The effect of season and ß-lactoglobulin phenotype on milk composition

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ABSTRACT

The influence of season on the composition of milk from approximately 200 ß-lactoglobulin (ß-LG) AA and 200 ß-lactoglobulin BB phenotype cows was determined for the 1992/93 and 1993/94 seasons. Marked seasonal fluctuations were observed in all components measured: protein, casein, whey protein, ash, lactose, α-lactalbumin, ß-LG, α_s-casein, ß-casein, κ-casein (κ-CN), bovine serum albumin, calcium, magnesium, sodium, potassium, chloride, and phosphate. Significant differences in composition were observed between the AA and BB phenotype milks, with the ß-LG BB phenotype milk containing more total protein, casein, fat, and total solids, whereas the ß-LG AA phenotype milk contained more whey protein, ß-LG, and had a higher ratio of ß-LG to κ-CN. Such differences in composition could have a marked effect on the physicochemical characteristics of these milks. The higher concentration of casein found in the ß-lactoglobulin BB type milk should make this milk type more suitable for the manufacture of cheese and casein.

INTRODUCTION

Previous studies (Hill, 1993; Hill *et al.*, 1993; Hill, 1994, Hill and Paterson, 1994) have shown that the composition of bulk milk produced under New Zealand dairy farming conditions is markedly influenced by ß-LG phenotype. Changes in farming conditions between dairying seasons can influence milk production and composition. This study extends the previous findings by analysis of the differences in the composition of the milks from ß-LG AA and BB phenotype cows over two consecutive New Zealand dairy seasons (1992/93 and 1993/94). In this way the effect of ß-LG phenotype on milk composition throughout the season and between different seasons was determined.

METHODS

From a mixed herd of approximately 200 ß-LG AA and 200 ß-LG BB phenotype cows (Hill and Paterson, 1994) bulk milk samples were collected and analyzed as described by Hill (1993) throughout the 1992/93 and 1993/94 dairy seasons. The content of sodium in the bulk milk samples was determined by flame emission photometry at 589 nm, using an Instrumentation Laboratory (Lexington, MA, USA) model 443 flame photometer following the addition of lithium as an internal standard. The relative levels of individual milk proteins were determined by polyacryamide gel electrophoresis and laser densitometry (Hill, 1993) and presented as adjusted band volumes, where this represents the relative absorbance of protein bound Coomassie Brilliant Blue R250 dye for each protein type. Differences between the compositions of the ß-LG AA and BB phenotype milks were analyzed using a two-tailed t-test.

RESULTS AND DISCUSSION

Significant differences in the composition of the ß-LG AA and BB phenotype milks were observed (Table 1). Marked seasonal variations in the composition of the ß-LG AA and BB phenotype milks were observed throughout the 1992/93 season (Figures 1-9) and this was also the case for the 1993/94 season. The seasonal variation in milk composition was equivalent to or greater than the differences in composition that was observed between the ß-LG AA and BB phenotype milks.

Milk from ß-LG BB phenotype cows contained more casein and less whey protein than milk from ß-LG AA phenotype cows (Figures 1 and 2). The higher casein contents found in the ß-LG BB milks during the 1992/93 (8%) and 1993/94 (5%) seasons are very similar to those found previously during the 1991/92 season (5-7%) involving only Friesian cows located on a different farm to the one used in this study (Hill, 1993, 1994), as were the higher whey protein contents observed in the ß-LG AA milks during the 1992/93 (18%) and 1993/94 (14%) when compared with the 1991/92 season (14-28%). The higher whey protein content of the milk from ß-LG AA phenotype cows was due to a higher level of ß-LG in this milk type (Figure 3). The content of α-lactalbumin in the milk from ß-LG AA and BB phenotype cows was not significantly different.

Figure 4 shows that the milk from ß-LG BB phenotype cows was found to contain more fat than the milk from ß-LG

TABLE 1: Relative differences in the compositions of the milks from ß-LG AA and BB phenotype cows.

Component	BB-AA/AA x 100 (%) 1992/93 n[a] = 18	BB-AA/AA x 100 (%) 1993/94 n[a] = 21
Total Protein	1.61*	1.21**
Casein	7.97***	5.03***
Whey Protein	-18.07***	-14.52***
Fat	8.9***	2.94**
Total Solids	3.18***	2.28**
ß-Lactoglobulin	-29.56***	-26.26***
Sodium	-7.77***	-4.64***
ß-LG/κ-CN	-31.84***	-38.51***

*ρ<0.1, **ρ<.05, ***ρ<.01

a. n represents the number of bulk samples analyzed in each season.

FIGURES 1-9: Variation in the composition of milks produced by ß-lactoglobulin AA and BB phenotype cows throughout the 1992/93 New Zealand dairy season.

