Variation in protein composition between the milk of individual cows and impacts on physicochemical properties

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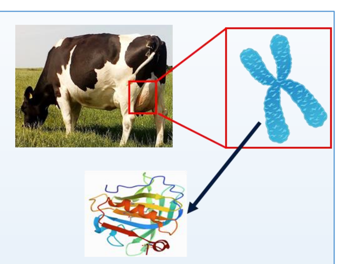
Introduction:



- The nitrogen content of milk is distributed among the caseins, whey proteins and non-protein nitrogen, each of which has an effect on the nutritional value of milk.
- Genetic factors have a major influence on the protein profiles of milk, which in turn are reported to influence milk yield, composition, and milk processability.

Objectives:
- Investigate natural variations in the nitrogen composition and protein profile of individual cows.
- Determine potential correlations between specific protein variants and milk nitrogen fractions and determine the potential for tailoring milk for specific protein dominant product classes.

Methods:

- Samples were fractionated and total nitrogen (TN), non-casein nitrogen (NCN) and non-protein nitrogen (NPN) of all individual milk samples were determined using the Kjeldahl method.

Kjeldahl Titration

- The identification, separation, and quantification of constituent casein and whey proteins was carried out by Reverse Phase High Performance Liquid Chromatography (RP-HPLC).

HPLC

- Heat stability was measured using the oil bath method.
- Casein micelle size and zeta-potential was measured by Malvern Zeta sizer.

Results:

Table 1. Descriptive analysis of 95 individual milk samples

Variable	Mean
Milk yield (kg/milking)	8.78 ± 3.71
SCC	175775 ± 353076
Lactose (%)	4.75 ± 0.16
Total solids (%)	14.30 ± 0.82
Crude protein (%)	3.77 ± 0.38
True protein (%)	3.59 ± 0.45
NCN (%)	0.11 ± 0.02
NPN (%)	0.03 ± 0.004
% Casein	3.08 ± 0.47
% Whey protein	0.53 ± 0.13
Casein number	80.89 ± 3.54

Analysis:

