OnLine Journal of Biological Sciences

Original Research Paper

Comparative Assessment of Meat Qualities of Purebred and Crossbred Kalmyk Bulls

I. N. Aitzhanova, G. I. Shaikamal, L. A. Seleuova, Sh. S. Gabdullin and A. T. Bekbolatova

Department of Technology of Livestock Products, Akhmet Baitursynov Kostanay Regional University, Kazakhstan

Article history
Received: 01-07-2022
Revised: 31-08-2022
Accepted: 03-09-2022

Corresponding Author:
I. N. Aitzhanova
Department of Technology of Livestock Products, Akhmet Baitursynov Kostanay Regional University, Kazakhstan
Email: www.indira.rz@mail.ru

Abstract: The purpose of this study was to review the meat qualities of Kalmyk cattle by the method of lifetime evaluation of the meat forms of purebred and crossbred bulls by studying growth and development, as well as determining the thickness of subcutaneous fat, the loin eye area and the meat marbling. Throughout the experiment (from 6 to 12 months), Kalmyk bulls were characterized by significantly ($p \leq 0.01$) higher average daily growth than crossbred bulls obtained from Angus and Kalmyk breeds (750 g vs. 670 g). The average daily increase in purebred Kalmyk bulls reached 750 g and was significantly higher ($p<0.05$) than in bulls obtained from crossbreeds of Kazakh white-headed and Kalmyk breeds. Despite such indicators as the thickness of subcutaneous fat, the area of the loin eye and meat marbling among the studied groups for the evaluation of meat qualities in points, purebred bulls had higher indicators for the loin eye area and meat marbling and lower feed costs per 1 kg of live weight gain. They significantly surpassed their peers, the Kazakh white-headed and Aberdeen-Angus breeds (at $p<0.001$) in terms of the thickness of subcutaneous fat and meat marbling. The young animals of this group had lower feed costs per 1 kg of growth, by 1.1 feed units, or 14%, compared with the peers from the Kazakh white-headed x Kalmyk group and by 3.4 feed units, or 44%, compared with the Angus x Kalmyk group. This is since the cattle of this breed are characterized by endurance, unpretentiousness to feed, high adaptive plasticity, good weight gain per quantity of feed both during fattening and graziery and early meat maturity, compared with the Angus and Kazakh white-headed breeds.

Keywords: Meat Qualities, Cattle, Marbling, Dynamics of Live Weight, Ultrasound Scanner

Introduction

More than 1,000 existing cattle breeds in the world make up a vital economic part of each country, offering the main sources of food and non-food products, such as milk, meat, pelt and hair (FAO, 2015; Mei *et al*., 2021).

Beef provides consumers with high-quality protein, vitamins and minerals. Thus, fat makes an important contribution to various aspects of meat quality and nutritional value and can also affect sensory properties (Indurain *et al*., 2010).

The supply of good quality beef is essential to meet the needs of consumers by increasing the demand and profitability of the meat industry (Bonny *et al*., 2016; Malheiros *et al*., 2018). The quality of meat is a complex indicator including tenderness, juiciness, calorie content and color, which are the main factors of consumer recognition and pricing of products (Pegolo *et al*., 2020).

Beef production has recently increased due to global food demand and increased meat consumption (Pulina *et al*., 2021). Therefore, the beef carcass is a relevant and one of the most important elements of production and its quality is important for both consumers and producers. To meet the demand for high-quality carcasses, carcass classifications are applied to the quality level. According to the EUROP classification system, beef carcasses receive a score composed of one of the five letters (E, U, R, O, P) and five numbers (1 to 5) (Gonçalves *et al*., 2020).

In many regions of Kazakhstan, such as Western Kazakhstan, North Kazakhstan, Kostanay regions, etc. Kalmyk is considered a particularly promising breed among beef cattle breeds (Kayumov *et al*., 2012; Okunev, 2020). The Kalmyk cattle breed has "marbled" meat of excellent taste qualities, which is not inferior to the best world standards (meat of Kalmyk cattle meets the requirements of world standards, as it is thin-fiber and has

a high energy content and biological value; animals reach a live weight of 400-450 kg by the age of 18 months and give a carcass weighing 185-220 kg. The meat of the carcass contains 17.5-19.5% protein, 15-17% fat and 17-18% bones; in terms of culinary qualities, it corresponds to the best table varieties of the world standard) (Amerkhanov *et al*., 2016).

This is since the animals of the Kalmyk breed have the most valuable biological features, such as adaptability to various natural, ecological and economic conditions, high meat productivity, early meat maturity, exceptional adaptability to a sharply continental climate, the ability to quickly fattening and fat accumulation under favorable feeding conditions. These important economic characteristics were developed as a result of natural and artificial selection in a harsh, sharply continental climate (long and harsh winters, hot and dry summers, steppe and semi-desert vegetation) with year-round pasture maintenance. All this suggests that the animals of the Kalmyk breed can compete with many imported meat breeds of cattle and meet modern market requirements.

