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STUDY OF BEEF NUTRITIONAL VALUE OF MEAT BREED CATTLE OF KAZAKHSTAN

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Abstract

The article discusses quality and nutritional value of meat of some meat breeds bred in Kazakhstan. Aim of this research was to study quality and nutritional value of meat.

The object of study was the longest back muscle, the meat content of the left half-carcass and the adipose tissue of young bovine stock of Kazakh white-headed and Kalmyk breeds. For the experiment, 3 carcasses from each breed were taken. The chemical composition of the meat of the half carcass and the longest back muscle was determined: moisture, total nitrogen, nitrogen of extractive substances, lipids and protein fractions according to: GOST 9793-2016, GOST 32008-2012 (ISO 937:1978), and GOST 34132-2017

Significant breed differences in the fractional composition of proteins, in amino acid and fatty acid compositions of meat of the studied species were revealed.

Data on biochemical composition and nutritional value of young bovine stock meat of Kazakh white-headed and Kalmyk breeds will serve as a proper incentive for their purposeful breeding in order to provide the population with high-quality animal products. They may be useful to dietitians, catering technologists and employees of the agro-industrial complex.

***Key words**: Meat of young bovine stock, Quality, Nutritional value, Biochemical composition of meat.*

1. Introduction

Current problem of modernity is the accelerated and directed formation of muscle tissue and the improvement of biological value of its proteins in farm animals. Science has accumulated materials revealing ways to form the productive qualities of farm animals, the essence of their age-related breed and other differences. The natural course of development of the organism is known, general provisions on age transformations in ontogenesis are established, against which the differences and peculiarities formed under the influence of living conditions can be considered. Thus, the entire scientific activity of zootechnicians, geneticists, and breeders is aimed at improving the meat or dairy productivity of livestock, which is of tremendous national economic importance. But one should not forget about the quality and nutritional value of the meat produced.

In Kazakhstan, meat breeds account for about 30% of the total cattle population. And therefore, the previous approach to evaluating the nutritional value of meat and its quality on the basis of its chemical composition, energy value, determination of usefulness of proteins (by the amount of tryptophan and oxyproline) does not give exhaustive results.

Modern meat science of, when evaluating its quality, takes into account a set of important indicators, united under the term "nutritional value". Based on this, we decided to study the quality and nutritional value of meat of certain meat breeds bred in Kazakhstan.

The quality and nutritional value were studied by the fractional composition of proteins, chemical, amino acid, lipid, mineral and vitamin composition of meat.

2. Materials and Methods

Object of study were the longest back muscle, the meat content of the left half-carcass and the adipose tissue of young bovine of Kazakh white-headed and Kalmyk breeds. For the experiment, 3 carcasses from each breed were taken.

When conducting the experimental work, identical sampling conditions were strictly observed, which concerned both a specific section of the carcass and the accepted post-slaughter sample from the carcass. Samples of the longest back muscle and meat content of the half-carcass were taken after 48 hours, since by this time there is a relative stabilization of pH and other physico-chemical parameters. Samples of the longest muscle were cleared of adipose and large connective tissue formations. Sample for analysis was taken after grinding the samples in a meat grinder and micro-grinder and thorough mixing.

Indicators of meat total chemical composition of the half carcass and the longest back muscle were determined on a mass spectrometer Trace 1310, a gas chromatograph Shimadzu GC-2010, for determining protein, Kjeldahl apparatus (UDK 159, Italy), for determining fat-acid composition (Shimadzu GC-2010, Japan), and in order to determine the acidity we used pH meter (Metrohm 827 pH, Switzerland) in the laboratory of the Kazakhstan-Japan Innovation Center (KJIC) KazNAU.

3. Results and Discussions

The modern theory of human need for food is determined by the proportions of individual components in human rations. However, the main focus here is on components that are not (recoverable) nutrition factors. These substances can only be extracted from components of products, but they cannot be synthesized by the enzyme systems of human body.

There are the average data on human need for nutrients according to the balanced nutrition formula. The conclusions from this theory of balanced nutrition allowed us to substantiate the integral system for determining the biological value of products based on their chemical composition and to develop an amino acid score (count) method that allows determining the degree of deviation of amino acid composition of this product from the hypothetical ideal amino acid scale.

On the basis of this scale introduced the concept of different categories of product values. The term "nutritional value" of product is used to determine the percentage of compliance with the chemical composition of product under investigation to the balanced nutrition formula, that is, this term reflects the fullness of useful qualities of product.

