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Correlation between productive and interior traits of steers of different genotypes

[*Correlação entre traços produtivos e interiores de bois de diferentes genótipos*]

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ABSTRACT

The objective was to study the productive and biological traits of young cattle of the Kalmyk breed and its crosses. The experiment was conducted on 4 groups of steers, 10 heads each, at OAO Shurupovskoe, Frolovsky District, Volgograd Region. The experimental steers were kept in rooms separately in groups on a deep bed of straw and had free access to walking yards with mounds. The hemoglobin content and the numbers of erythrocytes and leukocytes were determined on a Medonic CA 530 hematological analyzer. The total protein in blood serum and protein fractions were found on an automatic biochemical analyzer Stat Faks 1904. The digital experimental data were processed by the variation statistics method in terms of the significance of the compared parameters using the Student's test accepted in biology and animal science. The study evidenced that the contents of morphological elements and proteins in blood reflected the metabolism and potential for crossbred steers to gain muscle mass.

Keywords: body weight, beef cattle, productivity, breed, erythrocytes, hemoglobin, leukocytes, proteins, albumins, globulins

RESUMO

O objetivo era estudar os traços produtivos e biológicos do gado jovem da raça Kalmyk e seus cruzamentos. A experiência foi conduzida em 4 grupos de bois, 10 cabeças cada, na OAO Shurupovskoe, Distrito de Frolovsky, Região de Volgograd. Os bois experimentais foram mantidos em quartos separados em grupos em uma cama de palha profunda e tiveram livre acesso a pátios de caminhada com montes. O conteúdo de hemoglobina e o número de eritrócitos e leucócitos foram determinados em um analisador hematológico Medonic CA 530. A proteína total em soro sanguíneo e frações proteicas foram encontradas em um analisador bioquímico automático Stat Faks 1904. Os dados experimentais digitais foram processados pelo método de estatística de variação em termos da significância dos parâmetros comparados usando o teste de Student aceito em biologia e ciência animal. O estudo evidenciou que o conteúdo de elementos morfológicos e proteínas no sangue refletia o metabolismo e o potencial de bois cruzados para ganhar massa muscular.

Palavras-chave: peso corporal, gado de corte, produtividade, raça, eritrócitos, hemoglobina, leucócitos, proteínas, albuminas, globulinas

INTRODUCTION

In many countries, beef cattle breeding is of particular importance, especially in the production of safe environmentally friendly livestock products. Genetic material of high-yield beef cattle has been used in recent years to increase the meat production in Russia. This enables providing the population with high quality beef, including marbled meat. However, the production volume of this kind of meat is still insufficient. Therefore, reserves for the intensification of beef production are being

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intensively searched for, with special attention being paid to the development of new approaches to the issues of selective breeding and crossbreeding to create the most suitable hybrid individuals capable of fulfilling their genetic potential.

Russia ranks 10th among the world's largest exporters of beef. However, due to government subsidies, there has been a positive trend in the development of beef cattle breeding and its investment attractiveness has increased in the last 5-7 years.

The fastest growth in beef production is known to be ensured by fulfilling of the animal genetic potential (Amerkhanov *et al.,* 2019; Bashirov *et al.,* 2004; Belyaev and Gorlov, 2010; Gorlov *et al.,* 2016, 2019; Dunin *et al.,* 2012; Shakhbazova *et al.,* 2018; Randelin, 2013; Sazonova, 2012). An increase in the animal productivity by 35-40% is caused by determinacy due to the synergy of modern advances in genetics, genetic engineering, biotechnology, and breeding. One of the main selection areas is improving the meat quality and increasing the beef carcass yield. Moreover, the most complete fulfillment of the genetic potential is ensured by optimized nutrition in accordance with the criteria of feeding standards for farm animals, depending on the age, body weight, breed, and physiological state (Belyaev and Gorlov, 2010; Gorlov *et al.,* 2016).

Researchers (Amash *et al.,* 2021; Nogalski *et al.,* 2013, 2014; Sharman *et al.,* 2013; Weglarz, 2010) noted better prospects of hybrid livestock (compared with purebred animals) in increasing growth, development, and meat productivity.

