Microelement composition of arid pastures: impact on productive qualities of Kazakh white-headed steers

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Abstract. The article describes the results of a scientific experiment in the beef production in arid areas of the Volgograd Trans-Volga region. Being one of the main branches of agriculture, livestock provides the population with food of animal origin and is a raw material base for corresponding branches of the processing industry. The need to intensify beef cattle breeding is a nationwide task aimed at solving the challenges of food security through innovative methods and tools used for feeding and breeding beef cattle in arid areas of the southern Russia. The article substantiates the need to improve the fodder base for breeding beef cattle in loose and tie-up housing. Feeds enriched with microelements for the intensive growth and development of animals have been found to have quite good effect on the live weight gain and fleshiness of steers. Therefore, the norms of feeding and microelement supplements developed for the rations will enable producing more meat raw materials of high nutritional value in local climatic and natural conditions.

1. Introduction
The diets of Russians should feature beef as a regular product; therefore, the development of the beef cattle industry should be a task of national importance and be based on scientific achievements and genetic abilities of animals, allowing shortening the period of meat production, without its qualitative composition being deteriorated. Furthermore, the industry’s high dependence on the import of raw materials, genetic material and feed undermines the foundations of national security. In this connection, the search and implementation of home-grown technologies, especially to improve the conditions for feeding and keeping animals into production must be supported and developed [1, 2].

The beef production dynamics in Russia with respect to various categories of producers for the period 2010-2018 is presented in Figure 1.

Beef production volumes showed a decline from 1,727 thousand tons in 2010 to 1,621 thousand tons in 2018. The decline in production occurred in private farms that could not compete with large industrial complexes. The industrial sector was reducing the volumes, but since 2016 it has been increasing them, mainly due to the state support for animal husbandry. The reasons for the overall reduction in beef production are a long payback period for in the livestock industry. So, the average period of poultry growth is 1.5-2 months, while the growth of beef cattle takes 2 years. Such a long period affects the cost of meat, i.e., poultry is 3-3.5 times cheaper than beef. Therefore, in a period of erosion of purchasing power of many citizens, poultry is very popular. The problem is that the development of highly profitable
poultry and pig raising industries outcompete the production of red meat that is rich in macro- and microelements and necessary for nutrition for medical reasons. Red meat cannot be fully replaced by the white one, since beef contains conjugated linoleic acids (CLA) produced exceptionally in the stomachs of ruminants [3]. The CLAs promote the formation and maintenance of immunity and reduce the risk of cardiovascular diseases, certain types of cancer, diabetes, etc. Artificial analogues of such acids have not been obtained yet.

![Figure 1](image.png)

**Figure 1.** Analysis of the beef production volumes in Russia, thousand tons.

### 2. Methods and materials

The studies were conducted using the methods of graphical presentation of information, trend analysis and comparison, analog and collation methods. For the scientific experiment, zootechnical, biochemical, analytical, ethological, computational-statistical, economic and mathematical methods generally accepted in animal husbandry were applied and allowed obtaining external evidence.

Theoretical and applied issues of evaluating the meat production efficiency were considered in the works of many authors (Gorlov et al., 2015), (Fedotova, 2018), (Omarov et al., 2017), (Gorlov et al., 2017), (Gorlov et al., 2019), (Sobol et al., 2017).

Despite the abundance of related publications, the challenges of providing the population with affordable meat products and meat production growth in modern conditions are poorly understood. In terms of developing the meat production in Russia, it is necessary to revise the current tools of state management in the agro-industrial sector as well as additional measures to improve the effectiveness and safety of their implementation for creating food security.

### 3. Results and discussion

The successful development of the animal husbandry by 70% depends on the effectiveness of the feeding technology and keeping conditions of animals. The feed production depends on the technical equipment of agricultural producers, agro-ecological conditions of the territories, composition of herbage and scientific advances applied in production.

Forage harvesting is a particularly acute problem in the conditions of poor vegetation cover of areas prone to erosion processes. Arid territories in the South of Russia (Volgograd Trans-Volga region, Kalmykia, Dagestan and Bashkortostan) are usually referred to the territories of that kind [4].

Meat cattle breeding in the arid territories in the South of Russia is rather difficult to be implemented in the absence of a full-fledged forage base. The characteristics of drylands are associated with the desertification and dehydration that impede agriculture. The main population’s activity on these territories is meat cattle breeding. For beef cattle, the main requirement is the availability of a full-fledged forage base, rich in macro-and micronutrients. Evaluation of the chemical composition and
average nutritional value of pasture grass stand of arid areas using the example of the Volgograd Trans-Volga region showed that the chemical composition of pastures was noted for a variety of macro- and microelement composition (Table 1).