The meat productivity of an agricultural animal can be assessed in two ways: By the method of lifetime evaluation of meat forms and by the evaluation of meat productivity after slaughter (Kayumov *et al*., 2007). A lifetime visual assessment of the carcass makes it possible to assess the productivity of animals without slaughter according to the following indicators: Pre-slaughter live weight, weight gain, fatness and feed costs. This allows for more precise genetic selection, which lets breeders breed cattle that better meet slaughterhouse specifications and market requirements. The data of the lifetime evaluation of cattle will allow calculating the genetic parameters of the correlation and breeders will be able to choose animals that produce carcasses with a greater proportion of weight in more valuable carcass areas (Moore *et al*., 2017). The use of lifetime evaluation of animals to predict the future composition of carcasses allows producers to make informed management decisions before slaughter to increase profitability (McPhee *et al*., 2020).

Evaluation of meat productivity after slaughter is the most common method. In particular, measurements of the depth of fat and musculature of the carcass are used to evaluate the carcass and act as indirect indicators of meat quality (Drennan *et al*., 2008).

In Kazakhstan, in the group of young cattle for meat breeding, bulls raised according to semi-intensive systems and grazed on pastures are best suited for fattening. Two pasture cycles are usually performed. The average daily weight gain is approximately 800 g. Animals are slaughtered at the age of 15 or 18 months when they reach a body weight of about 550-600 kg (Coleman *et al*., 2016; Aitzhanova *et al*., 2017).

The purpose of this study was to review the influence of the sharply continental climate on the meat qualities of Kalmyk cattle by the method of lifetime evaluation of meat forms and evaluation of meat productivity after slaughter.

Materials and Methods

The study was carried out in 2020-2021 at the Department of Livestock Production Technology of the Kostanay Regional University named after A. Baitursynov in the laboratory for the evaluation of feed and the quality of livestock products according to the schedule of research work on the topic "Development of a program to improve the Kalmyk breed in the Kostanay region" under contract No. 212 dated November 12, 2020.

The territory of the Kostanay region is 196.0 thousand km^2 (Fig. 1). The region belongs to the West Siberian climatic region of the temperate zone with a sharply continental climate. Winters are long, frosty, with strong winds and blizzards and summers are hot and dry. The annual precipitation is 350-500 mm in the north of the region and 240-280 mm in the south. The growing season is 150-175 days in the north and 180 days in the south.

The object of the study was purebred and crossbred Kalmyk bulls in the amount of 45 heads, fattened at the age of 6 to 12 months in Eurasia Invest LLP, Kostanay region, Kazakhstan.

The bulls were born in the early spring of 2020 and stayed with their mothers on pastures for up to 6-8 months. In the autumn, after weaning, the young bulls were kept in a box stall where they could walk freely. The animals were divided into three experimental groups. The first group (Kalmyk) consisted of 15 bulls of purebred Kalmyk breed, the second group (Angus x Kalmyk) included 15 bulls of a cross between Angus and Kalmyk breed and the third group (Kazakh white-headed x Kalmyk) consisted of 15 bulls of a cross between Kazakh white-headed and Kalmyk breeds who had been born and raised in Eurasia Invest LLP. During the fattening period (from 6 to 15 months), the bulls were placed in outdoor box stalls. Lifetime evaluation of meat forms of experimental animals was carried out at 12 months of age (±10 days).

During the experimental studies, the technology of animal husbandry used in beef cattle breeding was used. Before weaning, the young animals were kept together with cows using the "cow–calf" technology; after weaning at the age of 6-7 months, all animals were on pastures until the end of the experiment.

In the course of studying the genealogical structure of the population and productivity of breeding cattle, we used primary documents, such as catalogs, breeding books, breeding cards, bonus lists and zootechnical accounting data. For the reliability of genetic affiliation, the blood of experimental animals should have been studied but this was not prescribed in the research tasks.

To determine the quality of the feed, the NIRS DS2500 feed analyzer was used. The NIRS DS2500 feed analyzer is designed to measure the spectral optical density (decimal logarithm of the spectral reflection coefficient) of feed in the near-infrared and visible spectral range. The principle of operation of spectrophotometers is based on the comparison of two light streams: Full, taken as 100% reflection and attenuated when reflected from the sample under study.

The nutritional value of the feed was determined based on the analysis of the chemical composition and nutrient digestibility coefficients following the nutritional needs of cattle (Kalashnikov *et al*., 2003; Makarcev, 2012; Lozowicka *et al*., 2022). With semi-intensive fattening, the average daily diet per bull consisted of more than 10 kg of maize silage, 1 kg of grass hay, 0.5 kg of barley straw, 1 kg of ground wheat grain and 1 kg of ground barley grain supplemented with a Polfamix premix (50 g). The amount of silage fed to bulls increased evenly over a 30-day interval, until the end of the study, which allowed to receive 10% of the residues from daily fattening. The chemical composition of the feed is shown in Table 2 and the nutrient intake per kg of live weight gain is shown in Table 3.

