

Genetic potential of Kazakh White-headed and Hereford breeds for beef production in Purebred farms and crossbreeding

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Abstract. *Ibrayeva R, Nurgazy K, Satiyeva K, Gabit G, Mukhametzhanova O. 2025. Genetic potential of Kazakh White-headed and Hereford breeds for beef production in Purebred farms and crossbreeding. Biodiversitas 26: 761-769.* Kazakhstan is experiencing essential growth in the livestock sector, with the production of environmentally friendly products serving as a key competitive advantage for the nation. Our study analyzed the meat productivity indices of the Kazakh White-headed and Hereford breeds, along with their hybrids. The investigation focused on assessing the meat quality of Kazakh White-headed and Hereford bulls in different genotype combinations by comparing key meat productivity indices. The meat from the controlled slaughter of test bulls complied with Category I requirements. Carcass weights of Hereford bulls surpassed those of the Kazakh White-headed breed by 42.9 kg (18.1%, $P < 0.05$) and exceeded those of crossbreed bulls by 9.0 kg (3.3%, $P < 0.05$). The Kazakh White-headed breed demonstrated a higher yield of internal fat: internal fat yield varied on average from 2.5% to 3.2% (15 month aged bulls) that depended on the breed: Kazakh White-headed -3.2%, Hereford -2.5%, and crossed bulls - of 2.7%. However, in terms of flesh content, Kazakh White-headed bulls were 43.2 kg (22.5%, $P < 0.05$) lighter than Hereford bulls, and crossbreed bulls were 8.1 kg (3.6%, $P < 0.05$) lighter. In analyzing flesh yield, Kazakh White-headed bulls fell short by 2.4 kg (2.9%) compared to Hereford bulls, which were marginally lower by 0.1 kg (0.1%) compared to crossbreed bulls of the same age. The protein-fat ratio was determined to be 1:0.65 in Kazakh White-headed bulls and 1:0.64 in both Hereford and crossbreed bulls. Profitability was 22% for the Kazakh White-headed breed, 43% for the Hereford breed, and 39% for the crosses of the White-headed and Hereford breeds.

Keywords: Bulls, carcass, genotype, live mass, profitability

INTRODUCTION

Despite a recent decline in the overall profitability of livestock production in Kazakhstan, the profitability of cattle (*Bos taurus* Linnaeus, 1758) breeding has shown an increase from 3.6% to 10.1% (President of the Republic of Kazakhstan official site 2012). For livestock industries reliant on beef exports, attaining and maintaining the highest possible beef quality is imperative for sustaining and expanding their share in the global market (Pardo et al. 2020). Unfortunately, in recent years, a declining trend in production indicators within meat and milk cattle breeding has emerged as a concerning "norm" (Muratbayev et al. 2023). This trend adversely affects profitability and the availability of products in the food market. As traditional Kazakh food staples, meat and meat products play a pivotal role in the nation's protein intake. Therefore, any reduction in their consumption adversely impacts public health. To address this, long-term government initiatives are required to ensure the domestic market is adequately supplied with meat, particularly beef (Sukhanova et al. 2018).

Currently, Kazakhstan's agro-industrial complex is tasked with the rapid development and intensification of animal husbandry, underscoring the need to enhance the efficiency of raw meat processing (Kazakhstan President's Official site 2012). Efficient processing not only boosts product profitability and the meat industry's earnings but also

increases the availability of high-quality food products for all consumers (Gridneva et al. 2020). These tasks make necessary: 1) enhancing animal productivity by improving feeding and housing conditions; 2) augmenting the quality of meat products by elevating cattle's genetic potential, either through enhancing existing breeds or developing new breed groups with a meat production focus (Dolgova and Fomkina 2017; Khayatzadeh et al. 2019; Honig et al. 2020).

A promising region for meat breeding development is South Kazakhstan, with its expansive pasturelands and availability of grain production waste for breeding (Makhanbetova et al. 2023). However, this area, particularly the Kazakh Southern Balkhash region, comprises desert and semi-desert regions (Kaldybayev et al. 2019) characterized by sandy deserts belonging to the middle (present) subzonal variant of the deserts of Central Asia (Bragina et al. 2018). Therefore, the breeds selected for this region must be distinguished by their endurance, high adaptive plasticity, and good reproductive qualities (Muratbayev et al. 2023). Cattle breeds introduced in the national breeding program must efficiently convert feed into growth, ensuring effective pasture use in the conditions of a sharply continental climate. By adhering to these conditions, agrarians can achieve a large meat yield (Dolgova and Fomkina 2017; Bragina et al. 2018). Breed differences are pronounced and must be considered in the genetic evaluations of both animal and carcass traits (Pritchard et al. 2021). This fact

must be studied for each region with its specific climate conditions separately.

The Kazakh President, in his address “Let’s Build the Future Together!” (28 January 2011), set forth ambitious goals: achieving beef exports of 60,000 tons by 2016 and 180,000 tons by 2020. To boost beef production, leveraging the reserves of industrial crossbreeding and harnessing the heterosis effect—the beneficial deviation of crossbreed progeny from the mean of parental lines for specific traits—is essential (Khayat-zadeh et al. 2019; Clariget et al. 2021).

