International Journal of
Veterinary Science & Technology

Research Article

Accelerated Improvement of Carcass Characteristics in Pigs

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Submitted: 24 December 2017; **Approved:** 08 January 2018; **Published:** 09 January 2018

Cite this article: Bekenev VA, Mager SN, Frolova VI, Muratov AA, Deeva VS, et al. Accelerated Improvement of Carcass Characteristics in Pigs. Int J Vet Sci Technol. 2018;3(1): 001-005.

Abstract

Three experiments were carried out to improve the characteristics of the production of Large White pigs (LW) meat, selected in Russia, according to various variants of crossing with the breed of Yorkshire (Y) and the Landrace (L).The experiments did not reveal a significant difference between the groups in the characteristics of reproduction. The growth rates of piglets of two breeds (LW x Y) were slightly higher than in purebreds ($P < 0.05$).In 2-breed pigs, the back fat thickness at a body weight of 100 kg was 26.3 mm compared to 30.7 mm for purebred pigs ($P < 0.001$), and the area of the muscular eye was 45.1 cm^2 and 30.6 cm^2, respectively ($P < 0.001$). As for hybrids of three- breeds (LW x Y) x L, the age of 100 kg of body weight was less by 12.5 days ($P < 0.01$), and the back fat thickness was 11, 4 mm less (P < 0.001) compared with the control group. In the replacement pigs obtained as a result of absorbent crossing (LW x Y) x Y, the back fat thickness 19.2 mm, which was higher than that of pure-bred Y pigs (13.0 mm) ($P < 0.001$), but thinner than LW of 7.6 mm. Absorbing crossing with the Y breed to the level of the 3rd generation allowed to obtain genotypes with a back fat thickness of 9-10 mm less in the gilts than in the LW breed. The fastest growing pigs had the highest rate of EAE blood system's edg/edf genotype ($P < 0.05$), but at the same time this genotype is characteristic of the pigs with high back fat thickness ($P< 0.05$). The experimental data show that to improve the quality of carcasses of pigs of LW of the breed of Russian breeding, it is possible to use different variants of their crossing with boars of the Y breed of Canadian breeding.

Keywords: Breed; Crossing; Pigs; Fattening; Carcass Traits; Back Fat; Erythrocyte Antigen.

INTRODUCTION

The most popular swine breed in Russia and Kazakhstan is Large White (LW) imported from England about 100 years ago [1-4]. Animals of this breed are well adapted to the cold climate of these regions. The new genotypes of this breed in Russia are just as good as the best breeds in the world for reproductive and fattening characteristics.

However, their meat qualities are significantly lower than in modern foreign breeds, which is due to the long selection for high fat content at the carcass in cold climate, which contributes to better animal adaptation.

To quickly improve the characteristics of the carcasses, sows of this breed were crossed from the imported Yorkshire (Y) breed pigs imported into Russia in 2001 from Canada, which were selected under similar climatic conditions, and which showed excellent signs of carcasses [5]. According to the available data, the age of 100 kg of body weight of this breed in another region of Russia was 176 days, the average daily gain during the fattening period is 813 g, the thickness of the back fat thickness is 16.2 mm, the length of the carcass length, is 97 cm, the area of the eye muscle area is 48.9 cm^2, the weight of the rear ham is 12.3 kg. Animals of this breed showed high intensity of fattening and improvement of carcass characteristics when crossing with other breeds [6].

The purpose of this work was to develop ways to improve the characteristics of the carcass of LW breed of Russian breeding, mainly reducing the back fat thickness, through the rational use of the genetic potential of different breeds. More specifically, the research task was to determine the characteristics of reproduction, fattening and carcass of pigs obtained as a result of various variants of crossing the breed of pigs of the Novosibirsk genotype (micro breed) with animals of the Canadian Y breed, in industrial conditions in Siberia.

MATERIALS AND METHODS

Research involved several experiments

Experiment 1: Two groups consisting of randomly selected 50 LW breed sows of Novosibirsk type were used for the experiment. Sows of the first (control) group were fertilized (artificially inseminated) with the sperm of boars of the same breed, whereas sows of the second group were fertilized with the sperm of Canada bred Y boars, several generations of which had been grown in Russia (Tables 1,2).

