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STUDY OF MILK COAGULATION PROPERTIES IN MULTIBREED ITALIAN DAIRY HERDS

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ABSTRACT

The Italian dairy industry is making notable efforts to improve milk coagulation properties (MCP), as they affect the efficiency of cheese-making process. Individual milk samples (n = 8,525) of 3,057 Holstein-Friesian (HF), Brown Swiss (BS), and Simmental (SI) cows from 39 multibreed herds of Veneto region (northeast Italy) were collected from September 2011 to February 2012, and evaluated for quality traits and MCP predicted by mid-infrared spectroscopy (MIRS). Daily milk yield for each cow was also available. Milk coagulation properties were rennet coagulation time (RCT, min) and curd firmness (a_{30}, mm). Data were analyzed through a generalized linear mixed model including the fixed effects of month of sampling, parity, days in milk (DIM), herd, breed, and interactions between parity and breed, and DIM and breed. The random effects were cow nested within breed and residual. Breed and DIM were the most important sources of variation for MCP ($P < 0.001$). Milk from BS cows showed the shortest RCT (19.1 min) and the highest a_{30} (26.8 mm), whereas milk from HF cows had the worst MCP, with values of 21.0 min for RCT and 20.8 mm for a_{30}. Days in milk, breed, month of sampling, and herd effects were highly significant ($P < 0.001$) for all studied traits. Results from this study indicate that, under similar environmental and management conditions, the HF exhibits less favourable technological properties of milk than BS and SI breeds.

Key words: milk coagulation properties / multibreed herds / Italy

1 INTRODUCTION

The dairy industry plays an important economic role in the primary sector of Italy, as more than 70% of the milk available is destined to cheese production (ISTAT, 2005). In this context, the evaluation of milk coagulation properties (MCP) is valuable to improve the efficiency of milk transformation (Cassandro *et al*., 2008; De Marchi *et al*., 2008). Milk that promptly responds to the presence of the clotting enzyme and produces firm curds results in higher cheese yields (Bynum and Olson, 1982; Riddell-Lawrence and Hicks, 1989) and has positive effects on the entire cheese-making process (Mariani and Battistotti, 1999).

The ability of milk to react to rennet can be measured through different instruments as reported by O'Callaghan *et al.* (2002) in a comprehensive review. Among them, the Formagraph and the Computerized Renneting Meter have been widely used to assess MCP (e.g. Ikonen *et al.,* 1999; Cassandro *et al.,* 2008); these devices produce a graph as reported by Dal Zotto *et al.* (2008) and De Marchi *et al*. (2009), and provide measures of rennet coagulation time (RCT), which is the interval, in minutes, between the addition of the chymosin to the beginning of the coagulation, and curd firmness (a_{30}), defined as the width, in millimeters, of the diagram 30 min after the addition of rennet. The Formagraph and the Computerized Renneting Meter are time-consuming instruments able to process few samples per hour. To reduce the time and costs of analysis of the reference methods, the mid-infrared spectroscopy (MIRS) has been proposed as a fast, non-destructive and cheap method to assess MCP (De Marchi *et al*., 2009, 2012).

Milk coagulation properties are affected by physical

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and chemical parameters of milk such as titratable acidity (Formaggioni *et al.,* 2001), somatic cell count (SCC; Politis and Ng-Kwai-Hang, 1988), protein and casein contents, calcium and phosphorus concentrations (Summer *et al.,* 2002), and concentration of rennet added to milk (Van Hooydonk and Walstra, 1987; Pretto *et al*., 2011). Besides these factors, an important source of variation of MCP is the cow's breed (e.g. Macheboeuf *et al.,* 1993; Auldist *et al.,* 2004; Malacarne *et al.,* 2006; De Marchi *et al.,* 2007). However, most studies on MCP dealt with single-breed herds (e.g. Ikonen *et al*., 2004; Cassandro *et al*., 2008).

Therefore, the aim of this study was to compare three different dairy cattle breeds from multibreed herds of northeast Italy for milk quality traits and MCP predicted by MIRS, and for daily milk yield.