Terms "biological" and "energetic" values are a particular definition of the term "nutritional value". For example, the biological value reflects the quality of protein components of product, associated with both the digestibility of protein and the degree of balance of its amino acid composition.

In Table 1 the main chemical composition of the longest muscle of back and the meat content of 1 category carcasses, as well as their energy value is given.

Table 1. Chemical composition of meat

Indicators	Breed			
	Kalmyk		Kazakh white-headed	
	Muscle tissue	Meat content	Muscle tissue	Meat content
Water, %	72.92	63.1	74.39	64.64
Protein, %	22.56	20	22	19.46
Lipids, %	3.50	16.05	2.6	15
Ash, %	1.02	0.85	1.01	0.9
Energy value of 100 g, kJ	509	939	465	891

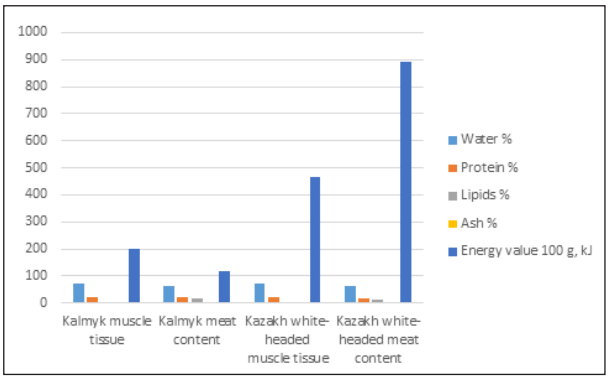

Figure 1. Chemical composition of the muscle tissue of meat of young bovine stock of Kazakh white-headed and Kalmyk breeds

From the data presented in Table 1 and Figure 1 it can be seen that the chemical composition of the muscle tissue of meat of young bovine stock of Kazakh white-headed and Kalmyk breeds is different. So, for example, Kalmyk meat has more proteins and lipids in comparison with the Kazakh white-headed breed, but less moisture [1, 2, 3, and 4].

The difference in chemical composition predetermines the difference in energy value. It turned out to be somewhat higher in Kalmyk meat.

Thus, based on the data of chemical composition, it was found that the energy value of 100 g Kalmyk meat is 48 kJ higher than the same amount of meat from the Kazakh white-headed breed. Table 2 and Figure 2 shows the fractional composition of proteins of meat, the studied breeds [1, 2, 3, and 4].

Studies have shown that the amount of complete proteins (sarcoplasm and myofibrils) was greater in the muscle tissue of Kalmyk breed, with less stroma proteins and nitrogenous extractive substances.

The data characterizing the fractional composition of the longest back muscle and the meat content of the carcass, suggests that the rate of formation of sarcoplasm proteins and myofibrils is ahead of the rate of stromal proteins synthesis, which leads to an increase in their concentration in these tissues.

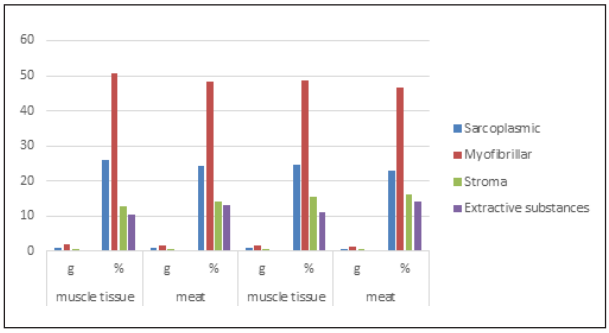

Figure 2. Fractional protein composition of Kazakh white-headed and Kalmyk breeds meat

When comparing the percentage of sarcoplasmic and myofibrillar proteins, a high value was found in the meat of the bulls of Kalmyk breed, and a low value in Kazakh white-headed breed [8, 9, and 10].

If we take into account that sarcoplasmic proteins are readily soluble hydrophilic proteins with the highest biological activity and nutritional value, then we can say that depending on the breed of animals, the activity of synthetic processes in organism and the formation of proteins with higher nutritional value is among bulls of Kalmyk breed.

For a more complete characterization of the biological value of the meat of young bovine stock meat breeds, we determined their amino acid composition (Table 3).