Experiment 2: In this experiment group I was the control group. The Large White sows of this group were impregnated with the sperm of the same breed swines. In this experiment, group I was the control group, in which the sows LW of the breed was inseminated with the sperm of boars of the same breed. The LW sows of the group II were fertilized with the sperm of Canada bred Yorkshire swines (Hypor company). Thus, two-breed hybrids were obtained. In the group III purebred LW sows were fertilized with the sperm of two-breed boars (LW x Y), while in the group IV two-breed sows were fertilized with the sperm of LW boars. In the group V two-breed hybrid sows were

Table 1: Reproduction characteristics of the Large White sows in the case of pure breeding and crossing with Yorkshire boars (Experiment 1).

Group	Numbers born alive	Litter weight at farrow, kg	Number of piglets at day 21	Weight of all piglets at 21 days, kg	At day 30		
					number of piglets	litter weight, kg	body weight of piglets, kg
1 - control LW x LW	10.0 ± 0.38	13.8 ± 0.48	9.9 ± 0.16	60.9 ± 0.87	9.8 ± 0.16	80.5 ± 1.38	8.2 ± 0.12
2 - LW x Y	10.0 ± 0.36	13.7 ± 0.51	9.8 ± 0.16	58.4 ± 0.97	9.7 ± 0.15	79.6 ± 1.90	8.2 ± 0.17

Table 2: Fattening and carcass traits of the purebred and hybrid young pigs (Experiment 1).

Group	n	Average daily gain, g	Age at 100 kg body weight, days	At 100 kg body weight			
				carcass weight, kg	carcass length, cm	back fat thickness at 6–7 dorsal vertebra, mm	weight of the rear ham, kg
1 - control LW x LW	19	819 ± 10.6	169.2 ± 1.37	69.6 ± 0.32	95.3 ± 0.48	30.7 ± 0.11	11.0 ± 0.03
2 -LW x Y	23	830 ± 14.6	166.9 ± 2.34	70.3 ± 0.31	95.8 ± 0.44	26.3 ± 0.07***	11.3 ± 0.06

Difference is significant, when ***$P < 0,001$.

fertilized with the sperm of two-breed boars, i.e. carried out pure breeding. Group VI was used to assess the efficiency of three-breed crossing, where Landrace (L) swines were used as the final breed (Tables 3,4).

Experiment 3: This experiment was carried out according to a scheme similar to that of experiment 2 with the introduction of a second control group II, in which the Y sows were fertilized with the sperm of the same wild boars, whereas in group IV two-breed sows were fertilized with the boar Y sperm, i.e, absorbent crossing was performed (Tables 5). Group V shows (Tables 6) the growth and development of replacement gilts of the third generation (F_3) absorbent crossing for the breed Y, in group VI - the reproductive crossing. The duration of fattening of pigs of different genotypes was 91-113 days, rearing of replacement gilts -104-118 days.

After farrow sows and young pigs were kept in the separate sections on slatted plastic floors of the farrowing pen. Then they were kept in the sections of weaning and fattening equipped with the system of automatic microclimate control, self-feeders, batch system of dung removal. At the age of 30 days young pigs were weaned and immediately transferred to the weaning group. At the age of 90 days young pigs of the control and experimental groups were transferred to the fattening group, where they were fed until their body weights were 100 kg. Experimental animals from various groups were fed similarly, using feeds produced industrially on the basis of appropriate recipes, balanced in accordance with the main nutrients. Housing conditions of all experimental animals were similar. Genetic structure of the animals from different groups was determined using approved methods of analysis of swines' blood types [7]. Digital data were processed on the basis of the standard practice [8,9] using Excel computer program for calculation of breeding and genetic parameters. Statistical analysis of the results was performed by a parametric method (t-Student tests) using the «Microsoft Excel» и «Statistica», 10.0 for Windows (StatSoft, Inc., USA).

