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STUDY OF THE EFFECT OF BETA-LACTOGLOBULIN AND PIT-1 GENES IN COWS ON HARD CHEESE PRODUCTION

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Abstract

The yield of hard cheese depends on the amount and ratio of milk components. Moreover, the yield of cottage cheese is significantly influenced by genetic variants of milk protein and other genes. The goal of this study is to examine the effect of variants A and B of beta-lactoglobulin and variants A and B of the PIT1 gene on cheese yield and its individual qualitative indicators. It has been found that the genotype of cows based on the beta-lactoglobulin gene affects the yield of cheese produced from their milk. The highest yield is obtained from milk of animals with the BB genotype. At the same time, a higher content of essential amino acids is characteristic of cheese made from milk obtained from animals with the AA genotype by beta-lactoglobulin. The PIT1 genotype has also affected the yield of cheese made from milk. Cheese samples made from milk of heterozygous animals (AB) have the best average values. The amount of essential amino acids in cheese prevails in samples made from milk of homozygous (BB) cows. Forming herds with the desired genotypes based on the studied genes for cheese production requires establishing contractual relations between milk producers and milk processing plants.

Key words**:** *milk, cheese, protein, genotype, beta-lactoglobulin, PIT1, amino acids, characteristics*

INTRODUCTION

The indicator of cheese yield is one of the most important for the profitability of enterprises from cheese making. This indicator reflects the amount of product manufactured per unit of dairy raw materials. It is significantly affected by the composition of milk and the ratio of its components. Recently, there has been a lot of interest in various genes that can affect the cheese yield [3].

Scientists note that various genetic variants of milk proteins (caseins, beta-lactoglobulin) have an impact on the indicators of milk quality, coagulation properties and cheese production [7].

According to the results of many studies, it is found that the BLG B genotype variant is associated with a higher content of dry matter, fat and protein in milk, and an increased yield of cottage cheese [1, 4]. The researchers also note that the quality of cheese from milk of animals with the BB genotype is better in this gene compared to milk from animals with the AA genotype [3, 2, 1]. Another group of scientists has concluded that variant A of BLG helps to reduce the time for rennet coagulation of milk [8]. Others have found no association between the BLG gene and quantitative and qualitative indicators of cheese production from cow's milk [5, 12].

Pituitary-Specific Positive Transcription Factor 1 (PIT1) affects the growth hormone and prolactin genes. Animals with the BB genotype are characterized by a higher level of milk fat and protein [9]. According to the results of other studies, the A allele of this gene is associated with higher milk yields and protein content in milk. The B allele is associated with a higher fat content in milk [11].

Most authors claim the existing influence of this gene on milk yield indicators, which

makes it attractive from a breeding point of view [10]. However, the literature does not mention its effect on the technological qualities of milk. Therefore, it is extremely important to study this issue as we did in this study.

MATERIALS AND METHODS

Milk (10 liters each) from cows of the Ukrainian Black-and-White dairy breed were selected for the planned research.

The animals were owned by the NAAS Institute of Agriculture of the North-East State Enterprise of Sumy Region, Ukraine. The animals were divided according to a genotype by the BLG gene (three heads with AA, AB, BB each) and by the PIT1 gene (three heads with AB, BB each).

No animals with the AA genotype were found in the herd.

Samples of Gouda hard cheese were examined. The cheese was made according to the generally accepted method. The examination of samples was carried out according to the accepted method in the conditions of the educational laboratories of Sumy National Agrarian University [6].

Mathematical and statistical processing of the obtained results was carried out on a computer using MS Excel 2016 Software.

RESULTS AND DISCUSSIONS

Our examination of the physical and chemical parameters of milk samples obtained from cows of the Ukrainian Black-and-White dairy breed with different genotypes according to the beta-lactoglobulin and PIT1 genes indicate that they fully meet the requirements for milk (in accordance with the State Standard 3662:2018). The acidity of milk, depending on the genotype of cows by the beta-lactoglobulin gene, did not differ significantly and was in the range of 6.36-6.55. The acidity of milk in animals with different genotypes according to the PIT1 gene (6.40-6.56) was approximately within these limits. In terms of milk density, there was also no significant difference between animals of different genotypes according to the studied genes (Table 1).

Among the studied animals, there were three genotypes for the BLG gene (AA, AB, BB) and two for the PIT1 gene (AB, BB).