The dynamics of the live weight of young animals were determined by weighing them at 6, 9 and 12 months of age and the following body measurements were also taken: Height at the withers, trunk length and chest circumference [cm].

The meat quality of bulls during life was assessed by the adjusted live weight at the age of 210 and 365 days in accordance with the "Guidelines for improving the classical method of testing beef bulls on their own productivity adjusted weight" (Saginbayev *et al*., 2017), which was calculated based on the average daily gain.

Determination of the thickness of subcutaneous fat and the area of the loin eye in animals was carried out at the age of 12 months. Lifetime measurement of the area of the loin eye was performed at the level between the 12^{th} and 13^{th} ribs (Fig. 2) using an EXAGO ultrasonograph. The meat marbling was also determined using an EXAGO ultrasonograph at the age of 12 months on a 10-point scale (Table 1).

The meat marbling was determined using a scanner that reads the incision between the 12^{th} and 13^{th} ribs and a computer. After that we analyzed the "degree of marbling", i.e., the ratio of intramuscular fat to meat. The category of beef marbling was determined by the meat quality standards developed in Japan. Later, due to its considerable popularity, other countries, including the United States, mastered the methods for producing "ideal meat", while developing their own marbling assessment system BMS (Beef Marbling Standard). Depending on the meat marbling, the color of muscle tissue, the color of subcutaneous fat, the thickness of subcutaneous fat and the loin eye area, beef is divided into classes according to the requirements: A-72% and above; B-69-71%; C-below 69%.

The results were analyzed statistically using the software Statisticaver 10.0 (Statsoft, 2004) by one-way analysis of variance (ANOVA) for non-orthogonal constructions at the significance level of $p \leq 0.05$ and $p \leq 0.01$. Arithmetic means (x) and Standard deviations (Sd) were calculated. The deviation value was determined using the Fischer test.

Fig. 1: Map of the kostanay region

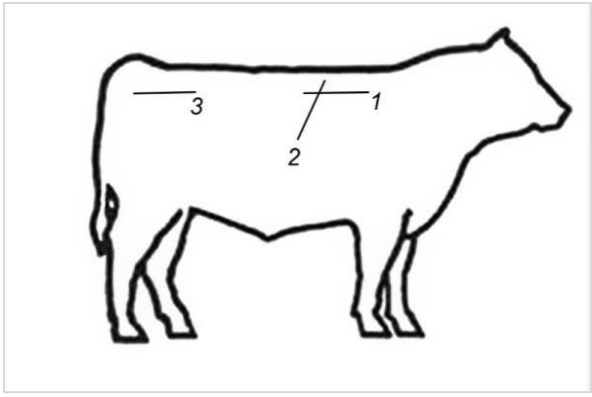

Fig. 2: Ultrasound scanning points of animals 1: Measurements of the percentage of intermuscular fat; 2: Measurements of the area of the "loin eye" and the depth of subcutaneous fat between the 12^{th} and 13^{th} ribs; 3: Measurements of the depth of subcutaneous fat on the sacrum

Results

The chemical composition of feed and the nutritional value of diets for experimental bulls are presented in Table 2. The nutrient content of maize silage corresponds to the recommended values, usually noted in production conditions. The quality of the grass hay was satisfactory and its nutritional value was maintained at a constant level throughout the experiment.

Nutrient intake per kg of live weight gain is also a reliable indicator of cattle fattening. The consumption of nutrients per kg of live weight gain is affected by the breed of cattle (Table 3). Purebred Kalmyk bulls are characterized by the highest energy efficiency and they need significantly ($p \leq 0.05$) fewer feed units and lower feed costs to produce 1 kg of weight gain in terms of feed units, metabolized energy (measured as MJ) and dry matter, compared to other animals studied. Thus, the energy consumption per kg of growth in the Kalmyk bulls was 44.9 MJ, which is 1.2 MJ less compared to the Angus and Kalmyk crosses and 2.5 MJ less compared to the Kazakh white-headed bulls. In other indicators of nutrients, Kalmyk bulls consumed less than similar groups.

Indicators of animal fattening are determined based on their live weight and average daily gain. Table 4 shows the indicators of live weight and daily growth of bulls, indicating statistically significant differences between the groups. There were no significant differences between the bulls at the age of 6 months (the beginning of the experiment). Throughout the experiment (from 6 to 12 months), K bulls were characterized by a significantly ($p \leq 0.01$) higher average daily increase than AxK bulls (750 gr. vs. 670 gr.). The average daily gain of bull calves reached 750 g and was significantly higher ($p \leq 0.05$) than that of KWHxK bull calves.

