J Biochem Technol (2021) 12(3): 22-26
https://doi.org/10.51847/AA7Njkgsc8
ISSN: 0974-2328

The Impact of Steer Genotype on Protein and Mineral Metabolism

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Received: 06 May 2021 / Received in revised form: 20 July 2021, Accepted: 02 August 2021, Published online: 22 August 2021

Abstract

It is necessary to develop and implement wide zootechnical practice techniques and methods that allow more fully realizing the genetic potential of meat productivity of fattening young animals. In this paper, the authors study the features of nitrogen exchange and calcium and phosphorus balance in steers of the Simmental breed and its first-generation crossbreds with red steppe and black-motley cattle. The impact of steer genotype on the efficiency of fodder nitrogen use on protein synthesis in muscular tissue was noted. The coefficient of utilization of nitrogen from consumed fodder in bulls of group I was 17.70% and from digested — 26.23%, in group II — 16.79% and 25.35%, and in group III — 18.06% and 26.32%, respectively. Similar intergroup differences were established for calcium and phosphorus balance. The calcium utilization rate of groups I, II, and III was 42.16%, 40.79%, and 42.39%, and the phosphorus utilization rate was 40.63%, 40.06%, and 41.18%, respectively.

Keywords: Cattle breeding, Steers, Simmentals, Nitrogen, Calcium, Phosphorus

Introduction

The most acute and urgent problem in the Russian Federation is the task of increasing meat production and, above all, beef production. This is so because the nutrients contained in beef are indispensable for a complete and well-balanced human diet (Leonid *et al.*, 2020). The difficulty in solving this problem is due to the insufficient number of cattle in the country, especially animals of specialized meat breeds. In this regard, the main contingent of the fattening herd is the over-reproduced young stock of dairy and combined breeds and the breeding stock that has been removed for various reasons from the main herd (Kosilov *et al.*, 1997; Kosilov *et al.*, 2006; Nikonova *et al.*, 2014; Speshilova *et al.*, 2014; Kharlamov *et al.*, 2015; Bozymov *et al.*, 2016).

Crossbreeding is a promising breeding technique that, if successfully selected, can significantly increase the level of meat productivity of young animals. In this respect, the Simmental breed has recently attracted the attention of breeders. Animals of this breed have a high level of meat productivity and pass this trait to their offspring in crossbreeding (Zadnepryanskii *et al.*, 2012; Kosilov *et al.*, 2017; Vil'ver *et al.*, 2017; Mironova *et al.*, 2018; Kayumov *et al.*, 2019).

The effect of crossbreeding on meat production can only be seen if a full, balanced feed is provided to the crossbreds. This can be monitored by determining the balance of nutrients and minerals in the body of fattened young animals (Kosilov *et al.*, 1997; Kosilov *et al.*, 2006; Zadnepryanskii *et al.*, 2012; Nikonova *et al.*, 2014; Speshilova *et al.*, 2014; Bozymov *et al.*, 2016; Kosilov *et al.*, 2017; Vil'ver *et al.*, 2017; Fatkullin *et al.*, 2018; Mironova *et al.*, 2018; Sedykh *et al.*, 2018; Kayumov *et al.*, 2019; Tyulebaev *et al.*, 2019; Nagdalian *et al.*, 2020).

Materials and Methods

To solve this problem, we formed three groups of 6-month-old steers with 15 animals in each group: group I — Simmental, group II — ½ Simmental × ½ red steppe, and group III — ½ Simmental × ½ black-motley.

The balance of nitrogen, calcium, and phosphorus was determined by a physiological (balance) experiment at 12 months.

Results and Discussion

No substance of biological origin is known to have such an important physiological significance and such a complex of important functions in the vital functions of the organism as proteins. Protein metabolism underlies all the vital processes of the body. On entering the gastrointestinal tract, the proteins of the diet fodder are broken down by the enzymes of the gastric juice into simpler substances, polypeptides, and amino acids. These simple

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substances are transported with the bloodstream to all organs and tissues. Eventually, they are directly involved in the synthesis of proteins and other compounds, in particular, biologically active substances (enzymes, antibodies, and hormones).

When assessing the efficiency of metabolism in young animals of different genotypes, two interrelated questions are addressed: what is the certain mass of protein required by the animal and what types of proteins ensure normal functioning of the organism and contribute to a fuller realization of the genetic potential of meat productivity.

Due to the fact that nitrogen is the main protein structure, a nitrogen balance is calculated to study the nature and intensity of protein metabolism in animals. This is determined by measuring the difference between the amount of nitrogen consumed by an animal with the proteins in its diet and the mass of nitrogen excreted by the body in feces and urine.

This describes the biological adequacy of the feed fed to the animal and is largely an indication of the degree of nitrogen utilization. In growing and fattening animals, the amount of nitrogen deposited in the body can indicate the intensity of growth.

