Effects of Cossbreeding of Holsteins Cows with Montbéliarde and Swedish Red in First and Second Generation on Cheese Yield Traits

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Summary

Crossbreeding in dairy cattle may improve functional traits of crossbred cows, but few are known on its effect on cheese-making traits. This study investigated the effects of crossbreeding of Holstein (HO) cows with Montbéliarde (MO) and Swedish Red (SR) on milk composition, cheese yield (CY) and other cheese-making traits. Milk samples from 188 cows were collected on 3 dairy herds producing PDO cheeses. Herds are following a 3-way rotational breeding scheme, so that parts of the cows were purebred HO and the remaining were 1st (SR × HO; MO × HO) and 2nd generation [MO x (SR x HO); SR x (MO x HO)] crossbred cows. Milk samples were analyzed for assessing milk composition, CY, curd composition, and recovery of milk nutrients (REC) in curd. Cows yielded nearly 30.5 kg/d milk, with a fat and protein content of 4.5 and 3.8 %, respectively, without any difference between purebred HO and crossbred cows. Milk coagulation time was influenced by breed combination ($P < 0.05$), but purebred HO performed similarly to crossbred cows. Milk yielded nearly 16.3% of curd, but again CY and curd composition were not affected by the breed combination. In conclusion, the crossbreeding scheme considered did not exert any negative effect on cheese-making properties of milk, and can be chosen even in farms specialized in PDO cheese production. Further studies with larger sample size are needed for obtaining more robust estimates and for evaluating the performance of the different breed combinations.

Key words

crossbreeding, Holstein, Swedish Red, Montbéliarde, cheese-making traits

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Introduction

Crossbreeding may positively affect profitability of dairy farms through its effects on milk production, fertility, and health of dairy cows (Weigel and Barlass, 2003; Funk, 2006; Hazel et al., 2017). For this reason crossbreeding programs of dairy cattle have been spread in the last decades in developed and developing countries. Among cows enrolled in milk recording system in the USA, the number of those deriving from crossbreeding programs has increased from 0.5 to 4.5 % in the period 2003 to 2014 (Hazel et al., 2017). Crossbreeding has become a significant breeding strategy also in several other countries, such as India (Singh, 2016), New Zealand and Ireland (Hazel et al., 2017).

Holstein (HO) is the predominant dairy breed in the world because of its ability to produce high volume of milk (VanRaden and Sanders, 2003). Thus, the interest in crossbreeding HO cows with other breeds has increased, and several studies have been conducted for comparing the milk production and milk quality of crossbred cows with HO in various environmental settings (Heins et al., 2006; Malchiodi et al., 2014; Hazel et al., 2017). Results of these studies reported that crossbred cows tended to produce less volume of milk than pure HO, whereas the effects of crossbreeding on the milk composition were not consistent among trials, differing according to the genetic lines involved in the crossbreeding programs. Hazel et al. (2017) reported that MO x HO and SR × HO cows yielded milk with greater content of fat and protein in comparison to purebred HO, even if with differences between the two crossbreds. Conversely, Blöttner et al. (2011) found no differences in fat and protein yield over the first three lactations between Brown Swiss × HO and pure HO.

Cheese yield (CY) ability of milk greatly relies on its composition and properties. Cheese production is the most important use of milk in many countries, such as Italy, where nearly 75 % milk is aimed to cheese production. Therefore, CY is a critical trait for the Italian dairy industry (Bittante et al., 2013). Among factors able to affect CY, the effects of different breeds have been well characterized and described by Cecchinato et al. (2015). Conversely, the effects of crossbreeding on CY have not been explored yet. Therefore, this study aimed to investigate the effect of crossing HO cows with MO and SR bulls on milk composition, CY and several other cheese- making traits.

Material and methods

Farms and animals

A total of 188 cows from 3 commercial dairy herds located in Northern Italy were used for this study. Management of herds was very similar and cows were fed using a total mixed ration based on dry roughage and concentrates but without silage and fresh herbage. Herds are following since several years a crossbreeding program (ProCross, Genesi Project Srl, Genova, Italy) based on a 3-breed rotational breeding system where SR and MO bull semen has been used on purebred and first-cross HO cows. Therefore, parts of cows in the herds were purebred HO and the remaining consisted on first and second generation crossbred cows, according to the following scheme:

Breeding type	Sire		Dam
Purebred	HO	x	HO
First cross	MO	x	HO
	SR	x	HO
Second cross	SR	x	MOHO
	MO	x	SRHO

Milk sample collection and analysis

The milk samples (1,000 mL) were collected from the evening milking of each cow and kept without preservative in refrigerator at 4ºC until analysis/processing. All the milk samples were analyzed for fat, protein, casein, lactose and total solids contents by using a Milkoscan FT2 infrared analyzer (Foss Electric A/S, Hillerød, Denmark) at the Milk Quality Laboratory of DAFNAE (University of Padova, Legnaro, Italy). Milk pH was measured using a Crison Basic 25 electrode (Crison Instruments SA, Barcelona, Spain).

