The Efficiency of Using Simmental x Holstein Hybrids of Various Types of Body Composition

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***Abstract*: *In crossbred cows, three exterior and body composition types are distinguished: dense shallow, dense medium, and dense broad. Cows of broad type were superior to their peers of shallow type in height at the withers by 3.98 cm, by chest depth by 3.33 cm, by chest width by 8.25 cm, by chest girth by 5.5 cm, and by the slope body length by 5.37 cm. Cows of the medium type take an intermediate position. The share of the cows of the broad type is 67.5 %, they have a broader body, have an advantage in the indices of the breast width (5.5 – 9.2 %, $P \leq 0.001$), and pelvic-thoracic width (7.2 – 13.1 %, $P \leq 0.001$), but are inferior in the index of leg length (0.6 – 0.9 %). During the first lactation, heifers of shallow type gave 5,353 kg of milk, which was more by 500 – 539 kg than from heifers of the medium and broad types ($P \geq 0.99$). In terms of the live weight, the calves obtained from the mothers of the broad type are superior to their peers at birth by 1.6 – 2.5 kg; at the age of three months, the difference between the groups of animals reached 8.0 – 13.0 kg ($P \leq 0.01$, $P \leq 0.001$); at the age of six months —15.0 – 25.0 kg ($P \leq 0.001$); at the age of nine-months — 17.0 – 28.0 kg ($P \leq 0.001$); at the age of twelve months — 25.0 – 44.0 kg ($P \leq 0.001$); at the age of fifteen months — 25.0 – 46.0 kg ($P \leq 0.001$); and at the age of eighteen months — 30.0 – 52.0 kg ($P \leq 0.001$). By the weight of hot carcass, calves of the broad type were superior to their peers of the shallow type by 38.9 kg ($P \leq 0.01$), and to those of the medium type — by 23 kg ($P \leq 0.05$). The yield of boneless meat per 1 kg of bones in the calves of the shallow type was 3.87 kg, of the medium type — 4.10 kg, and of the broad type — 4.22 kg ($P \leq 0.05$).*

***The coefficient of feed protein and energy conversion to the dietary protein in the edible part of the carcass was higher in the calves of the broad type, which was due to the more intensive accumulation of muscle and adipose tissues in their organisms*.**

Keywords*: *body composition, body type, carcass yield, exterior, fat, genotype, live weight, milk yield.

I. INTRODUCTION

The ongoing targeted selection and breeding work aimed at improving Simmental cattle with red motley Holstein calves has resulted in changes in the qualitative composition of the Simmental cattle. Animals that are dramatically different from the Simmental breed in terms of productivity, exterior and body composition have been obtained. Studying the exterior and the body composition of the crossbred animals, many authors noted that crossing had resulted in animals that clearly exhibit exterior and body composition traits that were characteristic of the Holstein breed [1]-[8]. Numerous experimental data and practical experience strongly indicate the high potential milk yield of cows and meat productivity of crossbred calves [9]-[13]. New genotypes of the animals are widespread in the Republic of Mordovia and require further improvement for efficient use of their breeding and productive qualities.

The purpose. The study was aimed at determining the exterior and body composition type of Simmental x Holstein cows and at studying the dynamics of growth and meat productivity in the calves obtained from the cows of various exterior and body composition types in the conditions of industrial technologies.

II. PROPOSED METHODOLOGY

A. General Description

The research studies were performed in 2016 – 2019 at OOO SUE RM "Plodovoiagodny pitomnik" (Fruit and Berry Nursery) in the Krasnoslobodsky region of the Republic of Moldova with crossbred Simmental x Holstein animals. Over the period of the research study, the animals were kept at a dairy complex in the same feeding and keeping conditions. Measuring the animals allowed calculating the indices of body composition and attributing them to one of three types. After that, the cows were check-milked in order to determine their milk productivity; these data were used for calculating the lactation persistency coefficient and the milk yield; the live weight of the heifers was determined by weighing.

The second stage of research was studying the growth dynamics of the calves obtained from the various body composition types of cows. The growth of the calves was determined by monthly weighing and by calculation based on the average daily data in separate age periods. After that, by the results of the check slaughtering of five animals from each group, the meat productivity was determined. The energy value of meat and the conversion of protein and feed energy into dietary protein were also calculated. All data were statistically processed.

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B. Algorithm

The animals were fed two times with the diets in accordance with the rules of the RAAS [14], with regard to the period of lactation, milk yield, live weight, and physiological state.

