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Accepted Version

Markey, O., Hobbs, D. and Givens, I. ORCID:
<https://orcid.org/0000-0002-6754-6935> (2015) Public health implications of milk fats: the current evidence base and future directions. *Clinical Lipidology*, 10 (1). pp. 5-8. ISSN 1758-4299
doi: <https://doi.org/10.2217/CLP.14.66> Available at
<https://centaur.reading.ac.uk/39444/>

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To link to this article DOI: <http://dx.doi.org/10.2217/CLP.14.66>

Publisher: Future Medicine

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Public health implications of milk fats: the current evidence base and future directions

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Keywords: cardiovascular disease risk, milk fat, saturated fatty acids, dairy consumption

1 **Introduction**

2 With cardiovascular disease (CVD) recognised as a leading cause of morbidity and mortality
3 in the UK, the contribution of major modifiable risk factors, such as diet, are becoming
4 increasingly more important in CVD prevention. A high saturated fatty acid (SFA) intake is
5 associated with an increased risk of coronary heart disease (CHD) and for this reason key
6 public health advice recommends that SFA should contribute less than 10% of total energy
7 (TE) [1] . However UK adults are currently exceeding this recommendation, with SFA intake
8 accounting for 12% of TE [2]. Therefore, there is a need for novel interventions to help
9 reduce or replace the amount of SFA in the diet. In comparison to substitution with
10 carbohydrates, evidence suggests that replacement of SFAs with unsaturated fatty acids
11 (FA) may provide a greater CVD risk reduction [3]. Indeed, lowering intake of SFA, through
12 modification of FA profile of the diet, as opposed to reduction in its total fat content, may
13 reduce cardiovascular events by up to 14% [3], which could have a major impact on public
14 health.

15 This article will present the current prospective evidence on milk and milk-derived
16 foods in relation to CVD events. The potential of ruminant feeding-based public health
17 strategies aimed at reducing cardiovascular risk markers, through replacement of SFA in
18 milk fat with unsaturated FAs, will also be discussed.

19 **Nutrient composition of milk and dairy foods**

20 Ruminant milk is nutrient dense and is a key source of energy, protein and micronutrients
21 such as calcium, phosphorus, potassium, iodine and vitamin D [4, 5]. Consequently,
22 reducing dairy consumption, as a means of lowering SFA intake, could lead to inadequate
23 intake of these nutrients, especially in vulnerable infant and elderly populations.

24 Additionally, other nutrients found in the dairy matrix may be cardio-protective.
25 Calcium and milk proteins (whey and casein) are linked to the blood pressure regulatory
26 properties of dairy; it is believed that protein-derived bioactive peptides have a role to play
27 in the anti-hypertensive aspects of dairy, in part, through inhibition of the angiotensin-I-
28 converting enzyme mechanism [5]. When compared with the intake of their industrially
29 produced counterparts, ruminant *trans* fatty acids (rTFA) do not appear to have the negative
30 effects on CVD risk, with some studies inferring that their intake may be associated with
31 reduced cardiovascular risk [4, 5]. It is recognised that rTFA are consumed at very small
32 quantities but research is needed to clarify whether increasing rTFA intake, through
33 manipulation of the fatty acid profile of dairy products, affects cardio-metabolic health.

34 While there are some limited data which suggest that the consumption of milk-derived
35 conjugated linoleic acid (CLA) may be associated with beneficial cardio-protective effects,
36 more conclusive evidence is needed to fully understand the impact of CLA on CVD risk
37 outcomes [6].

38 **Contribution of milk to saturated fat intake**

39 Milk and dairy products (excluding butter and composite dairy dishes) contribute to almost
40 one quarter of SFA intake the UK diet [7] . A large portion of energy in milk is derived from
41 fat, with SFA accounting for approximately 70% of total milk fat, predominantly in the form
42 of myristic (C14:0), palmitic (C16:0) and stearic (C18:0) acids. As a result of their major
43 contribution to SFA intake, it has been perceived that the consumption of milk and milk-
44 derived products should be limited as a means of reducing the risk of CVD. However, there
45 is good evidence of the contrary, as will be explored further in this article.

46 **Milk and cholesterol levels**

47 While it is recognised that the effect of SFA on CVD is linked to increases in serum lipids,
48 predominantly LDL-cholesterol (LDL-C), some intervention studies have revealed that milk or
49 dairy fat feeding does not significantly increase this risk marker for CVD and cross-sectional
50 evidence suggests that FAs associated with dairy fat intake may have a beneficial effect on
51 LDL-C particle size distribution; however these findings require further investigation (see
52 [5]). Furthermore, it is recognised that there is a differential effect of dairy product type on
53 CVD risk factors, such that fermented dairy products may have a more favourable effect on
54 blood lipid profiles than intake of butter, matched for fat and SFA content [8]. Although
55 limited data are available, it is hypothesised that the higher calcium content of the cheese
56 may lead to a reduced fat absorption when compared to butter, probably through the
57 intestinal formation of insoluble FA calcium soaps [8].

