A comparison of milk clotting characteristics and quality traits of Rendena and Holstein-Friesian cows

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Abstract

Milk coagulation properties (MCP) and composition, as predicted by mid-infrared spectroscopy (MIRS), were compared between Rendena (RE) local breed and Holstein-Friesian (HF) cows using 4614 individual milk samples from 28 single-breed herds. Records of rennet coagulation time (RCT, min), curd firmness (a30, mm), daily milk yield and quality traits were analysed using a linear mixed model which included fixed effects of breed, stage of lactation and parity of the cow, and stage of lactation and parity of the cow (Lindström et al., 1984; Okigbo et al., 1985; Penasa et al., 2014). Moreover, MCP vary greatly among cow breeds as reported in France (Macheboeuf et al., 1993), United Kingdom (Verdier-Metz et al., 1998), Ireland (Auldist et al., 2002), New Zealand (Auldist et al., 2004) and Italy (De Marchi et al., 2007). Several studies have been carried out on high productive and cosmopolitan breeds such as Holstein-Friesian (HF) and Brown Swiss, whereas only few reports have focused on local breeds which are often related to niche products (Chiofalo et al., 2000; De Marchi et al., 2007).

Local breeds can be considered strategic both from a cultural and genetic point of view since they are related to ancient traditions and food products (Dalvit et al., 2008). The Rendena (RE) is a dual-purpose alpine cattle breed characterized by medium to low size, good aptitude to pasture and appreciable functional traits, in particular longevity and fertility (Mantovani et al., 1997). According to national statistics (AIA, 2013), the population accounts for 4066 cows per month recorded for milk production and quality traits. Animals are mainly reared in northeast Italy, especially in low-output systems in which pasture represents the main source of feeding during the summer season. To our knowledge, only Pagnacco and Caroli (1987) investigated MCP of RE breed using individual milk samples, but their study was based on a rather low number of MCP records measured through lactodynamographic analysis. Therefore, the aims of this work were i) to characterize RE local breed for RCT and a30 predicted by MIRS; and ii) to compare MCP of RE with MCP of a cosmopolitan breed (HF) reared in northeast Italy, using repeated records per cow.

Materials and methods

Data

The data consisted of 4614 individual milk samples of 1488 HF and 521 RE cows, collected between September 2011 and January 2012 from 28 single-breed herds (20 HF and 8 RE) of the Veneto region (northeast Italy). Farms were enrolled in official monthly test-day milk recording and their size ranged from 12 to 216 with a mean of 74 cows for HF and from 28 to 115 with a mean of 65 cows for RE breed. Animals were from parity 1 to 5, and from 5 to 600 days in milk (DIM).

Milk samples were analysed in the laboratory of the Breeders Association of Veneto region (Padova, Italy) using Milko-Scan FT6000 (Foss, Hillerød Denmark). Traits recorded were fat, protein, casein and lactose contents,
somatic cell count (SCC) and pH. Milk clotting characteristics were predicted using MIRS models developed by De Marchi et al. (2012, 2013) on Milko-Scan FT6000 and they were defined as rennet coagulation time (RCT, min) and curd firmness 30 min after rennet addition ($a_{30}$, mm). In addition to previous traits, test-day milk yield was also available. Somatic cell score (SCS) was calculated via base-2 log-transformation of SCC as: SCS = $3 + \log_2(\text{SCC}/100,000)$.

### Statistical analysis

The following linear mixed model was used to analyse MCP, milk yield and composition traits:

$$y_{ijklm} = \mu + B_i + HTD_j(B_i) + D_{im} + P_l + (B \times D)_{mk} + (B \times P)_l + (D \times P)_m + \text{cow}_{(B_i)} + \epsilon_{ijklm}$$

where:

- $y_{ijklm}$ is the dependent variable (daily milk yield, fat content, protein content, casein content, lactose content, SCS, pH, RCT or $a_{30}$);
- $\mu$ is the overall intercept of the model; $B_i$ is the fixed effect of the $i$th breed of the cow ($i = 1$ to 2009); $HTD_j(B_i)$ is the fixed effect of the $j$th herd-test-date ($j = 1$ to 81) nested within the $i$th breed;
- $D_{im}$ is the fixed effect of the $k$th class of stage of lactation of the cow ($k = 1$ to 13, the first being a class from 5 to 35 d, followed by 11 classes of 30 d each, and the last being an open class beyond 365 d);
- $P_l$ is the fixed effect of the $l$th parity of the cow ($l = 1$, second, third, fourth, and fifth and later parities); $B \times D_{mk}$ is the fixed interaction effect between breed and DIM;
- $B \times P_{(D)l}$ is the fixed interaction effect between breed and parity;
- $D \times P_{(D)m}$ is the fixed interaction effect between DIM and parity;
- $\text{cow}_{(B_i)}$ is the random effect of the $m$th cow ($m = 1$ to 2009) nested within the $i$th breed $N \sim (0, \sigma^2_{\text{cow}}(B_i))$;
- $\epsilon_{ijklm}$ is the random residual $N \sim (0, \sigma_i^2)$.