In the first stage, the body type of the cows was studied. The exterior of the cows was evaluated in the second and the third months of the first lactation by taking the main measurements followed by the calculation of physique indexes, the results of which were used for determining the body types of the crossbred cows [15], [16]. The cross-bred cows were attributed to the shallow (narrow), medium (intermediate), and broad (broad-bodied) types.

The milk yield over the 305 days of the first lactation was calculated on the basis of the check milkings, which were performed three times a month. The content of fat and protein was determined on the "Clever – 1M" device in the conditions of the farm dairy lab once a month. The lactation persistency coefficient was calculated by the method proposed by Furhner (1964) modified by A. D. Aksennikova [17]. The live weight of the cows was determined by weighing during the second month of the first lactation. The milk yielding capacity was determined using conventional methods.

In the second stage, the authors studied the growth dynamics of the calves obtained from cows of various types of body composition. To study the growth and development of calves, three groups 15 animals in each were formed. The first group included the calves whose mothers were assigned to the shallow type, the second group – the calves with medium mothers, and the third group — of the calves from the broad-bodied mothers. The growth of the young animals was monitored by means of monthly individual weighing, and the average daily live weight gain was determined using conventional methods in certain age periods.

The meat productivity of the calves was studied using the methods adopted at the All-Russia Academy of Agricultural Sciences, the All-Russia Research Institute of Animal Breeding, the State Scientific-Research Institute of Meat Industry (1977), and the All-Russian Research Institute of Metrological Service (1984) by check slaughtering of five animals from each group at the age of 18 months.

To calculate the energy value of meat, conversion of feed protein and energy to dietary protein, the methods of the All-Russia Academy of Agricultural Sciences (1983) were used.

The obtained data were statistically processed using the "Statistics ver. 2.6." software package [18], [19].

C. Flow Chart

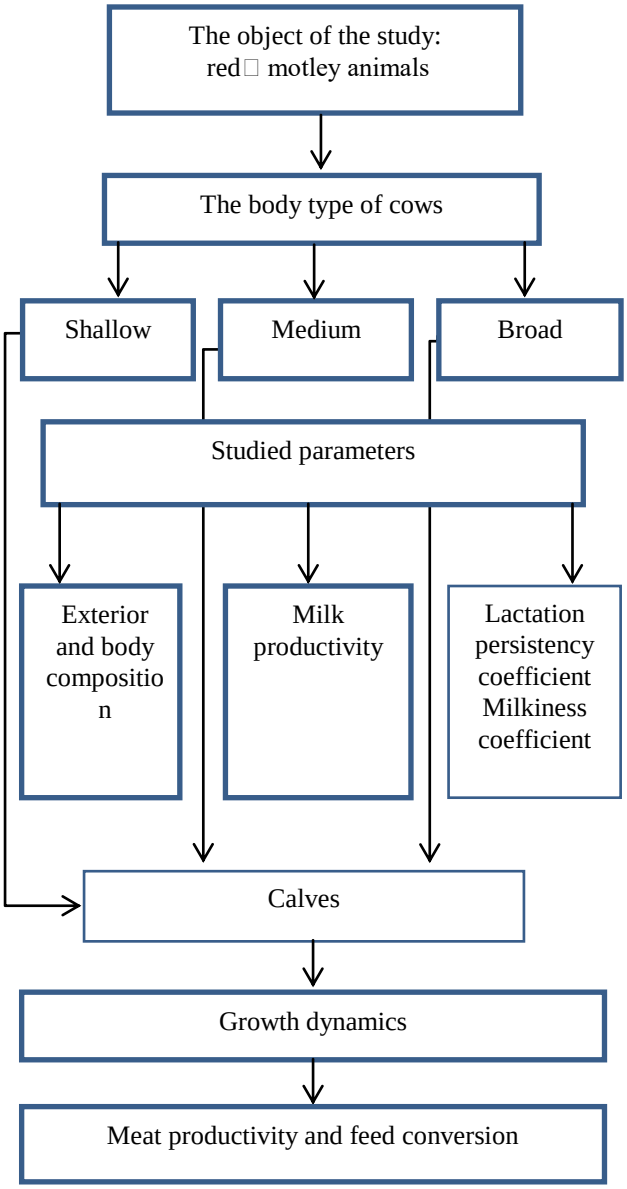

Fig. 1.The scheme of the studies

III. RESULT ANALYSIS

Out of 410 crossbred Simmental x Holstein cows, three exterior and body composition types are distinguished: dense shallow, dense medium, and dense broad. The cows of the broad type were superior to their peers of the shallow type in the height at the withers by 3.98 cm, by the chest depth by 3.33 cm, by the chest width by 8.25 cm, by the chest girth by 5.5 cm, and by the slope body length by 5.37 cm ($P \leq 0.001$). The cows of the medium type occupied an intermediate position (Table I).

