

## **UPDATE: MILK FAT AND HUMAN HEALTH – SEPARATING FACT FROM FICTION**

D. E. Bauman\* and A. L. Lock†

\*Department of Animal Science, Cornell University

†Department of Animal Science, Michigan State University

### **INTRODUCTION**

The importance of animal products in meeting global needs for food security is well established, and public health organizations around the world include milk and other dairy products in recommendations for a healthy, well-balanced diet. Dairy products are an important source for many vital nutrients including high quality protein, energy, and many essential minerals and vitamins (Bauman and Capper, 2011). However, dairy products are also a major food source of saturated fat, accounting for 20-30% of the saturated fat intake for the US population (USDA/USDHHS, 2010). For over a half-century, saturated fat has been demonized as the major cause of cardiovascular vascular disease and public health recommendations are to reduce dietary intake of saturated fat and food products containing saturated fatty acids (FA). As a consequence, the perception of the public, and much of the scientific community, is that milk fat is a negative component of dairy products and typical dietary advice is to consume only reduced-fat or no-fat dairy products. The net effect of this recommendation over the last 50 years has been a progressive reduction in fluid milk consumption and a shift toward fluid milk products containing less fat (Table 1).

Cardiovascular diseases (CVD) include coronary heart disease, cerebrovascular disease, and other related disorders of the heart and blood vessels. CVD is the leading cause of death in the US and globally, accounting for about one-third of all deaths (Roger et al., 2011). Strategies to reduce CVD involve reducing leading risk factors that include smoking, hypertension, and high cholesterol; doing so reduces the burden of CVD. The U.S. Center for Disease Control estimates that about 50% of the US population has at least one of these three risk factors with CVD-related health care costs in the US at over \$400 billion annually (CDC, 2011). At previous CNC Conferences we have discussed the important role of milk and milk fat in human health, and also addressed some of the myths, misconceptions and misrepresentations (Bauman and Lock, 2006; Lock and Bauman, 2011). Of special importance, new research and re-evaluation of previous research has challenged long-held dogma on the relationship between saturated fat, milk fat, and CVD. While national organizations, health professionals, and dietitians will be cautious in revising decade-old recommendations, there is no doubt that the last few years have provided game-changing scientific evidence that will revise the paradigm for the connection between saturated fat and CVD. Furthermore, these new studies and re-evaluations have convincingly demonstrated the important role that milk and dairy products play in health maintenance and the prevention of chronic diseases. Based on these developments, the CNC Program committee requested an update. In the following sections we will deal briefly with some background and historical aspects related to saturated fat and CVD, and then highlight recent findings related to the role of milk and milk fat in human health.

Table 1. U.S. per capita availability of fluid milk.<sup>1</sup>

Year	Total Consumption	Whole milk	Reduced fat (2%)	Low fat (1%)	Nonfat (<0.05%)
	Liters	Percent of total fluid milk			
1950	133.6	99.0	0	0	0.9
1960	125.6	95.6	0.7	0	3.1
1970	115.8	83.8	11.0	0.7	4.5
1980	99.7	62.7	24.9	7.0	5.3
1990	94.7	41.4	37.9	9.6	11.0
2000	81.4	36.5	34.2	12.5	16.2
2009	73.4	30.2	39.1	14.0	16.6

<sup>1</sup>Adapted from Huth and Park (2012)

