Grass-Fed Beef - The Paleo Diet Newsletter

Changes in Cattle Husbandry and Feeding Practices since the Industrial Revolution

Since their initial domestication, almost 800 breeds of cattle have been developed (1) as specific traits (milk production, meat, heat tolerance, behavior etc.) were selected by humans overseeing breeding and reproduction. Throughout most of recorded history, cattle were typically fed by providing them free access to pastures, grasslands and range land (2). Only in the past 150-200 years have these animal husbandry practices substantially changed…

Technological developments of the early and mid 19th century such as the steam engine, mechanical reaper, and railroads allowed for increased grain harvests and efficient transport of both grain and cattle, which in turn spawned the practice of feeding grain (corn primarily) to cattle sequestered in feedlots (3). In the U.S., prior to 1850 virtually all cattle were free range or pasture fed and typically slaughtered at 4-5 years of age (3). By about 1885, the science of rapidly fattening cattle in feedlots had advanced to the point where it was possible to produce a 545 kg steer ready for slaughter in 24 months and which exhibited "marbled meat" (3). Wild animals and free ranging or pasture fed cattle rarely display this trait (4). Marbled meat results from excessive triacylglycerol accumulation in muscle interfascicular adipocytes. Such meat typically has greatly increased total and saturated fatty acid contents, reduced protein (by energy), a lower proportion of ω-3 fatty acids, higher ω-6 fatty acids and a higher ω-6/ω-63 fatty acid ratio (4, 5).

Modern feedlot operations involving as many as 100,000 cattle emerged in the 1950s and have developed to the point where a characteristically obese (30 % body fat) (6) 545 kg pound steer can be brought to slaughter in 14 months (7). Although 99% of all the beef consumed in the U.S. is now produced from grain-fed, feedlot cattle (8), virtually no beef was produced in this manner as recently as 200 years ago (3). Accordingly, cattle meat (muscle tissue) with high total fat, low protein (by energy), high absolute saturated fatty acid content, low ω-3 fatty acid content, high ω-6 fatty acid content and an elevated ω-6/ω-3 fatty acid ratio represents a recent component of human diets that may adversely influence health and well being (4, 5, 9).

Grain Fed, Feed Lot Cattle: Nutritional Consequences for Humans

The practice of feeding grain and concentrated feed to cattle sequestered for long periods in feedlots is not necessarily benign, but rather yields meat with a number of potentially deleterious nutritional characteristics, particularly when compared to either wild animals or grass fed cattle (4, 5). Table 1 summarizes a number of potential nutritional differences that have been identified between the meat of feed lot and grass fed beef cattle.

Table 1. Potential nutritional differences between feed lot and grass fed beef.

Nutrient	Grass	Feed Lot	References
ω-3 fatty acids	Higher	Lower	(11, 15-30, 40, 47, 48)
ω-6 fatty acids	Lower	Higher	(15, 16, 18, 21, 27, 48)
ω-6/ ω-3 ratio	Lower	Higher	(11,15-21,27-30, 40, 47, 48)
Long chain fatty acids (both ω-3 and ω-6)	Higher	Lower	(11,15, 16, 17, 21, 28, 29, 47)
Fat content	Lower	Higher	(11, 15, 16, 18-21, 27, 40)
Saturated fatty acids	Lower	Higher	(11, 15-18, 27)
P/S Ratio	Higher	Lower	(11,15-18, 21, 27)
Conjugated linoleic acid	Higher	Lower	(11,15,17, 30-36)
Vitamin E	Higher	Lower	(25, 37-40)

Vitamin C	Higher	Lower	(40)
Beta carotene	Higher	Lower	(37, 40-42)
Protein content	Higher	Lower	(43)

Grass vs. Grain Fed Beef: Omega 3 and Omega 6 Fatty Acids

There is little argument that grass fed cattle accumulates more ω-3 fatty acids in their tissues than grain fed cattle (5, 10-28). This nutrient amplification in tissues occurs because the concentration of 18:3n3 (alpha linolenic acid [ALA]) in pasture grass is 10 to 15 times higher than in grain or typical feedlot concentrates (25). In mammals the liver represents the primary tissue which chain elongates and desaturates 18:3n3 into long chain ω-3 fatty acids (20:5n3, 22:5n3 and 22:6n3) which then can be deposited in muscles and other tissues (41).