The analysis of the data shows the influence of the genotype of steers on nitrogen intake with feed **(Table 1)**. The maximum value of the analyzed index was observed in crossbred steers (½ Simmental × ½ black-motley) of group III. The purebred steers of the Simmental breed of group I and crossbred youngsters (½ Simmental × ½ red steppe) of group II were 3.94 g (2.07%, P<0.05) and 20.28 g (11.67%, P<0.001) less by the amount of nitrogen consumed by them.

Table 1. Nitrogen balance of test steers (average per animal), g

Index	Group					
	I		II		III	
	index					
	$\bar{x} \pm S\bar{x}$	Cv	$\bar{x} \pm S\bar{x}$	Cv	$\bar{x} \pm S\bar{x}$	Cv
Received with fodder	190.16±1.90	1.50	173.82±2.01	1.55	194.10±2.12	1.58
Excreted in the faeces	61.97±1.33	2.40	58.70±1.44	2.36	60.88±1.50	2.23
Digested	128.19±1.02	1.88	115.12±1.18	1.90	133.22±1.21	6.71
Excreted with urine	94.56±1.12	1.70	85.94±1.36	1.81	98.16±1.43	7.56
Collected in the body	33.63±1.16	1.33	29.18±1.28	1.42	35.06±1.30	7.30
Utilization factor, %						
from ingested	17.70		16.79		18.06	
from digested	26.23		25.35		26.32	

The purebred steers of the Simmental breed of group I excelled their crossbred peers (½ Simmental × ½ red steppe) of group II by 16.34 g (9.4%, P<0.001).

As for the excretion of nitrogen with feces, the highest rate was in purebred steers of the Simmental breed of group I, the lowest — in mixed (½ Simmental × ½ red steppe) of group II, mixed youngsters (½ Simmental × ½ black-motley) of group III, the lowest rate was in mixed males (½ Simmental × ½ red steppe) of group II.

The effect of steers' genotype on nitrogen digestibility was also established. At the same time, there was an advantage of crossbred steers (½ Simmental × ½ black-motley) of group III. The purebred steers of the Simmental breed of group I and crossbred youngsters (½ Simmental × ½ red steppe) of group II were inferior to them in the mass of digested nitrogen by 5.03 g (3.92%, P<0.05) and 18.10 g (15.72, P<0.001).

Similar intergroup differences were found in the weight of nitrogen deposited in the body. It should be noted that crossbred steers (½ Simmental × ½ black-motley) of group III were superior to purebred peers of the Simmental breed of group I and crossbreds (½ Simmental × ½ red steppe) of group II in the amount of nitrogen deposited in the body by 1.43 g (4.25%, P<0.05) and 5.88 g (20.15%, P<0.01) respectively.

Characteristically, the minimum mass of digested and deposited nitrogen in the body differed in the crossbreds (½ Simmental × ½ red steppe) of group II. They were inferior to purebred Simmental breed peers of group I in the value of the first parameter by 13.07 g (11.35%, P<0,001), the second by 4.45 g (15.25%, P<0.05).

Intergroup differences in the amount of nitrogen consumed and digested influenced the value of the coefficient of its use for meat production synthesis. The advantage in its level was on the side of the crossbred young cattle (½ Simmental × ½ black-motley) of group III. Purebred steers of the Simmental breed (group I) and crossbred (½ Simmental × ½ red steppe) of group II were inferior to them by values of nitrogen use factor from ingested by 0.36% and 1.27% and from digested by 0.09% and 0.97% respectively. The lowest value of the analyzed indices was in the crossbred (½ Simmental × ½ red steppe) of group II.

The crossbred of this genotype were inferior to purebred peers of Simmental breed of group I in terms of nitrogen utilization factor from ingested (taken with fodder) by 0.91%, from digested — by 0.88%.

The organization of mineral nutrition of fattening animals is of great importance among a complex of paratypical factors characterizing and influencing the completeness of cattle feeding. The non-organic part of fodder, which includes various minerals, although it has no nutritional and energy value, plays an essential role in the vital activity of the animal's organism.

Minerals are the plastic material for the formation of various structural elements and, above all, the musculoskeletal system. They are also a part of enzymes, hemoglobin, phosphatides, nucleoproteins, and another wide range of organic compounds. Minerals are also directly involved in the processes of digestion and assimilation of fodder nutrients and energy, regulation of the osmotic pressure, and the maintenance of the acid-base balance in the animal's body.

Calcium and phosphorus play a special role in the large group of macronutrients that enter the animal's body with fodder, and there is a close relationship between them in the process of metabolism.

During our research, the diets of steers of the experimental groups were balanced in terms of mineral composition and fully provided the young animals with calcium and phosphorus, the balance of which in the body of animals was positive. This indicates the absence of any disorders in mineral metabolism in the body of experimental young animals. At the same time, the effect of the genotype of steers on the balance of calcium and phosphorus in their bodies was noted **(Table 2)**.