Table 1. Comparison of physical and chemical parameters of milk from animals with different genotypes by the BLG and PIT1 genes

Studied indicators	Genotypes by BLG genes			Genotypes by PIT1 genes	
	AA	AB	BB	AB	BB
Milk acidity, pH	6.36±0.01	6.55±0.01	6.55±0.01	6.40±0.01	6.56±0.01
Milk density, kg/m^3	1.026±0.0003	1.028±0.0003	1.028±0.0003	1.027±0.0003	1.026±0.0003
Dry matter content, %	12.7±0.02	11.2±0.02**	12.3±0.02	12.3±0.02	12.5±0.02
Protein content, %	2.87±0.01**	2.96±0.01	3.01±0.01	2.94±0.01	2.91±0.01
Fat content,%	4.69±0.01	2.83±0.01**	3.89±0.01	4.01±0.01	4.28±0.01**

Note: *P<0.05; **P<0.01

Source: Own research.

According to the analysis of the content of the main components of milk, we have established intergenotypic differentiation by the BLG gene. Milk of animals with the AA genotype is characterized by a higher content of dry matter and fat in milk. Animals with the BB genotype have a higher protein content in milk. The ratio of fat to protein is in the range of 1.05-1.63 and prevails in animals with the AA genotype. In animals with the AB genotype, this ratio approaches unity.

In terms of dry matter and protein content in milk, no differences are found between animals with different genotypes according to the PIT1 gene. Only in terms of fat content in milk, animals with the BB genotype prevail.

Based on the results of hard cheese production, we have determined that among

milk samples from cows with different genotypes by the BLG gene, differentiation is found in terms of cheese yield (Fig. 1).

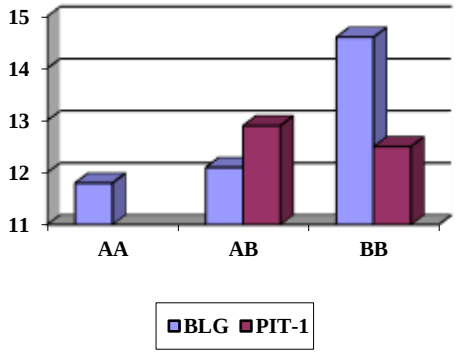

Fig. 1. Average yield of cheese from milk samples obtained from cows with different genotypes by the BLG and PIT-1 genes, %
Source: Own research.

A higher average yield of the finished product is observed in milk of animals with the BB genotype, and a smaller one – with the AA genotype.

Milk of animals with a different genotype by the PIT1 gene also varies in cheese yield. The yield of cottage cheese obtained from the milk of animals of the AB genotype is higher.

Cheese samples made from milk of cows with the AB genotype have a lower acidity value (Table 2).

The dry matter content of the finished products prevails in samples made from milk of cows with the AB genotype. The difference in this feature compared to animal samples with the AA, AB and BB genotypes is statistically significant.

A higher protein content in the finished product is observed in cheese obtained from the milk of cows with the BB genotype. Product samples obtained from an animal with this genotype significantly predominate by this trait samples from animals with the AA and AB genotypes.

Hard cheese obtained from milk of animals with different genotypes by the PIT-1 gene also has differentiation in physical and chemical parameters. Samples from the milk of animals with the BB genotype have a lower acidity value.

A higher average dry matter content in cheese is observed in samples obtained from milk of heterozygous animals (AB), while the protein content is higher in cheese made from milk samples from homozygous animals (BB).

According to the results of chromatographic analysis of the amino acid profile of the studied cheese samples, 17 amino acid residues have been identified.

The quantitative content of essential amino acids is dominated in cheese samples made from milk of animals with the AA genotype by the BLG gene.

They prevail in the content of such amino acids as: valine, leucine, isoleucine, lysine, threonine.

The content of the essential amino acid phenylalanine prevails in samples made from milk of heterozygous animals (AB).

In addition, cheese samples from the milk of these animals prevail by the content of glutamine, cysteine and tyrosine.

Samples taken from the milk of animals with the BB genotype also have a high cysteine content. In terms of the content of most amino acids, samples from milk of animals with the BB genotype prevail over samples from animals with the AB genotype (Fig. 2).

