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Effect of different feeding strategies in intensive dairy farming systems on milk fatty acid profiles, and implications on feeding costs in Italy

G. Borreani,* M. Coppa,*[1] A. Revello-Chion,† L. Comino,* D. Giaccone,† A. Ferlay,‡§ and E. Tabacco*
*University of Turin, Department of Agricultural, Forest and Food Sciences, Via L. da Vinci 44, 10095, Grugliasco (Turin), Italy
†Associazione Regionale Allevatori del Piemonte, Via Livorno 60, 10144, Turin, Italy
‡INRA, UMR 1213 Herbivores, F-63122 Saint-Genès-Champanelle, France
§Clermont Université, VetAgro Sup, UMR Herbivores, BP 10448, F-63000 Clermont-Ferrand, France

ABSTRACT

The aim of this work was to characterize the fatty acid (FA) profile of milk from intensive dairy farming systems in the Po Plain (Italy) to estimate the costs of the adopted feeding strategies and to simulate the effect of supplementary premiums on the basis of milk FA composition on milk income. Twenty dairy farms with 5 different feeding strategies were studied: 3 corn silage-based systems in which cows were supplemented with a great proportion (CCH), a medium proportion (CCM), or without commercial concentrate mix (CC0), and 2 systems in which part of corn silage was replaced with grass or legume silage (HF) or with fresh herbage (G), cut and fed indoors. Bulk milk was sampled and lactating cow performance, feeding strategies and forage characteristics were recorded through a survey, 3 times during a year. The milk FA supplementary premium was calculated considering C18:3n-3 and saturated FA (SFA) concentrations, and ratio of total *cis* C18:1 isomers to C16:0. The CCH, CCM, and CC0 systems bought most of their dairy cow feeds off farm, which allowed them to increase milk production to 35,000 L/yr per hectare. Their low dry matter and crude protein self-sufficiency led to higher feeding costs per liter of milk (from €0.158 to €0.184), and highest income over feed cost was achieved only for milk yield performance greater than 10,000 kg/cow per year. The use of home-grown forages in HF and G increased dry matter and crude protein self-sufficiency and reduced the feeding costs per liter of milk from 9 to 22%, compared with the other studied systems, making HF and G feeding economically competitive, even for a lower milk yield per cow. The studied systems highlighted a remarkable variation in FA profiles. The concentrations of C16:0 and SFA were the highest in CCH (31.53 and 67.84 g/100 g of FA) and G (31.23 and 68.45 g/100 g of FA), because of the larger proportion of commercial concentrate mix in the cow diet. The concentrations of C16:0 and SFA were the lowest in CCM (27.86 and 63.10 g/100 g of FA), because of low roughage-to-concentrate ratio in the cow diet, which is known to favor milk fat depression, affecting particularly these FA. The calculated supplementary premium was the highest in the CCM system, based on milk FA profiles from those herds. The HF diet was rich in forages and resulted in greater concentration of C18:3n-3 in milk (0.57 g/100 g of FA) than the other systems and thus led to an increase in milk FA supplementary premium. Milk from G and HF milk had the lowest ratio of Σn-6:Σn-3 FA compared with milk from the systems based on higher corn silage proportion in the cow diet (3.71, and 3.25, respectively, vs. 4.58 to 4.78), with the lower ratios being closer to recommendation for human nutrition.
Key words: milk fatty acid, intensive farming system, feeding costs, milk fatty acid supplementary premium

INTRODUCTION

The demand for dairy products with a great nutritional value has recently increased. Some milk FA, such as C18:2n-6 and C18:3n-3, are essential because they cannot be synthesized by the human body (Stark et al., 2008). In recent years, the consumption of n-6 FA, such as linoleic acid, has risen dramatically in developed nations (Stark et al., 2008). Over the last decade, several studies have highlighted cow feeding as the main factor of influence on milk FA composition (Dewhurst et al., 2006; Chilliard et al., 2007). However, the majority of these studies have been conducted in controlled conditions, in which contrasted and extreme diets were compared (Ferlay et al., 2006; Coppa et al., 2011a; Sterk et al., 2011). Only a few studies have been carried out at farm level, and most of them have been focused on mountain farming systems (Collomb et al., 2002; Lucas et al., 2006; Ferlay et al., 2008), or on organic farming systems (Butler et al., 2008; Slots et al., 2009), in which diets based on pasture and conserved grass feeding were the most common feeding strategies. However, little is

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[1]Corresponding author: mauro.coppa@unito.it

known about the intensive farming systems that are based on corn silage feeding or about the variations in FA composition of such milk, due to varying feeding strategies (Slots et al., 2009). Some experimental studies using corn-based diets have shown that milk from such systems has about 10 to 15 g/100 g of FA more of SFA; about double the amount of n-6 FA, with 25% less PUFA; and only 33 to 50% of the amount of n-3 FA as found in pasture-derived milk (Ferlay et al., 2006; Sterk et al., 2011).