Significance of breed effect was tested on the cow within breed variance. A multiple comparison of means was performed for the main effect of breed and for interactions between breed and DIM, and breed and parity using Bonferroni’s correction ($P<0.05$). Statistical analyses were performed using the MIXED procedure of the SAS software (SAS Institute Inc., Cary, NC, USA).

### Results and discussion

#### Descriptive statistics and significance of fixed effects

Rennet coagulation time and $a_{30}$ averaged 20.3 min and 22.8 mm, respectively, and coefficient of variation was much greater for $a_{30}$ (39.0%) than for RCT (19.9%; Table 1). Breed, HTD within breed, DIM and parity effects were statistically significant ($P<0.001$) in explaining the variability of milk quality traits (Table 2). The interaction between breed and DIM was important ($P<0.01$) for milk yield, protein content, casein content and pH, and the interaction between breed and parity was significant ($P<0.05$) only for milk yield, SCS and pH. Finally, the interaction between DIM and parity was found significant ($P<0.05$) for all traits, with the exception of protein and casein content (Table 2).

#### Effects of breed, days in milk and parity on milk coagulation properties

The structure of data analysed in the present study was based on single-breed herds, which means that herd effect was nested within breed. Even if information on rearing condi-

| Trait          | No. of samples | Mean | CV, % | Minimum | Maximum |
|---------------|---------------|------|-------|---------|---------|
| RCT, min      | 4474          | 20.3 | 19.9  | 7.05    | 30.8    |
| $a_{30}$, mm  | 4214          | 22.8 | 39.0  | 4.05    | 59.8    |
| MY, kg/d      | 4610          | 25.9 | 37.7  | 3.50    | 59.7    |
| Fat, g/100 g  | 4522          | 3.83 | 18.8  | 2.01    | 5.99    |
| Protein, g/100 g | 4614      | 3.49 | 12.5  | 2.16    | 5.49    |
| Casein, g/100 g | 4603       | 2.76 | 13.2  | 1.64    | 4.18    |
| Lactose, g/100 g | 4560      | 4.80 | 4.60  | 4.01    | 5.47    |
| SCS           | 4597          | 3.20 | 62.2  | -1.64   | 9.63    |
| pH            | 4037          | 6.61 | 1.20  | 6.41    | 6.92    |

RCT, rennet coagulation time; $a_{30}$, curd firmness 30 min after rennet addition; MY, milk yield; SCS, somatic cell score, defined as SCS = $3 + \log_2(\text{SCC}/100,000)$, where SCC is somatic cell count; CV, coefficient of variation.

**Table 2. F-value and significance of fixed effects included in the analysis for milk yield and quality traits.**

| Trait          | B    | HTD   | DIM | Parity | B x DIM | B x P | DIM x P | RSD   |
|---------------|------|-------|-----|--------|---------|-------|---------|-------|
| RCT, min      | 91.3*** | 14.7*** | 57.4*** | 5.36*** | 1.61 | 1.15 | 2.14 | 2.14 |
| $a_{30}$, mm  | 89.5*** | 13.6*** | 21.4*** | 10.1*** | 1.34 | 2.97 | 1.75 | 5.05 |
| MY, kg/d      | 703*** | 29.1*** | 23.8*** | 6.29*** | 2.79*** | 3.29 | 6.57*** | 3.52 |
| Fat, g/100 g  | 36.0*** | 11.5*** | 18.7*** | 0.13*** | 5.53 | 1.53 | 1.74 | 0.16 |
| Protein, g/100 g | 5.65*** | 12.8*** | 0.13*** | 6.89*** | 2.98*** | 1.85 | 0.87 | 0.20 |
| Casein, g/100 g | 11.3*** | 1.0*** | 0.13*** | 0.84*** | 0.47*** | 1.74 | 0.97 | 0.16 |
| Lactose, g/100 g | 28.7*** | 5.86*** | 27.9*** | 91.8*** | 1.64 | 2.26 | 2.92*** | 0.12 |
| SCS           | 0.01 | 6.45*** | 13.3*** | 43.1*** | 0.98 | 3.05 | 1.52 | 1.19 |
| pH            | 119*** | 44.1*** | 19.8*** | 3.14*** | 5.17*** | 4.34*** | 1.76*** | 0.04 |

B, breed; HTD, herd-test-date nested within breed; DIM, days in milk; P, parity; RSD, residual standard deviation; RCT, rennet coagulation time; $a_{30}$, curd firmness 30 min after rennet addition; MY, milk yield; SCS, somatic cell score, defined as SCS = $3 + \log_2(\text{SCC}/100,000)$, where SCC is somatic cell count. Breed effect was tested on the cow within breed variance. *P<0.05, **P<0.01, ***P<0.001.
tions of RE and HF was not available, it is likely that managerial and feeding strategies of RE herds were different than those of HF. Therefore, the breed-estimated effect also includes a part of the rearing conditions effect.

