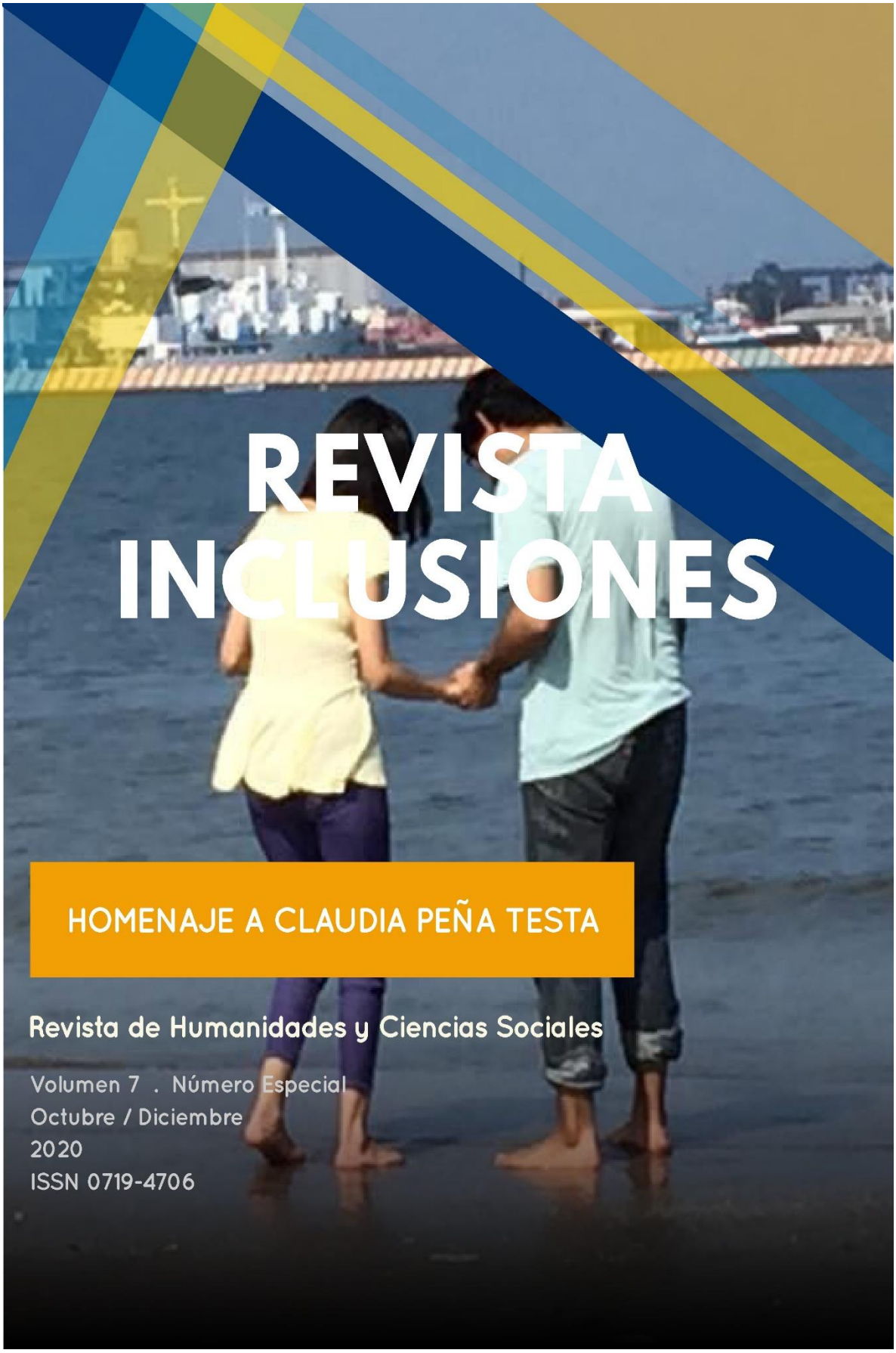

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FORMATION OF MEAT PRODUCTIVITY AND BEEF QUALITY OF THE SIMMENTHAL CATTLE AND THEIR CROSSES WITH HEREFORD AND CHAROLAIS BULLS

