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Consumer acceptance of dairy products with a saturated fatty acid–reduced, monounsaturated fatty acid–enriched content

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ABSTRACT

Agriculture-based reformulation initiatives, including oleic acid–rich lipid supplementation of the dairy cow diet, provide a novel means for reducing intake of saturated fatty acids (SFA) at a population level. In a blinded manner, this study evaluated the consumer acceptance of SFA-reduced, monounsaturated fatty acid–enriched (modified) milk, Cheddar cheese, and butter when compared with control and commercially available comparative samples. The effect of providing nutritional information about the modified cheese was also evaluated. Consumers (n = 115) rated samples for overall liking (appearance, flavor, and texture) using 9-point hedonic scales. Although no significant differences were found between the milk samples, the modified cheese was liked significantly less than a regular-fat commercial alternative for overall liking and liking of specific modalities and had a lower liking of texture score compared with the control cheese. The provision of health information significantly increased the overall liking of the modified cheese compared with tasting the same sample in a blinded manner. Significant differences were evident between the butter samples for overall liking and modalities of liking; all of the samples were significantly more liked than the commercial butter and sunflower oil spread. In conclusion, this study illustrated that consumer acceptance of SFA-reduced, monounsaturated fatty acid–enriched dairy products was dependent on product type. Future research should consider how optimization of the textural properties of fatty acid–modified (and fat-reduced) cheese might enhance consumer acceptance of this product.

Key words: cardiovascular disease, consumer acceptance, dairy product, monounsaturated fatty acid, saturated fatty acid

INTRODUCTION

It is well established that supplementation of the dairy cow diet with plant oil, oilseeds, or marine lipids can be used as a strategy to partially replace the SFA content of ruminant milk with MUFA and, to a more limited extent, PUFA (Baer et al., 2001; Givens, 2008; Lourenço et al., 2010; Lock et al., 2014; Kliem and Shingfield, 2016). Findings from a systematic review suggest that consumption of modified dairy products, in which SFA was partially replaced with MUFA or PUFA, had a beneficial effect on plasma lipid markers of cardiovascular disease risk (Livingstone et al., 2012). Replacement of regular dairy products with SFA-reduced alternatives is one approach that could facilitate achievement of the SFA dietary recommendations for human health (i.e., to $\leq$10% of total energy; COMA, 1994) while minimizing the necessity for consumers to make significant changes to their habitual diet (Givens and Shingfield, 2006; Markey et al., 2014, 2017). Consequently, this reformulation initiative has the potential to provide a sustainable means of reducing the entry of SFA into dairy products and the wider food chain.

Sensory characteristics are one of the most influential determinants of food preference (Moskowitz et al., 2008). Thus, it is necessary to consider the potential impact of milk fatty acid (**FA**) modification on the sensorial characteristics (including texture and flavor) of milk and milk-derived foods, which are likely to relate to consumer acceptance and are key drivers in the commercial success of foods (Chilliard and Ferlay, 2004; Moskowitz et al., 2008). It is expected that reducing the SFA content will lead to a reduction in the melting point

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of the dairy products and thus affect properties including texture, spreadability, and mouthfeel (Rios et al., 2014). Some studies have highlighted that FA composition may alter the textural profile of cheese (Palmquist et al., 1993; Chilliard and Ferlay, 2004; Jones et al., 2005; Givens and Shingfield, 2006). Conversely, other studies have shown no effect of PUFA supplementation of the ruminant diet, which predominantly incorporated fish oil, on the sensory characteristics of milk (Baer et al., 2001; Ramaswamy et al., 2001; Kitessa et al., 2004; Lynch et al., 2005), cheese (Jones et al., 2005; Vargas-Bello-Pérez et al., 2015), or butter (Baer et al., 2001). More research is needed to examine the acceptability of milk and dairy products produced from ruminants that have been subjected to a period of oleic acid–rich supplementation. Although the aforementioned studies have evaluated the sensory properties of FA-modified milk or dairy products in trained panelists or consumers, further research is needed to provide a combined overview of the consumer acceptance and sensory profile of dairy products that have been produced from SFA-reduced, MUFA-enriched milk.