From Table 3 data it can be seen that the amino acid composition of proteins in meat varies depending on the species. Muscle tissue proteins and meat contents

Table 2. Fractional protein composition of meat

Fractions	Kalmyk				Kazakh white-headed			
	Nitrogen							
	Muscle tissue		Meat		Muscle tissue		Meat	
	g	%	g	%	g	%	g	%
Sarcoplasmic	0.94	26.04	0.78	24.4	0.87	24.72	0.72	23.1
Myofibrillar	1.83	50.69	1.55	48.32	1.71	48.58	1.45	46.5
Stroma	0.46	12.74	0.45	14	0.55	15.62	0.5	16.17
Extractive substances	0.38	10.53	0.42	13.28	0.39	11.08	0.44	14.23

Table 3. Amino acid composition of meat of young bovine stock mg per 100 g

Amino acids	Kalmyk		Kazakh white-headed	
	Muscle tissue	Meat content	Muscle tissue	Meat content
Essential including:	8,574	7,581	8,247	7,293
Valine	1,231	1,099	1,170	1,058
Isoleucine	1,009	829	959	798
Leucine	1,732	1,543	1,655	1,510
Lysine	1,835	1,687	1,775	1,623
Methionine	615	472	598	456
Threonine	901	820	890	821
Tryptophan	286	232	279	215
Phenylalanine	965	899	921	812
Non-essential including:	13,406	11,704	13,214	11,537
Alanine	1,404	1,099	1,391	1,109
Arginine	1,332	1,080	1,320	1,066
Aspartic acid	2,418	1,890	2,369	1,810
Histidine	780	714	783	725
Glycine	895	964	895	957
Glutamic acid	3,737	3,240	3,672	3,141
Oxyproline	55	270	60	296
Proline	692	694	672	700
Serine	921	798	921	796
Tyrosine	842	689	816	672
Cystine	330	266	315	265
Total	**21,980**	**19,285**	**21,461**	**18,830**

of Kalmyk bulls contain more essential amino acids than proteins of Kazakh white-headed breed (39.01 and 39.31%, respectively, against 38.43 and 38.73%).

For an adult, eight amino acids - valine, isoleucine, leucine, lysine, methionine, threonine, tryptophan, phenylalanine are essential, and for a child also histidine. Kalmyk breed meat proteins contained more amino acids such as valine, isoleucine, tryptophan, but less threonine and lysine and about the same amount of leucine.

The biological usefulness of meat proteins depends on the ratio of essential amino acids, in order to establish it, determine the so-called threonine and tryptophan amino acid formulas of product and compare with the optimal proposed by various bodies [6,7]. Tryptophan is the most deficient amino acid in human nutrition, so its content is taken as a unit and all other amino acids are calculated for it. With threonine, which occupies an intermediate position in this respect, they act in the same way as with tryptophan. Comparison, which was carried out by us, showed that the ratio of essential amino acids in meat of studied breeds by tryptophan formula exceeds the optimal formula, and by threonine one is close to these requirements (Table 4).

If we compare the amino acid composition of meat of young stock of the studied breeds with the so-called ideal scale of amino acids corresponding to the hypothetical protein that is completely balanced in amino acid composition, for example, using the amino acid score (count) method, we can establish the biological value of studied meat type [4, 5, and 6].

The FAO/WHO for the determination of amino acid scores (counts) suggested a time scale for the most deficient essential amino acids, most often in 3 of them: lysine, tryptophan and the amount of sulfur-containing amino acids (methionine and cystine). In Table 5 amino acid score of meat of young bovine stock meat breeds is given according to the amino acid scale recommended by FAO/WHO [6, 7].

From Table 5 data it can be seen that the meat of young bovine stock meat breeds exceeds the standard hypothetical FAO/WHO protein in biological value in almost all types of deficient amino acids, except to some extent the amount of phenylalanine and tyrosine. Thus, the meat of young bovine stock belongs to the highly biological valuable products, supplying valuable proteins with mainly animal proteins. It should be noted

Table 4. The ratio of essential amino acids in meat of young bovine stock (in comparison with the optimal FAO/WHO tryptophan and threonine formulas)

