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Change in physiological parameters of calves of various breeds under the transport and pre-slaughter stress

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Abstract. *Levakhin VI, Gorlov IF, Azhmuldinov EA, Levakhin YI, Duskaev GK, Zlobina EY, Karpenko EV. 2017. Change in physiological parameters of calves of various breeds under the transport and pre-slaughter stress. Nusantara Bioscience 9: 1-5.* The purpose of the research was to study the effect of the animal breed on the stress resistance of young cattle during the motor transportation. Six groups of animals were chosen for the experiment. The first group consisted of calves crossbred from dairy Black and White cows with Hereford bulls, the second – of calves crossbred from dairy cows of Bestuscheff breed with Hereford bulls, the third – of calves purebred of Simmental, the fourth – of calves purebred of Hereford, the fifth – of calves purebred of Aberdeen-Angus, and the sixth – of calves purebred of Limousine breed. The total length of transport was 180 km of highways and local roads. The route consisted of a 5-hour trip without a rest period. The greatest loss in the body weight was determined in the Limousine calves. The calves purebred of Hereford and Simmental breeds are more stress-resistant during the transporting and the pre-slaughter treatment.

Key words: breed, calf, clinical score, pre-slaughter period, stress-resistant
Abbreviations: BW = body weight, HB = hemoglobin level

INTRODUCTION

The cattle transporting to the fattening or slaughter place is one of the most stressful situations that affect the beef production process (Arthington et al. 2005, 2008; Carroll and Forsberg 2007; Levakhin et al. 2010 and 2014; Cooke and Bohnert 2011a; Nielsen et al. 2011). To find a stress relieving factor, various researches developing antistress preparations (Mapiye et al. 2011; Cooke et al. 2013a; Guarnieri Filho et al. 2014), a combination of different diets (Belyaev and Gorlov 2010; Gorlov et al. 2011; Goldhawk et al. 2014a, 2014c), a microclimate control in the vehicle (Cooke et al. 2011b; Goldhawk et al. 2014b), change in the supply chain (Romero et al. 2013; Miranda-de la Lama and Villarroel María 2014) had been conducted. The possibility of making breaks during a long carriage with a feed table (Cooke et al. 2013b), as well as the influence of the density of cattle transported in a vehicle on the number of bruises, abrasions, and the decrease in the pH of the final product (Merrill et al. 2007; Earley et al. 2013) had also been studied. To examine the impact of breed on the physiological factors of young cattle during transportation on road transport is also important. Due to the heterogeneity of cattle delivered for slaughter in the Russian Federation, the practical relevance of this study is high, as it allows revealing the relation between the breed factor and the transportation stress.

MATERIALS AND METHODS

Study area

The experimental part of the work was carried out on an industrial complex, designed for 10 thousand heads under an Italian license, in the Republic of Tatarstan, Russian Federation. For the experiment, six groups of animals, 12 heads in each, were chosen. The first group consisted of calves crossbred from dairy cows of Black and White breed with Hereford bulls (I), the second group was made up of calves crossbred from dairy cows of Bestuscheff breed with Hereford bulls (II), in the third group there was young stock purebred of Simmental (III), the fourth consisted of young stock purebred of Hereford (IV), the fifth contained young stock purebred of Aberdeen-Angus (V), and in the sixth there was young stock purebred of Limousine breed (VI).

Procedures

Calves of all groups studied were in an industrial fattening complex of enclosed type. The experiment lasted till the youngsters were at the age of 15 months. Prior to the transporting, the animals were fasted for 10 hours, but they had free access to water, during the transport the calves had no access to food and water. The total length of transport (180 km) included a combination of highways and local roads. The route was a 5-hour trip without a rest period. Before transporting, the animals were driven into a

road receiving lair equipped with a headlock, electronic scales, and a loading deck. Unloading of the animals at the slaughtering and meat-processing plant went on in the same way: a road receiving lair, weighing, clamping for blood sampling and determination of clinical parameters. The pre-slaughter holding (24 hours) was conducted for the animals to rest and clinical parameters to normalize. The animals were kept in an unheated space with straw bedding, at a density of 2 m^2 per head, without food, with free access to water. The pre-slaughter treatment involved cleaning, washing, veterinary and sanitary inspection of animals and their pre-slaughter thermometry. The slaughter method at the plant was stunning with alternating current power of 1-1.5 A and voltage up to 125 V.

Measurement of the body temperature was conducted using a rectal electronic thermometer for veterinary SC 12 (Hauptner and Herberholz, Germany) one hour prior to and after the transportation.

