And vaccenic acid should be viewed in its role as a precursor to CLA, thus potentially offering health benefits. This was also acknowledged in the Science Base for the section on Fats, of the 2005 Dietary Guidelines Advisory Committee Report.[34] This discussion went on to say…"Most *trans* fat comes from industrial sources of fat."…"meat and dairy products contain naturally occurring *trans* fatty acids as vaccenic acid and conjugated linoleic acid (CLA). There is emerging evidence that the naturally occurring *trans* fatty acids, vaccenic and conjugated linoleic acid, have unique biological effects." And, for Research Recommendations, it was noted: "Investigate the effect of various types of fatty acids (i.e. -… *trans* fatty acids…) on…the incidence and prevention of cancer," and…"Compare the effects of various sources of *trans* fatty acids on lipid metabolism and health outcomes."

Ultimately, it is essential to recognize that the structural differences among the various *trans* fatty acids result in different health effects.

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NUTRIENT FACTS

TRANS FATTY ACIDS

OVERVIEW

It is important to realize all trans *fatty acids are not created equal. There are two general categories of* trans *fatty acids: man-made and naturally occurring. While all* trans *fatty acids can be either manufactured or naturally occurring in foods, there is a predominant category for each* trans *fatty acid. For simplicity, "man-made" and "naturally occurring" will be used in this fact sheet to distinguish between the two types of* trans *fatty acids, recognizing that each can occur in trace amounts in the other category.*

The structural differences between man-made and naturally occurring trans *fatty acids result in different health effects. The relationship between* trans *fatty acids and the risk of coronary heart disease (CHD) is related specifically to the intake of man-made* trans *fatty acids derived from vegetable fats and the primary source in the diet. Conjugated linoleic acid (CLA), a naturally occurring* trans *fatty acid in beef and dairy products, has been shown to have positive health benefits and the Food and Drug Administration excludes CLA from nutrition labeling regulations.*

Trans Fatty Acids: What They Are and Where They're Found

Trans fatty acids, also known as *trans* fat, are a group of unsaturated fatty acids with unique shapes and properties. They are found mainly in processed foods that contain partially hydrogenated vegetable oils (Table 1.). They also occur naturally in some animal products. Man-made *trans* fat is created during a chemical process called hydrogenation. Hydrogenation is the process of adding hydrogen molecules directly to a monounsaturated or polyunsaturated fatty acid, making it more saturated. Hydrogenation converts liquid oils to a semi-solid form which adds functionalities such as shelf-life, maintaining flavor and textural properties.

In recent years, the food industry has been developing new techniques that allow for hydrogenation without the development of man-made *trans* fat, or are experimenting with other alternatives to *trans* fats. Until recently, the vast majority — approximately 80% — of all *trans* fat consumed in the American diet came from processed and snack foods such as chips, cookies, crackers, vegetable shortening and commercial baked goods, as well as fried foods like French fries and fried chicken.[1,2] Elaidic acid (18:1, *trans*-9) is the major

TABLE 1.
Major *Trans* Fatty Acids

Name	Class of *trans* fatty acid	Food Source
Elaidic acid	18:1, *trans*-9	Major source in hydrogenated vegetable oils, and processed foods
	18:1, *trans*-8, 10, 11	Present in varying amounts in hydrogenated oil products and in small amounts of dairy and beef
	18:1, *trans*-7, 12, 13, 14	Present in trace amounts in hydrogenated oils
	18:2, *trans*-9, *cis*-12 18:2, *trans*-12, *cis*-9	Produced in small amounts with hydrogenation of vegetable oils
Hexadecenoic acid (Palmitelaidic)	16:1, *trans*-9	Present in dairy fats and meats
Vaccenic acid	18:1, *trans*-11	Relatively abundant in dairy fat and meat
Conjugated linoleic acid	18:2, *cis*-9, *trans*-11 18:2, *trans*-10, *cis*-12	Present in greater amounts in dairy fat and meat than in processed foods

man-made *trans* fat found in hydrogenated vegetable oils and processed foods.

Low amounts of *trans* fatty acids occur naturally in animal products, such as beef, lamb and dairy products.

