Fattening Bull Calves for Baby Beef for Baby Food

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Abstract. Studies have been carried out to study the meat productivity and safety of beef for the production of canned meat for baby food, obtained under conditions of environmentally friendly keeping and feeding in Bratkovsky Dairy Fattening Complex, Korenovsky District, Krasnodar Territory, the raw material zone of the Branch of Plant for Children's Canned Meat "Tikhoretsky" JSC "DANONE RUSSIA", Krasnodar Territory. The average daily gain in live weight of the experimental Simmental and Black-and-White breeds of dairy breeds for 9 months of intensive fattening was, respectively, 1050 ± 13.2 and 1024.35 ± 11.6 g. In meat bulls of Hereford and Kalmyk breeds, the average daily gain in live weight did not differ significantly from dairy breeds and amounted to 1070.95 ± 9.3 and 1097.30 ± 7.45 g, respectively. High-quality beef was obtained from bull-calves of four breeds fattened in an ecologically friendly raw material zone with a three-month intensive final fattening up to 15 months in accordance with the interstate standard. Carcasses of Simmental, Black-and-White, Hereford and Kalmyk bulls had a high biological value of meat, respectively, 87.92; 86.78; 88.56 and 87.31 g of essential amino acids per 1 kg of natural beef. The protein quality index (ratio of tryptophan to hydroxyproline) of the longissimus muscle was high and amounted to 4.8; 4.6; 5.7 and 5.5, respectively.

Keywords: Ecologically friendly raw material zone · Meat and dairy bulls · Chemical composition of the longissimus dorsi muscle · Safety of beef

1 Introduction

Improving the meat productivity and safety of beef from young bull calves of adapted breeds of dairy and beef cattle in the raw material zone for the production of canned meat for children in the Krasnodar Territory of Russia is especially important due to the growing consumer demand for baby food [1]. The baby food industry needs lean beef that is high in protein (18–20%) and low in fat (up to 10%) [2]. A large number of chemical compounds are used directly or indirectly in the production, processing and storage of meat and meat products. Even the misuse of veterinary drugs can cause the presence of toxic residues in raw meat, which can pose a serious threat [2, 3]. The environmental safety of beef depends on the purity of the soil, drinking water, plants and animal feed additives. The exclusive experience of the Tikhoretsk children's canned meat factory

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proved the impossibility of using ordinary meat due to exceeding the permissible levels of toxic substances in it. Young bulls spend less feed for live weight gain, i.e. higher feed conversion efficiency and, as a result, higher quality meat compared to those from carcasses of older animals. Thus, young fattening animals for up to 12 months require from 6.1 to 8.4 EFU, and over two years old - more than 9.5 EFU per 1 kg of live weight gain [4, 5]. Researchers do not recommend castrating bull calves intended for meat. Non-castrated bulls have good meat productivity when they are grown up to 12–15 months of age. Live weight of meat and dairy bull calves by 15 months reaches at least 450 kg in the conditions of the steppe resource zone and foothills of the Southern Federal District [6].

According to the authors, there is an additional reserve for increasing beef production by growing bulls of highly productive dairy and dairy-and-beef breeds when kept on a feed and barnyard of a summer type [18]. Bulls of Black-and-white and Simmental breeds reached a live weight of more than 480 kg by 15 months with an average daily gain of more than 850 g and feed conversion rate of 7.4–7.9 FU per 1 kg of live weight gain [7].

The authors noted the greater tenderness of the meat of 15-month-old bulls in comparison with more aged groups of animals. However, the taste and aroma were the highest in the bulls of 18 month [8].

The tenderness of meat is associated with the content of connective tissue in the muscles. In connective tissue collagen, up to 14% is accounted for by the amino acid hydroxyproline, which is absent in complete meat proteins [9].

The content of complete proteins is determined by the amount of essential amino acid - tryptophan, and the content of incomplete proteins - by the amount of hydroxyproline. The so-called protein quality index (PQI) is recommended to be determined when studying the fattening and meat qualities of young cattle. PQI is the ratio of tryptophan to hydroxyproline. Its value characterizes the completeness of meat proteins. Beef contains 14–19% protein, and PQI, according to some authors, ranges from 4.0 to 6.7 [10–12].

The solubility of collagen decreases with the age of animals. The red colour of fresh muscle tissue is associated with the presence of myoglobin in it, which, depending on its saturation with oxygen, gives the meat a red or pink colour. The dependence of the meat colour on the pH value was revealed. Meat immediately after slaughter has a pH of 5.6 and below, and after maturation for 1–2 days; it normalizes to 5.9 and above [13].