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Abstract

In the conditions of the State Scientific Establishment (SSE) Tula Research Institute of Agriculture of the RAAS, the productivity and quality of Simmental beef bull calves and their crosses with Hereford and Charolais breeds were studied from 2010 to 2016. Three groups of bull calves, 17 animals in each, were chosen and formed. The first group (reference) included purebred Simmental bull calves (S), the second and the third (experimental) groups contained the crossbred bull calves obtained by crossing the Simmental cows with the Hereford (S x H) and the Charolais (S x C) bulls, respectively. The calves were grown from birth to weaning at the age of six months using the Cow – Calf technology of beef cattle breeding. After weaning the young animals, the technology envisaged keeping them tied in the stalls. A check slaughtering was performed at the age of 6 and 18 months.

Keywords

Meat productivity – Beef – Simmentals – Charolais – Herefords – Crosses

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Introduction

Increasing beef production and improving its quality are some of the major problems of the agro-industrial complex of the Russian Federation. The problem of increasing beef production and improving its quality in Russia is increasing, which is due not only to the increasing importance of beef in human nutrition but also to the steady tendency towards the existing reduction of the livestock. Besides, the implementation of the economic reforms in Russia since the 90ies of the last century has resulted in a sharp reduction of beef production[1]. Due to the drastic reduction of the livestock, especially cows, the slaughter contingent substantially reduced in the public sector. According to the FAO Yearbook, the yearly beef production per person in Russia is 12.8 kg (with the norm of 32 kg), while in such countries as New Zealand it is 152.5 kg, and in the USA — 43.9 kg[2].

The results of many studies show that with the existing fatting contingent in the country, the beef import will continue without the development of beef cattle breeding. Moreover, solving the problem of the beef deficit without the development of beef cattle breeding at an accelerated pace is almost impossible[3].

In Russia, like in many European countries, beef will now and in the future be produced through breeding specialized beef and dairy animal breeds and breeds of combined productivity. Therefore, the most effective method of beef production and improving its quality is the use of intensive technologies for growing and fattening young cattle, and the widespread use of bulls of specialized beef breeds in crossbreeding with dairy and combined productivity cows.

According to many experts, beef cattle breeding in the conditions of qualitative growth of the livestock and development of the territory is a tremendous additional incentive for the development of other areas of the economy and can involve large circles of entrepreneurship and cooperation. However, to achieve such goals, fundamental qualitative changes in the industry itself are required. Undoubtedly, there are not enough specialized beef breeds in the country for accelerating the growth of the breeding stock. In this regard, involving the animals of dairy breeds for crossing them with the bulls of the specialized beef breeds will increase the total beef, which proves sufficiently good for the finished meat products.[4]

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[1] H. A. Amerkhanov; S. A. Miroshnikov; R. V. Kostyuk; I. M. Dunin y G. P. Legoshin, “Proekt Kontseptsii ustoichivogo razvitiya myasnogo skotovodstva v Rossiiskoi Federatsii na period do 2030 goda”, Vestnik myasnogo skotovodstva Vol: 1 num 97 (2017): 7-11; V. V. Kalashnikov, “Zhivotnovodstvo Rossii. Sostoyanie i napravleniya povysheniya effektivnosti”, Zootechny Vol: 6 (2005): 2–8 y A. T. Mysyk, “Zhivotnovodstvo stran mira”, Zootechny Vol: 2 (2005): 2–7.

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[4] T. S. Kubatbekov y E. O. Oganov, Anatomiya produktivnykh zhivotnykh (Moscow: Workshop for specialists in veterinary-sanitary expertise, 2016); T. S. Kubatbekov; V. I. Kosilov; S. S. Mamaev; J. A. Yuldashbaev y E. A. Nikonova, Rost, razvitie i produktivnye kachestva ovets (Moscow, 2016); P. Hajas y T. Dohy, A. Javor, Comparision of progeny for different beef traits of dairy and beef bulls, in: Proc. of the XXXIII annual conference of the European Association for animal production, pp. 1-6. 1982; W. Cheng; J. H. Cheng; D. W. Sun y H. Pu, “Marbling Analysis for Evaluating Meat Quality:

As a rule, the offsprings of the breeds successfully chosen for crossing combine high growth energy, meat quality, and early maturity approaching those of the improving breed. According to some researchers, the average daily gains of the crossbred animals increase by 10 – 20 % and more, the feed consumption per unit of weight gain reduces, and the meat quality improves. With that, the meat quality of the carcasses of the crossbred animals greatly improves[5].