## BACKGROUND AND HISTORICAL ASPECTS

Ancil Keys (University of Minnesota) played a central role in identifying dietary fat, specifically saturated fat, as a major public health concern in CVD. Using population data obtained from WHO reports, Keys (1953) reported a curvilinear relationship between the intake of fat and deaths from coronary heart disease for six countries (open circles in Figure 1). Keys was featured on the cover of TIME magazine and this was the beginning of the “diet-heart hypothesis” proposing a sequence of etiologic relations between dietary saturated fat, circulating cholesterol, and the development of CVD. However, Yerushalmy and Hilleboe (1957) examined Keys’ publication and concluded that many aspects were flawed including the fact that the 6 countries had been cherry-picked from a data set for 22 countries (Figure 1). This represented an extraordinary critique, and based on a rigorous analysis of Keys’ publication, they concluded “The association between the percent of fat calories available for consumption in national diets and degenerative heart disease (reported by Keys) is not valid; the association is specific neither for dietary fat nor for heart disease mortality” (Yerushalmy and Hilleboe, 1957). Despite this, Keys (1980) continued promoting the diet-heart hypothesis and followed-up with a seven country comparison showing that dietary intake of saturated fat as a percentage of calories was strongly correlated with coronary death rates ( $r = 0.84$ ). Again, other scientists pointed out major flaws in his study, e.g. countries chosen by Keys to represent low saturated fat intake and low incidence of CVD were in fact less industrialized and differed in many ways including smoking habits, physical activity, and obesity (Willett, 2012). Nevertheless, the diet-heart hypothesis was well received by many health practitioners and policy makers.

Historically, serum cholesterol has served as a surrogate marker for the risk of CVD. Low-density lipoprotein cholesterol (LDL-C) is correlated with risk of CVD; thus, the discovery that saturated fat resulted in an increase in LDL-C provided support for the diet-heart hypothesis, and some concluded that saturated fat must be the major cause of CVD (Ordovas, 2005). This particularly impacted public perception of dairy products because dairy fat contains 60 to 70% saturated FA (Table 2). Additionally, it was discovered that individual FA differ in their effects on serum LDL-C; whereas most saturated FA were neutral, lauric acid (C12:0), myristic acid (C14:0), and palmitic acid

(C16:0) caused pronounced increases in LDL-C (Hegsted et al., 1965) and these three FA represent about 40% of total milk fat (Table 2). This led to the development of an atherogenic index which ranked foods based on their content of these three FA (Ulbricht and Southgate, 1991); needless to say, the atherogenic index ranked dairy products as problematic.