In this context, our research aimed to analyze the current state of Kazakh beef cattle, focusing on the rise in cattle numbers and identifying key challenges in Kazakh beef breeding.

MATERIALS AND METHODS

Study area

Research and production studies were conducted in the southeastern part of the Republic of Kazakhstan, in the Almaty region. All stages of the conducted research were acted adhering to Helsinki principles that was approved by the Ethical Committee of the Kazakh National Agrarian University (protocol no. 5, 22 August 2016).

The study has been focused on two cattle breeds: Hereford and Kazakh White-headed. The subjects of the study included the progeny of purebred Kazakh White-headed, Hereford breeds, and their F1 crossbreeds (σ Hereford \times ♀ Kazakh White-headed) (Figure 1).

Hereford and Kazakh White-headed cattle were selected for their endurance, high adaptive plasticity, and robust reproductive qualities in a sharply continental climate. These cattle breeds are renowned for their efficient utilization of excellent feed conversion, and substantial meat yield (Abugaliyev et al. 2019). The animals for this study were randomly selected at the age of 15 months from the agricultural enterprise ‘Dinara-Ranch’. The study was conducted according to the VIZH and VNIIMP methodology, with $n = 3$ for the studied group in the experiment.

Additionally, the study incorporated Limousin, Simmental, and Hungarian Grey (a local Hungarian breed) cattle as part of an individual Ph.D. project (No. 119D from 19.09.2018). Data collection for these breeds occurred from 13.10.2018 to 28.10.2018 during a foreign internship in Hungary at Debrecen University’s Faculty of Agriculture, Food Science, and Environmental Management, and at the JMK Ltd farm in Hajdúszoboszló, Hungary (Figure 2). It has excellent meat qualities, with the end product yielding a high carcass slaughter rate, fecundity of 98%, and a carcass yield of 60-62%.



Figure 1. A. Hereford; B. Kazakh white-headed cattle at the Dinara-Ranch enterprise, South Kazakhstan



Figure 2. Hungary cattle breeds at the JMK Ltd farm. A. Simmental cattle, cow No. 5468; B. Hungary grey cattle, bull No. 32456; C. Limousin cattle, cow No. 1596 and 2 month-old calf No. 9913

The objectives of the experiments were multifaceted: (i) To investigate the morphological and chemical composition of the carcasses of the experimental bulls, (ii) To evaluate the meat quality derived from bulls of various genotypes, (iii) To determine the feed cost in fodder units per 1 kg of live weight gain over defined periods: a 6-month suckling period, 5 months of stall feeding (from November to March), and a 4-month pasture period (from April to July), totaling 15 months, (iv) To calculate the cost per centner of live weight gain in dollars, considering expenses for feed, wages, electricity, and water, (v) To ascertain the level of profitability in percentage terms (%), as defined by equation (1):

$$\text{Profitability} = \frac{\text{Profit}}{\text{Total Cost}} \times 100\% \quad (1)$$

Where 'Profit' represents the total income from the bulls' meat productivity realization, with the selling price based on live weight, carcass weight, and fatness category; 'Total Cost' encompasses feed, wages, electricity, and water costs for bull growth.

The economic efficiency of the bulls' growth was calculated by considering the costs of feed, wages, electricity, and water. The calculation of economic efficiency was conducted for bulls raised over a 15-month period: the suckling period lasted for 6 months; the stall period (November-March) for 5 months; and the grazing period (April-July) for 4 months.

Considered indicators included pre-slaughter live weight, carcass weight, carcass yield, raw fat weight, slaughter weight, and slaughter yield. Ethical standards for animal treatment were strictly adhered to during these procedures. The animals were deprived of food 8 hours prior to slaughter (with free access to water) and were deprived of water three hours before the process.

The morphological composition of individual natural anatomical parts and the carcass as a whole was determined by deboning the right half-carcass, which was pre-cooled for 8 hours at 0 to +4°C. Deboning was conducted according to the 5 main natural anatomical parts: neck, shoulder and shoulder blades, spine ribs, lumbar, and hips. This process enabled the determination of the absolute and relative content of bones, cartilage, tendons, and flesh (including muscle tissue and subcutaneous fat), as well as the meatiness index (flesh yield per kg of bone) in the carcass and in individual parts. For sausage classification, the flesh was categorized into three grades: premium, first, and second (according to GOST 31797-2012 - 'Meat. Cutting beef into cuts'): (i) Premium grade. Muscle tissue without bright visible connections and any fat manifestations; it is allowed up to 3% of fatty and connective tissues. It is obtained from the hip, back, shoulder and lumbar parts of the carcass; (ii) The first grade. Muscle tissue with a small proportion of fat and connective tissue; it is allowed up to 6%. First grade meat can be obtained from all parts of the carcass; (iii) The second grade. Muscles contain a mass fraction of fat and connective tissue which does not exceed 20% of the total mass. It can be obtained from the breast, neck parts, shank,

knuckle, flank, and other parts of the carcass (Rastorgueva and Prusakova 2019).