The pulse was determined by imposing a finger on the femoral artery. The respiratory rate was determined from the movement of the chest and from the thrust of exhaled air.

Morphological and biochemical parameters of blood were determined using an automatic hematology analyzer for veterinary BC-2900 Vet and biochemistry analyzer Stat Fax1904+.

The animals were weighed immediately prior to and at the end of the transportation. The following parameters were also determined: the body weight (BW) at the end of breeding or fattening, which is measured before sending animals for slaughter; the live weight after the calves transportation that is determined at the end of the transport; the loss on the way is the difference between the live weight at the beginning and the end of the shipment; the live weight after the pre-slaughter care is measured after the 24-hour fasting at the factory, but with free access to water, which ceased three hours before slaughter; the loss of live weight at the pre-slaughter care is the difference in BW after the transport and after the pre-slaughter treatment; the total loss of live weight is the difference in BW before the transport and after the pre-slaughter treatment.

Data analysis

The data on different variables, obtained from the experiment, were statistically analyzed by Statistica 10 package (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: $^aP < 0.001$; $^bP < 0.01$; $^cP < 0.05$; ns = not significant at $P > 0.05$). Student's t-test was applied for the statistical analysis (Johnson and Bhattacharyya 2010).

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 a 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 by 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 to the non-sampling error. The test of the difference validity was determined by the formula: $t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s.e._1^2 + s.e._2^2}} \geq t_{st}(d.f. = n_1 + n_2 - 2)$, where t is a Student's t-distribution; $(\bar{x}_1 - \bar{x}_2)$ is a difference of the sample mean measurements; $\sqrt{s.e.m._1^2 + s.e.m._2^2}$ is a sample difference error; $s.e.m._1$, $s.e.m._2$ is a non-sampling error of the sample statistics compared; t_{st} is a standard criterion according to the t-Table for the probability threshold preset depending on degrees of freedom; n_1, n_2 is a number of measurements in the samples compared; *d.f.* is a degrees of freedom for difference of two mean measurements.

MS Office 2010 package was employed for graphical presentation of the data.

RESULTS AND DISCUSSION

The animals were transported in special vehicles at the density of 1.6-1.7 m^2 per head late March. The ambient temperature was 3ºC, the humidity – 82%, in the absence of rainfall, the air movement – 3.5 m/sec., in the transport sections 1.2 m/sec.

The study noted significant changes in clinical scores of the experimental animals under the stress caused by their transport for slaughter (Table 1).

Before the transportation, the clinical scores of animals in the test groups were similar and were as follows: the body temperature of 38.6-38,7 ^oC, the pulse rate – 65.3-67.0 beats per minute, the respiratory rate – 29.7-30.7 breaths per minute.

During the carriage the body temperature of the animals increased on the average by 0.3ºC (0.78%, $P < 0.001$), the heart rate increased by 19.4 contractions (29.0%, $P < 0.001$), and the respiration rate - by 4.5 respiratory movements (14.9%, $P < 0.001$).

The calves of Aberdeen-Angus and Limousine breeds had the greatest changes in clinical scores. Less change was observed in the calves crossbred from Black and White and Hereford breeds and then in the calves from Bestuscheff and Hereford breeds. So, their body temperature increased by 1.03 ($P < 0.001$); 1.03 ($P < 0.001$); 1.03 ($P < 0.001$), and 0.78% ($P < 0.001$), respectively, as compared to the conditions of physiological rest; the pulse rate – by 33.9 ($P < 0.001$); 37.6 ($P < 0.001$); 28.8 ($P < 0.001$), and 27.0% ($P < 0.001$), the respiratory rate – by 17.7 ($P < 0.001$); 17.3 ($P < 0.001$); 15,5 ($P < 0.001$), and 15.5% ($P < 0.001$). This

scores increase in the calves of Simmental and Hereford breeds was only 0.78 ($P < 0.001$) and 0.52% ($P < 0.001$), 24.2 ($P < 0.001$) and 23.0% ($P < 0.001$), 12.3 ($P < 0.05$) and 11.1% ($P < 0.05$).

Therefore, if you use the clinical scores as a test of the animals stress state, the young stock of Hereford and Simmental breeds has the greatest stress resistance, and the Limousines and the Aberdeen-Anguses are more susceptible to the influence of the environmental factors. The latter ones however adopt more rapidly than the Limousines.