RESULTS AND DISCUSSION

Experiment 1: Has shown that reproduction characteristics (according to the first farrow) of the LW sows were approximately on the same level as in Canada both in the case of pure breeding and in the case of crossing with Y boars under industrial conditions. Numbers born alive of Canada bred Y sows in the case of pure breeding is 9.6-10.6 numbers born alive [10], while numbers born alive of the crossbred Y-L sows is 10.2-10.9 numbers born alive per farrow [11].

There has been no significant difference between control and experimental animals in the terms of research parameters. The number of emergency farrows in the control group was 13%, while in the control group it was 14%, viability of piglets was 98% and 97%, respectively (Table 1). Crossing did not result in improvement of reproduction characteristics of the LW pigs of Novosibirsk type

Table 3: Reproduction characteristics of Large White sows in the case of pure breeding and crossing with Yorkshire and Landrace boars (Experiment 2).

Group	n	Numbers born alive	Litter weight at birth, kg	Weight of piglets at birth, kg	At 30 days		
					number of piglets,	litter weight, kg	body weight of piglets, kg
I – control (LW x LW)	10	10.3 ± 0.4	12.8 ± 0.55	1.24 ± 0.02	9.6 ± 0.16	76 ± 2.6	7.9 ± 0.3
II - LW x Y	10	10.1 ± 0.4	12.5 ± 0.6	1.23 ± 0.02	9.6 ± 0.3	83.6 ± 3.6	8.7* ± 0.2
III – LW x (LWxY)	10	10.2 ± 0.53	12.9 ± 0.84	1.22 ± 0.02	9.5 ± 0.17	76.2 ± 2.85	8.0 ± 0.19
IV – (LWxY) x LW	10	10.6 ± 0.52	12.4 ± 0.67	1.17 ± 0.01	9.8 ± 0.2	78.7 ± 3.16	8.1 ± 0.3
V – (LWxY) x (LWxY)	10	10.8 ± 0.57	12.7 ± 0.73	1.17 ± 1.01	9.6 ± 0.4	75.93 ± 3.76	7.9 ± 0.23
VI – (LWxY) x L	10	11.1 ± 0.77	13.5 ± 0.92	1.21 ± 1.01	9.7 ± 0.33	74.5 ± 3.55	7.7 ± 0.23

* - difference compared to control is significant, when $P < 0.05$.

Table 4: Fattening and carcass traits of the purebred and hybrid young pigs (Experiment 2).

Group	n	Average daily gain, g	Age at 100 kg body weight, days	At 100 kg body weight				
				carcass weight, kg	carcass length, cm	back fat thickness at 6–7 dorsal vertebra, mm	weight of the rear ham, kg	eye muscle area, cm^2
I-control (LWxLW)	18	728 ± 16.71	173.4 ± 3.11	68.8 ± 0.40	95.0 ± 0.37	35.0 ± 1.27	10.5 ± 0.10	30.6 ± 3.08
II- (LWxY)	20	751 ± 8.70	169.2 ± 1.49	69.56 ± 0.42	97.0 ± 0.46**	26.5 ± 1.29***	10.6 ± 0.08	45.1 ± 1.18***
III – LWx (LWxY)	10	737 ± 14.09	173.2 ± 1.58	69.43 ± 0.93	95.6 ± 0.63	23.5 ± 0.89***	10.8 ± 0.09	42.9 ± 1.58**
IV – (LWxY) x LW	12	682 ± 16.64	183.1 ± 3.21	67.6 ± 0.33	95.30 ± 0.46	29.9 ± 0.85	10.5 ± 0.07	-
V - (LWxY) x (LWxY)	10	696 ± 19.81	178.5 ± 3.66	68.21 ± 0.64	95.24 ± 0.38	28.0 ± 1.15	10.6 ± 0.08	-
VI – (LWxY) x L	17	789 ± 9.15**	160.9 ± 1.62**	69.3 ± 0.50	96.6 ± 0.27**	23.6 ± 0.51***	10.8 ± 0.13	41.8 ± 3.00*

Difference compared to control group is significant, provided that:
* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

Table 5: Reproduction characteristics of Large White sows and Yorkshire sows in the case of pure breeding and crossing (Experiment 3).