Table I: Basic measurements of the exterior of the cows of various constitutional types

Value	Shallow (n = 56)		Medium (n = 77)		Broad (n = 277)	
	M ± m	Cv	M ± m	Cv	M ± m	Cv
Height at the withers	129.5 ± 0.79	3.1	130.3 ± 0.36	2.9	133.4 ± 0.25	3.1
Chest depth	67.9 ± 0.73	5.5	68.8 ± 0.24	3.6	71.2 ± 0.16	3.7
Chest width	34.5 ± 0.57	8.3	37.6 ± 0.11	3.0	42.8 ± 0.15	5.9
Chest girth	183.5 ± 1.4	3.9	184.8 ± 0.64	3.5	189.0 ± 0.43	3.8
Metacarpus girth	18.3 ± 0.20	5.4	18.5 ± 0.09	4.8	18.8 ± 0.07	5.8
Hips width	49.6 ± 0.54	5.5	49.8 ± 0.24	5.0	51.8 ± 0.17	5.4
Slope body length	148.9 ± 1.26	4.3	151.4 ± 0.44	3.0	154.3 ± 0.32	3.4

The share of the cows of the broad type was 67.5 %, they had broader bodies, had an advantage in the breast width (5.5 – 9.2 %, $P \leq 0.001$), and the pelvic-thoracic width (7.2 – 13.1 %, $P \leq 0.001$), but were inferior in the leg length (0.6 – 0.9 %); as to other values, the differences were minor and insignificant.

The experimental cows had relatively high milk productivity. During the first lactation, the heifers of the shallow type gave 5,353 kg of milk, which was more by 500 – 539 kg than from the heifers of the medium and the broad types ($P \geq 0.99$). In the milk from the ebroad-bodied cows, the share of fat was about 3.79 %, which was more by 0.04 – 0.07 % than in their peers of the medium and the shallow body type ($P \leq 0.001$) (Table II).

Table II: The effect of body type on the productive qualities of the cows

Indicators	Shallow (n = 56)		Medium (n = 77)		Broad (n = 277)	
	M ± m	Cv	M ± m	Cv	M ± m	Cv
Milk yield over the 305 days of lactation, kg	5.353 ± 186.5	17.8	4.853 ± 56.9	16.1	4.814 ± 51.15	17.0
Mass fraction of fat, %	3.72 ± 0.02	3.3	3.75 ± 0.01	3.07	3.79 ± 0.01	3.4
Milk fat, kg	199.2 ± 7.16	18.3	181.7 ± 5.14	16.1	182.4 ± 2.0	18.2
Live weight, kg	502 ± 6.7	6.8	505 ± 3.19	6.5	524 ± 2.4	7.9
Milkiness coefficient	1,069 ± 38.0	18.1	965 ± 13.3	14.2	923 ± 9.9	17.9
Lactation persistency coefficient	90.7 ± 4.1	17.9	86.3 ± 5.1	20.1	86.0 ± 4.9	19.9

The yield of milk fat from the cows of the shallow type was higher by 16.8 – 17.5 kg ($P \geq 0.05$) than from their peers of the broad and the medium body type. The heifers of the shallow body type showed the highest values of the lactation persistency coefficient (90.7 %), whereas in the animals of the medium and broad body type, this value was 86.1 – 86.4 %. The crossbred cows had a high milkiness coefficient (923 – 1,069), which was an evidence of the dairy type of the animals; it was especially high in the cows of the shallow body type.

To study the growth dynamics of the calves born from mothers of various exterior and body composition types, equal feeding and keeling conditions were created. The diets were developed for the experimental calves according to the detailed rules of feeding and were periodically adjusted, depending on the age and the live weight.

Over the entire period of growth, each of the calves consumed the following amounts of energetic feed units (EFU): of the shallow type — 3,478 EFU, of the medium type — 3,674 EFU, and of the broad type — 3,987 EFU. One EFU accounted for 114 g of digestible protein.

