

## Influence of maintenance technology in arid conditions on efficiency of marbled beef production

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### ABSTRACT

In recent years, Russia has been developing domestic single-purpose meat cattle breeding. Some livestock farms have focused on the production of high-quality grades of raw meat, i.e. 'marbled' beef. Meat of that kind is in great demand in the premium meat market. At the same time, production of beef without using steroids and hormonal drugs increases the competitiveness of this product on the world market in countries of the West and the Middle East. Within the framework of our study, an experiment was conducted on Kalmyk cattle in the arid conditions of OAO Kirovskij in the Republic of Kalmykia. Standardized methods of analysis were used. For the experiment, 10-month-old steers were selected and divided into two groups (Control and Test), 30 heads each. They were kept and fed according to different technologies until the age of

19 months. The Test group steers were kept tied up and fed with a diet developed by the Volga Region Research Institute of Manufacture and Processing of Meat-and-Milk Production; the Control group steers were kept according to conventional beef cattle production technology. The wide expansion range and popularity of this cattle breed are caused by the high productivity of steers whether kept tied up or allowed to graze free. The compared qualities of beef obtained from Kalmyk steers proved that keeping them tied up allows increased production efficiency of raw meat which is an important factor for meat production, being intensified in an unstable situation in agriculture.

**Keywords:** beef; feeding technology; grass-fed; 'marbled'; meat cattle breeding

### INTRODUCTION

Meat is of great importance for the human diet, as it is a source of complete animal protein (Avilés et al., 2015; Johnson et al., 2019). Research shows that most high-quality and balanced meat is obtained from cattle of meat breeds grown according to special fattening technology for the production of 'marbled' meat grades (Culbertson et al., 2015; Kenny et al., 2018; Shumilina, Skvortsova and Grebenshchikov, 2012). The meat of various animal species can be marbled, i.e. cattle, small ruminants and pigs (Belyaev et al., 2004; Burrow, 2001; Kayumov, 2008). The prospects of beef production and modern technologies for keeping and feeding cattle of different breeds in different regions of Russia and elsewhere in the world have been developed, investigated and scientifically substantiated by some scientists (Adeyemi et al., 2019; Kelly et al., 2019; Lindholm-Perry et al., 2017; McIvor and Monypenny, 1995).

According to the literature, the Kalmyk breed has a genetic potential for the formation of marbled beef and is best adapted for the arid territories of southern Russia. Steers of this breed are widespread and popular in Russia

due to their adaptive abilities (Randelin et al., 2018). Currently, the Kalmyk breed of cattle is grown in 34 regions of Russia, i.e. in the regions of the North Caucasus, Southeast, Volga, Urals and the Far East.

The above-mentioned advantages of the Kalmyk breed caused its expansion into areas with severe agro-climatic conditions: Siberia, the Caucasus and Transbaikalia. Kalmyk cattle are kept and bred most often on pastures in natural habitat.

However, in recent years, there has been an insufficient number of pasture lands on farms, especially in regions with a severe harsh continental climate and features of desert invasion. For this reason, beef cattle are kept and raised tied up. In the absence of large pasture resources, this technology allows the production of raw meat in arid territories. At the present stage of cattle breeding, scientific investigations of the Kalmyk breed and the quality characteristics of the beef obtained do not pay attention to comparing the technologies under which livestock are kept: tied up or in free stalls. This led us to a scientific experiment aimed at comparing the productivity and quality characteristics of beef obtained by the technologies

under which steers are kept and fattened either tied up or in free stalls in the arid conditions of the Republic of Kalmykia.

### Scientific hypothesis

The maintenance technology and feeding animals with a specially formulated feed contributes to the rapid maturation and marbling of beef.

## MATERIAL AND METHODOLOGY

### Ethical approval

The authors confirm that the studies were conducted in accordance with internationally recognized ethical standards of the Helsinki Declaration on clinical researches.

### Experimental design

The study was conducted on the territory of a farm in the South of Russia. We studied two groups of bull calves that were raised using different feeding and keeping technologies. An experiment was conducted to assess the process of forming marbled meat in the arid conditions of the Republic of Kalmykia. For this purpose, 60 animals of the Kalmyk breed, formed into two groups (experimental and control), were selected from the Kirovsky livestock farm. The animals of the control group were kept and fed according to the traditional technology without binding and on pastures, while the experimental group received green feed mown on specially designated areas of pasture on the farm and were kept on a leash in stalls. The rations for the experimental animals were developed using the Feed Optima Expert program by the standards and age.