Degustation test for studied meat samples

To check the test proprieties of the meat samples in the study we have prepared broth samples separately for each breed according to the GOST 20730-75. In this case, follow conditions were kipping: (i) Technical conditions. The broths were made from meat water according to GOST 20729-75 with the addition of 1% peptone and 0.5% sodium chloride in dilutions of 1:1, 1:2, and 1:4; (ii) Quality indicators. The broth should be a transparent yellow liquid with a specific smell of fresh meat extract and peptone without mechanical impurities, mold, flakes, and sediment;

Meat water preparation method: (i) Chilled beef is freed from bones, tendons, fat, and chopped; (ii) 1 kg of the resulting minced meat is poured with two or four times the amount of drinking water (by weight); (iii) Heat slowly to boiling and boil for 1.5 h, stirring constantly and removing scale; (iv) After boiling, cool the meat with water and take off fat; (v) Filter the liquid through cotton wool, then through filter paper until completely transparent; (vi) Measure the filtrate and top up to the original volume with boiled drinking water, then pour into bottles and sterilize.

Tasting of broth was carried out according to the GOST 9959-2015 follows: (i) Preparation of broth: pour it into glass cups in an amount of at least 50 mL; (ii) Determination of broth indicators: appearance and color, smell (aroma), taste, and richness (saturation with nitrogenous extractive substances); (iii) Assessment according to a 5-point system was used. For the recording of the results, each taster wrote his assessments and comments on the tasting sheet. The tasting results were recorded in a protocol. For tasting the boiled meat GOST 9959-2015 methodology was used.

Heat treatment

Meat weighing about 1 kg is placed in a saucepan with cold water (water to meat ratio 3:1), covered with a lid, brought to a boil, and cooked over low heat for 1-1.5 hours until the temperature in the center of the piece is (75±5)°C. 30 minutes before the end of cooking, add table salt in an amount of 1% of the meat weight.

Preparation for tasting

After cooking, the meat is removed from the broth, cooled to 35±5°C, cut into slices weighing at least 50 g, and sent for tasting. After conducting an organoleptic assessment of 7-8 samples, take a break for at least 10 min.

Meat assessment

The meat was assessed according to follow parameters: appearance, smell (aroma), taste, consistency (rigidity, tenderness), and juiciness. The assessment was conducted by a point system and a descriptive method (for compliance with quality indicators requirements of regulatory documentation). The tasting was conducted by specialists - tasters with great experience in assessing the quality of meat products.

Data analysis

Comprehensive carcass evaluation included measuring and calculating indices of fullness and thigh completion in the animal or carcass. For all indices, the P-value indicating the level of reliability was calculated. The reliability criterion depended on the number of observations in the sample and was determined using the Student's t-table. All obtained from the experiment data have been biometric processed: the reliability coefficient was calculated, the number of degrees of freedom was determined, and the calculated t value was compared with the critical value. A P-value lower than 0.05 signified reliable data.

RESULTS AND DISCUSSION

Study of the beef yield and meat quality

In the comprehensive evaluation, the fatness of bulls across different genotypes was evaluated according to the GOST 779-55 and were classified in the first category. The controlled slaughter revealed notably high slaughter qualities in bulls of various genotypes. In terms of pre-slaughter live weight, Hereford bulls surpassed the Kazakh White-headed breed and crossbred bulls of the same age by 44.1 kg ($P<0.05$) and 9.4 kg ($P<0.05$), respectively.

Carcass weight comparisons showed that Hereford bulls exceeded Kazakh White-headed breed bulls by 42.9 kg or 18.1% ($P<0.05$). The Kazakh White-headed breed, in turn, was 33.9 kg or 14.4% ($P<0.05$) heavier than the crossbred bulls in carcass weight. Moreover, Hereford bulls were 9 kg or 3.3% ($P<0.05$) heavier in carcass weight compared to crossbred bulls. However, Kazakh White-headed bulls exhibited a lower carcass yield, being 3.9 kg or 6.9% ($P<0.05$) less than Hereford bulls and 3.2 kg or 5.6% less than crossbred bulls. The internal fat yield of Hereford breed bulls was 0.7 kg or 28% less compared to the Kazakh White-headed breed, and 0.5 kg or 18.5% less than that of crossbred bulls. Regarding slaughter weight and yield, Hereford breed bulls displayed considerable advantages (Table 1).

Crossbred bulls occupied an intermediate position in terms of slaughter quality, while bulls of the Kazakh

White-headed breed were inferior to those of the Hereford breed and crossbred bulls according to these metrics. Notably, a heterosis effect was observed in the crossbred bulls. The value of a carcass is significantly determined by the weight of its fleshy part. Hereford bulls were found to be 43.2 kg or 22.5% ($P<0.05$) fleshier than Kazakh White-headed breed bulls. Crossbred bulls surpassed the Kazakh White-headed bulls by 35.1 kg or 18.3% ($P<0.05$). In terms of flesh yield, Hereford bulls exceeded Kazakh White-headed breed bulls by 2.4 kg or 2.9%. Remarkably, crossbred bulls were marginally fleshier by 0.1 kg or 0.1% compared to the Hereford bulls. Bone yield was notably highest in Kazakh White-headed bulls, reaching 16.5%, compared to 14.3% and 14.2% in Hereford and crossbred bulls, respectively. This indicates that Hereford breed bulls and crossbreeds were 2.2% ($P<0.05$) behind the Kazakh White-headed breed and 2.3 kg ($P<0.95$) behind crossbred bulls in bone yield.