The nutritional value of beef is determined by the qualitative and quantitative chemical composition and reflects the full range of useful properties, including protein quality, energy value (carbohydrates and fats are mostly important energy components) [14].

With higher levels of protein and fat content in absolute units, the value of dry matter in the longissimus dorsi increases. Mineral substances in beef are represented by a certain qualitative and quantitative composition. In comparison with pork and lamb, it has more potassium and phosphorus, a high iron content with a higher digestibility for humans compared to iron of plant origin [15].

2 Materials and Methods

In order to maximize the biological potential of adapted breeds of fattening bulls, researches were carried out to study the meat productivity and safety of beef for the

production of canned meat for baby food, obtained under conditions of environmentally friendly keeping and feeding on the farm of Bratkovsky Dairy Fattening Complex, Korenovsky District, Krasnodar Territory, located in a raw material zone of the Branch of Plant of Children's Canned Meat "Tikhoretsky" JSC "DANONE RUSSIA".

Bulls of Simmental and Black-and-White dairy breeds were kept up to six months of age in calf houses in groups of 9 heads, from 6 to 15 months - on summer type feedlots with free range in the feed yard, indoors - with a total area of 3.5 m^2 for 1 bull, feeding front - 0.6 m per 1 head.

Beef bulls of Hereford and Kalmyk breeds were kept under specialized meat technology for up to 8 months under cows, including keeping calves in a summer type room equipped with a rest area on deep straw litter, linear feeders for hay and haylage, as well as a feeding and watering station. The calves are provided with free access to the ban and fodder yard to the nursing cows. For experimental fattening in 4 groups of six-month-old bulls of Simmental, Black-and-White and eight-month-old bulls of Hereford and Kalmyk breeds were selected according to the principle of balanced groups. Bulls were weighed at the beginning of fattening, at 12 and 15 months. Average daily gains in live weight were calculated. Live assessment of meat productivity ($n = 9$), composition and quality of carcasses and meat raw materials were carried out according to the results of the control slaughter of bulls at 15 months. (For the purposes of baby food) according to the standard method.

Determination of slaughter qualities ($n = 9$) was carried out according to the following indicators: Pre-slaughter live weight, slaughter weight, fresh carcass weight, slaughter yield, bone weight, meat weight, and visceral fat weight. To study the chemical composition, average samples of the longissimus dorsi muscle of the right half carcass of bulls were taken ($n = 9$). To determine the moisture capacity, pressing with squeezing out the juice was used.

3 Results and Discussion

The dynamics of the live weight of experimental calves of four breeds of dairy and meat productivity is presented in Table 1.

The average daily gain in live weight of experimental dairy bulls (groups 1 and 2) for 9 months of intensive fattening was, respectively, 1050.0 ± 13.2 and 1024.35 ± 11.6 g. In beef bulls of the Hereford and Kalmyk breeds (groups 3 and 4), the average daily gain in live weight did not differ significantly from groups one and 2 and amounted to 1070.95 ± 9.3 and 1097.30 ± 7.45 g, respectively.

From bulls of four breeds at 15 months. Carcasses of the first category were obtained with an average live weight of at least 420.8 ± 7.8 kg with a slaughter yield of at least 57.1% (Table 2).

The yield of carcasses without visceral fat was 54.3; 55.6; 56.5 and 56.4% for Simmental, Black-and-White, Hereford and Kalmyk breeds. The amount of visceral fat is an indirect indicator of the fatness of the animal and is 1–5% of the Pre-slaughter live weight.

The fleshing index (the ratio of the mass of beef to the inedible components of the carcass - bones and tendons) at 15 months was higher in the carcasses of Kalmyk bulls (5.73).

Table 1. Live weight dynamics of dairy (6–15 months) and beef (8–15 months) bulls, n = 9

