Genotype Influence on the Consumption and Use of Fodder Nutrients by Pure-Breed and Cross-Breed Bull Calves

Tursun Satymbaevich Kubatbekov[1], Vladimir Ivanovich Kosilov[2], Ekaterina Olegovna Rystsova[3], Marina Vladimirovna Bolshakova[3], Anna Valievna Tadzhieva[3], Evgeniya Igorevna Simonova[3]

[1]Department of Morphology and Veterinary Sciences, Russian State Agrarian University – Moscow Timiryazev Agricultural Academy, Russia;

[2]Department of Production Technology and Processing of animal origin produce, Orenburg State Agrarian University, Russia;

[3]Department of Veterinary Medicine, Peoples' Friendship University of Russia, Russia

Keywords: *Simmentals, crossbred bulls, Russian Black Pied cattle, nutrients, consumption*

Abstract. *The research was conducted to assess the positive influence of the bull calf genotypes on nutrient use efficiency in their diet to increase meat productivity. The aim of this study was to perform an analysis of the efficiency of consumption and use of nutrients in the diet by purebred Simmental calves and their first-generation crosses (F1) with Red Steppe and Russian Black Pied cattle.*

The results of the study show that crossbred bulls ½ Simmental x ½ Russian Black Pied cattle exceeded thoroughbred calves of the same age of the Simmental breed and crossbred youngsters ½ Simmental x ½ Red Steppe breed in terms of nutrient consumption by 8.4-1030.5 g (2.0–11.70%), the amount of digested nutrients by 10.7–948.7 g (3.5–16.0%) and the value of the digestibility coefficient by 0.28–3.24%. Crossbred calves ½ Simmental x ½ Red Steppe breed showed minimal differences in the analyzed indicators. This study shows that the targeted selection of animals from different breeds for crossbreeding results in better nutrient intake and productivity, which opens new perspectives for the meat industry.

Introduction

Currently, there is a shortage of meat production, especially beef production, in the Russian Federation. It is necessary to develop and implement a program for the accelerated development of cattle breeding to fulfill the missing amounts of meat (Sedykh, 2018) to solve this problem. Therefore, the industry's primary direction is the rational use of genetic resources in Russian selection (Kayumov, 2019). In the Russian Federation, the foremost amounts of beef are obtained from the rearing of the super-replaced young herd and rejected animals from the main herds of dairy and mixed breeds such as Red Steppe, Russian Black Pied cattle, and Simmental.

Recently, the breeders have paid much attention to the Simmental cattle breed. The performance potential of the Simmental fattening bulls has been improved by selective breeding during the past decades, resulting in changes in fattening and slaughter traits of bulls (Honig, 2020). This breed has plenty of economically useful qualities, such as a high level of meat productivity and others. Simultaneously, the valuable properties of the Simmental animals are inherited not only during purebred breeding but also during crossbreeding (D'Occhio, 2019).

The purpose of this study was to assess the efficiency of consumption and use of nutrients in the diet by purebred Simmental calves and their first-generation crosses (F1) with Red Steppe and Russian Black Pied cattle.

Correspondence to Ekaterina Olegovna Rystsova, Department of Veterinary Medicine, Peoples' Friendship University of Russia, Miklukho-Maklaya, 8/2, 117198, Moscow, Russia.
E-mail: rystsova-eo@rudn.ru

Materials and Methods

The studies were carried out in 2016–2018 in the Limited liability company (LLC) "Zailechye" in the Orenburg region. During this scientific experiment, three groups of 6-month-old bulls (15 animals in each group) were formed according to the following genotypes: group I – Simmental breed, group II – ½ Simmental x ½ Red Steppe, and group III – ½ Simmental x ½ Russian Black Pied cattle.

Animals in the groups differed only in the breed. Other indicators such as age and weight were balanced in all three groups and did not significantly differ.

