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Productive longevity of cows depending on the genotype of the growth Hormone Gene

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ABSTRACT

An analysis of the influence of the growth hormone genes and insulin-like growth factor 1 on the quality of milk and the milk productivity of the Holstein breed has been made. The preferred for the Holstein breed *bGH*-AluI^{VV} genotype has been identified, which is associated with the higher rates of the life-long milk yield per entire lactation, the life-long milk yield per 305 days, the life-long milk fat yield, and the life-long milk protein yield.

Key words : *Growth hormone (bGH), Insulin-like growth factor 1 (bIGF-1), PCR-RFLP, Milk yield, Productive longevity, Holstein breed*

Introduction

In the conditions of intensive technology, introduction of innovative and information technologies in dairy cattle breeding, highly productive livestock breeds characterized by productive longevity are needed (Valitov, Karamaev, 2012).

For increasing the milk productivity of cows, somatotropin cascade genes, the protein products of which are the key links of the same humoral chain (*bGH, bIGF-1*), are of great interest (Mikhailova, Belaya, 2011; IGF1 insulin like growth factor 1, 2020; Safina *et al.,* 2019; Heidari *et al.,* 2012; Sönmez *et al.,* 2018; Sadeghi *et al.,* 2008; Hartatik, Kurniawati, 2015).

Given the aforesaid, the goals of the study included the following:

– determining the level of the milk productivity of cows in the context of lactations, depending on the genotype according to the somatotropin cascade genes;

– identifying the most preferred genotypes, given the level of the milk productivity and the longevity of cows.

The study aimed at studying the effect of growth hormone genes polymorphism and insulin-like growth factor 1 on the quality of milk and the milk productivity of Holstein cows.

Materials and Methods

The objects of the study were the Holstein cows at LLP Bek+ in the Kostanay region of the Republic of Kazakhstan. The breeding stock population was more than 900 animals. The DNA samples were isolated from blood samples of 200 cows for genotyping by the growth hormone gene (*bGH*) and the insulin-like growth factor 1 gene (*bIGF-1*) using the PCR-RFLP analysis method. *bGH* and *bIGF-1* genes were considered as a factor with three gradations (*bGH*-AluI^{LL}, *bGH*-AluI^{LV}, and *bGH*-AluI^{VV} genotypes by the growth hormone gene, as well as

bIGF-1-SnaBI^{AA}, *bIGF-1*-SnaBI^{AB}, and *bIGF-1*-SnaBI^{BB} genotypes by the insulin-like growth factor 1 gene). For the polymorphisms in which groups of animals with various genotypes were significantly different from each other in terms of a specific trait, the genotype with the highest level of productivity was preferable, and the other two were undesirable in the selection of animals during the breeding process.

Results

As a result of the molecular genetic studies performed in the Holstein breed population at LLP Bek+, the authors identified all possible growth hormone genes combinations (*bGH*-AluI^{LL}, *bGH*-AluI^{LV}, and *bGH*-AluI^{VV}).

It should be noted that *bGH*-AluI^{LL} genotype, i.e. the gene that coded the growth hormone gene with amino acid leucine at the 127th position of the amino acid protein sequence, was more typical for the studied group of the Holstein cows. The share of the cows with this gene was 60 – 66 % of the total number of the animals studied. The effect of various growth hormone gene variations on the milk productivity in the Holstein cows is shown in Table 1.

In analyzing the milk productivity of the cows per complete lactation, the advantage of those with the allelic state of *bGH*-AluI^{LL} gene was clearly visible. For instance, starting from the first lactation and until the highest lactation, the cows with *bGH*-AluI^{LL} genotype had a significant advantage in terms of the milk productivity. The difference between the groups in terms of the analyzed parameter during the first lactation was 25 – 855 kg; during the second lactation — 415 – 433 kg; during the third lactation — 1,216 – 1,942 kg; and during the fourth lactation — 1,097 – 1,199 kg, respectively, compared to *bGH*-AluI^{LV} and *bGH*-AluI^{VV} genotypes. It should also be noted that the cows with *bGH*-AluI^{LV} genotype took an intermediate position; apparently, this was due to the heterozygous state of this gene. The cows with *bGH*-AluI^{VV} genotype had the lowest milk yield per entire lactation. However, the duration of lactation in all groups did not show strong fluctuations.

Analyzing the milk productivity per 305 days of lactation, an opposite pattern can be noted. For instance, from the second until the fourth lactations, the cows with *bGH*-AluI^{VV} genotype featured greater milk productivity than those with *bGH*-AluI^{LL} and *bGH*-AluI^{LV} genotypes. The milk yield per 305 days of the second lactation in the Holstein cows with *bGH*-AluI^{VV} genotype was 8,868.5 kg, which was 1,770.2 kg and 969.2 kg more than in those with *bGH*-AluI^{LL} and *bGH*-AluI^{LV} genotypes. It should be noted that the animals with *bGH*-AluI^{LL} genotype showed the lowest values in terms of the above characteristics, which allowed suggesting the undesirable effect of the *bGH*-AluI^{L} allele on the milk productivity.

