to determine how a disease progresses or what factors affect disease development or progression.

Concentrate
Cattle feed containing either a corn-based mix, barley meal, a barley-soybean mix, or unspecified grains. It is high in energy and usually lower in fiber content than **forage**.

Concentrated (or confined) animal feeding operation (CAFO)
A food production system in which large numbers of animals are housed in often-crowded **feedlots**. CAFOs are associated with many problems including pollution and odors from manure, a high prevalence of animal disease, antibiotic overuse, and poor conditions for farm workers.

Conjugated linoleic acid (CLA)
A collective term for about 20 conjugated **isomers** of **linoleic acid** (LA) found primarily in dairy products but also in **ruminant** meats.

Conventional feeding/production systems
Cattle-raising strategies that rely heavily on grain-based feeds, growth hormones, antibiotics, and **finishing** animals in **feedlots**.

Coronary heart disease (CHD)
A number of heart conditions for which the risk increases with high dietary intake of **total fat** and **saturated fat**, as well as other factors such as smoking.

Daily Value (DV)
On a nutrition label, the amount of a nutrient supplied by a single serving of food, usually expressed as a percentage of the **Recommended Dietary Allowance**.

Dietary Goals
Dietary recommendations released by the U.S. Senate Select Committee on Nutrition and Human Needs in 1977.

Dietary Guidelines
Dietary recommendations released by the **U.S. Department of Agriculture** and the U.S. Department of Health and Human Services approximately every five years.

Dietary Reference Intakes (DRIs)
A set of dietary recommendations established by the **Food and Nutrition Board** that includes **Acceptable Macronutrient Distribution Range**, **Adequate Intake**, and **Recommended Dietary Allowance**.

Docosahexaenoic acid (DHA)
An **omega-3 fatty acid** predominantly found, along with **EPA**, in fish and fish oils. DHA is the most abundant fatty acid in the brain.

E. coli
Species of bacterium (full name *Escherichia coli*) that exists naturally in the guts of humans and cattle. Strains of *E. coli* can be harmful or even life-threatening under certain conditions.

Eicosapentaenoic acid (EPA)
An **omega-3 fatty acid** predominantly found, along with **DHA**, in fish and fish oils.

Essential nutrients
Food substances that are essential to human health but cannot be synthesized by the body; they must therefore be consumed in the diet. **Linoleic acid** (LA) and **alpha-linolenic acid** (ALA) are the two **fatty acids** currently considered essential.

Extra lean
As defined by the U.S. **Food and Drug Administration** and **U.S. Department of Agriculture**, the term applied to seafood or meat containing less than five grams of **total fat**, two grams of **saturated fat**, and 95 milligrams of **cholesterol** per serving (and per 100 grams).

Fatty acids
The basic chemical units of fat, composed of chains of 4 to 30 carbon atoms with hydrogen atoms attached.

Federal Trade Commission (FTC)
The U.S. government agency that regulates competition and trade practices, including the advertising of foods.

Feedlot
A facility where beef cattle are kept in close confinement for **finishing**, or a similar facility where dairy cattle are fed.

Finishing
The stage of beef production in which cattle are typically confined in **feedlots** for about five months prior to slaughter and fattened on a high-**concentrate** diet. Cattle can also be "finished" on pasture.

Food and Drug Administration (FDA)
The U.S. government agency that regulates the safety and labeling of food, drugs, and cosmetics.

Food and Nutrition Board (FNB)
Unit of the National Academy of Sciences' Institute of Medicine responsible for disseminating reports on food, nutrition, and health (including nutrient and dietary recommendations).

Forage
Plant material (other than grains) consumed by grazing animals.

Grass-fed
A term generally understood to describe a dairy or beef production system in which close to 100 percent of a cow's diet over the course of its lifetime consists of **forage**.

High-density lipoprotein (HDL)
A molecule that transports water-insoluble fats in the blood, known as "good" **cholesterol** because high levels seem to protect against heart attack (as opposed to **low-density lipoprotein**).

Hydrogenation
The chemical process by which additional hydrogen atoms are attached to **fatty acids**, converting liquid fats such as vegetable oils into solid fats such as margarine and shortening.

Isomer
A compound that has the same molecular formula as one or more other compounds, but a different arrangement of atoms.

Lean
As defined by the U.S. **Food and Drug Administration** and **U.S. Department of Agriculture**, the term applied to seafood or meat containing less than 10 grams of **total fat**, 4.5 grams of **saturated fat**, and 95 milligrams of **cholesterol** per serving (and per 100 grams).

Linoleic acid (LA)
The most common **polyunsaturated fatty acid** in both plant and animal tissues, this **essential nutrient** is found in large quantities in many plant seeds and oils such as corn, peanut, soy, sunflower, and walnut. Moderate intake levels of LA reduce the risk of **coronary heart disease**.

Lipids
Also called fats; in the body these substances store energy, transport fat-soluble vitamins, serve as the building blocks of membranes, and regulate biological functions.

Lipoproteins
Clusters of mixed **lipids** and proteins that transport **cholesterol** and other fatty substances in the blood.

Low-density lipoprotein (LDL)
A molecule that transports water-insoluble fats in the blood, known as "bad" **cholesterol** because high levels increase the risk of heart disease (as opposed to **high-density lipoprotein**). LDL carries 75 percent of the body's blood cholesterol.

Marbling
The degree of intramuscular fat in a cut of meat. Though a high degree of marbling is considered desirable because it imparts more flavor to the meat, it also increases the **total fat** content.

Monounsaturated fatty acid
A **fatty acid** that has one double bond and is therefore not "saturated" with a full complement of hydrogen atoms.

