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Growth, Carcass, Organ Characteristics and Meat Quality of Crossbred Steers from Kalmyk Cows and Kalmyk, Simmental, Hereford, and Kazakh White Headed Bulls

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Key words
Longissimus dorsi, Steer, Slaughter yield, Genotype, Simmental

ABSTRACT

Crossbred 7-month old steers from Kalmyk cows bred to Kalmyk (I, control), Simmental (II), Hereford (III), or Kazakh white-headed (IV) bulls were housed and fed under the same conditions. The bulls used were all classed as Elite. The feeding rate was intense. Steers in all groups were raised in the feedlot throughout the year. Growth rate of the crossbred steers was greater than the purebred steers. This was reflected in higher yields of the most valuable parts of the carcasses, the rump and saddle. Simmental crosses were distinguished by the lower fat content of their muscle tissue compared to the purebred Kalmyk steers and crossbred steers in groups III and IV. However, the differences in the energy value of the muscles analyzed was insignificant (P>0.05). We revealed a comparatively high biological value of flesh from steers in all groups. The moisture retention capacity ranged from 63.75 to 64.12% due to intramuscular fat in the meat. The pH value of the beef samples in all studied groups was at the optimal level.

INTRODUCTION

The agro-industry in modern Russia is of great importance for the national economy. The agricultural sector consists of large, medium, and small businesses, which complement each other by interacting and bridging gaps in the market, and make an important contribution in meeting the needs for raw materials and food for all sectors of the economy (Gorlov *et al*., 2020).

In recent years, Russia has been developing domestic beef cattle breeding. Some livestock farms focus on the production of high-quality beef, without the intervention of steroids and hormonal agents. This type of product is in great demand in the home and overseas markets of Western and the Middle Eastern countries. Therefore, the production of beef must expand to allow both choice of product without interruptions in the supply chain (Narmaev, 1963).

At the present time, production of high-quality beef within an environmentally friendly system is needed. It is also more resource-intensive than in other areas of the agro-industry within the Russian Federation. To solve this problem, it is necessary to actively use the genetic potential of selected exotic beef cattle breeds (Coleman *et al*., 2016; Neves *et al*., 2021).

Within Russia, research teams and livestock breeders have over many years identified and developed specialized breeds and crosses. One of the most useful beef breeds is Kalmyk cattle that are distinguished for several valuable breed traits and high meat output (Liu *et al*., 2020). However, this breed has several characteristics that do not meet modern requirements, *i.e*., it is relatively small, the meat contains too much fat for current tastes, and milk yield is low (Plascencia and Zinn, 2021).

To overcome these constraints, crossbreeding Kalmyk cows with beef bulls of the Simmental Hereford, and Kazakh white-headed breeds is widely used to improve output (Burrow, 2001). Kalmyk cows as the dams have been bred because of their mothering capacity and their ability to survive. The work reported here is one aspect of

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the production process (Lloyd *et al*., 2017).

The Lower Volga region is one of the largest livestock regions in Russia. It is here that beef cattle production is prevalent. Breeding, searching for new ways to improve the beef cattle available in the region is continuous. The most effective approach is to cross local breeds with those of higher genetic potential. In this regard, we conducted research to develop effective schemes for crossing Kalmyk cows with bulls of Simmental, Kazakh white-headed, and Hereford breeds. The work was performed in the territory of JSC Berdievsky Elevator. The farm was located in the center of the Volgograd region, on the banks of the Berdia River. The site was 120 km from Volograd, and 35 km from Ilovlya. The climate in that area is continental, with little rainfall; strong and dry winds are a common feature. From local long-term meteorological data, the average temperature is -9.40 in January and +26.5^{0}C in July, with the lowest being -39.1 in January, and the highest +42^{0}C in July. The average amount of rain is 310-320 mm per year, with most (up to 200 mm) falling in the warm season. Southeast winds are common throughout the year. The "Berdievsky Elevator" OJSC has two independent production subdivisions that separately procure feed and keep livestock. They have defined areas for arable crops. The subdivisions, known as JV "B-Ivanovo" and JV "Aleksandrovskoe" have their own directors and approved specialists. Natural forage lands are mainly sandy pastures of average growth, predominately wormwood-grain grass. The main water sources are groundwater, springs, and the Berdia-river.

