Joint effects of *CSN3* and *LGB* genes on coagulation properties in Czech Fleckvieh

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Abstract
The aim of this study was to determine the joint effects of *CSN3* and *LGB* genotypes on parameters of quality and coagulation of milk in Czech Fleckvieh cows. Three hundred and twenty-eight Czech Fleckvieh cows were determined for *CSN3* (kappa-casein) and *LGB* (beta-lactoglobulin) genotypes using the PCR-RFLP method, milk quality parameters and coagulation properties. Fifteen genotype combinations were detected, with *ABAB* (21.0%) and *AAAB* (18.3%) occurring as the most frequent. The observed genes significantly affected the contents of milk protein (crude protein, true protein, casein and whey protein) as well as solid non-fat in milk, casein number and curd quality. *BBAA* was found to be the genotype with the highest positive impact on most of the milk characteristics evaluated. Whereas *ABBB*, *BBBB*, *BBAB* and *ABAB* had a positive influence on milk quality and milk coagulation properties, genotypes containing *CSN3* allele *E* had a negative effect.

Keywords: cattle; milk protein genes; kappa-casein; beta-lactoglobulin; milk production parameters; coagulation properties

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Introduction

Milk protein genes, especially kappa-casein (*CSN3*) and beta-lactoglobulin (*LGB*), are important determinants of milk quality and milk coagulation properties. The kappa-casein gene (*CSN3*) is situated on bovine chromosome 6. Allele *A* has been reported as the most frequent, with the effect of increasing milk yield but decreasing protein content (Neubauerová, 2001; Kučerová et al., 2005). Allele *B* is often referred to as a “key allele”, increasing milk protein quality and coagulation properties (Hanuš et al., 1995; Amigo et al., 2001; Comin et al., 2006), whereas a negative effect of allele *E* on milk coagulation properties was reported by Ikonen et al. (1999a) and Comin et al. (2006). The gene for beta-lactoglobulin (*LGB*) is situated on bovine chromosome 11. Allele *B* was reported to increase milk protein and milk fat contents, while allele *A* increases milk and protein yields (Neubauerová, 2001; Kaminski et al., 2002; Kučerová et al., 2006). The aim of the present study was to investigate the joint effects of *CSN3* and *LGB* genotypes on parameters of milk quality and milk coagulation properties of Czech Fleckvieh cows.

Material and Methods

Three hundred twenty eight of Czech Fleckvieh (CF) cows were genotyped for *CSN3* and *LGB* genotypes by use of PCR-RFLP. Milk samples were collected between 50 and 140 days after first calving and analyzed for contents of dry matter (%), solid non-fat (%), crude protein (%), true protein (%), casein (%), whey protein (%), non-protein nitrogen substances (%), true protein (%), casein number, coagulation time (s), curd quality (graded from 1=excellent to

4=poor), curd firmness (mm) and whey amount (ml). Statistical analysis was carried out by means of the program package SAS using GLM and the following model equation:

$$y_{ijkl} = \mu + HYS_i + G_j + bA_k + e_{ijkl}$$

where:
y = observed characteristic
μ = average of the characteristic
HYS = effect of herd, year and season of calving
G = joint effect of *CSN3* and *LGB* genotypes
bA = effect of the age at first calving of cow
e = residual effect

Results and discussion

Fifteen genotype combinations of *CSN3* and *LGB* genes were detected, with *ABAB* (21.0%) and *AAAB* (18.3%) occurring as the most frequent. A significant effect of *CSN3* + *LGB* genotypes was found in almost all milk quality parameters (Table 1), except for the contents of dry matter (DM) and non-protein nitrogen substances (NPNS). This effect was highly significant ($P < 0.001$) for the contents of true protein (TP), casein (C) and whey protein (WP), and for casein number (CN). The most favourable results were associated with genotype combinations *BBAA*, *BBBB* and *ABBB*. Genotype *BBAA* excelled in all parameters except for whey protein content and casein number. Genotypes *BBBB* and *ABBB* resulted in a high casein content and low whey protein content. Genotypes *AAAA*, *ABAA*, *AEAA*, *AAAB* and *BEAB* were linked with the least favourable results. Hanuš at al. (2000) reported that genotypes *BB* of *CSN3* and *LGB* genes significantly increased casein content and casein number, and genotype *AA* of *LGB* gene increased whey protein content in milk of Czech Fleckvieh cows.

Table 1. Joint effects of *CSN*3 + *LGB* genotypes on milk quality parameters (n = 328)

Genotype	*n*	Milk quality parameter							
		DM(%)	SNF**(%)	CP**(%)	TP***(%)	NPNS(%)	C***(%)	WP***(%)	CN***(%)
AAAA	43	13.03	9.05	3.38	3.17	0.21	2.64	0.53	78.05
AAAB	60	13.02	9.04	3.36	3.17	0.19	2.69	0.48	79.87
AABB	35	13.14	9.06	3.39	3.20	0.19	2.73	0.49	80.51
ABAA	33	12.98	8.96	3.32	3.13	0.20	2.59	0.54	77.89
ABAB	69	13.13	9.11	3.44	3.25	0.20	2.76	0.49	80.23
ABBB	33	13.35	9.19	3.54	3.34	0.20	2.90	0.43	82.08
AEAA	2	12.37	9.20	3.32	3.14	0.17	2.58	0.57	77.67
AEAB	6	12.98	9.08	3.35	3.16	0.19	2.68	0.48	80.05
AEBB	6	12.96	8.98	3.29	3.10	0.19	2.72	0.37	82.82
BBAA	5	13.49	9.54	3.78	3.62	0.16	3.07	0.55	81.19
BBAB	12	13.25	9.07	3.44	3.24	0.20	2.77	0.47	80.40
BBBB	12	13.01	9.09	3.47	3.27	0.20	2.82	0.45	81.41
BEAB	6	13.41	8.95	3.33	3.10	0.24	2.65	0.45	79.32
BEBB	5	13.19	9.23	3.49	3.24	0.24	2.83	0.41	81.13