Index	Breed, group			
	Simmental, 1	Black-and-White, 2	Hereford, 3	Kalmyk, 4
Initial live body weight at 6 months of age (kg)	213.8 ± 9.2	200.5 ± 9.5		
Initial live body weight at 8 months of age (kg)			210.5 ± 7.1	196.7 ± 2.4
Live weight at 12 months (kg)	373.19 ± 10.4	353.5 ± 11.3	323.9 ± 8.5	312.45 ± 2,6
Average daily live weight gain in the period of 6–12 months (g)	885.5 ± 11.8	850.0 ± 12.5		
Average daily live weight gain in the period of 8–12 months (g)			945.0 ± 9.5	948.8 ± 3.4
Live weight at 15 months (kg)	483.71 ± 12.6	462.58 ± 10.1	432.82 ± 8.2	425.82 ± 4,2
Average daily live weight gain in the period of 12–15 months (kg)	1214.5 ± 14.6	1198.7 ± 10.7	1196.9 ± 9.1	1245.8 ± 11,5
Average daily live weight gain in the period of 6–15 months (g)	1050.0 ± 13.2	1024.35 ± 11.6		
Average daily live weight gain in the period of 8–15 months (g)			1070.95 ± 9.3	1097.30 ± 7,45

The value of beef depends on the content of lean meat in it, which is its protein part, necessary for the production of baby food in accordance with the interstate standard. The amount of visceral fat in relation to Pre-slaughter live weight at 15 months was minimal, which corresponds to the standard for baby food, and amounted in the carcasses of Simmental, Black-and-White, Hereford and Kalmyk bulls, respectively, 1.0; 0.9; 1.2 and 0.9%.

Table 2. Slaughter rates and results of deboning half-carcasses of steers (n = 9)

Index	Breed, group			
	Simmental, 1	Black-and-White, 2	Hereford, 3	Kalmyk, 4
Pre-slaughter weight, kg	480.0 ± 5.1	460.7 ± 6.4	430.0 ± 5.5	420.8 ± 7.8
Slaughtered weight, kg	274.1 ± 2.6	265.4 ± 2.2	250.0 ± 2.7	242.0 ± 2.1
Slaughtered yield, %	57.1	57.6	58.1	57.5
Fresh-killed Carcass, kg	267.4 ± 2.0	261.0 ± 1.8	248.0 ± 1.9	240.0 ± 2.3
Called carcass, kg	260.8 ± 1.6	256.3 ± 1.4	243.0 ± 1.5	237.5 ± 1.7
Carcass yield, %	54.3	55.6	56.5	56.4
Muscle, kg	212.8 ± 1.5	207.1 ± 1.6	196.4 ± 1.4	199.0 ± 1.2
Bones and tendons, kg	43.0 ± 1.4	42.2 ± 0.9	41.3 ± 1.1	34.7 ± 1.0
Meat ratio (mass of boneless beef, kg per 1 kg of bones and tendons)	4.95	4.90	4.76	5.73
Visceral fat, kg	5.0 ± 0,5	4.3 ± 0,4	5.3 ± 0,3	3.8 ± 0,2
The amount of fat in relation to Pre-slaughter live weight, %	1.0	0.9	1.2	0.9

The content of bones and tendons fluctuated within small limits and had no breed differences. Muscle tissue from bull carcasses differed in juiciness or moisture capacity (Table 3).

Most of the bound water in relation to the total amount of moisture was noted in the meat of the Kalmyk bull-calves - 61.0% and in the Black-and-White breed bulls - 59.4%. According to the authors, the water-holding capacity decreases as the fat content in raw materials increases [8]. The fat content did not exceed 9.5%, which met the standard for baby food.

According to the authors, the quality of beef depends on the breed of animals [9]. The data on the chemical composition of the longissimus muscle showed that the protein in beef was not significantly higher (18.4%) in Hereford bulls, and the ratio of protein and fat for four breeds was optimal: from 1.9: 1.0 for Simmental bulls to 2.2: 1.0 for Black-and-White and Kalmyk bulls. The protein yield per 1 kg of Pre-slaughter live weight, expressed in grams, was significantly higher ($p < 0.05$) in bulls of beef breeds of groups 3 and 4.

The conducted studies of the organoleptic properties of beef from 15-month carcasses of bulls of four breeds of dairy and beef productivity did not reveal significant differences. The ratio of tryptophan and hydroxyproline (protein quality index) was within 4.6–5.7.

Significant differences were found in the mineral and amino acid composition of the longissimus muscle (Tables 4, 5).

