Scientific Papers. Series D. Animal Science. Vol. LXVIII, No. 2, 2025
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

GROWTH INTENSITY AND FATTENING PERFORMANCE OF PUREBRED PIGS OF DIFFERENT BREEDING LINES AND CROSSBRED AND HYBRID ANIMALS BASED ON THEM

Mykola KREMEZ[1], Oleksandr MYKHALKO[1], Mykola POVOD[1], Bogdan GUTYJ[2], Oleksandr TSERENIUK[3], Natalia KRYGINA[3], Inna KEPKALO[4], Mykhailo KUZMENKO[4], Kostiantyn MAKHNO[4]

[1]Sumy National Agrarian University, Department of Feed Technology and Animal Feeding, 160 H. Kondratiiev Street, Sumy, Ukraine
[2]Stepan Gzhytskyi National University of Veterinary Medicine and Biotechnologies, Department of Pharmacology and Toxicology Employment, 50 Pekarska Street, Lviv, Ukraine
[3]Institute of Pig Breeding and Agroindustrial Production of the National Academy of Agrarian Sciences of Ukraine, 1 Swedish Grave Street, Poltava, Ukraine
[4]Separated Subdivision National University of Life and Environmental Sciences of Ukraine «Nizhyn Agrotechnical Institute», Shevchenko Street, 10 Nizhyn, Chernihiv Region, Ukraine

Corresponding author email: snau.cz@ukr.net

Abstract

The article analyzed growth intensity, feed efficiency, fattening costs and profitability of pigs of maternal, paternal and hybrid genotypes. The study found that the pigs of the synthetic parental line outperformed their maternal counterparts in daily and absolute gains by 25.1 to 28.8% and in final weight by 24.9 to 28.9% and reached 120 kg, 14.6 to 16.5% earlier due to index selection for fattening traits. These pigs also had 13.3-13.8% better feed conversion and 80.4-92.5% higher total fattening index, albeit with a slightly lower survival rate (0.04-0.73 %). Hybrid piglets showed 17.6-21.2% higher gains, reached 120 kg 10.2-11.5% earlier and had a 16.4-18.8% higher final weight. They also had 2.2 to 3.4% better feed conversion, resulting in 41.7 to 51.7% higher fattening indices than purebred dam genotypes, with no clear survival trend. The results underline the advantages of hybridization and targeted selection to improve growth performance and feed efficiency in pig production.

***Key words**: breeding methods, genotype, income, pigs, profitability.*

INTRODUCTION

It is known that modern approaches in pig breeding are based on crossbreeding, which contributes to higher productivity and lower meat costs due to heterosis, which increases average daily gain and reduces feed costs (Voloshynov & Povod, 2023; Voloshynov & Povod, 2024). And the use of single nucleotide polymorphisms and the BLUP system improves the accuracy of animal performance evaluation, optimising breeding investments and economic forecasts (Ma et al., 2024; Rasal et al., 2024).

Hybrid pigs as a product of the breeding process exhibit higher productivity that provides farmers with stable financial results (Budakva et al., 2023; Ibatullin & Khakhula, 2020; Tishchenko & Moysey, 2024), especially through the integration of additive and dominance effects in breeding models (Qiao et al., 2024; Zhu et al., 2020). Genetic correlations between breeds have been shown to allow the selection of genotypes to maximise economic benefits and reduce the risk of inbreeding depression, which can negatively affect productivity (Gutierrez-Reinoso et al., 2021; Mota et al., 2024). As a result, genetic evaluation contributes to the creation of animals with increased stress resistance, which reduces production losses, and regression models optimise maintenance costs (Cheruiyot et al., 2022; Singh & Ali, 2021) by reducing correlations between indicators in nucleus and commercial herds, which has a positive impact on the profitability and stability of economic results of pork producers (Gruhot et al., 2017; Sanz-Fernández et al., 2024). The transfer of breeding successes therefore makes it possible to increase the competitiveness of farms both nationally and internationally and to ensure a rapid return on investment thanks to highly productive inbred pigs (Gupta et al., 2022; Kremez & Shpetnyi, 2024). And automated evaluation systems speed up breeding processes and reduce labour costs for pig farms (Dambaulova et al., 2024; Thoma et al., 2024). Thanks to the prediction of individual heterosis, even small farms can achieve high economic efficiency (Liu et al., 2023; Tsiouni et al., 2023).