Table III: Dynamics of the live weight of the calves, kg

Age, months	Body type		
	Shallow	Medium	Broad
	M ± m	M ± m	M ± m
At birth	35.4 ± 0.86	36.3 ± 0.84	37.9 ± 0.94
3	94 ± 1.54***	99 ± 1.77	107 ± 2.12
6	170 ± 2.37***	180 ± 2.50**	195 ± 2.78
9	247 ± 3.03***	258 ± 3.11***	275 ± 3.17
12	315 ± 3.37***	334 ± 3.74***	359 ± 3.89
15	394 ± 3.54***	415 ± 4.02**	440 ± 4.34
18	456 ± 3.78****	478 ± 4.27***	508 ± 4.62

The live weight of the calves born from mothers with the broad body type at birth was higher by 1.6 – 2.5 kg than that of their peers; at the age of three months, the difference between the groups of animals reached 8.0 – 13.0 kg ($P \leq 0.01$, $P \leq 0.001$), at the age of six months — 15.0 – 25.0 kg ($P \leq 0.001$); at the age of nine months — 17.0 – 28.0 kg ($P \leq 0.001$); at the age of twelve months — 25.0 – 44.0 kg ($P \leq 0.001$); at the age of fifteen months — 25.0 – 46.0 kg ($P \leq 0.001$); and at the age of eighteen months — 30.0 – 52.0 kg ($P \leq 0.001$) (Table III).

As to the average daily weight gain, an advantage was noted in the calves born from the cows of the broad body type. Particularly high average daily weight gain was noted in the period between three and six months, and between 12 and 15 months ($P \leq 0.001$).

The high growth rate of the calves born from the mothers of the broad body type shows that they develop completely earlier than their peers from other groups, which is mainly due to the heredity and the good feeding conditions.

Table IV: Results of check slaughtering of the calves at the age of 18 months

Value	Type of animals		
	Shallow	Medium	Broad
	M ± m	M ± m	M ± m
Number of animals	5	5	5
Live weight at the end of growing, kg	457.0 ± 2.33***	479.7 ± 9.94	513.3 ± 5.46
Pre slaughter live weight, kg	437.0 ± 3.03***	460.7 ± 7.14*	493.3 ± 8.55
Hot carcass weight, kg	243.1 ± 3.31**	259.0 ± 4.78*	282.0 ± 6.16
Carcass yield, %	55.5 ± 0.37	56.2 ± 0.29	57.1 ± 0.67
Weight of internal fat, kg	6.7 ± 0.49**	8.6 ± 0.44*	11.1 ± 0.64
Slaughter yield, %	57.2 ± 0.39*	58.0 ± 0.24	59.4 ± 0.61

For studying the meat productivity of the calves, five animals from each group were slaughtered. As the data from Table IV show, the live weight at the end of growth of the calves of the shallow type was 457.0 kg, of the medium type — 479.7 kg, and of the broad type — 513.3 kg, with a high degree of veracity.

After fasting for 24 hours, the losses in the live weight of the calves after the transportation to the distance of over 100 km amounted to 19 – 20 kg.

By the weight of hot carcass, the calves of the broad type were superior to their peers of the shallow type by 38.9 kg ($P \leq 0.01$), and to the peers of the medium type — by 23 kg ($P \leq 0.05$). The same level of veracity ($P \leq 0.01$) was observed for the weight of internal fat in the calves of the broad and the shallow body type.

Table V: The morphological composition of the carcasses of the calves

Value	The genotype of the calves		
	Shallow	Medium	Broad
	M ± m	M ± m	M ± m
Number of animals	5	5	5
Chilled carcass weight, kg	239.3 ± 3.54**	255.0 ± 4.03*	278.6 ± 6.09
Boneless meat, kg	186.6 ± 1.63**	200.9 ± 2.94*	220.6 ± 4.64
Bones, kg	48.1 ± 1.28	49.0 ± 0.81	52.3 ± 1.37
Tendons, kg	4.6 ± 0.75	5.1 ± 0.31	5.6 ± 0.50
The yield of boneless meat per 1 kg of bones, kg	3.87 ± 0.08**	4.10 ± 0.01*	4.22 ± 0.04

In assessing the slaughter qualities of the calves, an important indicator is the morphological composition of the carcasses. The share of boneless meat in the carcasses of the calves in all studied groups ranged between 77.9 and 79.1 %. The weight of boneless meat in the calves of the broad type was higher than in the calves of the medium and the shallow types by 19.7 – 34.0 kg ($P \leq 0.01$, $P \leq 0.05$). The weight of the bones ranged between 48.1 – 52.3 kg, and the weight of tendons — between 4.6 and 5.6 kg.

The yield of boneless meat per 1 kg of bones in the calves of the shallow type was 3.87 kg, of the medium type — 4.10 kg, and of the broad type — 4.22 kg (Table V).