According to the characteristics of the mentioned region and the importance of the genetic potential of valuable traits of different breeds in the production of quality meat, the present experiment was conducted to investigate the growth, carcass, organ characteristics and meat quality of crossbred steers from Kalmyk cows and Kalmyk, Simmental, Hereford, and Kazakh white-headed and bulls.

MATERIALS AND METHODS

Four groups of 7-month old steers were comprised of a purebred Kalmyk group, and three groups of crossbred steers, one of each from Kalmyk cows bred to Simmental, Hereford, or Kazakh white-headed bulls. All bulls belonged to the elite and elite-record classes.

The steers were fed according to the requirements developed by Slozhenkina *et al*. (2020), and the "Feed Optima Expert" modular program for this class and age of animal according to season. The diets included feeds produced by the JSC "Berdievsky Elevator" (Table I). The steers were fed as one group. The feeding rate was intense. Steers in all groups were raised in the feedlot throughout the year.

All data collected during the experiment and laboratory traits were analysed by proc SAS statistical software (SAS, 2012). The comparison of the means was performed with Duncan's multiple-range test with $P<0.05$ as the threshold for statistical significance.

Table I. The rations of experimental steers in different seasons.

Feed	Daily amount, kg/ DM
Winter	
Sudan hay	0.7-4.7
Corn silage	10-12
Triticale silage	10-14
Mixed fodder	2.7-3.8
Summer	
Green mass	10-25
Barley-wheat mixture	2.7-3.8
Chalk	0.007-0.024
Salt	0.025-0.030

RESULTS AND DISCUSSION

The live weight of the steers is shown in Table II. The crossbred steers in groups II, III and IV consumed more DM than those in group I (purebred, control). The influence of the paternal breed resulted in greater birth weights of the crossbred calves compared to the purebred Kalmyk calves (an increase of 7.8, 6.8, and 6.4 kg or 26, 23.5, and 22.4% in groups II, III, and IV, respectively). Crossbred calves also grew faster than the purebred calves. The main changes in the growth of muscle tissue occurred in the first 8 months of life.

Greater live weight of the crossbred steers compared to the purebred steers of the Kalmyk breed was maintained throughout the trial. Live weight at 12 months for the crossbred steers in group II, III, and IV exceeded that of the pure-bred group by 73.0 (18.8%), 89.9 (22.2%), and 77.5 kg (19.6%), respectively; at the end of the experiment, this superiority amounted to 79.2 (13.6%), 96.6 (16.1%), and 77.9 kg (13.4%), respectively. It is worth noting the greater total growth of the Hereford crosses over the Simmental and Kazakh white-headed crosses.

Under intensive rearing, the difference between the purebred steers and crossbred steers can be explained by the lower genetic potential for growth of the Kalmyk breed compared to the Simmental, Hereford, and Kazahk white-headed breeds (Mcivor and Monypenny, 1995).

Table II. The live-weight (kg) of four groups of steers from birth to 17 months (n=10).

	1. Kalmyk pure bred (control)	11. Kalmyk x Simmental	111. Kalmyk x Hereford	1V. Kalmyk x Kazakh white headed
At birth	22.2±0.25	30.0±0.37***	29.0±0.34***	28.6±0.31***
6	195.7±3.07	238.0±5.82***	245.4±5.97***	232.1±3.20***
9	221.3±3.10	294.0±5.34***	304.1±5.13***	287.4±4.83***
12	315.4±3.62	388.4±4.96***	405.3±3.22***	392.9±4.35***
15	443.0±2.92	503.5±4.34***	523.3±3.13***	506.4±4.48***
17	502.1±2.25	581.3±3.83***	598.7±3.22***	580.0±4.00***

Note: P≤0.05; *, P≤0.01; **, P≤0.001; ***, P-value indicator when comparing the control group with the experimental ones.

Table III. Slaughter data of experimental steers at 17 months of age (n=3) (Mean±SEM).