Cheese production was performed on the basis of a laboratory model-cheese making method proposed by Cologna et al. (2009) for assessing the CY and modified by Cipolat et al. (2013). Briefly, 500 mL of each milk sample was poured in stainless steel vat and moved to a pre-warmed water bath (3 water baths; 8 vats per water bath; 24 vats per day) for heating to 35°C (30 min). Then thermophilic starter cultures (Delvo-Tec TS-10A DSL, DSM, Netherlands) were added. After 90 min of acidification time, 0.16 mL calf rennet (Naturen TM standard 160; Pacovis Amrein AG, Bern, Switzerland) diluted 20 fold in distilled water was added. Ten minutes after the milk gelation, the curd was cut into cubes of about 0.5 cm^3. After 5 min from the cut, the curd was separated from the whey and suspended over the whey-containing vat in a stainless-steel cheese mold. The curd was turned after 30 min and then it was pressed for 18 h at room temperature using a 1-kg weight. After that, the curd and whey were weighed (g). Whey compositions (whey fat, protein, lactose and total solids) and acidity (pH) were analyzed by using a Milkoscan FT2 (Foss Electric A/S, Hillerød, Denmark and a Crison Basic 25 electrode (Crison Instruments SA, Barcelona, Spain), respectively. Curd composition was calculated by the difference between milk and whey composition. Also, using the weight and the composition of milk and whey, the percentage of 3 CY traits, representing respectively the weights of curd, and total solids, as a percentage of the processed milk, and 4 REC traits representing the percentage ratio between the fat, protein, total solids and energy of curd and the respective nutrient in the processed milk, and the daily cheese yield (kg/d) were calculated according to Cipolat-Gotet et al. (2013).

Statistical analysis

Before data analysis, all cows were categorized within parity (primiparous and multiparous) and days in milk (DIM < 60; DIM 60 to 120 d; DIM 121 to 180; DIM 181 to 240 and DIM >240). Then, cows were assigned to the following breed combinations: purebred (HO × HO); first generation crosses (MO × HO; SR × HO); second generation crosses: [MO × (SR × HO); SR × (MO × HO)]. Finally, data from 188 cows were analyzed by using the

MIXED procedure of SAS (9.4, SAS Institute Inc., Cary, NC) to conduct ANOVA including into the model the following effects: combined herd x sampling date (random), parity, DIM, vat, and breed combinations (fixed). Orthogonal contrasts were estimated between the least square means of traits for the effect of DIM (linear and quadratic) and breed combination: 1) the effect of cross breeding (HO vs all crossbred cows), 2) the effect of generation (first cross vs second cross cows), 3) the effect of SR sire against MO sire in first generation (MO x HO vs SR x HO), 4) the effect of SR sire against MO sire in second generation [MO x (SR x HO)] vs [SR x (MO x HO)].

Results and discussion

Least squares means of different breed combinations for milk and cheese yield traits are given in table 1. On average, sampled cows yielded nearly 30.5 kg milk per day, with a fat and protein content close to 4.5 and 3.8 %, respectively. Purebred HO did not differ from crossbred cows for milk yield and milk composition ($P > 0.05$). Recently, Hazel et al. (2017) reported that purebred HO cows yielded in their first lactation nearly 2% more fluid volume of milk than first lactation MO x HO and SR x HO crossbred cows, but with lower fat and protein content. Also Ezra et al. (2016) found that purebred HO had greater 305-day milk yield than Norwegian Red x HO crossbred cows, whereas crossbred cows had greater milk protein content but similar milk fat content compared to purebred HO. Conversely, Blöttner et al. (2011) found no differences in milk yield, milk fat and protein content between pure HO and Brown swiss × HO crossbred cows over the first three lactations. Milk pH was slightly influenced by cow breed combination, and second generation crossbred cows showed greater milk pH than first generation crossbred ones ($P < 0.05$). Also coagulation time measured in the vats, which is an important trait in the definition of cheese making properties of milk (Ikonen et al., 2004), was influenced by cow breed combination ($P < 0.05$). Milk coagulation time of purebred HO did not differ from that of crossbred cows, but milk from MO x HO cows showed a faster coagulation than milk from SR x HO cows ($P < 0.05$). Also Malchiodi et al. (2014) did not find significant difference in rennet coagulation time (RCT) measured using lactodynamographs between purebred HO and crossbred cows derived from HO, MO and SR breeds, and reported better RCT for MO x HO among first generation crosses and SR × (MO × HO) among second generation crosses.