Table 2. Study of physical and chemical parameters of cheese made from milk from cows with different genotypes by the BLG and PIT1 genes

Studied indicators	**Genotypes by BLG genes**			**Genotypes by PIT1 genes**	
	AA	AB	BB	AB	BB
Cheese acidity, pH	5.42±0.01	5.13±0.01	5.45±0.01	5.48±0.01	5.20±0.01
Dry matter content, %	62.8±0.02***	66.8±0.02***	58.1±0.02	62.5±0.02**	60.8±0.02
Protein content, %	18.6±0.1	17.2±0.1	26.0±0.1**	24.8±0.1	35.6±0.1**

Note: **P<0.01; P<0.001
Source: Own research.

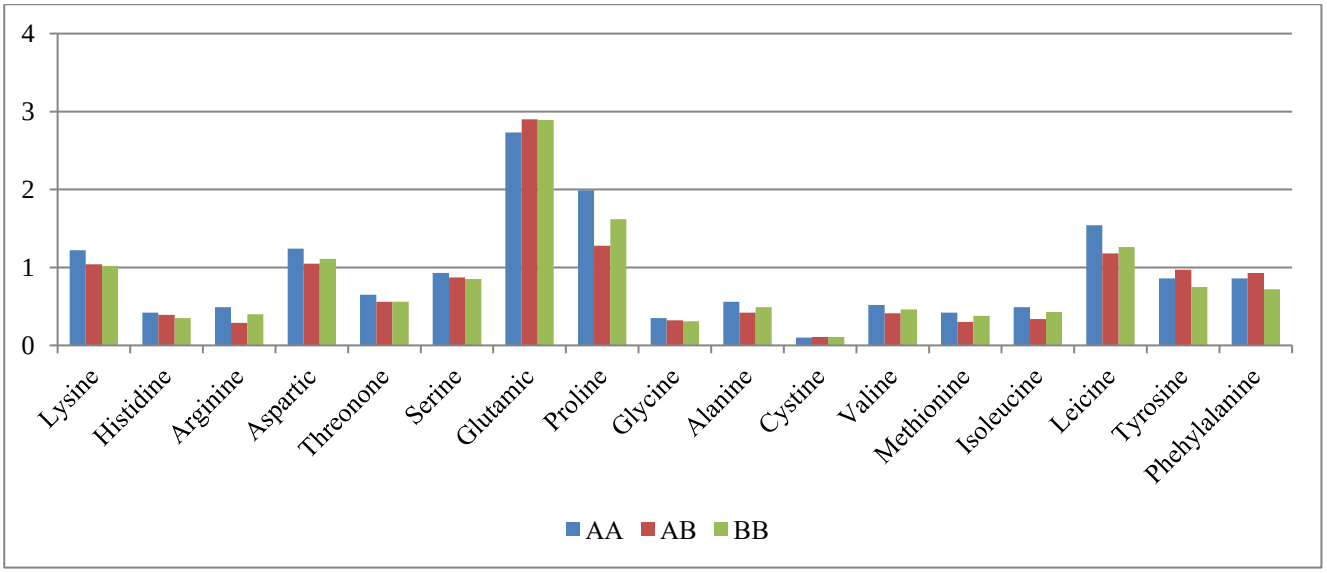

Fig. 2. Average amino acid profile of hard cheese samples made from milk of cows of different BLG genotypes, mg/g
Source: The authors' own research.

The overall average amino acid content prevailed in samples from animals with the homozygous AA (15.39 mg/g) and BB (13.72 mg/g) genotypes. In cheese made from milk of heterozygous animals (AB), their content was 12.95 mg/g (Figure 2).
The content of both essential and non-essential amino acids prevailed in cheese samples obtained from milk of animals with the BB genotype by the PIT1 gene.
The overall average amino acid content prevailed in samples from animals with the homozygous BB genotype (15.56 mg/g), while in milk samples from animals with the heterozygous AB genotype, the amino acid content was 12.42 mg/g.