Research materials were processed using graphical, trend and statistical analysis methods, as well as using the Microsoft Office software package. The paper uses generally accepted standardized methods of analysis of the studied objects.

### Dynamics of live weight, and meat yield

The dynamics of live weight were studied by weighing experimental animals, calculating the absolute and average daily growth, and slaughter indicators: carcass weight, pulp, slaughter yield, etc., according to approved methods. The morphological composition of carcasses was studied by cutting them into cuts according to state standard no. 31797-2012 'Meat. Dressing of beef into cuts. Specifications'. To determine the quality indicators, average samples of the pulp and the longest back muscle were then selected. The meat index has the following formula:

$$\frac{\text{half - girth of the back}}{\text{height at the withers}} * 100\%$$

### Histological analysis

Microscopy of samples of the longest back muscle of experimental bulls was performed using an electron microscope (Zeiss AxioImager.Z2), synchronized with a personal computer, having previously prepared a sample - a tool for preparing sections of a fixed 'Microtome' with the MS-1 system ('MicroM').

### Statistical analysis

The experimental data on different variables were statistically analysed using the 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: \*\*\* $p < 0.001$ ; \*\* $p < 0.01$ ; \* $p < 0.05$ ; ns = not significant at  $p > 0.05$ ). Student's t-test was applied for the statistical analysis.

## RESULTS AND DISCUSSION

Domestic and foreign scientists have shown the relevance of a comprehensive study of raw meat production technology in natural pasture conditions (Asp et al., 2012; Fedotova et al., 2019; Shumilina, Skvortsova and Grebenshchikov, 2012; Troy, Tiwari and Joo, 2016).

The results of the experiment showed that steers gained live weight differently during the observation period from the 10<sup>th</sup> to 19<sup>th</sup> months of age, depending on the keeping and feeding technology.

It was determined that marbled beef is obtained from animals that are kept in stalls for a long time. It is obvious that by adjusting the percentage of intermuscular fat by changing the nutritional content of diets, you can win more consumers by producing various products with the necessary characteristics; this is confirmed by modern research (Basarab et al., 2003; Luo et al., 2019). Marbling also depends on the time of feeding and the type of feed. The longer the cattle are fed high-calorie food, the more likely it is that they will have higher quality indicators, but significantly less marbled meat (as a percentage of the carcass, that is, the ratio of lean meat to marbled meat). The period after setting the animals to fattening lasts approximately 3 – 4 months and if the diet is not balanced it can lead to gastrointestinal pathology, so it is not recommended that the period of rearing livestock is extended (Gorlov, Mokhov and Vorontsova, 2018; Samikshya et al., 2019). Feeding with a large amount of cereals, such as corn or barley, will change the colour of the fat from yellowish to white. Low physical activity is also

a factor that affects marbling. In cows and steers that have grown up in tight stalls, the meat becomes softer than in free-grazing animals. Thus, animals that are restricted in movement easily accumulate intramuscular fat, and their meat becomes soft (Adeyemi et al., 2019; Troy, Tiwari and Joo, 2016). The worldwide accepted technology for growing and fattening cattle to produce marbled meat is feedlots – platforms for final fattening with high-calorie diets for at least 120 days before slaughter, before animals graze free (El-Khadrawy, Ahmed and Hanafi, 2011; Gorlov, Mokhov and Vorontsova, 2018).

The live weight (kg) and growth dynamics in the experimental groups of steers are presented in Table 1.