It was studied the efficiency of fattening pigs of commercial genotypes of Danish origin in crossbreeding and hybridisation under the conditions of industrial pork production in Ukraine and found that hybrid pigs from the combination ¼Y ¼L ½D grew 5.4% faster, reached a mass of 110 kg 5.5 days earlier, had a 5.2% better feed conversion ratio and a 6.6% higher profitability of fattening hybrid pigs of Danish origin compared to bibreed crosses of the maternal genotypes ½Y ½L (Chernenko et al., 2022). In a three-way cross between Irish Large White and Landrace crossbred sows with Duroc boars, 5 higher average daily gain and 4 better feed efficiency was found in pigs from the three-way cross compared to a two-way cross between Irish Large White and Landrace (McGloughlin et al., 1988). At the same time, it was reported (Nielsen & Velander, 2016) that when comparing the fattening performance of purebred Danish Duroc pigs with crossbred animals from the Duroc × (Landrace × Yorkshire) (D(LY)) combination, no difference in average daily gain was found between animals of both genotypes, while feed conversion efficiency was 0.09 kg better in purebred animals compared to D(LY) crosses. At the same time, Danish pigs from the Duroc × Landrace × Yorkshire (DLY) cross had an average daily gain of 1059 g, which is 142 g higher than pigs from the Pietren × Landrace × Yorkshire (PLY) cross, and a 0.13 kg better feed conversion efficiency (Maribo et al., 2018). Under the conditions of industrial pork production in Ukraine, according to published data (Povod et al., 2021) hybrid pigs of American origin kept in industrial pig farms reached a weight of 100 kg in 156.8-157.7 days, with average daily gains in the range of 848.1-875.2 g with a feed conversion ratio of 2.73-2.84 kg. According to (Rasal et al., 2024), hybrid pigs of Irish origin reached a weight of 100 kg in 151.1-160.0 days, with average daily gains of 850.9-929.7 g and a feed conversion ratio of 2.5-2.51 kg. At the same time, according to (Mykhalko, 2021), even under the conditions of industrial technology in Ukraine, hybrid young animals of Danish origin reached a weight of 100 kg within 146.1-151.7 days and showed an average daily live weight gain of 926.0-1013 g with a feed efficiency per 1 kg of gain of 2.66-2.75 kg. Another opinion is expressed by (Khramkova & Povod, 2017) according to whose study results, the best fattening indicators among the animals of foreign selection bred in the same pig complex were shown by hybrids of Irish Yorkshire and Landrace sows fertilised with semen from boars of the synthetic Maxgro line of Irish selection. Their fattening qualities exceeded those of their counterparts, which were inseminated with the genetic material of boars of English and French origin. The better results of industrial crossbreeding and hybridisation with foreign pig genotypes are reported (Birta & Burhu, 2022; Fediaieva, 2018; Koroban & Lykhach, 2018; Vashchenko, 2017) it also contributes to increasing the economic efficiency of pork production.

According to Maksym et al. (2022), Neeteson et al. (2023), Rodenburg & Turner (2012), increasing the number of breeds involved in obtaining hybrid young pigs for fattening increases the efficiency of hybridisation, but at the same time requires constant study of their combinability.

The subject of the study was the growth intensity, feed utilisation efficiency, cost of fattening an animal and 1 kg gain, profitability and profitability of fattening pigs of maternal and paternal genotypes and their crosses and hybrids.

MATERIALS AND METHODS

To conduct the research in the NPP "Globinsky Pig Complex" by the method of analogue groups, 7 groups of 10 sows were formed according to the scheme shown in the table. 1.

Groups 1 and 4 comprised large white purebred sows, groups 2 and 5 comprised purebred Landrace animals, group 6 comprised crossbred animals from large white sows and Landrace boars and group 7 comprised animals from the reciprocal crossing of animals of these breeds. Group 3 comprised sows of the synthetic line PIC337.

The animals in groups 1 and 5 were inseminated with semen from large white boars, while the corresponding animals in groups 2 and 4 were inseminated with semen from Landrace boars. The sows in groups 3, 6 and 7 were inseminated with semen from boars of the synthetic parent line PIC337.

Table 1. Experimental design

Pig genotype	GW	L	PIC337	½GW½ L	½L ½GW	¼ GW¼ L ½ PIC337	¼ L ¼ GW ½ PIC337
Number of pigs at the beginning of the experiment, head	75	75	75	75	75	75	75
Age of piglets at the beginning of the experiment, days	77	77	77	77	77	77	77
Fattening duration, days	109	109	109	109	109	109	109

When the piglets were weaned at 28 days of age, test groups of 75 animals were formed from each test group using the analogue group method and transferred to fattening complex no. 4 for rearing and further fattening. In this case, all experimental piglets were marked with number tags of different colors or shapes for each of the experimental groups. During rearing and fattening, the animals in all groups were fed a liquid feed mixture in a ratio of 1 part dry complete feed to 3 parts water in several phases. At the end of rearing, all test animals were weighed individually and the weight of the animals was recorded on the body. The average weight of the piglets in each group was then determined and 75 animals were selected that were closest to the average weight in each group. They were housed in identical pens on a fully slatted floor with an area of 0.73 square meters per animal. On the 35th day after the start of fattening, all piglets in the test groups were vaccinated with the Improvac vaccine from Zoetis at a rate of 2 ml per animal and on the 75th day of fattening, all test pigs were weighed individually and taken to the slaughterhouse. On the 109th day of fattening, all test pigs were weighed individually and taken to the slaughterhouse.

The conditions for feeding and housing the animals and all veterinary procedures in the experiments were carried out in accordance with European and national requirements for the care of pigs during the experiments.

The growth rate of the pigs during the fattening period was calculated on the basis of individual measurements of the pigs' weight at the beginning and end of the fattening period. Taking into account the feed consumption per group of pigs and their group weight, the average daily feed consumption and its conversion were calculated according to the generally recognised method (Ladyka et al., 2023). Using the methods described in the same textbook, the feed costs for fattening purebred, crossbred and hybrid pigs of the experimental groups and their growth units during fattening were calculated, as well as the efficiency and profitability of their fattening.

For a more comprehensive evaluation of the fattening qualities of purebred, crossbred and hybrid pigs of different breeding lines, the fattening quality indicator was calculated according to the following (Ladyka et al., 2023).

$$I=A^2/(B\times C) \quad 1)$$

where: A – absolute gain during the fattening period, kg;

B – duration of fattening, days;

C – feed consumption per 1 kg of gain, kg.

The experimental data were processed by the method of variation statistics (Ladyka et al., 2023) using the MS Excel 2016 application package and presented in the form of M±m, and the probabilities of differences in piglet growth indicators were calculated using the Student's t-test (*P <0.05; **P <0.01 and ***P <0.001).

RESULTS AND DISCUSSIONS

According to the research results, significant differences were found in the indicators of fattening productivity between animals of different breeding directions and different methods of their rearing. As shown in Table 2, a significant difference was found in the indicators of fattening productivity of pigs of great-grandparent forms between animals selected for maternal and paternal traits. At the same time, no significant difference was found in the fattening productivity indicators between animals of the Large White and Landrace breeds for their pure breeding.

