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Review

Health effects of oleic acid and long chain omega-3 fatty acids (EPA and DHA) enriched milks. A review of intervention studies

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ABSTRACT

Substitution of dietary saturated fat by oleic acid and/or polyunsaturated fatty acids (PUFA) has been described to reduce the cardiovascular risk by reducing blood lipids, mainly cholesterol. Additional benefits have been described for long chain omega-3 PUFA (eicosapentaenoic acid—EPA and docosahexaenoic acid—DHA) from fish oils. In recent years, food technology has been used to produce dairy drinks with a reduced content of saturated fat in favour of those fatty acids, most of them claiming cardiovascular benefits. This review summarises all the scientific evidence regarding the effects of milks enriched with long chain omega-3 PUFA (EPA + DHA) and/or oleic acid on cardiovascular health. Nine controlled intervention studies with enriched milks have reported effects on healthy volunteers, subjects with increased risk factors and cardiovascular patients. The main effects observed were reductions of blood lipids, mainly cholesterol, LDL-cholesterol and triglycerides.

Contents

Abbreviations: CV, cardiovascular; CVD, cardiovascular disease; CHD, coronary heart diseaase; DHA, docosahexaenoic acid; EFSA, European Food Safety Agency; EPA, eicosapentaenoic acid; HDL, high-density lipoprotein; LDL, low-density lipoprotein; MI, myocardial infarction; MS, metabolic syndrome; MUFA, mono-unsaturated fatty acids; PUFA, poly-unsaturated fatty acids; PVD, peripheral vascular disease; SFA, saturated fatty acids; TG, triglycerides; RCT, randomised controlled trial; RDI, recommended daily intake.

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1. Introduction

In the last decade we have witnessed an extraordinary increase in the number of functional foods targeted to the ever-growing health conscious population. Several categories among these foods can be found according to their health target, including the cardiovascular (CV) system. These foods, when they are consumed regularly and in the context of a healthy diet and lifestyle, intend to maintain or improve the CV health by reducing the levels of risk factors such as cholesterol.

Milk and dairy products are every day consumed foods and constitute a good and popular source of bioavailable calcium. Whilst milk and dairy foods in general are perceived as healthy foods, milk fat contains about 70% of saturated fatty acids (SFA). These fatty acids (mainly myristic and palmitic acids) may raise total and low-density lipoprotein (LDL) cholesterol, increasing the risk of CV disease (CVD), hence the consumption of milk fat should be limited [1].

Since the most effective replacement for saturated fatty acids in terms of coronary heart disease (CHD) outcome are polyunsaturated fatty acids (PUFA) and oleic acid (the main fatty acid from olive oil) [2], a number of dairy companies have used food technology to substitute milk fat with PUFA, oleic acid, or combinations of both to produce "healthier" milks. Whilst this substitution should produce nutritional benefits derived from the overall reduced intake of saturated fat, many of the final products obtained claim beneticial effects on blood lipids, i.e. reductions on total and/or LDL-cholesterol, triglycerides or increases of HDL-cholesterol in blood.

This review summarises all the scientific evidence regarding the effects of milks enriched with long chain omega-3 PUFA (EPA + DHA) and/or oleic acid on CV health. A critical discussion and a few concluding remarks are also presented.

2. Health effects of oleic acid, EPA and DHA

There is ample scientific evidence showing that modulation of dietary fat composition affects blood-lipid concentrations. Regarding oleic acid, or monounsaturated fatty acids (MUFA), the most noticeable effects come from studies where the substitution of saturated fat with oleic acid has been tested. Isocaloric replacement of about 5% of energy from saturated fatty acids by oleic acid (or PUFA) has been estimated to reduce coronary heart disease risk by 20–40% mainly via LDL-cholesterol reduction [3]. Other beneficial effects on risk factors for CVD such as factors related to thrombogenesis, *in vitro* LDL oxidative susceptibility and insulin sensitivity have also been reported [3–6]. As intakes of saturated fat in many countries are higher that the recommended levels [7], an increase in the intake of oleic acid may be beneficial as it limits the intake of saturated fat. This can be achieved by changing dietary patterns like using olive oil instead of butter, or by using food technology to modify the fatty acid profile of foods naturally rich in saturated fatty acids in favour of oleic acid.

