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An update to the fatty acid profiles of bovine retail milk in the United Kingdom: Implications for nutrition in different age and gender groups

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ABSTRACT

This study investigated the effect of UK dairy production system, month, and their interaction, on retail milk fatty acid (FA) profile throughout the year. Milk samples (n = 120) from four conventional (CON), four organic (ORG) and two free-range (FR) brands were collected monthly. ORG milk had more nutritionally-desirable polyunsaturated FA, including rumenic acid and the omega-3 PUFA α-linolenic, eicosapentaenoic and docosapentaenoic acids, and less of the nutritionally-undesirable palmitic acid. Milk FA profile was similar between FR and CON systems, but FR milk had less saturated FA (SFA) and/or palmitic acid, and/or greater α-linolenic and rumenic acids in certain months within the peak-grazing season. According to the measured milk FA profiles and UK milk fat intakes, milk and dairy products contribute around one-third of the maximum recommended SFA intake. A small increased intake of beneficial PUFA may be expected by consuming ORG milk but human health implications from such differences are unknown.

1. Introduction

Milk and dairy products provide a range of beneficial nutrients for human health, including fatty acids (FA), proteins, bioactive peptides, minerals, carotenoids and vitamins (Haug, Hostmark, & Harstad, 2007; Pereira, 2014; Thorning et al., 2017). However, milk and dairy products are dietary sources of saturated fatty acids (SFA), such as C12:0, C14:0 and C16:0, elevated consumption of which may increase the risk of cardiovascular disease (CVD) (EFSA, 2010; FAO, 2010). These concerns and the increased incidence of lifestyle-related diseases, such as obesity and CVD, may have contributed to the reduction in whole milk consumption in developed countries, including UK, Denmark, France, USA, Canada and Germany (Kliem & Givens, 2011). In the UK, whole milk consumption has decreased 5-fold compared with 1970s' levels, and despite the simultaneous increase in semi-skimmed milk consumption, the overall milk intake has declined (Kliem & Givens, 2011). In contrast, milk is also rich in FA with potentially beneficial effects on human health (see reviews from Barcelo-Goblijn & Murphy, 2009; Dilzer & Park, 2012; Field, Blewett, Proctor, & Vine, 2009; Haug et al., 2007; Swanson, Block, & Mousa, 2012), such as the monounsaturated FA (MUFA) *t*11 C18:1 (VA, vaccenic acid) and *c*9 C18:1 (OA, oleic acid), the polyunsaturated FA (PUFA) *c*9*c*12*c*15 C18:3 (ALNA, α-linolenic acid), *c*5*c*8*c*11*c*14*c*17 C20:5 (eicosapentaenoic, EPA), *c*7*c*10*c*13*c*16*c*19 C22:5 (docosapentaenoic, DPA) and *c*4*c*7*c*10*c*13*c*16*c*19 C22:6 (docosahexaenoic acid, DHA), which are omega-3 PUFA (n-3), the *c*9*c*12 C18:2 (LA, linoleic acid), which is an omega-6 PUFA (n-6), and the conjugated FA *c*9*t*11 C18:2 (RA, rumenic acid) (Kliem & Shingfield, 2016; Pereira, 2014).

Current nutritional recommendations are to reduce SFA consumption (as low as possible and not exceeding 10% of total energy intake) and substitute dietary SFA with MUFA and/or PUFA (EFSA, 2010; FAO, 2010). Previous research has shown that dairy management, and especially cow diet, influence milk FA profiles; for example, cows with increased fresh grass intake, higher dietary forage:concentrate ratio, and/or diets supplemented with plant oils, oilseeds or protected lipids may produce milk with a FA profile that contains less SFA and more n-3 PUFA and RA (Chilliard et al., 2007; Elgersma, 2015; Kliem & Shingfield, 2016). Therefore, potential differences between different dairy production systems, which involve differences in cow nutrition, may reflect on milk FA composition. In the UK, organic milk contained greater concentrations of ALNA, EPA and n-3 PUFA all year round, and less SFA in milk fat, including C16:0, during summer, when compared

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with conventional milk (Butler, Stergiadis, Seal, Eyre, & Leifert, 2011; Stergiadis et al., 2012). A seasonal effect on milk FA composition has been previously demonstrated in UK retail milk (Kliem, Shingfield, Livingstone, & Givens, 2013), which also influences the extent of the compositional differences between organic and conventional milk (Butler, Seal, et al., 2011). However, the interaction between production system and season has been assessed only during January and July (Butler, Seal, et al., 2011), which are potentially among the months with the highest difference in pasture intake in UK dairy systems (Stergiadis et al., 2012), so a more detailed assessment throughout the year is required.

Fresh grass intake strongly influences n-3 PUFA content of milk fat, as recently highlighted in several multivariate redundancy analyses (Stergiadis, Bieber, et al., 2015; Stergiadis, Leifert, et al., 2015; Stergiadis et al., 2012). Bulk tank milk from conventional low-input pasture-based farms, (pasture intake contributing more than 90% of cow dry matter intake), contained more of the potentially nutritionally beneficial, when replacing SFA in human diets, MUFA and/or PUFA and less SFA when compared with conventional and/or organic milk, although differences were not consistent throughout the year or in all studies (Butler et al., 2008; Stergiadis, Leifert, et al., 2015). Recently, free-range milk, certified on farms where cows have access to pasture for a minimum of 180 days/year and are outdoors for a minimum of 23 h/day during the grazing season, reached the UK market. In the Netherlands, retail milk from dairy farms under a similar certification scheme, but with less mandatory access to pasture (minimum 120 days/year at pasture and 6 h/day), had a similar FA profile to retail conventional milk (Capuano, Gravink, Boerrigter-Eenling, & van Ruth, 2015) but potential differences under the UK dairy management practices have not yet been investigated.