Analysis of the chemical composition of an average sample revealed a relatively higher content of dry matter in the calves of the broad body type. By this value, their advantage over the other groups amounted to 0.33 – 0.35 %. These differences may primarily be attributed to the fact that the meat of the calves of the broad body type contains by 0.68 % more fat than the meat of the calves of the shallow type, and by 0.46% more than the meat of the calves of the medium type. In terms of protein content, no significant differences were found between the groups of the animals; however, a slight advantage was noted for shallow-bodied calves, the meat of which contained 17.74 % of protein (Table VI).

The coefficient of the consumed feed conversion to the main nutrients in the edible part of the carcass shows that in the boneless meat of the bulls of the broad body type, 38.45 kg of protein were accumulated, while in the boneless meat of their peers of the shallow and the medium type — 33.10 – 35.26 kg, respectively, which was less by 3.19 – 5.35 kg. In terms of fat deposition, the advantage stayed with the calves of the broad body type, in the boneless meat of which 32.96 kg of fat had deposited, which was higher by 3.87 – 6.35 kg than in the calves of the medium and the shallow body type.

Table VI: Chemical composition of the boneless meat of the calves, % (general sample)

Value	The genotype of the calves		
	Shallow	Medium	Broad
	M ± m	M ± m	M ± m
Number of animals	5	5	5
Moisture, %	67.04 ± 0.21	67.02 ± 0.29	66.71 ± 0.28
Dry matter, %	32.96 ± 0.22	32.98 ± 0.31	33.29 ± 0.32
Fat, %	14.26 ± 0.17	14.48 ± 0.21	14.94 ± 0.23
Protein, %	17.74 ± 0.31	17.55 ± 0.38	17.43 ± 0.42
Ash, %	0.96 ± 0.01	0.96 ± 0.01	0.92 ± 0.02
Energy value of 1 kg of boneless meat, MJ	4.89	4.93	5.05
Protein to fat ratio	1.24 ± 0.11	1.21 ± 0.14	1.16 ± 0.15

The yield of protein per one kg of the live weight in the group of calves of the shallow body type amounted to 72.4 g, of the medium type — to 73.47 g, and of the broad type — to 74.9 g; the difference in favor of the calves of broad body type amounted to 1.43 and 2.50 g, respectively. By the fat yield, the advantage stayed with the calves of the broad body type; the fat yield per 1 kg of the live weight of the calves amounted to 64.2 g, which was higher by 3.6 — 6.0 g than in their peers.

Table VII: Feed conversion to meat products

Value	The genotype of the calves		
	Shallow	Medium	Broad
Deposited in the tissues of the body, kg			
protein, kg	33.10	35.26	38.45
fat, kg	26.61	29.09	32.96
energy, MJ	912.4	990.4	1114.0
Protein yield per 1 kg of the live weight, g	72.4	73.47	74.9
Fat yield per 1 kg of the live weight, g	58.2	60.6	64.2
The coefficient of the feed crude protein conversion to the protein in the edible part of the product, %	11.98	12.10	12.60
The coefficient of feed energy conversion to meat products, %	35.9	36.3	36.7

The coefficient of feed protein feed conversion to meat products shows that the calves of the broad body type convert feed protein into meat products more efficiently by 0.4 – 0.8 %, compared to their peers; a similar regularity is also observed for the conversion of the metabolizable energy (Table VII).

Thus, the coefficient of feed protein and energy conversion to dietary protein in the edible part of the carcass was higher in the calves of the broad type, which is due to a more intensive accumulation of muscle and adipose tissues in their organisms.

IV. CONCLUSION

1. During the first lactation, the heifers of the shallow type gave 5,353 kg of milk, which was more by 500 – 539 kg than from the heifers of the medium and the broad types ($P \geq 0.01$). In the milk from the broad-bodied cows, the share of fat was about 3.79 %, which was more by 0.04 – 0.07 % than in the milk from their peers of the medium and the shallow body type ($P \leq 0.001$).
2. The high growth rate of the calves born from the mothers of the broad body type shows that they develop completely earlier than their peers from other groups, which is mainly due to the heredity and the good feeding conditions.
3. The results of slaughtering have shown that the carcasses of the calves of the broad body type have high meatiness index and feature high yields of protein and fat. The coefficient of feed protein conversion to meat products shows that the calves of the broad body type convert feed protein into meat products more efficiently by 0.4 – 0.8 %, compared to their peers; a similar regularity is also observed for the conversion of the metabolizable energy.

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