To increase the efficiency of beef production and improve its quality, in many countries of the world, as well as in Russia, breeds of British origin have traditionally been used for the industrial crossing: the Shorthorn, the Hereford, and the Aberdeen-Angus breeds[6]. The animals of these breeds are early maturing, and are capable of early fat deposition with the predominance of the intermuscular and subcutaneous fat.

In recent decades, the French meat breed – Charolais[7] – has gained particular popularity in crossbreeding. This breed features a large size, high growth energy, body height, the ability for prolonged muscle growth, and relatively lean beef.

Many scientific papers have been published aimed at studying growth, development, and meat productivity of domestic dairy and combined breeds of animals, as well as various variants of their crossbreeding with meat breeds.

However, research materials vary widely due to the different feeding and keeping conditions.

In this regard, this work was aimed at studying the characteristics of forming beef productivity and the quality of the Simmentals and their crosses with the Hereford and Charolais bulls.

Methods and Techniques" Comprehensive Reviews in Food Science and Food Safety Vol: 14 num 5 (2015): 523-535; V. V. Gudymenko, Osobennosti rosta, razvitiya i myasnoi produktivnosti bychkov simmentalskoi, limuzinskoi porod i ikh pomesei: Ph.D. thesis (Belgorod, 2004); H. H. Stonacker; M. N. Harallns y S. S. Wheeker, "Feedlot and carcass characteristics of individually feu comprest and conventional tye Hereforde steers", Journal of Animal Science Vol: 11 (1952): 6–8; I. P. Prokhorov, Formirovanie myasnoi produktivnosti molodnyaka krupnogo rogatogo skota pri promyshlennom skreshchivanii: Ph.D. thesis (Moscow, 2013); A. I. Ryazanov, Osobennosti rosta, razvitiya i myasnoi produktivnosti bychkov frantsuzskikh myasnykh porod v usloviyakh Tsentralno-Chernozemnoi zony: Ph.D. thesis (Belgorod, 2003) y T. N. Shchukina, "Rost i razvitie pomesei cherno-pestroi porody s bykami porod limuzin i sharole, vyrashchivaemykh po myasnoi tekhnologii", Husbandry Vol: 3 (2008): 18–20.

[5] G. I. Ragimov, Productive and meat qualities in bulls of different breeds and there crosses, in: Egypt: Book of Abstracts of the 53-rd Annual Meeting of the European Association for Animal Production Vol: 4 (2002): 72-76 y H. Brandt; A. Müllenhoff; C. Lambertz; G. Erhardt y M. Gauly, "Estimation of genetic and crossbreeding parameters for preweaning 297 traits in German Angus and Simmental beef cattle and the reciprocal crosses", Journal of Animal Science Vol: 88 num 1 (2010): 80-86.

[6] V. V. Gudymenko, Osobennosti rosta, razvitiya i myasnoi produktivnosti bychkov simmentalskoi, limuzinskoi porod i ikh pomesei: Ph.D. thesis (Belgorod, 2004).

[7] H. H. Stonacker, M.N. Harallns, S.S. Wheeker, "Feedlot and carcass characteristics of individually feu comprest and conventional tye Hereforde steers", Journal of Animal Science Vol: 11 (1952): 6–8 y I. P. Prokhorov, Formirovanie myasnoi produktivnosti molodnyaka krupnogo rogatogo skota pri promyshlennom skreshchivanii: Ph.D. thesis (Moscow, 2013).