All *Trans* Fatty Acids are Not Created Equal

In terms of both structure and function, all *trans* fatty acids are not alike. Naturally occurring *trans* fat is structurally different than man-made *trans* fat and therefore acts very differently in terms of health effects.[3,4] Man-made *trans* fat is a concern because research shows it raises LDL cholesterol levels[5] and also lowers HDL cholesterol levels, thereby increasing risk for heart disease.[6,7] Most of the available data linking *trans* fat intake to negative health effects focus on the use of foods containing partially hydrogenated vegetable oils.

Because of their structural differences (specifically, the position of the double bond), the *trans* fatty acids naturally occurring in beef and dairy foods have very different physiological and biological functions compared to the man-made *trans* fatty acids found in processed foods.[3,4] While data from the Nurses Health Study reveal that man-made *trans* fat derived from vegetable fats increases risk of coronary heart disease, naturally occurring *trans* fat of animal origin does not increase the risk, and may decrease it.[8] As illustrated in Table 2, the highest intakes of vegetable *trans* fat were associated with a 78% increase in risk of CHD (RR 1.78) while the highest intakes of animal *trans* fat had a 41% reduction in risk (RR 0.59). Other epidemiological data support this finding.[9,10] Hodgson and colleagues also found that while intake of man-made elaidic acid and *trans*-10 octadecaenoic acid was positively correlated with coronary heart disease, intake of other *trans* fat, including naturally occurring vaccenic acid (found in ruminant animal fats), was not.[11]

CLA and VA: Beneficial *Trans* Fatty Acids Specific to Animal Products

Unlike the man-made *trans* fat found in processed foods, the two major *trans* fatty acids occurring naturally in foods from animal sources appear to have beneficial health effects. These are conjugated linoleic acid (CLA 18:2 *cis*-9, *trans*-11 and *trans*-10, *cis*-12) and vaccenic acid (VA 18:1, *trans*-11).[4]

Conjugated Linoleic Acid (CLA)
Conjugated linoleic acid is a naturally occurring *trans* fat that may have beneficial effects on genomic regulation, metabolic function, and physiological outcomes.[12] The major dietary sources of CLA are foods from ruminant animal sources, with about 70% from dairy products and 25% from red meat (i.e, beef, lamb and veal).[13] These foods generally have CLA levels in the range of 3-7 mg/g fat.[14] (Table 3.).

Most research demonstrating the beneficial effects of CLA in protecting against cancer, heart disease and obesity has been conducted with animal models and cell/tissue culture systems. For example, several animal studies have demonstrated the significant anticarcinogenic effects of CLA for many types of cancer.[12,15,16] The effect of CLA in modulating tumor development is specific and more powerful than for any other fatty acid.[17] The American Dietetic Association has issued a position paper on functional foods that identifies CLA as a component in dairy products and red meat that may beneficially alter cancer carcinogenesis.[18]

Animal studies also have found that dietary CLA reduces total and LDL plasma cholesterol levels and suppresses cholesterol-induced atherosclerosis.[19,20,21] Numerous reviews and other scientific literature acknowledge that the potential benefits of CLA include its anti-diabetic properties, enhanced immune response and positive effects on energy partitioning and growth.[17,22-25] Most of these studies have used mixtures of the two main isomers although some suggest the *trans*-10, *cis*-12 is the more bioactive isomer in these outcomes.

Due to its unique and beneficial properties that are unlike man-made *trans* fatty acids, the Food and Drug Administration excludes CLA from being listed on the Nutrition Facts Label as a *trans* fatty acid (effective as of 2006).[26]

The potential health benefits and biological activities of CLA are still being identified[3,4] and research on human subjects is underway to confirm findings from animal studies.

Vaccenic Acid (VA)
Vaccenic acid is the other naturally occurring *trans* fat that may have beneficial health effects. The major dietary sources of VA are foods from ruminant animal sources, particularly dairy products and red meat.[4] A significant percent of VA supplied in the diet is converted in vivo to *cis*-9, *trans*-11 CLA via endogenous synthesis. Several animal studies have investigated this precursor role as well as its anticarcinogenic properties.[27]

One study found that increased consumption of pure VA resulted in raised tissue concentrations of CLA and a decreased number of premalignant mammary lesions.[28] Another study using diets varying in VA and *cis*-9, *trans*-11 CLA content found that the conversion of dietary VA to CLA resulted in a dose dependent increase in the accumulation of CLA in mammary fat. The study found that the increased accumulation of CLA was accompanied by a corresponding decrease in both tumor incidence and number.[27] Limited studies in humans have also demonstrated that vaccenic acid intake can increase bioavailable CLA.[29,30,31]

Dietary Guidelines, Nutrition Labeling and *Trans* Fats

The 2005 Dietary Guidelines recommended that the intake of *trans* fats be as low as possible,[32] recognizing that some *trans* fats are naturally occurring and often present, at low levels, in nutrient dense foods such as animal products.

