

The Relationship between Different Body Types of Kalmyk Steers and Their Raw Meat Production and Quality

Research Article

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Received on: 8 Aug 2018

Revised on: 6 Oct 2018

Accepted on: 30 Oct 2018

Online Published on: Jun 2019

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Online version is available on: www.ijas.ir

ABSTRACT

The article presents the data on a comparative research study of the beef production of Kalmyk steers of compact (Group I), medium (Group II) and tall (Group III) body types. It has been found that the steers of a tall body type had higher pre-slaughter weight at the age of 16 months than steers of compact and medium types by 24.7 and 12.1 kg, respectively; the weight of hot carcasses by 15.9 and 7.6 kg; and the carcass yield was higher by 0.5 and 0.2%. The slaughter yield of steers varied from 58.50 (Group I) to 58.69% (Group III). Boning showed that tall youngsters had higher flesh weight in carcasses by 7.05 and 3.61% compared to their analogs of compact and medium types. The average flesh sample from animals of a tall type contained more protein than their analogs by 0.91 and 0.86%, respectively. The fat content in carcass flesh from steers of compact type was higher than from medium and tall steers by 1.05 and 2.56%, respectively. The longissimus dorsi muscle of tall steers contained more essential amino acid of tryptophan and less non-essential amino acid of hydroxyproline. Furthermore, a tendency of higher values of moisture-retaining ability of meat from steers of a compact type has been revealed. Organoleptic characteristics of meat from all experimental steers differed insignificantly.

KEY WORDS body type, carcass composition, cattle breeding, meat quality, slaughter traits.

INTRODUCTION

The development of beef cattle breeding in countries depends on the competitive ability of products in the world and domestic markets (Arango *et al.* 2002; Bownet *et al.* 2016). As the experience of developed countries shows, intensive beef production is possible only through the development of specialized beef cattle breeding (Marshall 1994; Buchanan and Lenstra, 2015; Ugnivenko, 2018). In the Russian Federation, there are considerable reserves for

beef cattle breeding, i.e., 43 million hectares of natural forage land, a large amount of waste from grain production and processing industry and domestic breeds of beef cattle: Kazakh White-headed, Russian hornless and Kalmyk (Phillips, 1960; Gorlov *et al.* 2014; Sulimova *et al.* 2016). The Kalmyk breed is the most numerous domestic meat breed of Russia (Komandzhaev *et al.* 2015).

Animals of this breed are hardy, unpretentious to forage and able to intensively gain live weight when kept on feed (Kayumov *et al.* 2018).

In this regard, the Kalmyk breed has become widespread in many regions of Russia (Sulimova *et al.* 2007; Ruzina *et al.* 2010). The goal-oriented selective breeding work resulted in creating intra-breed types of Kalmyk cattle that substantially differ in their productive qualities and body types. In some scientific works, there are noted significant differences in the productivity and qualitative indicators of meat from steers of different body types (Moiseikina *et al.* 2014; Shevkuzhev *et al.* 2018). The Kalmyk cattle breed is a historically developed breed. It was formed in extreme climatic conditions of the steppe and semi-desert zones of pastures where the air temperature in summertime reaches +40 °C, and in winter falls down to minus 40 °C. The main food for the cattle is grass of natural pastures, mostly scarce. In order to satisfy their nutritional needs, animals must travel long distances. The Kalmyk cattle breed is characterized by a high natural resistance and early maturation. This type of build does not allow the breed to remain consolidated. In conditions of abundant feeding (spring and autumn), animals intensively synthesize fat in the body. Attempts to grow large breed cattle imported from England and France in this zone were not successful. Crossing with these breeds turned out to be ineffective with this technology of keeping animals being applied. The Kalmyk breed is heterogeneous in the body type and body weight of individual animals. In a breed of animals, scientists usually distinguish compact (short), medium and tall body types. At the same time, in the process of improving the breed, the live weight gain of a certain type changes. However, depending on the herbage and climatic conditions in the breeding site, one or another body type can be more effective. The scientific interest in studying the features of this breed lies in the fact that the quality of the meat from animals of different body types differ in chemical and biochemical compositions. The meat of youngsters of a compact type contains more fat; the tall type steer meat contains more protein. The Kalmyk breed is grown mainly in the regions of the Russian Federation. The novelty of our research lies in the fact that we study features of the development of exterior articles, slaughter qualities and chemical and biochemical compositions of meat from Kalmyk youngsters of various body types, which will contribute to the expansion of the production of beef of different qualities in the market and increase in the profitability of its production. We have studied the productivity and quality of beef from Kalmyk steers of compact, medium and tall types.