Methods

The studies were performed in 2016 – 2017 according to the methodology developed at the State Scientific Establishment Tula Research Institute of Agricultural Sciences of Russia. Three groups of bull calves, 17 animals in each, were chosen and formed. The first group (control) included the purebred Simmental bull calves (S), the second and the third (experimental) groups contained the crossbred bull calves obtained, respectively, by crossing Simmental cows with Hereford (S x H) and Charolais (S x C) bulls. The calves were grown from birth to weaning at the age of six months using the technology of beef cattle breeding according to the "Cow – Calf" system. After weaning of young animals, the technology envisaged keeping them tied in stalls.

The level of the feeding of the experimental bull calves was medium intensive (the farm feeding level); it had been calculated following the detailed feeding norms for obtaining the average daily gain of 850 – 1,000 g and for achieving 450 – 500 kg of the live weight at the age of 18 months. The diets of the bull calves in all groups contained the same amounts of the coarse, succulent, and green fodder, as well as the combined feed following the feeding standards and the age of the animals[8].

To determine the effect of crossbreeding on the meat productivity of the crossbred young animals in various age periods, i.e., at the age of 6 and 18 months, a check slaughtering was made at the Tula Meat Processing Plant following the methodology of the All-Russia Research Institute of Meat Industry (VNIIMP), 1977; with that, the live and pre-slaughter weight, and the weight of a fresh carcass and internal fat were determined. The carcasses of the bull calves were assessed by the deposition of subcutaneous fat. The left semi-carcasses of the experimental bull calves after cooling for 24 hours in a refrigerator at 4 ^{0}C were deboned and veined for determining the absolute and relative weight of meat, bones, and tendons.

The physicochemical parameters of beef were determined as follows: the mass fraction of moisture was determined by drying following GOST 33319-2015; the mass fraction of protein — following the Kjeldahl's method — GOST 25011-2017; the mass fraction of fat — following the Soxhlet's extraction method — GOST 23042-2015.

Based on the morphological composition and the boneless meat part of the carcasses, the gross yield of protein and fat in the carcasses of the experimental animals was determined.

The economic efficiency of intensive calves growing and fattening in the experimental groups was determined by the difference in all costs for growing and fattening in the case of selling the animals for slaughter with the actual real value of gross production of each group of animals.

[8] A. I. Ryazanov, Osobennosti rosta, razvitiya i myasnoi produktivnosti bychkov frantsuzskikh myasnykh porod v usloviyakh Tsentralno-Chernozemnoi zony: Ph.D. thesis (Belgorod, 2003) y A. P. Kalashnikov; V. I. Fisinina; V. V. Shcheglova y N. I. Kleimenova, Normy i ratsiony kormleniya selskokhozyaistvennykh zhivotnykh (Moscow, 2003).

The obtained data were biometrically processed following the methodical instructions of A. M. Gataulin[9] for reporting the measurement results using Microsoft Excel; the reliability of the difference was adopted at the level of the reliability threshold $B_1 = 0.95$ (the level of significance $P < 0.05$).

Results and discussion

An important indicator characterizing the growth and development of the animals is their live weight determined in individual age periods. Intensive animal growing according to the technology of beef cattle breeding and the high level of feeding in the subsequent age periods ensured a high growth rate of the bull calves in all groups (Table 1).

Table 1 shows that at the age of six months, higher slaughter weights, compared to the Simmental cows, were obtained in the crosses with the Hereford and Charolais bull calves: by 21.6 kg ($P < 0.05$) and 2.0 kg, and at the age of 18 months — by 55.5 kg ($P < 0.01$) and 51.8 kg ($P < 0.01$), respectively. Therefore, the Charolais crosses had increased growth energy throughout the entire experimental period, and significantly exceeded the pre-slaughter mass of their peers in the other two groups at the age of 18 months.

The results of the check slaughtering show that at the age of six months, the difference in the fresh carcass weight between the Simmental bull calves, and the Hereford, and the Charolais crossbreeds was 3.2 kg and 13.8 kg ($P \leq 0.01$), and at the age of 18 months, it was 17.9 kg ($P < 0.01$) and 59.5 kg ($P < 0.01$), in the favor of the latter, respectively.

