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BEEF FACTS: Nutrition

Stearic Acid – A Unique Saturated Fat

Stearic acid (systematic name, octadecanoic acid, $CH_3(CH_2)_{16}COOH$) is a long-chain fatty acid consisting of 18 carbon atoms without double bonds. It is classified as a saturated fatty acid (SFA), both biochemically, and for purposes of food labeling and dietary recommendations. However, data from over 30 years ago suggests that in terms of diet and heart disease issues involving saturated fatty acids, stearic acid may not behave like other saturated fatty acids which occur in significant quantities in the diet (1).

The predominant long-chain saturated fatty acids in the diet are lauric (C12:0), myristic (C14:0), palmitic (C16:0) and stearic (C18:0). Stearic acid is a common component of many foods, with meat and fat-containing dairy products the major dietary sources. It has many of the desirable taste and texture characteristics of long chain saturated fatty acids.

Sources and Amounts

Stearic acid, as a percent of total fat calories, is fairly constant in beef, pork, lamb and veal at approximately 9% to 12%, with poultry lower at approximately 6% to 7%. (Table 1, page 2) Common cooking oils contain relatively small amounts of stearic acid, 2% to 4%, although hydrogenation of vegetable oils for the production of shortening and margarine can increase the concentration. Cocoa butter (typically consumed as chocolate) contributes proportionately the most stearic acid of commercially available fats. In terms of actual intake, stearic acid supplies approximately 3% to 4% of total calories in the U.S. diet (1,2).

Unique Behavior

The behavior of stearic acid is especially unique in effects on serum cholesterol levels. Studies in humans and experimental animals suggest that ingestion of stearic acid has a neutral or cholesterol-lowering effect in contrast to lauric, myristic and palmitic acids. Thus, there is controversy regarding the classification of stearic acid as a "saturated fat" for dietary recommendations and nutrition labeling purposes (3).

History

Knowledge of the effects of fatty acids on blood lipids in humans can be traced back to the studies of Keys and coworkers (4,5). Diets containing saturated fatty acids with chain lengths longer than 10 carbons raised serum cholesterol levels, polyunsaturated fatty acids depressed serum cholesterol levels, and monounsaturated fatty acids had very little effect. Likewise, Hegsted and coworkers (6) demonstrated a significant adverse effect of saturated fatty acids on blood lipids. Myristic acid was cited as having the greatest impact on serum cholesterol, followed by palmitic acid. Stearic acid had little if any effect on blood cholesterol (5,6,7). However, the blood lipid effects of fatty acids became grouped together, and the perception developed that all saturated fats raise blood cholesterol. This positioning of stearic acid has continued in recent years; however, there is renewed evidence that some current recommendations may not be appropriate (8).

Dietschy and coworkers (9) focused on the effect of long-chain fatty acids on low density lipoprotein-cholesterol (LDL-C) metabolism. They found that changes in plasma LDL-C concentration are secondary consequences to changes in liver metabolism of dietary cholesterol and fatty acids. When the liver is enriched with dietary saturated fatty acids (C12:0, 14:0, 16:0), cholesterol is shifted into a "regulatory pool" and out of an "ester pool." This results in a decrease in the level of liver LDL receptor activity and an increase in the LDL-C production rate. (There is a blockage of cholesterol ester formation by the saturated fatty acids.) In contrast, stearic acid and other dietary fatty acids, 6:0 (caproic), 8:0 (caprylic), 10:0 (capric), and 18:1 (oleic) are essentially biologically neutral and have no effect on liver receptor activity or plasma cholesterol levels.

Table 1. Total Fat and C18:0 Composition of Selected Foods, Fats and Oils (100 g portion)[1]

Food, Fat or Oil	Total Fat (g)	C18:0 (g)	C18:0 % total fat
Beef, composite, lean, cooked	9.9	1.2	12.1
Pork, composite, lean, cooked	9.4	1.1	11.7
Lamb, composite, lean, cooked	9.5	1.2	12.6
Veal, composite, lean, cooked	6.6	0.6	9.1
Broiler, composite, flesh, roasted	7.4	0.5	6.8
Milk chocolate	30.6	8.5	27.8
Dark (sweet) chocolate	34.2	11.4	33.3
Fats & oils			
Cocoa butter	100	33.2	33.2
Mutton tallow	100	19.5	19.5
Beef tallow	100	18.9	18.2
Lard	100	13.5	13.5
Butter	81.1	9.8	12.1
Soybean oil	100	3.8	3.8
Coconut oil	100	2.8	2.8
Olive oil	100	2.2	2.2
Corn oil	100	1.8	1.8

[1] Adapted from USDA Composition of Foods - Raw, Processed, Prepared. USDA Human Nutrition Information Service. Agriculture Handbook 8 Series (8-4, 1979; 8-5, 1979; 8-10, 1992; 8-13, 1990; 8-19, 1991)

