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Relationship Between β-Lactoglobulin Polymorphism and Production Traits in Holstein

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Abstract: Milk protein polymorphism such as β-Lg of Holstein dairy cows were investigated in this study. The relationships between milk protein genotypes and some milk production traits were determined. Genetic variants of milk protein were identified by horizontal starch-gel electrophoresis containing mercaptoethanol and urea. The allelice frequencies of A and B were found to be 0.362 and 0.648, respectively. Genotype frequencies were in accordance with the Hardy-Weinberg equilibrium. Milk production traits chosen in relation to β-Lg variants were: actual milk yield, 305 days milk yield, actual fat yield, 305 days fat yield, fat percentage in milk, lactation length. The effect of β-Lg genotypes on milk production traits were analysed using a General Linear Model (GLM). There was no significant association between different genotypes of β-Lg and milk production traits of the analysed cows.

Key words: β-lactoglobulin, protein polymorphism, Holstein, milk production traits, genotype frequency

INTRODUCTION

Milk protein genetic polymorphism has received considerable research interest fort he last 60 years because of possible relationship between milk protein genotypes and economically important traits in dairy cattle. Many research reports have indicated that certain milk protein variants may be associated with milk production (Ng-Kwai-Hang *et al*., 1984; Bech and Kristiansen, 1990; Vohra *et al*., 2006). Therefore, milk protein genes could be useful as genetic markers for additional selection principles in dairy cattle breeding. β-Lactoglobulin (β-Lg), the major whey protein was the first protein in which polymorphism was detected (Aschaffenburg and Drewry, 1955). Since, the idendification of alleles A and B of β-Lg in cattle, genetic polymorphism in milk proteins has raised great interest in animal breeding and dairy industry due to the relationship between milk proteins and milk yield, composition and quality (Aschaffenburg and Drewry, 1957; Ng-Kwai-Hang *et al*., 1990; Ng-Kwai-Hang, 1998; Aleandri *et al*., 1990; Caroli *et al*., 2004; De Marchi *et al*., 2008). The genetic causes of this relationship between milk protein polymorphism and production traits were thought to be due to pleiotropy, linkage and heterosis (Soysal, 1983).

Milk protein polymorphism and its relationship with commercial traits in cattle breeds were studied by many researchers and were argued in their papers. Some investigators described that this relationship was not important for milk production traits (Janicki, 1980; De Lange *et al*., 1990; Van Enennaam and Medrano, 1991). On the contrary, Chung *et al*. (1993) and Matejicek *et al*. (2007) recommended that genetic variant of milk protein could be a criterion for selection for the improvement of dairy cattle production. The target of this study was to determine the genetic structure of cows in terms of β-Lg genotype and also to investigate some relationship between milk protein genotypes and examined production traits.

MATERIALS AND METHODS

Milk samples were obtained from 64 Holstein cows reared at Research and Application Farm of College of Agriculture, Ataturk University to determine β-Lg protein. All animals were maintained at the Research and Application Farm of College of Agriculture, Ataturk University, Erzurum, Turkey under similar welfare and nutritional conditions. Totally 283 production records were obtained from Holstein cows. Four calving season were included such that every 3 months of the year starting from the last month of the previous year were considered as one group of seasons as winter, spring, summer and autumn. Five groups for number of lactations were included in the model. Lactation milk yields records were adjusted according to Anonymous.

About 10 mL of milk was collected from each animal and 20 mg potassium dichromate was added to each sample as a preservative. Fat-free milk samples were stored in a refrigerator at 4°C until they were analysed. Two or three drops of 2-mercapto ethanol were added to samples before electrophoresis. Milk protein genotyping was carried out by using horizontal starch-urea gel electrophoresis (Aschaffenburg and Thymann, 1965; Dogru, 1994). Direct counting was used to estimate gene and genotypic frequencies of the β-Lg proteins. The χ^2-test was used to check whether the population was in Hardy-Weinberg equilibrium (Soysal, 1998). The data on the milk production traits of the different β-Lg genotypes were subjected to Analyisis of Variance (ANOVA) using the General Linear Model (GLM) from the Statistical Analyisis Software (SPSS Statistics 17.0). The following statistical model used was:

$$Y_{ijkl} = \mu+G_i+A_j+S_k+e_{ijkl}$$

Where:

Y_{ijkl} = The observation on each trait of the ijklth animal
μ = the general mean of each trait
G_i = The fixed effect of ith β-Lg genotype (i = 1, 2, 3)
A_j = The fixed effect of jth parity number (j = 1, 2, ..., 5; parity number >5 were pooled with parity of 5)
S_k = The fixed effect of the kth season of calving (k = 1, 2, ..., 4)
e_{ijkl} = The random error effect associated to the ijklth observation