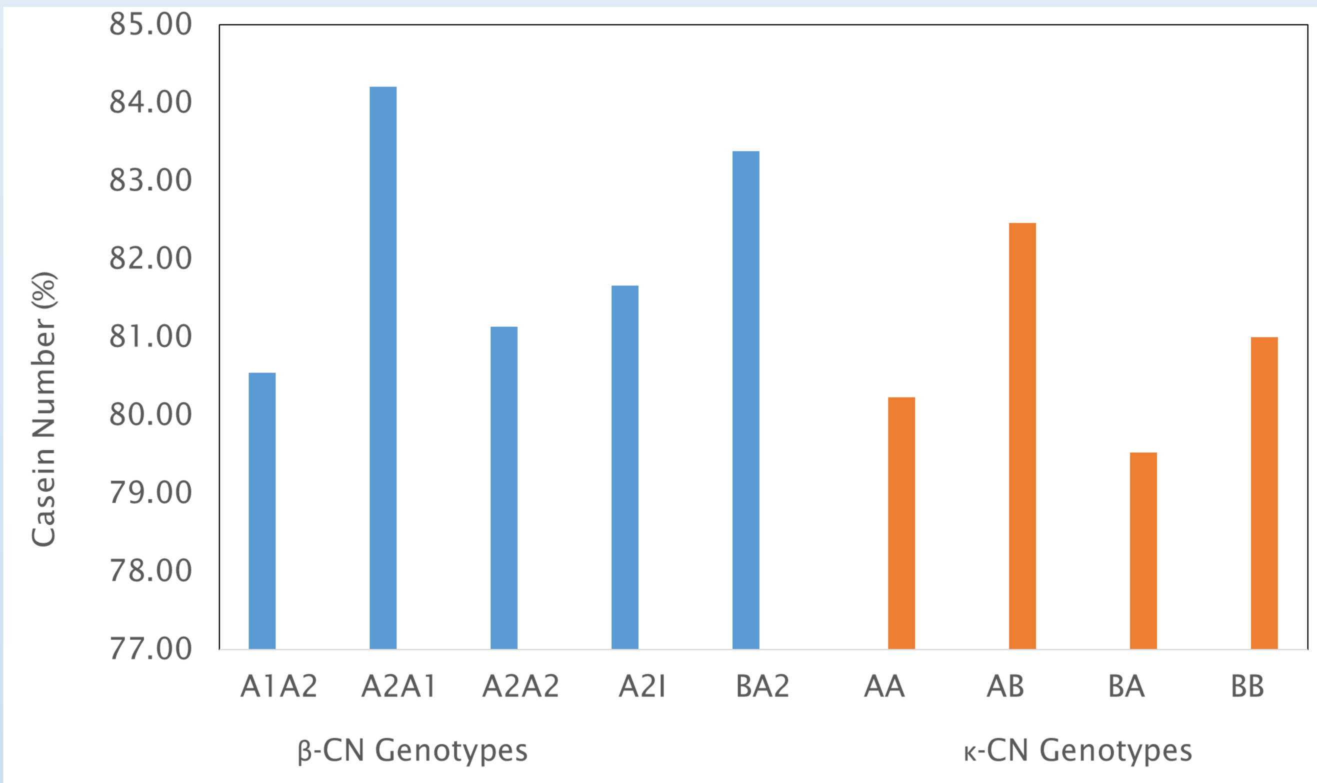


Figure 1. Analysis of different genotypes with casein number, showing moderate differences between β-CN and κ-CN genotypes and milk casein number.

- The presence of κ-CN AB genotype resulted in positive observations in casein number.
- β-CN A2A1 genotype resulted in an observable increase in casein number.

Table 2. Average heat stability, casein micelle size, zeta potential and casein number of high CN:WP ratio and low CN:WP ratio groups of cows.

Casein Number Category	Average heat stability (min)	Micelle Size (nm)	Zeta Potential (mV)	Casein Number
High casein number	12.02 ± 2.82	151.45 ± 17.94	- 24.4 ± 1.93	86.02 ± 5.59
Low casein number	10.65 ± 4.32	161.87 ± 9.37	- 25.7 ± 2.51	75.9 ± 2.83

- **Observations:** that high casein number milk had smaller average micelle size.
- Insubstantial variation in zeta-potential between both categories.
- A slight increase in heat stability was apparent for high casein milk samples.