Throughout the experiment, young animals were kept at the feedlot under year-round stall maintenance. The conditions of keeping and feeding corresponded to the Russian Federation's standards and were the same for all three groups (GOST 32855-2014 Requirements in raising and feeding cattle young livestock for meat production food-stuffs for children. Standard technological process). Feed consumption was promoted monthly for two adjacent days according to the difference in the mass of the given feed and uneaten residues. Young animals of all groups were provided with a complete, balanced feeding, which contributed to the manifestation of the genetic potential of meat productivity.

During the balance (physiological) experiment, feed consumption was assessed daily for three animals from the group. The consumption and use of nutrients were determined according to the balanced

experiment results, considering the diet's chemical composition. Three animals were selected from each group, composing balanced groups according to the principle of a mini-herd (from each already formed group of 15 animals, three bulls were selected, only for the balanced experiment) to carry out digestibility balance experiments, since they are costly.

The data were proceeded using the Statistica Statgraf software package. Arithmetic means with standard deviations are presented in Tables 1–3. The Student's t-test compared the mean values for independent variables (Tables 1–2). The significance of differences between means was reported at P 0.01 and P 0.05. In the physiological experiment, the number of animals was reduced. Only this experiment was conducted using the mini-herd principle due to the high complexity and cost of this study. It was not possible to carry out an accurate statistical analysis due to the small amount of data. However, it is planned to repeat this experiment with more animals in the future.

Results

The analysis results in the balanced experiment show the influence of genotype on the consumption of individual nutrients in the diet (Table 1).

The leading position in the consumption of all types of feed nutrients was occupied by crossbred bulls (½Simmental x ½ Russian Black Pied cattle.) of group III. Purebred bulls of the Simmental breed (group I) and their first-generation crossbreds (½ Simmental x ½ Red Steppe) of group II were inferior to them in dry matter consumption by 200.0 g (2.1%, P < 0.05) and 1030.0 g (11.7%, P < 0.01), organic matter by 189.4 g (2.1%, P < 0.05) and 968.6 g (11.6%), crude protein by 24.6 g (2.1%) and 126.7 g (11.7%, P < 0.01), crude fat by 8.4 g (2.0%, P < 0.05) and 43.2 g (11.6%, P < 0.01), crude fiber by 44.8 g (2.1%, P < 0.05) and 230.7 g (11.7%, P < 0.01), and nitrogen-free extractive substances (NFE) by 111.6 g (2.1%, P < 0.05) and 568 g (11.6%, P < 0.01).

Crossbred calves (½ Simmental x ½ Red Steppe) of group II showed the smallest consumption of all types of nutrients in feed. Purebred calves of the Simmental breed of group I surpassed them in dry matter consumption by 830.0 g (9.4%, P < 0.01), organic matter by 779.2 g (9.3%, P < 0.01) , crude protein by 102.1 g (9.4%, P < 0.01), crude fat by 34.8 g (9.3%, P < 0.05), crude fiber by 185.9 g (9.4%, P < 0.01), nitrogen-free extractives (NFE) by 456.4 g (9.3%, P < 0.01). It is known that nutrients received from food are digested and absorbed only partially. Then they are included in metabolic processes taking place in the animal's body. Undigested nutrients are excreted in the feces (Van Gastelen, 2019).

It should be taken into account that the efficiency of digestion of feed nutrients is significantly influenced by a complex of factors, both phenotypic and genotypic (Oss, 2017). This is confirmed by our study results, which show the influence of calf genotype in the experimental groups on the digestibility of nutrients (Table 2).

At the same time, the crossbred bulls (½ Simmental x ½ Russian Black Pied cattle) of group III showed the maximum amount of digested substances. They surpassed the purebred peers of the Simmental breed of group I and crossbred young animals (½ Simmental x ½ Red Steppe) of group II in terms of the amount of digested dry matter, respectively, by 244.8 g (3.7%, P < 0.05) and 948.7 g (16.0%, P < 0.01), or-

Table 1. Amount of nutrients taken with feed by experimental young animals (on average for one animal per day), g