The analysis of measurements of the physique of bulls showed that K bulls were characterized by the highest values of height at the withers, trunk length and chest circumference (Table 4). It should be noted that the AxK bulls had a high value of chest circumference (168.8 cm), but the lowest values of height at the withers and trunk length compared to the other groups.

The meat qualities of bulls during their lifetime were evaluated by adjusted live weight at 210 and 365 days, which was calculated based on the average daily increase.

The lifetime definition of meat qualities makes it possible only to pre-evaluate animals by meat productivity. The final judgment on the quantity and quality of meat is given by post-slaughter accounting and evaluation of the meat merits of animals. The rearing and fattening of young animals are quite expensive, so the faster their assessment is carried out in terms of the ability to grow and fatten, the more efficient the production. Therefore, we calculated the adjusted live weight at 7 and 12 months of age, by which we can judge the ability to fatten. The calculation of adjusted live weight indicators in 210 and 365 days to assess the results of their productivity showed that the bulls had lower live weight indicators in the bulls in both periods, compared with the calculations of adjusted weight in 210 and 365 days (Table 5).

Despite this, when assessing the rearing bulls of meat breeds by their productivity, namely live weight, all the bulls had a high breeding score for the periods of life. The difference between the achieved indicators (Table 6) and the adjusted live weight of rearing bulls aged 210 and 365 days is explained by the fact that paratypic conditions had not been created on the farm for a more complete manifestation of the genetic potential of meat productivity of animals. However, it should be noted that the best indicators were noted in the cultivation of Kalmyk bull calves, which already at the age of 12 months, although assigned to the 1st class, differed very slightly from the requirements of the elite class. The lifetime definition of meat qualities makes it possible only to pre-evaluate animals by meat productivity. The final judgment on the quantity and quality of meat is given by post-slaughter accounting and evaluation of the meat merits of animals. Table 6 presents data on the lifetime assessment of the meat qualities of bulls of different groups. Purebred Kalmyk bulls positively differed in meat qualities. Despite the average indicators among the animals of the studied groups for the evaluation of meat qualities in points, they had higher indicators for the loin eye area-50.1 cm^2, which is 1.8 cm^2, or 3.7%, higher than that of similar groups, marbling-7.9 points, which is 1.33 points higher than in the group of Angus and Kalmyk bulls and 1.61 points higher than in Kazakh white-headed bulls and lower feed costs per 1 kg of live weight gain-1.1 and 3.4, respectively. They significantly surpassed their peers, the Kazakh white-headed and Aberdeen-Angus breeds (at $p<0.001$) in terms of the thickness of subcutaneous fat and meat marbling. The young animals of this group had lower feed costs per 1 kg of growth, by 1.1 feed units, or 14%, compared with the peers from the KWH × K group and by 3.4 feed units, or 44%, compared with the AxK group.

Table 1: Degree and score of meat marbling

Degree of meat marbling	Marbling	Rating, score
Highest	Abundant	10.0-0.0
Highest	Moderately abundant	9.0-9.9
Highest	Slightly abundant	8.0-8.9
Choice	Moderate	7.0-7.9
Choice	Limited	6.0-6.9
Choice	Small	5.0-5.9
Selection	Light	4.0-4.9
Standard	Insignificant	3.0-3.9
Standard	Practically absent	2.0-2.9

Table 2: Chemical composition (%) and nutritional value of the diet

Indicator	DM	Crude ash	Crude protein	Crude fat	Crude fiber	Nitrogen-Free Extracts (NFE)	Content per kg DM of feed: Net energy, Feed units	Content per kg DM of feed: Net energy, MJ	Content per kg DM of feed: Crude protein [g]
Maize silage	19.4	4.3	2.0	1.25	7.9	10.8	0.16	0.94	18.3
Grass	82.5	6.1	10.5	1.58	25.9	36.1	0.42	3.48	104.3
Barley straw	87.6	7.0	3.9	0.48	38.8	48.0	0.34	2.01	44.6
Wheat grain	87.0	5.7	11.8	2.76	6.0	62.3	1.06	5.43	155.6
Barley grain	86.8	5.6	11.0	2.78	6.6	71.4	1.02	5.84	156.7

Explanatory notes: DM: Dry Matter

Table 3: Nutrient intake per kg of live weight of experimental bulls

Specification	Breed (x ± Sd) K	AxK	KWHxK
Oats feed units per kg of gain	7.59^{a}±0.41	8.21^{b}±0.87	8.12^{b}±0.76
Energy intake (MJ) per kg of gain	44.900±4.67	46.100±3.82	47.400±2.31
Crude protein intake (g) per kg of gain	1017.000±128	1024.000±126	1042.000±114
Dry matter intake (kg) per kg of gain	8.920±1.74	9.130±1.15	9.380±1.63

