A Study Of The Nutritional and Health Benefits of Grass-Fed Beef

More than three decades of research strongly suggests that cattle eating forage-only diets can have a profound impact on the nutritive attributes of beef by altering the lipid composition of meat through lower concentrations of saturated fatty acids and higher concentrations of long-chain polyunsaturated fatty acids. Numerous studies have also reported that grass fed beef contains increased concentrations of beta-carotene and alpha tocopherol, as well as higher concentrations of omega-3 fatty acids and conjugated linoleic acid, all substances reported to have favorable effects on human health [1]. Research to date supports the contention that grass-fed beef is higher in Vitamin A, Vitamin E, conjugated linoleic acid (CLA) and omega 3 fatty acids as compared to grain-fed beef when lipids are compared on a gram of fatty acid/gram of lipid basis, therefore when fed to the same degree of fatness, grass-fed meat products are higher in favorable lipids than conventionally produced products [1].

Recent studies have concluded that lean beef can be part of a cholesterol lowering diet if it is low in fat and the saturated fatty acid content of the remaining diet was kept low [2]. Several studies suggest lean beef can be used to reduce plasma concentrations of LDL, as well as very low density lipoprotein (VLDL) in both normal and hyper-cholesterolemic subjects, thus reducing risk of coronary heart disease [2-7].

Pro Vitamin A: Beta-Carotene:

Beta-Carotene is a fat-soluble antioxidant belonging to a family of natural chemicals known as carotenes or carotenoids. Carotenes produce the yellow and orange pigment in certain fruits and vegetables, and is converted to vitamin A (retinol) by the body. Vitamin A is important for normal vision, bone growth, reproduction, cell division, and cell differentiation [3] . Specifically, it helps maintain surface lining of the eyes and the lining of the respiratory, urinary, and intestinal tracts. Additionally, vitamin A maintains skin and mucous membranes integrity by creating a barrier to bacterial and viral infection [4,5], and is involved in the regulation of immune function by supporting the production and function of white blood cells [6,7].

Studies have shown that grass-fed steers incorporated significantly higher amounts of beta-carotene into muscle tissues as compared to grain-fed animals [9]. Concentrations ranged from 0.63 -0.45 µg/g and 0.06- 0.5 µg/g for meat from pasture and grain-fed cattle respectively, a **10 fold increase** in beta-carotene levels for grass-fed beef. Similar data has been reported in other research due to the high beta-carotene content of fresh forage as compared to cereal grains, such as corn [10-13].

Vitamin E: Alpha-tocopherol:

Vitamin E exhibits powerful antioxidant activity, with the most active being alpha-tocopherol [14]. Antioxidants protect cells against the effects of free radicals, which are potentially damaging by-products of the body's metabolism contributing to the development of chronic diseases such as cancer and cardiovascular disease.

Recent research shows vitamin E supplementation may help prevent or delay coronary heart disease [15-18], block the formation of nitrosamines (carcinogens formed in the stomach from dietary nitrates), and protect against cancer development through immune function enhancement [19]. Other studies have indicated that vitamin E may improve eye lens clarity and either reduce or prevent the development of cataracts [20,21].

Vitamin E concentration (natural alpha-tocopherol) ranges from 5.0 to 9.3 µg/g of tissue in grass fed beef compared to 2.0 µg/g of muscle tissue in grain fed beef [11,23]. Grass fed beef typically has alpha-tocopherol levels **3-times greater** than those found in conventional grain fed beef [24].

Omega 3: Omega 6 Fatty Acids:

Alpha-linolenic acid (ALA), an omega-3 fatty acid, and linoleic acid (LA), an omega-6 fatty acid, are essential fatty acids (EFA) in the human diet. They are considered essential because the human body cannot manufacture these fatty acids without direct consumption of these compounds or their precursors. Both ALA and LA are polyunsaturated and serve as precursors for many important compounds necessary to the body. For example, ALA is the precursor for the entire omega-3 pathway; all other omega-3 fatty acids are made from ALA. Likewise, LA is the parent fatty acid in the omega-6 pathway. Omega-3 (n-3) and omega-6 (n-6) fatty acids are two separate distinct families, yet they are synthesized by some of the same enzymes, i.e., delta-5-desaturase and delta-6-desaturase. Excess of one family of fatty acids can interfere with the metabolism of the other, reducing its incorporation into tissue lipids and altering their overall biological effects [25]. Omega-6 fatty acids are commonly found in grains and vegetable oils, whereas omega-3 fatty acids are commonly found in plant lipids. It is from consumption of plant lipids in livestock allowed free access to pasture and forages that they get their increased omega-3 fatty acid content. We know that human diets containing omega-6 or omega-3 fatty acids lower blood total and LDL cholesterol; however, omega-6 fatty acids also tend to lower HDL cholesterol [68]. Consumption of diets high in omega-3 fatty acids tend to increase HDL and are associated with reduced risk of heart disease, stroke and cancer [69].