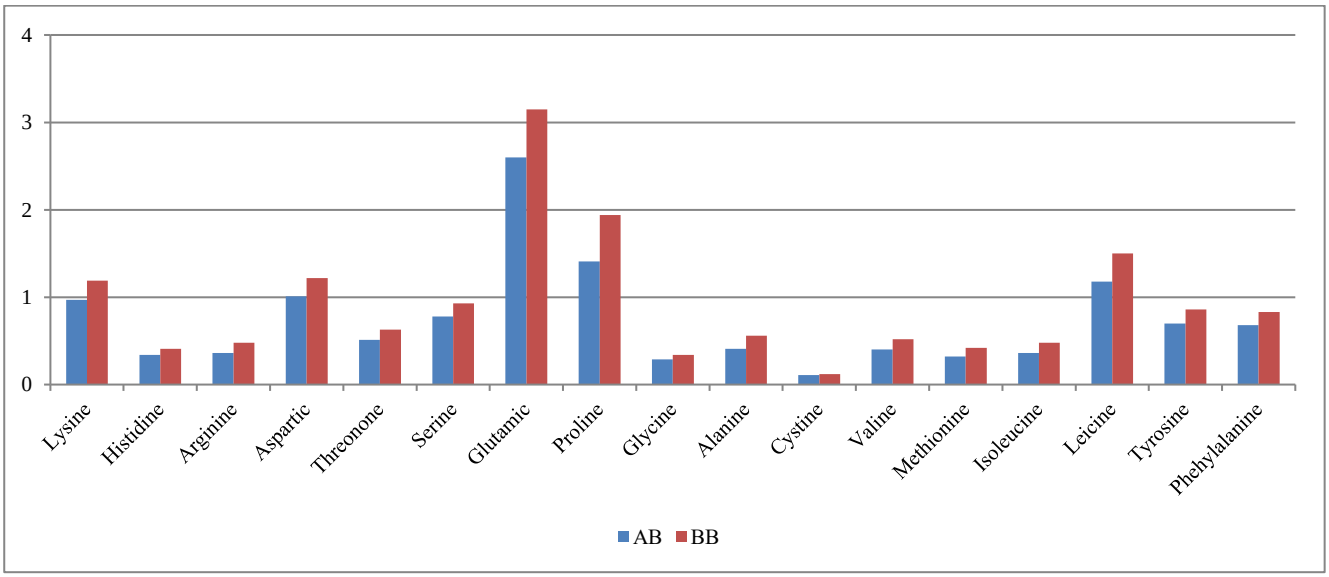

Fig. 3. Average amino acid profile of hard cheese samples made from milk of cows of different PIT1 genotypes, mg/g
Source: The authors' own research.

The formation of herds with the BB and AB genotypes, respectively, by the BLG and PIT-1 genes, requires not only genotyping of the breeding stock, but also the producers whose family is used (Figure 3). This is due to the fact that today the catalogues of producers do not contain information on the genotype of animals by the studied genes. Therefore, this

work can only be carried out with the consent of farmers and processing enterprises, in order to improve the economy of hard cheese production.

The results of our studies on the effect of the BLG gene on the content of milk components partially coincide with previous studies. This refers to the higher protein content in milk of animals with the BB genotype. However, our results do not coincide with the results of other authors regarding the preference for dry matter and fat content in milk in animals with the AA genotype [1, 4].

As for the PIT-1 genotype, we note that the results of our studies completely coincide with those previously conducted, regarding the preference of the BB genotype for fat content in milk [11, 9].

CONCLUSIONS

According to the results of the conducted studies, it can be concluded that milk obtained from cows of the Ukrainian Black-and-White dairy breed fully meets the state standard.

Intergenotypic differentiation by physical and chemical parameters of milk was established between animals with different genotypes according to the BLG gene. Higher dry matter and fat content was observed in animals with the homozygous AA genotype. Animals with the homozygous BB genotype showed a higher protein content in milk. Intergenotypic differentiation by protein content in milk was found in animals with different genotypes by the PIT-1 gene. This trait was dominated in animals with the BB genotype.

The genotype of animals based on the studied genes had an effect on the yield of hard cheese produced from the milk of these animals. The highest yield of the product is characteristic of milk obtained from animals with a homozygous (BB) genotype by the BLG gene. A higher yield of cheese was observed from milk of animals with a heterozygous genotype (AB) by the PIT1 gene.

The content of essential amino acids in milk prevailed in animals with the AA (BLG gene) and BB (PIT-1 gene) genotypes.

The work of forming herds with the desired genotype based on the BLG and PIT-1 genotypes for hard cheese production requires a consortium between the milk producer and its processor.

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