Table 2. Fattening qualities of pigs of the great-grandparent genotypes

Indicator	Groups		
	I	II	III
Genotype combination	♀GW×♂ GW	L ♀ ×♂L	PIC ×PIC337
Average weight of 1 piglet at the beginning of fattening, kg	26.9±0.401	27.9±0.361	34.6±0.611 $^{bbb\ ccc}$
Pig survival during fattening, %	98.6	98.0	97.9
Age of reaching 120 kg weight, days	200.6±2.06	196.1±1.99	167.5±2.71 $^{bbb\ ccc}$
Age at weaning from fattening, days	186	186	186
Pig weight at weaning from fattening, kg	108.1±2.74	111.6±2.36	139.4±3.27 $^{bbb\ ccc}$
Absolute gain, kg	81.3±1.69	83.7±1.33	104.7±2.01 $^{bbb\ ccc}$
Average daily gain, g	813±10.2	837±8.7	1047±16.7 $^{bbb\ ccc}$
Feed conversion, kg	3.06	3.04	2.64
Fattening quality index, points	19.82	21.14	38.14

Note here and further the probability of difference between groups: a –1 and 2; b – 1 and 3; c – between 2 and 3.
Source: own calculations.

When comparing the fattening productivity of purebred animals of the maternal lines with piglets of the paternal line, with their intra-line breeding, a significant advantage of the latter was found in all indicators of fattening productivity. As can be seen from the results of studies among all experimental animals, the highest average daily gains during fattening were recorded in animals of the PIS 337 synthetic parental line. According to this indicator, with a high probability (P <0.001), they surpassed the animals of the Landrace breed by 210 g and their analogues of the Large White breed by 234 g. Higher growth intensity during the fattening period contributed to their higher absolute gains of 21.0 and 23.40 kg (P <0.001) compared to Landrace and Large White animals, which in turn resulted in their weight being 27.8 and 31.3 kg (P <0.001) higher at the end of fattening. Higher average daily and absolute gains during the fattening period in the animals of the third group contributed to an improvement in feed conversion ratio by 0.40 and 0.42 kg compared to the Landrace and Large White animals, despite the higher average daily feed consumption. In addition, due to the higher growth intensity in the postnatal phase, they reached a live weight of 120 kg after 28.6 and 33.1 days (P <0.001). At the same time, the animals of the parental line had a 0.04 and 0.73% lower survival rate compared to the Landrace and Large White analogues.

A complex indicator that characterizes the fattening qualities of pigs is the index of fattening qualities, which takes into account both the growth intensity of pigs and the efficiency of their feed conversion. In our experiment, the pigs of the synthetic parent line, which were selected according to the specified character-ristics, clearly outperformed their conspecifics of the Large White and Landrace breeds in terms of this indicator. Thus, the advantage over animals of the Large White breed was 18.3 points or 92.5% and over analogues of the Landrace breed 17.0 points or 80.4%.

Thus, due to index selection to improve fattening qualities, the pigs of the synthetic parental line outperformed their parent breed counterparts by 25.1-28.8 in terms of average daily and absolute gains, 24.9-28.9% in terms of pig weight at the end of fattening, reached a live weight of 120 kg 14.6-16.5% earlier, were 13.3-13.8% better at paying for feed gains and had a comprehensive fattening index of 80.4-92.5%, but had a worse survival rate of animals during fattening by 0.04-0.73%.

Comparing the productivity indicators of inbred and hybrid animals, no significant difference was found between animals from direct and reciprocal crossing of the Large White and Landrace breeds (Table 3).

Table 3. Fattening qualities of crossbred and hybrid pigs

Indicator	Groups			
	IV	V	VI	VII
Combination of parental genotypes	♀GW×♂L	L♀×♂GW	(♀GW×♂L) ×PIC337	(L♀×♂GW) ×PIC337
Average weight of 1 piglet at the beginning of fattening, kg	29.3±0.411	28.7±0.396	32.1±0.508 $^{eee\ ggg}$	33.1±0.543 $^{fff\ hhh}$
Pig survival during fattening, %	98.0	98.6	98.6	98.0
Age at reaching 120 kg, days	192.2±2.11	194.4±2.01	172.1±2.17 $^{eee\ ggg}$	172.6±2.09 $^{fff\ hhh}$
Age at weaning, days	186	186	186	186
Weight of pigs at weaning, kg	114.7±2.27	113.0±2.76	134.2±2.94 $^{eee\ ggg}$	133.4±2.97 $^{fff\ hhh}$
Absolute gain, kg	85.4±2.26	84.3±2.77	102.2±2.92 $^{eee\ ggg}$	100.4±2.84 $^{fff\ hhh}$
Average daily gain, g	854±14.9	843±12.1	1022±19.3 $^{eee\ ggg}$	1004±17.7 $^{fff\ hhh}$
Feed conversion, kg	2.97	2.96	2.87	2.90
Fattening quality index, points	22.52	22.00	33.38	31.92

Note: probability of difference between groups: d – 4 and 5; e– 4 and 6; f– 4 and 7; g– 5 and 6; h – 5 and 7; i – 6 and 7.