However, the highest content of internal fat was obtained from the purebred Simmentals. It was found that the slaughter yield at the age of six months in the Simmental bull calves was 55.8 %, which was by 1.1 % and 0.5 % lower, respectively, than in the Hereford and Charolais crosses. The highest slaughter yield at the age of 18 months was obtained from the Charolais and Hereford bulls, 62.7 % and 61.8 %, respectively, which was higher than in Simmentals by 3.6 % and 0.9 %.

Group	Weight, kg			Slaughter weight, kg	Slaughter yield, %
	pre-slaughter	of steam carcass	of internal fat		
six months					
S	234.6 ± 2.5	128.2 ± 2.2	2.6 ± 0.7	130.9 ± 2.4	55.8 ± 0.5
S x H	236.6 ± 2.3	131.4 ± 2.1	3.4 ± 0.9	134.8 ± 2.2	56.9 ± 0.5
S x C	256.2 ± 3.1**	142.0 ± 2.7*	2.3 ± 0.5	144.3 ± 3.3*	56.3 ± 0.4
18 months					
S	562.1 ± 3.4	315.0 ± 3.2	17.2 ± 1.2	332.2 ± 3.2	59.1 ± 0.7
S x H	565.8 ± 4.2	332.9 ± 3.7**	16.8 ± 1.1	349.7 ± 3.7**	61.8 ± 0.8
S x C	617.6 ± 5.1***	374.5 ± 4.3***	12.7 ± 1.3*	387.2 ± 4.3***	62.7 ± 0.6**

* — $P < 0.05$; ** — $P < 0.01$; *** — $P < 0.001$.

Table 1

The results of the check slaughtering of the experimental animals (X ± SX)

[9] A. M. Gataulin, Sistema prikladnykh statistiko-matematicheskikh metodov obrabotki eksperimentalnykh dannykh v selskom khozyaistve (Moscow: Publishing House of TAA, 1992).

It is well known that, as a rule, higher carcass yield is achieved through the excessive accumulation of fat and excessive fat deposition. However, it should be noted that in the best Charolais animals, the slaughter yield is 64 – 65 %, and excessive fat is absent. Meatiness, i.e., considerable development of the hind third of the carcass with the absence of excessive fat, is the distinctive feature of this breed.

During the visual assessment of the carcasses according to the degree of subcutaneous fat deposition by the five-score system, the Hereford crosses had the highest score (4.5 points); their carcasses were covered with a uniform layer of fat from the dorsal part to the middle, and further to the abdominal part. The carcasses of the pedigree bull calves by the degree of fat deposition (4.3 points) were close to the Hereford crosses, however, they differed from the former in significant fat deposition in the abdominal part of the carcasses. The carcasses of the Charolais crosses were covered with a thin layer of fat with small openings from the back side along the line from the middle part of the hip to the scapulohumeral joint; the extent of fat deposition was the lowest (3.9 points). Despite the differences in the degree of fat deposition, the carcasses of the bull calves in all groups were highly rated and belonged to the first fatness category.

It is known that the age-related changes in the morphological composition of the carcasses are determined by the uneven growth and development of the main constituent tissues. In performing the morphological studies of the carcasses of the Simmental calves and their crosses with Herefords and Charolais, it was found that their absolute mass increased with the age, due to the more intensive growth of the meat part, and, to a lesser extent, due to the skeleton and tendons (Table 2).

It was found that the meat part of the carcass grew most intensively in the first six months of the life of the animals. For instance, the share of meat part in the carcasses of the bull calves at the age of six months was 73.2 %, 73.4 %, and 74.4 %, respectively; at the age of 18 months, the specific weight of the meat part of the carcasses by the groups was 80.2 %, 82.4 %, and 82.9 %, respectively.