	1. Kalmyk pure-bred (control)	11. Kalmyk x Simmental	111. Kalmyk x Hereford	1V. Kalmyk x Kazakh white-headed
Weight off- farm (kg)	502.3±3.86	581.3±2.65***	598.5±3.09**	580.0±1.73***
Pre-slaughter weight (kg)	474.0±3.21	551.0±2.51***	567.9±3.42***	551.7±2.38***
Weight loss (kg)	28.3±0.67	30.3±0.33	30.7±0.67	28.3±0.93
Carcass weight (kg)	272.8±2.40	314.8±2.61***	323.1±3.46***	315.8±1.85***
Carcass yield (%)	57.6	57.2	56.9	57.3
Fat weight (kg)	19.1±1.30	17.1±1.12	19.8±0.67	17.5±0.21
Fat yield (%)	4.0	3.1	3.5	3.2
Slaughter weight (kg)	291.9±3.69	331.9±1.59***	342.9±3.65***	333.3±0.98***
Slaughter yield (%)	61.6	60.2	60.4	60.4

Note: P≤0.05; *, P≤0.01; **, P≤0.001; ***, P-value indicator when comparing the control group with the experimental ones.

The slaughter data of 3 steers from each group are presented in Table III. The carcass data obtained by slaughtering animals at the age of 17 months was assessed by comparison with pre-slaughter weights. The superiority of the crossbred steers over purebred steers yielded an increase in pre-slaughter weight of 77.0 (16.2%), 93.3 (19.8%), and 77.7 kg (16.4%) for groups II, III and IV, respectively. The Hereford cross steers (group III) were distinguished by a greater weight of internal fat (19.8 kg). Carcass weight of the crossbred steers exceeded that of the purebreds by 42.0 (15.4%), 50.3 (18.4%), and 43.0 kg (15.8%) for groups II, III, and 1V, respectively, with a moderate uniform slaughter yield of 61.6, 60.2, 60.4, and 60.4% for groups I, II, III, and IV), respectively.

In group I, the carcasses were covered with a layer of water and tightly wrapped, which protected them from drying out and spoilage. The carcasses of the crossbred steers were well muscled with rumps and shoulders. Crossbreeding with beef breed bulls and Kalmyk cows contributed to an increase in the slaughter qualities of the resulting offspring (Culbertson *et al*., 2015; Teimouri Yansari *et al*., 2019).

The nutritional value of beef was determined by the morphological composition of the carcass (Table IV). The flesh weight of the carcasses was 227.5±1.87 kg (83.4%) in group I, 262.1±0.90 kg (83.3%) in group II, 278.4±2.06 kg (86.2%) in group III, and 266.3±2.40 kg (84.3%) in group IV. The carcasses of groups III and IV with the highest flesh yield had a meat index of 6.8 and 5.8, respectively.

To characterize the quantitative and qualitative indices of the meat content of the slaughter group, the ratio of specific anatomical parts in half carcasses was determined (Fig. 1). The highest yields of the most valuable parts of the carcasses, the rump and saddle, were characteristic of the crossbreds in group II, with the smallest yields in the Group 1 steers. An increase in the growth rate of muscle tissue in the carcass caused an increase in the meat index, and this was reflected in the morphological compositions of the carcasses (Gorlov *et al*., 2019).

Nutritional benefits such as juiciness, tenderness, and the presence of fat depend on the chemical composition of the meat (Scollan *et al*., 2017). In this regard, we conducted a chemical analysis of the *longissimus dorsi* muscles of the slaughtered steers (Table V). A detailed

study of the chemical composition of the *longissimus dorsi* muscle found no significant differences between the four groups of steers. However, the Simmental crosses were distinguished by the lower fat content of their muscle tissue compared to the pure-bred Kalmyk's and crossbred steers in groups III and IV. However, the differences in the energy value of the muscles analyzed was insignificant (P>0.05).

To find the biological value of the beef obtained, we calculated the protein-quality indicator (Table VI). Thus, we revealed a comparatively high biological value of flesh from steers in all groups. The moisture retention capacity ranged from 63.75 to 64.12% due to intramuscular fat in the meat. The pH value of the beef samples in all studied groups was at the optimal level.

CONCLUSION

In conclusion, we note that crossbreeding systems for beef cattle produces calves with higher productivity traits for beef production. The resulting young crossbred steers surpassed their purebred counterparts in many respects, including growth, development, beef and slaughter qualities, as well as the biological value of the beef. Thus, our research work resulted in establishing a positive benefit crossing the Simmental, Hereford, and Kazakh white-headed bulls with Kalmyk females.