The intensity of muscle tissue growth in young bulls of different genotypes is evident in the yield of flesh per 100 kg of pre-slaughter live weight. This index was significantly higher in Hereford bulls, surpassing Kazakh White-headed bulls and crossbreeds by 5.0 kg or 10.9% ($P<0.05$) and 0.8 kg or 1.6%, respectively. A trend towards superior musculature was observed in young bulls of the different genotypes. Moreover, Hereford breed bulls were characterized by notably high meat index data. Their superiority over the crossbreeds in this metric was 0.11 kg or 2.23%, and over the Kazakh White-headed breed, it was 0.55 kg or 12.2%. The quality of meat composition is substantially influenced by the absolute and relative weights of the natural anatomical cuts of animal carcasses. Notably, the dorsal rib and nutritionally valuable cuts such as the lumbar and hip were significantly heavier in the Hereford breed bulls (Table 2).

In the analysis of specific weight cuts, the highest proportion of cervical cuts was observed in Hereford bulls (11.3%), while brachial and spinal-cervical cuts were predominant in crossbred bulls (19.2% and 27.3%, respectively). The relative weight of the most valuable natural anatomical cuts, such as lumbar and hip, was nearly identical in Hereford and crossbred bulls, resulting in a higher yield of top-grade meat across different genotypes.

Table 1. Morphological content of experimental bulls carcasses

Indicator	Genotype					
	KB*		HF†		F ₁ ‡	
	$\bar{X} \pm m_x$	C _v	$\bar{X} \pm m_x$	C _v	$\bar{X} \pm m_x$	C _v
Chilled carcass weight (kg)	234.30±0.55	0.2	277.80±0.91	0.3	268.10±0.31	0.1
Weight of flesh (kg)	191.50±0.64	0.3	234.70±0.52	0.2	226.60±0.38	0.1
Meat yield (%)	82.00±0.42	0.5	84.40±0.38	0.4	84.50±0.32	0.3
Bone weight (kg)	38.90±0.10	0.2	39.50±0.21	0.5	38.10±0.06	0.1
Bone yield (%)	16.50±0.06	0.3	14.30±0.10	0.6	14.20±0.15	1.0
Weight of tendons and cartilage (kg)	3.60±0.03	0.8	3.60±0.03	0.6	3.40±0.01	0.2
Tendon yield (%)	1.50±0.01	0.6	1.30±0.01	0.7	1.30±0.01	0.7
Meat yield per 100 kg of pre-slaughter weight (kg)	45.60±0.25	0.5	50.60±0.42	0.8	49.80±0.35	0.7
Meat index	4.92±0.03	0.5	5.94±0.05	0.8	5.94±0.03	0.4

Note: *: Kazakh white-headed breed; †: Hereford breed; ‡: A first-generation hybrid of crossbreeding between the Kazakh white-headed and Hereford breeds; C_v: variation coefficient

The varietal composition of the carcass showed a distinct advantage for Hereford bulls and their crossbreed counterparts (Table 3). Hereford steers yielded the most substantial amount of premium and first-grade meats. Their advantage over the Kazakh White-headed breed and crossbreeds in the premium-grade meat was 7.8 kg or 24.2% ($P<0.05$) and 3.7 kg or 10.2% ($P<0.05$), respectively. A similar advantage was noted in the first-grade meat quantity, at 16.2 kg or 17.3% ($P<0.05$) and 8.0 kg or 7.8% ($P<0.05$), respectively. In the premium-grade meat category, Hereford bulls exceeded their Kazakh White-headed breed counterparts by 1.7%, and in the first grade by 1.6%. The trend in the relative weight of the premium and first-grade meats remained consistent across different genotypes. While carcass weight, yield, and morphological composition provide valuable insights, they do not fully encapsulate meat product quality. Therefore, factors such as the chemical composition of the meat, indicative of its physiological maturity and energy value as a foodstuff, are crucial. The presence of nutrients in meat in an assimilable form is particularly valuable for human nutrition. The primary constituents of meat, proteins and fats, are considered in most research assessing the nutritional and energy value of meat, not only in absolute terms but also in their proportional content.

Our investigations revealed that the dry substance content was higher in crossbreed bulls, owing to their elevated fat content. These crossbreeds surpassed Kazakh White-headed and Hereford bulls in this respect by 0.6% and 1.1%, respectively. Regarding protein content in carcass flesh, Hereford bulls had 0.2% and 0.3% less protein than their Kazakh White-headed and crossbreed counterparts. This suggests a more intense protein deposition in the carcass meat of Kazakh White-headed and crossbreed bulls compared to Hereford bulls. A higher deposition of fat in

the carcass of crossbreed bulls indicates their earlier maturation. The protein-to-fat ratio in the flesh of the test animals was 1:0.65 in Kazakh White-headed bulls and 1:0.64 in Hereford and crossbreed animals.

