

Modern Intensive Dairy Beef Production Systems in Russia

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Abstract

The objective of this study was to determine the biological and economic efficiency of growing-finishing young dairy bulls slaughtered at different live weights under current consumer's requirements and market conditions. Experiment was conducted with bull calves of Black and White breed with high level (>85%) Holstein blood (n=60). All animals were indoor housed and fed on diets consisting of forage (55 percent on dry matter basis) and concentrate (45 percent) with flat daily live weight gains 900-1000g. The overall findings for the dairy calf to beef system can be summarized as follows. Under current conditions optimum slaughter weights of young bulls are 500-550 kg at the ages of 17-18 months. Biological efficiency as measured by carcass weight production per animal, carcass and meat qualities, increased with increasing of slaughter weights from 400 to 550kg. The same pattern has occurred for net return, but profitability was unchanged. Production systems with light slaughter live weights require more number of cattle by 14-41 percent to produce the same carcass weights. On the other hand feed conversion of the bulls slaughtered at light live weights was higher. Meat potential of Black and white breed with high proportion of Holstein blood is good enough to produce quality lean carcasses.

Keywords: dairy beef, biological and economic efficiency, carcass characteristics, meat quality

1. Introduction

In Russia, about 87 percent of beef meat production stems from the fattening of young dairy bulls and cull dairy cows (Legoshin and Sharafeeva, 2013). In the last 20 years the number of dairy cattle was decreased from above 50 million head to 20 million head and has tendency to continue this decreasing. It means (a) decreasing of possibilities of dairy beef production, (b) the objective necessity of developing of large-scale beef cattle husbandry and the intensification of use decreased fattening contingent to produce more beef meat. Thus dairy beef production plays now and will play in the future very important role in Russia.

The main parameters of dairy beef production systems were described in several reports. For example, Hardy and Meadowcroft, 1990, have shown efficient systems of indoor beef production in Great Britain, Dunne and O'Neil, 1996, Fallon et al., 2001, Keane, 2003, Walsh et al., 2008, have reported many aspects of dairy beef production systems based on grass and grass silages in Ireland.

Many studies were conducted to indicate the optimal duration of fattening, ages and live weights of animals at finish. For example, Boreš and Bartoň, 2012 (Czech Republic), have shown that Charolais x Simmental bulls and heifers slaughtered at age of 18 months and live weights 698 and 553.7 kg, respectively, in comparison with analogs slaughtered at age of 14 months and live weights of 554 and 478.7 kg obtained higher scores for beef flavor, intensity, tenderness, juiciness and overall acceptance of meat. But it was clearly indicated by many studies, that there are a lot of variations in slaughter ages and live weights of animals from country to country. These parameters are dependent on breeds, sex, genetic potential, quality and quantity of feeds, market conditions and some other factors (Alberti et al., 2008, Alberti et al., 2005, Anderson et al., 2005, Antal et al., 1988, Brosh et al., 1995, Cuvelier et al., 2006, French et al., 1998, Frickh et al., 2002, Keane and Fallon, 2001, Keane and Darby, 2000, Kwon et al., 2009, Legoshin et al., 1995, Mossberg et al., 1992, O'Neil and Dunne, 1995, Orkisz, 1988, Rodbotten et al., 2002, Steinwider et al., 2002, Warithitham et al., 2010). On the other hand all beef production systems have to be examined from time to time to find out the advantages and disadvantages of different ages and live weights of animals at slaughter under modern conditions. Until relatively recently, intensive dairy bull calves growing-finishing system, so-called Voronovo's technology, was

the most popular among the beef producers in Russia. The main features of this system include the start rearing at 45-50 kg of live weights, finish at ages 13-14 months and 400 kg of live weights, flat daily live weight gain 900-1000 g, rations based on concentrates (60-65 percent on dry matter basis) and forage (grass or corn silages and small quantity of hay), indoor housing. This system was economically efficient under specific conditions and among them low demand and low prices on calves and good prices for fattened animals. At the modern time there are deficit of calves and feeders, high level of competition of beef with pork and chicken, high prices on grains. Meat industry requirement is to get the fattened cattle with higher live weights. In this connection the first goal of our study was to determine the optimum live weights at which dairy bull calves attain an acceptable degree of finish associated with a carcass characteristics and meat quality of high classes in accordance with Russian and international standards and to examine economic efficiency of dairy beef production systems.