The American Medical Association and the World Health Organization recommend a healthy diet consist of a ratio of roughly one to four parts omega-6 fatty acids to one part omega-3 fatty acids. However, the typical American diet tends to contain 11 to 30 times more omega -6 fatty acids than omega -3. This recent negative dietary trend has been hypothesized to be a significant factor in the rising rate of inflammatory disorders in the United States [26].

The major types of omega-3 fatty acids used by the body include: alpha-linolenic acid (C18:3n-3, ALA), eicosapentaenoic acid (C20:5n-3, EPA), docosapentaenoic acid (C22:5n-3, DPA), and docosahexaenoic acid (C22:6n-3, DHA). Once consumed, the body can convert ALA omega-3 fatty acid to EPA, DPA and DHA.

Research conducted by Sinclair and co-workers showed that beef consumption increased serum concentrations of a number of n-3 fatty acids including, EPA, DPA and DHA in humans [39]. Likewise, a number of studies that have reported that animals that consume rations high in precursor lipids produce meat products higher in essential fatty acids [40,41]. Cattle fed primarily grass and other forages increased the omega-3 content of the meat by **60%** and also produced a more favorable omega-6 to omega-3 ratio when compared to conventional grain-fed beef. [12, 33, 42, 43]. Additionally, when comparing omega-3 availability in grass fed compared to grain fed beef at a standard lipid content of 10% fat, the grain fed beef provided only 84 mg of omega-3 per 100 g serving compared to 136 mg of omega-3 per 100 g serving of grass fed beef [42].

It is clear that grass fed cattle accumulate more omega-3 fatty acids in their tissues than grain fed cattle [65, 75-85, 13, 66, 40, 42-43], primarily due to the fact that the concentration of 18:3n3 (ALA) in pasture grass is **10 to 15 times greater** than in grain or typical feedlot concentrates [85] (Figure 1). In cattle and other mammals, the liver is the primary tissue responsible for chain elongation and desaturation of 18:3n3 (ALA) into long chain omega-3 fatty acids (20:5n3, 22:5n3 and 22:6n3) which are then deposited in muscles and other tissues [86]. It is important to note that grain fed cattle maintain lower omega-3 fatty acids in their tissues than grass fed cattle, with a significantly higher omega-6 fatty acid concentration [75, 43, 40, 13, 82, 88] as a result of grain feeding [43]. The cereal grains typically fed to cattle, such as corn and sorghum, have very low levels of omega-3 and much higher levels of omega-6 fatty acids [89], with the cattle's tissues reflecting the fatty acid balance of the grains they consume.

In looking at a nutritionally relevant comparison of the actual availability of Omega-3 fatty acids in the human diet from the consumption of grass fed beef, Dr. Loren Cordain, renowned nutritional researcher and author of the *Paleo Diet*, states that we must examine it by energy contribution. For example, "in order to achieve 25 % (160 mg) of the recommended 18:3n3 (ALA) intake, it would require 482 kcal from a grass produced serving of beef, whereas to reach a similar level, it would require 1,677 kcal from grain produced beef. Hence from an energetic perspective, increased grass beef consumption could make a significant contribution to the 18:3n3 intake in the U.S. diet while not excessively increasing energy intake. On average grass produced beef contains 60 mg of LC omega-3 fatty acids whereas grain produced beef contains roughly half as much (28.5 mg). Accordingly, at current levels of beef consumption in the U.S. (82 g/day) grass fed beef would contribute 20 % of the recommended LC omega-3 fatty acids while grain produced beef contributes 9.5 % of these fatty acids. Once again a more nutritionally relevant comparison is by energy. In order to achieve 50 % of the recommended LC omega-3 fatty acids (150 mg) it would require 295 kcal from a grass produced serving of beef, whereas to reach a similar level, it would require 673 kcal from grain produced beef. In summary, the concentrations of both 18:3n3 and LC omega-3 fatty acids are significantly greater in grass produced beef than in grain produced beef, and when considered on an energetic basis support the notion that increased consumption of grass fed beef could provide an important source of omega-3 fatty acids in the U.S. diet."