Explanatory notes: A and b are statistically significant differences at p≤0.05. K: Kalmyk breed; AxK: Angus x Kalmyk breed; KWHxK: Kazakh white-headed x Kalmyk breed

Table 4: Live weight of experimental bulls

Specification	Breed (x ± Sd) K	AxK	KWHxK
Bodyweight at 6 months of age [kg]	179.9±3.4	177.5±2.8	175.10±1.1
Bodyweight at 12 months of age [kg]	314.9^{a}±9.6	298.1±9.8	285.4^{b}±2.5
Total body weight gain from 6 to 12 months of age [kg]	135.0^{a}±8.0	120.6±6.0	110.3^{b}±4.4
Total daily gains from 6 to 12 months of age [g]	750^{A}±30	670^{a}±32	613^{Bb}±36.0
Height at withers [cm]	116.4±0.4	112.3±0.4	114.1±00.3
Trunk length [cm]	145.7^{a}±0.6	141.5^{b}±0.9	142.1^{b}±0.6
Spiral thigh circumference [cm]	165.7^{a}±0.7	168.8±0.7	159.3^{b}±0.6

Explanatory notes as in Table 3. a and b are statistically significant differences at p≤0.05

Table 5: Adjusted live weight, kg

Age period, day	Groups (x ± Sd) K	AxK	KWHxK
210	197.1^{a}±2.2	193.4^{b}±1.2	188.2±2.5
365	309.9^{a}±3.8	298.1±1.9	285.4^{b}±4.3

Explanatory notes as in Table 3. a and b are statistically significant differences at p≤0.05

Table 6: Lifetime assessment of meat qualities of bulls

Indicators	Groups K x ± Sd	K Cv	AxK x ± Sd	AxK Cv	KWHxK x ± Sd	KWHxK Cv
The thickness of subcutaneous fat, mm	3.34^{b}±0.01	1.13	2.51^{a}±0.01	3.97	2.50^{a}±0.01	3.40
The area of the loin eye, cm^2	50.1^{a}±1.23	12.07	48.3±00.74	9.97	48.3^{b}±00.78	15.68
Marbling, class	AA	-	A	-	A	-
Marbling, score	7.9	-	6,57.0	-	6.29	-
Meat qualities, score	50.0±0.64	6.27	49.0^{b}±0.82	10.95	52.4±0.23	4.43
Feed costs per 1 kg of gain	7.7±0.15	9.79	8.8±0.34	25.39	11.1±0.10	17.33

Discussion

The productivity of animals is completely dependent on the state of the farm's food supply, that is, on the ability to provide animals with feed, taking into account their productivity and age.

Feed plays a crucial role not only as the main source of animal productivity but also largely characterizes the production efficiency of the industry since more than 50% of the costs fall on feeding.

According to the main indicators of feed, wheat grain and barley grain are the most nutritious kinds of feed (Table 2). The use of maize silage in feeding beef cattle is a positive aspect to increase weight gain, which is also proved by studies by other authors.

Keady *et al*. (2007) showed that replacing grass silage with maize silage contributed to a higher average daily increase in the number of beef cattle and that feeding cattle with maize silage was more effective than feeding them with grass silage. In the work of Młynek and Guliński (2007), fast-growing black-and-white bulls fed hay supplemented with maize silage, received on average only 905 g of feed per day, which indicates that intensive feeding with maize silage significantly increases the daily increase. According to Litwińczuk *et al*. (2013), a wider range of feed, i.e., hay in addition to maize silage, could contribute to the higher efficiency of nutrient absorption and, as a consequence, a higher daily weight gain rate in young bulls. Dijkstra *et al*. (1996) observed a correlation between higher nutrient utilization efficiency and higher daily body weight gains in cattle.

The most rational feeding can be organized only based on scientifically based norms. Feeding standards are developed after studying the nutritional needs of farm animals. It has been established that cattle need 80 nutrients and biologically active substances. These include proteins, essential amino acids, fiber, starch, fat, minerals, trace elements and vitamins. It is very difficult to control the intake of all nutrients into the body of animals with feed and it is almost impractical. Therefore, when feeding, one usually takes into account only some of the most important nutrition indicators.

The needs of cattle in the following substances are necessarily taken into account: DM, digestible protein, calcium, phosphorus and carotene.

The consumption of nutrients per kg of live weight of experimental calves, presented in Table 3, shows that purebred calves of the Kalmyk breed were characterized by the most effective feed consumption. Energy consumption (MJ) per kg of weight gain compared to analogs was 44.9%, which is 1.2 and 2.5% lower than bulls obtained from crossbreeds of Angus and Kazakh white-headed breeds.

The need for nutrition in feed units has been calculated. The feed unit adopted for assessing the nutritional value of feed and determining the total needs of animals is equal in total nutritional value to 1 kg of oats. The need for feed units is the main quantitative indicator of the feed rate, which was 7.59% in purebred bulls against 8.21 and 8.12%, respectively, in crossbreeds of the Angus and Kazakh white-headed breed.