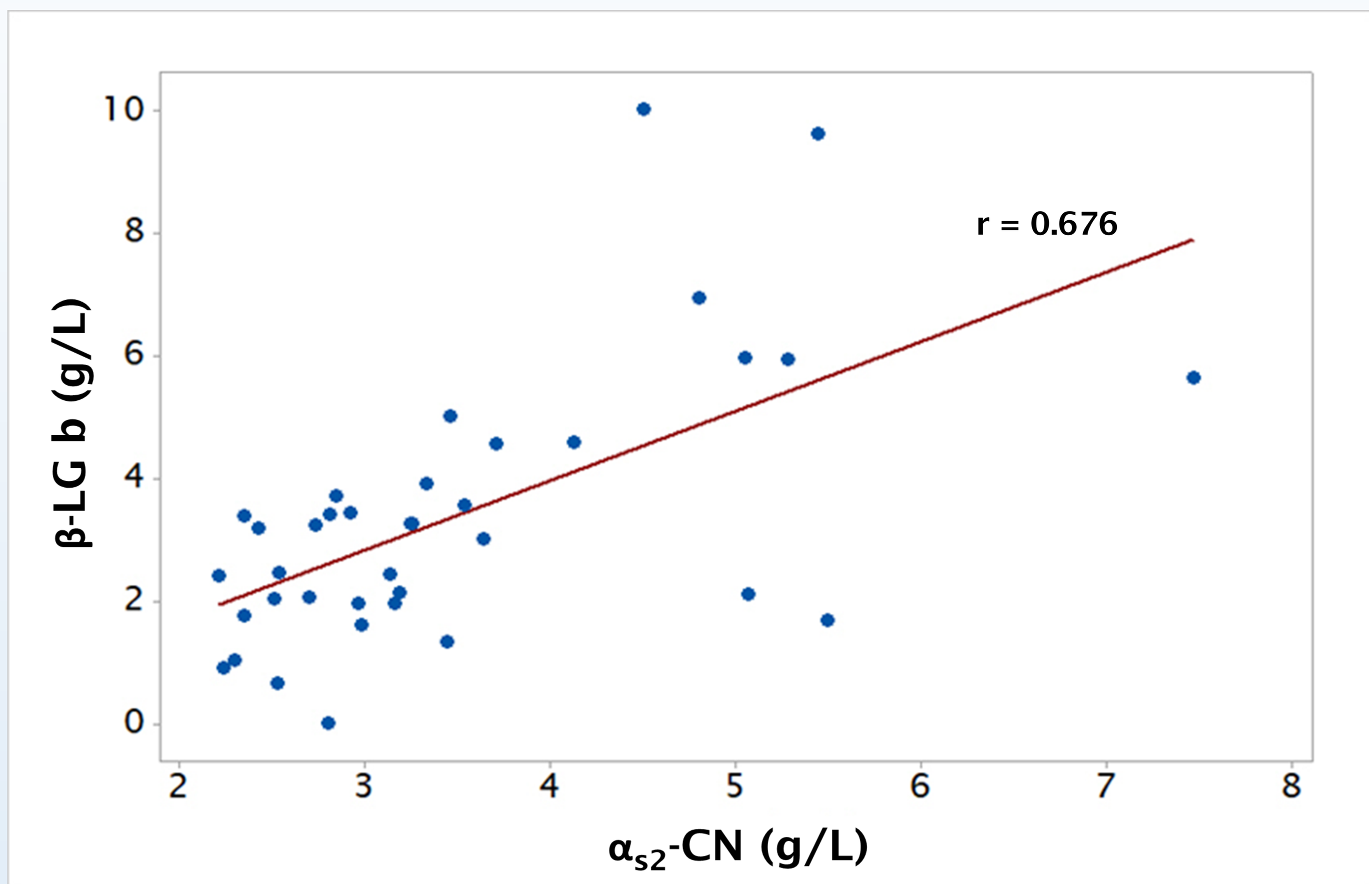


Figure 2. Scatterplot indicating the relationship between individual protein fractions (**n =37**).

- α_{s2}-CN (g/L) was positively correlated with β-LG level (g/L; **p < 0.05**).

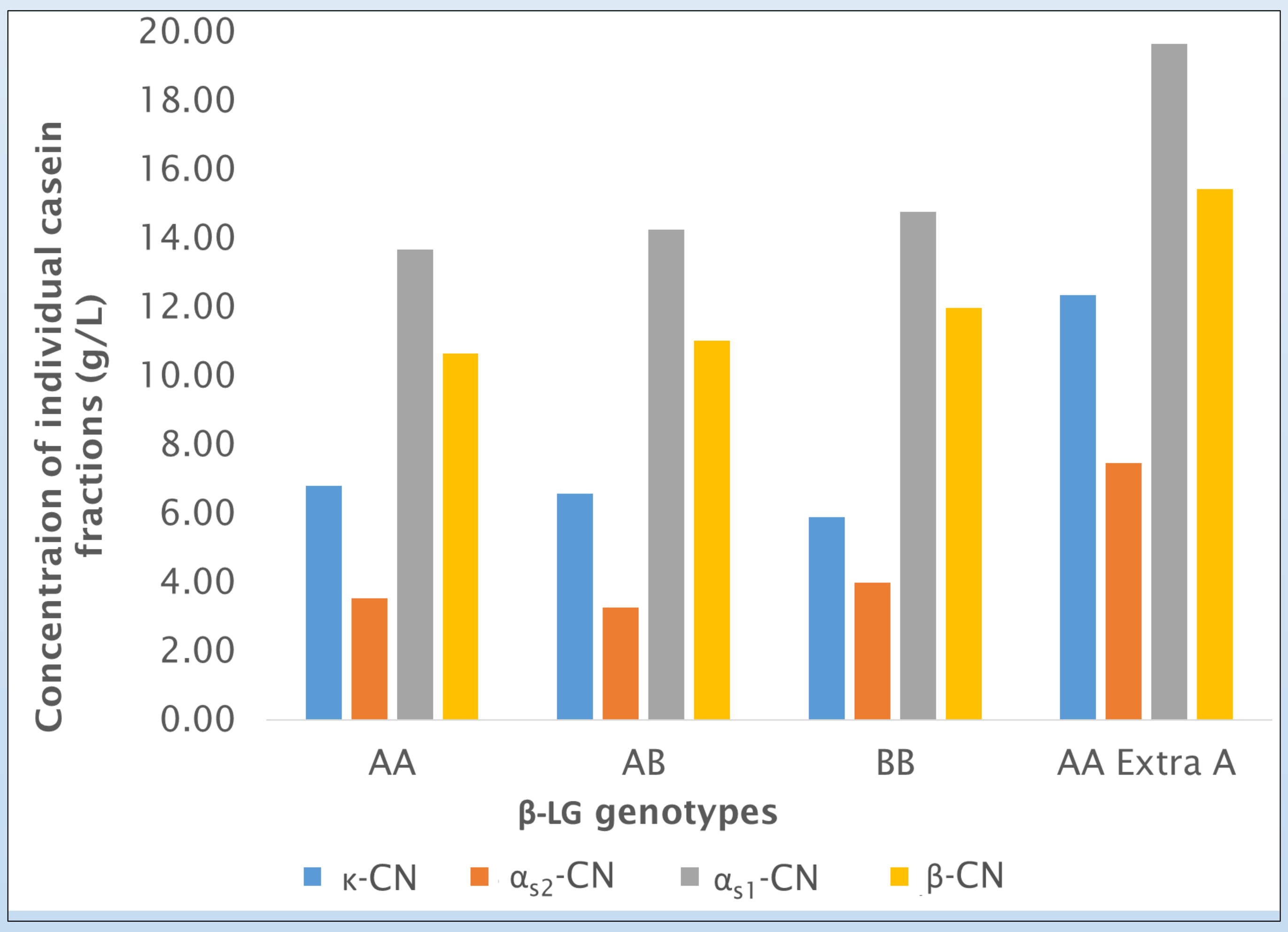


Figure 3. Relative concentration of casein fractions for milk of cows expressing different β-LG genotypes

- The κ-CN AA extra A genotype significantly influences α_{s2}-CN levels (**p < 0.05**).
- The significance of the result for κ-CN AA extra A should be interpreted with caution as only 2 individual samples had this genotype.