Thus, according to the indications of the milk yield per 305 days, the absolute fat and absolute protein values, *bGH*-AluI^{VV} genotype was preferred for the Holstein breed. It may be assumed that the cows with *bGH*-AluI^{VV} genotype are characterized by high milk productivity in the first 10 months of lactation, and those with *bGH*-AluI^{LL} genotype have more levelled off lactation curve throughout the lactation and are characterized by a high milk yield in the second half of the lactation.

Table 2 shows the data that characterize the productive longevity of the Holstein cows with various genotypes of *bGH*-AluI polymorphisms.

Table 2 shows that relative to *bGH*-AluI polymorphism, the Holstein animals with *bGH*-AluI^{VV} genotype were characterized by high productive longevity, unlike the animals with *bGH*-AluI^{LL} and *bGH*-AluI^{LV} genotypes. For instance, the life-long milk yield per entire lactation in the cows with *bGH*-AluI^{VV} genotype was 34,721.2 kg, which was 7,044.0 – 14,259.5 kg more than in those with *bGH*-AluI^{LL} and *bGH*-AluI^{LV} genotypes. In the cows with *bGH*-AluI^{VV} genotype, longevity was 3.50 lactations, which was 0.6 – 0.95 lactations more than in the cows with *bGH*-AluI^{LL} and *bGH*-AluI^{LV} genotypes. The number of milking days per life in the cows with *bGH*-AluI^{VV} genotype was 1,214 days, which was 229 – 373 days more than that in the cows with *bGH*-AluI^{LL} and *bGH*-AluI^{LV} genotypes. The milk yield per day of productive life in the cows with *bGH*-AluI^{VV} genotype was 30.2 kg, which was 0.7 – 5.8 kg more than that in the cows with *bGH*-AluI^{LL} and *bGH*-AluI^{LV} genotypes. It should be noted that all these data, except for longevity, are statistically veracious, which confirms the positive influence of *bGH*-AluI^{VV} genotype not only on the milk productivity of the Holstein cows but on their productive longevity as well.

Conclusion

As a result of the study, the superiority of the cows

Table 1. The milk productivity of the herd of the Holstein cows of various genotypes in terms of the bGH gene polymorphism