Not only do feed lot cattle maintain lower ω-3 fatty acids in their tissues than grass fed cattle, but a characteristic increase in the total ω-6 fatty acids occurs (10, 11, 13, 16, 22, 28) as a result of grain feeding (11). Because typical cereals fed to cattle such as maize (ω-3/ ω-6 = 70.7) and sorghum (ω-6/ ω-3 = 16.2) contain very little 18:3n3 and much higher 18:2n6 (42), the cattle's tissues reflect the fatty acid balance of the grains they consume.

The case for increasing ω-3 fatty acids in the U.S. diet has broad and wide sweeping potential to improve human health. Specifically, ω-3 fatty acids and their balance with ω-6 fatty acids play an important role in the prevention and treatment of coronary heart disease, hypertension, type 2 diabetes, arthritis and other inflammatory diseases, autoimmune diseases, and cancer (43, 44).

Dietary Saturated Fat

From per capita data it can be inferred that the average U.S. citizen consumes 82 g of beef per day (45), with ground beef (42 %), steaks (20 %), and processed beef (13 %) comprising the bulk of the beef consumed (46). Ground beef, choice and prime USDA quality steaks and processed beef (frankfurters, lunch meats etc) represent some of the highest total fat and saturated fat sources found in any cuts of beef. An 82 g serving of fatty (22 % fat) ground beef can contain 8.8 g or more of saturated fat, whereas a comparable serving of lean (2.5 % fat) grass fed beef may contain as little as 1.2 g of saturated fat. Hence a daily reduction of up to 7.6 g of saturated fat could be achieved in this scenario involving only displacement of high fat beef with lean grass fed beef.

Saturated fat intakes of < 10 % total energy are recommended to reduce the risk of cardiovascular disease (47). Accordingly in a 2,200 kcal diet, saturated fat (9 kcal/g) should be limited to 24.4 g. Thus, the savings accrued (7.6 g of saturated fat) in this scenario by replacing fatty ground beef with lean grass fed beef represents a substantial 31 % reduction in total saturated fat.

Dietary Protein

Because of it's inherently low fat content (2.6 % by weight), grass fed beef is also a high protein food averaging 76.5 % protein by total energy. Contrast these values to USDA Choice (+) beef with only 48.7 % protein by energy, or USDA Prime (o) beef with 40.8 % protein by energy, or worse still, fatty ground beef with 20.3 % protein by energy. A litany of recent human studies demonstrates that isocaloric replacement of dietary fat by lean protein has numerous health promoting effects.

Potential Health Improvements by Increasing Grass Fed Beef Consumption

A number of scenarios involving improvements in human health can be envisioned by including more and more lean grass fed beef into the diets of U.S. citizens. These scenarios are dependent upon the specific foods and food groups that would be potentially displaced by grass fed beef and by the amount of grass fed beef that would included in the diet. The health impact of such scenarios could range from minimal to highly significant.

References:

1. Food and Agriculture Organization. World Watch List for Domestic Animal Diversity, Scherf, B.D. (Ed), Food Agriculture Organization, United Nations Environmental Protection Programme, Rome, 2000.

2. Clutton-Brook J. Natural History of Domesticated Mammals, 2nd Edition. Cambridge, UK: Cambridge University Press, 1999.

3. Whitaker JW. Feedlot empire: beef cattle feeding in Illinois and Iowa, 1840-1900. Ames, Iowa: The Iowa State University Press, 1975.

4. Cordain L, Watkins BA, Florant GL, Kehler M, Rogers L, Li Y. Fatty acid analysis of wild ruminant tissues: Evolutionary implications for reducing diet-related chronic disease. Eur J Clin Nutr 2002;56:181-91.

5. Rule DC, Broughton KS, Shellito SM, Maiorano G. Comparison of muscle fatty acid profiles and cholesterol concentrations of bison, beef cattle, elk, and chicken. J Anim Sci 2002;80:1202-11.

6. Wells RS, Preston RL. 1998. Effects of repeated urea dilution measurement on feedlot performance and consistency of estimated body composition in steers of different breed types. J Anim Sci 1998;76:2799-2804.

7. Pollan M. 2002. Power steer. New York Times Magazine, March 31: (accessed 11 May 11, 2004)

8. Kidwell B. 2002. All grass, no grain. Progressive Farmer Magazine, October 8: (accessed May 11, 2004).

9. Eaton SB. Humans, lipids and evolution. Lipids 1992;27: 814-820.

10. Ponnampalam EN, Mann NJ, Sinclair AJ. Effect of feeding systems on omega-3 fatty acids, conjugated linoleic acid and trans fatty acids in Australian beef cuts: potential impact on human health. Asia Pac J Clin Nutr. 2006;15(1):21-9.