The most important long chain omega-3 PUFA are EPA and DHA found in fish oils from marine products. The benefits derived from these fatty acids are based on the convincing inverse relationship observed between its consumption and a decreased risk of CVD, particularly the coronary hearth disease [2]. The biological effects of EPA and DHA are wide ranging, involving lipoproteins, blood pressure, cardiac function, endothelial function, vascular reactivity and cardiac electrophysiology, as well as potent antiplatelet and anti-inflammatory effects [8–10]. These effects depend on dose, time and baseline characteristics of the subjects. In addition, EPA and DHA specifically reduce plasma triglyceride levels and thereby the risk of CVD [11].

3. Current intakes and recommendations of LC-*n* – 3-PUFA and oleic acid

Intakes of EPA + DHA are based on food-consumption data and chemical analyses of diets. Unfortunately, due to the lack of reliable food survey data in many European countries, estimates of EPA + DHA intake are rather scarce. Mean dietary intakes of these fatty acids among adults have recently reported a daily intake of 265 mg in Austria, 380 mg in France, 250 in Germany and 90 mg in The Netherlands [12]. These figures are high compared with the EPA + DHA calculated intake in the US (100–200 mg/day), but low compared to the values reported for Japan (up to 2 g/day) where fish consumption is very high [13].

Recommendations of EPA + DHA intake from national and international authorities range 200–650 mg per day and are based on the convincing inverse relationship observed between its consumption and a decreased risk of CVD [2,14]. However, intake recommendations for the general population established by national authorities are not uniform and reflect the different criteria on which they are based. A selection of these recommendations is given as follows:

- The World Health Organisation (WHO) recommendations for the general population established that regular fish consumption (1–2 servings per week) providing 200–500 mg of EPA + DHA per serving is protective against coronary heart disease and ischaemic stroke [2]. Therefore their recommendations range from 200 to 1000 mg. WHO also indicates that people who are vegetarians and do not take fish are recommended to ensure adequate intake of plant sources of alpha-linolenic acid, as some of it (0.5–20% depending on various factors) is metabolised to EPA [15,16].
- The American Heart Association (AHA), also recommends for the general population to consume fish, especially oily fish, at least twice a week [11]. Estimates based on consumption of one portion (125 g) of oily fish (2 g EPA + DHA per 100 g on average) and one portion of lean fish (0.2 g/100 g) result in an approximate intake of 3 g of DHA + EPA per week or 430 mg per day. This association also established intakes of 1 g of EPA + DHA from fish or fish oils for subjects with clinical history of CVD and a 2–4 g supplement for subjects with high blood triglycerides which produces typical 20–40% reductions [17].
- The Foods Standards Agency of the UK, based on work from the Joint Health Claims Initiative group of experts (http://www.jhci.org.uk/approv/omega.htm), established Recommended Daily Intakes (RDI) of EPA + DHA of 3 g per week or 450 mg per day [18].
- The French authority for food safety also established recommendations for adult men (500 mg/day) and adult women (400 mg/day) [19] whereas The Netherlands proposed 450 mg per day [20].
- The European Food Safety Agency (EFSA) has recently reviewed and proposed labelling reference intakes values of 250 mg per day of EPA + DHA [12]. These values intend to represent the European recommended daily intakes (RDI) for adults in the future (as currently RDI values in Europe are not harmonised across countries). Interestingly, although the above mentioned RDI currently used in Europe are well above this value (400–450 mg/day), EFSA argues that the most recent evidence shows that, when only healthy subjects are considered, the intake of EPA + DHA is negatively related to CV risk in a dose-dependent way up to 250 mg/day (1–2 servings of oily fish per week) [12]. These recommendations should in the future extend to all European countries.

As oleic acid is the quantitatively most important representative of MUFA in the diet, oleic acid and MUFA intakes and recommendations are virtually the same. According to the TRANSFAIR study and recent national surveys, the total intake of oleic acid in adults varies