Pasture-based farming systems are widely diffused in the European countries with great milk production (i.e., France, Germany, and the Netherlands, among others). Italy produces about 10 million metric tonnes of milk per year, which represents substantial proportion of the milk production in the European Union 15 (EU-15; CLAL S.r.l., 2013). However, the milk obtained from pasture-based farming systems in Italy is negligible on a national scale. About 80% of Italian milk comes from intensive farming systems located in the Po Plain, where the high-yielding Italian Holstein breed is raised. There is a scarcity of arable land in the Po Plain and land charge/rent is high. However, soil fertility and the climate are favorable for crops such as corn silage with high DM yield potential per hectare. As a consequence, most dairy farms have specialized in corn silage production, with the aim of being self-sufficient for the animals' energy requirements, but buy most of the protein sources from the market. This has led to an extreme simplification of the dairy forage system, with corn silage representing up to 90% of the total roughage in lactating cow diets, and concentrates representing from 30 to 55% of total DM in the cow diet. Two different strategies are diffused in Italy to supply protein for lactating cows: buying directly from the market raw materials (e.g., soybean and rapeseed meals) or buying commercial concentrate mixes from specialized companies. This second feed supply seems much simpler to manage for farmers, but it requires a preparation step in specialized companies and this implies greater prices for concentrates.

Recent volatility in corn and soybean market prices has resulted in increased uncertainty about concentrate costs and thus the corn silage-based dairy farming system no longer seems to be economically sustainable. Therefore, to maintain farm competitiveness, a decrease in feeding costs is needed (Wolf, 2012). As a consequence, feeding strategies based on greater self-sufficiency in the production of cow feeds are spreading in the Po Plain; this is achieved by increasing the proportion of conserved forages with great nutritional quality in the lactating cow diet, or by introducing fresh herbage, cut and fed indoors. Another strategy to maintain economic efficiency of the intensive dairy farms in the Po Plain could be increasing the milk price through a valorization of milk FA profile. Recently some European countries (such as France and the Netherlands) have introduced supplementary premiums for farmers, based on FA composition of milk and, in particular, on SFA, n-3 FA, total C18:1 FA, C18:3n-3, *cis*-9 C18:1, and C16:0.

The main aim of this work was to characterize the FA composition of the milk produced in the different intensive dairy farming systems of the Po Plain, Italy. The second aim was to estimate the costs of feeding strategies adopted in these farming systems and to simulate the effect of supplementary premiums, based on milk FA composition, on milk income.

MATERIALS AND METHODS

Experimental Design, Milk Sampling, and Data Collection

The research was conducted in the lowland area (about 250 m above sea level) of the Piedmont Region, in northwestern Italy. Twenty dairy farms raising Italian Holsteins, which adopted 5 different feeding strategies (4 farms per group) were selected to be representative of the intensive farming systems of northern Italy. Three of the 5 farming systems were selected according to the proportion of commercial concentrate mix fed to lactating cows: great proportion (**CCH**), medium proportion (**CCM**), or no commercial concentrate mix in cow feeding (**CC0**). The commercial concentrate mix was replaced by increasing proportions of soybean meal and other single raw concentrates. The first 3 systems all used corn silage as the main component of the diet. The fourth and the fifth systems replaced part of the corn silage in the cow diet with grass or legume (mainly alfalfa) silage (**HF**) or with fresh herbage (**G**), cut and fed indoors. Bulk milk samples were collected 3 times on each farm [June to July 2011 (period 1, **P1**), November to December 2011 (period 2, **P2**), and February to March 2012 (period 3, **P3**)]. During each milk sampling, the performance of lactating cows and herd characteristics (number of cows, DIM, and milk yield), feeding strategies (forage source), and forage characteristics (harvesting and conservation methods, cutting dates, and cropping agronomic management) were recorded through a detailed survey made directly on farm by the authors. Corn silage contains great proportions of starch because of its grain, even though it is considered a forage in protected designation of origin (PDO) specifications. For these reasons, the total concentrate and roughage were calculated in 2 ways: considering corn silage (1) as roughage and (2) 40% of DM as a concentrate and 60% as roughage, as