Dr. Cordain goes on to say, "The case for increasing omega-3 fatty acids in the U.S. diet has broad and wide sweeping potential to improve human health. Specifically, omega-3 fatty acids and their balance with omega-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."

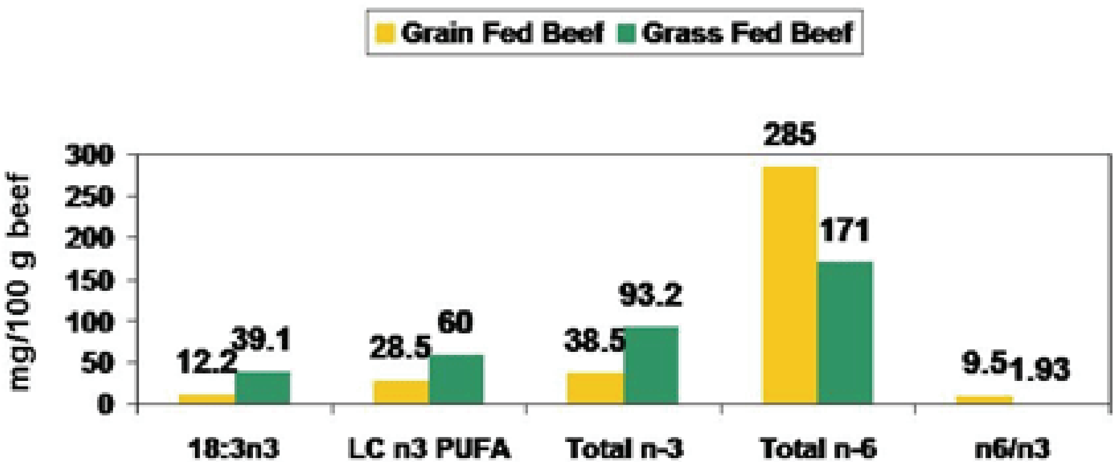


Figure 1: Literature Summary of Omega-3 and Omega-6 Fatty Acid Differences Between Grass and Grain Produced Beef. Long Chain Omega-3 (20:5n3, 22:5n3, 22:6n3). *Source: Cordain, L. 2007.*

Conjugated Linoleic Acid (CLA):

Conjugated linoleic acid (CLA) is a group of polyunsaturated fatty acids that are produced in the rumen of cattle and other ruminant animals through microbial conversion of linoleic and linolenic acids. Thus, CLA is commonly found in the meat and milk of ruminant animals [46-48,73,74]. CLA has been demonstrated to have significant health benefits in the human body, including the reduction of carcinogenesis, atherosclerosis, and the onset of diabetes [47,49,52-55,72]. Ruminant animals, such as cattle, can readily synthesize CLA when supplied with the proper precursors in their daily diet. These precursors include linoleic acid (LA) and linolenic acid (LNA). Both are found in lush, growing forages and enable cattle that are predominantly grass fed to produce **2 to 3** times more CLA than cattle fed in confinement on grain (corn) based rations [42-43, 65-66]. Studies show that growing forages typically have 10 to 12 times more C18:3 than cereal grains, such as corn and sorghum [67]. Dried and cured forages, such as hay, will possess slightly lower amounts of CLA precursor, but a dietary shift to cereal grains in the ruminant's diet will significantly alter the favorable fatty acid profile in the meat and milk [43].

From a nutritional standpoint, grass fed beef will typically provide approximately **123 mg** of CLA for a standard hamburger at 10% fat. The same hamburger produced from grain-fed beef would provide **only 48.3 mg**. However, ruminants on a grass fed diet also produce large amounts of a major trans fatty acid called vaccenic acid (VA), which is a C18:1 t11 isomer. This particular trans fatty acid is actually very good for humans because the human body can convert an average of 19 -30% of VA into CLA [70]. Research has indicated that VA also has cancer-fighting properties. Therefore, in considering total CLA benefit derived from grass fed beef, one must consider the total CLA derived from both direct CLA and conversion of VA to CLA by the body [70,71].

Dietary Protein:

Grass fed beef, due to it's inherent leaner nature, can also be considered a high protein food (Figure 2). In looking at the percent protein consumed as a percent of total energy consumed, it is found grass fed beef averages **76.5% protein** by total energy, as compared to typical USDA Choice+ grain fed beef which averages **only 48.9% protein** by energy. As a further contrast, fatty ground beef offers **only 20.3% protein** by energy. Many recent human studies clearly show that isocaloric replacement of dietary fat by lean protein has numerous health promoting effects.