Comparative analysis showed that the chemical composition of the longest back muscle closely mirrored the average meat sample in the carcass. The muscle tissue of crossbreed bulls, compared to their counterparts, had a higher fat content. Young cattle of the Kazakh White-headed and Hereford breeds had 0.4% and 0.6% less fat, respectively, than crossbreed bulls. The caloric value of 1 kg of meat across various genotypes ranged from 6762 to 7099 kJ. The protein quality index in bull breeds was higher than in analogs by 0.3-0.6, underscoring the high value of their meat (Table 4).

Table 2. Ratio of natural anatomical cuts in bovine carcasses of different body types

Cut	Genotype		
	KB*	HF†	F1‡
Absolute weight (kg)			
Cervical	18.2	26.5	24.3
Brachioradialis	36.2	44.7	43.5
Spinocervical	51.8	63.8	61.9
Lumbar	22.3	25.8	24.4
Hip	63.0	73.9	72.5
Carcass flesh	191.5	234.7	226.6
Relative weight, in % to carcass weight			
Cervical	9.5	11.3	10.7
Brachioradialis	19.0	19.0	19.2
Spinocervical	27.0	27.2	27.3
Lumbar	11.6	11.0	10.8
Hip	32.9	31.5	32

Note: *: Kazakh white-headed breed; †: Hereford breed; ‡: A first-generation hybrid of crossbreeding between the Kazakh white-headed and Hereford breeds

Table 3. Grade composition of the beef

Indicator	Genotype					
	KB*		HF†		F1‡	
	$\bar{X} \pm m_x$	C _v	$\bar{X} \pm m_x$	C _v	$\bar{X} \pm m_x$	C _v
Flesh yield (kg)	191.50±0.64	0.3	234.70±0.52	0.2	226.60±0.38	0.1
Premium grade (kg)	32.10±0.10	0.3	39.90±0.26	0.7	36.20±0.15	0.4
%	18.40		20.10		19.30	
First grade (kg)	93.50±0.15	0.1	109.70±0.15	0.1	101.70±0.40	0.4
%	53.60		55.20		54.20	
Second grade (kg)	48.90±0.15	0.3	49.10±0.06	0.1	49.70±0.65	1.3
%	28.00		24.70		26.50	

Note: *: Kazakh white-headed breed; †: Hereford breed; ‡: A first-generation hybrid of crossbreeding between the Kazakh white-headed and Hereford breeds; C_v: Variation coefficient

Table 4. Chemical composition of average minced meat sample, % ($\bar{X} \pm m_x$)

Indicator	Genotype					
	KB*		HF†		F1‡	
	$\bar{X} \pm m_x$	C _v	$\bar{X} \pm m_x$	C _v	$\bar{X} \pm m_x$	C _v
Moisture	72.20±0.60	0.8	72.70±0.15	0.2	71.60±0.59	0.8
Dry substance	27.80±0.60	2.1	27.30±0.15	0.5	28.40±0.50	2.0
Including: protein	16.50±0.35	2.1	16.40±0.25	1.5	16.70±0.21	1.2
Fat	10.40±0.25	2.4	10.00±0.23	2.3	10.80±0.45	4.1
Ash	0.90±0.02	1.6	0.90±0.02	1.6	0.90±0.02	1.6

Note: *: Kazakh white-headed breed; †: Hereford breed; ‡: A first-generation hybrid of crossbreeding between the Kazakh white-headed and Hereford breeds

In the first generation of crossbreeds, indicators such as weight of paired carcass, carcass yield, meat index, and protein quality indicator showed significant increases. The broth made from the meat of young animals of different genotypes was transparent, with a yellowish hue, pleasant aroma, and taste. The broth from Kazakh White-headed breed animals scored the premium (4.0 points). Broth from Hereford and crossbreed animals slightly trailed, scoring 0.10 (2.33%) and 0.20 points (4.88%) lower, respectively (Table 5). According to the results of the cooked meat tasting, all samples were noted for their absence of any unpleasant aftertaste. The meat from Hereford breed cattle was particularly lauded, scoring 4.22. This score was notably higher than that of the young Kazakh White-headed breed and crossbreed cattle, by 0.51 points (12.9%) and 0.22 points (5.21%), respectively.

In comparison, the cooked meat of the Kazakh White-headed breed was found to be less juicy and tender, leaving a larger residue after chewing than the meat from young Hereford cattle. While the meat of crossbreed animals surpassed that of their Kazakh White-headed counterparts, it did not quite reach the quality level of the Hereford breed. In evaluating the two dishes-broth and boiled meat-for their eating qualities, the highest overall score was awarded to the young Hereford breed at 8.32 (average score of 4.16). The lowest overall score was attributed to the Kazakh White-headed breed at 8.01 (average score of 4.00), aligning with data on the chemical composition of the meat and its technological properties.

The efficiency of the bulls growing

The results of the economic efficiency analysis revealed that, over the experiment period from birth to 15 months of age, the absolute gain in Hereford bulls was 39.9 kg, which was 6.1 kg higher compared to the Kazakh White-headed breed and their littermates. The average daily gain was greater by 62 g and 13 g, and the relative gain by 58% and 6%, respectively. Consequently, the cost of feed per 1 kg of live weight gain amounted to 12 currency units. For the analysis of the economic efficiency of the bulls' growth, the following parameters were calculated for the 15-month period needed to grow beef yield:

Feed requirements per animal (12 feed units).