Similar changes in the blood of the experimental animals, but to an even greater degree, they were observed during their transportation for slaughter. Prior to the transport stress, the content of red blood cells ranged from 7.83 to $8.47 \cdot 10^{12}$/l, of white blood cells – $7.28\text{-}7.36 \cdot 10^{9}$/l, hemoglobin (Hb) level and total protein – 116.0-118.1 g/l and 63.1-65.7 g/l, respectively, lipids – 4.31-4.68 mmol/l, sugar – 2.90-3.29 mmol/l, hematocrit – 38.6-40.6%, with the animals of Simmental and Hereford breeds to have the highest values (Table 2).

After transporting, the hematologic parameters in all groups of young stock markedly increased, indicating a physiological stress and an activation of oxidative processes in the body. So, the number of red blood cells increased on average by 13.6%, white blood cells – by 7.5%, Hb level – by 2.1%, total protein – by 4.1%, lipids – by 9.6%, sugar – by 23.1%, hematocrit – 3.6% compared to the baseline in blood of the animals in the studied groups (Table 3).

The greatest changes in the blood were observed in the calves of Limousine and Aberdeen-Angus breeds: red blood cells increased by 9.4-9.9% ($P < 0.05$), Hb – by 2.3-2.7% ($P < 0.05$), total protein – by 4.7-5.1% ($P < 0.01$), lipids – by 8.5-14.0% ($P < 0.05$), sugar – by 21.9-31.0% ($P < 0.01$), and to a lesser extent in the Simmental and Hereford calves – by 6.0-6.1 ($P < 0.05$); 1.4-1.6 ($P > 0.05$); 1.4-3.4 ($P > 0.05$); 5.6-7.1 ($P < 0.05$), and 12.4-16.4% ($P < 0.05$), respectively. The crossbred young stock was intermediate according to these indicators.

In the beef production the most effective stressors accompanied by a production loss are the transport and pre-slaughter treatment of the animals. The loss in BW during the transport can reach 6-9% of the original. However, the value depends on the transport distance, the mode of transport, the weather, the animal breed, the stress resistance level of the animals, etc. During the pre-slaughter treatment the loss in BW continues to grow and for one day may increase by 2-3% with the weight of the carcass to reduce by 1.5-2.0%.

Our results show that the young animals of various breeds and genotypes respond differently to the transport and pre-slaughter stress that affected the loss of their live weight (Table 4).

Table 1. Clinical scores of experimental animals (mean ± s.e.m.)

Indices	Black and White x Hereford	Bestuscheff x Hereford	Purebred of Simmental	Purebred of Hereford	Purebred of Aberdeen-Angus	Purebred of Limousine
Prior to transportation						
Body temperature, °C	38.7 ± 0.01	38.6 ± 0.02	38.7 ± 0.01	38.6 ± 0.01	38.6 ± 0.01	38.7 ± 0.02
Rate per min: pulse	67.0 ± 0.22	66.7 ± 0.19	66.0 ± 0.25	65.3 ± 0.30	67.0 ± 0.17	68.3 ± 0.25
respiratory	30.3 ± 0.26	29.7 ± 0.21	30.0 ± 0.32	29.7 ± 0.18	30.0 ± 0.20	30.7 ± 0.27
After transportation						
Body temperature, °C	39.0 ± 0.03[a]	38.9 ± 0.02[a]	39.0 ± 0.02[a]	38.8 ± 0.01[a]	39.0 ± 0.03[a]	39.1 ± 0.02[a]
Rate per min: pulse	86.4 ± 0.41[a]	84.7 ± 0.65[a]	82.0 ± 0.44[a]	80.3 ± 0.53[a]	89.7 ± 0.60[a]	94.0 ± 0.48[a]
Respiratory	34.8 ± 0.37[a]	34.3 ± 0.45[a]	33.7 ± 0.39[c]	33.0 ± 0.48[c]	35.3 ± 0.34[a]	36.0 ± 0.31[a]

Note: s.e.m. = standard error of mean; P = probability; [a]$P < 0.001$; [b]$P < 0.01$; [c]$P < 0.05$ compared with data on the prior to transportation

Table 2. Morphological and biochemical composition of blood of experimental animals prior to transportation (mean ± s.e.m.)

