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A novel processing-based classification and conventional food grouping to estimate milk product consumption in Finnish children

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ABSTRACT

As more information is needed about the health aspects of milk processing; we classified milk products based on their homogenisation and heat-treatment history in the following inclusive classes: (i) homogenised, (ii) non-homogenised, (iii) fat-free; and (i) low-pasteurised or less heat-treated, (ii) high-pasteurised at <100 °C, (iii) high-pasteurised at ≥100 °C or sterilised. Milk product consumption of Finnish children was studied at the age of 6 months (n = 1305), 1 y (n = 1513), and 3 y (n = 1328) both using conventional food grouping and the novel processing-based grouping. At 6 months, more than three quarters of the children consumed cows' milk products (median consumption 511 g d^{-1}); at 3 y most of the consumed milk products were low-pasteurised or less heat-treated and homogenised. In contrast to children aged 3 y, almost all milk products consumed by infants aged 6 months were pasteurised at high temperature or sterilised.

1. Introduction

Different types of cows' milk products have been associated with various disease outcomes such as type 1 and type 2 diabetes and asthma (Aune, Norat, Romundstad, & Vatten, 2013; Virtanen et al., 1993; Waser et al., 2006). Thus, in addition to the type of milk product consumed, milk processing may play a role in health effects of milk. Some studies on the aetiology of diabetes and asthma have considered separately fresh milk, sour milk products, raw milk, high- and low-fat milk, and cheeses, but the processing of the milk and milk products have not been taken into account systematically. The two most important and common treatments of milk for decades have been homogenisation and heat-treatment. However, both processing methods and the consumption of differently processed milk products have changed over time.

Heat-treatment of milk is known to affect not only the microbiological characteristics of milk, but also its nutritional components such as proteins. Common heat-treatments of milk include thermalisation, low pasteurisation, high pasteurisation and sterilisation (Walstra, Wouters, & Geurts, 2006). Low pasteurisation is known to have little effect on milk composition, whereas sterilising ultra-high temperature (UHT)-treatment especially together with

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homogenisation has been observed to alter the tertiary structural stability of whey proteins (Qi, Ren, Xiao, and Tomasula (2015). Bovine immunoglobulins (IgG) have been observed to be at least partly active in low-pasteurised milk, whereas in canned evaporated and UHT-sterilised milk there has been little or no active IgG (Li-Chan, Kummer, Losso, Kitts, & Nakai, 1995). Intensive heat-treatment can also cause Maillard reactions, destroy endogenous antimicrobial systems of milk (Walstra et al., 2006), cause vitamin loss during storage (FAO, 2013) and affect the solubility of caseins (Douglas, Greenberg, Farrell, & Edmondson, 1981). Homogenisation instead breaks the milk fat globules into smaller particles so that the original phospholipid layer is substituted with milk proteins (Michalski & Januel, 2006). This changes the physiological and possibly also the biological characteristics of milk. Homogenisation has also been reported to reduce the levels of non-denaturated proteins detectable by liquid chromatography/tandem mass spectrometry in milk (Brick et al., 2017). Homogenised milk has been shown to increase the levels of milk antibodies in rats compared with non-homogenised milk (Feng & Collins, 1999). However, as far as we know, evidence of associations between milk homogenisation and untoward health effects in humans is scarce. In children allergic to milk, homogenisation did not affect the allergenic reactions (Høst & Samuelsson, 1988). Currently there is very little information on how children consume differently processed milk products.

The aims of the current study were to create a novel classification of milk products based on homogenisation and heat-treatment, and to estimate consumption of differently processed and produced milk products by Finnish infants and pre-schoolers. To gather more information about milk product consumption, we also used a conventional milk product classification to assess children's milk product consumption.