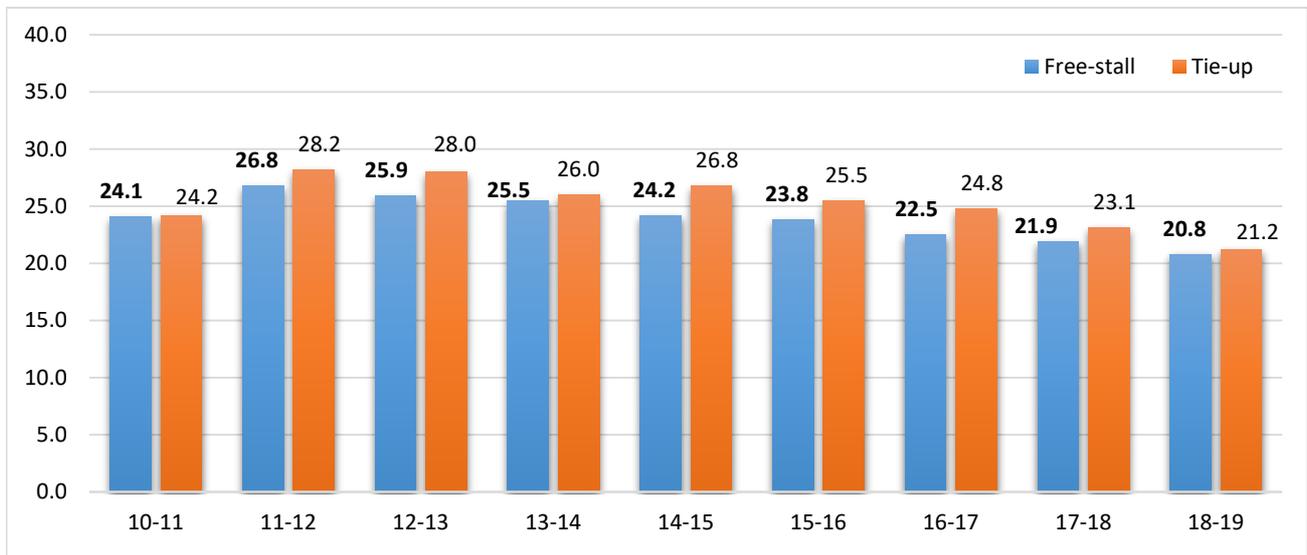
Assessment of the weight gain rate of steers showed that live weight gain in the Test group was faster, which affected the weight dynamics in different months. According to the study results in Table 1, higher live weight dynamics were shown by the Test group steers kept tied up and fed with the special recipe fodder developed by the Volga Research Institute (Gorlov, 2018).

Comparing the dynamics of average daily live weight gain (kg) in the groups enabled observation of the

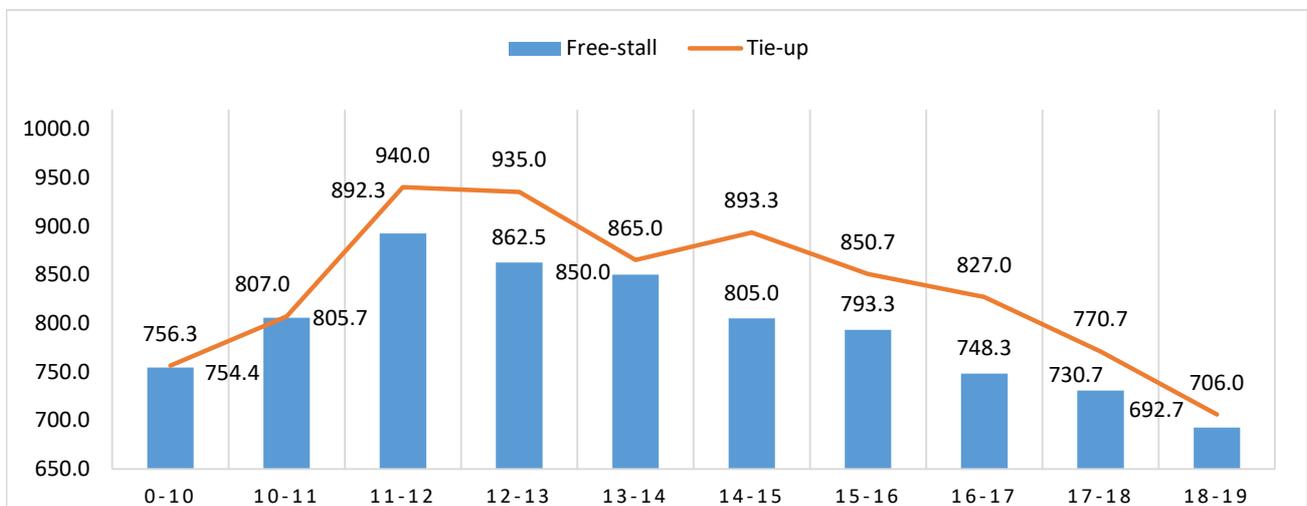
maximum growth energy in Test steers at the age of 16 to 18 months. Therefore, we recommend raising steers to 18 months old (Figure 1, Figure 2).