**Table 1.** The content of macro- and micronutrients in the vegetation of natural pastures in arid territories of southern Russia (in 1 g of dry weight)

| Plant                     | Macronutrients, g | Micronutrients, mg |
|---------------------------|-------------------|--------------------|
|                           | Ca    | P     | R    | S    | Mg   | Cu   | Zn   | Mn   | Fe   |
| Kochia prostrata          | 5.7   | 1.6   | 6.4  | 0.5  | 4.4  | 4.5  | 11.8 | 71.5 | 199  |
| Artemisia austriaca       | 4.9   | 1.6   | 10.2 | 0.8  | 1.7  | 7.2  | 12.8 | 62.5 | 211  |
| Artemisia lechiana        | 5.4   | 1.1   | 10.4 | 0.5  | 1.3  | 1.6  | 16.5 | 34.9 | 470  |
| Camphorosma lessingii     | 5.3   | 1.1   | 16.3 | 0.7  | 5.3  | 5.4  | 20.2 | 67   | 428  |
| Salsola ruthenica Iljin   | 5.8   | 0.4   | 2.9  | 0.5  | 3.8  | 10.5 | 27.7 | 41.2 | 208  |
| Medicago falcata          | 2     | 0.5   | 3.8  | 0.3  | 2.6  | 9    | 30   | 53.9 | 136  |
| Onobrychis arenaria       | 1.1   | 0.1   | 1.5  | 0.2  | 2.3  | 6    | 25   | 32.2 | 190  |
| Astragalus cicer          | 2.5   | 0.5   | 5.2  | 0.3  | 2.8  | 11.5 | 43.3 | 35.6 | 128  |
| Galega orientalis Lam.    | 2.9   | 0.3   | 3.1  | 0.2  | 2.5  | 6.5  | 17.5 | 41.2 | 154  |
| Vicia cracca             | 1.3   | 0.6   | 6.3  | 0.5  | 1    | 4.5  | 25   | 95.1 | 84   |
| Agropyrum tenerum         | 1     | 0.6   | 5.4  | 0.4  | 0.9  | 3.5  | 25   | 90.1 | 84   |
| Agropyron glaucum        | 2.2   | 1.2   | 7.7  | 0.7  | 0.7  | 4.5  | 22.5 | 41.2 | 75   |
| Stipa lessingiana         | 1.2   | 0.2   | 2.6  | 0.4  | 0.4  | 3    | 17.5 | 49.1 | 170  |

Evaluation of the chemical composition of natural pastures showed that the grass cover contained enough nutrients to maintain normal growth and life sustenance of farm animals. But due to dry periods and erosion processes, a large amount of nutrient reserves of the grass stand was lost and weathered by about 25-30% (according to the scientists of the Volga Region Research Institute of Manufacture and Processing of Meat-and-Milk Production). Such a volume of nutrients of pasture grass stand was not received by animals, which caused the need to search for new technologies for growing beef cattle under conditions of aridization and improving optimal feeding rates for arid territories and enriching the daily ration with chemical elements [5, 6].

The research study established that arid grazing resources did not provide enough feed, which required a search for compensating feed supplements for animal rations.

To produce a scientific experiment to assess the effect of microelements on the growth and development dynamics of beef cattle, there were two groups of animals at 10 months of age formed, i.e., steers of the Kazakh white-headed breed of domestic breeding, 30 heads each.

Group I included animals that were kept loose on walking grounds.

Group II included animals in tie-up housing.

For the experiment, there were prepared mineral supplements with reduced and optimal contents of the following trace elements: manganese, molybdenum, copper, bromine, cobalt, selenium and zinc.

A similar experiment should be noted to have been conducted by scientists of the Zootechny Department, Kalmyk State University. They evaluated the microelement exchange in the bodies of Kalmyk cattle in the conditions of the sharply continental climate of the steppe zone [7].

In our experiment, there were 2 groups of animals observed that were fed with 2 types of feed: 1) with optimal content of trace elements and 2) with the microelement content reduced by 15-43%, depending on the element. For feeding animals, 2 types of rations and levels of trace elements in them were developed depending on the age and type of housing (Table 2).
Table 2. Scheme of the scientific experiment and level of trace elements in feed supplements