The maximum intake of calcium with fodder was observed in crossbred steers (½ Simmental × ½ black-motley) of group III. They surpassed purebred steers of the Simmental breed of group I and young cattle (½ Simmental × ½ red steppe) of group II by 2.00 g (3.67%, $P<0.05$) and 4.46 g (8.58%, $P<0.01$). The lowest calcium intake was in the crossbreds (½ Simmental × ½ red steppe) of group II. They were inferior to purebred Simmental breed peers of group I by 2.46 g (4.73%, $P<0.05$).

There were no statistically significant intergroup differences in calcium excretion with feces and urine. There was also an intergroup difference in the deposition of calcium in the body of steers.

Table 2. The average daily calcium and phosphorus balance of test steers (average per animal), g

Index	Group					
	I		II		III	
	index					
	$\bar{x} \pm S\bar{x}$	Cv	$\bar{x} \pm S\bar{x}$	Cv	$\bar{x} \pm S\bar{x}$	Cv
Calcium						
Received with fodder	54.43±0.12	1.08	51.97±0.14	1.12	56.43±0.18	1.40
Excreted: in the faeces	31.14±0.16	1.14	30.66±0.18	1.18	32.15±0.22	1.23
with urine	0.34±0.08	1.10	0.31±0.11	1.22	0.36±0.10	1.20
total	31.48±0.26	1.22	30.97±0.32	1.40	32.51±0.38	1.38
Deposited in the body	22.95±0.14	2.04	21.00±0.16	2.10	23.92±0.21	1.90
Utilization factor, %	42.16		40.40		42.39	
of ingested						
Phosphorus	32.51±0.16	1.33	31.56±0.18	1.41	33.24±0.20	1.43
Received with fodder	17.22±0.11	1.42	16.90±0.19	1.55	17.41±0.20	1.64
Excreted: in the feces	2.08±0.07	1.12	2.02±0.10	1.30	2.14±0.11	1.29
with urine	19.30±0.13	2.40	18.92±0.16	2.38	19.55±0.15	2.26
total	13.21±0.18	1.31	12.64±0.20	1.35	13.69±0.19	1.38
Deposited in the body	40.63		40.05		41.18	

The leading position by this characteristic was occupied by crossbred steers (½ Simmental × ½ black-motley) of group III. The purebred young animals of the Simmental breed of group I and crossbred young animals (½ Simmental × ½ red steppe) of group

II were inferior to them by 0.97 g (4.23%, P<0.05) and 2.92 g (13.90%, P<0.01) in calcium content in the body.

In their turn, steers of the Simmental breed of group I surpassed their crossbred peers (½ Simmental × ½ red steppe) of group II with 1.95 g (9.29%, P<0.05).

Intergroup differences in the mass of calcium entering steers with fodder and its amount deposited in the body have caused an unequal rate of nitrogen use from accepted in young steers of different genotypes. The crossbred steers (½ Simmental × ½ black-motley) of group III were superior to their peers of Simmental breed of group I and crossbred youngsters (½ Simmental × ½ red steppe) of group II according to the value of the analyzed indicator by 0.23% and 1.99% respectively. The crossbred (½ Simmental × ½ red steppe) of group II was inferior in the value of the coefficient of use of calcium from the taken with fodder by 1.76%.

The analysis of phosphorus balance in steers of experimental groups revealed the same pattern as in calcium balance. The steers of crossbred bulls (½ Simmental × ½ black-motley) of group III were superior to their purebred peers of Simmental breed and crossbred young cattle (½ Simmental × ½ red steppe) of group II by mass of phosphorus entering the body with feed by 0.73 g (2.25%, P<0.05) and 1.68 (5.32%, P<0.05), deposited in the body — 0.48 g (3.63%, P<0.05) and (8.31%, P<0.01), and the value of phosphorus utilization ratio from entering into the body with fodder (taken) — 0.55% (P<0.05) and 1.13% (P<0.05).

The minimum value of the analyzed indicators was observed in crossbred steers (½ Simmental × ½ red steppe) of group II. They were inferior to purebred Simmental breeds of group I in the mass of phosphorus taken with fodder by 0.95 g (3.01%, P<0.05), in the amount deposited in the body by 0.57 g (4.51%, P<0.05), and in phosphorus utilization rate from phosphorus taken with fodder by 0.58 g (1.45%, P<0.05).

There were no statistically significant intergroup differences in the amount of phosphorus excreted by steers of the experimental groups with feces and urine.

Conclusion

Steers of all genotypes had high levels of protein and mineral metabolism, as evidenced by the balance of nitrogen, calcium, and phosphorus. The crossbred (½ Simmental × ½ black-motley) steers of group III were more efficient in using them.

Acknowledgments: None

Conflict of interest: None

Financial support: None

Ethics statement: None

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