Group	n	Numbers born alive	Litter weight at farrow, kg	At 30 days		
				number of piglets	litter weight, kg	body weight of piglets, kg
I – control (LWxLW)	6	12.5 ± 0.92	16.9 ± 1.05	10.3 ± 0.21	81.0 ± 2.01	7.8 ± 0.17
II – (LWxY)	27	11.2 ± 0.20	13.7 ± 0.35	10.3 ± 0.13	84.2 ± 1.84	8.19* ± 0.17
III – LW x (LWxY)	14	12.2 ± 0.41	15.0 ± 0.60	10.4 ± 0.16	84.0 ± 2.59	8.10 ± 0.20
IV – (LWxY) x LW	10	11.3 ± 0.3	13.9 ± 0.48	10.3 ± 0.21	77.9 ± 3.23	7.6 ± 0.29
V – (LWxY)x (LWxY)	60	12.3 ± 0.20	15.3 ± 0.33	10.4 ± 0.08	84.8 ± 1.40	8.17* ± 0.13
VI – (LWxY) x Y	63	11.9 ± 0.23	14.7 ± 0.34	10.3 ± 0.09	83.6 ± 1.31	8.12* ± 0.11
VII- (Y x Y)	6	13.3 ± 1.77	17.2 ± 2.11	10.6 ± 0.87	92.1 ± 8.05	8.72 ± 0.43

Difference as compared to the control group I is significant, provided that * $P < 0.05$.

Table 6: Growth and development of purebred and hybrid replacement gilts.

Group	n	Age at weight 100 kg, days	Back fat at 6–7 dorsal vertebra, mm	Carcass length, cm
I – control (LW x LW)	20	188 ± 3,0	26,8 ± 0,2	125,6 ± 0,4
II – (Y x Y)	20	179 ± 2,9*	13 ± 0,4***	125,7 ± 0,3
III – (LW x Y)	20	186 ± 2,1	22,6 ± 0,1***	125,7 ± 0,2
IV – (LW x Y) x Y	40	184,4 ± 1,2	19,2 ± 0,2***	125,3 ± 0,2
V – (F_3) absorbent crossing : [(LW x Y) x Y] x Y ; [(LW x Y) x (LW x Y)] x Y	40	180,5 ± 2,1*	16,4 ± 0,4***	125,6 ± 0,2
VI – (F_3) reproductive crossing : (LW x Y) x [(LW x Y) x (LW x Y)] ; [(LW x Y) x Y] x [(LW x Y) x (LW x Y)]; [(LW x Y) x (LW x Y) x Y] x [(LW x Y) x (LW x Y)];	40	184,5 ± 1,4	17,4 ± 0,2***	125,7 ± 0,3

Pigs - difference as compared to the control group I is significant, provided that: * - P < 0.05; ** - P < 0.01; *** - P < 0.001.

that had been well bred, in order to obtain superior reproduction characteristics. When the body weight of purebred and hybrid pigs was 30 kg, they were transferred to the fattening group and fed until their body weight became 100 kg (Table 2). In this context animals' growth rate turned to be high and exceeded requirements of elite class in terms of age at 100 kg body weight by 21-23 days (according to Russian standard). Hybrid animals tended to have higher growing power. Average daily growth gain of pigs in the experimental group was 830 g against 819 g in the control group. In this context age at 100 kg body weight was 166.9 days or 2.3 days (1%) less compared to purebred gilts. At gilts' age at 100 kg body weight 11 animals were killed in each group. In thickness of back fat at 6-7 dorsal vertebra the best results were recorded for two-breed hybrids: 26.3 mm against 30.7 mm recorded for purebred L W pigs (P < 0.001).