At the same time, the animals of these groups were clearly inferior to the hybrid analogues, which were obtained from crossed F1 sows of the maternal line and boars of the paternal line PIC337. There were also no differences between the pigs of the sixth and seventh experimental groups in terms of the level of basic fattening indicators. No clear trend was observed between inbred and hybrid animals in terms of survival rate during fattening, while the hybrid piglets outperformed their inbred counterparts by 150-179 g (P <0.001) in terms of average daily gains during this period, which in turn led to 15.0-18.9 kg (P <0.001) higher absolute gains and 18.8- 21.3 kg (P <0.001) higher weight at weaning. In addition, the higher growth intensity of the hybrid pigs contributed to a 19.6-22.3 days reduction in age to reach 120 kg. Their feed conversion during fattening was also 0.07- 1.10 kg better, which contributed to higher complex indicators of fattening quality by 9.9-11.4 points.

Thus, no significant difference was found between the indicators for the fattening productivity of piglets from direct crossbreeding and backcrossing of the dam breeds. There was also no difference in these traits between hybrid pigs derived from dams of maternal breeds from direct and backcrossing and boars of the paternal line. At the same time, the hybrid piglets had 17.6-21.2% higher average daily and absolute gains, reached a weight of 120 kg 10.2-11.5% earlier, had 16.4-18.8% higher post–fattening weight and 2.2-3.4% higher feed conversion ratio during this period, resulting in 41.7-51.7% higher complex indices of fattening qualities, while no clear pattern was found for piglet safety.

Pigs from purebred, crossbred and hybrid nests utilised feed differently during fattening. As shown in Table 4, no practical difference was found between the pigs of the parent breeds in terms of average daily feed consumption when comparing purebred and line-bred animals (Table 4). At the same time, the animals of the synthetic parent line consumed 0.25 kg more feed than the animals of the Large White breed and 0.20 kg more than the animals of the Landrace breed. During the entire fattening period, the difference in feed consumption between the animals of the Large White and Landrace breeds was 5.67 kg in favour of the latter. However, the animals of the synthetic parent line consumed 27.32 kg more than the animals of the Landrace breed and 21.65 kg more than the animals of the Large White breed and the Landrace breed. However, taking into account the higher growth intensity during fattening of the pigs in the third group, their feed conversion was 0.42 kg better than that of the Large White breed and 0.40 kg better than that of the Landrace breed. At the same time, the difference in feed conversion during fattening between the Large White and Landrace breeds was practically non-existent.

Table 4. Feed consumption and feed costs during fattening of purebred and linebred pigs

Indicator	Groups		
	I	II	III
Genotype combination	♀GW×♂ GW	L♀×♂L	PIC337×PIC337
Total feed consumption per 1 pig, kg	248.8	254.4	276.1
Average daily feed consumption during fattening, kg	2.28	2.33	2.53
Cost of feed consumed during fattening, EUR	39.31	40.20	43.62
Feed cost per 1 kg of gain during fattening, EUR	0.48	0.48	0.42

The different feed consumption and growth rates of pigs of the maternal and paternal genotypes also affected the feed costs for 1 kg gain during fattening. In the animals of the maternal breeds, they amounted to 0.48-0.49 EUR, while in the animals of the third group they were 0.63-0.66 EUR lower. A comparison of costs and feed conversion efficiency between inbred and hybrid animals shows that the latter have an advantage in these indicators (Table 5).

Table 5. Feed consumption and feed cost of fattening inbred and hybrid pigs

Indicator	Groups			
	IV	V	VI	VII
Combination of parental genotypes	♀GW×♂L	L♀×♂GW	(♀GW×♂L) ×PIC337	(L♀×♂GW) ×PIC337
Total feed consumption per 1 pig, kg	253.7	249.8	293.4	290.9
Average daily feed consumption during fattening, kg	2.33	2.29	2.69	2.67
Cost of feed consumed during fattening, EUR	39.47	46.36	45.96	0.88
Feed cost per 1 kg of gain during fattening, EUR	0.47	0.45	0.46	0.01

Thus, the average daily feed consumption during fattening was 0.34-0.40 kg higher in the hybrid animals than in the inbred animals, resulting in an increase in feed consumption during the entire fattening period of 37.1-43.6 kg in the hybrid animals compared to the inbred animals. Taking into account the different growth intensity, the feed conversion of the hybrids was also 0.07-0.10 kg better than that of the inbred animals.

At the same time, the difference between the feed consumption of inbred animals proved to be very insignificant. For example, inbred pigs from a combination of the Large White and Landrace breeds consumed 0.04 kg less feed, ate 3.94 kg less during the entire fattening period and had a 0.01 kg better feed conversion ratio during the fattening period compared to their counterparts from the reverse crossbred variant.

At the same time, when comparing the results of feed consumption and feed conversion efficiency of purebred animals of the initial forms with the hybrid analogues of the sixth and seventh groups, significant advantages in all these indicators were found in the hybrid animals compared to their purebred analogues of the maternal genotypes.

The presence of inheritance of the final parental form in the genotype of hybrid animals increased the level of average daily feed consumption during fattening by 0.33-0.41 kg, which caused an excess of consumption for the entire fattening period by 36.4-44.6 kg and, under the influence of the sire's genotype, an improvement in feed conversion ratio by 0.14-0.19 kg.

Improved feed conversion at the same price per kilogram led to a slight decrease in feed costs per kg gain in crossbred pigs by EUR 0.010-0.015 compared to purebred pigs, while in hybrid pigs of groups 6 and 7 the feed costs per kg gain were EUR 0.022-0.029 lower.

A slightly different picture emerged when comparing purebred animals of the synthetic line PC 337 with their hybrid offspring. Thus, the average daily feed consumption during fattening of the hybrids exceeded the corresponding indicator of the purebred animals by 0.14–0.16 kg, which resulted in the hybrid animals consuming 14.8–17.50 kg more feed during the entire fattening period.