Indicators of growth and development of young animals are important in cultivation and characterize the efficiency of production as a whole. The live weight of the studied bulls was within the normal range, providing average daily gains of at least 610-750 g. The purebred Kalmyk bulls were distinguished by the highest growth intensity, with the excess over the live weight of their peers in 12 months equaling 16-29 kg.

Litwińczuk *et al*. (2012) demonstrated that the live weight of bulls was influenced by both the breed of cattle and the intensity of feeding. The cited authors did not note any disproportion in hip circumference relative to the length of the trunk and height at the withers, which was observed in our studies. Thus, the evaluation of the studied groups by live weight indicates the patterns of growth and development of bulls. Purebred Kalmyk bulls had the best growth indicators.

When assessing the rearing bulls of meat breeds by their productivity, namely live weight, all bulls had a class not lower than the breed standard. The difference between the achieved indicators and the adjusted live weight of rearing bulls aged 210 and 365 days was insignificant and is explained by unfavorable conditions during the specified period for a more complete manifestation of the genetic potential of meat productivity of animals. However, it should be noted that the best indicators were noted when growing Kalmyk bulls compared to other breeds by 12-24 kg, or 3.9-8.1%, respectively.

In the practice of animal husbandry, the lifetime evaluation of animals by meat qualities is of greater importance. New methods of carcass evaluation include an optical probe that measures the depth of fat and the depth of the loin, which can then be used to estimate the percentage of lean meat. Newer systems measure the lean content of meat in the carcass.

Due to the growing need for the qualitative value of carcasses and the possibility of improving the consistency of evaluation, instrumental methods of carcass evaluation, including ultrasound, X-ray computed tomography, nuclear Magnetic Resonance Imaging (MRI), general body conductivity and Video Image Analysis (VIA) are becoming increasingly important in the meat industry (Ojha *et al*., 2016).

L. Aass and other authors believe that to study the accuracy of Ultrasound Semitendinosus Maximal Fat (USMF) prediction, prediction models based on 325 purebred and crossbred dual-purpose bulls originating from the I commercial herds (n No 180) and II performance testing station (n No 145) were developed. The bulls were scanned using a pie 200 SLC scanner.

The results indicate that ultrasound has the potential to predict the meat productivity of livestock, although the importance of the indirect selection of breeding cattle for meat quality needs to be further evaluated (Aass *et al*., 2006).

When assessing the meat qualities of the studied groups, we used similar instrumental methods for determining the thickness of subcutaneous fat and the loin eye area and meat marbling using an EXAGO ultrasonograph. Bulls of the purebred Kalmyk breed significantly surpassed their peers, the Kazakh white-headed and Aberdeen-Angus breeds (at $p<0.001$) in terms of the thickness of subcutaneous fat and meat marbling. The young animals of this group had lower feed costs per 1 kg, an increase of 14% compared to their KBG x K peers and 44% compared to the AxK group.

Rezagholivand *et al*. (2021) argue that cross-breeding can be a winning strategy to improve beef production and profitability. In our study, a comparative assessment of animals obtained as a result of crossing different breeds was carried out.

The results of our study will be useful to future researchers from various countries involved in the evaluation of rearing bulls of various breeds.

Conclusion

A lifetime assessment of meat productivity makes it possible to identify animals with excellent meat qualities and improve the breeding value of herds of beef cattle, which will invariably lead to an increase in beef production in Kazakhstan. Lifetime evaluation of the rearing of young meat breeds by their productivity allows for quickly increasing the number of breeding stock. The animals of all the studied breeds of beef cattle in terms of growth and lifetime assessment of meat qualities met the requirements of the breed standard. However, they did not fully show their genetic potential for productivity, since the necessary conditions for feeding and maintenance of rearing young meat breeds of cattle had not been created.

Acknowledgment

The study was conducted in 2020-2021 as part of the scientific project with the individual registration number (IRN) AP08956453 on the topic "Development of a program to improve the Kalmyk breed in the conditions of the Kostanay region".

Author's Contributions

All authors equally contributed in this study.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues are involved.

References

Aass, L., Gresham, J. D., & Klemetsdal, G. (2006). Prediction of intramuscular fat by ultrasound in lean cattle. *Livestock Science*, *101*(1-3), 228-241. https://doi.org/10.1016/j.livprodsci.2005.11.014

Aitzhanova, I., Naimanov, D. K., Miciński, B., Dzik, S., & Miciński, J. (2017). Fattening performance of bulls of three breeds fattened semi-intensively in the Kostanay Region. *OnLine Journal of Biological Sciences*, *17*(3), 157-165. https://doi.org/10.3844/ojbsci.2017.157.165