Research trials involving human dietary intervention have demonstrated favorable impacts of lean, animal based protein upon blood lipid parameters. Studies showing the isocaloric substitution of protein (23% energy) for carbohydrate in hypercholesterolemic subjects yielded significant decreases in total, LDL and VLDL cholesterol, and triglycerides, while HDL cholesterol increased [90]. Favorable changes in blood lipids have also been observed in normal healthy subjects [91], as well as significant improvements in obese patients [94-100]. In addition, patients with type II diabetes have seen both favorable impacts on blood lipids coupled with improvement in glucose and insulin metabolism [92-93]. Although the mechanism of action for producing favorable blood lipid chemistry is not clear, studies indicate it may be through the inhibition of hepatic VLDL synthesis, perhaps by altering apoprotein synthesis and assembly in the liver [101].

Another positive impact of increased dietary protein intake is the observational lowering of blood pressure [102-104]. A number of randomized controlled trials have shown that increased dietary protein from soy [105-107], mixed dietary sources [100] or from lean red meat [108] can significantly lower blood pressure.

In summarizing studies conducted by Dr. Loren Cordain and others, Dr. Cordain states that "high protein diets have been shown to improve insulin sensitivity and glycemic control (94, 96, 99, 109-111) while promoting greater weight loss (95, 98, 99, 112**,** 113) and improved long term sustained weight maintenance (114**,** 115) when compared with low fat, high-carbohydrate calorie restricted diets. The weight loss superiority of higher protein, calorie restricted diets over either calorie restricted (low fat/ high carbohydrate) diets or calorie restricted (high fat/low carbohydrate) appears to be caused by the greater satiety value of protein compared to either fat or carbohydrate (112, 115-118). Of the three macronutrients (protein, fat, carbohydrate), protein causes the greatest release of a gut hormone (PYY) that reduces hunger (118) while simultaneously improving central nervous system sensitivity to leptin (112), another hormone that controls appetite and body weight regulation."

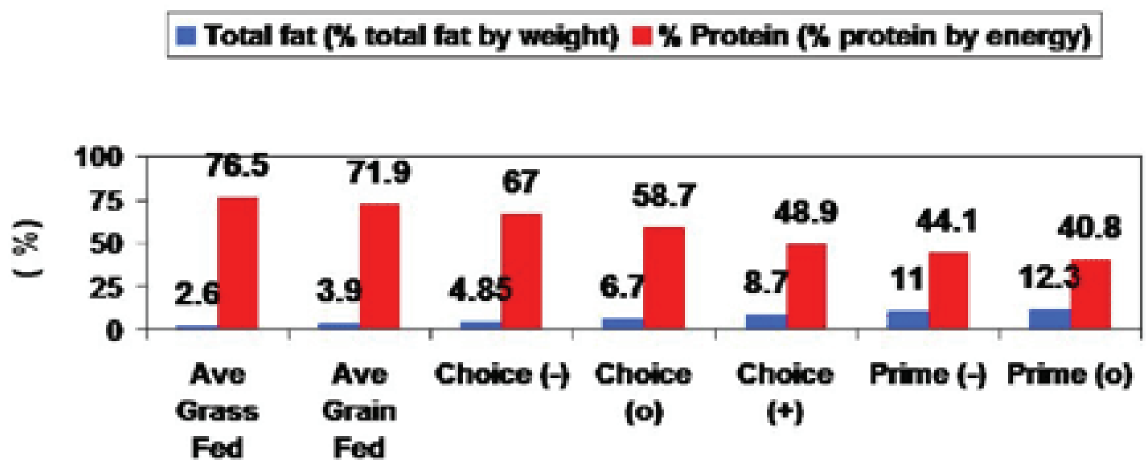
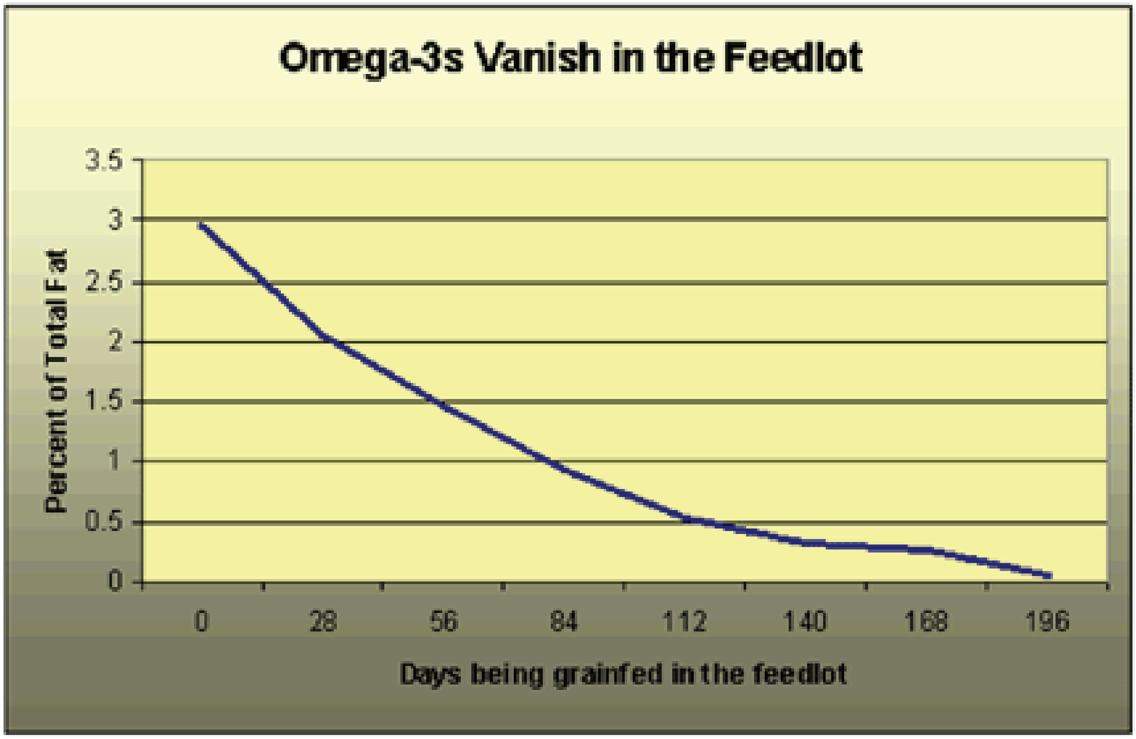