2. Subjects and methods

2.1. Subjects and study design

This study was based on data collected within the Finnish Type 1 Diabetes Prediction and Prevention (DIPP) Nutrition Study. DIPP Nutrition Study is a part of a larger DIPP Study and it sets out to assess the role of the nutrition in the development of type 1 diabetes (Virtanen et al., 2012). The genetic screening of the type 1 diabetes risk alleles was carried out in newborn infants born since 1996 in University Hospitals in Tampere and Oulu in Finland. The parents were asked for permission to examine a blood sample from the umbilical cord, from which the child's genotypes for specific HLA-DQB1 alleles were determined (Kupila et al., 2001). The children with DQB1*02/DQB1*03:02 or DQB1*03:02/x genotypes (x not DQB1*02, DQB1*03:01 or DQB1*06:02/3) were invited to a follow-up study, in which their nutrition, growth, viral infections and levels of diabetes associated antibodies were followed regularly. All the parents gave their written consent to the study.

Childhood food consumption data was collected by 3-d food records from the children recruited to the study between 1996 and 2004. In the current study, when creating the milk product classification based on processing, all food items from food records collected during the whole DIPP Nutrition Study were utilised. In the milk product consumption calculations of the current study only children born in certain years were included. We observed the food consumption at 3 different age points: at the age of 6 months ($n = 1305$), 1 y ($n = 1513$), and 3 y ($n = 1328$). The food records at the age of 6 months were from children born from 1.7.2002 to 30.6.2004, the food records at the age of 1 y from children born from 1.1.2002 to 5.9.2004 and the food records at the age of 3 y from children born from 1.1.2000 to 31.12.2002. Hence, some children can be observed at two or more of the age points. We chose the 3 age groups since we considered that there would be major changes in nutrition between the age groups – children at the age of 6 months consume mostly breast milk or infant formulas, children at the age of 1 y have already more food items in the diet and children at the age of 3 y have a diet close to that of the rest of the family.

The families completed the background information forms and food records for 3 d at the age of 3 and 6 months and 1, 2, 3, 4 and 6 y (Virtanen et al., 2012). The food records were filled out on 2 weekdays and on 1 weekend day. The food records were checked by a trained research nurse. The nurses were trained to pay attention to the type of foods eaten, whether they were homemade, commercial or from a restaurant and to check amounts of foods and drinks; what information was or was not necessary in the recording. They were educated to have knowledge of the composition of foods and dishes (brand names, recipes, and preparation and processing methods) and of dietary supplements and foods enriched with nutrients. The amounts were marked using a booklet of different portion sizes as help. For all commercial infant foods, infant formulas and dietary supplements brand names were asked.

Trained nutritionists entered the food records using the Finnish national food composition database Fineli and the in-house software Finessi of the National Institute for Health and Welfare, Finland. In the food composition database there are recipes created for food items. These recipes are based on the food item ingredients and nutrition values declared by the manufacturer or ingredient information from commonly used Finnish cookery books. The food items in the calculation process can be broken down into ingredients and hence intake of ingredients from different food items can also be summarised: thus, for example the amount of milk from foods containing milk can be calculated. The food composition database is updated annually. Most of the products consumed by the children have been recorded using the common noun for the food item, with the information of for example the food item being low-lactose and its fat percentage (e.g., cottage cheese, fat 2–5%, low-lactose). For commercial baby foods and infant formulas brand names were also known.

2.2. Principles for creating the processing-based classification

The milk products that appeared in the food records were classified as accurately as possible according to the process treatments of the milk used for the milk product. In addition to milk products, also some other food items considered as remarkable sources of milk for small children were classified. The classification was created based on homogenisation and heat-treatment. First grouping principle was the information of whether the milk product was (i) homogenised, (ii) non-homogenised or (iii) fat-free. Several fat-free products could also have been homogenised based on manufacturers' information, but since in fat-free products there are no fat globules present, on which homogenisation has the strongest impact, they were considered as their own group. Products that included fat not more than 0.5 g 100 g^{-1} or 0.5 mL 100 mL^{-1} were classified as fat-free. This limit was based on Regulation (EC) No 1924/2006 of the European Parliament and of the Council of 20 December 2006 on nutrition and health claims made on foods.

The second grouping principle was heat-treatment: information whether the milk was (i) low-pasteurised (treated at highest for approximately 15 s at approximately 73 °C or corresponding conditions where milk alkaline phosphatase is inactivated) or less heat-treated, (ii) high-pasteurised at <100 °C or (iii) high-pasteurised at ≥100 °C or sterilised. The categories were designed to be the most accurate possible, so that the number of classes would not be too high. The exact temperature/time