In almost all regions of Russia, high-yield beef cattle of domestic and foreign selections are grown. For example, genetic potentials of purebred animals of the Kalmyk, Simmental, Hereford and Kazakh white-headed breeds and their crosses are considered promising for growing in the Southern Federal District. Despite the rather great popularity of the Kalmyk breed in Russia, its interbreeding opportunities have not yet been studied. This requires a study of the quantitative and qualitative indicators of the products obtained, as well as most acceptable potential of natural and climatic zones, where it is advisable to raise cattle of this breed and its *hybrids (Levakhin et al, 2016; Randelin, 2013;* Sazonova, 2012; Weglarz, 2010).

The objective of our scientific research was to study the productive and biological traits of young cattle of the Kalmyk breed and its crosses. In accordance with the goal set, we identified the following tasks:

- to study the fattening and meat traits of young cattle of different genotypes;
- evaluate the interior features of cattle of different genotypes; and
- determine the direction and degree of correlations between biochemical parameters of blood and meat productivity of steers.

MATERIALS AND METHOD

The experiment was conducted on 4 groups of steers, 10 head each, at OAO Shurupovskoye, Frolovsky District, Volgograd Region. The groups were formed considering the age and breeds of the steers. Group I included purebred Kalmyk steers; Groups II, III and IV consisted of hybrids obtained from crossing Simmental, Hereford, and Kazakh white-headed cows with breeding bulls of the Kalmyk breed. The steers were kept in the same conditions of feeding and housing, which made it possible to objectively judge the characteristics of their productive capacity.

The experimental steers were kept in rooms separately in groups on an irremovable bed made of straw and had free access to walking yards with mounds. The steers were fed according to generally accepted norms of average daily body weight gain of 900 grams or more. At the age of 16 months, a control slaughter of steers, 3 head from each group, was carried out according to the procedure developed and approved by L.K. Ernst Federal Research Center for Animal Husbandry (VIZH) and Volga Research Institute of Production and Processing of Meat and Dairy Products (VNIIMP) in Russia.

The hemoglobin content and the numbers of erythrocytes and leukocytes were determined on a Medonic CA 530 hematological analyzer. The total protein in blood serum and protein fractions were found on an automatic biochemical analyzer Stat Faks 1904.

The digital experimental data were processed by the variation statistics method in terms of the significance of the compared parameters using the Student's test accepted in biology and animal science, using the Microsoft Excel software package. The statistical significance values of the processed data were P<0.05*; P<0.01**; and P<0.001***.

RESULTS AND DISCUSSION

The studies revealed that young steers differed in the body weight with respect to their breed. For the research, we used experimental groups of steers aged 8 months. Weighing showed that purebred Kalmyk steers were inferior to their hybrids at all ages studied. The steers in experimental Groups II, III and IV exceeded the Kalmyk steers in Group I by 1.9kg, or 0.97%, 10.7kg, or 5.47% (P≤0.01) and 6.6kg, or 3.37% (P≤0.05) at the age of 8 months; by 5.8kg, or 2.42%, 28.7kg, or 11.97% (P≤0.001) and 13.8kg, or 5.75% (P≤0.001) at the age of 10 months; by 14.3kg, or 4.71% (P≤0.001), 25.2kg, or 8.31% (P≤0.001) and 21.3kg, or 7.02% (P≤0.001) at the age of 12 months; by 17.7kg, or 5.06% (P≤0.001), 29.5kg, or 8.43% (P≤0.001) and 25.0kg, or 7.15% (P≤0.001) at the age of 14 months; and by 15.3kg, or 3.79% (P≤0.001), 36.4kg, or 9.02% (P≤0.001) and 23.3kg, or 5.78% (P≤0.001) at the age of 16 months, respectively (Table 1).

For a more complete study, we recorded the dynamics of overall and average daily body weight gains (Tables 2 and 3).

Table 2 shows that the values of the overall body weight gain of steers in Groups II, III and IV were higher than those in Group I by 3.9kg, or 8.84% (P≤0.05), 18kg, or 40.82% (P≤0.001) and 7.2kg, or 16.32% (P≤0.001) at the age of 7-9 months; and by 3.4kg, or 7.33%, 4.3kg, or 9.27% (P≤0.05) and 3.7kg, or 7.97% at the age of 12-14 months, respectively.