Milk from RE coagulated 2.1 min earlier (P<0.05) and exhibited a firmer curd by 4.8 mm (P<0.05) than milk from HF cows, respectively (Table 3). The local breed produced 9.7 kg/d less milk (P<0.05) with 0.22 g/100 g less fat (P<0.05) than HF, whereas protein (+0.05 g/100 g), casein (+0.06 g/100 g) and lactose (+0.06 g/100 g) contents were greater (P<0.05) in milk of RE than HF cows. Somatic cell score did not differ (P>0.05) between the two breeds, and pH was slightly lower (P<0.05) in milk of HF than RE (Table 3). Several authors (Macheboeuf et al., 1993; Ikonen et al., 2004; Penasa et al., 2014) reported that breed is an important source of variation for MCP, and De Marchi et al. (2007) found more favourable clotting ability of milk from local than cosmopolitan breeds, especially HF, which exhibited the worst values of RCT and a30. Nevertheless, the comparison between our results and those of De Marchi et al. (2007) is quite difficult because the latter authors analysed MCP of bulk milk instead of individual samples and they used a mechanical instrument instead of MIRS.

Compared with HF, milk from RE had slightly greater protein and casein contents, lower fat content, and very similar values of SCS and pH. Therefore, better coagulation ability of milk from RE than HF cows seemed not to be due to quality traits, but to other aspects that deserve further investigation. Also, RE performed better than HF cows across DIM and parity. These findings along with overall better performance of RE than HF in terms of functional traits such as robustness, fertility, longevity and adaptability to pasture (Mantovani et al., 1997), can partly compensate the lower milk production of the local breed.

Milk coagulation properties were at their best at the beginning of lactation, deteriorated rather quickly during the first 3 months after calving and exhibited the worst values in mid-lactation (Figure 1). Curd firmness improved slightly during the last third of lactation, but it did not reach the levels observed immediately after calving. Differences between RE and HF cows were found comparing MCP within each class of DIM (Figure 1). In particular, RCT and a30 predicted in milk of RE breed were shorter and firmer, respectively, than the same traits predicted in milk of HF. Significance was found across all lactation, with the exception of few cases in mid and end of lactation. Stage of lac-

| Trait | Rendena | Holstein-Friesian |
|-------|---------|------------------|
| RCT, min | 18.9 (0.18)a | 21.0 (0.12)b |
| a30, mm | 25.8 (0.42)a | 21.0 (0.27)b |
| MY, kg/d | 17.2 (0.30)a | 26.9 (0.20)b |
| Fat, g/100 g | 3.69 (0.03)a | 3.91 (0.02)b |
| Protein, g/100 g | 3.54 (0.02)a | 3.49 (0.01)b |
| Casein, g/100 g | 2.81 (0.01)a | 2.75 (0.01)b |
| Lactose, g/100 g | 4.79 (0.01)a | 4.73 (0.01)b |
| SCS | 3.59 (0.09) | 3.60 (0.06) |
| pH | 6.64 (0.01)b | 6.60 (0.01) |

Table 3. Least squares means (with standard errors) of milk coagulation, yield and quality traits of cows of Rendena and Holstein-Friesian breeds.

Figure 1. Least squares means (with standard errors) of (a) rennet coagulation time (RCT, min) and (b) curd firmness (a30, mm) across classes of days in milk (solid line, Holstein-Friesian; dashed line, Rendena). a,bLeast squares means with different superscripts within a row are significantly different according to Bonferroni’s correction (P<0.05).
tation was an important source of variation for MCP. Rennet coagulation time was better at earlier DIM and worst from mid-lactation onward, whereas a30 exhibited an opposite trend, with the best values at beginning and end of lactation. These results agree with those reported by Ostersen et al. (1997), Tyrisevä et al. (2003) and Ikonen et al. (2004) on several breeds.

Rennet coagulation time was shorter and a30 firmer in first- than later-parity cows, and RE exhibited better performance than HF breed within each parity (Figure 2). Regarding the effect of parity on milk clotting ability, the literature reports controversial results. Similar to our study, Tyrisevä et al. (2003) and Penasa et al. (2014) reported that MCP deteriorated with parity, whereas Ikonen et al. (2004) and Tyrisevä et al. (2004) found better performance in later- than first-parity cows.

Conclusions

The present study characterized MCP of RE local cattle breed. Rendena and HF differed notably in terms of MCP; in particular, milk from the local breed coagulated earlier and exhibited a firmer curd than that of HF cows.

Coagulation characteristics of milk were also influenced by herd-test-date, lactation stage and parity. Because quality traits did not differ largely between RE and HF, further research is needed to better understand mechanisms underlying better coagulation characteristics of RE compared with HF breed. Rennet coagulation time and a30 are gaining more and more interest in Italy as they have technical and economic implications in the dairy industry, and thus findings of the present study support the importance of safeguarding local breeds such as RE.

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