RESULTS AND DISCUSSION

The aim of this study was to identify β-LgA and β-LgB alleles and β-Lg AA, β-Lg AB and β-Lg BB genotypes of β-Lg in a population of Holstein cows. Out of 64 studied cows, genotypic frequencies of β-Lg genotypes were: 4 cows of the β-Lg AA genotype, 34 of genotype AB and 26 of BB genotype. The χ^2-test for deviations from the Hardy-Weinberg equilibrium were carried out to determine statistical significance. Deviations from the Hardy-Weinberg equilibrium was not significant (χ^2 = 2.69). Such findings have been well reported by a number of other investigators (Van Eenennaam and Medrano, 1991; Chung *et al*., 1995; Lunden *et al*., 1997). The frequencies obtained by Rachagani *et al*. (2006) for Sahiwal and Tharparkar breeds are similar to those reported for Gyr, Nelore and Sindi breeds by Del Lama and Zago (1996). These results primarily show that the frequency of A allele in the native breeds of cattle is lower than the European breeds.

Table 1 shows the effect of β-Lg genotypes, parity and season of calving on milk production traits in Holstein cattle. The results indicate that β-Lg genotypes do not have statistically significant effect on all examined milk production traits. Similar results coincide with those reported by various workers (Janicki, 1980; De Lange *et al*., 1990; Ng-Kwai-Hang *et al*., 1990; Van Eenennaam and Medrano, 1991; Lunden *et al*., 1997; Ojala *et al*., 1997; Gurcan, 2011). On the other hand, our result disagree with the literature data demonstrated by Tsiaras *et al*. (2005) who claimed that there were significant reletionship between β-Lg genotypes of higher milk yield and fat yield traits and this relationship could be used in indirect selection. β-Lg BB is associated with higher casein and fat contents which are favourable for cheese making properties (Aleandri *et al*., 1990; Lodes *et al*., 1997). Samarineanu *et al*. (1982) found an association of β-Lg AA genotype with milk yield in Black and White cattle and Brown-Swiss cattle breeds, respectively.

Table 1: Least square means and standard errors of milk production traits of β-Lg genotype, parity and season of calving

Parameters	N	Actual milk yield (kg)	305 day milk yield (kg)	Actual fat yield (kg)	305 days fat yield (kg)	Fat in milk (%)	Lactation length (day)
β-Lg genotype							
AA	13	3851.1±309.9^{NS}	3379.1±230.3^{NS}	151.4±20.9^{NS}	138.5±10.5^{NS}	3.91±12.5^{NS}	337.3±23.3^{NS}
AB	158	3829.9±93.50	3504.0±69.50	147.6±6.30	133.3±3.20	370.20±3.80	332.4±7.00
BB	112	3624.3±109.9	3342.1±81.60	133.9±7.40	128.5±3.70	3.70±4.40	318.1±8.30
Parity							
1	61	3462.2±171.3^{b}	3008.1±127.2^{c}	131.6±11.6^{b}	126.7±5.80^{b}	3.91±6.90^{a}	354.0±12.9^{a}
2	62	3771.9±165.1^{ab}	3326.0±122.7^{bc}	144.5±11.2^{ab}	131.5±5.60^{b}	3.83±6.70^{ab}	346.4±12.4^{a}
3	49	3892.9±185.1^{ab}	3609.6±137.5^{ab}	162.3±12.5^{a}	135.3±6.30^{b}	3.70±7.50^{b}	317.5±13.9^{ab}
4	34	4178.3±203.1^{a}	3831.8±150.9^{a}	154.4±13.8^{a}	150.0±6.90^{a}	3.74±8.20^{ab}	331.2±15.3^{a}
≥5	77	3536.9±163.5^{b}	3266.6±121.5^{c}	128.6±11.1^{b}	123.6±5.60^{b}	3.68±6.60^{b}	297.1±12.3^{b}
Season of calving							
Spring	84	3487.7±150.3^{b}	3188.6±111.7^{b}	124.1±10.2^{b}	119.4±5.10^{b}	3.60±6.10^{b}	322.0±11.3^{NS}
Summer	68	3824.8±162.6^{ab}	3408.5±120.8^{ab}	159.6±11.0^{a}	136.8±5.50^{a}	3.85±6.50^{a}	327.4±12.2
Autumn	54	3796.6±178.8^{ab}	3448.3±132.8^{ab}	146.5±12.1^{ab}	134.3±6.10^{ab}	3.81±7.20^{a}	326.4±13.5
Winter	77	3964.7±160.6^{a}	3588.2±119.3^{a}	149.9±10.9^{ab}	143.1±5.50^{a}	3.82±6.50^{a}	341.2±12.1
Overall	283	3768.4±113.3	3408.4±84.20	144.3±7.70	133.4±3.90	3.77±4.60	329.3±8.50

NS: Non-Significant; $^{a-c}$Means with same superscripts are not significantly different ($p<0.05$) from one another

CONCLUSION

Among genotypic groups concerning various protein polymorphic sytems, relative or statistical superiority for milk yield, composition and quality characteristics varies with breeds or herds within the same breed. This is caused particularly by interactions between polymorphic systems and herd and polymorphic systems and breed. Therefore, more studies need to be conducted with different herds to confirm the evidence found in present study.

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