At the same time, feed conversion was 0.23-0.26 kg worse compared to the animals of the parental form, but 0.16-0.19 kg better compared to the maternal form, which confirms the intermediate nature of the inheritance of this trait. These changes in feed conversion also affected the feed cost per 1 kg gain, which was 0.036-0.041 EUR higher in the animals of the parental line than in the hybrids, 0.051-0.52 EUR higher than in the crossbred animals and 2.87-3.01 EUR higher than in the purebred animals of the maternal genotypes.

Crossbred pigs from a combination of dam breeds had a 0.4-1.8% higher daily feed intake, a 2.5-3.2% better conversion and feed cost per 1 kg gain during fattening compared to the original dam forms, but were 8.1-9.5% in average daily feed intake and by 12.4-12.7% in feed conversion and feed cost per 1 kg gain during fattening compared to animals of the parental form, and by 16.4-17.5% in average daily feed intake and 2.2-3.4% in feed conversion compared to hybrid pigs combining the sire's genotypes.

The unequal growth rate of the pigs during rearing and fattening as well as the different daily feed intake resulted in a difference in the efficiency of the fattening pigs in purebred, crossbred and hybridization. As can be seen from Table 6, the economic indicators of fattening in the animals differed significantly both according to the direction of selection and the methods of their rearing.

Table 6. Efficiency of fattening purebred and linear pigs

Indicator	Groups		
	I	II	III
Genotype combination	♀GW×♂ GW	L♀×♂L	PIC337× PIC337
Operational cost of fattening 1 pig, EUR	53.85	55.07	59.76
Cost of 1 head after completion of fattening, EUR	104.95	107.78	122.46
Cost of 1 kg of live weight after completion of fattening, EUR	43.69	43.47	39.54
Cost of 1 pig without VAT after completion of fattening, EUR	5296.63	5467.20	6828.58
Income from fattening 1 pig, EUR	12.75	13.71	29.29
Profitability of fattening 1 pig, EUR	0.27	0.28	0.53

The lowest feed costs in fattening amounted to EUR 0.039 for pigs of the Large White breed. For Landrace pigs, feed consumption costs were EUR 0.895 higher, while their counterparts from synthetic parental lines consumed EUR 4.316 more than their Large White counterparts and EUR 3.420 more than their Landrace counterparts during the fattening period. The different feed costs during the fattening period also led to different fattening costs per animal. For example, the operating costs for fattening a purebred animal of the Large White breed amounted to EUR 53.840. For animals of the Landrace breed, they were slightly higher by EUR 55.22, while for pigs from synthetic parent lines they were EUR 5.91 higher compared to animals of the Large White breed and EUR 4.685 higher compared to animals of the Landrace breed. A completely different picture emerged for the costs per 1 kg of growth in purebred pigs. Due to higher growth intensity and better feed conversion, the cost of 1 kg of live weight at the end of fattening was lowest in pigs of the parental genotype at 0.878 EUR, while it was 0.088-0.094 EUR higher in their analogues of the maternal productivity direction.

The higher cost of a piglet at the beginning of fattening and the higher cost of fattening resulted in the cost of an animal at the end of fattening being 17.255 EUR higher for animals of the synthetic parental line than for the Large White breed analogues and 15.520 EUR higher than for animals of the Landrace breed.

At the same time, the higher live weight of the animals of the synthetic parental line at the end of fattening due to their higher growth intensity contributed to the fact that the market value of a piece of pigs of this line increased by 34.04 EUR compared to animals of the Large White breed and by 3.790 EUR compared to analogues of the Landrace breed. The difference in market value between Large White and Landrace animals was only 3.790 EUR in favor of Landrace pigs.

The difference in the realisation of the value of an animal at the end of fattening and its cost in animals of the maternal and paternal genotypes led to unequal income from the fattening of an animal. Thus, in pigs of the Large White breed, this income amounted to 12.658 EUR and was 1.055 EUR higher than in the analogues of another maternal Landrace. While pigs of the synthetic parental line, due to their higher growth intensity and better feed conversion, showed 16.788 EUR higher profitability from fattening one animal compared to animals of the Large White breed and 15.73 EUR compared to analogues of the Landrace breed.

Taking into account the different costs and the unequal utilisation value of an animal, different costs for fattening an animal were also determined. For example, they amounted to 12.5 for pigs of the Large White breed and 12.72% for pigs of the Landrace breed, while the profitability of fattening was 11.35 higher for animals of the synthetic parental line compared to analogues of the Landrace breed and 12.03% higher compared to animals of the Large White breed.

Thus, the young animals of the synthetic parental line had 8.5-11 higher feed and operating costs per animal during fattening compared to the animals of the maternal lines, but due to a higher mass of the animals by 24.9-28.9% compared to the analogs of the maternal genotypes, they had a lower cost per kilogram of gain by 13.3-13.8% and a higher market value per animal by 24.9-28.9% at the end of fattening, and despite the higher fattening costs, they had a 114.7-132.6% higher income and 11.35-12.03% better profitability of fattening.

Compared to the hybrid animals, the parent line pigs had 5.3-6.3% lower feed and operating costs for fattening an animal, 8.9-9.9% lower cost for 1 kg gain, 41.4-4.5% higher cost for a kilogram of live weight of pigs after finishing fattening, but 3.7-4.3% higher market value of an animal, 20.1-22.0% higher income and 4.89-5.29% better profitability of fattening. At the same time, the fattening efficiency of purebred and crossbred pigs of the parental lines showed a slight influence of crossbreeding on the productivity of these pigs (Tables 6 and 7).