Group	Weight, kg				Meatiness coefficient
	chilled semi-carcass	meat part	bones and cartilages	tendons	
six months					
S	63.5 ± 2.2	46.5 ± 2.1	14.9 ± 0.5	2.1 ± 0.1	3.1 ± 0.1
S x H	65.1 ± 2.0	47.8 ± 2.2	15.1 ± 0.4	2.2 ± 0.1	3.2 ± 0.1
S x C	70.3 ± 2.6	52.3 ± 2.7	15.7 ± 0.7	2.3 ± 0.1	3.3 ± 0.1
18 months					
S	156.8 ± 3.2	125.7 ± 3.3	26.9 ± 0.8	4.2 ± 0.1	4.7 ± 0.1
S x H	164.0 ± 3.7	135.2 ± 3.6	25.1 ± 0.7	3.9 ± 0.1	5.4 ± 0.1
S x C	183.9 ± 4.4***	152.4 ± 4.2***	27.2 ± 1.0	4.3 ± 0.1	5.6 ± 0.1

Table 2
The morphological composition of the semi-carcasses
of the experimental animals, (X ± SX)

Thus, the share of the meat part increased with the growth of the animals, while the share of bones and tendons in the carcass decreased. The Simmental bull calves in all age periods in terms of the meat parts growth intensity were inferior to the Hereford and Charolais crosses.

The meatiness coefficient (the weight of the meat cuts to the weight of the bones and cartilage ratio) in the animals in all groups increased with the age, and at the end of the experimental period, it was the highest (5.6) in the Charolais crosses, and the lowest (4.7) in the Simmental bull calves.

The most objective assessment of meat quality and its caloric value may be given by the results of chemical analysis. The data in Table 3 show that an inverse relationship exists between the content of fat and water in the meat, i.e., the moisture content in the meat of the bull calves decreases with their age. The lowest moisture content at the end of the experimental period was noted in an average meat sample from the Hereford crossbreeds. No significant age-related changes were found in the protein content in the rib eye, as well as the differences between the groups in the value of this index. In the experiment with fattening the Simmental bull calves and their Hereford and Charolais crosses, it was found that the fat content in an average meat sample increased with the age of the animals. For instance, while the fat content in an average sample of the bull calves at the age of six months was 3.62 – 4.81 %, at the age of 18 months, this value increased to 12.51 % – 16.22 %.

Group	Water	Protein	Fat	Ash
six months				
S	74.94 ± 0.97	19.23 ± 0.24	4.81 ± 0.94	1.02 ± 0.01
S x H	74.48 ± 0.92	19.36 ± 0.25	5.12 ± 0.87	1.06 ± 0.01
S x C	76.23 ± 0.86	19.18 ± 0.23	3.62 ± 0.84	0.97 ± 0.03
18 months				
S	65.43 ± 0.91	18.17 ± 0.34	15.42 ± 0.84	0.98 ± 0.03
S x H	64.65 ± 0.57	18.11 ± 0.36	16.22 ± 0.92	1.02 ± 0.02
S x C	68.22 ± 0.74	18.23 ± 0.38	12.51 ± 0.68*	1.04 ± 0.03

Table 3
Chemical composition of the average meat sample %

The Charolais bull calves from the age of six months until the end of the experimental period were inferior by the fat content in the average meat sample to their peers in the other two groups. By this indicator, the Simmental bull calves occupied an intermediate position.

In our country, preference is given to the lean meat of young animals. However, it should be noted that the existing system for assessment and classification of the animals and their carcasses does not contribute to stimulating the growth of beef production and improving its quality, since meat quality assessment usually involves the subjective principles that include the use of visual and organoleptic methods. In particular, the rate of fat deposition has been recognized as the main indicator that cannot meet the modern requirements of the consumer. In this case, the protein yield is not considered, although, from the physiology of nutrition, this particular meat component is of the greatest importance.

The yield of the main nutrients and energy in the boneless part of the carcasses is shown in Figure 1. The analysis of these age-related changes in the accumulation of the main nutrients showed that the difference between the groups in terms of the yield of food protein and chemically pure fat in the carcasses had increased significantly. For instance, in the carcasses of the six-months-old animals, the yield of protein increased 5.8 – 7.0 times, compared to the baseline. At the end of the experimental period, the gross yield of protein in the groups in the ascending number order was 45.68, 48.97, and 55.56 kg. The analysis of age-related changes in protein accumulation showed that the difference in this value between the groups up to the age of six months was insignificant, while at the end of the experimental period, it was 9.88 kg and 6.59 kg, or 21.6 % and 13.5 %.

