Enhanced nutrient content of Grass Fed Beef: Justification for Health Benefit Label Claim

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The premise of this document is to provide a scientific review of the health benefits of consuming grass fed beef that can be used by producers to make a label claim to USDA for their product.

Grass-fed beef, or beef produced from cattle fattened on forage only diets (little or no grain), has been reported to contain elevated concentrations of vitamin A, vitamin E, increased levels of omega-3, a more desirable omega-3:omega-6 ratio, and increased levels of conjugated linoleic acid (CLA), all substances with favorable biological effects on human health. In an effort to support a health claim for grass-fed products, it will be important to determine the actual concentrations and relative amounts required to produce desirable effects.

The following information summarizes what is known in regard to grass diets and the beef that is produced as a result of a grazing regime to justify specific health claims on labeled product.

ProVitamin A: Beta-Carotene:

Beta-carotene, derived from the Latin name for carrot, belongs to a family of natural chemicals known as carotenes or carotenoids. Carotenes produce the yellow and orange color found in fruits and vegetables and is converted to vitamin A (retinol) by the body. While excessive amounts of vitamin A in supplement form can be toxic, the body will only convert as much vitamin A from beta-carotene as it needs, thus beta-carotene is a safe dietary source for vitamin A supplementation.(University of Maryland Medicine, 2002)

Vitamin A is a critical fat-soluble vitamin that is important for normal vision, bone growth, reproduction, cell division, and cell differentiation (Stephens et al., 1996). Specifically, it is responsible for maintaining the surface lining of the eyes and also the lining of the respiratory, urinary, and intestinal tracts. The overall integrity of skin and mucous membranes is maintained by vitamin A, creating a barrier to bacterial and viral infection (Semba, 1998; Harbige, 1996). In addition, vitamin A is involved in the regulation of immune function by supporting the production and function of white blood cells (Ross, 1999; Gerster, 1997).

The current recommended intake of vitamin A is 3,000-5,000 IU (International Units) for men and 2,300-4,000 IU for women (National Institute of Health Clinical Center, 2002; Harvard School of Public Health) which is equivalent to 900 – 1500 micrograms (μg). While there is no recommended dietary allowance (RDA) for beta-carotene or other pro-vitamin A carotenoids, the Institute of Medicine report suggests that consuming 3 milligrams(mg) of beta-carotene daily to maintain plasma beta-carotene in the range associated with normal function and a lowered risk of chronic diseases (National Institute of Health Clinical Center, 2002).

Recent data suggests dietary sources of beta-carotene (pro-vitamin A) are superior to supplemental Vitamin A (retinol) because of suspected interference with normal calcium absorption. Dietary retinol (Vitamin A) intake greater than 1,500 µg/day was associated with reduced bone mineral density and increase risk of hip fracture as compared to women who consumed less than 500 µg per day (Melhus et al., 1998). Thus, dietary sources of beta-carotene continues to be a preferred method of meeting daily requirements for Vitamin A.

Beef fed through conventional feedlots contains approximately 41 µg of beta-carotene/100 grams (g) of ground beef and approximately 36 µg in a typical ribeye steak. Cattle fattened predominately on ryegrass effectively doubles the beta-carotene content in both steak (64 µg) and groundbeef (87 µg) (Simonne, et al., 1996).

Although beef is not a major source of beta-carotene, grass-fed beef supplies two times the beta-carotene of conventional beef. A typical 3 ounce (oz.) serving would provide 10% of the recommended dietary allowance (RDA) for beta-carotene for women as compared to 5 % supplied by conventional beef (National Institute of Health Clinical Center, 2002).

There is currently no data available on the fluctuation of beta-carotene content in beef from cattle fattened on various forages. Likewise, there is no data available regarding seasonal effects on beta-carotene content in grass-fed beef grazing pasture or native grass.

Vitamin E: Alpha-tocopherol:

Vitamin E is also a fat-soluble vitamin that exists in eight different forms with powerful antioxidant activity, the most active being alpha-tocopherol. Antioxidants protect cells against the effects of free radicals. Free radicals are potentially damaging by-products of the body's metabolism that may contribute to the development of chronic diseases such as cancer and cardiovascular disease.

Preliminary research shows vitamin E supplementation may help prevent or delay coronary heart disease (Lonn and Yusuf, 1997; Jialal and Fuller, 1995; Stampfer et al., 1993; Knekt et al., 1994). Vitamin E may also block the formation of nitrosamines, which are carcinogens formed in the stomach from nitrites consumed in the diet. It may also protect against the development of cancers by enhancing immune function (Weitberg and Corvese, 1997).