58 **Prospective evidence on milk/dairy foods and cardiovascular disease**

59 There have been a number of overviews published on the relationship between consumption
60 of milk and dairy foods and CVD. To date, the largest was a meta-analysis based on 38
61 cohort studies [9]. This meta-analysis with the addition of data from six recently published
62 studies (see [10] for details) showed that the overall relative risk (RR) for CHD was 0.92,
63 suggesting a reduction of about 8% in those subjects who reported the highest milk/dairy
64 intake, compared with subjects with the lowest intake (17 studies RR: 0.92; 95% CI, 0.86–

65 0.99). This meta-analysis also showed that a higher milk/dairy intake was related to a 19%
66 lower risk of stroke (12 studies RR: 0.81; 95% CI, 0.71–0.92). Five studies reported on risk
67 of haemorrhagic strokes (RR: 0.75; 95% CI, 0.60-0.94) and three studies on subarachnoid
68 bleeds (RR 0.93; 95% CI, 0.84-1.02) and these studies suggested a 25% and 7% reduction
69 in risk with the highest milk/dairy intake for haemorrhagic strokes and subarachnoid bleeds,
70 respectively [10].

71 In line with the aforementioned, meta-analysis evidence from prospective cohort
72 studies show no association between individual dairy foods and CHD risk [11-15], except for
73 an inverse association between cheese consumption and risk of myocardial infarction [16],
74 and between low-fat milk and incident CHD [17]. In relation to stroke, the findings were
75 inconsistent, with several studies showing a significant inverse association with low-fat milk
76 [17], low-fat dairy [18] and fermented dairy products [17, 19], whereas in four other
77 studies the consumption of specific dairy foods was not related to stroke [12, 13, 15, 20].

78 Overall, the evidence from prospective cohort studies shows that milk/dairy
79 consumption does not increase CVD risk. Conversely, individuals with the highest milk/dairy
80 intake had the lowest risk of CVD. However, the effects of individual dairy foods such as
81 butter and cheese, as well as benefits of fat-reduced milk and SFA-reduced milk are less
82 certain.

83 **Modification of the fatty acid profile of ruminant milk**

84 Although some argue that the nutrients within the dairy food matrix may act synergistically
85 with SFA to prevent the onset of CVD, the potential additional cardio-protective benefits of
86 replacing milk SFA with *cis*-MUFA or *cis*-PUFA, through dietary supplementation of the
87 bovine diet with oil seeds or plant oils (typically rich in C18 MUFA and/or PUFA), needs to be
88 further explored [4, 5]. Supplementation of the diet with oils that are rich in long chain
89 unsaturated FA reduces the mammary gland synthesis of short- and medium chain SFA
90 (C6:0-C16:0) and subsequently increases long-chain FA profile of the milk [4, 5].
91 Additionally, this strategy has the added benefit of removing SFA from the food chain, whilst
92 maintaining the valuable contribution that milk makes to macro- and micronutrient intake.

93 **Modified saturated fat-reduced dairy consumption and cardiovascular disease** 94 **risk**

95 There is a scarcity of randomised controlled trial data that has examined the impact of
96 consuming saturated fat-reduced, unsaturated fat-rich modified milk and dairy products on

97 CVD risk. Although the limited research suggests that intake of modified dairy products may
98 favourably impact on CVD risk markers, an inherent limitation of these studies was a
99 reliance on fasting circulating lipid levels as a biomarker for CVD risk (for detailed review,
100 see [5]). Given the aforementioned complexity of the structural properties of milk, and
101 considering that humans spend the majority of their time in the postprandial state, future
102 research needs to provide a more meaningful holistic evaluation and examine the impact of
103 modified dairy consumption on a variety of risk factors linked to the pathophysiology of CVD
104 including endothelial function, arterial stiffness, postprandial lipaemia and inflammatory
105 biomarkers [4].

106 The University of Reading is contributing to this fundamental research gap by
107 conducting a UK Medical Research Council-funded project called the RESET (*REplacement of*
108 *SaturatEd fat in dairy on Total cholesterol*) study; it is testing the hypothesis that modified
109 dairy products (milk, cheese and butter), which have a substantial proportion of SFA
110 replaced with *cis*-MUFA, will improve vascular function, reduce inflammatory markers and
111 other risk markers for CVD relative to matched commercially available products in both
112 chronic and acute within chronic settings (ClinicalTrials.gov NCT02089035). Findings from
113 the RESET intervention study (anticipated to be completed in December 2015), will help to
114 elucidate if reducing the SFA content of dairy products is beneficial to numerous
115 components of cardiovascular health and may have potential for improving the overall
116 health of the population.

117 **Conclusion**

118 Milk and milk-derived products are complex, nutrient dense foods but there is some concern
119 that their intake could increase risk of CVD. Despite the significant SFA profile of milk fat,
120 epidemiological evidence and experimental data challenge this perception. Indeed, these
121 data suggest that milk may afford some protection from cardiovascular events, but the
122 evidence is less substantial for other dairy products. There is a need to carry out well-
123 designed, human dietary intervention studies to determine whether consumption of modified
124 milk and dairy products, with an unsaturated FA enhanced profile, may provide more
125 protection from CVD in both healthy and at-risk populations.

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129 **Financial & competing interests disclosure**

130 *The authors have no relevant affiliations or financial involvement with any organization or*
131 *entity with a financial interest in or financial conflict with the subject matter or material*
132 *discussed in the manuscript. This includes employment, consultancies, honoraria, stock*
133 *ownership or options, expert testimony, grants or patents received or pending, or royalties.*

134 *No writing assistance was utilized in the production of this manuscript.*

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