11. Duckett, S. K., D. G. Wagner, L. D. Yates, H. G. Dolezal, and S. G. May. "Effects of Time on Feed on Beef Nutrient Composition." J Anim Sci 71, no. 8 (1993): 2079-88.

12. French P, Stanton C, Lawless F, O'Riordan EG, Monahan FJ, Caffrey PJ, Moloney AP. Fatty acid composition, including conjugated linoleic acid, of intramuscular fat from steers offered grazed grass, grass silage, or concentrate-based diets. J Anim Sci. 2000 Nov;78(11):2849-55.

13. Marmer WN, Maxwell RJ, Williams JE. Effects of dietary regimen and tissue site on bovine fatty acid profiles. J Animal Sci 1984;59:109-121.

14. Miller GJ, Field RA, Riley ML, Williams, JC. Lipids in wild ruminant animals and steers. J Food Qual 1986;9:331-343.

15. Mandell, I. B., J. G. Buchanan-Smith, and C. P. Campbell. "Effects of Forage Vs Grain Feeding on Carcass Characteristics, Fatty Acid Composition, and Beef Quality in Limousin-Cross Steers When Time on Feed Is Controlled." J Anim Sci 76, no. 10 (1998): 2619-30.

16. Enser M, Hallet MK, Hewit B, Fursey AJ, Wood JD, Harrington G. Fatty acid content and composition of UK beef and lamb muscle in relation to production system and implications for human nutrition. Meat Sci 19998;49: 329-341.

17. Mitchell GE, Reed AW, Rogers SA. Influence of feeding regimen on the sensory qualities and fatty acid contents of beef steaks. J Food Sci 1991;56:1102-1103.

18. Brown HG, Melton SL, Riemann MJ, Backus WR. Effects of energy intake and feed source on chemical changes and flavour of ground beef during frozen storage. J Anim Sci 1979;48:338.

19. Melton SL, Amiri M, Davis GW, Backus WR. Flavor and chemical characteristics of ground beef from grass-, forage-grain, and grain-finished steers. J Anim Sci 1982;55:77-87.

20. O'Sullivan, A., K. O'Sullivan, K. Galvin, A. P. Moloney, D. J. Troy, and J. P. Kerry. "Grass Silage Versus Maize Silage Effects on Retail Packaged Beef Quality." J Anim Sci 80, no. 6 (2002): 1556-63.

21. Larick DK, Turner BE. Influence of finishing diet on the phospholipid composition and fatty acid profile of individual phospholipids in lean muscle of beef cattle. J Anim Sci 1989;67:2282-2293.

22. Medeiros LC, Busboom JR, Field RA, Williams JC. Nutritional content of game meat. Cooperative Extension Service, University of Wyoming, Laramie, WY 82071, 1992.

23. Nuernberg K, Nuernberg G, Ender K et al. N-3 fatty acids and conjugated linoleic acids of longissimus muscle in beef cattle. Eur J Lipid Sci Technol 2002;104:463-471.

24. Dannenberger D, Nuernberg G, Scollan N et al. Effect of diet on the deposition of n-3 fatty acids, conjugated linoleic and C18 :1 trans fatty acid isomers in mscle lipids of German Holstein bulls. J Agric Food Chem 2004;52:6607-6615.

25. Nuernberg K, Dannenberger D, Nuernberg G et al. Effect of a grass-based and a concentrate feeding system on meat quality characteristics and fatty acid composition of longissimus muscle in different cattle breeds. Livest Prod Sci 2005;94:137-147

26. Descalzo AM, Insani EM, Biolatto A et a. Influence of pasture or grain-based diets supplemented with vitamin E on antioxidant/oxidative balance of Argentine beef. Meat Sci 2005;70:35-44.

27. Raes K, Balcaen A, Dirinck P, De Winne A, Claeys E, Demeyer D, De Smet S. Meat quality, fatty acid composition and flavour analysis in Belgian retail beef. Meat Sci 2003;65: 1237-1246.

28. Razminowicz RH, Kreuzer M, Scheeder MR. Quality of retail beef from two grass-based production systems in comparison with conventional beef. Meat Sci 2006;73:351-361.

