Development of milk coagulation properties during cold storage

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It is well reported in the literature that good coagulating milk has higher contents of micellar minerals and different casein profile compared with poor coagulating milk. When cold stored, casein micelles undergo dissolution of the colloidal calcium phosphate and casein fractions, which is reported to impair milk rennet coagulation by increasing the rennet coagulation time (RCT), reducing curd firming rate (CFR) and curd firmness (G'max), hence potentially lowering the cheese yield at the dairies. However, it is still unknown whether cold storage impacts chymosin-induced coagulation of milks with distinct coagulation abilities in the same way. The aim of the present work was to study the effect of cold storage (0, 24, 48, 72 h) on chymosin-induced coagulation properties (RCT, CFR and G'max), and evaluate the effect of coagulation in relation to micelle size, mineral distribution, pH, and caseinomacropeptide (CMP) formation in milk samples from individual Holstein cows, previously classified as yielding milk with 'good' (n=4) or 'poor' (n=4) coagulation properties. Coagulation properties were measured by an oscillatory rheometer (ReoRox 4), P content was quantified by a vanadomolybdate colorimetric procedure, and Ca and Mg content were determined by atomic absorption spectrometry. Average micelle diameter and size distribution of casein micelles were determined by dynamic light scattering. The caseinomacropeptide content was determined at 0, 0.5 and 60 minutes after chymosin addition and quantified by RP-HPLC. The obtained data for the above mentioned parameters were subjected to statistical analysis by the Generalised Linear Model (GLM) procedure using a two-way model. Results showed that good coagulating milk presented casein micelles with smaller size ($P < 0.064$), 14 and 8% higher levels of total and colloidal calcium, respectively ($P < 0.01$), and a tendency of higher amounts of colloidal phosphorus ($P = 0.10$). No significant differences were found in the mineral distribution or pH when comparing poor and good coagulating milk in relation to cold storage. Overall there was no significant difference in the CMP content between milk types ($P < 0.05$), and the maximum CMP content was reached within 0.5 min after

chymosin addition. This result confirms that the first phase of the enzymatic coagulation, i.e. hydrolysis of the κ-casein by chymosin, occurs at comparable levels in both good and poor coagulating milks. After 24 h of cold storage the mean level of CMP had significantly increased by ~70%, and remained at the same also after 72 h storage. RCT was significantly increased after 24 h of cold storage in both good and poor coagulating milk samples, while no significant effect was noticed for the development in CFR during cold storage. Intriguingly, the RCT of poor coagulating milk samples remained significantly longer after 72h of cold storage, showing that milk with different coagulation background stored at low temperatures a few days prior to processing may develop differently in relation to their raw milk quality, and could potentially introduce variability during further processing at the dairy. Indeed, G'max of good coagulating milk samples was reduced after 72 h of cold storage, whereas no impairment was noticed for poor coagulating samples. Such differences found in the coagulation properties of the studied milks are presumably attributed to changes in micelle size as a result of β-CN migration and potential degradation by plasmin. However, further studies are needed to fully understand the physicochemical mechanisms behind chymosin-induced coagulation impairment on milk with distinct coagulation abilities.