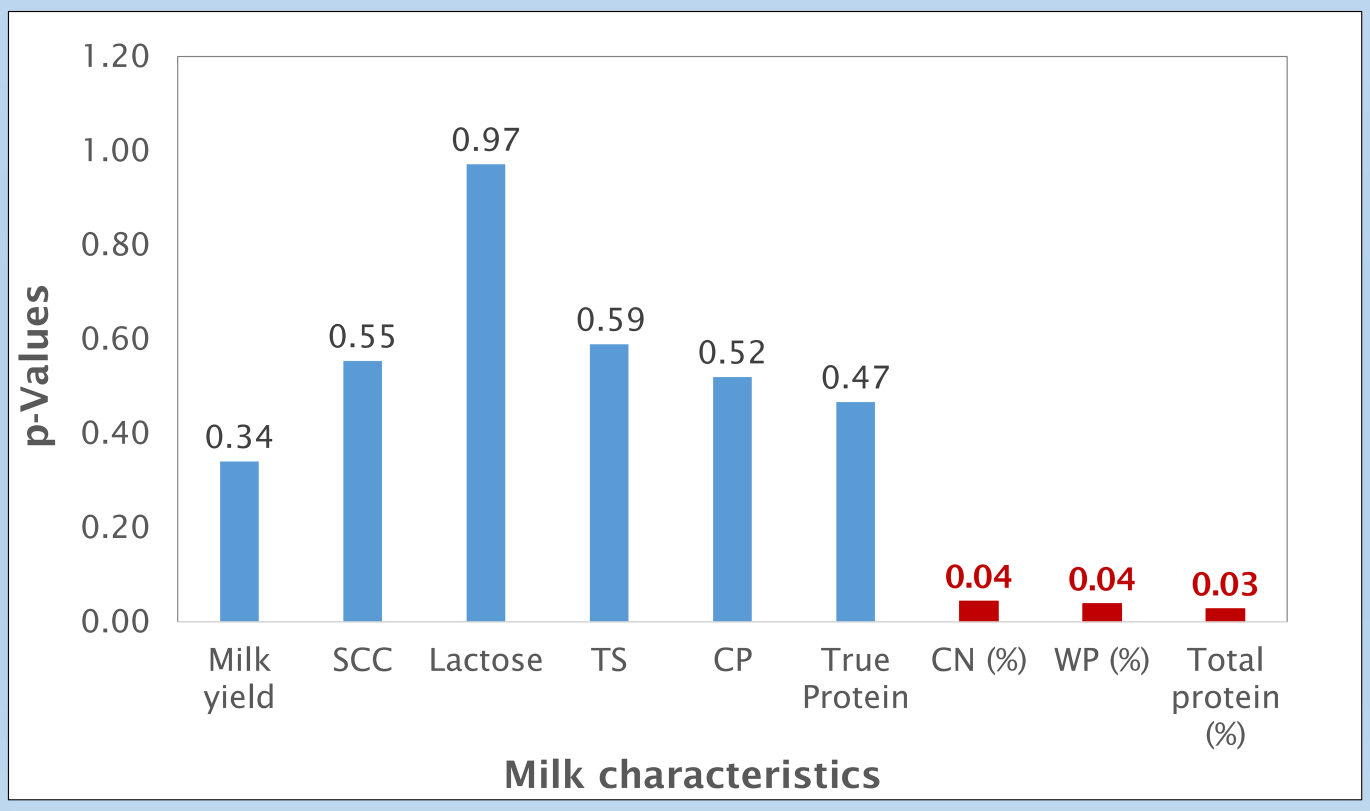


Figure 4. One-way ANOVA analysis of the effect of β-CN genotypes on milk characteristics (red effects are statistically significant).

- Results indicate that β-CN genotype has a statistically significant influence on:
  - Total casein % (**p = 0.04**)
  - Total whey protein % (**p = 0.04**)
  - Total protein % (**p = 0.03**)

Discussion and conclusions:

- Correlation analysis revealed several relationships between the genotypes and protein fractions. However, only the β-LG genotype shows a statistically significant effect on the κ-CN concentration and β-CN genotype shows a statistically significant effect on milk characteristics.
- A better understanding of the functional properties of milk protein genetic variants is key to improving the value of dairy products and the processing behaviour of these protein variants.
- Preliminary results investigating the genotypes, protein profiles and nitrogen fractions, from a random selection of cows, demonstrates that different protein variants present in the milk of individual cows impacts milk composition and has potential to be utilised for different product streams.

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