In addition to the cancer fighting affects, there are some observational studies that found lens clarity (a diagnostic tool for cataracts) was better in patients who regularly use vitamin E (Leske et al., 1998; Teikari et al., 1997).

The current recommended intake of vitamin E is 22 IU (natural source) or 33 IU (synthetic source) for men and women (National Institute of Health Clinical Center, 2002; Harvard School of Public Health; ARS, United States Department of Agriculture, 2000) is necessary for biological activity. Twenty-two international units is equivalent to 15 milligrams by weight. Interestingly, the synthetic version of alpha-tocopherol made in the laboratory and found in supplements is not identical to the natural form and is not quite as active as the natural compound.

The amount of natural alpha-tocopherol (vitamin E) found in beef raised on a concentrate-based diet is 3.7 μg/gram of tissue (McClure et al., 2002), where as the amount of vitamin E in beef raised on a grass-based diet is 9.3 μg/gram (Faustman et al., 1998), there is a approximately a three fold increase over conventional beef. A 100 gram serving (approximately 3.5 oz.) would yield 930 μg of vitamin E, about 7% of the daily dietary requirement for this nutrient.

Omega 3: Omega 6 fatty acids:

Omega-3 fatty acids are considered essential fatty acids (EFA), which means that they are essential to human health but cannot be manufactured by the body. For this reason, omega-3 fatty acids must be obtained from food.

Essential fatty acids are polyunsaturated and grouped into two families, the omega-6 EFAs and the omega-3 EFAs. Although there are just minor differences in their molecular structure the two EFA families act very differently in the body. While the metabolic products of omega-6 acids promote inflammation, blood clotting, and tumor growth, the omega-3 acids act entirely opposite. It is important to **maintain a balance** of omega-3 and omega-6 in the diet as these two substances **work together to promote health**.

There are 3 major types of omega-3 fatty acids that are ingested in foods and used by the body: alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA). Once eaten, the body converts ALA to EPA and DHA, the two types of omega-3 fatty acids more readily used by the body. "*Extensive research indicates that omega-3 fatty acids reduce inflammation and help prevent certain chronic disease such as heart disease and arthritis. These essential fatty acids are highly concentrated in the brain and appear to be particularly important for cognitive and behavioral function* (University of Maryland, College of Medicine)."

According to the University of Maryland, an inappropriate balance of these essential fatty acids (high omega-6/omega-3 ratio) contributes to the development of disease while a proper balance helps maintain and even improves health. A healthy diet should consist of roughly one to four times more omega-6 fatty acids than omega-3 fatty acids. The typical American diet tends to contain 11 to 30 times more omega-6 fatty acids than omega-3 and many researchers believe this imbalance is a significant factor in the rising rate of inflammatory disorders in the United States.

Scientists discovered the many benefits of EPA and DHA in the early 1970's when Danish physicians observed that Greenland Eskimos had an exceptionally low incidence of heart disease and arthritis despite the fact that they consumed a high-fat diet. More recent research has established that EPA and DHA play a crucial role in the prevention of atherosclerosis, heart attack, depression and cancer (Simopoulos, 1991; Simopoulos 2002; Connor, 2000). In addition, omega-3 consumption by individuals with rheumatoid arthritis has led to the reduction or discontinuation of their ordinary treatment (Kremer, 1989; DiGiacomo, 1989).

The human brain has a high requirement for DHA. Low DHA levels have been linked to low brain serotonin levels, which are connected to an increased tendency for depression and suicide. Several studies have established a clear association between low levels of omega-3 fatty acids and depression. In fact, countries with a high level of omega-3 consumption have fewer cases of depression, decreased incidence of age-related memory loss as well as a reduction in impaired cognitive function and a lower risk of developing Alzheimer's disease (Kalmijn et al., 1997a; Kalmijn et al., 1997b; Yehuda et al., 1996; Hibbeln, 1998; Hibbeln et al., 1995; Stoll et al., 1999; Calabrese et al., 1999; Laugharne et al., 1996).

Many scientists believe that increases in these chronic diseases are no accident, it is directly related to the change in our dietary patterns over the last 200 years. Our ancestors lived on an omega-6:omega-3 ratio of 1:1, while our current dietary habits are closer to 10-20:1 (Simopoulos, 1991; Pepping, 1999). Researchers believe the ideal omega-6 intake should be no more than 4-5 times that of our omega-3 intake. The National Institutes of Health recently published recommended daily intakes of fatty acids, specific recommendations include 650 mg of EPA and DHA, 2.22 g/day of alpha-linolenic acid and 4.44 g/day of linoleic acid.