Figure 2. The Exponential Decline in the Protein Energy of Various Beef Samples With Increasing Fat % by Weight. *Source: Cordain, L. et al. 2000. Am. J. Clin. Nutr.[42].*

Summary:

Grass fed beef contains greater concentrations of conjugated linoleic acid (CLA), vaccenic acid (VA), and omega-3 polyunsaturated fatty acids when compared to concentrate or grain fed beef. Additionally, the omega-6 to omega-3 ratio in grass fed beef is considerably more favorable than that of grain fed beef. Grass-fed beef also contains lower total fat content when finished to similar time endpoints, resulting in a reduction in total fat content, including lower saturated fat, monounsaturated fat, and omega-6 polyunsaturated fatty acid content in one 3 oz. serving of grass-fed beef. On a per serving basis, CLA content is similar among grass fed and grain fed beef, **but** VA (which is converted to CLA by the human body) content is **4-fold greater** for grass fed beef. Finally, favorable monounsaturated fatty acids (**MUFA**) are the predominant fatty acid in ruminant animal products and comprises from 30-50% of the total fatty acids present. Consumption of diets rich in monounsaturated fatty acids increases good (HDL) and lowers bad (LDL) cholesterol levels [68].



Data from: J Animal Sci (1993) 71(8):2079-88.

Table. Nutritional Differences Between Grain Fed and Grass Fed Beef.

Nutrient	**Grass**	**Grain**	**References**
ω-3 fatty acids	Higher	Lower	(65, 75-85, 9, 87,88)
ω-6 fatty acids	Lower	Higher	(75, 43, 40, 13, 82, 88)
ω-6/ ω-3 ratio	Lower	Higher	(65,75,42-43,13,82-85,9,87)
(both ω-3 and ω-6)	Higher	Lower	(65,75,43,42,13,83,84,87)
Fat content	Lower	Higher	(65,75,43,40,76,66,13,82,9)
Saturated fatty acids	Lower	Higher	(65, 75, 43, 42, 40, 82)
P/S Ratio*	Higher	Lower	(65, 75, 43, 42, 40, 13, 82)
Conjugated linoleic acid	Higher	Lower	(65,75,42,85)
Vitamin E	Higher	Lower	(80, 9)
Vitamin C	Higher	Lower	(9)
Beta carotene	Higher	Lower	(9)
Protein content	Higher	Lower	

*Polyunsaturated to Saturated Fat Ratio
Source: Cordain, L.

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