2 MATERIALS AND METHODS

Thirty-nine multibreed herds enrolled in the official monthly test-day milk recording scheme were selected from the database of the Breeders Association of Veneto Region (Padova, Italy). Dairy breeds involved in the study were Holstein-Friesian (HF), Brown Swiss (BS), and Simmental (SI). Herds were required to rear at least two of the aforementioned breeds. Moreover, the breed contribution within each herd was calculated and the most represented breed was required to account for at most 90% of total heads within the herd. At the same time, the less represented breed was imposed to have at least 5 cows controlled within each herd.

Individual milk samples (n = 8,525) were collected on 3,057 cows between September 2011 and February 2012, and analyzed for fat, protein and casein contents, SCC, RCT, and a_{30} in the laboratory of the Breeders Association of Veneto Region (Padova, Italy) using MilkoScan FT6000 (Foss Electric A/S, Hillerød, Denmark). Besides quality traits, daily milk yield was also available. Casein index was calculated as the ratio between casein content and protein content, and somatic cell score (SCS) was obtained via log-transformation of SCC as SCS = [$\log_2$(SCC/100,000) + 3]. Days in milk were restricted to be between 5 and 600 days, and parities between 1 and 6. Samples that did not coagulate within 30 minutes from rennet addition (2%) were discarded from the dataset, as well as those exceeding 4 standard deviations from the mean of each trait.

Data were analyzed through a generalized linear model using the MIXED procedure of SAS (SAS, 2008). The model included fixed effects of month of sampling (6 levels), parity (4 classes, the last class including parities 4 to 6), DIM (12 monthly classes, the first class including DIM between 5 and 30 days, and the last between 360 and 600 days), herd, breed, interaction between parity and breed, and interaction between DIM and breed, and the random effects of cow nested within breed and residual.

3 RESULTS AND DISCUSSION

Descriptive statistics of the studied traits are shown in Table 1. Means (standard deviation) of milk yield (kg/d), fat content (%), protein content (%), casein content (%), casein index, and SCS were 27.7 (9.22), 3.97 (0.86), 3.57 (0.45), 2.82 (0.38), 79.1 (2.12), and 3.11 (1.94), respectively. Rennet coagulation time and a_{30} averaged 20.2 min and 23.5 mm, respectively, and showed an appreciable coefficient of variation (20% and 39%). Values of MCP were slightly worse than those reported by Cassandro *et al.* (2008) for Italian Holstein-Friesian cows reread in the same area (northeast Italy), but similar to those reported by De Marchi *et al.* (2008), who compared MCP from farms having both BS and HF cows. Multibreed herds are essential to estimate the effect of different breeds on MCP under similar rearing conditions.

Results from the analysis of variance are reported in Table 2. Days in milk, month of sampling, breed and herd effects were highly significant (P < 0.001) in explaining the variability of the studied traits. Breed and DIM were the most important sources of variation for RCT and a_{30}, as previously reported De Marchi *et al.* (2007), along with month of sampling for RCT.

As expected, the HF breed exhibited the highest milk yield (27.5 kg/d) and the worst quality of milk; fat, protein, and casein contents were 3.83%, 3.47%, and

Table 1: *Mean, standard deviation (SD), and range of milk yield, composition, and coagulation properties of individual samples (n = 8,525)*

Trait[1]	Mean	SD	Range
Milk, kg/d	27.7	9.22	60.4
Fat, %	3.97	0.86	9.2
Protein, %	3.57	0.45	2.97
Casein, %	2.82	0.38	2.48
Casein index	79.1	2.12	19.8
SCS	3.11	1.94	12.04
RCT, min	20.2	4.05	27.04
a_{30}, mm	23.5	9.11	58.36

[1] SCS = somatic cell score; RCT = rennet coagulation time; a_{30} = curd firmness 30 min after coagulant addition.