Thus, the feed costs of the crossbred pigs were EUR 0.158-0.781 higher compared to animals of the Large White breed, but EUR 0.114-0.737 lower compared to the Landrace analogues. As a result, the operating costs for fattening one animal were 0.217-1.070 EUR higher for crossbred animals than for Large White animals, but 0.156-1.010 EUR lower than for Landrace animals. As the cost of an animal at the end of the fattening period is made up of the cost of the animal at entry to the fattening period and the operating costs of the fattening period itself, no significant difference in the cost of an animal at the end of the fattening period was found between purebred and crossbred animals of the maternal genotype. Thus, the cost of an animal after fattening was 2.393-3.336 EUR higher for the crossbred animals than for the animals of the Large White breed and was almost at the level of a Landrace pig. However, taking into account the greater mass of crossbred animals compared to purebred animals, it turned out that the market value of crossbred animals at the end of fattening at the same market price per 1 kg of live weight was 1.498-3.367 EUR higher for crossbred pigs than for purebred analogues of the Landrace breed and 5.289-7.157 EUR higher than for animals of the Large White breed. Accordingly, the profitability of fattening an animal was higher for crossbred animals than for purebred parent forms. The income from fattening crossbred animals was 1.841-2.766 EUR higher than that of Landrace animals and 2.89-3.821 EUR higher than that of Large White animals.

Table 7. Efficiency of fattening of crossbred and hybrid pigs

Indicator	Groups			
	IV	V	VI	VII
Combination of parental genotypes	♀GW×♂L	L♀×♂GW	(♀GW×♂L) ×PIC337	(L♀×♂GW) ×PIC337
Operating cost of fattening 1 pig, EUR	54.06	63.51	62.95	1.20
Cost of 1 pig after completion of fattening, EUR	107.44	122.56	122.24	2.39
Cost of 1 kg of live weight after completion of fattening, EUR	0.95	0.91	0.92	0.02
Cost of 1 head without VAT after completion of fattening, EUR	122.99	146.17	145.29	2.73
Income from fattening 1 pig, EUR	15.55	23.61	23.06	0.35
Profitability of fattening 1 pig, EUR	0.32	0.43	0.42	0.01

Accordingly, the profitability of fattening an animal was higher for crossbred animals than for purebred parent forms. The income from fattening crossbred animals was 1.841-2.766 EUR higher than that of Landrace animals and 2.89-3.821 EUR higher than that of Large White animals. The profitability of fattening by crossbreeding was 1.75-3.15% higher than that of purebred breeding of maternal genotypes. At the same time, the cost of one kilogram of live weight of pigs at the end of fattening was 0.028-0.037 EUR lower for hybrid pigs than for crossbred pigs.

When comparing the efficiency of hybridization with purebred and linear breeding of animals, clear advantages of hybrid animals over purebred breeding of their analogues of maternal genotypes were found. At the same time, the hybrids were inferior to the animals of the synthetic parental line in terms of fattening efficiency. Thus, the cost of feed consumed during the fattening of hybrid piglets was EUR 5.75-7.052 higher than that of purebred analogues of the original maternal genotypes and EUR 2.332-2.736 higher than that of animals of the synthetic parental line. This in turn affected the operating costs of the hybrid piglets, which were 7.880-8.432 EUR higher than purebred analogues of the

Landrace breed and 9.108-9.661 EUR higher than animals of the Large White breed. At the same time, the hybrid animals also had higher operating costs of 3.195-3.749 EUR compared to purebred analogues of the synthetic line PIC 337. Taking into account the different costs of the piglets during fattening, it was found that the costs of fattening were not the same and that the costs of the animal after fattening were also different. Thus, hybrid animals at 14.537-14.8759 EUR had significantly higher costs than their counterparts of the Landrace breed and at 17.271-17.595 EUR than animals of the Large White breed and were almost on a par with animals of the synthetic parental line in this indicator.

At the same time, the cost of one kilograms of live weight of pigs after fattening was 0.049–0.058 EUR lower in the hybrid pigs compared to the purebred analogues of the maternal genotypes, but 0.036-0.039 EUR lower compared to the animals of the synthetic parental line.

At the same market price of 1 kg live weight, a significant difference in the market value of an animal at the end of fattening was found between animals with different selection directions and different breeding options due to the difference in weight between purebred and hybrid animals at the end of fattening. The highest cost of an animal excluding VAT was found for hybrid animals and amounted to 146.157 and 145.293 EUR for animals of the sixth and seventh groups, respectively. Compared to purebred animals of the Large White breed, they were EUR 27.590-28.464 higher, compared to purebred animals of the Landrace breed they were EUR 23.800-24.673 higher, but compared to purebred animals of the synthetic parental line they were EUR 5.579-6.452 lower.

The difference in the weight of the animals at fattening, the cost of fattening and the market value of an animal at the end of fattening determined the profitability of fattening pigs of different breeding orientations under different breeding options. It was found that the highest income from fattening an animal was obtained from animals of the parental synthetic line under their linear breeding, which means 5.919-6.468 EUR higher profitability compared to the income from fattening hybrid animals, 15.732 EUR compared to purebred animals of the Landrace breed and 16.788 EUR compared to analogues of the Large White breed. At the same time, the hybrid animals had a higher income from fattening one animal of 9.264-9.813 EUR compared to Landrace analogues and 464.37-489.10% compared to Large White analogues.

Parallel to the highest profitability of the fattening pigs of the specialized parental line, the highest profitability was also found in animals of this combination. According to the results of our study, it amounted to 24.08%, while it was 4.89-5.29% lower in hybrid animals. At the same time, hybrid pigs had 6.06-7.13% higher profitability than purebred animals of the maternal genotypes.

