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Real-time evaluation of individual cow milk for higher cheese-milk quality with increased cheese yield

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ABSTRACT

Cheese was produced in a series of experiments from milk separated in real time during milking by using the Afilab MCS milk classification service (Afikim, Israel), which is installed on the milk line in every stall and sorts milk in real time into 2 target tanks: the A tank for cheese production (CM) and the B tank for fluid milk products (FM). The cheese milk was prepared in varying ratios ranging from ~10:90 to ~90:10 CM:FM by using this system. Cheese was made with corrected protein-to-fat ratio and without it, as well as from milk stored at 4°C for 1, 2, 3, 4, and 8 d before production. Cheese weight at 24 h increased along the separation cutoff level with no difference in moisture, and dry matter increased. The data compiled allowed a theoretical calculation of cheese yield and comparing it to the original van Slyke equation. Whenever the value of Afi-Cf, which is the optical measure of curd firmness obtained by the Afilab instrument, was used, a better predicted level of cheese yield was obtained. In addition, 27 bulk milk tanks with milk separated at a 50:50 CM:FM ratio resulted in cheese with a significantly higher fat and protein, dry matter, and weight at 24 h. Moreover, solids incorporated from the milk into the cheese were significantly higher in cheeses made of milk from A tanks. The influence of storage of milk up to 8 d before cheese making was tested. Gross milk composition did not change and no differences were found in cheese moisture, but dry matter and protein incorporated in the cheese dropped significantly along the storage time. These findings confirm that storage of milk for several days before processing is prone to physico-chemical deterioration processes, which result in loss of milk constituents to the whey and therefore reduced product yield. The study demonstrates that introducing the unknown parameters for calculating the predicted cheese yield, such as the empiric measured Afi-Cf properties, are more accurate and the increase in cheese yield is more than increasing just the protein level, the value that is being tested by the dairies, or even casein.
Key words: real-time milk sorting, cheese-milk quality, cheese yield

INTRODUCTION

Over the years, the term "milk quality" has been used in its general sense, and several standard manuals and textbooks are available on milk quality control. In the recent edition of the *Dairy Encyclopedia*, Kelly et al. (2011) used a more general approach, stating that, "The quality of milk may be evaluated by measuring the parameters that indicate both its suitability for consumption or processing into dairy products and the health status of the cow or herd producing the milk." However, searching for the term "milk quality" results mostly in programs to reduce SCC and lower bacteria counts in the bulk milk tank. Moreover, milk quality is usually bound to safety, making use of a new term, "milk safety," which is actually used as a synonymous term to "milk quality" (Leitner et al., 2015).

On farm, bulk milk composition is the sum of the milk contributed by all the animals milked into it, and it depends on breed, nutrition, and time in lactation as well as udder infection of the individuals in the herd. Nonetheless, high-quality milk composition and properties for drinking milk are stricter than that of milk intended for manufacturing of cheese or yogurt. For that, different animals and different breeds may be selected and diverse products have been developed according to standard desirable dairy products (Wedholm et al., 2006; De Marchi et al., 2008). Consequently, high fat or protein can be related to higher cheese yield and therefore important in the term high-quality milk for cheese making, whereas for drinking milk, a high fat level may not be preferred and a high protein level may be associated with economic loss to the milk producer. Similarly, time in lactation, low milk solids at the early

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stages and high solids at the end of the lactation period can result in different products (Palmquist et al., 1993; Auldist et al., 1996; Auldist and Hubble, 1998; Tufarelli et al., 2009). Thus, increased milk quality derived from increased milk safety could partially be achieved by withholding milk of infected glands from the bulk milk tank and could enable the industry to focus on new quality parameters.

The cheese industry depends on milk quality for achieving a high yield and reputability in texture and taste. Properties of milk quality for cheese making were discussed long ago by van Slyke (1907) and later on by van Slyke and Price (1941). The incentive to predict the yield of cheese from a given volume of milk was first documented by S. M. Babcock in 1895 (Emmons and Modler, 2010). All the predictive yield formulas deal with milk composition (or formulation) and its influence when producing cheeses of various compositions. Although the prediction was not totally accurate, the perception of milk quality was in line as it was related to milk composition and quality of the cheese, moisture, and constituent levels (Bangstra et al., 1988; Aleandri et al., 1989; Guinee et al., 2006).