Amino acids	FAO/WHO optimal formula	Kalmyk		Kazakh white-headed	
		Muscle tissue	Meat	Muscle tissue	Meat
By tryptophan formula					
Tryptophan	1	1	1	1	1
Valine	3.2	4.3	4.7	4.2	4.9
Isoleucine	2.8	3.5	3.6	3.4	3.7
Leucine	4.4	6.1	6.7	5.9	7
Lysine	3.2	6.4	7.3	6.4	7.5
Methionine	0.8	2.2	2	2.1	2.1
Threonine	2	3.2	3.5	3.2	3.8
Phenylalanine	1.2 - 4.4	3.4	3.9	3.3	3.8
By threonine formula					
Threonine	1	1	1	1	1
Valine	2.6	1.4	1.3	1.3	1.3
Isoleucine	1.4	1	1	1.1	1
Leucine	2.2	1.9	1.9	1.9	1.8
Lysine	1.6	2	2.1	2	2
Methionine	0.4 - 2.2	0.7	0.6	0.7	0.6
Tryptophan	0.5	0.3	0.3	0.3	0.3
Phenylalanine	0.6 - 2.2	1.1	1.1	1	1

Table 5. Amino acid score of meat

Amino acids	Standard scale FAO/WHO mg per 1 g of protein	MG per 1 g of protein in meat		Score of meat, %	
		Kalmyk breed	Kazakh white-headed breed	Kalmyk breed	Kazakh white-headed breed
Leucine	70	80	80	114	114
Isoleucine	40	43	42	108	105
Valine	50	57	56	114	112
Lysine	55	88	86	160	156
Phenylalanine + tyrosine	60	51	47	85	78
Threonine	40	43	44	108	110
Tryptophan	10	12	11	120	111
Methionine + Cysteine	35	39	37	111	106

that the meat of young Kalmyk breed differs from the meat of Kazakh white-headed breed by a slightly higher biological value.

Lipids are an essential part of a balanced human diet: they should account for about 30% of the food total energy value. They are used by organism as a reserve substance and as a source of energy. Lipids are also involved in the construction of cells. Together, the body receives lipids and a number of physiologically important substances: phosphatides, essential polyunsaturated fatty acids, vitamins, sterols [5, 6]. In Table 6 the fatty acid composition of muscle and adipose tissue of young bovine stock, depending on the breed of animals is given [11, 12 and 17].

The data show that the breed of animals has a significant impact on the fatty acid composition of muscle and adipose tissue. Thus, in the longest back muscle, adipose tissue and in the meat of young Kalmyk breed there appeared more lipids, including phospholipids, monounsaturated and polyunsaturated fatty acids, but less saturated fatty acids [13,14].

Phospholipids and polyunsaturated fatty acids play a special biological role in animals and humans, therefore their accumulation in muscle and adipose tissue is of particular interest. From Table 6 it can be seen that the muscle and adipose tissue of young cattle of meat breeds have a high physiological value. Moreover, meat from the young Kalmyk breed in fatty acid composition exceeds its counterparts, especially in the indispensable and biologically active factor.

It should be noted that the determination of biological value of meat by its protein and amino acid composition does not provide a complete picture of its quality and overall nutritional value. Therefore, we calculated its total nutritional value according to the balanced nutrition formula proposed by the Institute of Nutrition of the Academy of Medical Sciences (Table 7).

Table 6. Fatty acid composition of meat lipids, depending on the breed of animals, g per 100 edible parts

Composition	Kalmyk			Kazakh white-headed		
	Muscle tissue	Adipose tissue	Meat	Muscle tissue	Adipose tissue	Meat
The amount of lipids	3.50	86.20	16.05	2.60	85.50	15.00
Triglycerides	2.40	84.56	15.00	1.80	84.00	14.10
Phospholipids	1.04	1.55	0.98	0.74	1.40	0.82
Cholesterol	0.06	0.09	0.07	0.06	0.10	0.08
Fatty acids (amount)	3.21	82.10	15.31	2.39	81.53	14.34
Saturated	1.56	37.62	6.67	1.16	38.01	6.72
including:						
$C_{14:0}$ **(Myristic)**	0.08	3.00	0.50	0.06	3.03	0.52
$C_{15:0}$ **(Pentadecane)**	0.024	0.550	0.08	0.014	0.57	0.10
$C_{16:0}$ **(Palmitic)**	0.91	22.06	3.92	0.68	22.26	3.94
$C_{17:0}$ **(Margarine)**	0.03	1.51	0.27	0.02	1.55	0.25
$C_{18:0}$ **(Stearic)**	0.52	10.50	1.90	0.39	10.60	1.91
Monounsaturated	1.47	41.53	8.03	1.09	40.82	7.10
including:						
$C_{14:1}$ **(Myristoleic)**	0.02	1.65	0.26	0.02	1.57	0.24
$C_{16:1}$ **(Palmitoleic)**	0.09	5.60	1.15	0.09	5.33	0.91
$C_{18:1}$ **(Oleic)**	1.26	34.28	6.62	0.99	33.92	5.85
Polyunsaturated	0.18	2.95	0.61	0.14	2.70	0.52
including:						
$C_{18:2}$ **(Linoleic)**	0.12	2.18	0.44	0.10	1.96	0.36
$C_{18:1}$ **(Linolenic)**	0.03	0.76	0.15	0.02	0.73	0.14
$C_{18:1}$ **(Arachidonic)**	0.03	0.01	0.018	0.02	0.01	0.018