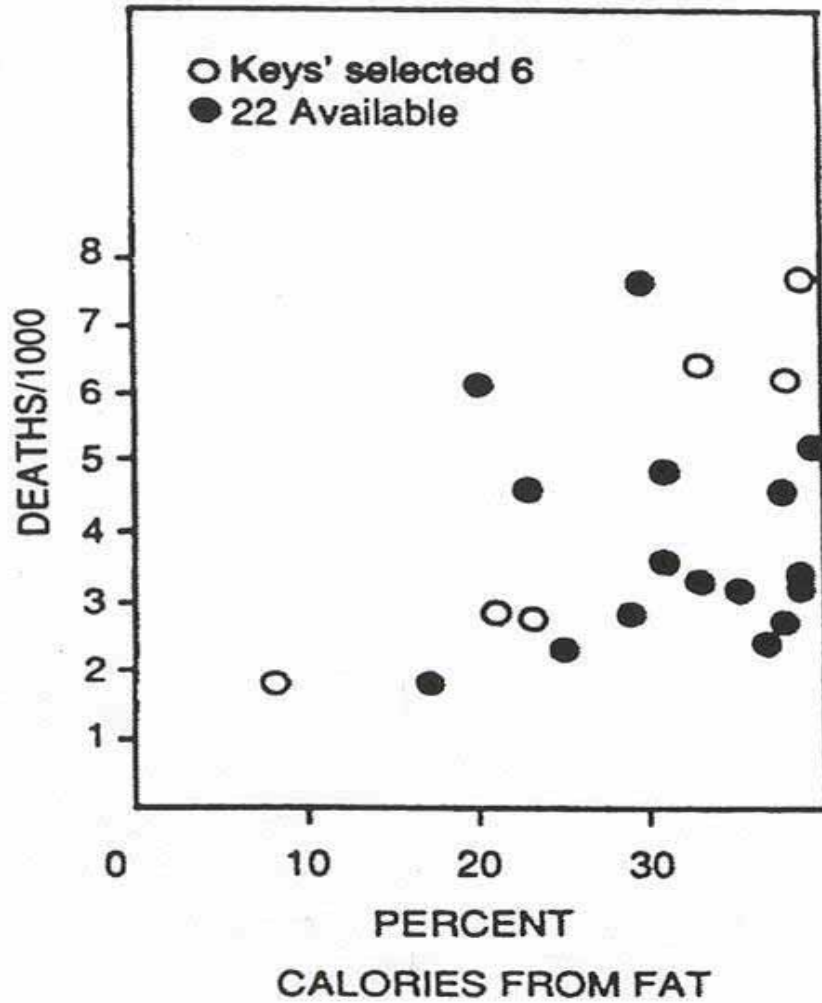


Figure 1. Relationship between percent of calories from fat and mortality from atherosclerotic and degenerative heart disease. Six countries (open circles) selected by Keys (1953) from a WHO data set for 22 countries (unselected countries shown by solid circles). Adapted from Yerushalmy and Hilleboe (1957) and Majjala (2000). Relationship for the six selected countries represented the foundation for Keys diet-heart hypothesis to explain cause of cardiovascular disease.

Table 2. Fatty acid composition of retail milk samples in the United States.<sup>1</sup>

Fatty Acid	Percent of Total	
	Mean	SEM
C4:0	4.15	0.017
C6:0	2.13	0.008
C8:0	1.19	0.006
C10:0	2.59	0.015
C12:0	2.87	0.018
C14:0	9.53	0.039
C14:1	0.82	0.007
C15:0	0.89	0.004
C16:0	28.08	0.078
C16:1	1.48	0.011
C17:0	0.52	0.002
C18:0	11.68	0.078
C18:1, <i>t</i> 6	0.32	0.002
C18:1, <i>t</i> 9	0.29	0.002
C18:1, <i>t</i> 10	0.55	0.007
C18:1, <i>t</i> 11	1.48	0.013
C18:1, <i>t</i> 12	0.54	0.004
C18:1, <i>c</i> 9	23.58	0.074
C18:2, <i>c</i> 9, <i>c</i> 12	3.19	0.019
C20:0	0.09	0.001
C18:3	0.38	0.004
C18:2, <i>c</i> 9, <i>t</i> 11	0.55	0.004
C18:2, <i>t</i> 10, <i>c</i> 12	ND	-
Other	3.09	0.021

<sup>1</sup>Adapted from O'Donnell-Megararo et al. (2011). Milk samples were obtained from 56 milk processing plants representing all US regions and seasons over a 12 month period.

Public health recommendations in the 1970s and 1980s were to dramatically reduce the intake of saturated fat. This included recommendations to reduce intake of dairy products and/or a shift to low-fat or no-fat dairy products. One specific recommendation was to replace butter with margarine, and this was particularly unfortunate as it markedly increased the risk of CVD for millions of people; during this era margarine had high levels of *trans* FA and subsequent research has established that intake of industrial sources of *trans* FA are a major risk for CVD (Lock and Bauman, 2011). Much of the case against dairy foods is linked to an imperfect understanding of cholesterol as a surrogate marker of CVD risk. In addition to effects on LDL-C, saturated FA, in particular lauric acid, myristic acid, and palmitic acid cause an increase in serum high-density lipoprotein-cholesterol (HDL-C) and this cholesterol fraction reduces the risk of

CVD. Thus, when changes in both LDL-C and HDL-C are considered, saturated FA have no adverse effect on serum cholesterol as a risk factor for the incidence of CVD. A meta-analysis by Mensink et al. (2003) provides convincing evidence for this; using data from 60 clinical studies, they evaluated CVD risk on the basis of ratio of serum total cholesterol:HDL-C. As illustrated in Figure 2, ratios for lauric acid, myristic acid, and palmitic acid provide little or no evidence for an atherogenic effect when compared to an isoenergetic carbohydrate substitution; in fact the ratio for lauric acid was significantly decreased. When compared by fat type, the meta-analysis revealed no effect of saturated FA when compared to carbohydrate substitution on an isoenergetic basis (Figure 2). Nonetheless, changes in the ratio of serum total cholesterol:HDL-C were indicative of the well-established beneficial effects of monosaturated and polyunsaturated FA and the increased atherogenic risk of *trans* FA. Thus, this classic meta-analysis utilizing cholesterol-related surrogate markers provides no support for saturated fat in general or the major individual saturated FA in milk fat as risk factors in CVD.

