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Regression Models for Predicting Production of Three Main Beef Cattle Breeds Grown in Russia with Respect to Biochemical Parameters of Blood.

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ABSTRACT

The article defines the interrelationships between internal and fattening parameters of steers in three test groups. Main predicting factors of meat productivity indices have been substantiated. There have been found regression coefficients that take into account the dynamics of live weight changes, depending on the main factors. The meat production prediction models have been developed with respect to the protein content in blood serum for three most popular beef cattle breeds in Russia. The entire population of young cattle under study has been found to have a clear relationship between the live weight and content of total protein and albumins. The correlation between globulin fraction of proteins and live weight of the steers was not significant. The study has established the possibility of predicting the live weight of steers at the end of fattening, depending on the protein content in blood serum.

Keywords: Beef cattle breeding; Blood; Genotype; Live weight; Productivity; Regression analysis

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INTRODUCTION

Modern animal selection is based on selection in terms of a set of characteristics [1]. Animals are considered the most valuable in breeding if they have desirable qualities [2]. The aim singled by a breeder can be achieved under condition of knowing the biological nature of high productivity and treating the animal organism as a whole [3]. At present, the interior is considered as a set of morpho-physiological features in the organism associated with the productive qualities of animals [4,5]. Unfortunately, traditional system of animal husbandry in Russia does not fully take into account biochemical individuality that indicates the level and pattern of metabolic processes in the body [6]. To successfully solve the problem of increasing the meat production of highly specialized meat cattle breeds in the Russian Federation under conditions of biologically complete feeding is possible on the basis of an interior complementary selection, taking into account the most important indices of blood [7,8]. In animal husbandry, blood is the most accessible material for internal examination and subsequent use of biochemical tests [9,10]. The blood composition of animals indicates their conformation and metabolic pattern [11]. Thus, the evaluation of the steers' metabolic statuses that is based on the analysis of biochemical blood parameters and allows determining the formation of productive qualities in the long term is obviously of high priority and relevant[12].

The residue in blood serum basically contains proteins, i.e., albumins and globulins. The albumins are the amino acid reserve of the organism in the event of acute insufficiency (they contain up to 600 amino acid residues), act as a separate buffer system and actively participate in the transport of various substances—hormones, vitamins, bilirubin, fatty acids, mineral compounds, etc. The globulins are characterized as carrier proteins that specialize in the transfer of metals. Some of the proteins in this fraction are involved in blood clotting; some are antibodies.

Deficiency of proteins in the rations of animals leads to severe consequences, i.e., the productivity decreases; the product quality deteriorates; the growth of young animals slows down; the length of growing and fattening increases; the feed costs per unit of output increase;deterioration of digestibility and consumption of feed nutrients [13-15].

Thus, to predict economic characteristics in meat cattle breeding, it is possible to consider interior parameters, since they indicate the metabolic pattern in the animal body. This actualizes research studies in the field of physiology and biochemistry of livestock aimed at revealing the persistent mechanisms of the growing animal organism.

With this background, the authors set a goal to develop a predictive model for the fattening parameters of steers of three beef cattle breeds, the most common in the territory of the Russian Federation, on the basis of the relationship between the level of serum blood proteins and live weight in different fattening periods.

MATERIALS AND METHODS

The experimental part of the research work was conducted in OOO Tingutinskoyein the Volgograd Region (the Russian Federation). According to the analogue principle, three groups of steers wereformed,30 heads in each. Test Group I included steers of Russian hornless breed, test Group II Kazakh White-headed steers and test Group III steers of Kalmyk breed. The test groups were formed when the steers reached the age of 8 months. The animals were in the same conditions of feeding and keeping, which made it possible to objectively judge their differences in productivity.

Animal rations were similar in structure and nutritional value, consistent with the standard ration and calculated taking into account the average daily gain of live weight of 950-1000g. The withdrawal of animals from fattening was carried out at 17 months of age.

The material for the research was blood taken in the morning before feeding. In the blood serum samples (n = 90), the concentration of total protein, albumins and globulins was determined by the colorimetric method using the Klini-Test, Eko-service and PLIVA-Lachema Diagnostika reagents kits.

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The statistical processing of the data was carried out by the variation statistics on a PC using the Microsoft Excell-2007 program, the Biometrics application package and statistical analysis package Statistica 10 (StatSoft Inc.).