Our results that the hybrids had higher average daily gains, reached 120 kg weight earlier and had better feed conversion compared to purebred animals of the maternal genotypes and their crosses are consistent with the data of (Chernenko et al., 2022; McGloughlin at al., 1988; Mykhalko, 2020; Mykhalko, 2021; Voloshynov & Povod, 2023). At the same time, our results regarding the higher growth intensity of animals of the parental line compared to the hybrids did not coincide with the data (Nielsen & Velander, 2016) who found no difference in average daily gain between animals of the parental genotype and hybrids based on it, while they were identical in terms of better feed conversion by linear animals of the parental genotype compared to hybrids based on it.

The results of our studies are similar to the findings (Budakva et al., 2023; Ibatullin, M., Khakhula, 2020; Tishchenko & Moysey, 2024; Vashchenko, 2017) regarding the higher efficiency of fattening hybrid pigs compared to purebred and crossbred animals. We consider it advisable to continue the comparative study of the productivity of hybrid pigs of different origins and the relationship between the level of productivity in breeding and commercial herds.

CONCLUSIONS

The pigs of the synthetic parental line surpassed the analogues of the maternal breeds in average daily and absolute gains, the weight of the pigs at the end of fattening reached a live weight of 120 kg earlier, it is better to pay the feed with the gains, but had worse animal safety during fattening.

Hybrid pigs of the combination ¼ GW¼ L½ PIC337 and ¼ L ¼ GW ½ PIC337 showed higher average daily and absolute gains, reached a mass of 120 kg earlier, had a higher mass at the end of fattening and a better feed conversion ratio compared to purebred animals of the maternal genotypes and their crosses, while no clear pattern was found in the survival rate of the piglets.

Crossbred pigs from the combination of dam breeds had higher daily feed consumption, better feed conversion and lower feed cost per 1 kg gain during fattening compared to the original dam forms, but were inferior in average daily feed consumption, feed conversion and feed cost per 1 kg gain during fattening to the animals of the parental form, and in average daily feed intake and feed conversion to the hybrid pigs of the combination ¼ GW¼ L½ PIC337 and ¼ L ¼ GW½ L½ PIC337.

Pigs of the synthetic parental line had higher feed and operating costs per animal during fattening, higher live weight of animals, higher fattening costs and market value of an animal after completion of fattening, higher income and profitability of fattening but lower costs per kilogram gain compared to the analogs of the maternal genotypes, compared to the animals of the maternal lines.

Hybrid animals of the combination ¼ WB¼ L½ PIC337 and ¼ L ¼ GW ½ PIC337 had higher feed and operating costs for fattening an animal, the cost of 1 kg of gain, higher costs for a kilogram of live weight of pigs after fattening, but lower market value of an animal as well as lower income and lower profitability of fattening compared to the analogs of the synthetic parental line.

The highest profitability and fattening profitability were observed in pigs of the specialized parental line, while it was lower in hybrid animals compared to animals of the parental form, but higher compared to purebred animals of the maternal genotypes.

ACKNOWLEDGEMENTS

This study was conducted thanks to the support of LLC "NVP "Globynsky Pig Complex".

REFERENCES

Birta, H. O., & Burhu, Y. H. (2022). Corresponding qualities of pigs of different genotypes. *Bulletin of the Sumy National Agrarian University. Series: Livestock*, 2, 3–7. https://snaubulletin.com.ua/index.php/ls/article/download/649/586

Budakva, Y. O., Bankovska, I. B., Pochernyaev, K. F., & Zinoviev, S. H. (2023). The use of marker breeding in the original breeds of pigs according to the indicators of genetic variability of their hybrid descendants. *Bulletin of Sumy National Agrarian University. Series: Livestock*, 4, 8–14. [in Ukrainian]. https://doi.org/10.32845/bsnau.lvst.2022.4.2

Chernenko, O. M., Chernenko, O. I., Mylostyvyi, R. V., Khmeleva, O. V., Garashchenko, V. Y., Bordunova, O. G., & Dutka, V. R. (2022). The results of fattening hybrid pigs of Danish selection. *Ukrainian Journal of Veterinary and Agricultural Sciences*, 5(1), 3–7. https://doi.org/10.32718/ujvas5–1.01

Cheruiyot, E. K., Haile-Mariam, M., Cocks, B. G., & Pryce, J. E. (2022). Improving genomic selection for heat tolerance in dairy cattle: Current opportunities and future directions. *Frontiers in Genetics*, 13, 894067. https://doi.org/10.3389/fgene.2022.894067

Dambaulova, G. K., Madin, V. A., Utebayeva, Z. A., Baimyrzaeva, M. K., & Shora, L. Z. (2023). Benefits of automated pig feeding system: A simplified cost-benefit analysis in the context of Kazakhstan. *Veterinary World*, 16(11), 2205–2209. https://doi.org/10.14202/vetworld.2023.2205–2209

Fediaieva, A. S. (2018). Fattening of pigs using different genotypes in industrial production. *Scientific and Technical Bulletin of the Research and Development Center for Biosafety and Environmental Control of Agricultural and Industrial Complex Resources*, 6(1), 57–60. https://bulletin–biosafety.com/index.php/journal/article/view/172

Găureanu, M.E., Stanciu M.A., Cocîrcă, D.I., Vidu, L., & Vlad, I., (2017). Technical aspects regarding the classification of pig carcasses in Romania, *Sci Papers Ser. Management, Economic Engineering in Agriculture and Rural Development, 17(*3), 139-145 *https://managementjournal.usamv.ro/pdf/vol.17_3/Art19.pdf*

Gruhot, T. R., Calderón, Díaz J. A., & Baas, T. J. (2017). An economic analysis of sow retention in a United States breed-to-wean system. *Journal of Swine Health and Production*, 25(5), 238–246. https://doi.org/10.54846/jshap/994

