ASSOCIATION OF MILK PROTEIN POLYMORPHISMS WITH MILK PRODUCTION TRAITS IN TWO BELGIAN DAIRY BREEDS USING AN ANIMAL MODEL

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SUMMARY

Milk from a representative sample of the Belgian dairy cattle composed of 797 Black and White and 226 Red and White cows was collected at the milk station in the State Agricultural Research Station in Gembloux. These samples were phenotyped for α_{s1}-casein, β-casein, κ-casein and β-lactoglobulin by isoelectric focusing on an acrylamide gel. Milk, fat and protein productions were available on these cows. Linkage disequilibrium of the casein loci and the relationship between milk protein genotypes and production traits (milk yield, fat yield, protein yield, fat percentage, protein percentage) was investigated. Gene frequencies were similar to those found in other studies. Linkage was confirmed between β-CN and κ-CN , and also between the αs1-CN and β-CN loci for the two breeds. In the Belgian Black and White, linkage between αs1-CN and κ-CN was confirmed as well. As in other studies, casein haplotypes (α_{s1}-, β- and κ-CN) BBB and CA_3A occurred in the population more often than would be expected from a random combination of the alleles. Animal model analysis of the production data indicated a significant positive effect of the BB genotype of the κ-CN on protein percentage in the Red and White breed. In the Black and White breed, the AA genotype of the β-LG genotype had a negative impact on fat production compared to AB and BB genotypes, while the BB genotype of the α_{s1}-CN had a positive effect on fat yield, and the A_1A_1 genotype of the β-CN had a negative effect on milk production, and a positive one on fat percentage (significant when compared to A_1A_2 and to A_2A_2).

<u>Abbreviations</u>: CN = casein, LG = lactoglobulin, BW = Black and White, RW = Red and White.

INTRODUCTION

The effects of the milk protein genotype variants on milk production traits have been examined in several studies ((Mac Lean et al., 1984), (Bovenhuis et al., 1992), (Van Eenennaam et al., 1992), (Ng-Kwai-Hang et al., 1984), (Lin et al.,1989), (Ng-Kwai-Hang et al., 1986)). Often, results of these studies conflict with respect to the significance and the size of genotype effects. According to Bovenhuis et al. (1992), a reason for those conflicting results might be that the associations are due to the effects of linked genes rather than to the milk protein loci themselves (in this case, the associations in different populations might differ); another reason could be the statistical model used to analyse the data. Bovenhuis et al. (1992), using the results from Kennedy et al (1992), concluded that the animal model was the method of choice for estimating genotype effects, taking into account relationships between animals and selection bias.

The aim of the present study was to estimate associations between milk protein genotypes and production traits in Belgium using an animal model.

MATERIAL AND METHODS

Analysis of genotypes

Allelic frequencies were determined by gene counting. The genotype distribution within codominant systems was examined for Hardy-Weinberg equilibrium. Comparison of allelic frequencies for the four milk protein loci and testing of nonindependant segregation between pair of milk protein genes within each breed was accomplished using two-way contingency tables. Linkage disequilibrium analysis of the protein loci was done by comparing the expected frequencies of casein haplotypes (α_{S1}-casein, β-casein, κ-casein) based on independant segregation of the alleles with their observed frequencies. Significant differences between two values were considered to indicate disequilibrium ((Van Eenennaam et al., 1991), (Mac Lean et al., 1984)).

Mathematical model

The following animal model was used to estimate effects of milk protein genotypes on milk production traits, using genetic parameters given in Leroy et al. (1993):

$$\mathbf{y} = \mathbf{X}\ \mathbf{b} + \mathbf{Z}\ \mathbf{u} + \mathbf{Z}\ \mathbf{k} + \mathbf{e}$$

where:

- **y** = observations (305-d milk, fat, protein yield , fat%, protein%, ≤ 3 lac)
- **b** = vector of fixed effects (management group , age at calving , current calving interval, month of calving, α_{S1}-CN genotype w. (w = 1,2), β-CN genotype x. (x = 1..7), κ-CN y. (y = 1,2,3), β-LG z. (z = 1,2,3)
- **u** = vector of random genetic additive effects plus genetic group effect
- **k** = vector of random permanent effects
- **e** = vector of random residual error