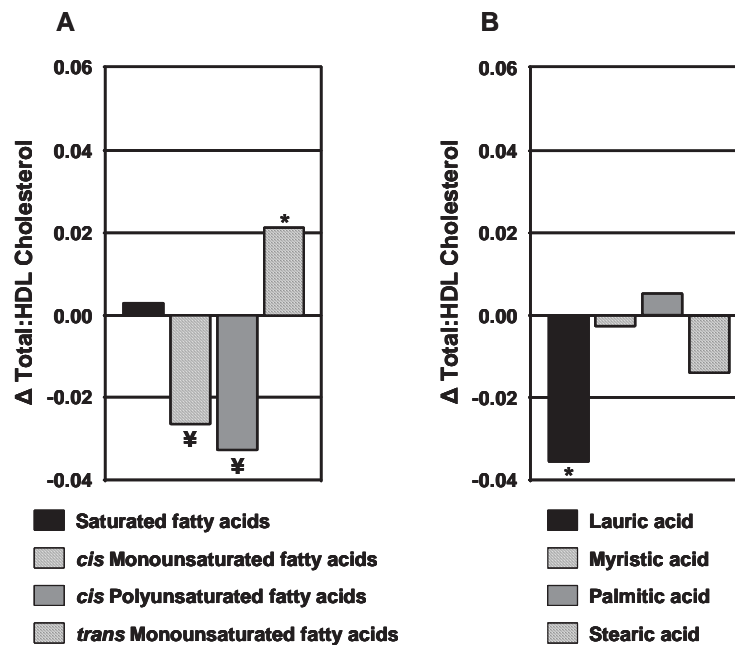


Figure 2. Meta-analysis (n = 60 trials) to examine changes in serum ratio of total cholesterol to HDL-cholesterol when carbohydrates constituting 1% of energy are replaced isoenergetically with fatty acids (Mensink et al., 2003). Panel A represents comparison of saturated, *cis*-monounsaturated, *cis*-polyunsaturated, and *trans*-monounsaturated fatty acids (\*= $P < 0.05$ ; ‡= $P < 0.001$ ). Panel B represents comparison of lauric acid (12:0), myristic acid (14:0), palmitic acid (16:0), and stearic acid (18:0) (\*= $P < 0.001$ ). Mensink et al., 2003).

For the last 50 years medical societies and government agencies have embraced the concept that nutrition, specifically saturated fat, is a major player in the epidemic of CVD. As discussed previously, the diet-heart hypothesis and the use of LDL-C as a

surrogate marker were perceived to offer support for this concept. Acceptance by the scientific community, however, was far from unanimous (e.g. Ravnskov, 2002; Weinberg, 2004; Ordovas, 2005) and a growing body of scientific studies offered no support (see discussion in Lock and Bauman (2011)). The classic study by Mensink et al. (2003) discussed above was of special importance in challenging the dogma on the relationship between dietary saturated fat, serum cholesterol, and incidence of CVD. Two additional game-changing examples were investigations by Elwood et al. (2008) and Siri-Tarino et al. (2010). Elwood et al. (2008) summarized 15 prospective cohort studies and their meta-analysis showed that patients with high intake of dairy products had a lower relative risk of stroke and heart disease. The meta-analysis of prospective epidemiologic studies by Siri-Tarino et al. (2010) covered a 5 to 23 year follow-up of 347,747 subjects and again results indicated “there is no significant evidence that dietary saturated fat is associated with an increased risk of coronary heart disease or CVD”.