Nitrates
Chemical compounds containing nitrogen that are the basic ingredient of fertilizers. Excessive nitrate loads result in runoff into nearby waterways, causing environmental problems such as an overgrowth of algae or other problems.

Non-therapeutic antibiotic use
The use of antibiotics for purposes other than the treatment of disease, such as growth promotion, disease prevention, or improved feed efficiency (the amount of milk or meat produced per pound of feed consumed).

Nutrition Labeling and Education Act (NLEA)
A 1990 amendment to the Food Drug and Cosmetic Act that requires mandatory nutrition labeling of many foods, and standards for nutrient and health claims about foods.

Omega designation
The number of carbon atoms from the methyl (omega) end of a **fatty acid** chain to the first double bond. For example, if the double bond falls between the third and fourth carbon atoms from the methyl end of the chain, the fatty acid is designated **omega-3**, n-3, or ω-3.

Omega-3 fatty acids
Fatty acids that have generated interest among nutritionists and consumers because of potentially beneficial health effects (also see **omega designation**). **ALA**, **EPA**, and **DHA** are the most discussed and researched of these compounds.

Omega-6/omega-3 ratio
Ratio of omega-6 **fatty acid** levels in the diet to **omega-3 fatty acid** levels. A ratio of roughly 1:1 is currently considered optimal for health, but the typical ratio in the U.S. diet is closer to 10:1.

Organic
A term that can be applied to foods produced in compliance with a comprehensive set of U.S. government standards. Organic grains and produce must be grown without synthetic pesticides or fertilizers. Animals raised organically may not be treated with antibiotics or hormones, must be fed organic grains or **forage**, and must have some access to pasture.

Phospholipids
Lipids or glycerides that contain a phosphate group; these substances are a major component of cell membranes.

Polyunsaturated fatty acid (PUFA)
A **fatty acid** that has two or more double bonds and is therefore not "saturated" with a full complement of hydrogen atoms.

Recommended Dietary Allowance (RDA)
The average daily dietary nutrient intake level sufficient to meet the nutrient requirement of nearly all healthy individuals grouped by age and gender. These levels are established by the **Food and Nutrition Board**.

Rotational grazing
A system in which animals are moved to fresh pastures once or twice a day so their grazing does not damage any one pasture beyond its ability to regenerate. Also called management-intensive grazing.

Ruminants
Animals with a rumen, an organ that helps digest plant fibers (in cows it is also referred to as the first stomach). Sheep and goats are examples of other ruminants.

Saturated fat
Any **fatty acid** composed of a carbon chain with hydrogen atoms attached to each carbon atom in the chain, and single bonds between each carbon atom. Saturated fats are usually solid at room temperature.

Silage
Animal feed in the form of plant material that has fermented while in storage.

Source
As defined by the U.S. **Food and Drug Administration** and **U.S. Department of Agriculture** under the **Nutrition Labeling and Education Act**, the term for a food that provides at least 10 percent of the **Recommended Dietary Allowance** or **Adequate Intake** of a given nutrient.

Total fat
The percentage of **calories** in a food or in the diet classified as fat.

Total mixed rations (TMR)
A feed mixture given to dairy or beef cattle. Total mixed rations for U.S. dairy cattle typically contain alfalfa hay, corn **silage**, shelled corn, and soybean meal; rations for U.S. beef cattle typically contain sorghum silage, alfalfa hay, corn, and grain sorghum. Vitamin and mineral supplements are usually included in total mixed rations as well.

Trans
A chemical configuration in which the two pieces of the carbon chain are on opposite sides of the double bond.

Trans fatty acids
Fatty acids in which a portion of the carbon chain features a ***trans*** configuration. Naturally occurring trans fatty acids include **conjugated linoleic acid** (**CLA**) and **vaccenic acid** (**VA**); so-called industrial trans fatty acids can be produced via the **hydrogenation** of vegetable oils. Also called trans fats or TFAs.

Triglycerides
Fat molecules consisting of three **fatty acids** attached to a glycerol molecule. Also called triacylglycerols.

Unsaturated fat
Any **fatty acid** composed of a chain of carbon atoms with two hydrogen atoms attached to each of two consecutive carbon atoms joined by a double bond.

U.S. Department of Agriculture (USDA)
The federal agency that regulates the labeling of meat and develops standards for various animal production systems.

Vaccenic acid (VA)
A precursor to **conjugated linoleic acid** (**CLA**) formed in cows' rumens from either **alpha-linolenic acid** (**ALA**) or **linoleic acid** (**LA**). Humans can also convert a portion of vaccenic acid into CLA.

Greener Pastures

How grass-fed beef and milk contribute to healthy eating

Beef and dairy production is a huge segment of American agriculture, with enormous implications for our economy, the environment, and human health. Conventional production systems increasingly feed confined animals a grain-based diet and routinely use antibiotics that undercut the efficacy of human drugs. These systems also degrade air and water quality, produce noxious odors, and impair animal health.

Innovative beef and dairy producers, however, are developing systems that raise cattle on pastures and rely on grasses and other forage for feed. When well managed, these systems protect air and water quality and produce healthy animals that rarely need to be treated with antibiotics. In addition, the milk and meat from animals raised in these systems may contribute to healthy diets.

In this report, the Union of Concerned Scientists reviews and analyzes the scientific literature comparing levels of fats in beef and dairy products from animals raised on pasture or grass with products from animals raised in conventional systems. We conclude that meat from grass-fed cattle contains lower total fat than meat from conventionally raised animals, and that both meat and milk from pasture-raised animals generally contain higher levels of specific fatty acids that may provide human health benefits.

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