Roughage: $10 \text{ kg} \times 0.40 = 4$ feed units ($10 \text{ kg} \times 150 \text{ days} = 1.5$ tons); Grass: $8 \text{ kg} \times 0.16 = 1.2$ units ($8 \text{ kg} \times 150 \text{ days} = 1.2$ tons); Compound feed: $7 \text{ kg} \times 0.98 = 6.8$ units ($7 \text{ kg} \times 150 \text{ days} = 1050 \text{ kg}$).

Total feed cost for 39 bulls. 58 tons of roughage = 580,000 tenge (10,000 tenge per ton); Grass feed = 235,000 tenge (47 tons \times 5,000 tenge); Compound feed = 1,640,000 tenge (41 tons \times 40,000 tenge).

Total feed cost for 39 heads. $580,000 + 235,000 + 1,640,000 = 2,455,000$ tenge.

Wage expenses. 100,000 tenge was paid as a worker's salary during the pasture period (so, for the 4-month pasture period = 400,000 tenge); 120,000 tenge was paid during the stall period (involving 2 persons), so for the 5-month stall period, the cost is $5 \times 240,000 = 1,200,000$ tenge. The wage of the veterinary specialist was 120,000 tenge \times 15 months = 1,800,000 tenge, and the wage of the

machine operator was 1,200,000 tenge for 15 months.

Total wage spending. $120,000 + 400,000 + 1,800,000 + 1,200,000 = 3,520,000$ tenge.

Electricity expenses (for room lighting). The length (L) of the room was 120 meters; M = 20; the room's area (S) = 1440 m²; the number of hours of lighting per month (F) = 300 hours; specific electricity consumption per 1 square meter of plot area (g) = 16 W/m²; the price of 1 kWh of electricity for legal entities = 16.22 tenge.

Total hours of lighting. $300 \times 15 \text{ months} = 45,000$ hours

$$1440 : 1000 = 1.4$$

$$1.4 \times 16 \text{ W/m}^2 = 22.4 \text{ kW/h}$$

$$45000 \times 22.4 = 1008000$$

And in the end, we have: $1008 \times 16.22 = 1,634,976$ tenge.

Water costs. The water consumption per head is 30 liters; 30 liters \times 39 heads = 1,170 liters \times 15 months = 526,500 liters; $526,500 / 1,000 = 526.5 \times 128 = 67,328$ tenge. So, the total spending for bull growth over 15 months is: $2,455,000 + 1,600,000 + 1,634,976 + 67,328 + 1,800,000 + 1,200,000 = 8,757,304$ tenge. However, the income from bull growth varies according to the different flesh yields. For Kazakh White-headed bulls, the income was 1,954,826 tenge with a profitability of P = 22%. For Hereford bulls, these figures were 4,257,892 tenge with profitability of 43%, and for crossbreed bulls, they were 13,668,160 tenge with profitability of 39%. Finally, we must analyze cost price and income. The cost-to-income ratio for Kazakh White-headed bulls was calculated at $8,757,304 : 9,738.3 = 899$; for Hereford bulls, it was $9,816,828 : 12,795.2 = 767$; and for crossbreed bulls, it was $9,816,828 : 12,425.6 = 790$. When converted to US dollars, the production costs amounted to \$20,690.22 for Kazakh White-headed bulls, \$23,193.48 for Hereford bulls, and \$23,193.48 for crossbreed bulls (Table 6).

Table 5. Results of the tasting assessment

Genotype	Broth		Boiled meat		Total Average point	Average point
	Total point	Average point	Total point	Average point		
KB*	17.40	4.30	15.30	3.71	8.01	4.00
HF†	16.60	4.10	16.90	4.22	8.32	4.16
F1‡	17.00	4.20	16.00	4.00	8.20	4.10

Note: *: Kazakh white-headed breed; †: Hereford breed; ‡: A first-generation hybrid of crossbreeding between the Kazakh white-headed and Hereford breeds

Table 6. Cost-effectiveness of growing and fattening bulls of different genotypes

Indicator	Genotype		
	KB*	HF†	F1‡
Feed consumption per kg of live weight gain fodder unit	12	12	12
Production costs, \$	20690.22	23193.48	23193.48
Cost of 1 quintal of live weight gain, \$	2.12	1.81	1.87
Realizable value, \$	2.60	2.60	2.60
Profit, \$	4618.52	10059.80	9099.25
Profitability level	22	43	39

Note: *: Kazakh white-headed breed; †: Hereford breed; ‡: A first-generation hybrid of crossbreeding between the Kazakh white-headed and Hereford breeds

In terms of profitability, Hereford bulls exceeded their Kazakh White-headed counterparts by \$5,441.28 and crossbreed bulls by \$960.55. The profitability percentages were 22% for the Kazakh White-headed breed, 43% for the Hereford breed, and 39% for the crossbreed bulls.