Table 7. Nutritional value of meat depending on the breed of animals

Nutrients	Daily need	%, satisfaction due to 100g			
		Muscle tissue	Meat content	Muscle tissue	Meat content
		Kalmyk	Kazakh white-headed	Kalmyk	Kazakh white-headed
Proteins, g	80-100 / 90	25.1	22.2	24.4	21.6
including animal origin	45	50.1	44.4	48.9	43.2
Fats, g	80-100 / 90	3.9	17.8	2.9	16.7
including animal origin	70	5	22.9	3.7	21.4
Essential amino acids, g					
Tryptophan	1	28.6	23.2	27.9	21.5
Leucine	4-6	34.6	30.9	33.1	30.2
Isoleucine	3.5	28.8	23.7	27.4	22.8
Valine	3.5	35.2	31.4	33.4	30.2
Threonine	2.5	36	32.8	35.6	32.8
Lysine	4	45.9	42.2	44.3	40.6
Methionine	3	20.5	15.7	19.9	15.2
Phenylalanine	3	32.2	30	30.7	27.1
Non-essential amino acids, g					
Histidine	1.5	52	47.6	52.2	48.3
Arginine	5.5	24.2	19.6	24	19.4
Cystine	2.5	13.2	10.6	12.6	10.6
Tyrosine	3.5	24.1	19.7	23.3	19.2
Alanine	3	46.8	36.6	46.4	37
Serine	3	30.7	26.6	30.7	26.5
Glutamic acid	16	23.4	20.3	23	19.6
Aspartic acid	5	13.8	13.9	13.4	14
Proline	3	29.8	32.1	29.8	31.9

From Table 7 data it can be seen that 100 g of meat content of young bovine stock by 21.6 - 22.2% satisfies the daily human need for proteins, while 43.2 - 44.4% in animal protein. In other words, 100 g meat of young meat species satisfies by almost half the normal daily human need for animal protein. It should be noted that the situation is somewhat better with proteins of the meat of young Kalmyk breed.

The daily need for essential amino acids is satisfied by 21.5 - 44.2%, including those with deficient amino acids like tryptophan - from 21.5 to 23.2%, threonine to 32.8% and lysine from 40.6 to 42.2%. Much less meat of young bovine stock of meat breeds satisfies human in usual non-essential amino acids, especially such as cysteine, aspartic acid, arginine and tyrosine. At the same time, we found no particular differences in the content of these amino acids in meat from animals of studied species, although there are significant differences in essential amino acids in favor of meat from bulls of Kalmyk breed [15, 16].

When speaking about the fats, 100 g of meat content satisfies 16.7 - 17.8%, while for fats of animal origin by 21.4 - 22.9%. These data suggest that meat of young bovine stock meat breed is of great value to human as a supplier of complete proteins, but not animal fats. These data suggest that meat of young bovine stock meat breeds is characterized by moderate fat content, high biological value and good dietary indicators, in this respect meat differs particularly from Kalmyk animals.

4. Conclusions

- Based on a study of chemical, protein, amino acid, fatty acid composition, an objective evaluation was made of quality and nutritional value of young bovine stock meat of Kazakh white-headed and Kalmyk breeds.

- It has been established that meat of young bovine stock meat breeds has a high biological and nutritional value, especially in this respect meat of young Kalmyk breed differs.

- We identified significant breed differences in the fractional composition of proteins, amino acids and in the fatty acid composition of meat, the studied breeds.

- Data on biochemical composition and nutritional value of young bovine stock meat of Kazakh white-headed and Kalmyk breeds will serve as a proper incentive for their purposeful breeding in order to provide the population with high-quality animal products. They may be useful to dietitians, catering technologists and employees of the agro-industrial complex.

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