Diet can significantly alter the fatty acid composition in fed cattle. Cattle fed primarily grass enhanced the omega-3 content of beef by 60% and also produces a more favorable omega-6 to omega-3 ratio. Conventional beef contains a 4:1 6:3 ratio while grass-only diets produce a 2:1 6:3 ratio (French et al., 2000; Duckett et al., 1993; Marmer et al, 1984; Wood and Enser, 1997). Values reported in Table 1 reflect the number of grams/ 100 grams of fatty acids.

	Treatment				
Fattya cid	Grass silage for ad-libitum +4kg of conc.	8kg of concentrate +1kg of hay	6kg grass of DM +5kg of concentrate	12kg of grass DM +2.5kg of concentrate	22kg of grass DM
n-6 Fatty acids	2.96	3.21	3.12	3.04	3.14
n-3 Fatty acids	.91^{y}	.84^{y}	1.13^{x}	1.25^{wx}	1.36^{w}
n-6:*n*-3 ratio	3.61^{w}	4.15^{w}	2.86^{x}	2.47^{x}	2.33^{x}

^{w,x,y,z} Means within rows with common superscripts are not significantly different (*P>.05)*.

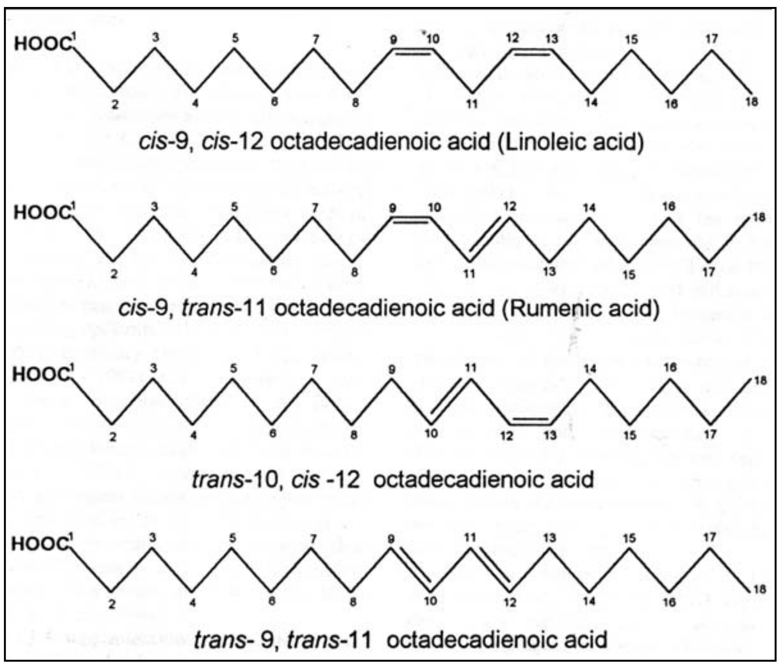
The amount of lipid in beef is highly variable depending on diet and cut of beef. Estimates within the longissimus muscle range from 40 to 100 mg/gram of tissue (French et al., 2000; Duckett et al., 1993). When lipid content is standard, a serving of grass-fed beef would provide 88.5 mg of omega-3, roughly 13% of the RDI for EPA/DHA, while the conventional product would supply an estimated 54.6 mg or 8% of RDI for omega-3.

More important is the ratio of omega-3 to omega-6. Both conventional and grass-fed beef provide acceptable 6:3 ratios, however grass-fed beef is closer to the ideal of a 1:1 ratio. Interestingly, diet has little effect on the proportion of omega-6 fatty acids, however the method of feeding did significantly alter the omega-3 content of fed beef.

Conjugated Linoleic Acid (CLA):

The term conjugated linoleic acid and its acronym CLA is a group of polyunsaturated fatty acids found in beef, lamb, and diary products that exist as general mixture of positional and geometric conjugated isomers of linoleic acid (Sehat et al., 1999). These compounds are produced in the rumen of cattle and other ruminant animals during the microbial biohydrogenation of linoleic and linolenic acids by an anaerobic rumen bacterium *Butyrivibrio fibrisolvens.* (Pariza et al., 2000).

Nine different positional and geometrical isomers result from this process, of which, cis-9, trans-11 is the most abundant and is the biologically active form. Cis-9, trans-11 makes up 75% or more of the total CLA in beef (Ip, et al, 1994; Chin et al., 1992; Parodi, 1997).



