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Prediction of bulk milk fatty acid composition based on farming practices collected through on-farm surveys

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ABSTRACT

The aim of this study was to predict the fatty acid (FA) composition of bulk milk using data describing farming practices collected via on-farm surveys. The FA composition of 1,248 bulk cow milk samples and the related farming practices were collected from 20 experiments led in 10 different European countries at 44°N to 60°N latitude and sea level to 2,000 m altitude. Farming practice-based FA predictions [coefficient of determination (R^2) >0.50] were good for C16:0, C17:0, saturated FA, polyunsaturated FA, and odd-chain FA, and very good (R^2 ≥0.60) for *trans*-11 C18:1, *trans*-10 + *trans*-11 C18:1, *cis*-9,*trans*-11 conjugated linoleic acid, total *trans* FA, C18:3n-3, n-6:n-3 ratio, and branched-chain FA. Fatty acids were predicted by cow diet composition and by the altitude at which milk was produced, whereas animal-related factors (i.e., lactation stage, breed, milk yield, and proportion of primiparous cows in the herd) were not significant in any of the models. Proportion of fresh herbage in the cow diet was the main predictor, with the highest effect in almost all FA models. However, models built solely on conserved forage-derived samples gave good predictions for odd-chain FA, branched-chain FA, *trans*-10 C18:1 and C18:3n-3 (R^2 ≥0.46, 0.54, 0.52, and 0.70, respectively). These prediction models could offer farmers a valuable tool to help improve the nutritional quality of the milk they produce.

Key words: bulk milk, fatty acid, farming practices, prediction model

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INTRODUCTION

Dairy product consumption in Europe is about 92.9 kg/capita per year (FAO, 2012). Research has made huge strides forward on the effect of FA intake on human health issues such as cardiovascular disease, obesity, and metabolic syndrome (Givens, 2010; Kratz et al., 2013). The World Health Organization (2008) recommends reducing SFA intake and increasing PUFA intake. The risk of cardiovascular disease factors was found to be lower after the consumption of dairy products rich in n-3 long-chain FA (Dawczynski et al., 2010).

Decades of research have highlighted several factors affecting milk FA profile, in particular cow diet, breed, lactation stage, animal health, and altitude (Griinari et al., 1998; Dewhurst et al., 2006; Elgersma et al., 2006). Cow diet composition is the key factor (Palmquist et al., 1993). Increasing forage-to-concentrate ratio in cow diet increased milk PUFA and n-3 FA proportions and decreased SFA proportion (Dewhurst et al., 2006). Feeding cows fresh herbage greatly enhances these trends, and also increases milk *trans*-11 C18:1, *cis*-9,*trans*-11 conjugated linoleic acid (**CLA**), and C18:3n-3 proportions, reaching a highly favorable FA profile for human health (Chilliard et al., 2007). The C18:3n-3 can also be increased by supplementing cows with linseed, but the associated increase in *trans* C18:1 isomers, particularly *trans*-10 C18:1, results in a less-favorable FA profile for human health (Dewhurst et al., 2006; Chilliard et al., 2007). An increase in *trans*-10 C18:1 instead of *trans*-11 C18:1 has also been observed when cows are fed starch-rich diets based on concentrates and corn silages (Griinari et al., 1998). These diets also increased milk C18:2n-6 and total n-6 FA proportions (Griinari et al., 1998).

In agreement with the World Health Organization (2008) recommendations on FA consumption for human nutrition, several dairy companies in various European Union (**EU**) countries (including France, Belgium, and the Netherlands, among others) apply a price premium for cow milk rich in health-promoting FA (i.e., n-3 and PUFA). Thus, farmers need to recover information on the expected FA profile of their milk to identify management strategies to increase the proportion of health-promoting FA in milk fat and consequently increase their income. However, the majority of studies investigating the effect of diet and animal-related factors on milk FA profile were controlled trials (i.e., Leiber et al., 2005; Ferlay et al., 2006; Colman et al., 2010), analyzing individual milk or testing diets not always reflecting common practice in commercial farms (i.e., extreme amounts of concentrate or lipid supplements), or applying measurements of farming practices not suitable on farm. This is also the case for milk FA prediction models reported in the literature. Glasser et al. (2008) predicted the main milk FA proportions focusing only on diets supplemented with different forms of oilseed. Sterk et al. (2011) predicted milk FA composition according to grass silage/corn silage proportion, forage:concentrate ratio and crushed linseed supplementation. Moate et al. (2008) developed FA prediction models for long-chain FA using intestinal FA flow and absorption and cow diet composition (fresh herbage vs. TMR only). To our knowledge, no model has yet attempted to predict FA composition of bulk milk from commercial farms, based on simple farm practice data collected on farm.

Farming practices vary widely according to country and agronomical context, but most of the literature tends to operate at tight territorial scale. Collecting data from a wide territory makes it possible to explore a broad range of farming practices and, thus, of FA profiles in commercial milk. The aim of this work was to predict the FA composition of bulk milk based on farming practices collected via on-farm surveys in different EU countries.

MATERIALS AND METHODS

Data Collection

The FA profiles of 1,248 bulk cow milk or cheese samples and their related farming practices were compiled from a selection of 20 published or unpublished studies carried out from 2000 to 2010 in 10 different EU countries: France (650 samples), Germany (157 samples), Italy (152 samples), Norway (104 samples), Slovakia (100 samples), Slovenia (75 samples), Czech Republic (3 samples), Denmark (3 samples), Sweden (2 samples), and the Netherlands (2 samples). As the cheesemaking process does not affect milk FA profile (Lucas et al., 2006b; Revello Chion et al., 2010b), cheese FA composition data were included in the dataset and considered equivalent to the bulk milk from which they derived. Table 1 details and references the studies included in the dataset. The majority of experiments were conducted on farm and included milk collected on commercial farms at between 44°N to 60°N latitude, from sea level to 2,000-m altitude, from 13 different cow breeds and in all seasons. For the experiments carried out in controlled conditions, only bulk milks derived from diets routinely found in commercial farms were considered. Concerning published experiments, the original FA profiles and farming practices data (given directly by the authors) was used instead of the published means per dietary treatment.

Farming Practices

Data on farming practices, collected at each milk sampling via on-farm surveys according to Agabriel et al. (2007), included herd characteristics (number of cows, breed, milk yield, DIM, and proportion of primiparous cows), diet composition of lactating cows, and altitude of the farm (or grazed plots). Special attention was paid to forage source (corn or grass) and, within grasses, to conservation method and utilization (fresh herbage, hay, or silage). During surveys led at each milk sampling, the quantities of the different feedstuffs [grass silage (**GS**), hay (**H**), corn silage (**CS**), and concentrates (**C**)] given to lactating cows were estimated directly by the farmers. The animal maintenance requirements and energy value of each feedstuff were estimated according to Institut National de la Recherche Agronomique (INRA) tables (Faverdin et al., 2007). Depending on the farming practices data available, fresh herbage intake at pasture was estimated either (1) by the difference between the energy requirements of the herd and the energy provided by the known quantities of feeds offered in the diet, working to the hypothesis that energy balance was null, or (2) by the difference between the potential intake capacity of the herd and the rumen fill of the known quantities of feeds offered in the diet. Cow breed data were expressed as proportion of each breed in the herd, whereas animal feed was described as proportion of each feedstuff in the cow diet on a DM basis.

FA Composition

The milk and cheeses included were FA profiled by 5 different laboratories over the 2001-to-2010 period, using gas-chromatographic methods. References of analytical methods used are reported in Table 1.