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The impact of cheese consumption on markers of cardiovascular risk in rats

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Abstract

We examined the influence of cheddar cheese compared with beef meat/tallow and casein/canola oil diets on biomarkers of cardiovascular health, using male Sprague Dawley laboratory rats. The total omega 3 (ω3) fatty acid content of cheese was 50% higher than that of tallow, and 20% higher than that of canola oil diets. Diets were designed to simulate a 'western style' diet (high fat/low protein/low calcium). Diets were balanced for energy and major nutrients, and contained 17.6% (w/w) fat and 13.7% protein, except for the 50% cheese diet, which had higher total cholesterol and calcium. We observed significantly lower plasma total cholesterol and non-HDL (LDL, IDL VLDL) cholesterol concentrations (−46%) and higher plasma triglyceride concentrations (+50%) in the 50% cheese diet-fed rats than in the beef meat/tallow-fed rats. The amount of triglyceride in rat livers was about 30% higher in the casein + tallow and beef meat + tallow-fed rats than in the other treatments. Fatty acid content of the liver triglycerides showed lower 18:1 and higher ω3 fatty acids: 18:3 (α-linolenic), 20:5 (eicosapentaenoic) and 22:6 (docosahexaenoic) in the cheese-fed than the tallow-fed rats, these concentrations being equivalent to that of the canola oil-fed rats. Liver triglyceride arachidonic acid (20:4) concentration was comparable between the cheese and canola oil sources of fat, but lower in the tallow-fed rats. These concentrations could be interpreted as indicating a good balance between the ω3 and ω6 long-chain precursors of eicosanoids responsible for significant biological effects, and representing a healthier fatty acid profile in cheese-fed animals than with the other dietary treatment groups. Other markers examined showed no significant deleterious effects associated with cheese consumption. The evidence in this rat study suggests that the fat derived from cheese could offer some significant benefits to health, as shown by the long-chain ω3 fatty acid composition of liver triglycerides and their known benefits to health.

Keywords: Cheese; Cardiovascular risk; Cholesterol; Plasma triglycerides; Liver triglycerides

1. Introduction

Cardiovascular disease (CVD) is one of Australia's leading health problems with 190 deaths per 100,000 men and 120 deaths per 100,000 women annually attributable to ischemic heart disease. Dietary fats are known to play an important role in CVD risk (Hu, Manson, & Willett, 2001).

Many epidemiological studies have been carried out world-wide on the effect of diet on a number of medical conditions and some of these studies indicate that cheese consumption may have a protective role in various disease states (reviewed by Roupas, 2001). Dairy food fats, unlike bovine body or carcass fat, contain, along with saturated fatty acids, other components, which might be considered to be of dietary benefit and health promoting value, such as fat soluble vitamins A, D and K, conjugated linoleic acid (CLA), butyrate and sphingolipids. Dairy foods have been proposed as having a significant influence in reducing expression of

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disease conditions such as syndrome X when consumed in reasonable amounts daily by overweight Americans (Mennen et al., 2000; Pereira et al., 2002). There is also evidence of dairy foods having a significant benefit in hypertension prevention via calcium, magnesium and oligopeptides (the Dash diet study, McCarron, 1998), and of obesity reducing effects attributable to calcium and other factors (Zemel et al., 2002). American diet intake data could be signalling a general reluctance to consume dairy foods by some of the adult population, due to the negative messages with regard to health, which have been attributed to dairy food consumption and its fat content.

There is evidence indicating that dairy foods as a source of fat and protein in the diet may not be associated with increased expression of heart disease, but the opposite (Ness, Davey-Smith, & Hart, 2001; Sjogren et al., 2004). Recent evidence has suggested that cheese is different, even from butter, in its influence on the serum cholesterol in humans, having minimal effects on plasma lipid profiles (Biong, Muller, Seljeflot, Veierod, & Pederson, 2004). Others have reported changes to butter fat composition from diet perturbing changes in dairy cow rations (protected lipids), which could improve the fatty acid profile and consequently further improving the plasma lipid profile in humans (Poppitt et al., 2002).

The rat is a useful mammalian monogastric species for general investigative and screening work, readily available and at reasonable cost, and there is a large amount of background scientific information, which can be accessed to better develop an understanding of dietary perturbations and mechanisms involved in disease pathogenesis. Significant and relevant biological changes in laboratory rats were observed in comparative fat studies, including ω3-rich tuna oil (McIntosh, McLennan, Lawson, Bulman, & Charnock, 1985).

This study compares dairy cheese with ruminant beef meat and tallow, with canola oil, which is considered an optimal fat in terms of its fatty acid ω3 profile and its influence on CVD risk. Using the rat model, the objective of this work was to examine some biomarkers of cardiovascular risk and fatty acid metabolism, after ingestion of cheese as a major source of fat. Comparisons were also made with alternatives such as beef meat and tallow, with which cheese is commonly included, when referring to animal protein and fat sources in the diet and their negative influence on health.

2. Materials and methods

2.1. Animals

Sixty male Sprague Dawley rats, at 8 weeks of age, were purchased from the Animal Resource Centre, Murdoch University, Perth, Western Australia. After an initial 24 h acclimatization period, the animals were randomly sorted into five individual groups of equal body weight of 275 ± 29 g (mean $\pm$ SD). Each of these groups was allocated to one of five American Institute of Nutrition (AIN-93)-based rodent diets as shown in Table 1. The animals were maintained in a 12:12 light:dark cycle in a constant temperature environment of 21 °C. For the duration of the study (5 weeks), experimental diets and water were fed ad libitum and feed intakes recorded. At the conclusion of the study, un-fasted animals were euthanased, autopsied and samples taken at the same time of the day across all groups. The experimental protocol was approved by the CSIRO Health Sciences and Nutrition Animal Ethics Committee prior to commencement.

Table 1
Detailed composition of the experimental diets fed to rats over the 5-week study period

Diet component (%)	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
	50% cheese	25% cheese + casein + canola oil	Casein + canola oil	Casein + tallow	Beef meat + tallow
Cheese[a]	50	25	—	—	—
Casein[b]	—	8.2	16.3	16.3	—
Beef meat[c]	—	—	—	—	23.6
Sucrose	14	17	20	19.6	20
Cornstarch	29	34	39.1	39.5	40
Fibre (α-cellulose)	2	2	2	2	2
Tallow	—	—	—	17.6	9.3
Canola oil	—	8.8	17.6	—	—
AIN-93 vitamins & minerals	5.0	5.0	5.0	5.0	5.0

[a]Cheese was analysed to be 35.5% water, 28% protein ($N \times 6.38$, IDF recommended conversion factor for milk proteins), 35.2% fat, 1.0% ash, 0.8% Ca, 0.1% cholesterol.

[b]Casein was analysed to be 85.7% protein ($N \times 6.38$), 9% water, 1.0% ash, 0.3% fat.

[c]Barbecued lean ground beef was analysed to be 58% protein ($N \times 6.25$, IDF recommended "universal" conversion factor for (non-milk) proteins), 4% water, 35% fat, 2.5% ash, 0.09% cholesterol.