Economic Values of Milk Production and Milk Coagulation Properties in Italian Holstein-Friesian Dairy Cattle

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ABSTRACT: The economic values (EV) of production traits, rennet coagulation time (RCT, min), and curd firmness (a_{30}, mm) were derived for Italian Holstein-Friesian dairy cattle, based on the Grana Padano cheese industry. Three different sets of EV for RCT and a_{30} were estimated, assuming +2.5% (scenario 1), +5% (scenario 2) and +10% (scenario 3) increments in cheese yield due to the effect of milk coagulation properties (MCP). A profit equation based on a linear model was developed to simulate the transformation of milk into Grana Padano cheese. The EV of RCT were -2.18, -4.36, and -8.71 Euro/min for scenarios 1, 2, and 3, respectively, and +0.86, +1.73, and +3.45 Euro/mm for a_{30}, respectively. Relative emphasis of traits in the breeding objectives for Italian Holstein-Friesian dairy cattle population should account for the effect of MCP on cheese yield.
Keywords: Economic value; Milk yield; Milk coagulation properties; Italian Holstein-Friesian

Introduction

Animal breeding is an economic activity based on the definition of breeding objectives that include traits aimed at improving the profit of the production system. The breeding objectives will likely change over time, along with the trait focus and the economic perspective, and as a consequence, the traits included in a selection index will also change. In this context, selection indices are continuously improved as new technologies and information become available (Shook (2006)). The economic value (EV) of a trait can be defined as the change in profit of the farm expressed per lactating cow per year, as a consequence of one unit of change in the genetic merit of the trait considered, keeping all other traits in the aggregate genotype constant (Groen (1989)). Italy has a peculiar and specialized structure of dairy industry, producing many high value and traditional cheeses, in particular Protected Designation of Origin (PDO) products like the Grana Padano, Parmigiano Reggiano, Gorgonzola, and Asiago (Pieri (2010)). The most popular Italian PDO cheese, with 158,326 tons produced and 16% of total milk processed, is Grana Padano (Pieri (2010)). The quality of milk used for cheese production is very important and milk coagulation properties (MCP) are of particular interest (Cassandro et al. (2008); Vallas et al. (2010)). The MCP have been widely studied in recent years and have been proposed as technological traits to increase the efficiency of the dairy industry (Cassandro et al. (2008); De Marchi et al. (2008 and 2009); Penasa et al. (2010); Pretto et al. (2012 and 2013)). Few studies have estimated the effect of MCP on cheese yield: the difference in cheese yield from milk with good to undesirable MCP ranges from 2 to 10% (Aleandri et al. (1989); Pretto et al. (2013)). Due to their importance in Italy, there is notable interest to include MCP in milk payment systems and in selection indices. Estimates of EV are necessary to determine the relative importance of the traits in the breeding objective. However, no studies are currently available that attempted to estimate EV for MCP.

The objective of this study was to calculate EV of MCP and milk production traits for milk destined to manufacture Grana Padano cheese in Italian Holstein-Friesian dairy cattle.

Materials and Methods

Model description. The profit per cow per year was calculated using the following function:

$$P = R - C,$$

where P is the profitability, R are revenues, and C are costs. In the present study, revenues were related to the sale of Grana Padano (a cooked, hard, and long-ripened cheese from partially skimmed raw milk), butter and whey, and costs were related to feed and cheese processing. Revenues and costs were obtained using the following equations:

$$R = (Pcheese * CY * MY) + (Pbutter * BY * MY) + (Pwhey * WY * MY)$$

and

$$C = (Ccheese * CY * MY) + Cmaintenance + Ccarrier + Cfat + Cprotein,$$

where MY is the annual milk yield per cow (kg); CY, BY, and WY are yields (kg/100) of cheese, butter, and whey per kg milk, respectively; Pcheese, Pbutter, and Pwhey are prices per kg cheese, butter, and whey, respectively (€); Ccheese are costs for cheese processing (€/kg cheese); and Cmaintenance, Ccarrier, Cfat, and Cprotein are annual feed costs for maintenance, milk carrier, milk fat, and milk protein, respectively (€/cow).

The annual profit per cow was calculated considering the effect of MCP, namely rennet coagulation time (RCT, min) and curd firmness (a_{30}, mm), on cheese yield, by simulating different scenarios.

The EV of trait X was obtained as the partial derivative of the profit function with respect to that trait, evaluated at the current population mean:

$$EV_x = \frac{\partial P}{\partial x} = \frac{\partial R}{\partial x} - \frac{\partial C}{\partial x}.$$

The dairy market in Italy has been restricted by the quota system introduced by the European Union in 1984. In this situation, a reformulation of the profit equation is needed, with the addition of a scaling factor that considers the total amount of output to be constant and any increase in milk or fat yield per cow is then reflected by a decrease in the number of cows (Pieters et al. (1997)). However, future market liberalization is expected in the European Union as the quota system will expire in 2015. Moreover, in Italy the self-supply of dairy chain is around 70% and the export of processed dairy products is increasing (Pieri (2010)). For these reasons, EV were calculated in a non-quota restriction and in a non-saturated market.