29. Mir PS, McAllister TA, Scott S, Aalhus J, Baron V, McCartney D, Charmley E, Goonewardene L, Basarab J, Okine E, Weselake RJ, Mir Z. Conjugated linoleic acid-enriched beef production. Am J Clin Nutr. 2004;79(6 Suppl):1207S-1211S.

30. Shanta NC, Moody WG, Tabeidi Z. Conjugated linoleic acid concentration in semimembranousus muscle of grass and grain fed and zeranol implanted beef cattle. J Muscle Foods 1997;8:105-110.

31. Enser M, Scollan ND, Choi NJ et al. Effect of dietary lipid on the content of conjugated linoleic acid (CLA) in beef muscle. Anim Sci 1999;69:143-146.

32. Dhiman TR. Role of diet on conjugated linoleic acid content of milk and meat. J Anim Sci 2001;79 (Supp 1): 241.

33. Poulson CS, Dhiman TR, Cornforth D et al. Influence of diet on conjugated linoleic acid content in beef. J Anim Sci 2001; 79(Suppl 1): 159.

34. Steen RW, Porter MG. The effects of high concentrate diets and pasture on the concentration of conjugated linoleic acid in beef muscle and subcutaneous fat. Grass Forage Sci 2003;58:50-57.

35. Yang A, Brewster MJ, Lanari MC, Tume RK. Effect of vitamin E supplementation on α-tocopherol and β-carotene concentrations in tissues from pasture- and grain-fed cattle. Meat Sci 202;60:35-40.

36. Daly CC, Young OA, Graafhuis AE, Moorhead SM. Some effects of diet on beef meat and fat attributes. NZJ Agricul Res 1999;42:279-287.

37. Gatellier P, Mercier Y, Renerre M. Effect of diet finishing mode (pasture or mixed diet) on antioxidant status of Charolais bovine meat. Meat Sci 2004;67: 385-394.

38. Simonne AH, Green NR, Bransby JI. Consumer acceptability and beta-carotene content of beef as related to cattle finishing diets. J Food Sci 1996;61:1254-1256.

39. Cordain L, Miller JB, Eaton SB, Mann N, Holt SH, Speth JD. Plant-animal subsistence ratios and macronutrient energy estimations in worldwide hunter-gatherer diets. Am J Clin Nutr. 2000;71:682-92.

40. Gerrior S, Bente I. 2002. Nutrient Content of the U.S. Food Supply, 1909-99: A Summary Report. U.S.D.A, Center for Nutrition Policy and Promotion. Home Economics Research Report No. 55

41. Simopoulos AP. n-3 fatty acids and human health: defining strategies for public policy. Lipids. 2001;36 Suppl:S83-9.

42. Cordain L. Cereal grains: humanity's doubled edged sword. World Rev Nutr Diet. 1999;84:19-73.

43. Kris-Etherton PM, Harris WS, Appel LJ; Nutrition Committee. Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. Arterioscler Thromb Vasc Biol. 2003;23(2):e20-30.

44. Simopoulos AP. Essential fatty acids in health and chronic disease. Am J Clin Nutr. 1999 Sep;70(3 Suppl):560S-569S."

45. U.S.D.A. Per capita beef supply and use.

46. Davis CG, Lin BH. Factors Affecting U.S. Beef Consumption. USDA Economic Research Service, Publication LDP-M-135-02, October 2005,

47. Krauss RM, Eckel RH, Howard B, Appel LJ, Daniels SR, Deckelbaum RJ, Erdman JW Jr, Kris-Etherton P, Goldberg IJ, Kotchen TA, Lichtenstein AH, Mitch WE, Mullis R, Robinson K, Wylie-Rosett J, St Jeor S, Suttie J, Tribble DL, Bazzarre TL. AHA Dietary Guidelines: revision 2000: A statement for healthcare professionals from the Nutrition Committee of the American Heart Association. Circulation 2000; 102(18): 2284-99.

Supporting Science:

Omega 3s and Bone Health

The results of a 10-year Swedish study on bone health were published this month in the American Journal of Clinical Nutrition. Seventy-three healthy, 16-year-old males participated in the Northern Osteoporosis and Obesity Study (NO_2 Study) aimed at determining the role fatty acids play in bone accumulation and peak bone mass. Bone mineral density (BMD) of the hip, spine, and total body was measured in each individual at the beginning of the study, and again six and eight years later. Researchers found a positive association between blood concentrations of omega 3 fatty acids and bone mineral accumulation and peak density in the young men. The correlation between decosahexaenoic (DHA) and total body and spine BMD was especially strong.