Table 3. Physical and chemical parameters of *longissimus dorsi* of bulls, n = 9

Index	Breed, group			
	Simmental, 1	Black-and-White, 2	Hereford, 3	Kalmyk, 4
Moisture capacity, %	57.2	59.4	55.4	61.0
Colour intensity, Ext. Units	77.0 ± 0.9	75.5 ± 1.2	76.5 ± 1.1	78.3 ± 0.8
pH After maturation	6.2	6.4	6.5	6.2
Moisture content, %	71.26	72.2	71.9	72.5
Mass fraction of protein, including collagen and elastin, %	18.2	18.3	18.4	18.1
	1.7	1.8	1.5	1.6
Protein yield per 1 kg of Pre-slaughter live weight, g	80.0 ± 0.6	82.3 ± 0.2	84.1 ± 0.4	85.6 ± 0.5
Mass fraction of crude fat, %	9.5	8.3	8.7	8.2
NFE, %	0.13	0.10	0.12	0.11
Mass fraction of crude ash, %	0.91	1.01	0.89	1.11
Protein to fat ratio	1.9:1.0	2.2:1.0	2.1:1.0	2.2:1.0
Tryptophan, g/kg beef	3.31	2.94	3.42	3.41
Tryptophan, g/kg beef	0.69	0.64	0.60	0.62
PQI - the ratio of tryptophan and hydroxyproline	4.8	4.6	5.7	5.5

Potassium, phosphorus, magnesium, zinc, iron, copper, iodine and selenium were significantly higher in the longissimus muscle of Kalmyk bulls. Sodium and calcium were significantly higher in Simmental and Black-and-White bulls.

Beef with high biological value of groups 1–4 contained all essential amino acids in the amount of 87.92; 86.78; 88.56 and 87.31 g/kg of muscle tissue of the longissimus muscle, respectively, from Simmental, Black-and-White, Hereford and Kalmyk bulls. Among the essential amino acids, there are differences in their content in the longissimus muscle of four breeds of bulls.

Beef from Hereford bulls contained significantly more histidine, lysine, valine and arginine, which are important for children under 3 years of age.

In the muscle tissue of the longissimus dorsi of Simmental bulls, there was significantly more of the threonine essential amino acid, in Black-and-White bulls there was a maximum content of isoleucine, in Kalmyk bulls in the longissimus muscle there was significantly more of methionine and phenylalanine, important amino acids for children older than 3 years.

Table 4. Mineral composition of *longissimus dorsi* in 15 month old bulls, n = 9 ($Mean_{SEM}$)

Element, mg/kg	Breed, group			
	Simmental, 1	Black-and-White, 2	Hereford, 3	Kalmyk, 4
Potassium, K	$3112.50_{6.21}$	$3143.54_{4.33}$	$3212.41_{3.21}$	$3295.84_{5.65}$
Phosphorus, P	$2015.12_{1.12}$	$1983.31_{1.24}$	$2109.21_{2.15}$	$2143.68_{2.61}$
Sodium, Na	$619.72_{1.45}$	$619.51_{1.37}$	$578.22_{2.21}$	$544.873_{3.76}$
Magnesium, Mg	$192.74_{3.43}$	$188.11_{5.42}$	$196.42_{3.22}$	$197.76_{2.32}$
Calcium, Ca	$42.95_{0.55}$	$42.10_{0.16}$	$34.00_{0.43}$	$36.13_{0.18}$
Zinc, Zn	$34.15_{0.07}$	$34.98_{0.08}$	$45.75_{0.09}$	$47.22_{0.07}$
Iron, Fe	$18.17_{0.09}$	$17.14_{1.12}$	$19.54_{0.09}$	$20.29_{1.05}$
Copper	$1.42_{0.04}$	$1.46_{0.05}$	$2.52_{0.06}$	$2.74_{0.05}$
Iodine, J	$0.045_{0.02}$	$0.055_{0.03}$	$0.075_{0.03}$	$0.077_{0.05}$
Selenium, Se	$0.027_{0.02}$	$0.028_{0.01}$	$0.044_{0.02}$	$0.045_{0.03}$

The content of residual traces of toxic substances in the tissue of longissimus dorsi of the bulls was within the limits allowed by the standard requirements for the production of canned meat for children (Table 6).

4 Conclusion

From bull-calves of dairy and beef breeds, acclimatized in Bratkovsky Dairy Fattening Complex of Korenovsky district of the Krasnodar Territory, located in an ecologically friendly raw material zone of the canned meat factory for children, when fattening up to 15 months of age, high-quality safe beef was obtained, suitable for the production of children's canned meat.

Our results agree with the data of other authors who studied 15 month of age as the limiting age for slaughtering beef bulls of the Charolais breed for meat [19]. An experiment was conducted to study the effect of animal age on slaughter. At the same time, the age of slaughter did not have a significant effect on the tenderness of the beef of young bulls [6].

