Heritability and genetic correlations between milk composition and milk coagulation traits in Bulgarian Brown cattle

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Abstract

The aim of the present study was to determine the heritability and to evaluate genetic correlations between milk composition traits and milk coagulation properties in Bulgarian Brown cattle. The analysis included 155 cows from 4 herds in different regions of the country regardless of lactation number and days in milk. Heritability coefficients and genetic correlations describing milk quality and milk coagulation properties were determined on the basis of records for animals' origin from herdbooks. The analysis of milk composition was done in the lab of the Agriculture Institute – Stara Zagora on Lactoscan ultrasound milk analyzer, whereas coagulaiton properties of individual milk samples were evaluated on a Computerized Renneting Metter – Polo Trade, Italy. For unbiased estimation of additive and environmental variance and co-variance components, fir calculation of heritability and genetic correlations between production / milk composition / traits and milk coagulation traits, a Random Regression Test day model was used. Coefficients of heritability of traits for milk quality composition – daily milk yield, fat and protein contents were 0.29, 0.39 and 0.33, respectively. The traits characterizing milk coagulation properties (RCT, A_{30} and K_{20}) were outlined with medium and low heritability coefficients: 0.34, 0.15 and 0.04. Daily milk yield correlated negatively with milk fat (-0.394) but positively with milk protein (0.253). The three studied traits describing the qualitative composition of milk – daily milk yield, fat and protein substances have a negative correlation with the rennet coagulation time (-0.027, -0.294 and -0.104) and a positive correlation with the curd firmness (0.231, 0.356 and 0.208) respectively.

Key words: Heritability and genetic correlations, Brown cattle, coagulation properties, milk production

Introduction

Brown cattle is the second most spread dairy cattle breed at a global scale after Holsteins. This is probably the oldest of all dairy breeds. According to the Brown Swiss Cattle Breeders' Association of the USA, the current global population of the breed is about 6 million animals (www.brownswissusa.com).

The milk produced by animals offers a perfect balance between yield and quality. The most recent data of ICAR from 2019 about most European countries demonstrate milk yield over 7000 kg, with fat content about 4% and high protein content – about 3.5 to 3.8% (ICAR, 2019). The milk of this breed is appropriate for production of high-quality dairy products, especially cheeses. The fat-to-protein ratio of 1.22 places milk

of Brown Swiss cattle in the leading three cattle breeds in France, suitable for production of durable dairy products after Normande (1.23) and Jersey (1.45) cattle breeds (The European Brown Swiss journal, 2020).

A number of researchers (Gibson and Dechow, 2018; Cecchinato et al., 2011, 2013; Dal Zotto, 2007) have reported heritability coefficients and investigated genetic correlations between milk production traits and milk coagulation traits of Brown cattle. Şahin et al. (2014) found out heritability coefficients for milk production traits in Brown cattle in Turkey. The results from their study showed that first lactation could be used in developing schedules for efficient genetic improvement of animals.

Macciotta et al. (2012) reported a low negative genetic correlation between milk yield and milk coagulation properties: -0.147, whereas the correlation coefficient between milk quality composition and coagulation properties was -0.116.

Nowadays, on a national scale, the breed develops at the background of general trends in cattle husbandry due to its valuable economic traits and competitiveness. In 2006, Krastanov (2006) has performed the last detailed analysis of the breed in our country that encompassed all genetic and economic factors influencing Brown cattle farming.

The aim of the present study was to determine the heritability and to evaluate genetic correlations between milk composition traits and milk coagulation properties in Bulgarian Brown cattle.

Material and methods

Animals

The analysis included 155 cows from 4 herds in different regions of the country regardless of lactation number and days in milk. Heritability coefficients and genetic correlations describing milk quality and milk coagulation properties were determined on the basis of records for animals' origin from herd books.

Laboratory analyses

The analysis of milk composition was done in the lab of the Agriculture Institute – Stara Zagora on Lactoscan ultrasound milk analyzer, whereas coagulaiton properties of individual milk samples were evaluated on a Computerized Renneting Metter – Polo Trade, Italy. Milk samples were obtained by milk meters, recording also milk yields (kg). The milk was analyzed within 3 hours after sample collection.

Statistical analysis

For unbiased estimation of additive and environmental variance and co-variance components, fir calculation of heritability and genetic correlations between production / milk composition / traits and milk coagulation traits, a Random Regression Test day model was used. The mixed model was as followed:

$$Y_{ijklmn} = HYM_i + Age_j + Par_k + Testdim_l + Animal_m + e_{ijklmn}$$

where:

Y_{ijklm} – n^{th} observation of the respective trait;

Age_j – fixed effect of the i^{th} herd-year-month;

Par_k – fixed effect of the k^{th} parity;

$Testdim_l$ – random regression effect of days in milk to the date of milk test-day of the respective lactation;

$Animal_m$ – random effect of the m^{th} animal;

e_{ijklm} – random effect of unobserved factors.

The data were processed with statistical software products SYSTAT 13, VCE, Pest /Groeneveld/.

Results and discussion

It could be noticed that coefficients of heritability of traits for milk quality composition – daily milk yield, fat and protein contents were 0.29, 0.39 and 0.33, respectively. A similar heritability coefficient for milk yield was reported by Gibson and Dechow (2018) on US Brown Swiss dairy cattle. In this study the authors found out h^2 of 0.30 for milk yield and h^2 of 0.20 for milk fat and protein percentages – lower than values from the present study.