Amerkhanov, Kh. A., Polovinko, L. M., Kalashnikov, N. A., & Kayumov, F. G. (2016). Kharakteristika geneticheskogo materiala pri vyvedenii vysokoproduktivnogo tipa "Voznesenovskii" kalmytskoi porody skota [Characterization of the genetic material in the breeding of the Voznesenovsky highly productive type of the Kalmyk cattle breed]. Vestnik myasnogo skotovodstva, 4 (96), 15-21. https://www.elibrary.ru/item.asp?id=27713677

Bonny, S. P. F., Hocquette, J. F., Pethick, D. W., Farmer, L. J., Legrand, I., Wierzbicki, J., ... & Gardner, G. E. (2016). The variation in the eating quality of beef from different sexes and breed classes cannot be completely explained by carcass measurements. *Animal*, *10*(6), 987-995. http://dx.doi.org/10.1017/S175173111500292X

Coleman, L. W., Hickson, R. E., Schreurs, N. M., Martin, N. P., Kenyon, P. R., Lopez-Villalobos, N., & Morris, S. T. (2016). Carcass characteristics and meat quality of Hereford sired steers born to beef-cross-dairy and Angus breeding cows. *Meat science*, *121*, 403-408. https://doi.org/10.1016/j.meatsci.2016.07.011

Dijkstra, J., France, J., Neal, H. S. C., Assis, A. G., Aroeira, L. J. M., & Campos, O. F. (1996). Simulation of digestion in cattle fed sugarcane: Model development. *The Journal of Agricultural Science*, *127*(2), 231-246. https://doi.org/10.1017/S0021859600078011

Drennan, M. J., McGee, M., & Keane, M. G. (2008). The value of muscular and skeletal scores in the live animal and carcass classification scores as indicators of carcass composition in cattle. *Animal*, *2*(5), 752-760. http://dx.doi.org/10.1017/S1751731108001754

FAO. (201)5. The second report on the state of the world's animal genetic resources for food and agriculture, Scherf, B.D. and D. Pilling, (Eds.), FAO Commission on Genetic Resources for Food and Agriculture Assessments, Rome. https://www.fao.org/documents/card/ru/c/fea3da3d-d6ed-4a27-8f58-2d83222b29d9/

Gonçalves, D. N., de Moares Weber, V. A., Pistori, J. G. B., da Costa Gomes, R., de Araujo, A. V., Pereira, M. F., ... & Pistori, H. (2020). Carcass image segmentation using CNN-based methods. *Information Processing in Agriculture*. https://doi.org/10.1016/j.inpa.2020.11.004

Indurain, G., Beriain, M. J., Sarries, M. V., & Insausti, K. (2010). Effect of weight at slaughter and breed on beef intramuscular lipid classes and fatty acid profile. *Animal*, *4*(10), 1771-1780. http://dx.doi.org/10.1017/S1751731110000923

Kalashnikov, A. P., Fisinin, I. V., Shcheglov, V. V., Pervov, & N. G., Kleimenov. (2003). Norms and rations of feeding farm animals. Izdatel'stvo "Znaniye", Moscow. ISBN: 5945870935, pp: 456. https://38308.selcdn.ru/meta2017/storage13oc/1488/normy_kormleniya_i_raciony_kalashnikov_-2003.pdf

Kayumov, F. G., Kadysheva, M. D., & Tyulebaev, S. D. (2007). Kachestvo govyadiny simmentalskogo myasnogo tipa [Quality of the Simmental meat type beef]. Molochnoe i myasnoe skotovodstvo, 6, 19-22. https://www.elibrary.ru/item.asp?id=9547285

Kayumov, F. G., Sidikhov, T. M., & Khainatskii, V. Yu. (2012). Vliyanie porody na myasnye kachestva bychkov v sukhostepnoi zone Zapadnogo Kazakhstana [Influence of the breed on the meat quality of bulls in the dry steppe zone of Western Kazakhstan]. Dostizheniya nauki i tekhniki APK, 8: 81-82. http://agroapk.ru/files/2012/082012en.rtf

Keady, T. W. J., Lively, F. O., Kilpatrick, D. J., & Moss, B. W. (2007). Effects of replacing grass silage with either maize or whole-crop wheat silages on the performance and meat quality of beef cattle offered two levels of concentrates. *Animal*, *1*(4), 613-623. https://doi.org/10.1017/s1751731107685024

Litwińczuk, Z., Chabuz, W., Domaradzki, P., & Jankowski, P. (2012). Slaughter value of young Polish Black-and-White, White-Backed, Polish Holstein-Friesian and Limousin bulls under semi-intensive fattening. *Annals of Animal Science*, 12(2), 159. http://dx.doi.org/10.2478/v10220-012-0013-7

Litwińczuk, Z., Żółkiewski, P., Chabuz, W., & Florek, M. (2013). Daily weight gain and slaughter value of young bulls fattened on fodders from permanent grassland and maize silage, taking into account the nutritional value of the fodder. http://rn.ptz.icm.edu.pl/wp-content/uploads/2013/01/Litwin%CC%81czuk-ang.pdf

Lozowicka, B., Iwaniuk, P., Konecki, R., Kaczynski, P., Kuldybayev, N., & Dutbayev, Y. (2022). Impact of Diversified Chemical and Biostimulator Protection on Yield, Health Status, Mycotoxin Level and Economic Profitability in Spring Wheat (*Triticum aestivum L.*) Cultivation. *Agronomy*, *12*(2), 258. https://doi.org/10.3390/agronomy12020258

Makarcev, N.G., 2012. Feeding farm animals. Noosfera, Kaluga. ISBN 9785905856013, pp, 641.