Experiment 2: Table 3 did not reveal significant differences between the groups in terms of prolificacy. When the purebred sows of experimental group 2 were crossed with Y boars, body weight of piglets weaned at the age of 30 days was 0.8 kg (10.1%) higher (P < 0.05). Two-breed hybrid young pigs of the II experimental group demonstrated higher growing power and faster gaining of 100 kg body weight as compared to the purebred counterparts (Table 4). Average daily growth gain of the hybrids in this group was 751 g against 728 g in control group, i.e. was 23 g (3.2%) higher. In this context their age at 100 kg body weight was 169.2 days or 4.2 days (2.4%) less compared to purebred gilts. The heterosis effect was more complete among the three-breed hybrids (group VI), where the average daily gain was 61 g (8.4%) higher (P < 0.01), they reached a live weight of 100 kg for 12.5 days (7, 2%) faster (P < 0.01) than in the I control group. As for pigs from experimental group II, their average daily gain was 38.3 g (5.1%) (P < 0.01), and the age of reaching 100 kg was 8.4 days (4.9%) better (P < 0.01). All the options of animal crossing facilitated reduction of the thickness back fat. Thus, the thickness back fat of two-breed hybrids (♀LW x ♂Y) was 26.5 mm, the thickness back fat of three-breed animals (♀(LW x Y) x ♂L) was 23.6 mm, whereas difference compared to the purebred animals was highly significant (P < 0.001). Minimum the thickness back fat (23.5 mm) was recorded for the gilts obtained in the result of crossing of purebred LW sows with two-breed LW x Y boars (group III). Two- and three-breed hybrid animals from the groups II, VI demonstrated carcass enlargement by 1.6 and 2 cm (P < 0.01), eye muscle area (longissimus dorsi muscle), of the gilts from experimental groups II, III and VI increased by 14.5 cm^2 (P < 0.001), 12.3 cm^2 (P < 0.01) and 11.2 cm^2 (P < 0.05) respectively as compared to their counterparts from the control group.

Experiment 3: Did not reveal significant differences in terms of production performance among the sows of initial breeds in the case of pure breeding (control groups I and VII).

Likewise in the Experiment 2, weight of two-breed piglets from experimental group II at 30 days was 0.4 kg or 4.8% higher than the weight of purebred piglets of the LW sows (control group I) (P < 0.05). Similar superiority over the control group I in terms of piglets's body weight at the moment of weaning could be observed in group V consisting of hybrids obtained in the result of reproductive cross (by 0.4 kg or 4.6%) and in group VI consisting of hybrids obtained in the result of absorbent crossing of Y (0.3 kg or 4%), whereas the difference was significant (P < 0.05). There was no significant difference between hybrids obtained in the result of back crossing of any initial breed or reproductive crossing in terms of test characteristics. We evaluated the development of replacement gilts obtained as a result of purebred breeding (KB and Y) and their hybrids of the first, second and third generations (Table 6). 2-breed first-generation pigs (LWxY) reached a weight of 100 kg for 2 days, hybrids of the second generation (LWxY) xY are 3.6 days faster than purebred pigs LW. Hybrids obtained as a result of absorbent crossing [(LWxY) xY] xY reached this weight earlier by 7.5 days (P < 0.05), and hybrids obtained as a result of reproductive crossings by 3.5 days compared to purebred pigs LW of the breed.

Age at 100 kg body weight of the purebred Y pigs was 179 days, i.e. it was approximately similar to their counterparts bred in Canada [12]. The thickness of back fat in the 6-7 dorsal vertebrae of the hybrid replacements gilts of the first and second generations of the experimental groups was 22.6-19.2 mm (P < 0.001) versus 26.8 mm in purebred pigs LW and 13.0 mm in pigs of breed Y. Optimal results of back fat were recorded for second-generation hybrids obtained as a result of absorbent crossing (LW × Y) × Y - 19.2 mm (P < 0.001).

However, the back fat was thicker, than in purebred gilts Y (13.0 mm). Approximately the same thickness of back fat was recorded for gilts of this breed in Canada [10]. According to the Canadian center for the Improvement of pigs in 2012, the age of reaching 100 kg of boars was 152 days, the gilts-162 days. The thickness of the back fat in the boars was 9.8 mm, in gilts 10.4 mm (at the level of 12-13 ribs) [13]. In gilts of the third generation of absorbent and reproductive crossings, back fat was even thinner -16.4 and 17.4 cm, respectively. This is 9-10 mm less than that of pigs of LW breed. Sows LW differed from Y in the frequency of occurrence of genotypes of Erythrocyte Antigens (EA). According to the EAA system, $A^{cp/-}$ the genotype among the sows had a frequency of 0.42, versus 0.69 in pure-bred Yorkshire sows.