**Table 1** Live weight (kg) dynamics of steers.

Age, months	Group	
	Free-stall (Control)	Tie-up (Test)
10	260.7 ±1.03	261.2 ±1.17*
11	284.9 ±1.13	285.4 ±1.83
12	311.7 ±1.54	313.6 ±1.66**
13	337.5 ±1.71	341.7 ±1.95
14	363.0 ±1.62	367.6 ±1.81
15	387.2 ±2.23	394.4 ±2.82
16	411.0 ±2.05	420.0 ±2.12*
17	433.4 ±2.18	444.8 ±1.77
18	455.4 ±1.97	467.9 ±2.33
19	476.1 ±2.25	489.1 ±2.71***



**Figure 1** The overall live weight gain (kg) of experimental steers.



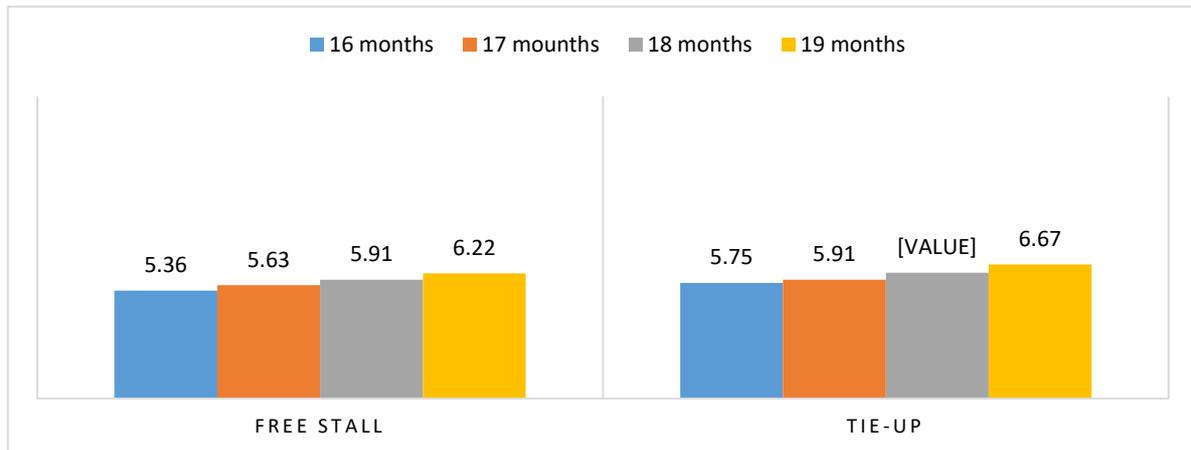
**Figure 2** Average daily gain (g) of experimental steers.