In the age period from 14 to 16 months, the steers in Group III exceeded the steers in Groups I (control), II and IV by 6.9kg, or 12.87% (P≤0.01), 9.3kg, or 18.16% (P≤ 0.01) and 8.6kg, or 16.57% (P≤0.01), respectively.

Table 1. The body weight dynamics of experimental steers, kg (n=10)

Age, months	Group			
	I	II	III	IV
8	195.7±1.54	197.6±2.12	206.4±2.34***	202.3±2.6**
10	239.8±1.73	245.6±2.24	268.5±2.19***	253.6±2.54***
12	303.4±1.81	317.7±2.19***	328.6±2.21***	324.7±2.34***
14	349.8±2.06	367.5±2.34***	379.3±2.49***	374.8±2.43***
16	403.4±2.34	418.7±2.57**	439.8±2.64***	426.7±2.35***

Table 2. The overall body weight gain of steers, kg (n=10)

Age, months	Group			
	I	II	III	IV
8-10	44.1±1.2	48.0±0.95*	62.1±1.3***	51.3±0.97***
10-12	63.6±1.4	72.1±1.3***	60.1±1.2	71.1±1.4***
12-14	46.4±1.5	49.8±1.4	50.7±1.3*	50.1±1.2
14-16	53.6±1.3	51.2±1.5	60.5±1.4**	51.9±1.6

The highest average daily gain for the entire experimental age period from 8 to 16 months was characteristic of the steers in Group III (972.5 g), which was by 11.01, 5.27 and 3.86% higher than in Groups I, II and IV, respectively.

The study of the growth and development characteristics of experimental steers established the unequal behavior of their body weight and overall and average daily gains depending on the age. Differences in the growth rates of the experimental steers can be explained by the

hybrids' specific metabolism caused by the heterosis and heredity of the Kalmyk breed.

The control slaughter of experimental steers at the age of 18 months showed their high meat productivity. However, the steers in Group III were distinguished by higher slaughter values. It was the Group III steers that had heavier carcasses in comparison with other groups (Table 3).

Table 3. Control slaughter indices of experimental steers (n=3)

Parameter	Group			
	I	II	III	IV
Pre-slaughter weight, kg	404.0±2.5	420.0±2.47**	441.0±3.12***	430.0±2.66***
Carcass weight, kg	224.79±2.40	233.77±2.61	248.9±3.46**	241.66±1.85**
Carcass yield, %	55.64	55.66	56.44	56.2
Fat weight, kg	11.4±0.15	10.8±0.14	11.6±0.17	11.5±0.16
Fat yield, %	2.83	2.79	2.64	2.68
Slaughter weight, kg	235.33±1.24	245.74±1.18**	259.57±1.16***	252.32±1.17***
Slaughter yield, %	58.25	58.51	58.86	58.68

The data in Table 3 show, that steers in Groups II, III and IV exceeded steers Group I by 8.98 kg, or 4.00%, 24.11kg, or 10.73% (P<0.01) and 16.87kg, or 7.51% (P<0.01) in terms of the carcass weight; and by 10.41kg, or 4.42% (P<0.01), 24.24kg, or 10.30% (P<0.001) and 16.99kg, or 7.22% (P<0.001) with respect to the slaughter weight, respectively, with the higher value of the slaughter yield of carcasses being registered in Group III. However, no statistical significance was found in terms of the fat parameter.

The most important parameter of the meat productivity is the morphological composition of carcasses (Table 4).

Table 4. Morphological carcass compositions of experimental steers (n=3)

Parameter	Group			
	I	II	III	IV
Carcass weight, kg	224.79±2.40	233.77±2.61	248.9±3.46**	241.66±1.85**
Flesh weight, kg	192.1±1.87	202±0.90**	213.94±2.06***	207.79±2.40***
Flesh yield, %	81.63	82.20	82.40	82.35
Bone weight, kg	38.12±0.52	38.58±0.31	40.23±1.47	39.36±1.53
Bone yield, %	16.2	15.7	15.5	15.6
Tendon weight, kg	5.11±0.13	5.16±0.15	5.40±0.12	5.17±0.09
Tendon yield, %	2.17	2.10	2.08	2.05
Fleshing index, %	5.04	5.24	5.32	5.28

The data in Table 4 show that the flesh carcass yield of steers in Group III was by 0.79; 0.22 and 0.07% higher than that of steers in Groups I, II and IV.