Discussion

The modern market economy is characterized by the strategic use of financial leverage in investment processes. Financing and crediting of pivotal economic sectors have become a cornerstone of government strategy (Morhachov et al. 2021). The sandy deserts of the Southern Balkhash region, part of Central Asia's mid-subzonal deserts, boast a rich flora of over 200 higher plant (Embryophyte) species. The herbaceous and shrub vegetation of these deserts is characterized by low, sparse plants. The extended daylight in summer, early snow melt by mid-December, and the establishment of a thick grass cover by April offer fresh grazing opportunities, though summer burnout is common. However, autumn sees the regrowth of plants like ebelek, which are useful for cattle feeding (Isanova et al. 2017; Kaldybayev et al. 2019). Thus, the influence of the food supply during the grazing period from spring to late autumn (8-9 months) and in winter stall housing (3-4 months) must be studied in meat productivity analysis in sandy desert conditions (Kaldybayev et al. 2019; Zhumanov et al. 2022). Therefore, we focused on the important issue of analyzing the efficiency of beef cattle breeding in the sandy deserts of the Southern Balkhash region.

The beef cattle industry aims to rear offspring more rapidly to achieve earlier slaughter weights and enhance feed utilization efficiency. Factors such as carcass weight, proportion of marketable cuts, and meat tenderness are integral to carcass quality and value (Hickson et al. 2014). A crucial criterion in assessing the efficacy of crossbreeding Kazakh White-headed cows with Hereford bulls is the economic efficiency of raising and marketing young animals for meat. The sale price, a key determinant of farm revenues and, consequently, production profitability, plays a pivotal role in this context (Abugaliyev et al. 2019; Kubatbekov et al. 2021).

Data on targeted selection and breeding work in White-headed, Auliyekolsky, and Hereford cattle breeds in

Kazakhstan have been documented. Breeding research was undertaken at state farms such as Barysh Seisenbay (Baizak district, Jambyl region), Bagration (Ulan district, East Kazakhstan region), and Kegen-agro LLP (Raiymbek District, Almaty Region), with participation from scientists at the Kazakh National Agrarian University. The research findings suggest that raising crossbreed bulls yields more significant effects. Notably, using crossbreed Hereford bulls of the high-growth Canadian breed in crossbreeding proved to be highly beneficial. Despite equal feed costs (feed units) per kg of live weight gain and production costs, more meat production was obtained from Hereford bulls compared to the Kazakh White-headed breed and crossbreed bulls.

Weights and weight gains at specific ages or periods are commonly utilized as selection criteria in global beef cattle breeding programs. These traits, which have moderate to high genetic correlations with carcass weight and are readily measurable, respond well to selection (Vázquez-Mosquera et al. 2023). However, live weight and appearance alone provide insufficiently objective or accurate data on meat productivity. Therefore, a comprehensive assessment can only be achieved post-slaughter, evaluating the products both as a food product and as raw material for meat processing factories (Blanso et al. 2020; Pardo et al. 2020).

Crossbreeding Herefords with the Kazakh White-headed breed yielded positive results such as superior growth intensity and better feed conversion by improving taste qualities of the crossed bull's flesh compared to the Kazakh white-headed breed due to heterosis effect. An extensive analysis indicated that from both an economic and production standpoint, breeding pure Hereford cattle of the Canadian selection, as well as utilizing crosses of the Hereford breed with the Kazakh White-headed breed, is highly profitable. The first crossbreed (F1) generation exhibited superior meat yield qualities due to the Hereford bull's higher carcass fleshing and adaptability to local climatic conditions, combined with the high palatability, marbling of the meat, adaptability, and low maintenance of the Kazakh White-headed bulls. This study confirms that crossbreeding different breeds can enhance the growth intensity of crossbreed calves and improve meat quality. It is particularly advantageous to use high-growth type Canadian selection Hereford crossbreed bulls (Table 7).

Table 7. The results of the slaughter of experimental bulls ($\pm m_x$)

Indexes	Genetic cattle type									
	KB*		HF†		F1‡		Limousin		Simmental	
	$\bar{X} \pm m_x$	C _v	$\bar{X} \pm m_x$	C _v	$\bar{X} \pm m_x$	C _v	$\bar{X} \pm m_x$	C _v	$\bar{X} \pm m_x$	C _v
Live weight (kg)	419.7±0.6	0.1	463.8±0.3	0.1	454.4±0.5	0.1	498.7±0.2	1.1	475.6±0.4	0.1
Butchered carcass weight (kg)	236.1±1.1	0.4	279.0±0.7	0.2	270.0±0.2	0.1	293.5±0.6	0.2	277.5±0.6	0.2
Flesh yield (%)	56.2±0.4	0.6	60.1±0.3	0.4	59.4±0.1	0.1	59.0±0.8	1.3	58.3±0.5	0.8
The internal fat weight (kg)	13.6±0.1	0.4	11.8±0.2	1.2	12.4±0.2	1.4	20.0±0.2	0.7	19.8±0.2	0.7
Internal fat output (%)	3.2±0.1	1.2	2.5±0.0	1.0	2.7±0.0	0.9	4.0±0.2	3.7	4.1±0.1	2.4
Butchered weight (kg)	249.7±0.3	0.1	290.8±0.2	0.1	282.4±0.5	0.1	313.5±0.5	0.1	297.3±0.6	0.1
Butchered output (%)	59.4±0.4	0.6	62.6±0.3	0.4	62.1±0.4	0.5	62.8±0.1	0.1	62.5 ±0.2	0.2