As well as gaining insight into the general liking tendencies of a population, it is important to identify groups of consumers that are homogeneous with regard to their overall liking of products using cluster analysis (Beck et al., 2015). A previous cluster analysis of liquid dairy products highlighted that liking varied according to age, sex, and income (Richardson-Harman et al., 2000). Using a cluster approach, we have shown that a distinct cluster of consumers that were representative of the UK population with regard to age, sex, body mass index (**BMI**), and socioeconomic class (**SEC**) had less of a preference for a range of reformulated, sugar-reduced products when compared with regular-sugar alternatives (Markey et al., 2015). To our knowledge, no study has used a cluster approach to investigate consumer acceptance of FA-modified dairy products and to examine whether consumer clusters of liking for such products are associated with sociodemographic characteristics.

Furthermore, the effect of nutrition information on product liking and purchase intent needs to be considered (Kähkönen et al., 1996). It has been previously illustrated that acceptance may be dependent on the product type as well as information provided to consumers about fat content of a specific product (Kähkönen et al., 1996; Westcombe and Wardle, 1997; Rapp et al., 2009). The objective of the current study was to examine, in a blinded manner, the study population's general acceptance and purchase intent of SFA-reduced, MUFA-enriched (modified) milk, Cheddar cheese, and butter (control) and commercially available comparators.

MATERIALS AND METHODS

Bovine Supplementation Regimen

A bovine supplementation regimen was used to supply raw milk for production of modified dairy products. The production period took place from November 2014 to May 2015 and has been described previously (K. E. Kliem, D. J. Humphries, O. Markey, D. Vasilopoulou, C. C. Fagan, A. S. Grandison, S. Todd, D. I. Givens, and J. A. Lovegrove, unpublished data). Briefly, the habitual TMR diet of 41 multiparous Holstein-Friesian dairy cows [205 d in lactation (SE = 7.2); milk yield at start = 33.4 L/d (SE = 0.91)] was supplemented with approximately 1 kg/cow per day of high-oleic sunflower oil [80 g/100 g of total FA in the form of oleic acid (C18:1 *cis*-9); AAK Ltd., Hull, UK] for a ≥28-d period at the Centre for Dairy Research (University of Reading, Reading, Berkshire, UK).

Manufacturing Process of the Modified and Control Dairy Products

The SFA-reduced, MUFA-enriched (modified) milk, Cheddar cheese, and butter were produced from raw milk collected after cows had been supplemented with high-oleic sunflower oil for ≥4 wk. Control raw milk, Cheddar cheese, and butter with FA profiles that were representative of commercial retail dairy products were supplied by Arla UK Plc. (Taw Valley Creamery, North Tawton, UK). The details for milk production and butter and cheese making were previously given (K. E. Kliem, D. J. Humphries, O. Markey, D. Vasilopoulou, C. C. Fagan, A. S. Grandison, S. Todd, D. I. Givens, and J. A. Lovegrove, unpublished data) and are described briefly below.

All UHT modified and control milks were processed in single batches (1,400 kg) at Framptons Ltd. (Shepton Mallet, Somerset, UK). Prior to UHT processing, control milk was standardized to match the fat content of the modified milk (2.8 g/100 g). Both raw modified milk and standardized control milk were preheated to 85°C using a plate heat exchanger and homogenized. Direct steam infusion was used to heat the milk to 142°C for 5 s (Framptons Ltd., Shepton Mallet, Somerset, UK). Subsequently, the milk was cooled to 5°C and aseptically packaged into 330-mL cartons and stored at 4°C.

Modified Cheddar cheese was manufactured at the University of Reading's Food Processing Centre (Reading, Berkshire, UK) as a single batch (180 kg). Processing parameters were selected to mimic, at pilot scale, the process used at Arla UK Plc. to produce the single batch of control Cheddar cheese (180 kg). After pro-