The fat was the most intensively accumulated in the bodies of the Hereford crosses, and this value at the age of 18 months was higher by 5.1 kg and 5.63 kg.

Thus, by the end of the experimental period, the highest amount of protein (55.56 kg) had been obtained from the crossbred Charolais bull calves, and the highest amount of fat (43.86 kg) — from the Hereford crosses.

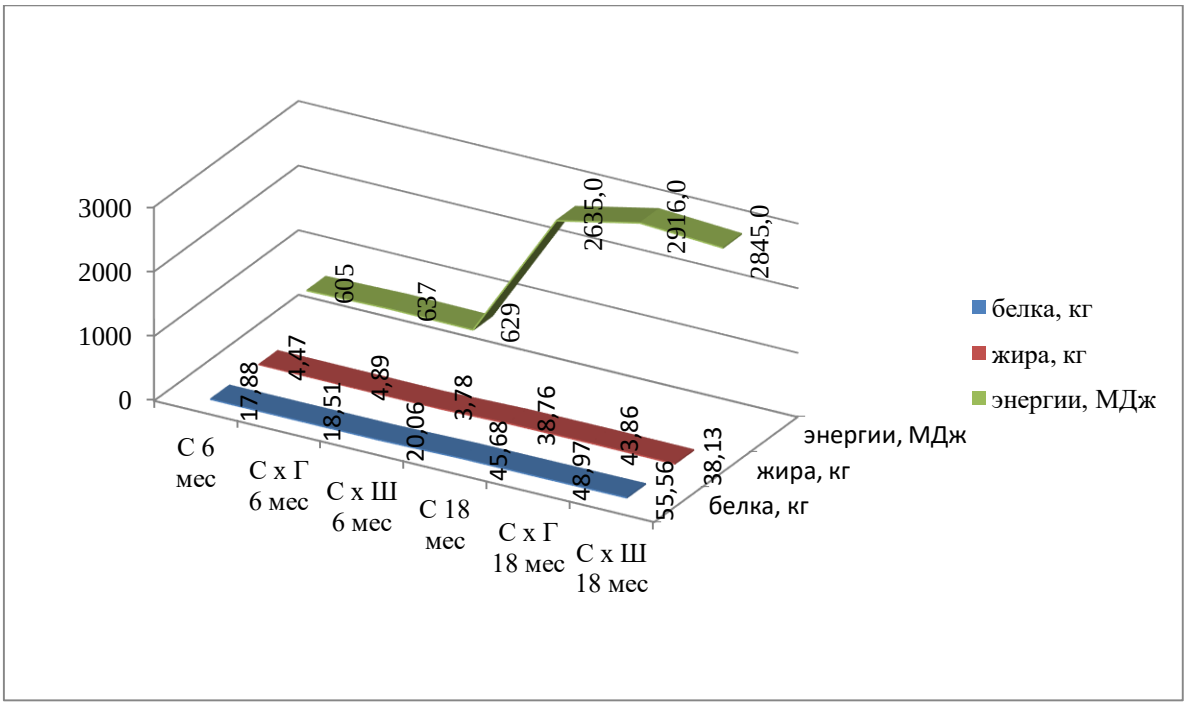

Figure 1
The content of protein, fat, and energy in the boneless part of the carcass

The analysis of the data about the age-related changes in the accumulation of the essential nutrients per 1 kg of the live weight showed that the difference between the groups in terms of the dietary protein and the fat yield in the carcasses remained the same. For instance, the highest protein yield at the age of six months was obtained from the crossbred bull calves (SxH) and (SxC) – 75 g per 1 kg of the live weight. At the age of 18 months, the highest fat content was obtained from the crossbred bull calves (SxC) — 74 g per 1 kg of the live weight (Fig. 2).