The significance of differences between the indices was determined using the criteria of nonparametric statistics for the linked populations (differences with P<0.05 were considered significant; ns = not significant at P>0.05). Student's t-test was applied for the statistical analysis [16]. The mean of a set of measurements was calculated according to the formula: $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$, where $\bar{x}$ is a mean value; $\sum_{i=1}^{n} x_i$ is the sum of all x_i with i ranging from 1 to n, n is the number of measurements. The residual variation is expressed as a root mean square error (*r.m.s.e.*): $\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$. The standard error of mean (*s.e.m.*) was calculated using the formula: $s.e.m.(\bar{x}) = \frac{\sigma}{\sqrt{n}}$. The reliability of a sample difference (*Student's t-distribution*) was estimated by the test of the difference validity, which is the ratio between the sample difference and the non-sampling error. The test of the difference validity was determined by the formula: $t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s.e.m._1^2 + s.e.m._2^2}} \geq t_{st.}(d.f. = n_1 + n_2 - 2)$, where t is a Student's t-distribution; $\bar{x}_1 - \bar{x}_2$ is the difference of the sample mean measurements; $\sqrt{s.e.m._1{}^2 + s.e.m._2{}^2}$ is the sample difference error; *s.e.m.*$_1$and *s.e.m.*$_2$ are the a non sampling errors of the compared sample statistics; t_{st} is the standard criterion according to the t-Table for the probability threshold preset depending on degrees of freedom; n_1 and n_2 are the numbers of measurements in the samples compared; *d.f.* is the degrees of freedom for the difference of two mean measurements.

RESULTS AND DISCUSSION

The live weight is an indicator of the development, fatness, physiological condition and level of provision of the animal body with nutrients. At the beginning of the experiment, the Kazakh White-headed steers outperformed their analogues in test Groups I and III in terms of live weight parameter by 1.9 (P<0.001) and 10.3% (P<0.001), respectively (Table 1). At the end of the fattening, this difference was 1.5 (P<0.05) and 8.4% (P<0.001), respectively.

Table 1: Live weight of test steers and biochemical blood indices in different age periods (mean±s.e.m.)

Parameter	RussianHornless (Group I, n = 30)	Kazakh White-headed (Group II, n = 30)	Kalmyk (Group III, n = 30)
Age, 8 months			
Live weight, kg	210.0 ±0.84[a]	214.1±0.60	192.0±1.62[a]
Total protein, g/l	83.64±0.29	85.37±0.24[B]	82.28±0.32[b]
Albumins, g/l	36.30±0.08	37.81±0.06	35.12±0.11
Globulins, g/l	47.34±0.12	47.56±0.09	47.16±0.15
Age, 17 months			
Live weight, kg	460.0±2.1[c]	466.9±2.13	427.6±2.1[a]
Total protein, g/l	84.87±0.35	86.72±0.28[A]	83.94±1.31
Albumins, g/l	36.97±0.10	38.83±0.12[C]	36.19±0.06
Globulins, g/l	47.90+0.13	47.89±0.08	47.75+0.11
*Note:*a = P<0.001; c = P<0.05 compared with data on Group II; B = P < 0.001 compared with data on Group III; b= P < 0.001 compared with data on Group II; A = P < 0.001 compared with data on Group I; C = P < 0.001 compared with data on Group II (8 months)			

Proteins play an important role in the vital activity and construction of the animal organism. Proteins have building, biological and energy functions. The building function consists in the fact that proteins are the building material for the synthesis of body proteins, forming part of all organs and tissues that are an integral part of the production. The biological function is that proteins are an integral part of many biologically active substances, i.e., enzymes that determine the rate of synthesis and decay processes occurring at the cellular level and hormones involved in the regulation of vital processes. Proteins are a part of antibiotics and immune bodies that determine the protective functions of the body. Proceeding from the fact that the growth processes of the animal organism are associated with the intensity of protein metabolism, an evaluation of its activity and pattern on the blood parameters in steers in test groups was performed (Table 1). So, at the beginning of the experiment, the greatest amount of total protein was contained in blood of the steers in Group II ($P<0.001$), and the smallest number was in blood of the steers in Group III ($P<0.001$). As the steers grew older, the total protein content in their blood also increased. So, at the age of 17 months, the value of this indicator in Group II exceeded that in Group I by 2.1% ($P<0.001$). The increase in the indicator is mainly due to an increase in albumin concentration by 2.6% ($P<0.001$) compared with the 8-month age.

Consequently, the growth of a young organism was accompanied by an increase in the synthesis intensity of the albumins that served both as a source of amino acids in protein synthesis processes and as a vehicle for various low-molecular compounds.

The relationship between the signs (protein composition of blood serum, live weight in different age periods and pedigree) was determined by calculating the correlation coefficients with the T-Tests for statistical significance for different degrees of probability to be conducted [17,18]. It has been proved that the relationships between serum proteins and live weight in different age periods have significant differences in test steers of different breeds.

The study has established positive correlations between the serum proteins and live weight of test steers at the age of 8 months (Table 2). With a positive correlation between the growth energy and concentration of total protein, albumins and globulins, the correlation between globulins and living weight in all groups was noted to be at a low positive level. Similar results were obtained in the analysis of correlative connections between the blood proteins and live weight of test steers at the age of 17 months. Thus, the strongest interdependence was revealed between the live weight and content of total protein and albumins in the entire young cattle population. There was no significant correlation revealed between the globulin fraction of proteins and live weight of steers. Consequently, the content of serum proteins indicates the potential ability of animals to gain body weight.