MATERIALS AND METHODS

To solve the tasks set, a scientific experiment was organized under conditions of the Kalmyk breeding farm "Kirovskiy" for 1800 animals in the Republic of Kalmykia.

The samples analysis and data analysis were performed in the laboratory of the Volga Region Research Institute of Manufacture and Processing of Meat-And-Milk Production (Volgograd, Russia).

Animals and sampling

To conduct the experiment, three groups (compact, medium and tall body types) of Kalmyk steers at the age of 10 months were formed (groups I, II and III, respectively) with 120 animals each, according to the coevals principle (Table 1). The experimental steers were grazed on natural pastures and fed with a grain mix at a dosage of 2-3 kg per head, depending on the age from 10 to 16 months.

The housing conditions and the feed of all of the animals were similar. The rations were developed on the basis of the requirements established (Kalashnikov *et al.* 2003) with the "Korm Optima Expert" program complex (KormOptima, Russia) used. During the research period, the experimental youngsters were kept in fly camps and grazed on natural pastures. The watering place was made from an open reservoir. Pens for night live-stock handling were equipped with feeding troughs, troughs for watering, a race, headlock and weights for weighing animals. The pens were equipped with sections for observing experimental animals, control feedings and physiological studies. Recording for eaten green mass was determined on the basis of the difference between the pasture productivities before and after feeding (by mowing).

During the period of control feeding and digestion trial, the steers received mowed grass from pastures and concentrated feed according to the ration; watering was carried out from the troughs. During the period of the experiment, the diet of the test steers was designed to obtain an average daily live weight gain of 900 g and consisted of pasture grass in amount of 12.1-13.9 kg, grain mixture 3.5-4.9 kg, salt 38.6-50.0 g, feed phosphate 8.9-22.0 g and premix 34.5-50.0 g.

Feed additives and premixes were fed to animals in combination with grain mixtures. The diet contained from 7.1 to 8.6 energetic feed units, from 7.4 to 9.0 kg of dry matter, from 980 to 1200 g of crude protein, from 641 to 771 g of digestible protein, from 1705 to 2221 g of crude fiber, from 510.0 to 628.0 g of sugars and from 212 to 279 g of crude fat.

Exterior parameters, dynamics of live weight gain (including overall live weight gain and average daily weight gain) were estimated in accordance with government standard (GOST) 25967-83 "Breeding registered cattle, Methods for determination of productive parameters of beef cattle".

All applicable international, national, and institutional guidelines for the care and use of animals were followed.

Table 1 Measurements of exterior parameters of steers at the beginning (10 months) and at the end of experiment (16 months) and their live weight (Mean±SE)