This study therefore aimed to (i) investigate the effect of production system (conventional, organic and, for the first time in the UK, free-range), month (March through to February) and their interaction, on retail milk FA profile throughout the year, and (ii) assess the potential implications on the intakes of FA which are relevant to human health.

2. Materials and methods

2.1. Experiment/survey design

All milk samples (n = 120) in the present study were collected from retail outlets in England. The survey lasted for 12 months and samples were collected monthly between March 2016 and February 2017. Four brands of conventional milk and four brands of organic milk were sampled monthly from four retail outlets within a 8 km radius of the University of Reading. The only two brands of free-range-certified milk available to UK consumers during the period of this study were obtained monthly from dairies in Lancashire and Gloucestershire. All retail milk samples were whole, pasteurized and homogenized, while conventional and free-range milk had also their fat content standardized to approximately 3.5 and 3.7 g/100 g milk, respectively. Milk samples were collected to represent the latest “best before” date, available at the day of sampling, to ensure minimum storage time at retail outlet. Milk samples in commercial packaging were immediately transferred to the laboratories of the University of Reading, aliquoted into 30-ml sterile polypropylene screw-top containers and frozen at −20 °C until analysis.

2.2. Milk analysis

Concentrations of fat, protein, casein, and lactose were analysed using a Milkoscan FT6000 (Foss Electric, Hillerod, Denmark), while somatic cell count (SCC) was analysed by a Fossomatic (Foss Electric, Hillerod, Denmark), in the National Milk Laboratories (Wolverhampton, UK). Milk FA profiles were analysed by GC flame ionisation detection (Bruker 350 GC, Bruker, Germany) according to previously described methods of esterification and methylation (Chilliard, Martin, Rouel, & Doreau, 2009), and techniques of peak identification and quantification (Kliem et al., 2013). A combined correction factor, to account for carbon deficiency in the response of flame ionization detector for FA methyl esters with 4–10 atoms of carbon was used (Ulberth, Gabernig, & Schrammel, 1999).

2.3. Statistical analysis

Analysis of variance (ANOVA), derived from linear mixed effects models (residual maximum likelihood analysis; REML) (Gilmour, Thompson, & Cullis, 1995) in GenStat (VSN International, 17th Edition, Hempstead, UK), by considering management (Conventional, CON; Organic, ORG; Free-Range, FR) and month (March, April, May, June, July, August, September, October, November, December, January, February), and their interaction, as fixed factors and milk ID (which was unique for each combination of brand/retailer and management) as a random factor. Significant effect of the main treatments was declared when $P < 0.05$ and tendencies were declared when $0.05 < P < 0.10$. The residual diagnostics of the final model were assessed using normality plots, with no data showing deviation from normality except for SCC which were log-transformed prior to ANOVA. Pairwise comparisons of means ($P < 0.05$) were performed using Fisher’s Least Significant Difference test. Milk FA profiles are reported as g/kg milk fat. Atherogenicity index (AI), thrombogenicity index (TI), as markers to indicate potential risk of CVD, were calculated according to Srednicka-Tober et al. (2016), as follows:

- AI = (C12:0 + 4 × C14:0 + C16:0)/(MUFA + PUFA),
- TI = (C14:0 + C16:0 + C18:0)/[(0.5 × MUFA) + (0.5 × n-6) + (3 × n-3) + (n-3/n-6)].

Δ^9-desaturase activity index (Δ^9I) was calculated according to Kay, Mackle, Auldist, Thomson, and Bauman (2004) as:

- Δ^9I = (*c*9 C14:1 + *c*9 C16:1 + OA + RA)/(*c*9 C14:1 + *c*9 C16:1 + OA + RA + C14:0 + C16:0 + C18:0 + VA)

For the purposes of the intake calculations, this study assumes that all dairy products produced in the UK have the same FA profile as the whole milk analysed. Intakes of individual FA or FA groups, for males/females/all for the age groups of 4–10/11–18/19–64/65+ were estimated separately as:

FA intake (g/d) = fat intake (g/d) (Bates et al., 2014) × contribution of fat from milk and dairy products (% of total fat intake) (Bates et al., 2014) × 0.933 (correction factor representing % of FA in total milk fat) (Kliem et al., 2013) × milk FA concentration (% of total FA).

3. Results

All differences discussed in the Results section were statistically significant ($P < 0.05$) unless otherwise stated.

3.1. Milk basic composition

3.1.1. Effect of production system

Significant effect of production system was identified for milk concentrations of fat and lactose (Table 1). Compared with CON and FR milk, respectively, ORG milk contained more fat and less lactose (Table 1). There were no significant differences in milk composition between CON and FR milk (Table 1).

3.1.2. Effect of month

Significant effects of month were identified for milk concentrations of all basic composition parameters (Table 2). Milk contained less fat during May-September and December than in March-April, with the