Tullo et al. (2016) observed a heritability coefficient for milk fat content on Brown Swiss cows

Table 1. Heritability of traits related to milk composition and milk coagulation traits

Trait	h^2	References	
Daily milk, kg	0.29	0.24 (Gorbani, 2011)	0.30 (Dogan, 1999)
Fat, %	0.39	0.14 (Tullo et al., 2016)	0.10 (Cecchinato et. al., 2011)
Protein, %	0.33	0.25 (Tullo et al., 2014)	0.20 (Gibson and Dechow, 2018)
Rennet coagulation time RCT, min.	0.34	0.24(Dal Zotto, 2008)	0.21 (Cecchinato et.al., 2011)
Curd firmness, a_{30}, mm	0.15	0.14 (Dal Zotto, 2008)	0.17 (Cecchinato et.al., 2011)
Curd firming time, k_{20}, min	0.04		

which is lower than that established in our study: 0.14. A rather lower values of the heritability coefficient for milk fat content (0.10) and milk protein content (0.20) were reported by Cecchinato et al. (2011) and Gibson and Dechow (2018). The value for daily milk yield in this study corresponded to that found out by Dogan (1999): 0.30.

The traits characterizing milk coagulation properties (RCT, A_{30} and K_{20}) were outlined with medium and low heritability coefficients: 0.34, 0.15 and 0.04. A lower heritability coefficient for RCT on Brown Swiss cows was observed by Dal Zotto (2007) and Cecchinato et al. (2011) – 0.24 and 0.21, respectively. In another study of this research team, where milk coagulation properties were determined by means of Formagraph and Optigraph, Cecchinato et al. (2013) reported heritability coefficients for rennet coagulation time of 0.230 (Formagraph) and 0.241 (Optigraph) and for curd firmness – 0.171 (Formagraph) and 0.205 (Optigraph). Comparable coefficients for curd firmness (A_{30}) were demonstrated by Dal Zotto (2008) and Cecchinato et al. (2011) – 0.14 and 0.17, respectively.

Genetic correlations between traits of milk composition and milk coagulation properties in Brown cattle are presented in Table 2. Daily milk yield correlated negatively with milk fat (-0.394) but positively with milk protein (0.253). The three studied traits describing the qualitative composition of milk – daily milk yield, fat and protein substances have a negative correlation with the rennet coagulation time (-0.027, -0.294 and -0.104) and a positive correlation with the curd firmness (0.231, 0.356 and 0.208) respectively. Rennet coagulation time demonstrated strong negative correlation with curd firmness (-0.856). Similar genetic correlation between these two traits was found out by Cecchinato et al. (2011): -0.86. The authors reported also negative correlation between rennet coagulation time and milk protein content (-0.02), but unlike our finding for negative correlation between RCT and milk fat, they provided proof for weak positive correlation between both traits on Brown Swiss cows. Curd firming time showed a positive relationship with all studied traits except for milk fat content whose correlation was inverse (-0.265). A strong positive relationship was found out between curd firming time and daily milk yield: 0.699. Toffanin et al. (2012) and Pretto et al. (2013) concluded that milk coagulation properties were influenced by several factors, among which milk composition. Dal Zotto et al. (2007) affirmed that Brown cows produced milk with best cheesemaking technological quality among the commonly used breeds.

The selection of animals carrying the BB genotype of the kappa casein gene is among the main goals of selection in line with global practices in Brown cattle breeding. With respect to this fact, the results from presented studies would be a good background for preservation and improvement of this cattle breed. The established genetic correlations between production traits and traits of milk coagulation properties, as well as their heritability, provide the necessary information

Table 2. Genetic correlations between milk composition traits and milk coagulation traits in Bulgarian Brown cattle

Parameters	Milk yield, kg/ day	Fat, %	Protein, %	Rennet coagulation time RCT, min	Curd firmness A_{30}, mm	Curd firming time K_{20}, min
Milk yield, kg/day		-0.394	0.253	-0.027	0.231	0.699
			0.037	-0.294	0.356	-0.265
Protein, %				-0.104	0.208	0.069
Rennet coagulation time RCT, min					-0.856	0.293
Curd firmness A30, mm						0.187
Curd firming time K_{20}, min						

for management of selection in dairy cattle husbandry to serve as an economic bridge between milk producers and dairy processing industry.

Of course, from the point of view of population size, the possibilities for detection and development of new genetic variability are considerable, which makes our results far more practically applicable in selection schedules of specific herds or producers' organisations. To accomplish a higher efficiency in selection, research on the functional relationships of traits of individual coagulation properties and those describing quality of milk as a raw material for production of Bulgarian dairy products, should be further expanded.

Conclusion

1. Coefficients of heritability of traits for milk quality composition – daily milk yield, fat and protein contents were 0.29, 0.39 and 0.33, respectively.

2. The traits characterizing milk coagulation properties (RCT, A_{30} and K_{20}) were outlined with medium and low heritability coefficients: 0.34, 0.15 and 0.04.

3. Daily milk yield correlated negatively with milk fat (-0.394) but positively with milk protein (0.253).

4. The three studied traits describing the qualitative composition of milk – daily milk yield, fat and protein substances have a negative correlation with the rennet coagulation time (-0.027, -0.294 and -0.104) and a positive correlation with the curd firmness (0.231, 0.356 and 0.208) respectively.

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