J. Dairy Sci. 101:1–13
https://doi.org/10.3168/jds.2017-14342

From cow to cheese: Novel phenotypes related to the sensory profile of model cheeses from individual cows

C. Cipolat-Gotet,*[1] A. Cecchinato,* M. A. Drake,† A. Marangon,‡ B. Martin,§ and G. Bittante*
*Department of Agronomy, Food, Natural Resources, Animals and Environment (DAFNAE), University of Padova (Padua), viale dell'Università 16, 35020 Legnaro (PD), Italy
†Department of Food, Bioprocessing and Nutrition Sciences, Southeast Dairy Foods Research Center, North Carolina State University, Raleigh 27695
‡Sensory Analysis Laboratory AVISP Veneto Agricoltura, via S. Gaetano 74, 36016 Thiene (VI), Italy
§INRA, UMR1213 Herbivores, VetAgro Sup, F-63122 Saint-Genès-Champanelle, France

ABSTRACT

Milk samples were taken once from a total of 1,224 Brown Swiss cows from 83 herds, and 1,500 mL of raw full-fat milk from each cow was processed according to a laboratory-scale model-cheese-making procedure. A sensory panel was assembled and the members trained to evaluate the sensory profile of individual model cheeses. The protocol scorecard was composed of 7 main sensory descriptors related to smell intensity, flavor intensity, taste (salt and sour), and texture (elasticity, firmness, and moisture), and 40 sensory attributes describing smell and flavor profiles. Sensory data were analyzed using a mixed model that included random effects of herd, animal, and panelist, as well as fixed effects of dairy system, days in milk, parity, and order of cheese presentation, and covariates for cheese weight and fat:protein ratio. The sensory profile was not much affected by the dairy farming systems included in the trial, but it was affected by farm within dairy system: cheeses from traditional dairy farms had a greater wood/humus attribute of both smell and flavor than those from modern farm. Of the modern farms, cheeses from those using total mixed rations including silages had a more intense smell of sour milk and a firmer, less moist texture than those using total mixed rations without silages. Moreover, for all the sensory traits, we found less variance related to herd and animals than that related to the panelists and the residuals. Stage of lactation was found to be the most important, whereas parity was not relevant. In particular, cheese smell intensity (and some related attributes) exhibited a quadratic trend with lower values in mid-lactation, whereas flavor and salt descriptors were more intense in the last period of lactation.

Key words: cheese aroma, cheese odor, cheese texture, dairy system, silage

INTRODUCTION

The perception of cheese sensory characteristics influences consumers' choices and food-related behaviors (Drake, 2007). To produce a cheese with a suitable flavor and texture profile, the dairy industry has to monitor all the outcomes of the entire process, which involves many factors concerning the herd, dairy plant, and distribution network. A key issue to consider in monitoring and assessing a cheese sensory profile is the interaction between milk quality and the type of cheese to be produced. Reliable and sufficiently comprehensive milk composition and quality traits are essential to classify and assess products for their nutritional, organoleptic, microbiological, and technological characteristics (Clark et al., 2009). These are particularly crucial for the Protected Designation of Origin (**PDO**) dairy chain in light of strict regulations and restrictions governing milk treatments and modifications carried out before and during cheesemaking (Verdier-Metz et al., 2000; Bittante et al., 2011; Ojeda et al., 2015). In these regulated production systems, all factors influencing milk yield and composition at the farm level, such as individual animal characteristics and dairy herd system, have to be strictly controlled and have particular significance for the sensory quality of dairy products (Bertoni et al., 2005).

Some researchers have explored the effects of bovine milk characteristics on cheese sensory profiles by investigating the influence of lactating animals and environmental factors. These studies have looked at the effects of breed (Martin et al., 2009), lactation stage (Kefford et al., 1995; Coulon et al., 1998), animal health status (Auldist et al., 1996), feeding regimen (Verdier-Metz et al., 1998; Carpino et al., 2004), and dairy farm system (Agabriel et al., 2004) on cheese sensory profiles. Most

Received December 24, 2017.
Accepted March 9, 2018.
[1]Corresponding author: claudio.cipolatgotet@unipd.it

have attempted to eliminate noise factors as much as possible through experimental design, which has involved, depending on the objectives of the trial, (1) selecting a small number of animals (based on their genetic background and their physiological status); (2) selecting animals from a few farms or just one farm; and (3) producing a small number of cheeses from bulk milk, often with a standardized fat:protein ratio. These studies show frequent low variability and have found few relationships between the factors tested and cheese quality.