Indicator	Body types		
	Compact (n=120)	Medium (n=120)	Tall (n=120)
	10 months		
Height at withers (cm)	100.10±0.24 ^a	102.10±0.19 ^a	104.20±0.25
Height at hips (cm)	102.10±0.23 ^a	104.10±0.20 ^a	106.30±0.21
Oblique body length (cm)	112.20±0.28 ^a	112.80±0.34 ^{ns}	113.40±0.21
Chest girth (cm)	148.40±0.36 ^c	148.30±0.39 ^c	149.50±0.29
Pastern girth (cm)	15.20±0.13 ^{ns}	15.10±0.11 ^{ns}	15.10±0.09
Width of chest (cm)	31.80±0.28 ^c	32.10±0.23 ^{ns}	32.60±0.17
Chest depth (cm)	52.40±0.19 ^a	51.30±0.16 ^{ns}	51.40±0.21
Oblique loin length (cm)	36.40±0.16 ^a	37.20±0.19 ^a	38.10±0.15
Width at hips (cm)	32.80±0.21 ^c	32.10±0.14 ^{ns}	32.20±0.19
Width of loin (cm)	16.60±0.18 ^{ns}	16.20±0.24 ^{ns}	16.20±0.16
Live weight (kg)	259.3±2.04 ^b	263.8±1.96 ^{ns}	268.5±2.17
	16 months		
Height at withers (cm)	116.10±0.64 ^a	118.80±0.61 ^b	121.50±0.67
Height at hips (cm)	118.3±0.61 ^a	121.40±0.63 ^a	123.70±0.62
Oblique body length (cm)	135.30±1.08 ^b	137.10±1.02 ^b	140.20±1.09
Chest girth (cm)	181.30±1.45 ^{ns}	180.60±1.36 ^{ns}	180.80±1.48
Pastern girth (cm)	20.00±0.06 ^b	19.70±0.13 ^{ns}	19.70±0.08
Width of chest (cm)	43.40±0.27 ^{ns}	43.40±0.34 ^{ns}	43.60±0.31
Chest depth (cm)	64.90±0.38 ^c	63.80±0.22 ^{ns}	63.90±0.28
Oblique loin length (cm)	45.30±0.18 ^a	46.90±0.25 ^{ns}	47.20±0.15
Width at hips (cm)	46.10±0.29 ^{ns}	45.70±0.19 ^{ns}	45.90±0.23
Width of loin (cm)	21.10±0.09 ^a	21.40±0.08 ^{ns}	21.60±0.12
Live weight (kg)	407.1±2.42 ^a	418.9±2.54 ^a	431.0±2.31

The means within the same row with at least one common letter, do not have significant difference ($P>0.05$).

NS: non significant.

Experiments were performed in accordance with the guide for the care and use of laboratory animals.

Raw meat samples evaluation

Slaughter traits were studied at 16 months using GOST 18157-88 "Slaughtered animal products. Terms and definitions" and GOST R 54315-2011 "cattle for slaughter. Beef and veal carcasses, semi-carcasses and quarters. Specifications".

Chemical composition of meat was analyzed in accordance with following GOST: 33319-2015 "Meat and meat products. Method for determination of moisture content", 25011-81 "Meat and meat products. Methods of protein determination", 23042-2015 "Meat and meat products. Methods of fat determination", 31727-2012 (ISO 936:1998) "Meat and meat products.

Determination of total ash", 23041-2015 "Meat and meat products. Method for determination of oxyproline"; the content of tryptophan was established using a capillary electrophoresis system "KAPEL®-105M" (Lumeks, Russia). The protein quality indicator (PQI) was calculated using the following formula:

$PQI = \text{tryptophan} / \text{hydroxyproline}$

The functional and technological properties: the water binding capacity (WBC, moisture retention) was determined by the method of Tuominen and Honkavaara (1982); the water holding capacity (WHC, ability to cook down) was determined by Grau and Hamm (1957) method.

The culinary and technological index (CTI) was calculated using the following formula:

$CTI = \text{moisture} / \text{retention ability to cook down}$

Statistical 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: ^a $P<0.001$; ^b $P<0.01$; ^c $P<0.05$; ns= non 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} : mean value.

$\sum_{i=1}^n x_i$: sum of all x_i with i ranging from 1 to n .

n : number of measurements.

The residual variation is expressed as a root mean square error (RMSE):

$$\sigma = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}}$$

The standard error of mean (SEM) was calculated by the formula:

$$SEM(\bar{x}) = \frac{\sigma}{\sqrt{n}}$$

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:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{SEM_1^2 + SEM_2^2}} \geq t_{st} (d.f. = n_1 + n_2 - 2)$$

Where:

t : Student's t -distribution.

$(\bar{x}_1 - \bar{x}_2)$: difference of the sample mean measurements.

$\sqrt{SEM_1^2 + SEM_2^2}$: sample difference error.

SEM_1, SEM_2 : non-sampling error of the sample statistics compared.

t_{st} : standard criterion according to the t -Table for the probability threshold preset depending on degrees of freedom.

n_1, n_2 : number of measurements in the samples compared.

$d.f.$: degrees of freedom for difference of two mean measurements.

RESULTS AND DISCUSSION

The average daily weight gain for the period (from 10 to 16 months) of the experiment was 821.1 g in Group I, 859.4 g

in Group II and 902.8 g in Group III.

