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Estimation of economic values for milk coagulation properties in Italian Holstein-Friesian cattle

M. Cassandro,*[1] D. Pretto,† N. Lopez-Villalobos,‡ M. De Marchi,* and M. Penasa*
*Department of Agronomy, Food, Natural Resources, Animals and Environment, University of Padova, Viale dell'Università 16, 35020 Legnaro (PD), Italy
†Institute of Veterinary Medicine and Animal Sciences, Estonian University of Life Sciences, Kreutzwaldi 1, 51014 Tartu, Estonia
‡Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Private Bag 11-222, Palmerston North, New Zealand

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) increment in cheese yield due to the effect of milk coagulation properties (MCP). A model was developed to simulate the transformation of milk into Grana Padano cheese. The EV of RCT and a_{30} were −€2.213, −€4.426, and −€8.852/min, and €0.877, €1.755, and €3.509/mm for scenarios 1, 2, and 3, respectively. Relative emphasis of traits in the breeding objectives of the Italian Holstein-Friesian dairy cattle population should account for the effect of MCP on cheese yield. Economic values for milk components and MCP were affected by changes of dairy products, whereas variations of feed prices did not influence EV of RCT and a_{30}.
Key words: economic value, milk coagulation property, milk production, Italian Holstein-Friesian cattle

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 are prone to change over time, along with the trait focus and the economic perspective, and as a consequence, traits included in a selection index can also change (Groen, 1989). In this context, selection indices are continuously improved as new technologies and information become available (Shook, 2006). A breeding scheme based on progeny testing and a selection index giving large emphasis on milk, fat, and protein production per cow were defined in Italian Holstein dairy cattle in 1985 (Burnside et al., 1992) and several changes in the selection index have occurred during the years to include functional and type traits. 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 (Hazel, 1943).

In Italy, the amount of cheese manufactured per year is 1,171,000 t (274,000 t are exported; ISTAT, 2011), which represents 6.1% of worldwide cheese production, and the amount of butter produced is 102,400 t (ISTAT, 2011). The Italian Holstein-Friesian is the most important dairy cattle breed and it accounts for 1,128,626 herd-tested cows reared in 12,922 farms, which means an average herd size of 87 cows. The breed is spread across the country, but 80% of animals are concentrated in the north. 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 such as the Grana Padano, Parmigiano-Reggiano, Gorgonzola, and Asiago (Pieri, 2010). Therefore, the quality of milk used for cheese production is very important in Italy and milk coagulation properties (**MCP**) are of particular interest (Cassandro et al., 2008). The MCP have been widely studied in recent years and have been proposed as technological traits to increase the efficiency of the dairy industry (De Marchi et al., 2008; Pretto et al., 2012, 2013). Also, MCP can be rapidly and cheaply predicted using mid-infrared spectroscopy, which allows the collection of phenotypes at the population level (De Marchi et al., 2014).

The genetic background for MCP has been investigated in several studies that have examined breed effects (De Marchi et al., 2008; Varotto et al., 2015) and exploitable additive genetic variation for the aptitude of milk to coagulate (Cassandro et al., 2008; Tiezzi et al., 2013). Moreover, Pretto et al. (2012) estimated

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[1]Corresponding author: martino.cassandro@unipd.it

the genetic responses for MCP in the Italian Holstein-Friesian dairy population under the current and alternative selection indices and breeding objectives. Those authors demonstrated the possibility of including MCP in the selection index to obtain annual genetic gains for rennet coagulation time (**RCT**) and curd firmness (**a_{30}**) without deteriorating the annual genetic response for milk, fat, and protein yields.

Few studies have estimated the effect of MCP on cheese yield under field conditions, that is, at an industry level where milk with good MCP can produce between 2 to 10% more cheese than milk with poorer suitability to coagulate (Aleandri et al., 1989; Pretto et al., 2013). Due to the importance of MCP in Italy, interest is notable to include MCP in milk payment systems and selection indices. Estimates of EV are necessary to determine the relative importance of the traits in the breeding objective (Hazel, 1943). Therefore, the aim of this study was to calculate the EV for RCT, a_{30}, and production traits of milk destined for the manufacture of Grana Padano cheese in Italian Holstein-Friesian dairy cattle.

MATERIALS AND METHODS

Basic Situation

Production parameters used in this study as the basic situation (Table 1) reflect the structure of the Italian dairy industry where the pure breed system is largely adopted, Italian Holstein-Friesian is the main dairy cattle breed, and Grana Padano is the most popular dairy product. The average Italian Holstein-Friesian cow reared in a typical herd of the Grana Padano area had a predicted BW of 668 kg (Cassandro et al., 1997), and a median for days open of 147 d (AIA, 2012). Average 305-d milk production, fat content, and protein content were 9,072 kg, 3.66%, and 3.31%, respectively (AIA, 2012). Mean values of MCP were retrieved from Cassandro et al. (2008) and casein content was calculated from protein content assuming a casein-to-protein ratio of 0.78 (Norman et al., 1991).

According to Pieri (2010), about 16% of total Italian milk is used to produce Grana Padano, a hard and long-ripened PDO cheese obtained from partially skimmed raw milk. The production follows a strict protocol according to European regulations (no. 2081/92 and no. 1107/96) and the Grana Padano Consortium. Full details of the cheese-making process can be obtained from Pretto et al. (2013). Briefly, after collection, the milk is stored in shallow settling tanks for about 12 h so that the fat can naturally rise to the surface (natural creaming). This process is driven to obtain a partially skim milk with fat-to-casein ratio (**F:C**) of about 1. The cream resulting from the natural creaming is usually destined for the production of butter. Partially skim milk is then transferred to copper bell-shaped vats that contain 1,000 kg of milk and processed according to the following steps: (1) addition of natural whey starter, (2) heating of milk to 30°C; (3) addition of powder calf rennet, (4) breaking up of the curd, and (5) cooking of the curd until temperature reaches 53.5°C. Two wheels are obtained for each vat. After 2 d of drainage, the wheels are placed into brine for approximately 3 wk and then transferred to the warehouse for a minimum ripening period of 9 mo, under controlled conditions of temperature and humidity.

Profit Function

The profit per cow per year (Π) was calculated using the following function:

$$\Pi = R - C, \quad [1]$$

where R are revenues and C are costs per cow. In the present study, only revenues from selling of Grana Padano cheese, butter and whey, and only costs for feed related to milk production, milk collection, and cheese processing were assumed to be a function of the evaluated milk traits. All other revenues and costs on farms were not considered in the profit function because their partial derivative with respect to these milk traits is zero.

The dairy market in Europe has been restricted by a quota system, which was introduced by the European Union and was in place from 1984 to April 2015. In

Table 1. Production parameters in the basic situation

Production parameter[1]	Mean
305-d milk production, kg	9,072[2]
Fat, %	3.66[2]
Protein, %	3.31[2]
Casein, %	2.58[3]
305-d fat production, kg	332
305-d protein production, kg	300
305-d milk carrier production, kg	8,440[4]
RCT, min	16.90[5]
a_{30}, mm	32.00[5]

[1]RCT = rennet coagulation time; a_{30} = curd firmness 30 min after rennet addition.

[2]AIA (2012).

[3]Assuming a protein to casein ratio of 0.78 (Norman et al., 1991).

[4]Calculated as milk production − (fat production + protein production).

[5]Cassandro et al. (2008).

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