Characteristic	Group						Significance		
	I		II		III		I and II	I and III	II and III
	Statistical indicator								
	X ± Se	Cv	X ± Se	Cv	X ± Se	Cv			
Dry matter	9662.5 ± 56.42	2.14	8832.5 ± 52.34	2.02	9862.5 ± 64.21	2.16	**	*	**
Organic matter	9102.1 ± 46.46	2.01	8322.9 ± 47.12	2.14	9291.5 ± 52.19	2.33	**	*	-
Crude protein	1188.5 ± 15.64	1.88	1086.4 ± 14.21	1.7	1213.1 ± 15.92	1.88	**	-	**
Crude fat	405.8 ± 4.81	2.1	371.0 ± 4.24	1.66	414.2 ± 5.12	2.18	*	*	**
Crude fiber	2164.4 ± 29.22	3.14	1978.5 ± 28.06	3.01	2209.2 ± 30.01	3.23	**	*	**
NFE	5343.4 ± 34.11	3.2	4887.0 ± 36.18	3.32	5455.0 ± 38.71	3.31	**	*	**

*Mean values in rows differ at P ⩽ 0.05; ** Mean values in rows differ at P ⩽ 0.01.
«-» inaccurate data. X – mass (g); Se – standard error; Cy – digestibility coefficient (%)

Table 2. The number of nutrients digested by the experimental young animals (on average per one animal per day), g

Characteristic	Group						Significance		
	I		II		III		I and II	I and III	II and III
	Statistical Indicator								
	X ± Se	Cv	X ± Se	Cv	X ± Se	Cv			
Dry matter	6632.3 ± 40.31	1.3	5928.4±39.61	1.22	6877.1 ± 41.62	1.33	***	*	**
Organic matter	6424.3 ± 28.16	1.16	5762.8 ± 24.84	1.08	6610.0 ± 26.23	1.1	***	*	***
Crude protein	801.2 ± 6.28	1.9	719.5 ± 5.85	1.88	832.6 ± 6.18	1.82	**	**	***
Crude fat	293.6 ± 4.13	2.16	260.6 ± 3.09	2.04	304.3 ± 3.21	2.1	***	**	***
Crude fiber	1225.9 ± 17.42	2.33	1095.3 ± 15.21	2.1	1268.5 ± 19.43	2.52	**	**	***
NFE	4103.6 ± 28.12	1.9	3,687.4 ± 26.21	1.81	4204.6 ± 29.32	2.02	**	*	**

*Mean values in rows differ at P ⩽ 0.05; **Mean values in rows differ at P ⩽ 0.01.
***Mean values in rows differ at P ⩾ 0.001.
X – mass (g); Se – standard error; Cy – digestibility coefficient (%).

ganic matter by 186.0% g (2.9%, P < 0.05) and 847.2 g (14.7%, P < 0.001), crude protein by 31.4 g (3.9%, P < 0.01) and 113.1 g (15.7%, P < 0.001), crude fat by 10.7 g (3.6%, P < 0.01) and 43.7 g (16.8%, P < 0.001), crude fiber by 42.9 g (3.5%, P < 0.01) and 173.2 g (15.8%, P < 0.001), and nitrogen-free extractives (NFE) by 101.0 g (2.5%, P < 0.05) and 517.2 g (14.0%, P < 0.01).

Purebred bulls of the Simmental breed of group I surpassed the crossbred bulls (½ Simmental x ½ red steppe) of group II in terms of the amount of digested dry matter by 703.9 g (11.9%, P < 0.001), organic matter by 661.5 g (11.5%, P < 0.001), crude protein by 81.7 g (11.4%, P < 0.01), crude fat by 33.0 g (12.7%, P < 0.001), crude fiber by 130.6 g (11.9%, P < 0.01), and nitrogen-free extractives (NFE) by 416.2 g (11.3%, P < 0.01).

In the process of digestion of nutrients in the gastrointestinal tract of animals, they undergo significant structural changes. At the same time, they acquire the ability to take part in metabolic processes and the formation of organs and tissues.

The value of the digestibility coefficient characterizes the diet effectiveness in the animal's body, expressed as a percentage. Moreover, in certain types of nutrients, its level has significant differences. Besides, the value of the digestibility coefficient depends on the genetic characteristics of animals. This position is confirmed by the results of our research (Table 3).

