

Effect of cold storage and calcium addition on milk with distinct coagulation abilities

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Introduction

The coagulation properties of milk from individual cows is among others affected by the mineral content and casein profile (Frederiksen et al., 2011; Jensen et al., 2012). This project aims to study how processing steps – cold storage, CaCl₂ addition and pH adjustment – can impact rennet-induced coagulation and calcium distribution of milks with distinct coagulation abilities.

Experiments

In *Experiment 1* we studied the effect storage time at 4 °C (0, 24, 48 and 72 h) on the rennet coagulation time (min) and curd firming rate ($[\Delta G'/\Delta t]_{lin}$, in Pa/min) of milks from individual cows with a previous record of having significantly good (n=4) or poor (n=4) coagulation properties. In the *Experiment 2*, we made a preliminary screening to understand the effect of calcium addition (0.01% CaCl₂) and pH adjustment (6.50 ± 0.02) on milk coagulation properties in milk samples from cows presenting 'good', 'poor' and 'non-coagulating' properties.

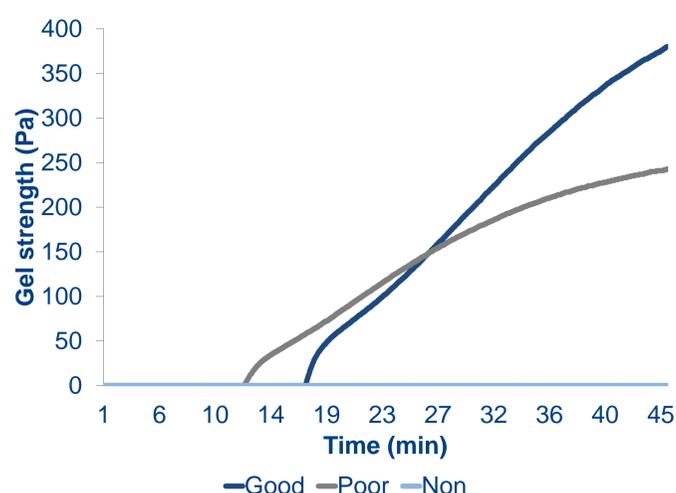


Figure 1. *Experiment 2.* Gel strengths as identified by free oscillatory rheology (ReoRox 4) in milk samples from individual cows with distinct coagulation abilities (good, poor and non).

Table 1. *Experiment 1.* LS-Means of rennet coagulation time (RCT) and curd firming rate (CFR) of milk as function of storage time and coagulating status (poor or good) as determined by ReoRox 4 (Medirox, Sweden).

Parameter		Storage time at 4° C			
		0 h	24 h	48 h	72 h
RCT (min)	Poor	17.1 ^b	20.5 ^a	20.3 ^a	20.2 ^a
	Good	13.1 ^d	16.1 ^{bc}	14.6 ^{cd}	15.2 ^{bcd}
CFR (Pa/min)	Poor	14.1 ^b	11.7 ^b	15.3 ^b	12.9 ^b
	Good	27.6 ^a	22.8 ^a	28.6 ^a	24.6 ^a

^{a-d} figures within same parameter (RCT or CFT) with different superscripts are significantly different (P<0.05).

Results

Milk samples with good, poor and non-coagulating properties show distinct coagulation time and gel strength (Figure 1). Cold storage did not affect CFR of poor and good coagulation milk (Table 1), whereas mean RCTs were 18% and 16% longer for good and poor coagulation milks, respectively. From the *Experiment 2*, it was shown that good coagulation properties were positively related to the total Ca level and inversely related to the serum Ca/total Ca ratio and micellar size (Table 2). Addition of CaCl₂ improved milk coagulation as reflected by higher CFRs and shorter RCTs irrespective of coagulation background (Fig. 2). This effect was even more pronounced, when pH was adjusted to 6.5. Differences in RCT were minimized by pH adjustment to 6.5

Conclusion

Improved coagulation properties in milk samples from individual cows seem to be related to micelle size as well as calcium content and distribution. CaCl₂ addition improved coagulation properties and the shorter RCTs at lower pH could reflect improved rennet activity. This preliminary study indicates that micellar calcium, rather than serum calcium, may play a major role in milk coagulation properties.

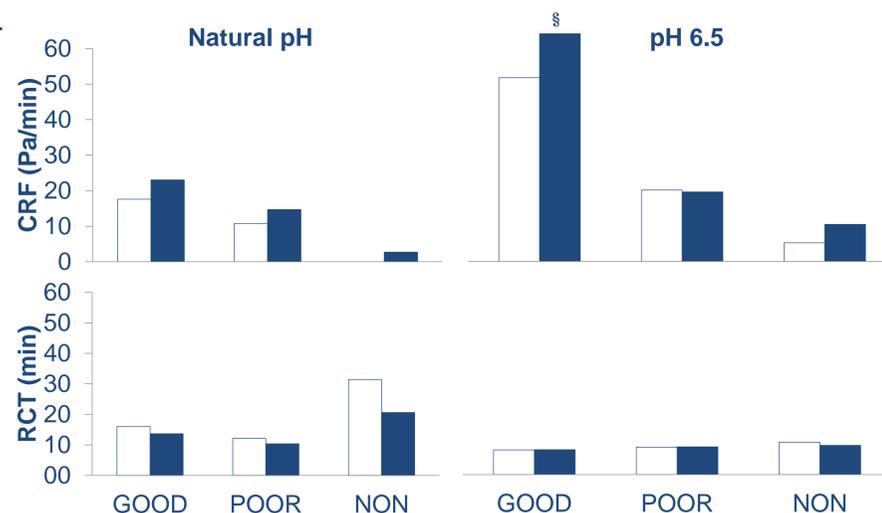


Figure 2. *Experiment 2.* Means of curding firming rate CFR (upper charts) and rennet coagulation time RCT (lower charts) of milks with different coagulation status with (closed bars) or without (open bars) CaCl₂ addition. § not detectable

Table 2. *Experiment 2.* pH, calcium distribution and casein micellar size (Mastersizer 3000, Malvern) of individual cows representing distinct coagulation properties as determined by ReoRox 4 (Medirox, Sweden).

Parameter	Good coagulating		Poor coagulating		Non-coagulating	
	Control ^a	CaCl ₂ ^b	Control	CaCl ₂	Control	CaCl ₂
pH	6.92 ^c	6.5 ^d	6.89	6.5	6.79	6.5
Total Ca (mM)	35.8	-	29.5	-	26.8	-
Serum Ca (mM)	6.4	7.8	6.8	8.1	6.7	8.4
Serum:Total Ca	0.18	0.22	-	-	0.23	0.28
Micellar size (um)	93.1	-	117.9	-	181.1	-

^a No addition of CaCl₂; ^b Addition of 0.01% CaCl₂; ^c Natural pH; ^d pH adjusted to 6.50 ± 0.02