At the age of 16 months, the steers of a tall type surpassed their analogs of compact and middle types in terms of withers height by 5.40 cm or 4.65% ($P < 0.001$) and 2.70 cm or 2.27% ($P < 0.01$); oblique body length by 4.90 cm or 3.62% and 3.10 cm or 2.26% ($P < 0.01$); and oblique loin length by 1.90 cm or 4.19% ($P < 0.001$) and 0.30 cm or 0.64% (ns), but were inferior in the chest depth ($P < 0.05$) and width at hips (ns) (Table 1).

The control slaughter showed that at the age of 16 months, the pre-slaughter weight of steers in Group III was higher by 24.7 kg or 6.32% ($P < 0.001$) than that of steers in Group I and by 12.1 kg or 3.00% ($P < 0.01$) in Group II. With respect to this indicator, the steers in Group II outperformed their analogs in Group I by 12.6 kg or 3.22% ($P < 0.01$) (Table 2).

The weight of hot carcass of the steers in Group III was on the average higher than that in Group I by 15.9 kg or 7.29% ($P < 0.001$) and in Group II by 7.6 kg or 3.36% ($P < 0.01$). In terms of the weight of hot carcass, the steers in Group II outperformed their analogs in Group I by 8.3 kg or 3.81% ($P < 0.01$). The carcass yield of steers in Group III was higher by 0.5 than in Group I and by 0.2% than in Group II.

The deposition of internal fat in the body of young cattle of tall type (Group III) was less intensive. The adipopexis was lower by 2.2 kg or 19.47% ($P < 0.001$) and 1.0 kg or 9.90% ($P < 0.05$) than in bodies of steers of compact (Group I) and middle (Group II) body types.

The slaughter weight of tall steers was larger by 13.7 kg or 5.97% ($P < 0.001$) and by 6.6 kg or 2.79% ($P < 0.01$) than of steers in Groups I and II. The slaughter yield varied in groups insignificantly, i.e., from 58.50 (Group III) to 58.69% (Group I).

Boning showed that the carcasses of steers of tall type contained more flesh than that of the steers in Groups I and II by 12.1 kg or 7.04% ($P < 0.001$) and 6.4 kg or 3.61% ($P < 0.05$).

The yields of flesh and bones in carcasses and fleshing index varied insignificantly. However, the flesh yield per 100 kg of pre-slaughter weight was higher in steers of tall type. Apparently, this was due to the fact that their oblique loin length (the most muscled part of the body) was larger.

Moreover, the steers of tall type had the most optimal variety assortment of carcass flesh. So, their carcasses contained more flesh of highest grade by 2.53 kg or 11.07% ($P < 0.001$) and 1.24 kg or 5.14% ($P < 0.05$); first grade flesh by 8.43 kg or 9.13% ($P < 0.05$) and 4.25 kg or 4.40% (ns), respectively. In the carcasses of steers in Group II, the yield of premium grade flesh was higher by 0.30% ($P < 0.05$) and the yield of first grade by 0.63% (ns), in comparison with Group I.

Table 2 Results of control slaughter of experimental steers, 16 months (Mean±SE)

Indicator	Body types		
	Compact (n=15)	Medium (n=15)	Tall (n=15)
Pre-slaughter weight, kg	390.9±2.42 ^a	403.5±3.15 ^b	415.6±2.37
Weight of hot carcass, kg	218.1±1.92 ^a	226.4±2.06 ^b	234.0±1.75
Carcass yield, %	35.8	56.1	56.3
Weight of internal fat, kg	11.3±0.31 ^a	10.1±0.36 ^c	9.1±0.28
Fat yield, %	2.9	2.5	2.2
Slaughter weight, kg	229.4±1.42 ^a	236.5±1.93 ^b	243.1±1.13
Slaughter yield, %	58.69	58.62	58.50
Weight of chilled carcass, kg	216.4±1.56 ^a	224.1±1.04 ^b	232.2±1.93
Flesh weight, kg, incl.	171.8±1.32 ^a	177.5±1.89 ^c	183.9±1.61
Highest grade, kg	22.85±0.46 ^a	24.14±0.39 ^c	25.38±0.37
First grade, kg	92.36±2.42 ^c	96.54±2.19 ^{ns}	100.79±2.74
Second grade, kg	56.59±0.97 ^{ns}	56.82±0.68 ^{ns}	57.73±0.80
Flesh yield, %	79.4	79.2	79.2
Weight of bones, kg	37.5±0.40 ^a	38.8±0.32 ^{ns}	39.9±0.47
Bone yield, %	17.3	17.3	17.2
Weight of tendons, kg	7.1±0.26 ^b	7.8±0.21 ^{ns}	8.4±0.32
Tendons yield, %	3.3	3.5	3.6
Fleshing index	4.58	4.57	4.61
Flesh yield per 100 kg of pre-slaughter weight	43.95	43.99	44.25