## RECENT DEVELOPMENTS IN SATURATED FAT AND MILK FAT

Dietary recommendations by nationally recognized bodies have a substantial impact on the nutrition and health community. The 2010 Dietary Guidelines for Americans recommended restricting the consumption of saturated fatty acids to less than 10% of total dietary calories (USDA/USDHHS, 2010). In a peer-reviewed publication Hite et al. (2010) challenged this report, including its specific conclusions regarding saturated fat, and pointed out that recommendations were based on science that was inaccurately represented and summarized (as we have discussed in the previous section), and even more serious that the report failed to include the full body of relevant research. Hoenselaar (2012) took this a step further in a peer-reviewed publication by examining recommendations on saturated fat from the report by USDA/USDHHS (2010) as well as reports from two additional important US and European advisory committees – the Institute of Medicine (IOM, 2005), and the European Food Safety Authority (EFSA, 2010). He summarized the recommendations from these advisory committees as follows:

1. Consume less than 10% of calories from saturated FA, replacing them with monounsaturated and polyunsaturated FA (USDA/USDHHS, 2010).
2. Keep the intake of saturated FA as low as possible while consuming a nutritionally adequate diet (IOM, 2005).
3. Saturated fat intake should be as low as possible (EFSA, 2010).

These advisory committees cited studies to support their recommendations, but Hoenselaar (2012) pointed out their conclusions were not based on a valid representation of the scientific literature. For example, the effect of saturated fat on LDL-cholesterol and its connection to an increased CVD risk was cited in all three reports, but concurrent beneficial effects of saturated fat to increase HDL-cholesterol thereby reducing CVD risk was systematically ignored. It is unfortunate that due to a focus on the small rise in blood cholesterol with milk consumption, the debate on milk fat has never achieved a reasonable balance in the evaluation of risks and benefits. The

overall conclusions by Hoenselaar (2012) were “Results and conclusions about saturated fat in relation to CVD, from leading advisory committees, do not reflect the available scientific literature”. Two additional public health advisory committees are World Health Organization (WHO) and American Heart Association (AHA). Although recommendations by these two bodies were not included in the critiques by Hite et al. (2010) and Hoenselaar (2012), their assessment would also apply to them. The WHO recommends saturated fat intake be reduced to less than 10% of dietary calories and the 2009 Guidelines by AHA recommends saturated fat be reduced to an even lower <7% of total calories (Huth and Park, 2012).

Support for a paradigm shift in conclusions for the relationship between saturated fat, milk fat and cardiovascular health also comes from recent reviews of the published literature. The comprehensive reviews of Parodi (2009), Givens and Minihane (2011), Kratz et al. (2012) and Huth and Park (2012) reached a similar conclusion – that the majority of observational studies have failed to support an adverse association between the intake of dairy products and CVD, regardless of milk fat levels, and in many cases a long-term beneficial effect was observed.

Table 3. Summary of recent prospective cohort studies.

<b>Reference</b>	<b>Description/Objective</b>	<b>Conclusion</b>
de Oliveira Otto et al. (2012)	Multi-ethnic study of saturated dairy fat intake and incidence of CVD; 5209 individuals for 10 yr period.	A higher intake of saturated fat from dairy products was associated with lower CVD risk.
Elwood et al. (2010)	Meta-analysis of cohort studies of dairy intake in relation to cardiac health.	Greater intake of milk and dairy products reduced incidence of ischemic heart disease and stroke.
Goldbohm et al. (2011)	Multivariate survival analysis of case cohorts to examine association between dairy product intake and risk of cardiac-related death. Data collected over 10 yr (n=120,853 patients).	Dairy product intake had neutral effects on mortality in men, but in women dairy fat intake was associated with slightly increased mortality from ischemic heart disease.
Soedamah-Muthu et al. (2011)	Dose-response meta-analysis of dairy consumption and incidence of CVD and all-cause mortality.	Milk intake was associated with reduction in overall CVD risk, but no relationship to total mortality.