There are some information that the increased proportion of Holstein blood in the dairy herd may have negative consequences for dairy beef production. Mc Gee et al., 2007, have found that high dairy genetic merit Holstein bulls in comparison with standard dairy genetic merit Friesian bulls had significantly higher values for withers height, pelvic height and chest depth, but narrower chest and a longer back, their carcasses had almost the same weights but much less fleshiness scores. Over 72 percent of dairy cattle population in Russia belong to Black and White (57.38%), Holstein (5.44%), Simmental (9.20%) and very closed to Simmental Sychevskaya (0.53%) breeds. Proportion of Holstein blood in Black and White population increases with every year through use of Holstein sires and now consists of more than 50% and even up to 90% at the farms in regions with intensive milk production (Amerchanov et al., 2013). Taking into consideration these figures our second aim was to estimate the current meat potential of the young bulls of main breed type.

The feeds are the main variable costs in beef production and can account for over 70% of all costs. In the most countries in the world, including Russia the hays, haylages and silages significantly cheaper (by 25-35% and more) than cereals and other concentrates. Proportion of concentrates in the diets for growing-finishing bulls depends on prices of different feeds and quality of forage and can vary from 30 to 65% for all cycle of growing – finishing period and up to over 80% for finishing stage at feedlots (Boreš and Bartoň, 2012, Clinquart et al., 1991, Cuvelier et al., 2006, Dunne and O'Neil, 1996, French et al., 1998, Madsen et al., 1991, O'Kiely et al., 2002, Rodbotten et al., 2002, Steinwider et al., 2002, Weeler, 2005). In our previous studies (Legoshin et al., 2008, Mambetov et al., 1998) we have examined the impact of different concentrate level (from 30 to 65 percent) in rations on growing performance, carcass characteristics and economic efficiency of young dairy bulls. It was shown by these studies that the best ratio between biological and economic efficiencies of beef production was achieved when the diets consist of 40-45 percent of concentrates on dry matter basis. Taking into account these observation all animals in this project were reared on the diets which consist of medium quality forage (55 percent) and grain concentrates (45 percent).

2. Material and Methods

2.1 Animals, Diets and Experimental Design

The experiment was conducted at the Dubrovitsy experimental farm. Sixty bull calves used in this experiment were the progeny of high dairy genetic merit Holstein sires and high-productive (milk yield \geq 8000 kg per lactation) Black and White dams with proportion of Holstein blood above 70%. After a mean rearing period of 112 ± 21 days all bulls were assigned randomly to four groups scheduled to slaughter after reaching target live weights of 400, 450, 500 or 550 kg. All animals were indoor housed in individual tie-up stalls. An identical mixed diet consisting (in dry matter basis) of corn (45%) and grass (10%) silages, barley and wheat-based concentrates (44.5%) and a mineral/vitamin mixture (0.5%) was given *ad libitum* after weighing to all the animals. The average chemical composition of the diet was a follows: dry matter (DM) 407 g/kg fresh weight, crude protein content 12-14%, metabolic energy concentration 10.7 MJ/kg DM.

2.2 Traits, Methods of Assessments and Measurements, Statistics

Unconsumed feed mixture was removed from the bunks and weighted on 10 days intervals to determine feed intake and feed conversion rate (DM intake/daily gain). The bulls were weighed at start of experiment (initial weights) and then every 30 days at the same time of day throughout experimental period, 3 days before slaughter (final weight, used for calculation of daily live weight gain, feed intake and feed conversion ratio) and before slaughter after 18h of fasting (slaughter weight used for the calculation of killing-out and internal fat proportion). When the target slaughter weights were achieved, the bulls were slaughtered in the small experimental abattoir of the experimental farm Dubrovitsy (5 animals on each slaughter day). Within 1h after slaughter, the carcasses were uniformly dressed and assessed by a trained classifier for conformation (EUROP scale 1 (P=poorest) to 5 (E=best) and fatness (EUROP scale 1(L-leanest) to 5 (F-fattest) according to the EU Beef Carcass Classification

Scheme (Commission of the European Communities, 1982) and for quality categories scale 1 (lowest) to 7 (the best) according to National Standard of Russian Federation GOST-P54315-2011, 2011, were calculated. The weights of hot carcasses and internal fat depots (kidney, heart, chanel and pelvic fats) were recorded. The killing out percentage was calculated as ratio (hot carcass weight/slaughter weight) x 100. After cooling for 24h pH values were measured, the weights of both carcass sides were recorded and the right sides were divided into lean meat, bones and tendens. The *musculus longissimus dorsi* (MLD) area (ribeye area), and subcutaneous fat thickness were measured at the section between the 12 and 13 ribs.

