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Milk acidity, curd firming time, curd firmness and protein and fat losses in the Parmigiano-Reggiano cheesemaking

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RIASSUNTO – Acidità del latte, tempo di rassodamento, consistenza del coagulo e perdite di grasso e di proteina nella caseificazione a Parmigiano-Reggiano. – *Sono state condotte 102 prove di caseificazione presso 3 caseifici in provincia di Parma. I campioni di latte sono stati prelevati da altrettante caldaie della capacità di 1100 kg ciascuna. Sui corrispondenti 102 campioni di siero sono stati determinati sostanza secca, grasso, proteina e curd fines (particelle di cagliata). Le perdite di grasso e di proteina sono state pari a 17,50 e 26,82%, rispettivamente. Il contenuto di curd fines è risultato di 108 mg per kg di siero. I parametri curd fines e perdita di proteina sono risultati correlati negativamente con l'acidità titolabile e con la consistenza del coagulo. Gli stessi sono risultati correlati positivamente con il tempo di rassodamento del coagulo. Ciò dimostra il ruolo primario che questa caratteristica svolge nel determinismo delle proprietà reologiche della cagliata nella produzione del Parmigiano-Reggiano.*

Key words: Parmigiano-Reggiano cheese, milk acidity, curd properties, cheesemaking losses.

INTRODUCTION – The cheese yield depends on the milk casein content and on the fat to casein ratio. The efficiency of the milk transformation depends on curd particles ("curd fines") that remain in the cooked whey and on the losses of fat and casein as it is. These variables are related to the rheological properties of the curd, and several milk characteristics, like acidity, reactivity with rennet, somatic cells, *etc.* (Barbano, 1994; Lucey and Kelly, 1994). The Parmigiano-Reggiano cheese is a hard and long ripened cheese, based on formation and dehydration of an acid-rennet curd. The aim of this research was to study the entity of cheesemaking losses in the Parmigiano-Reggiano manufacture and to make a relationship with titratable acidity and the main rennet-coagulation properties of milk.

MATERIAL AND METHODS – The study was carried out on partially skimmed vat milk. This milk was obtained by mixing the partially skimmed milk (by natural creaming for 12 hours) of the evening milking and the whole milk of the morning milking. A total of 102 samples of milk (M), each one representative of 1100 kg of milk and the corresponding 102 samples of cooked whey (W) were evaluated for the following parameters: crude protein and casein M and W (Aschaffenburg and Drewry, 1959); IR fat M according to Biggs (1978) with Milkoscan 134 A/B; Gerber fat W (Savini, 1946); lactodynamographic parameters M (Annibaldi *et al.*, 1977)

with Formagraph; titratable acidity M and dry matter M and W (Savini, 1946). Curd fines are determined by the following method (van den Berg, 1973): 240 g of cooked whey are weighed into a tube and centrifuged for 15 minutes at 300 rpm; the supernatant is removed. The sediment is quantitatively poured into a Buckner funnel containing a Watman 40 filter. The filter is dried in a stove for 2 h and then weighed. Curd fines are expressed as mg of sediment in 1000 g of cooked whey. Cheesemaking losses (fat loss, dry matter loss, protein loss) were calculated as follows (e.g. for fat loss): cooked whey fat (g/100 g) * 100 / vat milk fat (g/100 g). The values were tested by analysis of the variance (SPSS). Correlations were calculated after logarithmic transformation of the data.

RESULTS AND CONCLUSIONS – The partially skimmed vat milk had an average dry matter content of 11.69% (Table 1). Fat content on average was low. Fat to casein ratio was practically optimal for this particular manufacture, however it manifested a wide variability (from 0.87 to 1.25). Fat content variability (*min*. 2.02%; *max*. 3.13%) was higher than casein content variability, whose values were ranging from 2.11 to 2.65%. Titratable acidity was 3.28 °SH per 50 ml of milk. This value tends to confirm the worsening of such important dairy-technological property (Sandri *et al.*, 2001; Castagnetti and Bertolini, 2002). The clotting time resulted high (19.04 min). The curd firming time manifested a high variability (CV=45.92%). Also curd firmness showed a marked variation (CV=27.85%); however, its average value (24.67 mm) was lower than what expected. The dry matter of the cooked whey resulted equal to 7.74%. The fat content (0.46%) was characterised by a high variability. The crude protein was equal to 0.85%. Average values observed for cooked whey agree with the results reported by Fossa *et al.* (1994). The relative loss of dry matter, equal to 66.30%, was included between a *minimum* of 58.93 and a *maximum* of 72.89%. The loss of crude protein represented the 26.82% of the total nitrogen, in agreement with the data reported by Fossa *et al.* (1994). Fat loss, on average equal to 17.50%, was ranging between a *minimum* of 12.15 and a *maximum* of 24.10%. Tedeschi *et al.* (1993) reported a value of 18.90%.

Table 1. Vat milk, cooked whey characteristics and cheesemaking losses (see Materials and methods).

		Mean±ds	*min*.	*max*.
Vat milk[(1)]				
Dry matter	g/100g	11.69±0.36	10.67	12.45
Fat	g/100g	2.64±0.24	2.02	3.13
Crude protein	g/100g	3.17±0.13	2.76	3.40
Casein	g/100g	2.45±0.11	2.11	2.65
Titratable acidity	°SH/50	3.28±0.11	3.00	3.60
Clotting time, r	min	19.04±2.27	14.50	23.75
Curd firming time, k_{20}	min	7.84±3.60	2.75	22.00
Curd firmness, a_{30}	mm	24.67±6.87	9.44	38.10
Cooked whey				
Dry matter	g/100g	7.74±0.38	6.91	8.59
Fat	g/100g	0.46±0.10	0.30	0.70
Crude protein	g/100g	0.85±0.04	0.76	0.93
Curd fines	mg/kg	108±49	25	325
Cheesemaking losses				
Dry matter	%	66.30±3.07	58.93	72.89
Fat	%	17.50±3.12	12.15	24.10
Crude protein	%	26.82±0.82	23.45	28.58

[(1)]Partially skimmed milk (see the text).

The curd fines resulted negatively correlated both with titratable acidity (r=-0.22) and with curd firmness (r=-0.23) (Table 2). The same parameter was positively correlated with curd firming time (r=0.22). Also protein loss was positively correlated with curd firming time (r=0.25), while it was negatively correlated both with titratable acidity (r=-0.27) and with curd firmness (r=-0.21). These results indicate that the micelle aggregation rate can play a role, together with other factors, in the determinism of the rheological properties of the curd in the Parmigiano-Reggiano cheese manufacture.

Table 2. Correlations between titratable acidity, milk properties and cheesemaking losses.

	Titratable acidity	Clotting time	Curd firming time	Curd firmness
Curd fines	– 0.22 *	0.15	0.22 *	– 0.23 *
Dry matter loss	– 0.13	0.14	0.16	– 0.16
Fat loss	– 0.12	0.08	0.16	– 0.14
Crude protein loss	– 0.27 **	0.12	0.25 *	– 0.21 *

* P<0.05; ** P<0.01

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