Similarly, the fleshing index in Group III was higher than that in Groups I, II and IV by 0.28, 0.08 and 0.04%, respectively.

Indices of the slaughter weight, slaughter yield, flesh carcass yield and fleshing index indicated that steers in Group III had better slaughter qualities in comparison with other experimental steers.

To determine the nutritional value of beef, we studied the qualitative composition of proteins. For this purpose, the amino acid analysis of meat was conducted, the indices of the contents of nonessential and essential amino acids were determined, and their ratio was calculated.

Here are the indices of the contents of two amino acids, i.e. tryptophan (an essential amino acid) and hydroxyproline (a non-essential amino acid) that are usually determined to assess the protein value of meat. Tryptophan is known to be a part of muscle fibers, consisting of protein complexes. Their greater part accounts for complete proteins that are most optimally assimilated by the human body. Hydroxyproline is a defective protein, it is part of the connective tissue; its absorption by the human body is low. There is a direct correlation between the contents of these two amino acids in meat, and the ratio between them is called the protein quality index (PQI). A large amount of hydroxyproline and a small amount of tryptophan indicate tough meat with a low biological value (Table 5).

Table 5. Protein quality index of beef from experimental steers (n=3)

Parameter	Group			
	I	II	III	IV
Tryptophan, mg %	439.20±1.32	428.20±1.25	432.09±1.17*	448.10±1.33
Hydroxyproline, mg %	62.02±0.47	61.60±0.38	63.83±0.25	63.70±0.22
Protein quality index	7.08	6.95	6.77	7.03

In our studies, the highest PQI value was found in Group I steers, which allowed us to conclude about the full value condition of beef and its good digestibility. The steers of pure Kalmyk breed had a better quality of meat compared to crossbreeds.

The interior traits are known to characterize the productivity level of animals and the state of their natural resistance, so they are considered when developing tests to assess their breeding and productive qualities (Bashirov *et al.,* 2004; Gorlov *et al.*, 2019; McGee *et al*., 2020).

The growth rate of steers is due to the corresponding metabolic activity that can be objectively assessed by blood tests.

The analysis of hematological indices showed that the steers in Group III were superior to their analogs in Groups I, II and IV by 2.24, 0.17 and 0.09% in terms of the erythrocyte content of blood and by 0.67, 0.08 and 0.12% with respect to the hemoglobin content. In terms of the leukocyte level, the experimental steers did not differ and were approximately at the same level. It should be noted that all hematological indices obtained were within the physiological norm. This was probably due to the stress of oxidative processes in the body of experimental steers during the period of their maximum growth intensity.

Proceeding from the fact that the growth processes in the animal organism are associated with the protein metabolism intensity, we assessed its activity and orientation by blood parameters. An increase in the contents of erythrocytes and hemoglobin in blood is known to characterize a high level of metabolism in the animal body, which is caused by the direct correlation between morphological parameters of blood and an increase in the body weight.

Moreover, we determined the protein blood composition. Proteins play an important role in the life and building of the body. They are an integral part of many biologically active substances—enzymes that determine the rate of synthesis and decay processes at the cellular level and hormones involved in the regulation of vital processes. Proteins are part of the immune bodies that determine the protective functions (Dunin *et al.,* 2012; Levakhin *et al.,* 2006; Randelin, 2013).

Being in close connection with proteins of various tissues, blood proteins react very subtly to changes in physicochemical processes in the organs. Proceeding from the fact that the growth processes in the animal organism are associated with the protein metabolism intensity, we assessed the protein activity and direction according to the blood parameters of steers in the experimental groups.

Our study found that the protein blood compositions differed in groups of experimental steers, with the higher content of total protein and its fractions being recorded in blood of Group III steers (Table 6).