Possible Mechanisms

Why stearic acid does not raise blood cholesterol levels has been the basis for much research. Two possible explanations include: *first* - the absorption of stearic acid might be incomplete or significantly different than for other saturated fats, or *second* - stearic acid might be rapidly converted to monounsaturated oleic acid in the body (10). Both of these "explanations" have varying levels of support. Monsa and Ney examined the modes whereby stearic acid exerts its neutral or cholesterol- lowering effect (3). There was reduced absorption of stearate from naturally occurring stearate-rich dietary fats; however, there did not appear to be a rapid conversion of dietary stearate to oleate during feeding. Both stearic acid *content* and the *composition* of stearate-rich dietary fats influenced digestion and post-meal liver and blood lipid levels. Due to the *position* of stearic acid *on the glycerol molecule* in lard, beef tallow and cocoa butter, it is easily released during digestion, as the free acid, and poorly absorbed in the presence of calcium and magnesium. If stearic acid occurred more frequently in the "middle" position, its absorption might be improved. Positional distribution of long-chain saturated fatty acids may explain lower digestibility or absorption rates and some of the difference in response for stearic acid vs. other fatty acids in natural fats (3,11).

There is evidence for distinct metabolic utilization of stearic acid in comparison to palmitic and oleic acids during the postabsorptive phase (12,13). Stearic acid was removed from the plasma at a slower rate, relative to palmitic and oleic acids. Also, stearic acid was preferentially utilized for phospholipid (or membrane) synthesis in the liver, and was not converted to oleic acid to a significant extent in either intestine or liver. Its lipid-lowering effect did not appear to be related to its conversion to oleic acid, but to its favored utilization for membrane synthesis. Palmitic acid was most rapidly taken up and utilized for fat synthesis in the liver. This suggests that palmitic acid is more stimulatory (than stearic acid) to the liver synthesis of very low density lipoproteins (VLDL), contributing to higher blood lipid levels.

Human Studies and Real Foods

The unique cholesterolemic effects of stearic acid also have been demonstrated in clinical studies in young men consuming whole food diets and in those consuming diets prepared from ordinary food and natural fats (14,15,16).

The effects of stearic acid on metabolism must be evaluated both as an isolated dietary constituent and as a component of a natural fat such as the rendered product, beef tallow. Beef tallow triglycerides contain approximately 18% to 19% stearic acid and represent the major source of stearate in the American diet. Studies have specifically compared the cholesterol-raising potential of beef with other meats. Available data suggest that lean beef is no more hypercholesterolemic than chicken or fish and therefore need not be eliminated when following a cholesterol-lowering diet (17,18,19).

Effects on Blood Clotting

While the "neutral" effect of stearic acid on blood lipids is becoming more recognized, the effect of stearic acid on blood clotting (thrombogenesis) is less clear. Recent studies indicate a beneficial effect of stearic acid on clotting factors resulting in a less thrombogenic state (16). However, earlier epidemiological and experimental studies suggested that diets rich in polyunsaturated fatty acids decreased the tendency of blood to clot while those rich in saturated fats increased the tendency. Thus, some may still view the data as equivocal on measures of blood clotting tendency (platelet aggregation and thrombosis formation). Diets rich in stearic acid do not increase clotting tendency compared to either a typical American diet or diets rich in lauric and myristic acids (2).

Regulatory History

The regulatory history of stearic acid has closely followed that of saturated fats (20). As the relationship between saturated fat and blood cholesterol levels developed in the 1950's and 1960's, there were few distinctions made between the individual saturated fatty acids in the food supply. Rulemaking associated with implementation of the Nutrition Labeling and Education Act of 1990 raised the issue of whether information about the content of individual fatty acids in foods should be available to consumers. To date, FDA regulations have postponed labeling of individual fatty acids; but USDA has permitted optional stearic acid labeling. Arguments for considering stearic acid separately from other saturated fatty acids that raise plasma cholesterol levels have increased in recent years (2,8). Under current regulations, stearic acid is positioned "negatively," whereas other fats (such as unsaturated "trans" fats which raise cholesterol levels) are positioned "positively" among unsaturated fats.

Future Opportunities

The prospect of increased use of stearic acid as a replacement for cholesterol-raising saturated and unsaturated (trans) fatty acids has renewed interest in the metabolic effects of this fatty acid (2,8). This could result in a wider choice of foods in diets designed to lower plasma cholesterol, which could in turn increase palatability and lead to increased dietary adherence. Also, if stearic acid increases in the food supply (via food processing, agricultural biotechnology or increased usage as a replacement fat) it then will need to be excluded from the grouping of other SFAs if consumers are to monitor their intake of fats which raise blood cholesterol levels.

The uniqueness of stearic acid, relative to other saturated fatty acids, is becoming more widely recognized. With increased understanding of the scientific data base for stearic acid, future dietary recommendations and nutrition labeling can better position this unique fatty acid with health professionals and ultimately with the consumer.

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