**Table 2** Control slaughter results of experimental steers.

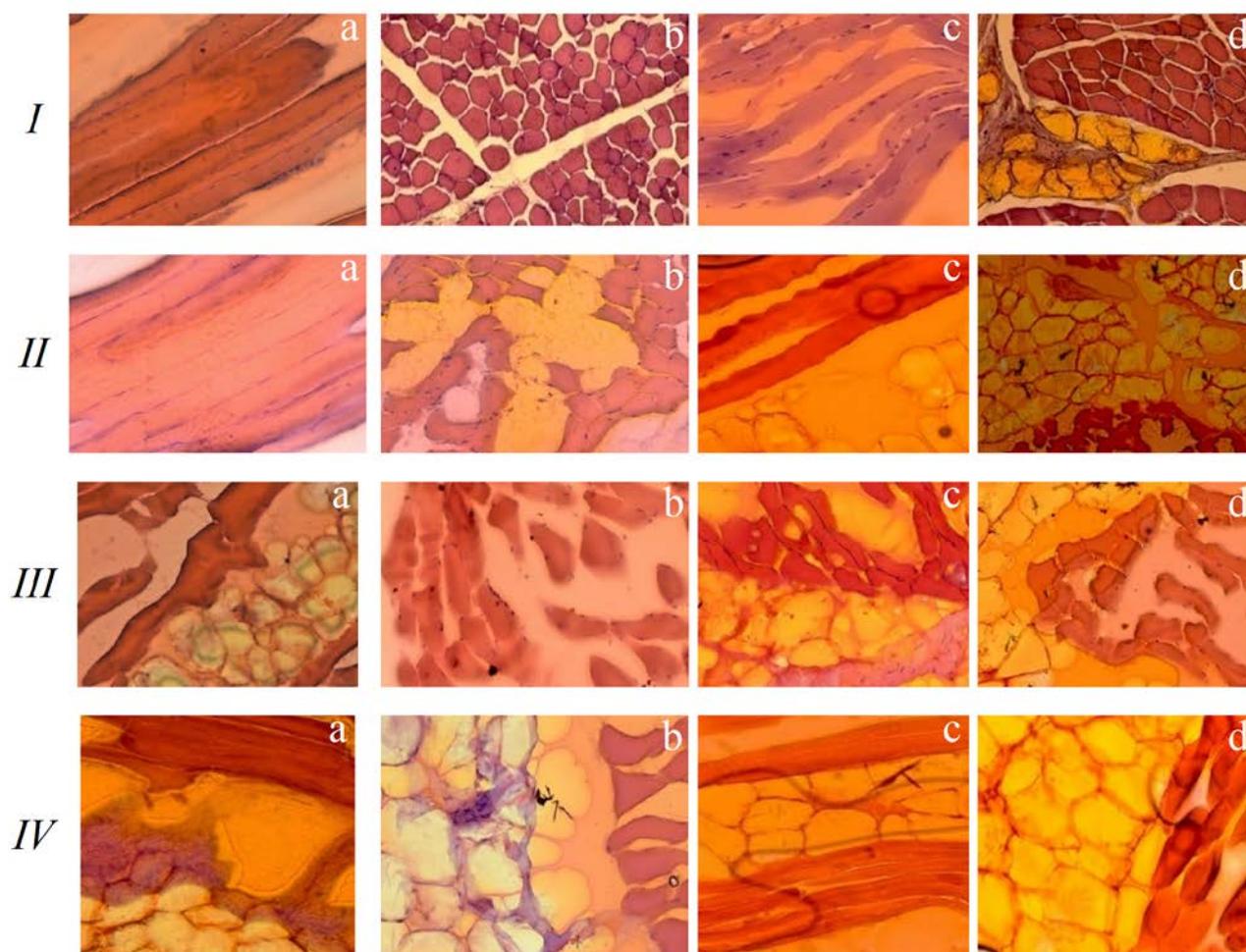
Indicator	16 months		17 months		18 months		19 months	
	Free-stall (Control)	Tie-up (Test)						
Pre-slaughter weight, kg	410.8 ±1.8	414.1 ±1.5*	431.6 ±1.8	436.5 ±1.8	449.7 ±1.8	453.9 ±1.95	471.0 ±1.6	474.1 ±2.2*
Carcass weight, kg	226.1 ±1.9	229.3 ±2.03	241.4 ±1.8	246.3 ±1.8*	253.9 ±1.8	258.1 ±1.8	269.1 ±1.8	272.3 ±1.8
Carcass yield, %	55.0	55.4	55.9	56.4	56.5	56.9	57.1	57.4
Slaughter weight, kg	237.6 ±1.5	240.8 ±1.7**	252.9 ±1.6	257.8 ±2.1	265.4 ±2.2	259.6 ±1.8	280.9 ±2.1*	284.1 ±1.8
Slaughter yield, %	57.8	58.2	58.6	59.1	59.0	59.4	59.7	59.9
Weight of chilled carcass, kg	210.4 ±1.4	213.6 ±1.8ns	225.7 ±1.8	230.6 ±2.0	238.2 ±2.1	242.3 ±1.6	253.4 ±1.6*	256.6 ±1.7
Flesh weight, kg	166.6 ±1.3	169.8 ±1.3	181.9 ±1.6	186.8 ±1.6	194.4 ±2.0	198.5 ±1.9	209.6 ±1.9	212.8 ±1.6*
Flesh yield, %	79.2	79.5	80.6	81.0	81.6	81.9	82.7	82.9