The means within the same row with at least one common letter, do not have significant difference ($P>0.05$).
NS: non significant.

The consumer value of beef is closely related to its chemical composition. The analyses indicated a tendency of steers of compact type to have higher content of dry matter and fat and of tall steers to have higher protein content (Table 3). The average sample of flesh from youngsters in Group III contained more protein than that in Groups I and II by 0.91 ($P<0.01$) and 0.86% ($P<0.01$). The steers of compact type had more fat in carcass flesh than their analogs in Groups II and III by 1.05 and 2.56% ($P<0.05$), respectively.

Due to the fact that the flesh weight of steers in Groups III and II was significantly larger and had a higher protein weight fraction than the steers in Group I, they had higher yields of dry matter and protein. So, the carcasses of steers of tall and middle body types synthesized more dry matter than that in Group I by 1.83 kg or 3.27% ($P<0.001$) and 0.07 kg or 0.13%; and protein by 3.94 kg or 12.24% ($P<0.001$) and 1.16 kg or 3.61% ($P<0.01$). Fat was more synthesized in carcass flesh of the steers in Group I in comparison with their analogs in Groups II and III by 1.13 kg or 5.41% ($P<0.01$) and 3.15 kg or 16.68% ($P<0.001$).

The study of chemical composition of the longissimus dorsi muscle showed the same tendency of higher protein content in meat from the steers in Group III and of higher fat content in Group I.

So, the weight fraction of dry matter in the longissimus dorsi muscle of steers in Group III was higher than that of their analogs in Groups I and II by 0.7 ($P<0.05$) and 0.1% (ns); protein by 1.3 ($P<0.001$) and 0.37% (ns); and fat less by 0.6 ($P<0.001$) and 0.3% ($P<0.001$), respectively.

The biological value of meat is largely related to the content of individual amino acids and their ratio. We have found that in the longissimus dorsi muscle of the steers in Group III, the content of essential amino acid tryptophan was higher than that of steers in Groups I and II by 68.89 mg % or 16.39% ($P<0.001$) and 32.79 mg % or 7.19% ($P<0.01$); and the nonessential amino acid hydroxyproline was less by 2.14 mg% or 3.48% (ns) and 1.10 mg % or 1.92% (ns), respectively, which caused the PQI of their muscle to be higher than that of their analogs by 10.37% and 9.13%.

At the same time, the research study has revealed the longissimus dorsi muscle to have an insignificant decrease in such a culinary and technological indicator as the moisture retention capacity and an increase in the ability to cook down in Group III in comparison with the steers in Groups I and II. The pH of the meat was within the normal range and varied from 5.82 to 5.89.

An important indicator for evaluating the beef quality is its tasting evaluation.

Table 3 Qualitative indicators of raw meat samples (%) from experimental steers (Mean±SE)