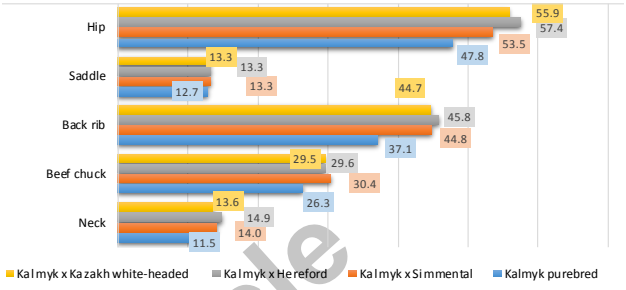

Fig. 1. The ratio of individual constituent anatomical parts in the carcasses of Kalmyk purebreds and Kalmyk crossbred beef steers.

Table IV. Morphological composition of experimental carcasses, (n=3) (Mean±SEM).

	1. Kalmyk pure-bred (control)	11. Kalmyk x Simmental	111. Kalmyk x Hereford	1V. Kalmyk x Kazakh white-headed
Carcass weight (kg)	272.8±2.40	314.8±2.61***	323.1±3.46***	315.8±1.85***
Flesh weight (kg)	227.5±1.87	262.1±0.90	278.4±2.06	266.3±2.40
Flesh yield (%)	83.4	83.3	86.2	84.3
Bone weight (kg)	43.1±0.52	48.8±0.31***	41.2±1.47	45.8±1.53
Bone yield (%)	15.8	15.5	12.8	14.5
Tendon weight (kg)	2.3±0.13	3.9±0.15**	3.5±0.12**	3.7±0.09**
Tendon yield (%)	0.8	1.2	1.1	1.2
Meat index (%)	5.3	5.4	6.8	5.8

Note: P≤0.05; *, P≤0.01; **, P≤0.001; ***, P-value indicator when comparing the control group with the experimental ones.

Table V. Chemical composition of experimental longissimus dorsi muscle (Mean±SEM).

	1. Kalmyk pure-bred (control)	11. Kalmyk x Simmental	111. Kalmyk x Hereford	1V. Kalmyk x Kazakh white headed
Moisture (%)	76.80±0.29	76.90±0.32	76.70±0.28	76.50±0.25
Dry matter (%)	23.20±0.11	23.10±0.15	23.30±0.17	23.50±0.17
Fat (%)	3.52±0.07	2.91±0.05**	3.82±0.04*	3.72±0.05
Protein (%)	19.38±0.12	19.98±0.09*	19.30±0.10	19.58±0.7
Ash (%)	0.30±0.01	0.21±0.02*	0.18±0.01**	0.20±0.01**
Protein to fat ratio	1:0.18	1:0.15	1:0.20	1:0.19
Energy value of 1 kg of flesh (MJ)	4.74	4.61	4.84	4.85

Note: P≤0.05; *, P≤0.01; **, P≤0.001; ***, P-value indicator when comparing the control group with the experimental ones.

Table VI. The biological value and culinary and processing properties of the beef from steers (Mean±SEM).

	1.Kalmyk pure-bred (control)	11. Kalmyk x Simmental	111. Kalmyk x Hereford	1V. Kalmyk x Kazakh white-headed
Tryptophan (mg)	439.20±1.32	428.20±1.25**	432.09±1.17*	448.10±1.33**
Oxyproline (mg)	62.02±0.47	61.60±0.38	63.83±0.25*	63.70±0.22*
Protein-quality indicator	7.08	6.95	6.77	7.03
Water retention (%)	63.75±0.15	64.12±0.18	64.01±0.16	63.89±0.17
Loss of weight after cooking (%)	35.31±0.14	35.05±0.17	34.58±0.20*	35.81±0.16
pH	5.79	5.90	5.92	1.84
Culinary and processing index	1.81	1.83	1.85	1.82

Note: P≤0.05; *, P≤0.01; **, P≤0.001; ***, P-value indicator when comparing the control group with the experimental ones.

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Statement of conflict of interest

The authors have declared no conflict of interest.

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