The chemical composition (ash, dry matter, protein, fat) of meat was assessed on freezedried average meat samples and samples of the MLD according to official procedures.

The tenderness, expressed by its opposite, the toughness, was estimated by the measurement of the Warner-Bratzler peak Shear force (WBPSF).

In order to calculate the economic parameters the following indicators were controlled and calculated in the course of fattening: costs for feeds, labor costs and other costs, including costs for preventive and medical treatment, water supply, electricity, transport, depreciations, etc. On that basis the prime costs of live weight gain and of yield were calculated. After adding the value of the calf as a feeder, the full cost was calculated. Both prime costs and full costs were calculated for 1 kg of live weight and 1 kg of yield (carcass weight). The incomes from the sale and the profit were calculated on the basis of the relevant prices currently in use in Russia.

The basic statistical processing was carried out using the respective models of «Statistical» Software, №1234. All parameters included in this study are presented as mean (\pm s.e.).

3. Results

3.1 Feed Intakes and Live Weight Gain

By design, there were no differences in ages and average daily live weight gains of animals from start of experiment to slaughter between the groups of bulls ($P>0.37$). As expected, days on feed and total dry matter intakes linearly increased with increasing live weights scheduled for slaughter ($P<0.001$), but feed conversion decreased ($P<0.05$; table 1).

Table 1. Feed intake and growth performance of young bulls slaughtered at different live weights

	Target of live weights at slaughter (kg) ¹				s.e. ²	Signifi-cance
	400	450	500	550		
Number of animals	15	15	15	15	15	
Initial age (days)	113.4	112.8	113.7	112.2	10.7	NS
Initial weights (kg) ³	147.2	146.7	148.0	146.9	21.4	NS
Days on feed	255.2	314.1	365.8	403.6	25.1	xxx
Final live weights (kg) ⁴	402.9	454.5	510.2	549.7	47.9	xxx
Live weight gains (kg) ⁵	255.7	307.8	362.2	402.8	44.2	xxx
Average daily gain (g/day)	1002	980	990	998	27.4	NS
Feed intake						
Dry matter						
(DM, kg per animal)	1571.2	1985.1	2470.4	2851.8	137.6	xxx
DM (kg/day per animal)	6.16	6.32	6.82	7.08	0.15	xxx
Feed conversion ratio						
(kg DM intake per kg gain)	5.91	6.45	6.89	7.09	0.19	xxx

¹ Groups of animals in accordance with target slaughter weights.

² In this and subsequent tables s.e. for n=15

³ Live weights at start of experiment.

⁴ Live weights 3 days before slaughter.

⁵ Calculated as difference between final LW and initial LW.

3.2 Carcass Evaluation

Carcass performance traits are given in tables 2. Higher values of killing out percent, subcutaneous fat thickness at 12th rib, carcass weight on day of age but lower values of bone content were indicated for bulls slaughtered at older ages and heavier live weights ($P < 0.05-0.001$). It is very important to determine that biological efficiency increased with increasing slaughter weights, but fatness of carcasses were acceptable for all age and slaughter weight groups of bulls. It was demonstrated that production systems with lighter slaughter weights require much more animals to produce 1000 kg of carcass weight in comparison with heavier animals.

The results of carcass grading by European and Russian Standards are given table 3.

It has been shown that carcass conformation scores ($P < 0.001$), quality grade of carcasses by Russian standard ($P < 0.001$), rib eye area ($P < 0.001$), rib eye area per kilo of carcass weight ($P < 0.001$) and tenderness ($P < 0.05$) were improved with increasing of slaughter weights. But carcass conformation scores and carcass fatness scores were relatively low. In accordance with Russian National standard, quality grades of bulls slaughtered at live weight 550 kg were by 63.7% higher (Scores 6.55 vs 4.00) in comparison with animals slaughtered at live weight 400 kg ($P < 0.001$) because the main goal of Russian standard is to enhance the carcass weight of young animals.