** , *** significance at $P < 0.01$ and $P < 0.001$
DM = dry matter; SNF = solid non-fat; CP = crude protein; TP = true protein; NPNS = non-protein nitrogen substances; C = casein; WP = whey protein; CN = casein number

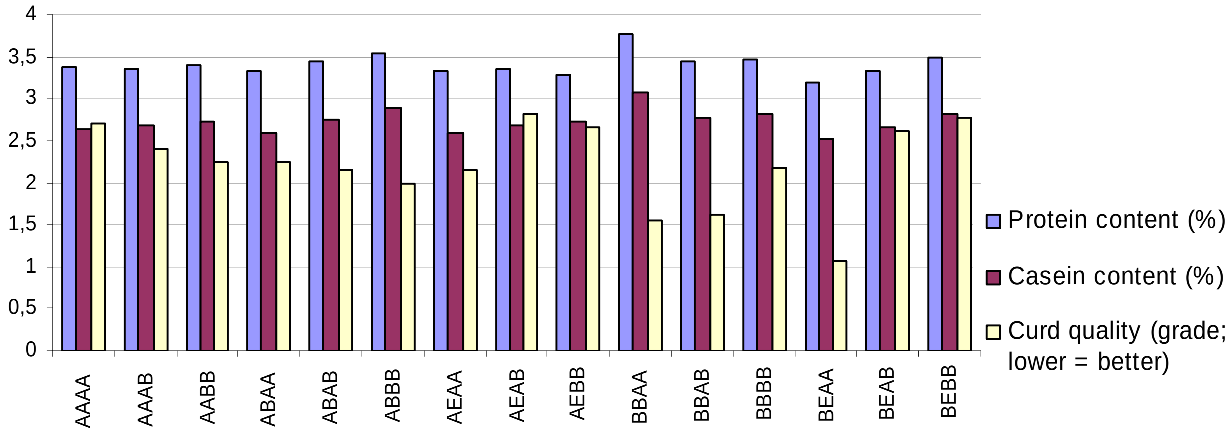
Regarding cheese-making characteristics, the joint effects of *CSN3* and *LGB* genes were significant only on curd quality (Table 2). As for milk quality and milk production characteristics, the genotype combination *BBAA* had the most favourable influence (Graph 1). Genotype *BBAA* was associated with the shortest coagulation time, and relatively high curd quality and firmness. However, it resulted in a lower amount of eliminated whey relative to other genotypes. Also genotypes *BBAB* and *ABBB* had a positive impact on cheese-making characteristics. Genotype *BBBB* was associated with relatively high curd firmness and good curd quality, but with a long coagulation time. A negative influence on cheesemaking characteristics was caused by genotypes *AEAB*, *AEBB*, *BEBB*, *BEAB* and *AAAA*. Results are in agreement with Choi and Ng-Kwai Hang (2002), who found that the genotype combinations *BBBB*, *BBAB*, *BBAA*, *ABBB* and *AABB* positively affected cheese-making parameters, whereas *AAAA* and *AAAB* had a negative influence. Unfortunately, they did not identify *CSN3* allele *E* in their study. Comin et al. (2006) reported that the genotypes containing *CSN3* allele *E* were associated with poor coagulating milk, and genotypes with *CSN3* allele *B* resulted in the best coagulation properties of milk.

Table 2. Joint effects of *CSN*3 + *LGB* genotypes on cheese-making parameters (n = 328)

Genotype	*n*	Cheese-making parameter			
		coagulation time(s)	curd quality*(grade)	curd firmness(mm)	whey amount(ml)
AAAA	43	126	2.70	1.82	33
AAAB	60	127	2.40	1.78	33
AABB	35	121	2.24	1.82	33
ABAA	33	105	2.24	1.82	34
ABAB	69	110	2.16	1.80	34
ABBB	33	123	1.98	1.77	33
AEAA	2	95	2.16	1.66	35
AEAB	6	181	2.83	1.72	31
AEBB	6	131	2.65	1.88	34
BBAA	5	90	1.55	1.79	32
BBAB	12	100	1.61	1.72	34
BBBB	12	135	2.17	1.68	33
BEAB	6	100	2.62	1.83	35
BEBB	5	110	2.77	1.88	30

* significance at $P < 0.05$

Graph 1. The effect of *CSN3+LGB* genotypes on protein content (%), casein content (%), and curd quality (grade; lower = better curd quality)



Conclusion

A strong influence of the *CSN3* gene in combination with the *LGB* gene on milk protein composition and milk coagulation properties was found. Whereas *CSN3* allele *B* had a positive influence on most characteristics evaluated, allele *E* had a negative impact. Genotypes *ABBB*, *BBBB, BBAB* and *ABAB* had a positive effect on milk quality and coagulation properties, while genotypes containing *CSN3* allele *E* caused a negative response.

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