Note: *: Kazakh white-headed breed; †: Hereford breed; ‡: A first-generation hybrid of crossbreeding between the Kazakh white-headed and Hereford breeds

At the Hajdúszoboszló farm (JMK Ltd.), breeding and crossing activities encompass Limousin, meat-oriented Simmental, and Hungarian Grey cattle. The Limousin breed, imported from France, is renowned for its excellent productivity and meat quality, characterized by ease of calving and robust calves from birth (Szűcs and Tózsér 2020). Research by Nurgazy et al. (2017) has demonstrated that the fertility rate of the Limousin breed in this region is 98%, with perinatal mortality at 3.3%. Bulls' birth weight averages around 42.1 kg, reaching 170 kg by 120 days and approximately 279 kg by 210 days. The average daily weight gain of bulls from birth to 120 days is 1068 g, increasing to 1207 g from 120 to 210 days, and averaging 1324 g from birth to slaughter at 16-18 months. The carcass weight of a young bull at 16-18 months is 411 kg, with a carcass slaughter yield of about 60-62%.

The Limousin breed's fertility rate was 98%, with perinatal mortality at 3.3%, and the weight of steers at birth was 42.1 kg. By 120 days, the weight increased to 170 kg, and by 210 days to 279 kg. The average daily weight gain for bulls aged 0-120 days was 1068 g, for 120-210 days was 1207 g, and from birth to slaughter (16-18 months) was 1324 g. At 16-18 months, the carcass weight of a young bull was 411 kg, with a slaughter yield of 60-62% (Table 1).

The Hungarian Grey breed is known for its robustness and late maturation, yielding organic lean beef with a slaughter yield of 60-62%. This breed is often used for crossbreeding with higher-yield breeds to enhance their hardiness for climatic conditions (Holló et al. 2012). However, it is important to consider the climatic differences between Hungary and Kazakhstan, as the Kazakh climate is more severe (Nasambaev et al. 2022).

Comparing the bulls bred in the Republic of Kazakhstan (Hereford, Kazakh White-headed breeds, and crosses (F1)) with those bred in Hungary (Limousin and Simmental), it is evident that Limousin calves have a significant advantage. They surpass Kazakh White-headed steers by 57.4 kg or 24.3% ($P < 0.05$), Hereford steers by 14.5 kg or 4.8% ($P < 0.05$), crossbred steers by 23.5 kg or 8.7% ($P < 0.05$), and Simmental steers by 16 kg or 5.7% ($P < 0.05$). In a decreasing sequence, the slaughter weight index was 249.7 kg for Kazakh White-headed bulls, 282.4 kg for mixed bulls, 290.8 kg for the Hereford breed, and 297.3 kg for Simmental cattle. Conversely, in ascending order, the Limousin breed steers had the highest index in slaughter weight, recorded at 313.5 kg.

The superior data on slaughter weight and yield were evident in Limousin breed steers at 313.5 kg (62.8%). Simmental and Hereford bulls held intermediate positions in slaughter qualities, recording 297.3 kg (62.5%) and 290.8 kg (62.6%), respectively. The lowest indicator was observed in Kazakh White-headed bulls at 249.7 kg (59.4%). The variability of meat productivity with age changed insignificantly, and the differences between the studied animals of different genotypes were minor. The yield of internal fat in Hereford breed bulls was lower than that in Kazakh White-headed bulls by 0.7 kg or 28% ($P < 0.05$), and 0.5 kg or 18.5% ($P < 0.05$) in comparison to crossbred bulls of the same age. Internal fat yield was high in bulls of the Limousin and Simmental breeds (4.0-4.1%);

in Simmental bulls, the variation coefficient for internal fat yield was 2.4 and for Kazakh White-headed bulls it was 1.2.

In conclusion, Using Hereford bulls for crossbreeding with Kazakh White-headed cattle positively impacts the taste, aroma, tenderness, and juiciness of the meat. Analysis of control slaughter results and examination of the morphological composition of carcasses support the conclusion that Hereford and crossbred bulls possess high slaughter qualities. The carcasses of 15-month-old Hereford bulls were heavier and had a higher carcass fat and meat content. Among the steers of different genotypes bred in Kazakhstan, compared to those bred in Hungary, the greatest live weight was observed in Limousin breed animals. Simmental and Hereford bulls occupied intermediate positions in terms of slaughter qualities, while the Kazakh White-headed breed exhibited the lowest indicators. Comparing bulls of different genotypes bred in Kazakhstan and Hungary reveals that Limousin breed animals had the largest live weight. Simmental and Hereford bulls demonstrated intermediate slaughter qualities, while the Kazakh White-headed breed exhibited lower rates. It is important to note that intensive breeding and fattening of Hereford and crossbred bulls are most profitable for farms, attributed to their superior growth intensity and better feed conversion.

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