| Level of trace elements in ration | Tie-up housing | Loose housing |
|----------------------------------|----------------|--------------|
|                                  | 10  | 13  | 16  | 10  | 13  | 16  |
| Manganese                        |     |     |     |     |     |     |
| reduced (15-24%)                 | 205.7 | 334.6 | 421.7 | 245.6 | 341.5 | 412.7 |
| optimum                          | 215.7 | 380.6 | 467.5 | 279.5 | 385.4 | 479.4 |
| Molybdenum                       |     |     |     |     |     |     |
| reduced (20%)                    | 12.9 | 17.7 | 21.9 | 11.2 | 20.7 | 26.3 |
| optimum                          | 13.8 | 19.4 | 23.6 | 12.3 | 21.4 | 28.4 |
| Cooper                           |     |     |     |     |     |     |
| reduced (33-43%)                 | 33.7 | 63.2 | 79.3 | 42.3 | 64.9 | 74.6 |
| optimum                          | 40.6 | 82.1 | 1132.8 | 57.9 | 94.8 | 131.9 |
| Bromine                          |     |     |     |     |     |     |
| reduced (26%)                    | 28.3 | 51.2 | 57.8 | 23.7 | 41.1 | 56.8 |
| optimum                          | 29.4 | 53.1 | 61.2 | 24.5 | 59.5 | 61.2 |
| Cobalt                           |     |     |     |     |     |     |
| reduced (30-41%)                 | 2.8  | 4.6  | 5.9  | 3.6  | 5.9  | 6.9  |
| optimum                          | 3.9  | 6.3  | 8.7  | 3.9  | 8.6  | 11.1 |
| Selenium                         |     |     |     |     |     |     |
| reduced (30%)                    | 1.7  | 2.6  | 3.9  | 1.4  | 2.6  | 3.4  |
| optimum                          | 1.8  | 2.9  | 4.1  | 1.7  | 1.9  | 2.6  |
| Zink                             |     |     |     |     |     |     |
| reduced (20-38%)                 | 138.7 | 223.5 | 302.9 | 194.5 | 296.4 | 362.6 |
| optimum                          | 173.1 | 367.1 | 459.8 | 209.5 | 438.4 | 557.1 |

The conducted research registered differences in assimilation degree of trace elements in terms of different ways of keeping animals. In addition, with age, the assimilation degree of trace elements also increased. Animals in tie-up housing regularly received the necessary micronutrients in the additional green feeding according to the optimal level of their keeping. Animals in loose housing received an additional ration with a reduced level of microelements. With the age, the levels of trace elements in diets varied depending on the theoretical need [8].

The results of the experiment allowed presenting the dynamics of growth and development of Kazakh white-headed steers of Russian breeding in Groups I and II. The evaluation of the live weight dynamics of steers showed that in tie-up housing, the weight growth was faster, which was explained by full feeding and low motion activity. On average, the dynamics in 16-month-old steers in Group II was higher by 7.8%. The overall weight gain in Group I was 198 kg and in Group II, 240 kg. In terms of the body weight, Group II exceeded Group I.

Evaluation of the control slaughter of experimental steers of the two groups showed the results presented in Table 3.

The control slaughter animals found
- the average weight of hot carcass in Group I was 283 kg and in Group II, 312 kg. This meant that animal carcasses in Group II were by 9% heavier than those in Group I;
- the carcass yield in Group I averaged 57.7%; in Group II it was about 61.8%, which exceeded the values in Group I by 4.1%;
- in terms of the weight of internal fat, animals in Group II exceeded their peers in Group I by 4.8 kg, since the tie-up housing of animals, absence of dynamic movement and full feeding contributed to the deposition of adipose tissue in the body;
- animals of this breed showed good flesh yields; so in Group I, it was 85.4% of the total weight of carcass and in Group II, about 95.11%;
- the weight of bones in Group II was higher, since due to the ration containing highly concentrated mineral feeds, more intensive assimilation of trace elements and growth of animals took place;
- the fleshing index of animals in Group II exceeded that of steers in Group I by 0.45; and
- the nutritional value of meat from steers in Group II was by 0.89 higher than that from animals in Group I.

| Table 3. Values obtained in control slaughter of experimental animals |
|---------------------------------------------------------------|
| Parameter                                      | Group I (loose housing) | Group II (tie-up housing) |
| Live weight, kg                                | 509.53±0.84              | 549.00±0.44               |
| Pre-slaughter weight, kg                       | 490.2±4.35               | 530.5±3.11                |
| Weight of hot carcass, kg                      | 283.1±0.4                | 312.2±0.47                |
| Carcass yield, %                               | 57.7±3.44                | 61.8±3.87                 |
| Weight of internal fat, kg                     | 10.1±4.34                | 14.9±2.61                 |
| Fat yield, %                                   | 1.9±0.78                 | 2.7±0.27                  |
| Slaughter weight, kg                           | 280.67±0.56              | 313.12±0.27               |
| Slaughter yield, %                             | 57.54±2.27               | 59.2±1.62                 |
| Weight of chilled carcass, kg                  | 273.0±4.54               | 302.0±3.43                |
| Flesh weight, kg                               | 237.1±8.43               | 285.5±6.15                |
| Flesh yield, %                                 | 85.4±2.95                | 95.11±3.39                |
| Weight of bones, kg                            | 36.45±7.21               | 38.56±1.84                |
| Bone yield, %                                  | 12.98±3.23               | 13.1±1.97                 |
| Weight of tendons, kg                          | 9.0±1.12                 | 8.2±0.45                  |
| Tendons yield, %                               | 4.0±3.11                 | 5.1±0.74                  |
| Fleshing index                                 | 6.43±3.23                | 6.89±2.54                 |
| Nutritional Value Index (PVI)                  | 5.23±2.45                | 6.120±3.23                |

Thus, the analysis established that animals in tie-up housing and fed with intensive ration with microelement supplement had better indices of slaughter, morphological composition of the carcass and degree of muscle and adipose tissues development. The quality of the beef produced depends on both morphological and chemical compositions of flesh. So, the chemical composition of meat from the steers was also assessed. The results of the experiment are shown in Table 4.