As of January 1, 2006, nutrition labeling requires disclosure of the level of *trans* fatty acids in each serving. This would be total *trans* fats less the CLA; however, it would include potentially beneficial *trans* fats such as vaccenic acid. For labeling, the level of *trans* fats must be listed if it equals or exceeds 0.5 g/serving. Virtually all beef products would fall below this minimal level and thus be listed as zero.

Beef's Fatty Acid Profile

Man-made *trans* fatty acids pack a double punch by raising harmful LDL cholesterol and lowering beneficial HDL cholesterol. While saturated fatty acids tend to raise LDL cholesterol, they have also been shown to beneficially **raise** HDL levels.

Stearic acid is a unique saturated fatty acid that has been found to have a neutral effect on serum cholesterol. It accounts for one-third of the saturated fatty acids found in beef. In addition, half of the fatty acids in beef are monounsaturated fatty acids, the same heart healthy kind found in olive oil.

There are at least twenty-nine cuts of beef that meet the government guidelines for lean. These cuts contain 4.5 grams or less of saturated fat (and less than 10 g of total fat and less than 95 mg of cholesterol) per 3-ounce serving. So a 3-ounce serving of lean beef falls well within the guidelines of a diet that contains no more than 7-10% of its calories from saturated fat. Also, virtually all beef cuts contain less than 0.5 g *trans* fat per serving and have a listing of zero on nutrition labels. In addition, research studies have shown that lean beef fits easily into heart healthy diets. One study of over 200 men and women found that lean beef is interchangeable with chicken and fish with regard to its influence on blood cholesterol levels.[33]

The Bottom Line

All *trans* fatty acids are not alike. There is enormous potential for confusion if education about *trans* fat is oversimplified and consumers assume all *trans* fat acts in the same way.[3] CLA, for example, because of its positive health benefits, cannot be categorized in the same way as the man-made *trans* fat found in baked goods and snack foods,[3] a point recognized by the Food and Drug Administration in their decision to exclude CLA from labeling.

TABLE 2.
Relative Risk of CHD in Relation to Energy-Adjusted *Trans* Fatty Acid Intake Among Women 1970-80* [adapted from Willett et al.[8]].

	RR (95%CI) in quintile					
	1	2	3	4	5	p
Total *trans* isomers	1.0	1.23 (0.50–1.79)	1.11 (.079–1.68)	1.36 (0.89–2.09)	1.67 (1.05–2.66)	0.002
Isomers from vegetable fats	1.0	1.43 (1.00–2.04)	1.11 (0.74–1.66)	1.39 (0.91–2.13)	1.78 (1.12–2.83)	0.009
Isomers from animal fats	1.0	0.76 (0.51–1.12)	0.69 (0.43–1.10)	0.55 (0.31–0.96)	0.59 (0.30–1.17)	0.230

*356 cases among 69,181 women: adjusted for age, smoking, body-mass index, hypertension, alcohol intake, menopausal status, postmenopausal estrogen use, energy intake, dietary lipids, family history of myocardial infraction before age 50 yr, and multivitamin use.

TABLE 3.
Representative/Relative Concentrations of CLA in Uncooked Foods [adapted from Chin et al.[14]].

Food	Total CLA (mg/g fat)	c9, t11 isomer (%)
Meat		
Fresh ground beef	4.3	85
Beef round	2.9	79
Beef frank	3.3	83
Beef smoked sausage	3.8	84
Veal	2.7	84
Lamb	5.6	92
Pork	0.6	82
Poultry		
Chicken	0.9	84
Fresh ground turkey	2.5	76
Seafood		
Salmon	0.3	n.d.*
Dairy Products		
Homogenized milk	5.5	92
Plain yogurt	4.8	84
Ice cream	3.6	86
Mozzarella cheese	4.9	95
Cottage cheese	4.5	83
Vegetable Oils		
Canola	0.5	44
Corn	0.2	39

* n.d. => not detectable