Malheiros, J. M., Enríquez-Valencia, C. E., da Silva Duran, B. O., de Paula, T. G., Curi, R. A., de Vasconcelos Silva, J. A. I., ... & Chardulo, L. A. L. (2018). Association of CAST2, HSP90AA1, DNAJA1 and HSPB1 genes with meat tenderness in Nellore cattle. *Meat Science*, *138*, 49-52. https://doi.org/10.1016/j.meatsci.2018.01.003

McPhee, M. J., Walmsley, B. J., Dougherty, H. C., McKiernan, W. A., & Oddy, V. H. (2020). Live animal predictions of carcass components and marble score in beef cattle: Model development and evaluation. *Animal*, *14*(S2), s396-s405. http://dx.doi.org/10.1017/S1751731120000324

Mei, C., Gui, L., Hong, J., Raza, S. H. A., Aorigele, C., Tian, W., ... & Zan, L. (2021). Insights into adaption and growth evolution: A comparative genomics study on two distinct cattle breeds from Northern and Southern China. *Molecular Therapy-Nucleic Acids*, *23*, 959-967. http://dx.doi.org/10.1016/j.omtn.2020.12.028

Młynek, K., & Guliński, P. (2007). The effect of growth rate and age at slaughter on dressing percentage and colour, pH48 and microstructure of longissimus dorsi muscle in Black-and-White (BW) bulls vs commercial crossbreds of BW with beef breeds. *Animal Science Papers and Reports*, *25*(2), 65-71.

Moore, K. L., Mrode, R., & Coffey, M. P. (2017). Genetic parameters of Visual Image Analysis primal cut carcass traits of commercial prime beef slaughter animals. *Animal*, *11*(10), 1653-1659. http://dx.doi.org/10.1017/S1751731117000489

Ojha, K. S., Tiwari, B. K., Kerry, J. P., & Troy, D. (2016). Beef. In: Encyclopedia of food and health, Caballero, B., P.M. Finglas and F. Toldrá, (Eds.), Academic Press, pp, 332-338. https://doi.org/10.1016/B978-0-12-384947-2.00056-8

Okunev, A. M. (2020). Kharakteristika epizooticheskogo protsessa pri virusnoi diaree krupnogo rogatogo skota v Severo-Kazakhstanskoi oblasti [Characteristics of the epizootic process in viral diarrhea of cattle in the North Kazakhstan region]. Vestnik Altaiskogo gosudarstvennogo agrarnogo universiteta, 1 (183), 103-111. http://vestnik.asau.ru/index.php/vestnik/article/view/550

Pegolo, S., Cecchinato, A., Savoia, S., Di Stasio, L., Pauciullo, A., Brugiapaglia, A., ... & Albera, A. (2020). Genome-wide association and pathway analysis of carcass and meat quality traits in Piemontese young bulls. *Animal*, *14*(2), 243-252. http://dx.doi.org/10.1017/S1751731119001812

Pulina, G., Acciaro, M., Atzori, A. S., Battacone, G., Crovetto, G. M., Mele, M., ... & Rassu, S. P. G. (2021). Animal board invited review–Beef for future: Technologies for a sustainable and profitable beef industry. *Animal*, *15*(11), 100358. https://doi.org/10.1016/j.animal.2021.100358

Rezagholivand, A., Nikkhah, A., Khabbazan, M. H., Mokhtarzadeh, S., Dehghan, M., Mokhtabad, Y., ... & Rajaee, A. (2021). Feedlot performance, carcass characteristics and economic profits in four Holstein-beef crosses compared with pure-bred Holstein cattle. *Livestock Science*, *244*, 104358. https://doi.org/10.1016/j.livsci.2020.104358

Saginbayev, A. K., Bisembaev, A. T., Gumerov, B. M., & Seytmuratov, A. E. (2017). Rukovodstvo po sovershenstvovaniyu klassicheskoy metodiki ispytaniya bychkov myasnykh porod po sobstvennoy produktivnosti skorrektirovannoy massoy [Guidelines for improving the classical method of testing beef bulls for their own productivity with corrected weight]. Astana.

Statsoft, I. N. C. (2004). STATISTICA (data analysis software system). *Version*, *7*, 1984-2004.