Base situation. The parameters in the profit equation reflect the Italian dairy industry situation, where a pure breed system is largely adopted and Italian Holstein-Friesian is the main dairy cattle breed. In 2012, the average 305-d milk yield, fat content, and protein content were 9,072 kg, 3.66%, and 3.31%, respectively (AIA (2012)). Milk carrier yield was calculated as the difference between lactation milk yield and protein and fat yields. Population means for SCS, RCT, and a_{30} were those reported by Cassandro et al. (2008) for Italian Holstein-Friesian cows. Estimation of costs for Grana Padano cheese production (Ccheese) were retrieved from Grana Padano Consortium (2011) and they included raw materials, electricity, milk collection (e.g., fuel), commercialization, work, depreciation charge, and other general expenses. Costs for cow maintenance (Cmaintenance), and milk carrier (Ccarrier), milk fat (Cfat), and milk protein (Cprotein) yields were obtained assuming a simple ration of 4 components and they were expressed as average costs per MJ metabolizable energy (ME).

Parameters for Grana Padano dairy industry. The production of Grana Padano cheese followed the official protocol approved by Grana Padano Consortium (2011). In order to assign a value to milk components, the payment system for milk destined to Grana Padano cheese production was considered. Product yields and values of milk components were estimated based on milk quality parameters in the basic situation and proper cheese yield formulas.

The estimation of prices for RCT and a_{30} were based on the simulation of three scenarios of payment systems. The payment systems assumed that the maximum difference in cheese yield between milk with the worst and the best MCP was 2.5, 5, or 10%.

Results and Discussion

The base situation considered the average cow reared in a typical herd of the Grana Padano area. This cow had a mature weight of 668 kg and produced 9,072 kg of milk per lactation (305 d) (AIA (2012)). Average fat content and protein content were 3.66% and 3.31%, respectively (AIA (2012)), and average SCS, RCT, and a_{30} were 3.08, 16.9 min, and 32.0 mm, respectively (Cassandro et al. (2008)). The energy level of the ration was 11.06 MJ ME/kg dry matter, with total energy requirements of 45,795.22 MJ net energy/year. The cost of processing cheese was assumed 20.5% of the price of 1 kg of cheese. Prices per kg of butter and whey were assumed 39.5% and 0.42% of the price of 1 kg of cheese, respectively.

As expected, fat, protein, and carrier yield showed positive EV (Table 1).

Table 1. Economic values (EV) of milk yield traits.

Trait	Base[§]	σ_g[¥]	EV, Euro/unit
Fat, kg/305 d	332	33.7	+2.118
Protein, kg/305 d	300	27.1	+8.442
Carrier, kg/305 d	8,440	875	+0.033

[§]Base = overall means of milk production with a calving interval of 365 d.
[¥]Genetic standard deviation (Interbull (2011)).

Per unit of genetic standard deviation, the ratio of EV of protein to fat yield was 3.99 (Table 1).

The most important results of this study were the EV for MCP (Table 2). Negative EV were estimated for RCT. In contrast, EV for a_{30} were positive and in absolute value they were 2.5 times lower than those of RCT.

Table 2. Economic values (EV) of milk coagulation properties (MCP) for different scenarios (+2.5, +5.0, and +10%) of increments in cheese yield due to the effect of MCP.

			EV, Euro/unit		
Trait[§]	Base[¥]	σ_g[&]	+2.5%	+5.0%	+10%
RCT, min	16.9	2.22	-2.178	-4.356	-8.711
a_{30}, mm	32.0	4.06	+0.863	+1.727	+3.453

[§]RCT = rennet coagulation time; a_{30} = curd firmness.
[¥]Base = overall means of RCT and a_{30} (Cassandro et al. (2008)).
[&]Genetic standard deviation (Cassandro et al. (2008)).

Estimated EV for RCT and a_{30} changed linearly (in absolute value) moving from +2.5 to +10% increments in cheese yield due to the effect of MCP. Further research is needed on the effect of MCP on different cheese productions.

Conclusions

This study estimated EV for MCP that can be combined with estimated breeding values to compute aggregate breeding values for Holstein-Friesian cattle in Italy for a PDO cheese making area. Economic values of MCP showed considerable variation among different scenarios of cheese yield affected by MCP. Application of breeding objectives for dairy cattle in PDO cheese area should pay for milk based on MCP.

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