When animal factors or herd characteristics have to be investigated, a large number of cheeses produced at the individual cow level are required. For example, in previous research, we devised a model cheese manufacturing procedure with high repeatability and reproducibility of cheese-making traits, which we used to process more than 1,000 individual Brown Swiss milk samples collected from 85 herds (Cipolat-Gotet et al., 2013). This allowed us to simultaneously quantify the effects of farming systems (with different feeding regimens), individual farms, and cow's parity and stage of lactation on individual cheese-making efficiency and cheese yield. This procedure also allowed us to analyze the release of volatile organic compounds characterizing cheese flavor in the ripened cheeses (Bergamaschi et al., 2015b), and to estimate the genetic parameters of these traits; that is, the link between the cow's genetics and a given organoleptic property of the cheese produced from its milk after 2 mo of ripening (Bergamaschi et al., 2016).

No previous study has looked at variability in the sensory profile of ripened cheeses made from individual milk samples from a large set of cows from many different farms. The aim of the present study, therefore, was to take a holistic approach to investigating the effect of several sources of variation affecting novel phenotypes related to the sensory profile of ripened individual model cheeses. In particular, we studied the effects of feeding regimens and management systems together with the effects of herd within dairy system, and the parity and stage of lactation of individual cows.

MATERIALS AND METHODS

Herd Selection

The present study is part of the "Cowability-Cowplus" project described previously (Cipolat-Gotet et al., 2013; Bittante et al., 2015). A total of 83 dairy herds located in Trento province (northeastern Italy) were selected from 610 farms representing different environments and dairy farming systems in this mountain area. The farms were sampled once during a calendar year, taking into account the distribution of herds over 4 different dairy systems: 1 traditional system of small farms with old barns and tied lactating cows milked at the stall and fed mainly on farm meadow hay (representing on average 61% of DMI) and a commercial compound feed (on average 18% of DMI); and 3 modern dairy systems, in all of which the cows were kept loose and milked in a milking parlor. The first modern system used a traditional feeding regimen without a TMR (no TMR), consisting mainly of farm hay (54% of DMI) and a commercial compound feed (30% of DMI). The second modern system (**TMR-s**) was similar to the first but used TMR including hay (22% of DMI), maize silage (in total 19% of DMI), imported alfalfa hay (16% of DMI), and concentrates consisting of either a commercial compound feed (15% of DMI) or, more often, a mix of cereals (especially maize grain; on average 23% of DMI), protein feed (often soybean meal), sometimes dry beet pulp, and supplements. The third modern system (**TMR-w**) used TMR but with silage replaced by a greater quantity of hay (39% of DMI) and concentrates, and with water added to the mixing wagon to increase the TMR moisture content to about 50%.

Milk Sampling and Analysis

Milk samples were taken once from a total of 1,224 Brown Swiss cows (generally 15 cows per dairy farm, with different parities and at different lactation stages). Briefly, during the evening milking, a 2-L milk sample was collected from each cow, taken to the Cheese-Making Laboratory of the Department of Agronomy, Food, Natural Resources, Animals and Environment (DAFNAE; University of Padova, Legnaro, Italy), and processed and analyzed within 20 h of collection. The dairy cows sampled (mean DIM = 179, mean number of parities = 2.54) produced, on average, 24.3 kg/d of milk containing 3.75% protein, 2.88% casein, 4.38% fat, 4.77% lactose, and 13.89% DM, and with an SCS of 2.98 (data not shown).

Individual Model Cheese Procedure and Analysis

Each raw full-fat milk sample (1,500 mL) was processed according to the protocol described by Cipolat-Gotet et al. (2013), taking all precautions to ensure maximum reproducibility from one cheese-making session to another. Briefly, each sample was heated (35°C), inoculated with starter cultures (using an industrial freeze-dried formulation of thermophilic lactic bacteria; Delvo-Tec TS-10A DSL; DSM Food Special-