and

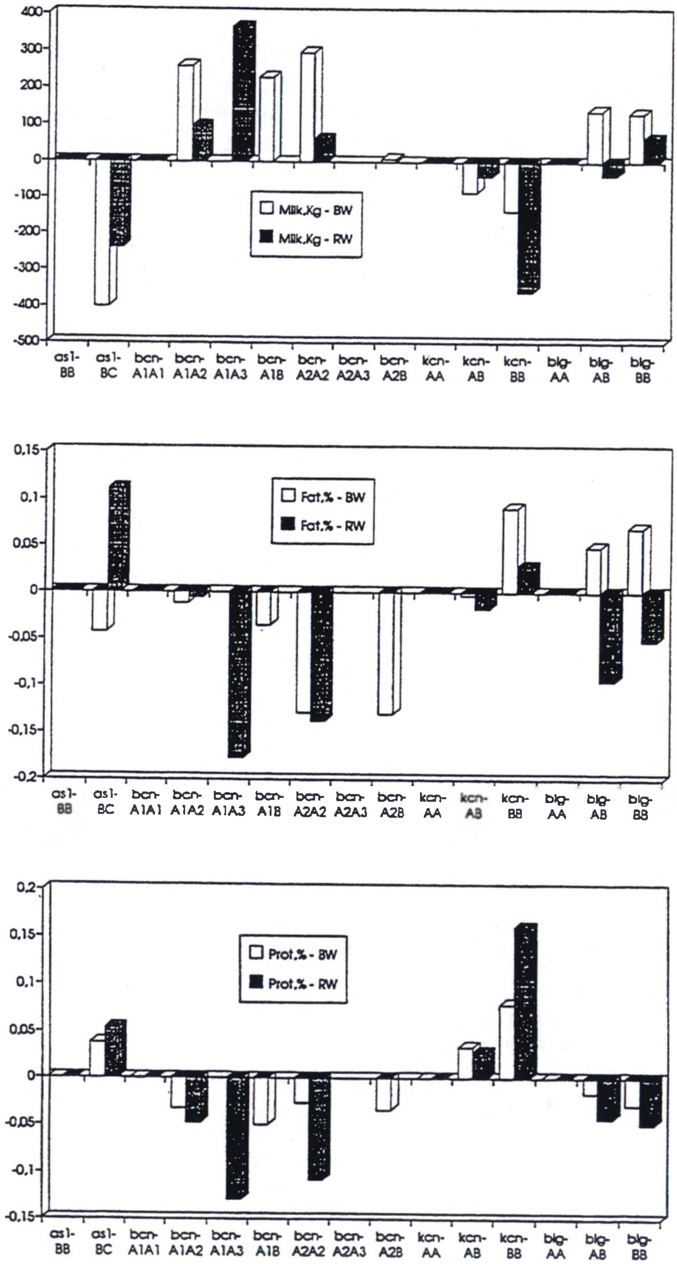
$$E(\mathbf{y})=\mathbf{X}\mathbf{b}+\mathbf{Z}\mathbf{Q}\mathbf{g} \text{ and } E(\mathbf{u})=E(\mathbf{k})=\mathbf{0}.$$

Since milk protein genes are analysed simultaneously, this model can be referred to as a multiple gene model. (Bovenhuis et al., 1992). The fixed effects for herds-year-season, calving interval, age at calving, interval of calving and season of calving have been obtained from the results of the national animal model (Leroy et al., 1993), and have been used to precorrect additively productions in order to leave the fixed variants effects as the only fixed effect to be evaluated.

RESULTS AND DISCUSSION

Contrasts between genotypes reveal significant ($P<0.02$) positive effect for the BB variant (+23.04±10.9) of the α_{S1}-casein locus for fat yield, significant negative effect of the A_1A_1 variant of the ß-CN on milk yield and a significant positive effect on fat percentage (when compared to A_1A_2 and A_2A_2 genotypes), and a significant negative effect of variant AA of the ß-LG on fat yield in the black and white breed. For the black and white breed, fat and protein percentage were higher ($P>0.05$) for the BB variant of the κ -casein. For the red and white breed, only a significant positive effect for the BB variant of the κ -casein on protein percentage was observed. Figure 1 summarizes trends for the genotype effects in Belgium. Significant results agree with those reviewed in (Bovenhuis et al., 1992). The results of the study indicates that κ-casein BB is associated with higher protein percentage. Since in Belgium, milk is paid according to its protein content, more attention should be paid to the protein polymorphisms in order to increase profit. New selection schemes could include the genetic variants, keeping in mind their possible negative effects on quantitative traits.

Figure 1: Milk protein genotype effects on 305-d milk, fat%, protein% in Black and White (BW) and Red and White (RW) Belgian dairy breeds (Significant effects are given in the text).



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