**Table 3** Morphological composition of the carcasses of experimental steers.

	16 months		17 months		18 months		19 months	
	Free-stall	Tie-up	Free-stall	Tie-up	Free-stall	Tie-up	Free-stall	Tie-up
Subscapular	15.76	16.21	17.38	18.78	18.71	19.54	19.14	21.45
Neck	44.85	46.11	49.31	51.36	53.02	54.13	56.09	58.97
Hip cut on bone without shank	25.07	26.43	27.88	28.97	30.12	32.07	31.93	32.76
Shoulder blade	42.66	44.56	46.57	48.04	50.23	52.09	53.21	54.78
Sterncostal	76.06	78.14	83.77	84.59	90.19	91.26	95.85	98.43
Saddle	28.25	29.54	31.08	32.89	33.6	34.78	36.26	39.53



**Figure 3** Dynamics of the meatiness index of experimental steers.



**Figure 4** Microstructure of the *Longissimus* muscle of experimental steers at different ages: (I – 16, II – 17, III – 18 and IV – 19 months; a, b – longitudinal section; c, d – cross section).

In the next stage of the experiment, steers at the age of 16, 17, 18 and 19 months were slaughtered in a slaughterhouse, to study the marble formation. The main indicators of the controlled slaughter of steers are presented in Table 2. The control slaughters of experimental steers at different ages showed that the live weight dynamics in the Test group were higher than in the Control group by 8.3 – 10.5 kg, pre-slaughter weight by 8.5 – 11.3 kg, slaughter weight by 9.5 – 13.9 kg, chilled carcasses by 9.5 – 13.9 kg and flesh weight by 9.4 – 15.3 kg. The Kalmyk breed under consideration was characterized by high meatiness and hardness with the meat index increasing for this keeping technology (Figure 3).

The morphological composition of the carcasses examined showed that in all steers, the most massive parts of the carcass are the hip cut, sternocostal and shoulder blade. In the Test group, these parts exceeded the weight of similar cuts of steers in the Control group (Table 3). Samples were taken from the rib-saddle part of Test steers to examine the microstructure of muscle tissue and assess the degree of marbling in the raw meat obtained. The results of the histological analysis are presented in Figure 4.

The muscle tissue samples were taken from animals at 16, 17, 18 and 19 months old in the Test group to establish the marbled structure of meat and its dynamic formation.

The unique ability of Kalmyk steers to accumulate reserve nutrients in the form of marbled layers gives high culinary qualities to their beef (**Prokhorov, Naumovich and Mulangi, 2016**). Moreover, the value of this meat grade is due to its high content of vitamins and minerals, and a unique ratio between monounsaturated and saturated fats (**Makayev, 2005; Šulcerová et al., 2017; Yaremchuk and Rodin, 2011**).

In assessing the microstructure of the muscle tissue, we found considerable fatty tissues in fibres, which characterized the degree of beef marbling. While some studies have shown that beef marbling is determined by the colour of muscle and fat tissue and marbling on the longest back muscle (*Longissimus dorsi*) of cattle (**Frank et al., 2016; Morozova, 2016; Yaremchuk and Rodin, 2011**). Fat inclusions were found in the samples of all age groups, but the maximum marbling had been reached by 19 months; these results support some of the results of other studies (**Wang et al., 2019; Kayumov, 2008; Randelin et al., 2018**).

Thus, it was proved that marbling is formed in the meat raw materials produced, depending on the feeding and keeping technology.

The tie-up keeping technology and feeding with a specially formulated feed mixture contributed to the early maturation and marbling of beef. In addition, the proven experimental technology developed by the Volga Research Institute contributed to the rapid weight gain of steers and production of premium beef grades.

## CONCLUSION

Single-purpose beef cattle breeding in the arid conditions of the South of Russia is the most promising direction for the development of agricultural production in these territories. The severe climatic conditions and waterless periods allow the breeding and keeping cattle of breeds best acclimatized to this area. The Kalmyk cattle breed grown in this area is the most promising in terms of the production of premium beef grades due to its genetic predisposition to marbling of the raw meat obtained. The wide expansion range and popularity of this cattle breed are caused by the high productivity of steers whether kept tied up or allowed to graze free. The compared qualities of beef obtained from Kalmyk steers proved that the tie-up keeping technology allowed increased production efficiency of raw meat.

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