Over the past two decades numerous health benefits have been attributed to CLA in experimental animal models including actions to reduce carcinogenesis, atherosclerosis, onset of diabetes, and body fat mass.

The anti-atherosclerotic evidence was first reported in CLA treated mice by Clement Ip in 1994. Ip and coworkers showed CLA levels as low as 0.05 percent of the diet can have a beneficial effect in mice. A level of 0.5 percent reduced the total number of mammary tumors by 32 percent. These results also demonstrated that CLA administered through a dietary route was effective in providing protection against cancer (Ip et al., 1994).

In a 1996 supplemental feeding study, Carol Steinhart showed a lower level of LDL ("bad") cholesterol in both rabbits and hamsters treated with oral CLA, resulting in significantly less plaque formation in the aortic artery of treated animals (Steinhart, 1996). Presumably this reduction in plaque formation would therefore reduce the incidence of heart disease. Likewise, David Kritchevsky demonstrated that CLA levels as low as 0.1 percent of the diet can have beneficial effects by inhibiting atherogenic activity in rabbits (Kritchevsky et al., 2000). This particular study also showed a 30 percent regression of established atherosclerosis with a CLA level of 1 percent of the diet.

There is a plethora of data to demonstrate that CLA modulates body composition by reducing the accumulation of adipose tissue, primarily in experimental animals. In mice, rats, pigs, and now humans, dietary CLA has been shown to reduce adipose tissue depots (Dugan et al., 1999; Park et al., 1997; Sisk et al., 2001; Smedmen et al., 2001) Although there is some controversy within the human data, it is likely that dose, duration, isomeric composition, age and gender influence the outcome of CLA supplementation. For instance, lower doses (3g/day: Blankson et al., 2000) had little effect while larger doses (3.4 – 6.0 g/day) significantly reduced fat mass in humans (Zambell et al., 2000). These ultra high doses of synthetic CLA reportedly do not produce ill side-effects, indirectly demonstrating that the compound is in fact safe. Little is known of upper toxicity levels because there doesn't appear to be an unsafe dose.

CLA is found naturally in a variety of ruminant meats (French, et al, 2000) and dairy products (Dhiman, et al, 1999), due to the anaerobic activity of the rumen bacterium *Butyrivibrio fibrisolvens.* This rumen organism is responsible for the biohydrogenation of linoleic and linolenic acids into the conjugated isomers referred to as CLA. Because linoleic and linolenic acid is a precursor, diets rich in these compounds increase the concentration of the CLA within the fat depot of the animal. Lush green forages are high in this precursor, therefore, **grass-fed ruminant species have been shown to produce 2 to 3 times more CLA than ruminants fed in confinement on concentrate-only diets** (French, et al, 2000; Duckett, et al, 1993; Rule, et al, 2002; Mandell et al, 1998).

Conjugated Linoleic Acid (g/100g or g/3.50oz.)			
Study	Feedlot/Concentrate	Range/Grass	Amount Increased
French, 2000	.37 ^{z}	1.08 ^{w}	2.92 X
Duckett, 1993	.82 ^{c}	2.2 ^{d}	2.69 X
*Rule, 2002	.26 ^{e}	.41 ^{c}	2.04 X

Table 1. Comparison of beef raised on grass-based diets vs. concentrate-based diets.

To achieve biological effects, the average human would need to consume approximately 5 grams CLA/day. On average, a single 3.5 oz. serving of grass-fed beef provides 1.23 grams of CLA, 25% of the daily requirement for a biological effect. Conversely, conventional beef provides 0.48 grams in a 3.5 oz. serving, providing 9.6% of the CLA needed for positive physiological effects.

Grass-fed beef, coupled with the consumption of grass-fed dairy products could provide higher daily doses of CLA from dietary sources, providing the concentration of CLA needed for a positive healthful effect.

There is a rising interest in consuming health promoting foods. A scientific basis on which those decisions can be made, provide for sound marketing and purchasing of foods. Beef in general supports considerable healthful compounds, including a high proportion of monosaturated fatty acids, a number of vitamins, minerals and all the essential amino acids. However, the effect of diet, such as forage or grass only diets can enhance the proportion of CLA, omega-3 fatty acids and improve the concentration of Vitamins A and E. The scientific literature supports the hypothesis that grassfed beef contains a higher proportion of healthful lipids and antioxidants important to human health as compared to conventional beef.

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