The leading position in terms of the digestibility coefficient of all types of nutrients of the ration was occupied by crossbred bulls (½ Simmental x ½ Russian Black Pied cattle) of group III. Their advantage over purebred animals of the Simmental breed of group I and crossbred young animals (½ Simmental x ½ Red Steppe) of group II in terms of the digestibility coefficient was as follows: 1.09% and 2.61%, respectively, for dry matter; 0.56% and 1.90% for organic matter; 1.22% and 2.40% for crude protein; 1.12% and 3.24% for crude fat; 0.78% and 2.06% for crude fiber; and 0.28% and 1.63% for nitrogen-free extractive substances (NFE). Crossbred animals (½ Simmental x ½ Red Steppe) of group II slightly differed in the digestibility coefficient in all

Table 3. Digestibility coefficients by experimental young animals, %

Characteristic	Group					
	I		II		III	
	Statistical indicator					
	X ± Se	Cv	X ± Se	Cv	X ± Se	Cv
Dry matter	68.64 ± 0.12	0.30	67.12 ± 0.14	0.31	69.73 ± 0.17	0.36
Organic matter	70.58±0.24	0.81	69.24 ± 0.25	0.84	71.14 ± 0.23	0.80
Crude protein	67.41 ± 0.15	0.43	66.23 ± 0.12	0.40	68.63 ± 0.16	0.45
Crude fat	72.35 ± 0.22	2.30	70.23 ± 0.21	2.26	73.47 ± 0.24	2.33
Crude fiber	56.64 ± 0.30	1.33	55.36 ± 0.26	1.30	57.42 ± 0.29	1.30
NFE	76.80 ± 0.31	1.26	75.45 ± 0.28	1.23	77.08 ± 0.34	1.30

*X – mass (g); Se – standard error; Cy – digestibility coefficient (%).

types of nutrients. They were inferior to the purebred animals of the Simmental breed of group I in terms of the analyzed indicator to dry matter by 1.52%, organic matter by 1.34%, crude protein by 1.18%, crude fat by 2.13%, crude fiber by 1.28%, and nitrogen-free extractive substances (NFE)- by 1.35%.

Discussion and Conclusions

Animals receive nutrients with the consumption of feed, which contributes to the vital activity of their body. Nutrients entering the animal's body with feed become material for organ and tissue development and involve in all body metabolic processes (Broadhead et al., 2019).

In this study, the leading position in the consumption of all types of feed nutrients was occupied by crossbred bulls (½ Simmental x ½ Russian Black Pied cattle) of group III.

Crossbreeding is an up-and-coming method in animal husbandry. Crossbred bulls result in better nutrient intake and productivity, which opens new perspectives for the meat industry (Van Raden, 2020). The use of beef breed sires, especially of late-maturing breeds, in dairy herds improves the carcass characteristics and carcass gain of the slaughtered progeny, most noticeable in young bulls (Eriksson, 2020).

Three breed-sex types of cattle were examined within a similar study for their growth performance and carcass quality in an organic production setting (Murphy, 2017, 2018). It was concluded that combined use of genetically superior crossbred beef breed x Holstein bulls and heifers may be an alternative to purebred Holstein bulls in organic beef production of young cattle because of their improved carcass weight and carcass conformation, similar growth performance and lower total feed intake (Vestergaard, 2019).

In this study, young bulls of all experimental groups were distinguished by a high level of consumption and use of nutrients. However, the leading position was occupied by the first generation crossbred animals of Simmentals with Russian Black Pied cattle.