Table 2: Correlation coefficients between the protein content in blood serum and live weight of steers in different age periods

Parameter, g/l	Russian Hornless (Group I, n = 30)	Kazakh White-headed (Group II, n = 30)	Kalmyk (Group III, n = 30)
Age, 8 months			
Total protein	0.46	0.48	0.42
Albumins	0.67	0.60	0.80
Globulins	0.03	0.04	0.02
Age, 17 months			
Total protein	0.50	0.69	0.67
Albumins	0.62	0.87	0.78
Globulins	-0.02	0.19	0.18

Table 3: Correlation coefficients between protein content in blood serum at the age of 8 months and live weight of steers at the age of 17 months

Parameter, g/l	Russian Hornless (Group I, n = 30)	Kazakh White-headed (Group II, n = 30)	Kalmyk (Group III, n = 30)
Total protein	0.58	0.61	0.51
Albumins	0.61	0.67	0.56
Globulins	0.23	0.25	0.03

To model and predict the productivity of animals, it is necessary to establish the pattern and extent of the relationship between the blood proteins in test steers at 8 months of age and live weight at 17 months (Table 3). The correlation coefficient (r) between the total blood protein in the 8-months-animals and live weight in all studied groups at the age of 17 months had rather high values: 0.58, 0.61 and 0.51, respectively; the same high correlation of 0.61, 0.67 and 0.56 was established for albumins. The relationship between globulins in blood serum of the test steers of different genotypes was weak.

Considering that a high correlation between the blood proteins in 8-months-steers (X factors) and live weight of steers at 17 months (Y score) was stable and reliable, it was possible to develop a model of fattening parameters by the linear regression equation:

$$Y = a + b \cdot X$$

The regression coefficient *b* shows the average change in the score (in *Y* units) with an increase or decrease in the value of *X* factor per unit of its measurement. In linear regression analysis, it was assumed that the "yield – input data" relationship is linear [19, 20]. The regression analysis resulted in the linear decomposition coefficients that minimize deviations from a linear function on a given set of input data [21, 22]. The resulting linear pair regression coefficients are presented in Table 4.

Table 4: Regression coefficients between live weight of steers at the age of 17 months and biochemical blood parameters at 8 months

Parameter, g/l	Russian Hornless (Group I, n = 30)	Kazakh White-headed (Group II, n = 30)	Kalmyk (Group III, n = 30)
Total protein	2.83	3.41	2.01
Albumins	4.32	5.41	5.17
Globulins	1.63	1.93	–

The regression coefficient between the blood proteins at 8 months and live weight at 17 months showed that an increase in the total protein by 0.1 g/l in blood can be a basis for prediction of 2.8 kg of body weight gain of steers in Group I and 3.4 and 2.0 kg in Groups II and III, respectively.

Given that the regression coefficient between the serum albumin and live weight is higher, it can be assumed that their effect on the score is significant.

So, the main parameters, i.e., total protein and serum albumins that have the greatest influence on the meat productivity of the test steers have been determined and justified.

The conducted analysis made it possible to obtain an equation of multiple linear regression for the steers in all groups. The equation describes the relationship between the target Y trait, i.e., live weight of the test steers at the age of 17 months and parameters that are the total protein, albumins and globulins of serum at the age of 8 months. The resulting regression model can be applied in predicting productivity and selection.

The model of the relationship between the live weight and blood serum proteins for the steers in test Group I was represented by the following multiple regression equation:

$$Y = -55.66 + 3.7X_1 + 4.4X_2 + 1.02X_3, \text{ where}$$

$X_1$is the total protein, X_2 albumins and X_3 globulins, with the value of the multiple correlation coefficient to be R=0.99 and standard error of 0.04. The value of the confidence level in this case was P<0.01. The regression model is considered to be well-selected and describe the relationship between the factor and the effective parameter accurately, if the average approximation error did not exceed 10%. In this study, the average approximation error was 5.3%.

The modeling process has established that the equation of multiple regression for the test steers in Group II looks as follows:

$$Y = -168.1 + 3.9X_1 + 5.1X_2 + 2.3X_3$$

with a multiple correlation coefficient R=0.99 and a standard error of 0.45. The value of the confidence level in this case was P<0.01. The average approximation error was 0.3%.

The main parameters that had a significant effect on the increase in live weight for test steers in Group III were the total protein (X_1) and albumins (X_2). The model of the relationship between the live weight and blood serum proteins for test steers in Group III was represented by the following multiple regression equation:

$$Y = 179.9 + 2.7X_1 + 1.81X_2$$

The value of the multiple correlation coefficient R was 0.6 with a standard error of 5.4. The value of the confidence level in this case was P<0.05 and the average approximation error was 2.7%.

All the mathematical models obtained are reliable; the reliability of the correlation coefficients was verified according to the Student's criteria.

CONCLUSION

The research study established a positive correlation between the serum proteins and live weight of test steers of the breeds under study. Moreover, the strength and patterns of the relationship were different. On the basis of the foregoing, it was possible to predict the live weight of the test steers at the end of fattening, depending on the protein content in serum of steers.

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