Table 2. Carcass characteristics of young bulls slaughtered at different live weights

	Target of live weights at slaughter (kg) ¹				s.e. ²	Signifi-cance
	400	450	500	550		
Slaughter live weights(kg) ³	394.2	444.9	500.5	538.7	14	xxx
Hot carcass weights(kg)	212.5	242.5	276.3	300.5	4.69	xxx
Killing out (%) ⁴	53.90	54.51	55.20	55.78	0.31	x
Fat thickness at 12 th rib.(mm)	1.7	1.9	2.2	2.6	0.07	xx
Internal fat weight (kg) ⁵	7.15	9.21	11.43	13.90	0.09	xxx
Internal fat (%) ⁶	1.81	2.07	2.28	2.18	0.05	x
Bone content (%) ⁷	21.0	20.7	18.9	17.9	0.12	xxx
Carcass weight per day of age (g) ⁸	529	526	576	583	14	x
Number of bulls to produce 1000 kg of carcass weight (number) ⁹	4.70	4.12	3.62	3.33		

^{1,2} See footnotes to table 1.

³ Live weights before slaughter after 18h of fasting.

⁴ Calculated as ratio hot carcass weights and slaughter weights.

⁵ Kidney, heart, chanel and pelvic fats.

⁶ Calculated as ratio of internal fat weight and slaughter weight.

⁷ Calculated as ratio of bone weight and carcass weight.

⁸ Calculated by dividing of hot carcass weight on days of ages at slaughter.

⁹ Calculated by dividing of 1000 kg on average carcass weight.

Table 3. Impact of different live weights at slaughter on carcass grading of young bulls

Item	Target of live weights at slaughter (kg) ¹				s.e. ²	Signifi-cance
	400	450	500	550		
Carcass conformation ³	1.37	1.49	1.52	1.89	0.081	xxx
Carcass fatness ⁴	1.45	1.59	1.74	1.99	0.092	xxx
Quality grade by Russian standard ⁵	4.00	5.00	5.70	6.55	0.177	xxx
Bone content (%)	21.0	18.1	18.2	17.9	1.21	x
Rib eye area (cm ²)	70.6	75.2	81.3	87.8	1.87	xxx
Rib eye area per kg of carcass weight	0.332	0.310	0.294	0.292	0.004	xxx

(cm ²)						
Tenderness (kg/cm ²) ⁶	3.37	3.12	2.99	2.81	0.13	x

^{1,2} See footnotes to table 1.

³ EU Beef classification Scheme EUROP Scale 1 (poorest) to 5 (best).

⁴ EU Beef classification Scheme EUROP Scale 1(leanest) to 5 (fattest).

⁵ National standard of Russian Federation for beef carcasses classification Scale 1 (lowest category) to 7 (best-super category).

⁶ Warner-Bratzler Shear force.

3.3 Meat Chemical Composition and Economic Efficiency

Meat chemical traits are given in Table 4. Numerous significant effects of slaughter weights were demonstrated on meat quality attributes. Higher pH values ($P<0.001$), higher dry matter ($P<0.05-0.001$), and fat ($P<0.001$) content but lower protein content ($P<0.05-0.01$) were observed in meat samples from heavier and older animals.

Table 4. Impact of different live weights at slaughter on meat chemical composition of young bulls

Item	Target of live weights at slaughter (kg) ¹				s.e. ²	Signifi-cance
	400	450	500	550		
MLD:						
<i>pH 24h post mortem</i>	5.60	5.64	5.71	5.74	0.01	xxx
Dry matter (%)	22.37	23.31	23.70	24.06	0.27	x
Protein (%)	21.12	21.59	21.78	21.89	0.21	x
Fat (%)	0.76	1.23	1.42	1.67	0.02	xxx
Average meat sample						
Protein (%)	20.05	19.68	19.55	19.12	0.15	xx
Fat (%)	8.35	12.28	14.57	16.22	0.12	xxx
Dry matter (%)	28.91	32.47	34.63	35.84	0.27	xxx

^{1,2} See footnotes to table 1.

Economic efficiency of modern dairy beef production systems in Russia are given in Table 5. Under Russian conditions, proportion of feeder costs (in our experiment at the age of approximately 4 months) depends on slaughter weights and decreased from 39 percent for group animals slaughtered at live weight 400 kg to 27.8 percent for heaviest animals. Net return increased with increasing slaughter weights ($P<0.001$). But profitabilities were unchanged and were relatively low. It is very important to remark that in accordance with our findings (Table 2) the production systems with highest slaughter weights of animals in comparison with the lightest slaughter weights (550 vs 400 kg) require less number of bulls by 41.1 percent to produce 1000 kg of carcass weight.