Indicator	Body types		
	Compact (n=15)	Medium (n=15)	Tall (n=15)
	Average beef sample		
Moisture content	67.42±0.54 ^{ns}	68.43±0.35 ^{ns}	68.57±0.70
Weight fraction of dry matter	32.58±0.54	31.57±0.35 ^{ns}	31.43±0.70 ^{ns}
Weight fraction of fat	12.83±0.52	11.78±0.44 ^{ns}	10.27±0.69 ^B
Weight fraction of protein	18.75±0.16 ^b	18.80±0.15 ^b	19.66±0.19
Weight fraction of ash	1.00±0.03 ^{ns}	0.99±0.01 ^{ns}	1.04±0.03
Synthesized in carcass flesh, kg			
drymatter	55.97±0.15 ^a	56.04±0.21 ^a	57.80±0.17
fat	22.04±0.21	20.91±0.25 ^B	18.89±0.24 ^A
protein	32.21±0.09 ^a	33.37±0.18 ^a	36.15±0.12
	Longissimus dorsi muscle		
Moisture content	76.30±0.24	75.60±0.27 ^{ns}	75.50±0.21 ^C
Weight fraction of dry matter	23.80±0.24 ^c	24.40±0.27 ^{ns}	24.50±0.21
Weight fraction of fat	3.1±0.03	2.80±0.04 ^A	2.50±0.02 ^A
Weight fraction of protein	19.70±0.17 ^a	20.63±0.15 ^{ns}	21.00±0.19
Weight fraction of ash	0.99±0.02 ^{ns}	0.99±0.01 ^{ns}	1.00±0.03
Tryptophan, mg %	420.34±6.97 ^a	456.44±6.11 ^b	489.23±6.46
Hydroxyproline, mg %	61.44±1.72	60.40±1.46 ^{ns}	59.30±1.10
PQI	6.85	7.56	8.25
Moisture retention	58.91±1.57	58.71±1.23 ^{ns}	58.69±1.78 ^{ns}
Ability to cookdown	36.85±1.42 ^{ns}	37.04±1.80 ^{ns}	37.12±1.39
pH	5.89±0.08	5.83±0.04 ^{ns}	5.82±0.07 ^{ns}
CTI	1.60	1.59	1.59

PQI: protein quality indicator and CTI: culinary and technological index.

^{a, b, c}: the means within the same row with different letter, are significantly different (P<0.05).

^{A, B, C}: the means within the same row with different letter, are significantly different (P<0.05).

NS: non significant.

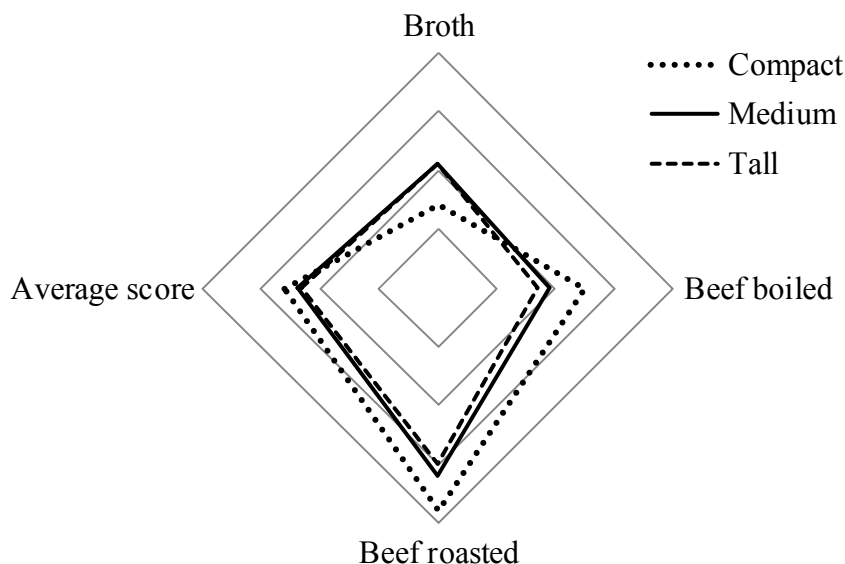


Figure 1 Tasting evaluation of beef, point from 1 to 5

In our studies, the tasting evaluation of meat was conducted by 7 experts on a 5-point scale. The results of the tasting indicated insignificant differences in the quality of the samples of broth, boiled and fried meat. The average score of the product varied from 4.63 (Group III) to 4.66 (Group I) (Figure 1).

CONCLUSION

Thus, according to the main indicators of meat production, tall steers surpassed their analogs of medium and compact body types with the meat from the steers of compact type to contain more fat that was characterized by higher culinary and technological properties.

ACKNOWLEDGEMENT

This study was funded by the Grant of the President of the Russian Federation MK-3731.2018.11.

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