References

1. Broadhead D., Mulliniks T.J., Funston R.N. Developmental Programming in a Beef Production System. Veterinary Clinics of North America: Food Animal Practice. 2019. T. 35. P. 379-390.
2. D'Occhio M.J., Baruselli P.S., Campanile G. Influence of nutrition, body condition, and metabolic status on reproduction in female beef cattle: A review. Theriogenology. 2019. T.125. P.277-284.
3. Eriksson S., Ask-Gullstrand P., Fikse W.F., Jonsson E., Eriksson J-A., Stalhammar H., Wallenbeck A., Hessle A. Different beef breed sires used for crossbreeding with Swedish dairy cows - effects on calving performance and carcass traits. Livestock Science. 2020. T. 232. 103209.
4. GOST (Russian National Standard) 32855-2014. Requirements in raising and feeding of cattle young livestock for the production of meat food-stuffs for children. Standard technological process. Standartinform. 2019. P. 1-15.
5. Honig A. C., Inhuber V., Spiekers H., Windisch W., Götz K-U., Ettle T. Influence of dietary energy concentration and body weight at slaughter on carcass tissue composition and beef cuts of modern type Fleckvieh (German Simmental) bulls. Meat Science. 2020. T. 169. 108209.
6. Kayumov F.G., Kosilov V.I., Gerasimov N.P., Bykova O.A. The effect of SNP polymorphisms in growth hormone gene on weight and linear growth in crossbred red Angus × Kalmyk heifers. Digital agriculture - development strategy Proceedings of the International Scientific and Practical Conference (ISPC 2019). Advances in Intelligent Systems Research. 2019. P. 325-328.
7. Oss D.B., Machado F.S., Tomich T.R., Pereira L.G.R., Campos M.M., Castro M.M.D., Da Silva T.E., Marcondes M.I. Energy and protein requirements of crossbred (Holstein × Gyr) growing bulls. Journal of Dairy Science. 2017. T. 100 N.4. P. 2603-2613.
8. Morales R, Phocas F, Solé M, Demyda-Peyrá S., Menéndez-Buxadera A., Molina A. Breeding beef cattle for an extended productive life: Evaluation of selection criteria in the Retinta breed. Livestock Science. 2017. T. 204. P. 115-121.
9. Murphy, B., Crosson, P., Kelly, A.K., Prendiville, R. Animal performance and economic implications of alternative production systems for dairy bulls slaughtered at 15 months of age. Irish J. Agric. Food Res. 2017. T. 56. P. 93–103.
10. Murphy, B., Kelly, A., Prendiville, R. Alternative finishing strategies for Holstein- Friesian bulls slaughtered at 15 months of age. Agric. Food Sci. 2018. T. 27. P. 28–37.
11. Schwarz, F.J., Röpke, R., Schams, D., Kirchgessner, M. Effects of sex and growth on plasma concentrations of growth hormone, insulin-like growth factor-I and insulin in fattening Simmental cattle. J. Anim. Physiol. Anim. Nutr. 1992. T. 68. P. 263–271.
12. Sedykh T.A., Gizatullin R.S., Kosilov V.I., Chudov I.V., Andreeva A.V., Giniyatullin M.G., Islamova S.G., Tagirov Kh. Kh., Kalashnikova L.A. Adapting Australian Hereford cattle to the conditions of the southern Urals. Research Journal of Pharmaceutical, Biological, and Chemical Sciences. 2018. T. 9. No 3. P. 885-898.
13. Van Gastelen S., Dijkstra J., Bannink A. Are dietary strategies to mitigate enteric methane emission equally effective across dairy cattle, beef cattle, and sheep? Journal of Dairy Science. 2019. T. 102. N. 7. P. 6109-6130.
14. Van Raden P.M., Tooker M.E., Chud T.C.S., Norman H.D., Megonigal J.H., Haagen I.W., Wiggans G.R. Genomic predictions for crossbred dairy cattle. Journal of Dairy Science. 2020. T. 103. N. 2. P. 1620-1631.
15. Vestergaard M., Jørgensen K.F., Çakmakçı C., Kargo M., Therkildsen M., Munk A., Kristensen T. Performance and carcass quality of crossbred beef x Holstein bull and heifer calves in comparison with purebred Holstein bull calves slaughtered at 17 months of age in an organic production system. Livestock Science. 2019. T. 223. P.184-192.

Received 20 October 2020
Accepted 15 December 2020