Table 5. Impact of different live weights at slaughter on economic efficiency of dairy beef production system

Item	Target of live weights at slaughter (kg) ¹				s.e. ²	Signifi-cance
	400	450	500	550		
Cost of bull at start (rubles) ³	13248	13203	13320	13221	121	N.S.
Feed cost of gain (rubles) ⁴	13433.8	16972.6	21121.9	24382.9	207	xxx
Other costs of gain(rubles) ⁵	7233.6	8743.5	10403.3	11474.3	99	xxx
All costs of gain(rubles per animal) ⁶	20337.4	25332.2	30611.1	34342.1	232	xxx
Total costs of bull (rubles) ⁶	33915.4	38535.2	43931.4	47563.1	311	xxx
Return per one bull (rubles) ⁷	37187	42437	48353	52588	302	xxx
Net return per one bull (rubles) ⁸	3271.6	3901.8	4421.6	5024.9	75	xxx

Profitability (%) ⁹	9.65	10.12	10.06	10.56	0.61	N.S.
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^{1,2} See footnotes to table 1.

³ Calculated as 90 rubles (average cost of 1 kg live weight of bulls at start) x live weights at start.

⁴ Calculated as Total DM feed intake x 8.55 rubles (average cost of 1 kg DM ration).

⁵ All costs excluding feed cost.

⁶ Calculated as cost of bull at start + All cost of gain.

⁷ Calculated as 175 rubles (average market price of 1 kg carcass weight) x carcass weights.

⁸ Calculated as differences between return and total costs.

⁹ Calculated as ratio net return and total costs.

4. Discussion

In many countries, as well in Russia, the main source of beef is the fattening contingent from the dairy farms. It has been shown by many studies (Madsen et al., 1992, Otonzborov, 2004, Steinwidder et al., 2002, Warithitham et al., 2010, Wheeler et al., 2005) that the increase in beef production has resulted from the increase of slaughter weights of young cattle. Our findings have demonstrated that at the present time in Russia optimum slaughter weights of young dairy bulls are 500-550 kg at the ages of 17-18 months. This conclusion is confirmed by our assessments of growing-finishing performance, carcass traits and profitability of modern dairy beef production system. Biological efficiency as measured by carcass weight production per animal, carcass and meat qualities, increased with increasing of slaughter weights from 400 to 550 kg. The same pattern was occurred for net return. In this connection we have stated one negative factor, namely, decreasing feed conversion. This fact may be explained by differing composition of gain (i.e., heavier animals deposited more fat than did lighter animals). This suggestion was confirmed by carcass characteristics. It was indicated that quantities ($P < 0.001$) and proportion ($P < 0.05$) of internal fat were increased with increasing slaughter weights (table 2). In contrast Bureš and Bartoň, 2012, reported that there was no significant difference in feed conversion between age (14 vs 18 months) and slaughter weight (554.3 vs 698.0 kg) groups of bulls. But many researchers (Anderson et al., 2005, Antal et al., 1988, Brosh et al., 1995, Dunne and O'Neil, 1996, Fallon et al., 2001, Frickh et al., 2002, and others) have shown the negative impacts of age and slaughter weights of animals on feed conversion. It has been shown in our experiment, that carcass conformation scores of all groups of bulls were relatively low (1.45-1.89) as well as filthiness scores (1.45-1.99). This result of carcass grading in accordance with EUROP system may be explained by high proportion of Holstein genes in bulls involved in experiment.

Our assessments of carcass conformation and fatness, other carcass traits and meat production's potential of modern Black and White bulls with high proportion of Holstein blood are in agreement with many other studies. For example, Mc Gee et al., 2007, (Ireland) concluded that there were large differences between high dairy genetic merit Holstein and standard dairy genetic merit Friesian in body and carcass measurements, and hence in carcass shape and compactness (carcass conformation score 1.51 for Holstein and 2.15 for Friesian bulls) but differences in live weight gains and carcass weights were small.

5. Conclusions

Summary, present study has shown clear increasing biological and economic efficiencies of dairy beef production systems with increasing slaughter weights of animals up to 550 kg when in these systems are used Black and White bulls. Increasing slaughter weights increased carcass weights, killing out proportion and improved some quality characteristics of carcasses and meat. The meat potential of modern Black and White breed with ≥ 85 percent of Holstein blood remains good enough to produce high quality lean carcasses in accordance with Russian National standard and EUROP standard as well. Practical implication of present observations i.e. necessary of fattening of dairy bulls to the live weights 500-550 kg instead of 370 kg (average slaughter weights of young cattle in Russia in 2013) has very high importance for increasing beef production in Russia. At the same time there are some problems to be investigated in the future and among them how to improve the feed conversion and economic efficiency of dairy beef production systems.

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