Table 6. Biochemical parameters of blood of experimental steers (n=3)

Parameter	Group			
	I	II	III	IV
Total protein, g/L	83.97±0.27	83.19±0.31	86.72±0.25**	84.92±0.26
Albumins, g/L	47.10±0.15	47.10±0.17	47.89±0.22*	47.72±0.13*
Globulins, g/L	36.87±0.16	36.09±0.17*	38.83±0.14***	36.29±0.18

The blood of the steers in Group III contained more total protein by 2.75g/L, or 3.27% (P<0.01), 3.53g/L, or 4.24% (P<0.01) and 1.8g/L, or 2.12% (P<0.05); albumin by 0.79g/L, or 1.68% (P<0.05), 0.79g/L, or 1.68% (P<0.05) and 0.17g/L, or 0.36%; and globulins by 1.96g/L, or 5.32 (P<0.001), 2.74g/L, or 7.59% (P<0.001) and 2.54g/L, or 7.00% (P<0.01), compared with the steers in Groups I, II and IV, respectively.

The most intensive synthesis of albumin and globulin protein fractions was found in Group III. It should be noted that the comparative analysis between the groups revealed lower concentrations of globulins in Group II.

The morphological and biochemical values indicated all changes in the blood composition being within the physiological norm. However, their higher value, as a rule, was accompanied by an increase in the growth intensity of steers in certain age periods.

The research results indicated that it is promising to create crossbreeds based on the Kalmyk breed, because it is distinguished by a high genetic potential for meat production.

In the research, we calculated the correlation between morphological and biochemical parameters of blood and the body weight of experimental steers of different genotypes in different age periods. The correlation between the traits was determined by calculating the correlation coefficients, with the statistical significance being assessed according to the Student's t-test.

The linear correlation coefficient takes on values from –1 to +1. The correlation between traits can be weak or strong. Their criteria are assessed in accordance with the Chaddock scale:

$0.1 < r_{xy} < 0.3$: practically absent;
$0.3 < r_{xy} < 0.5$: weak;
$0.5 < r_{xy} < 0.7$: noticeable;
$0.7 < r_{xy} < 0.9$: strong; and
$0.9 < r_{xy} < 1$: very strong.

The correlation between the morphological and biochemical blood parameters and the body weight of experimental steers of different breeds was significant in different age periods. So, our studies established positive correlations between the morphological and biochemical parameters of blood and the body weight of experimental steers (Table 7).

Table 7. Coefficients of correlation between morphological and biochemical parameters of blood and body weight of steers (n=10)

Parameter	Group			
	I	II	III	IV
Erythrocytes, 10^{12}/L	0.59	0.58	0.62	0.60
Leukocytes, 10^{9}/L	0.14	0.18	0.11	0.13
Hemoglobin, g/L	0.63	0.64	0.71	0.67
Total protein, g/L	0.66	0.55	0.57	0.58
Albumins, g/L	0.65	0.61	0.71	0.64
Globulins, g/L	0.05	0.08	0.07	0.07

In our studies, a strong positive correlation between the productivity of steers and the contents of hemoglobin and erythrocytes in their blood was established.

The correlation coefficient (r) between the number of erythrocytes in blood and the body weight of steers made 0.59, 0.58, 0.62 and 0.60. A stronger correlation was found between the level of hemoglobin in blood and the productivity index. The coefficients of the correlation between the hemoglobin content in blood and the body weight were 0.63, 0.64, 0.71 and 0.67 in Groups I-IV, respectively, with the correlation between the body weight and leukocytes being weak and the correlation coefficients being insignificant.

At the same time, we observed a general pattern of a strong positive correlation between the contents of total protein and albumin and the body weight and a weak positive correlation between the content of globulins and the body weight. A higher and significant correlation coefficient between the globulin content and the body weight was established in Group II steers, which might indicate the predominance of the lipid metabolism over the protein one.

The study also established that the strongest significant correlation ($P<0.001$) was between the total protein and albumin contents and the body weight during all periods of growth of steers in all groups studied. The globulin protein fraction had an insignificant correlation with the body weight of steers in different growth periods of ($P<0.001$).

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CONCLUSION

The studies showed that the contents of morphological elements and proteins in blood reflect the level of metabolism in the body and the potential for crossbred steers to accumulate muscle mass. The data obtained on the correlation between the interior traits and the fattening indices, in our opinion, make it possible to use the revealed strong correlations as markers in the selection to increase the meat productivity.

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