The yield of the protein live mass, fat, and energy per 1 kg of the live weight is shown in Figure 2

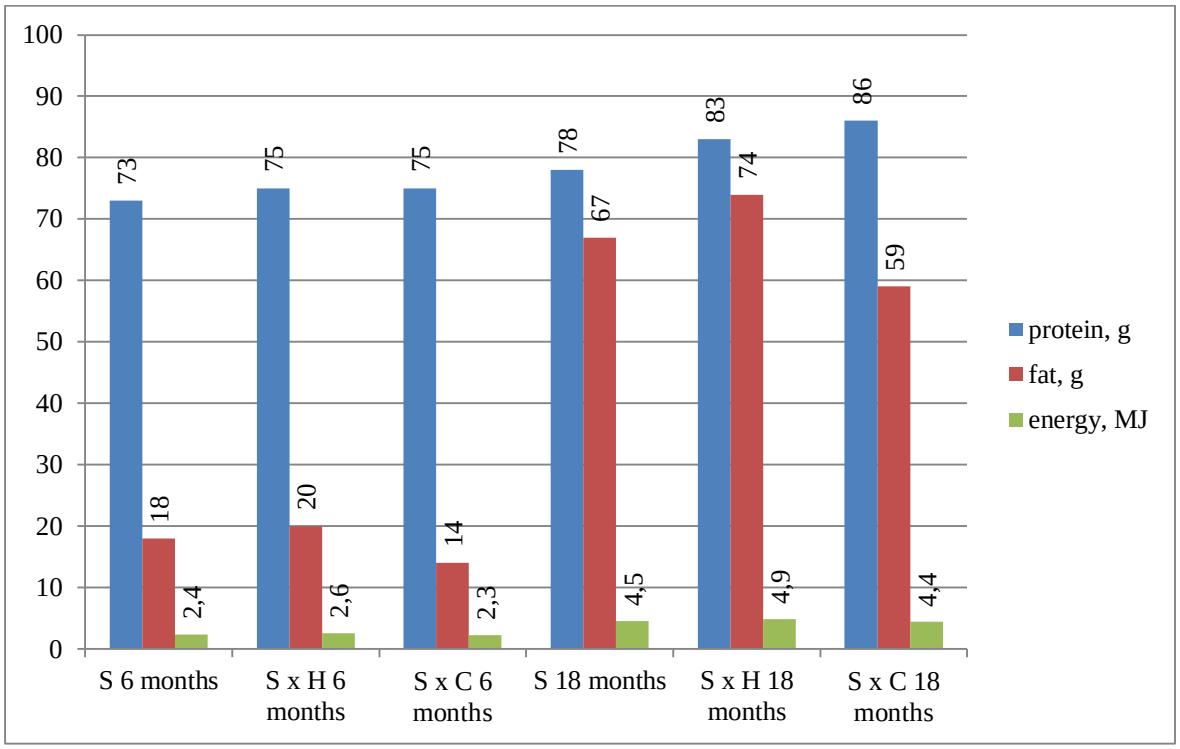

Figure 2
The yield of protein, fat, and energy per 1 kg of meat

It should be noted that the modern scientific requirements to the nutrition and the standards of the meat processing industry were satisfied by the meat of the young animals with the weight of 401 – 450 kg, the weight of steam carcasses of 220 – 230 kg, the protein to fat ratio of 1 : 0.70 – 0.75, and the gross yield of food protein and fat of 36.5 and 21.6 kg, respectively. Comparing the data about the live weight, the weight of the carcasses, protein component, and fat in the carcasses of the bull calves obtained during the experiment to the requirements and standards, it should be noted that the Simmental bull calves and the Hereford and Charolais crosses at the age of 18 months reached the required beef quality after intensive growing and fattening.

Conclusion

To increase beef production and improve its quality in the area of dairy cattle breeding, it is recommended to cross the Simmental cows with the Hereford and Charolais beef bulls using intensive technologies of growing and fattening the crossbred bulls.

The economic efficiency of growing and fattening the purebred and the crossbred bull calves until the age of 18 months has been calculated based on the feed consumption and their cost, as well as on the sales prices at the time of the animals slaughtering. The calculations show that the profit from fattening and selling the Simmental and the crossbred Hereford and Charolais bull calves amounted to 17.3, 43.2, and 45.9 dollars per 100 kg of the live weight, respectively.

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