Distribution of the genotypes in EAG and EAD blood systems turned to be similar in the both groups. The rate of $E^{aeg/bdg}$, $E^{aeg/bdf}$, $E^{aeg/edg}$, $E^{aeg/edf}$ genotype occurrence in multiform EAE blood system of the LW breed varied from 0.03 to 0.13, whereas the Y pigs had none of them. There were no Y pigs having $E^{aeg/edg}$, $E^{aeg/edf}$, $E^{aeg/bdg}$, $E^{aeg/edg}$, $E^{aeg/edf}$ blood genotypes. Rate of occurrence of $E^{bdg/edg}$ genotype was twice higher among the LW pigs (0.33) as compared to the rate of the Y pigs (0.16), whereas the higher rate of occurrence of $E^{edg/edg}$, $E^{edg/edf}$ genotypes was recorded for the Y breed (0.38) as compared to the LW sows - 0.11-0.20 respectively. The study revealed significant difference ($P < 0.01$) between the LW breed and Y breed in frequency of the rate of EAF $F^{a/b}$ genotype occurrence. There were no animals with EAF a/a genotype among both breeds. Hybrids of various options demonstrated an interesting consistent pattern: the fastest growing pigs had the highest rate of EAE blood system's edg/edf genotype ($P < 0.05$), but at the same time this genotype is characteristic of the pigs with high back fat thickness ($P < 0.05$). This is true not only for animals with this genotype, but in general for the animals having EAE^{edf} allelic gene irrespective of its presence in the composition of any genotype ($P < 0.05$). Therefore, in the case of breeding with the purpose of improvement of early maturity characteristics it is necessary to select animals having this allelic gene, while breeding with the purpose of back fat thickness reduction requires selection of the animal without this allele. As the climatic conditions of Canada are very similar to the conditions of Siberia of Russia, although slightly softer, we assumed that the adaptation of Canadian breeds of pigs to the Siberian climate will be easier compared to European breeds. Earlier (1966-1967), we evaluated the quality of the carcasses of Lacombe (LB) pigs imported from Canada, the Siberian Northern Breed (SN) that were bred in Siberia and their hybrids when fattened in conditions of negative air temperature in the handles [14]. The SN x LB hybrids were the best in terms of growth intensity. However, the back fat thickness, measured on 6-7 dorsal vertebrae of pigs killed with a weight of 95 kg, was quite high in these hybrids - 29.4 mm against 29 mm in SN pigs and 22.3 mm in L-breed. The complete dominance of the SN breed over the back fat thickness in these hybrids was probably the result of a reaction to cold conditions. It should be noted that the excellent quality of the carcass was typical for the animals LB even at that time. Technological conditions of maintenance and nutrition, used at that time in Siberia, did not allow to fully reveal the genetic potential of this breed. That is why their use was limited to crossing with other breeds. Currently, scientists are working to improve the meat and fattening qualities of animals, the breeding of new breeds, types and lines, the creation of inter-linear hybrids, using breeds of animals of foreign breeding. This ensures the production of pork with a high percentage of muscle tissue in the carcass for a shorter process cycle [15-17] develop feeding standards that allow to receive pork with low fat content [18].

CONCLUSION

The experimental data show that to improve the quality of carcasses of pigs of LW of the breed of Russian breeding, it is possible to use different variants of their crossing with boars of the Y breed of Canadian breeding. Absorptive crossing to the level of the 2nd-3rd generation allows obtaining the desired genotypes and creating herds of animals, with high productive and consumer qualities, with a muscular eye area of 45 cm^2 and the thickness of the back fat is 9 -10 mm less than that of the LW of the breed. At the same time, it is promising to use erythrocyte antigens as genetic markers in the process of further selection. Preliminary results of the observation indicate that the animals of breeds of Canadian selection recently imported into Siberia, as well as sows with 3/4 - 7/8 bloodiness in Y in the conditions of industrial technology for adaptive qualities, the duration of use is not inferior to the Siberian selection.

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