This research suggests that DHA, and other long chain omega 3 fatty acids, play a crucial role in bone development and mineralization. Osteoporosis and bone fractures afflict and disable many elderly people in the Western world. Accumulation of bone mass during adolescence and young adulthood is vital to preventing the disease; therefore identifying factors that enhance peak BMD is an important step in prevention. Incorporating grass-fed meats into your diet, which are naturally richer in omega 3 fatty acids, is a great way to support the health of growing bones.

Högström, M., Nordström, P., Nordström, A. n–3 Fatty acids are positively associated with peak bone mineral density and bone accrual in healthy men: the NO_2 Study. American Journal of Clinical Nutrition 2007 Mar; 3:803-807.

The ALA Anti-inflammatory

Also published in the American Journal of Clinical Nutrition this month, a study showing protective anti-inflammatory effects of alpha-linolenic acid (ALA), the long chain omega 3 precursor. Twenty-three men and women with elevated cholesterol were randomly assigned to one of three diet groups: the 'average American', the high linoleic acid (omega 6 vegetable oils), or the high alpha-linolenic (omega 3) diet

As previously discussed in this issue, the ALA concentration in grass-fed beef is 39 mg/100 g muscle tissue, on average, compared to only 12 mg ALA in the same serving size of grain-fed beef.

Zhao, G., Etherton, T.D., Martin, K.R., Gillies, P.J., West, S.G., Kris-Etherton, P.M. Dietary alpha-linolenic acid inhibits proinflammatory cytokine production by peripheral blood mononuclear cells in hypercholesterolemic subjects. American Journal of Clinical Nutrition 2007 Feb; 85:385-391.

The Paleo Diet for Pigs?

A recent study published in *Nutrition and Metabolism* has shown that pigs fed a Paleolithic diet are healthier than those raised on traditional cereal-based swine diets. Immediately after weaning, researchers randomly divided 24 piglets into either a Paleolithic group (meat, fruit, and vegetable-based diet) or a cereal group. After 15 months on the diets, glucose tolerance, insulin response, plasma-C reactive protein, and blood pressure were measured. Not surprisingly, the pigs on the Paleolithic diet had lower blood pressure, significantly higher insulin sensitivity, and an 82 % lower concentration of C-reactive protein (a marker of inflammation associated with insulin resistance and CVD) on average. Apart from these clinical measurements, pigs on the Paleolithic diet weighed 22 % less and had 43 % lower subcutaneous fat thicknesses after 15 months.

The importance of these data is two-fold: first, scientists agree that pigs are one of the best non-primate animal models from which to compare responses in humans. This study supports the notion that pigs, like humans, did not adapt through evolution to thrive on a cereal-based diet. Secondly, in the U.S. pigs are raised on cereal-based diets and in a similar manner to feedlot-produced beef. We can conclude the majority of our pork, like our beef, comes from obese, insulin-resistant animals with nutritional qualities inferior to their pasture raised, free-foraging counterparts.

Jönsson, T., Ahrén, B., Pacini, G., Sundler, F., Wierup, N., Steen, S., Sjöberg, T., Ugander, M., Frostegård, J., Göransson, L., Lindeberg, S. A Paleolithic diet confers higher insulin sensitivity, lower C-reactive protein and lower blood pressure than a cereal-based diet in domestic pigs. Nutrition and Metabolism 2006 Nov; 3:39.

News & Updates

We have recently found a source of quality 100% grass-fed beef that is raised correctly, fatty-acid tested, and reasonably priced, and are considering making it available to our readers. We are curious about the interest level there would be in among our readers, so please email Wiley@ThePaleoDiet.com if you would like a price list when it becomes available.

The Dietary Cure for Acne will soon be available in paperback. You cannot order it yet, but to be put on the notification list, please send an email to: Jess@DietaryAcneCure.com.

Dr. Cordain was featured in a recent article in **The Scientist**, titled "What's in your milk?". If you missed Dr. Cordain's article **Hazards of Dairy** in the December issue, you can access it on our previous issues page at www.thepaleodiet.com.

According to the celebrity gossip site www.femalefirst.co.uk, Elizabeth Hurley went on the Paleo Diet and lost 5 lbs prior to her wedding. As long-time readers know, the Paleo Diet is not a weight loss diet, but a lifetime way of eating that will naturally lead to a lean and well-functioning body.

Source: http://www.thepaleodiet.com/newsletter/PDUpdate0407.shtml