The quality and safety of meat raw materials obtained from Simmental, Black-and-White, Hereford and Kalmyk bulls meet the requirements of GOST 31798–2012 «Beef and veal for the production of baby food», TR CU 034/2013 «About the safety of meat and meat products» for raw meat for baby food and meet the needs of consumers.

Table 5. Amino acid content of longissimus dorsi in 15 month old bulls, n = 9 (Mean $_{SEM}$)

Amino acid, g/kg	Breed, group			
	Simmental, 1	Black-and-White, 2	Hereford, 3	Kalmyk, 4
Histidine	$6.97_{0.12}$	$5.89_{0.09}$	$7.14_{0.06}$	$6.46_{0.07}$
Isoleucine	$8.90_{0.08}$	$9.35_{0.11}$	$8.37_{0.12}$	$8.33_{0.14}$
Leucine	$15.58_{0.04}$	$15.83_{0.05}$	$14.37_{0.12}$	$14.73_{0.15}$
Lysine	$16.40_{0.08}$	$16.78_{0.07}$	$17.63_{0.09}$	$16.89_{0.17}$
Methionine	$4.51_{0.09}$	$4.37_{0.06}$	$4.66_{0.04}$	$4.71_{0.08}$
Phenylalanine	$7.75_{0.12}$	$7.50_{0.09}$	$8.00_{0.08}$	$8.54_{0.14}$
Threonine	$7.81_{0.06}$	$7.69_{0.08}$	$7.42_{0.12}$	$7.44_{0.11}$
Valine	$8.30_{0.08}$	$8.24_{0.09}$	$9.00_{0.10}$	$8.94_{0.12}$
Arginine	$11.70_{0.14}$	$11.13_{0.09}$	$11.98_{0.05}$	$11.28_{0.07}$
Tryptophan	$3.31_{0.03}$	$2.94_{0.02}$	$3.42_{0.05}$	$3.41_{0.04}$
TOTAL essential AA	$87.92_{0.18}$	$86.78_{0.11}$	$88.56_{0.15}$	$87.31_{0.17}$
Alanine	$9.88_{0.09}$	$10.74_{0.14}$	$10.32_{0.12}$	$10.12_{0.15}$
Asparaginic acid	$17.73_{0.17}$	$17.93_{0.15}$	$17.90_{0.14}$	$17.48_{0.12}$
Cystine	$2.31_{0.02}$	$2.10_{0.03}$	$1.78_{0.05}$	$1.70_{0.04}$
Glutaminic acid	$31.38_{0.16}$	$32.45_{0.23}$	$32.26_{0.35}$	$31.57_{0.34}$
Glycine	$8.65_{0.09}$	$8.80_{0.07}$	$8.41_{0.09}$	$7.76_{0.08}$
Proline	$8.48_{0.08}$	$8.05_{0.09}$	$9.05_{0.07}$	$9.03_{0.05}$
Serine	$7.03_{0.04}$	$6.92_{0.06}$	$6.46_{0.05}$	$6.70_{0.06}$
Tyrosine	$7.17_{0.06}$	$7.08_{0.09}$	$6.96_{0.12}$	$6.77_{0.07}$
TOTAL non-essential AA	$92.62_{0.35}$	$94.08_{0.23}$	$93.14_{0.43}$	$91.13_{0.17}$
Essential/non-essential	0.95	0.92	0.95	0.96

Table 6. Beef safety values, (n = 9)

Index	Result	Allowed [3] no more:	
	Mean value	for children under three years old	for children over three years old
Toxic elements, mg/kg			
lead	0.044 ± 0.23	0.1	0.2
cadmium	< 0.01	0.01	0.03
mercury	< 0.005	0.01	0.02

(*continued*)

Table 6. (*continued*)

Index	Result	Allowed [3] no more:	
	Mean value	for children under three years old	for children over three years old
arsenic	< 0.0025	0.1	0.1
Pesticides, mg/kg, not more than:			
DDT and its metabolites	< 0.010	0.010	0.015
Hexachlorocyclohexane (α, β, γ – isomers)	< 0.010	0.010	0.015
All other Pesticides	Not detected	Not allowed	
Antibiotics, mg/kg			
Levomycetin (chloramphenicol)	< 0.01	not allowed	< 0.0003
Tetracycline group	< 0.01	not allowed	< 0.01
Bacitracin	< 0.01	not allowed	< 0.02
Dioxins	Not detected	Not allowed	
Hormonal drugs	Not detected	Not allowed	
Radionuclides, Bq/kg Cesium-137 Strontium-90	2.3 1.2	40.0 25.0	40.0 25.0

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