Productivity	Genotype			P*
	bGH-AluI^{LL}	*bGH*-AluI^{LV}	*bGH*-AluI^{VV}	
Cow-heifers				
Number of cows, animals	106	47	6	
Milk yield per full lactation, kg	10,183.5 ± 269.8	10,158.2 ± 437.6	9,328.0 ± 740.6	0.73
Duration of lactation, days	360 ± 13	352 ± 7	360 ± 12	0.91
Milk yield per 305 days of lactation, kg	6,790.8 ± 147.2	7,117.9 ± 245.7	7,070.5 ± 349.4	0.47
Mass fraction of fat, %	3.62 ± 0.01	3.61 ± 0.01	3.61 ± 0.01	0.88
Amount of milk fat, kg	246.8 ± 5.8	257.7 ± 9.3	255.3 ± 12.9	0.52
Mass fraction of protein, %	3.24 ± 0.01	3.22 ± 0.01	3.24 ± 0.01	0.22
Amount of milk protein, kg	220.9 ± 5.2	230.2 ± 8.2	228.9 ± 11.9	0.58
Second lactation cows				
Number of cows, animals	86	43	6	
Milk yield per full lactation, kg	11,264.8 ± 385.9	10,850.0 ± 760.5	10,832.5 ± 1,117.3	0.85
Duration of lactation, days	341 ± 5	316 ± 14	340 ± 9	0.13
Milk yield per 305 days of lactation, kg	7,098.3 ± 173.8	7,899.3 ± 370.4	8,868.5 ± 648.3	**0.01**
Mass fraction of fat, %	3.61 ± 0.01	3.61 ± 0.01	3.61 ± 0.01	0.99
Amount of milk fat, kg	256.9 ± 6.6	285.5 ± 13.7	320.2 ± 23.8	**0.02**
Mass fraction of protein, %	3.23 ± 0.01	3.22 ± 0.01	3.23 ± 0.01	0.62
Amount of milk protein, kg	229.3 ± 5.7	255.0 ± 12.2	286.6 ± 21.7	**0.02**
Third lactation cows				
Number of cows, animals	68	20	5	
Milk yield per full lactation, kg	12,978.2 ± 338.2	11,761.9 ± 628.2	11,036.0 ± 804.7	0.10
Duration of lactation, days	340 ± 3	324 ± 9	354 ± 6	0.05
Milk yield per 305 days of lactation, kg	9,081.5 ± 251.3	9,711.3 ± 413.8	9,359.4 ± 342.5	0.45
Mass fraction of fat, %	3.60 ± 0.01	3.59 ± 0.02	3.61 ± 0.01	0.95
Amount of milk fat, kg	328.2 ± 9.5	350.1 ± 16.4	337.8 ± 13.1	0.46
Mass fraction of protein, %	3.22 ± 0.00	3.24 ± 0.02	3.23 ± 0.01	0.33
Amount of milk protein, kg	293.0 ± 8.2	314.8 ± 14.0	302.4 ± 11.6	0.37
Fourth lactation cows				
Number of cows, animals	37	5	5	
Milk yield per full lactation, kg	11,926.8 ± 624.1	10,830.3 ± 1973.0	10,728.0 ± 535.6	0.72
Duration of lactation, days	304 ± 10	291 ± 21	330 ± 18	0.64
Milk yield per 305 days of lactation, kg	8,426.6 ± 382.3	7,266.6 ± 867.7	10,235.3 ± 524.3	0.17
Mass fraction of fat, %	3.58 ± 0.02	3.58 ± 0.04	3.61 ± 0.01	0.90
Amount of milk fat, kg	303.4 ± 15.3	260.1 ± 31.3	369.9 ± 19.2	0.13
Mass fraction of protein, %	3.22 ± 0.01	3.22 ± 0.01	3.22 ± 0.00	0.86
Amount of milk protein, kg	271.3 ± 13.2	234.2 ± 27.9	329.6 ± 16.9	0.14
Cows with the highest lactation				
Milk yield per full lactation, kg	12,631.3 ± 294.4	12,045.0 ± 539.5	11,180.6 ± 757.9	0.39
Duration of lactation, days	345 ± 1	347 ± 4	344 ± 9	0.91
Milk yield per 305 days of lactation, kg	8,935.5 ± 188.1	9,292.8 ± 321.3	9,747.7 ± 380.7	0.42
Mass fraction of fat, %	3.61 ± 0.01	3.60 ± 0.01	3.61 ± 0.01	0.86
Amount of milk fat, kg	323.6 ± 7.3	335.4 ± 12.1	351.5 ± 14.4	0.45
Mass fraction of protein, %	3.23 ± 0.01	3.22 ± 0.01	3.23 ± 0.01	0.77
Amount of milk protein, kg	289.0 ± 6.3	300.3 ± 10.8	315.3 ± 12.8	0.44

Note: The difference between groups with bGH-AluI^{LL}, *bGH*-AluI^{LV}, and *bGH*-AluI^{VV} genotypes was significant at $P < 0.05$

with *bGH*-AluI^{VV} genotype over the animals with alternative combinations of the growth hormone gene in terms of the milk productivity per 305 days of lactation by 454.9 – 812.2 kg, or 4.7 – 8.3 %, as well as in terms of life-long productivity by 7,044 – 14,259.5 kg, or 20.3 – 41.1 %, has been veraciously

Table 2. Productive longevity of the Holstein cows depending on the genotypes of the growth hormone genes

Genotype	Life-long milk yield per full lactation, kg	Life-long milk fat yield, kg	Life-long milk protein yield, kg	Longevity, lactations	The number of milking days per life	Milk yield per one day of productive life, kg
AluI polymorphism of the growth hormone gene (*bGH*-AluI)						
LL	27.677.2 ± 1.138.6	796.0 ± 36.4	710.3 ± 32.1	2.90 ± 0.12	985 ± 41	29.5 ± 0.8
LV	20.461.7 ± 1.508.5	728.4 ± 45.2	650.8 ± 40.0	2.55 ± 0.13	841 ± 50	24.4 ± 1.4
VV	34.721.2 ± 3.441.0	1.103.3 ± 146.4	989.3 ± 131.4	3.50 ± 0.43	1.214 ± 135	30.2 ± 2.0
P*	0.00	0.04	0.04	0.08	0.03	0.01

Notes: The difference between groups with *bGH*-AluI^{LL}, *bGH*-AluI^{LV}, and *bGH*-AluI^{VV} genotypes was significant at $P < 0.05$

established. To increase the protein and milk content, the butterfat content, and the milk yield of the Holstein cows, and to increase the productive life of cows, it is recommended to breed the animals with *bGH*-AluI^{VV} genotype, since this genotype still has a developed instinct to self-preservation, and they give milk sparingly for their organism. After 10 months of lactation, the cows of this genotype reduce the milk productivity and accumulate nutrients for the growth of the calf and subsequent lactation.

If farms aim at obtaining a lot of milk, and the issue of herd reproduction is not too urgent for them, *bGH*-AluI^{LL} genotype is recommended for breeding. This genotype is a classic example of the foreign Holstein cattle, when the animals are bred to produce "fast" milk (i.e., during the first and the second lactations) and can be milked during their entire life.

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