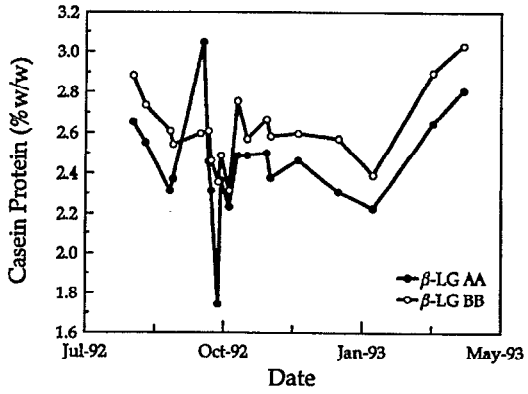

FIGURE 1: Casein

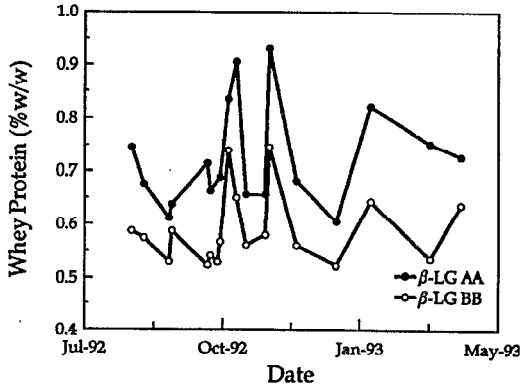

FIGURE 2: Whey

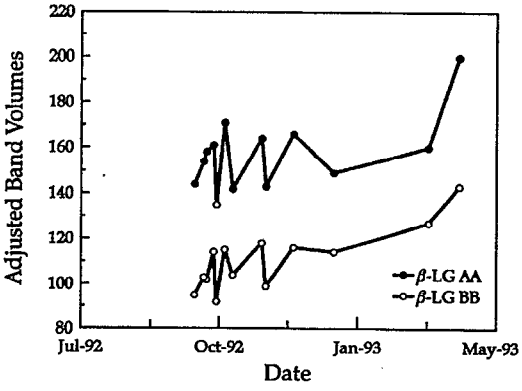

FIGURE 3: ß-LG

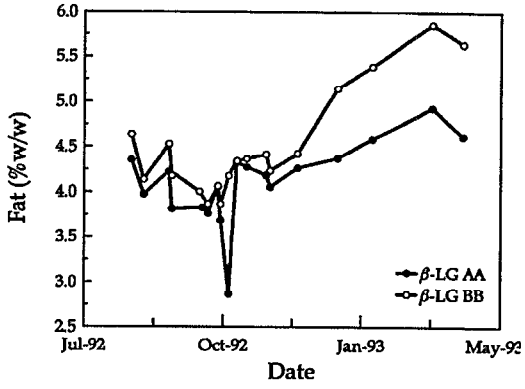

FIGURE 4: Fat

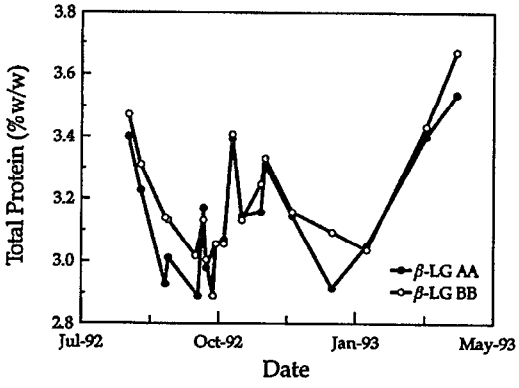

FIGURE 5: Total Protein

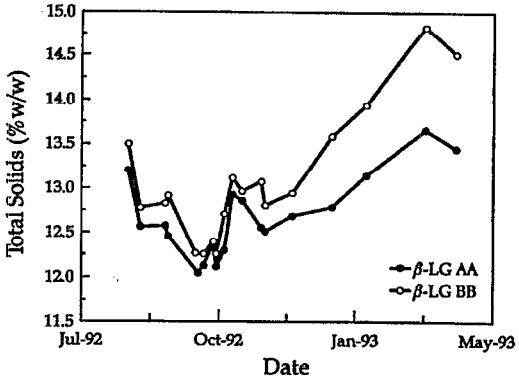

FIGURE 6: Total Solids

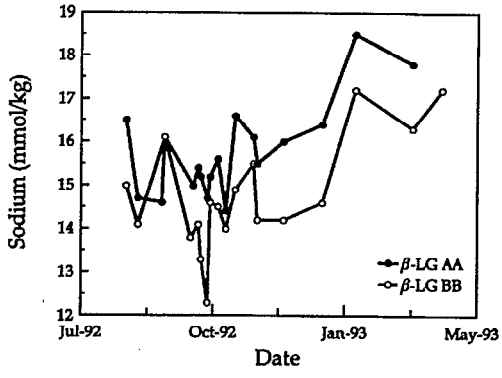

FIGURE 7: Sodium

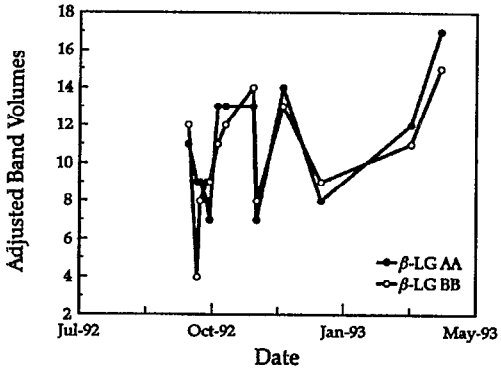

FIGURE 8: Bovine Serum Albumin

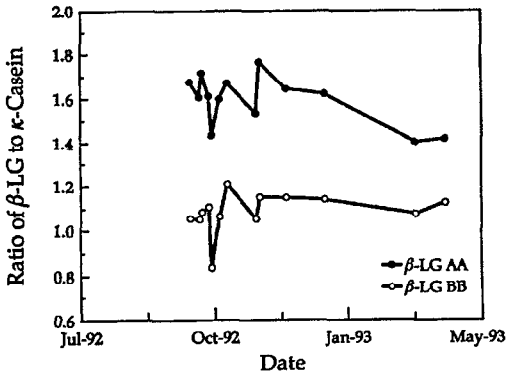

FIGURE 9: Ratio of ß-LG to κ-Casein

AA phenotype cows, however, the extent of this difference was quite variable between the 1992/93 and 1993/94 seasons (Table 1). Hill (1993, 1994) found that during the 1991/92 season the milk from ß-LG BB phenotype cows contained approximately 10% more fat than the milk from ß-LG AA phenotype cows. As highlighted by Ng-Kwai-Hang and Grosclaude (1992), the association of the ß-LG B variant gene with higher milk fat content has been observed in a number of other studies.

It is difficult to see how the ß-LG variants or variant genes have a direct influence the fat content of milk. It is possible that the ß-LG gene is linked to a gene which in turn affects the fat content of milk. Alternatively as proposed by Hill (1993), the ß-LG A variant gene is more active than some of the other mammary cell genes and diverts the available supply of amino acids towards the synthesis of ß-LG and away from the synthesis of other proteins. If these proteins were for example enzymes involved in the synthesis of fat, then a reduction in their synthesis could possibly then reduce the amount of fat synthesized by the gland.

In an earlier New Zealand study (Hill, 1993), the milk from ß-LG BB phenotype cows was found to contain approximately 1 % more total protein than the milk from ß-LG BB phenotype cows, although this difference was not found to be significant. This study has found ß-LG BB phenotype cows produce milk significantly higher in protein content and this was observed over both the 1992/93 and 1993/94 seasons (Table 1). This small difference in the protein content of the ß-LG AA and BB phenotype milks is highlighted in Figure 5 for the 1992/93 season. As a consequence of a higher fat and protein content, the milk from ß-LG BB phenotype cows had a higher content of total solids (Figure 6 and Table 1).