Several excellent investigations have been reported in the last two years and key ones are summarized in Table 3. de Oliveira Otto et al. (2012) conducted a multi-ethnic study examining the relationship between consumption of saturated dairy fat and CVD; they concluded that “a higher intake of saturated fat was associated with lower CVD risk”. Relative risk was 0.62 when 5% of energy was from dairy saturated fat (de Oliveira Otto et al., 2012). Elwood et al. (2010) conducted a meta-analysis of prospective cohort studies to examine associations between the intake of milk and dairy products and the incidence of ischemic heart disease and stroke. Results indicated “a reduction in risk in subjects with the highest dairy consumption relative to those with the lowest intake”; relative risk values were 0.92 for ischemic heart disease and 0.79 for stroke (Elwood et al., 2010). Goldbohm et al. (2011) reported results from a large cohort study designed to examine the association between the intake of dairy products and mortality; data covered a 10 year period for 120,852 men and women, and results indicated no association between dairy product consumption and stroke mortality for men or women. Likewise, there was no association between total milk intake and ischemic heart disease mortality in men, whereas a small positive association was observed for women (relative risk = 1.07; Goldbohm et al., 2011). Soedamah-Muthu et al. (2011) conducted a similar meta-analysis comparing intake of dairy products and the risk of CVD (including coronary heart disease, stroke, and mortality); their meta-analysis gained greater analytical power by including different dairy food categories and different ranges of intake. Results demonstrated that “milk intake was not associated with total mortality, but may be inversely associated with overall CVD risk”; relative risk for the later was 0.94 (Soedamah-Muthu et al., 2011).

## DAIRY PRODUCTS AND HUMAN HEALTH

Consumers are increasing aware of the connection between diet and health, and scientists are being asked to clarify the role of specific foods in health maintenance and the prevention of chronic diseases. Multidisciplinary studies in developing countries demonstrate that when diets of schoolchildren had little or no animal source foods, the intake of essential micronutrients was inadequate resulting in negative health outcomes including severe problems such as poor growth, impaired cognitive performance, neuromuscular deficits, psychiatric disorders and even death (Nuemann et al., 2002; Randolph et al., 2007). Long term effects of milk and dairy products on health and the prevention of chronic diseases of the general population are also of interest, and these would best be determined in randomized controlled trials. However, there have been no such trials and realistically none are likely because of the required number of subjects and the long latency period associated with chronic diseases. The best evidence, therefore, comes from prospective cohort studies with disease events or death as the outcome.

There have a number of prospective cohort studies that have evaluated the association between intake of milk and dairy products and the incident of chronic diseases. Results of meta-analysis of such studies provide convincing evidence that milk and dairy products are associated with beneficial effects for long-term health maintenance and the prevention of chronic diseases. The beneficial effects in reducing



the risk of CVD was discussed earlier, and additional examples of chronic diseases for which consumption of dairy products reduces risk include: diabetes, obesity, metabolic syndrome and many types of cancer (Elwood et al., 2008; 2010; Tremblay and Gilbert, 2009; Kliem and Givens, 2011; Grantham et al., 2012; Korhonen, 2012; Kratz et al., 2012). Overall, the science clearly demonstrates the importance of milk and dairy products in childhood development, health maintenance, and the prevention of chronic diseases.

## CONCLUSIONS

For over a half-century the concept of healthy eating has become synonymous with avoiding fat, especially saturated fat and this remains a center piece in nutritional advice of medical societies and government agencies world-wide. However, investigations have shown the science behind this advice was based on incomplete and in some cases flawed investigations. Nutritional science has advanced rapidly and evidence now demonstrates that the proportion of total energy from fat or saturated fat is largely unrelated to the risk of CVD or other chronic diseases. Indeed there appears to be an enormous disconnect between the evidence from long-term prospective studies and public perceptions of harm from the consumption of milk fat and dairy products. This clearly represents a new paradigm requiring a major shift in recommendations by national advisory groups. Furthermore, milk and dairy products are key components in dietary patterns chosen for optimum health maintenance and the prevention of chronic diseases.

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