Indices	Black and White x Hereford	Bestuscheff x Hereford	Purebred of Simmental	Purebred of Hereford	Purebred of Aberdeen-Angus	Purebred of Limousine
Erythrocytes, 10^{12}/L	7.8 ± 0.22	7.9 ± 0.30	8.4 ± 0.24	8.2 ± 0.35	8.1 ± 0.19	8.5 ± 0.28
Leukocytes, 10^{9}/L	7.4 ± 0.37	7.3 ± 0.25	7.4 ± 0.30	7.5 ± 0.27	7.3 ± 0.41	7.4 ± 0.33
Hemoglobin, g/L	116.3 ± 0.94	116.0 ± 0.81	118.1 ± 1.03	117.5 ± 0.79	116.8 ± 0.96	117.9 ± 0.85
Total protein, g/L	63.1 ± 0.40	63.8 ± 0.53	65.2 ± 0.59	64.8 ± 0.37	64.6 ± 0.28	65.7 ± 0.47
Lipids, mmol/L	4.5 ± 0.14	4.5 ± 0.20	4.4 ± 0.17	4.6 ± 0.21	4.7 ± 0.13	4.3 ± 0.16
Sugar, mmol/L	2.9 ± 0.09	3.0 ± 0.12	3.3 ± 0.10	3.1 ± 0.12	2.9 ± 0.08	3.2 ± 0.11
Calcium, mmol/L	2.5 ± 0.10	2.4 ± 0.08	2.6 ± 0.12	2.1 ± 0.10	2.3 ± 0.11	2.7 ± 0.09
Phosphorus, mmol/L	1.7 ± 0.07	1.7 ± 0.09	1.9 ± 0.07	1.8 ± 0.08	1.6 ± 0.10	1.9 ± 0.09
Hematocrit, %	39.2 ± 0.35	40.6 ± 0.41	38.8 ± 0.32	39.5 ± 0.30	39.0 ± 0.38	38.6 ± 0.27

Note: s.e.m. = standard error of mean

Table 3. Morphological and biochemical composition of blood of experimental animals after transportation (mean ± s.e.m.)

Indices	Black and White x Hereford	Bestuscheff x Hereford	Purebred of Simmental	Purebred of Hereford	Purebred of Aberdeen-Angus	Purebred of Limousine
Erythrocytes, 10^{12}/L	8.5 ± 0.19^{ns}	8.6 ± 0.25^{c}	8.9 ± 0.21^{c}	8.7 ± 0.30^{c}	8.9 ± 0.27^{c}	9.3 ± 0.22^{c}
Leukocytes, 10^{9}/L	7.8 ± 0.28^{ns}	7.7 ± 0.34^{ns}	7.8 ± 0.32^{ns}	7.9 ± 0.23^{ns}	8.0 ± 0.30^{ns}	8.1 ± 0.25^{ns}
Hemoglobin, g/L	119.3 ± 0.85^{ns}	118.8 ± 0.92^{ns}	119.7 ± 0.87^{ns}	119.4 ± 1.03^{ns}	120.0 ± 0.90^{c}	120.6 ± 0.96^{c}
Total protein, g/L	66.8 ± 0.52^{b}	66.2 ± 0.47^{c}	67.4 ± 0.65^{ns}	65.7 ± 0.59^{ns}	67.9 ± 0.42^{c}	68.8 ± 0.50^{c}
Lipids, mmol/L	5.0 ± 0.13^{c}	4.9 ± 0.11^{ns}	4.6 ± 0.16^{c}	4.8 ± 0.14^{c}	5.1 ± 0.16^{c}	4.9 ± 0.12^{c}
Sugar, mmol/L	3.7 ± 0.11^{b}	3.6 ± 0.12^{c}	3.7 ± 0.10^{c}	3.6 ± 0.11^{c}	3.8 ± 0.12^{b}	3.9 ± 0.09^{b}
Calcium, mmol/L	2.8 ± 0.09^{a}	2.7 ± 0.11^{c}	2.8 ± 0.10^{ns}	2.7 ± 0.12^{b}	2.8 ± 0.10^{c}	2.9 ± 0.11^{ns}
Phosphorus, mmol/L	2.0 ± 0.07^{c}	1.9 ± 0.08^{ns}	2.2 ± 0.09^{ns}	2.0 ± 0.10^{ns}	1.9 ± 0.08^{ns}	2.2 ± 0.07^{c}
Hematocrit, %	43.7 ± 0.29^{a}	43.2 ± 0.37^{b}	41.5 ± 0.34^{b}	41.9 ± 0.43^{b}	44.2 ± 0.25^{a}	43.1 ± 0.33^{a}

Note: s.e.m. = standard error of mean; P = probability; $^{a}P < 0.001$; $^{b}P < 0.01$; $^{c}P < 0.05$; ns = not significant at $P > 0.05$ compared with data on the prior to transportation

Table 4. Loss in the body weight (BW) of test animals during transport and pre-slaughter care (mean ± s.e.m.)