The chemical composition is known to vary, depending on the animal’s age, breed and growing technology, therefore the indices obtained were quite interesting. In Group II, the steers had a moisture content of 64.13%, which was by 0.98% lower than that of steers in Group I. For this reason, flesh from animals in Group II contained more dry nutrients by 0.73%.

Another important indicator of the meat quality was the level of fat content in meat. So, the steers in Group II surpassed the steers in Group I with an advantage of 1.01%.

The protein content did not vary greatly in groups. In Group I, its value was 18.98%, and in Group II, it was 19.37%. The ratio between protein and fat in meat in Group II was 1:0.87 and in Group II, it was 1:0.81.

The analysis of the Longissimus muscle showed that the steers in Group II had higher fat indices than those in Group I. The protein content was also higher in Group II.

The chemical composition of meat should also indicate the level of protein, as animal protein is a source of essential amino acids. Therefore, in our study, the levels of such amino acids as tryptophan (high-quality muscle protein) and hydroxyproline (connective tissue proteins), as well as the PQI
criterion of the biological value were established. The results of the analysis showed that in terms of the tryptophan content, the steers in Group II exceeded their peers by 54.2 mg; and in terms of the hydroxyproline content, the animals in Group I slightly exceeded those in Group II by 0.69 mg.

Table 4. The analysis results of the chemical composition of experimental steers

| Parameter                                      | Group I (loose housing) | Group II (tie-up housing) |
|------------------------------------------------|-------------------------|---------------------------|
| Average sample                                 |                         |                           |
| Moisture, %                                    | 65.11±0.16              | 64.13±0.19                |
| Dry matter, %                                  | 34.94±0.23              | 35.67±0.32                |
| Including - protein                            | 18.98±0.11              | 19.37±0.27                |
| - fat                                          | 16.18±0.24              | 17.19±0.04                |
| - ash                                          | 1.12±0.03               | 0.89±0.02                 |
| Ratio between protein and fat                  | 1:0.81                  | 1:0.87                    |
| Longissimus muscle                             |                         |                           |
| Moisture, %                                    | 74.00±0.87              | 73.41±0.35                |
| Dry matter, %                                  | 24.89±0.32              | 26.19±0.24                |
| Including - protein                            | 19.95±0.11              | 21.11±0.29                |
| - fat                                          | 2.56±0.04               | 2.88±0.17                 |
| - ash                                          | 0.93±0.02               | 0.96±0.02                 |
| Tryptophan, mg                                 | 418.05±8.19             | 472.25±11.07              |
| Oxypoline, mg                                  | 59.16±1.89              | 58.47±1.87                |
| PQI                                            | 6.76                    | 8.04                      |

In general, in the chemical composition of meat, the Group II steers exceeded their peers with respect to such criteria as the level of moisture, dry matter, protein and tryptophan.

At the next stage of our research study, the profitability of beef production in terms of weight gain, costs, revenue and profit was assessed (Figure 2).

Figure 2. Evaluation of the economic efficiency of the beef production.

The analysis of the beef production economic efficiency of steers of the Kazakh white-headed breed in the conditions of arid territories proved that the steers Group II had higher production, since their profit from the sale of meat was by 1587.9 RUB more than the profit from the sale of meat from steers Group I.
of Group I. Accordingly, the profitability level from the beef production of steers in Group II was 52.19%, which was by 6.23% more than in Group I.

4. Conclusions
Summarizing the results of the study, it should be noted that the beef production should be based on scientific methods of feeding animals on arid territories. The enrichment of the daily rations of animals with microelements affected their meat productivity and the quality of raw meat. Tie-up steers fed with rations enriched with various missing microelements showed higher growing power and weight gain and had greater fleshiness and indices of amino acid composition. The assessment of the economic efficiency of the beef production proved greater profitability of the tie-up growing technology and optimal microelement feeding ration.

5. Acknowledgments
The work was carried out within the framework of the grant of the Russian National Science Foundation No. 15-16-10000, the GNU NIIMMP “Development and scientific substantiation of new approaches to the production of livestock raw materials and increasing the biological value of socially significant products based on modern biotechnological and molecular genetic methods.”

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