During the last 5 yr, Afimilk (Afikim, Israel) introduced the AfiMilk MCS (online milk classification service), which is installed on the milk line in every stall and sorts milk in real time according to its optical measured coagulation properties: **Afi-Cf** (Leitner et al., 2011a, 2012). In addition, the system measures milk constituents: fat, protein, and lactose. Milk flows through 2 parallel milk lines according to Afi-Cf into target bulk milk A tank or B tank, resulting in milk suitable for desired dairy products. Bulk A tank is assigned for cheese manufacturing and contains ~7% higher protein and ~15% higher fat compared with the herd's basal milk levels, which increases cheese vat production yield by up to 15%, whereas B tank is suited for fermented and other fluid milk products (Leitner et al., 2011a, 2012, 2013). The volume of milk designated for cheese manufacturing is determined by pre-setting the Afi-Cf cutoff level at the milking parlor according to the level desired by the dairy plant. The unique method relies on optical observation only and milk channeling; it does not manipulate, modify, heat, or add any ingredients to the milk (Leitner et al., 2011a, 2012, 2013).

The objective was to evaluate raw milk value for a final product as the basis for its price. In the process of calibrating the AfiMilk MCS system, it was found that in comparison with van Slyke's equation, ~4% of the increased cheese yield was not explained by the equation. Because the increase in cheese yield was not fully related to the increase in milk constituents, further experiments were conducted to assess the contribution of the optical analysis and channeling milk with different composition to the increased yield of the cheese vats produced from designated cheese milk. In addition, van Slyke's equation was tested with stored milk, where fat, protein, and casein remained constant, to assess the effect of raw milk storage time on cheese yield.

MATERIALS AND METHODS

Animals, Milk Sampling, and Preparation for Cheese Making

The milk originated from 4 arbitrarily chosen commercial dairy farms (350–450 Israeli-Holstein cows/farm). The farm's milking parlors were equipped with the AfiLab MCS system, composed of 2 parallel milk lines and 2 target bulk milk tanks: A and B, which allowed a predefined separation of different ratios of milk into each target tank, A or B tank.

On Farm Milk Separation

Milk was separated into the 2 target tanks, A and B, where the A tank was assigned for cheese production (**CM**) and the B tank for fluid milk products (**FM**). The series of separation ratios ranged from ~10:90 to ~90:10 CM:FM and 2 extra bulk milk tanks represented unseparated milk that served as control. All bulk milk samples were of a whole day collection (× 3 milking). From each separation, 5 L of milk was sampled from the bulk milk tank and transferred to the laboratory in 1 h at 4°C. The milk was gently mixed and 40 mL was preserved with Bronopol (Broad Spectrum Microtabs II, D&F Control Systems Inc., San Ramon, CA) for gross milk composition testing. Protein, casein, fat, lactose, and urea contents were analyzed with the Milkoscan 6000 (Foss Electric, Hillerød, Denmark) and SCC with a Fossomatic 360 (Foss Electric). For cheese making, each milk sample of A tank and B tank was standardized for protein-to-fat ratio (**PTF**). Protein content of each separation at the farm was based on the protein level recorded by the Afilabs. Fat content was tested for each sample by Gerber butyrometer (Gerber Instruments AG, Effretikon, Switzerland) and 1 L milk was skimmed by centrifugation and added to achieve a PTF ratio of 1:0.95. After milk standardization, 40 mL was preserved with Bronopol for cheese-milk gross composition analysis. Cheese was made in 4 repetitions. Unpreserved milk (10 mL) was used for measuring rennet clotting time (min) and curd firmness (**Cf**; V) after 60 min (**CF-60**) using the Optigraph (Ysebaert, Frepillon, France) as described by Leitner et al. (2011b).

Milk samples of 27 AfiLab MCS bulk A and B tanks in the ratio of 50:50 CM:FM were collected, the milk