On average, milk sampled yielded nearly 16.3% of curd, containing nearly 45% of solids, 18% of protein and 26% of fat. Cheese yield and curd composition were not affected by the cow breed combination, and purebred HO cows provided values close to those measured for crossbred cows. As milk composition and CY traits were not affected by breed combination of cows, also all the recovery traits were comparable across different breed genetic types of cows. On average, nearly 52% of solids, 76% of protein and 95% of fat of the milk were recovered in the curd,

Table 1. Least squares means, standard error of the means (SEM) and *P*-value of different breed combinations for milk yield and composition, cheese yield, curd composition, curd nutrients and energy recovery (REC), and daily cheese yield

Traits	Breed combinations[1]					SEM	*P* value
	Pure breed	First generation crosses		Second generation crosses			
	HO × HO	MO × HO	SR × HO	MO ×(SR × HO)	SR× (MO × HO)		
Cow, no	58	22	57	34	17		
Milk yield, kg/d	31.13	31.52	30.82	29.30	29.77	1.400	0.79
Milk pH	6.46	6.44	6.46	6.50	6.47	0.015	0.06[2]
Milk composition, %:							
Total solids	13.64	13.92	13.76	13.64	14.01	0.172	0.52
Fat	4.35	4.71	4.48	4.27	4.74	0.191	0.39
Protein	3.82	3.78	3.83	3.84	3.87	0.047	0.85
Casein	2.98	2.97	2.99	3.00	3.01	0.039	0.97
Lactose	5.00	5.05	4.97	5.04	4.99	0.041	0.51
Coagulation time, min	12.52	10.38	12.83	12.69	11.34	0.901	0.04[3]
Cheese yield, %:							
Curd	16.05	16.21	16.31	16.10	16.64	0.358	0.81
Solids	7.15	7.43	7.23	7.10	7.50	0.184	0.55
Curd pH	5.17	5.22	5.19	5.17	5.19	0.038	0.55
Curd composition, %:							
Total solids	44.62	45.93	44.49	44.04	45.22	0.626	0.23
Protein	18.17	17.96	17.77	18.13	18.06	0.316	0.74
Fat	25.72	27.73	26.22	25.19	27.10	0.876	0.28
REC, %:							
protein	75.70	76.59	75.41	75.64	76.78	0.470	0.21
fat	95.15	95.38	95.00	95.45	95.31	0.283	0.55
solids	52.12	53.04	52.38	51.36	53.16	0.723	0.43
energy	69.51	69.31	69.79	69.38	70.41	0.693	0.87
Daily cheese yield, kg/d	4.91	5.03	4.94	4.67	4.86	0.225	0.85

[1]HO = Holstein; MO = Montbéliarde; SR = Swedish Red; [2]breed combinations in first and second generation cross differed ($P < 0.05$); [3]breed combinations in first generation cross differed ($P < 0.05$)

with very slight differences among cows of different genetic background. As a result of daily milk yield and cheese yield, daily cheese yield per cow averaged 4.9 kg/d, with only nominal and slight variation among cows of different breed combinations.

Conclusions

Crossbreeding is a tempting alternative to improve the robustness of dairy cows and enhance their health, fertility, and longevity in comparison with purebreds. However, effects of such breeding programs on milk properties should be better examined, particularly for those dairy chains where cheese making is the predominant purpose of milk. In this study 2-way and 3-way crossbred cows obtained under a breeding program which involved the use of MO and SR sires on purebred HO and 2-way crossbred cows produced similar volume of milk, milk composition, cheese yield and milk nutrient recovery in the curd as purebred HO. These findings suggest that the use of the 3-way rotational breeding system based on MO and SR sires on purebred and crossbred-derived HO cows did not affect negatively cheese-making properties of milk, and can be chosen even in farming systems specialized in PDO cheese production. However, further studies with increased cows sample size are needed for obtaining more robust estimates of effects and for better evaluating the performance of the different breed combinations.

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