Table 2: *Results from ANOVA for milk yield, composition, and coagulation properties of individual samples*

		Effect [1]						
Trait [2]	RSD [3]	Parity	DIM	Month	Breed [4]	Herd	D × B	P × B
Milk, kg	4.305	62.19***	211.4***	45.80***	107.9***	45.50***	1.47 †	0.26
Fat, %	0.651	1.4	39.6***	34.51***	97.13***	16.3***	2.21***	1.82 †
Protein, %	0.210	30.47***	352.74***	123.68***	237.82***	8.75***	4.22***	1.29
Casein, %	0.176	38.01***	340.48***	29.48***	238.62***	9.01***	4.03***	1.41
Casein index	1.039	126.9***	27.32***	2368.5***	48.15***	24.96***	0.92	0.92
SCS	0.125	39.07***	18.87***	9.66***	14.06***	10.35***	1.76*	4.41***
RCT, min	2.603	10.11***	117.2***	121.99***	78.68***	17.88***	2.11**	1.29
a_{30}, mm	5.736	26.65***	49.35***	8.98***	142.75***	10.46***	2.28***	1.88†

[1] DIM = days in milk; D × B = fixed interaction effect between days in milk and breed; P × B = fixed interaction effect between parity and breed.
[2] SCS = somatic cell score; RCT = rennet coagulation time; a30 = curd firmness 30 min after coagulant addition.
[3] RSD = residual standard deviation.
[4] Tested on the error line of cow nested within breed variance. † = P < 0.10; * = P < 0.05; ** = P < 0.01; *** = P < 0.001.

2.74%, respectively (data not shown). Previous studies confirmed that Friesian cows performed worse than other low-producing breeds for milk quality traits (e.g. Auldist *et al*., 2002; De Marchi *et al*., 2007). The BS breed exhibited the most favourable milk composition, with the highest content of protein (3.76%), casein (2.99%), and fat (4.25%), but lower milk yield (24.06 kg/d) than HF breed (data not shown). This was reported also by De Marchi *et al.* (2007). Finally, milk yield (23.6 kg/d) and composition of SI were intermediate between those of BS and HF cows. The SI showed the lowest value of SCS (2.96), confirming findings from previous studies (Vicario, 2005; De Marchi *et al*., 2007).

Brown Swiss cows showed the best values for RCT and a_{30} (19.1 min and 26.8 mm, respectively), whereas HF cows exhibited the worst MCP with 21.0 min of RCT and 20.8 mm of a_{30} (Fig. 1). Simmental cows were intermediate between BS and HF; the average RCT and a_{30} were 20.2 min and 23.6 mm, respectively. A slight worsening of MCP compared with values of other studies has been detected. However, the variability of RCT and a_{30} for HF and BS breeds is similar to that reported by De Marchi *et al.* (2008) on the same breeds.

4 CONCLUSIONS

Dairy cattle breeds largely differed in terms of milk composition and MCP. Holstein-Friesian cows showed the highest milk yield but suffered for scarce MCP, whereas BS produced less than HF cows, but exhibited the most favourable values of MCP and milk composition. Simmental breed was intermediate between HF and BS for MCP and quality of milk, and presented the low-

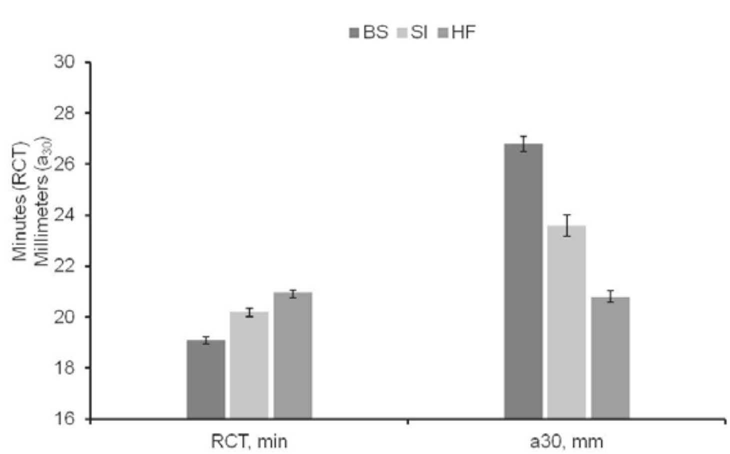

Figure 1: *Least squares means (with SE whiskers) of milk coagulation properties across different breeds. RCT = rennet coagulation time (min); a30 = curd firmness 30 min after coagulant addition (mm)*

est value of SCS. Findings form the present research suggest that, under similar environmental and management conditions, the HF exhibits less favourable technological properties of milk than BS and SI breeds.

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