Indices	Black and White x Hereford	Bestuscheff x Hereford	Purebred of Simmental	Purebred of Hereford	Purebred of Aberdeen-Angus	Purebred of Limousine
BW prior to transportation, kg	415.0 ± 2.78	421.7 ± 2.65	468.3 ± 2.90	436.0 ± 2.54	432.3 ± 2.63	459.7 ± 3.04
BW after transportation, kg	396.7 ± 2.21	404.3 ± 2.30	449.0 ± 2.49	419.3 ± 2.17	413.7 ± 2.51	439.3 ± 2.66
Loss on the way, kg	18.3 ± 0.45^{c}	17.4 ± 0.66^{c}	19.3 ± 0.51^{ns}	16.7 ± 0.52^{b}	18.6 ± 0.63^{ns}	20.4 ± 0.58
%	4.4	4.2	4.1	3.8	4.3	4.4
BW after pre-slaughter care, kg	384.0 ± 2.39	391.3 ± 2.12	435.0 ± 2.51	407.3 ± 2.25	399.7 ± 2.32	424.0 ± 2.89
BW loss in pre-slaughter care, kg	12.7 ± 0.61^{b}	13.0 ± 0.57^{b}	14.0 ± 0.52^{ns}	12.0 ± 0.43^{b}	14.0 ± 0.66^{c}	15.3 ± 0.54
%	3.0	3.0	2.9	2.7	3.2	3.3
Total BW loss, kg	31.0 ± 0.55	30.4 ± 0.49	33.3 ± 0.70	28.7 ± 0.63	32.6 ± 0.58	35.7 ± 0.60
%	7.4	7.2	7.1	6.5	7.5	7.7

Note: s.e.m. = standard error of mean; P = probability; $^{a}P < 0.001$; $^{b}P < 0.01$; $^{c}P < 0.05$; ns = not significant at $P > 0.05$ compared with data on the loss in the BW of the calves of Limousine breed

So, during the transportation, the greatest loss in the BW was determined in the calves of Limousine breed – 20.4 kg (4.44%) of the BW before transportation, while the calves in I, II, III, IV, and V groups had loss less than 2.1 (10.3%), 3.0 (14.7%) 1.1 (5.4%) 3.7 (18.1%), and 1.8 kg (8.8%), respectively in comparison with data of loss in the BW of the calves of Limousine breed. The smallest loss on the way was observed in the calves of Hereford breed – 16.7 kg (3.83% of the live weight before transportation).

For the period of pre-slaughter holding, further loss of production occurred in the calves of all test breeds that was caused by emptying of the gastrointestinal tract and an exhaustion of components of body tissues and organs, especially fat and glycogen, as outlined by Arthington et al. (2003; 2008). Further loss in BW of all breeds and genotypes studied that were 12.0-15.3 kg, or 2.75-3.33% of the live weight before transportation occurred during the pre-slaughter treatment, with the calves in group IV to have the minimum loss and the calves in group VI to have the greatest one.

Unequal loss in BW was also in general for the pre-slaughter period, or the total loss. So, the Hereford calves had the least loss – 28.7 kg (6.58%), the Limousines had the largest one – 35.7 kg (7.77%). For the pre-slaughter period, the calves of Limousine breed reduced the live BW loss more than the calves in group I by 4.7 kg (13.2%), II – by 5.3 kg (14.8%), III – by 2.4 kg (6,7%), IV – by 7.0 kg (19.6%), and V – by 3.1 kg (8.7%), or by 0.30; 0.56; 0.66; 1.19, and 0.23% from the live weight before transportation, respectively.

Thus, the physiological studies have shown that the purebred calves of Hereford and Simmental breeds were more stress resistant during the auto transportation and pre-slaughter preparation. Clinical parameters as a test for stress states of the animals showed that the young stock of Hereford and Simmental breeds had the greatest stress tolerance and the calves of Limousine and Aberdeen Angus breeds were more susceptible to the influence of environmental factors. However, the Aberdeen Angus breed rapidly moved to the adaptation phase in comparison with the Limousines. At the same time, the greatest changes in blood were observed in the calves of Limousine and Aberdeen Angus breeds. The relation between the physiological parameters, breed, and transport stress must be considered when predicting the stress affecting the beef production process for the companies involved in breeding and fattening of young cattle.

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