Milk from ß-LG AA phenotype cows contained more sodium than milk from ß-LG BB phenotype cows (Figure 7 and Table 1). This contrasts with previous findings (Hill *et al.*, 1993, Hill, 1994), but was observed throughout the 1992/93 and 1993/94 seasons. Although the increased sodium content of the milk from ß-LG AA phenotype cows did correspond to an increase in chloride content during the 1992/93 season, this was not the case for the 1993/94 season. Milk from ß-LG AA and BB phenotype cows had a similar content of bovine serum albumin (Figure 8 and Table 1); therefore, it is unlikely that higher the levels of sodium observed in milk from ß-LG AA phenotype cows is due to leakage from the blood into the milk, because the level of this blood serum protein would also be expected to be higher in this milk type.

The concentration of ß-LG in milk and also the ratio of this protein to other milk constituents can have a marked effect on the properties of milk (Singh and Creamer, 1992). Tessier and Rose (1964) have shown that the heat stability of milk is influenced by the ratio of ß-LG to κ-CN, the higher this ratio the lower the minimum in the milk heat stability-pH profile. In Figure 9 and Table 1 it is shown that this ratio is significantly higher in the milks from ß-LG AA phenotype cows.

CONCLUSIONS

This study, together with the earlier studies (Hill, 1993, 1994), confirms that the milk from ß-LG AA phenotype cows has a markedly different composition to the milk from ß-LG BB phenotype cows, that the differences in composition are consistent between seasons, despite the noticeable seasonal variations in milk composition in both the ß-LG AA and BB phenotype milks. With many milk components season had a more marked influence on composition than ß-LG phenotype. These differences in composition could have marked effects on the physicochemical characteristics of these milks. The higher concentration of casein found in the ß-lactoglobulin BB type milk should make this milk type more suitable for the manufacture of cheese and casein.

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