Gupta, V. K., Phand, S., Madhavan, M. M., Mohan, N. H., Islam, R., & Das, S. (2022). *Skills for entrepreneurship development in pig husbandry*. ICAR–National Research Centre on Pig, Rani, Guwahati & National Institute of Agricultural Extension Management, Hyderabad. Retrieved December 14, 2024, from https://www.manage.gov.in/publications/eBooks/pig%20husbandry.pdf

Gutierrez-Reinoso, M. A., Aponte, P. M., & Garcia-Herreros, M. (2021). Genomic analysis, progress and future perspectives in dairy cattle selection: A review. *Animals*, 11(3), Article 599. https://doi.org/10.3390/ani11030599

Ibatullin, M., & Khakhula, B. (2020). Influence of breeding pig breeding on efficiency production of the industry. *Economics and Management of the Agricultural Complex*, 2, 22–30. https://rep.btsau.edu.ua/bitstream/BNAU/5637/1/influence_of.pdf

Koroban, M. P., & Lykhach, V. Y. (2023). Fattening qualities of young pigs of modern genotypes under different weight conditions in industrial technology. *Podilskyi Visnyk: Agriculture, Technology, Economics*, 41, 26–32. Retrieved December 14, 2024, from https://journals.pdu.khmelnitskiy.ua/index.php/podilian_bulletin/article/view/296

Khramkova, O. M., & Povod, M. G. (2017). Feeding productivity of hybrid young pigs of domestic and foreign origin. *Bulletin of the Sumy National Agrarian University. Series: Animal Husbandry*, 7, 226–232. Retrieved December 14, 2024, from http://nbuv.gov.ua/UJRN/Vsna_tvar_2017_7_44

Kremez, M. I., & Shpetnyi, M. B. (2024). The current state of Ukrainian, European, and world pig farming and prospects for its development. *Bulletin of Sumy National Agrarian University. Series: Livestock*, 3, 51–60. https://doi.org/10.32782/bsnau.lvst.2024.3.6

Ladyka, V. I., Khmelnychiy, L. M., & Povod, M. G. (2023). *Technology of production and processing of livestock products: A textbook for graduate students*. Odesa, UA: Oldi+.

Liu, S., Yao, T., & Chen, D. (2023). Genomic prediction in pigs using data from a commercial crossbred population: Insights from the Duroc x (Landrace x Yorkshire) three-way crossbreeding system. *Genetics Selection Evolution*, 55, 21. https://doi.org/10.1186/s12711–023–00794–2

Ma, H., Li, H., Ge, F., Zhao, H., Zhu, B., Zhang, L., Gao, H., Xu, L., Li, J., & Wang, Z. (2024). Improving genomic predictions in multi-breed cattle populations: A comparative analysis of BayesR and GBLUP models. *Genes*, 15(2), 253. https://doi.org/10.3390/genes15020253

Maksym, V., Chemerys, V., Dushka, V., Dadak, O., & Martyniuk, U. (2022). Modeling of economic efficiency of pig farming in agricultural enterprises. *Agricultural and Resource Economics: International Scientific E-Journal*, 8(3), 178–199. https://doi.org/10.51599/are.2022.08.03.09

Maribo, H., Nielsen, B., & Nielsen, M. F. (2018). DanBred Duroc finisher pigs grow faster than German Pietrain crosses. *Meddelelse*, 1154. SEGES Pig Production. https://svineproduktion.dk/publikationer/kilder/lu_medd/2018/1154

McGloughlin, P., Allen, P., Tarrant, P. V., Joseph, R. L., Lynch, P. B., & Hanrahan, T. J. (1988). Growth and carcass quality of crossbred pigs sired by Duroc, Landrace and Large White boars. *Livestock Production Science*, 18(3–4), 275–288. https://doi.org/10.1016/0301-6226(88)90036-X

Mota, L. F. M., Carvajal, A. B., & Silva Neto, J. B. (2024). Assessment of inbreeding coefficients and inbreeding depression on complex traits from genomic and pedigree data in Nelore cattle. *BMC Genomics*, 25, 944. https://doi.org/10.1186/s12864-024-10842-w

Mykhalko, O. G. (2020). Feeding qualities of pigs of Irish origin under different types of feeding. *Bulletin of the Sumy National Agrarian University. Series "Livestock"*, 3(42), 51–57. https://doi.org/10.32845/bsnau.lvst.2020.3.9

Mykhalko, O. G. (2021). Dependence of the feeding qualities of pigs of Danish origin on the type of feeding. *Bulletin of the Sumy National Agrarian University. Series "Livestock"*, 4(47), 99–108. https://doi.org/10.32845/bsnau.lvst.2021.4.17

Neeteson, A. M., Avendaño, S., Koerhuis, A., Duggan, B., Souza, E., Mason, J., Ralph, J., Rohlf, P., Burnside, T., & Kranis, A. (2023). Evolutions in commercial meat poultry breeding. *Animals*, 13, 3150. https://doi.org/10.3390/ani13193150

Nielsen, B., & Velander, I. (2016). Production results of d(ly) crosses and duroc. *Meddelelse*, 1093.Retrieved December 14, 2024, from https://svineproduktion.dk/publikationer/kilder/lu_medd/2016/1093

Povod, M. G., Mykhalko, O. G., Verbelchuk, T. V., Shcherbyna, O. V., & Tyshchenko, O. S. (2021). Dependence of fattening qualities of pigs of American origin on different types of feeding. *Bulletin of the*

Sumy National Agrarian University. Series "Livestock", 4(47), 125–132. https://doi.org/10.32845/bsnau.lvst.2021.4.21

Rasal, K. D., Kumar, P. V., & Asgolkar, P. (2024). Single-Nucleotide Polymorphism (SNP) array: An array of hope for genetic improvement of aquatic species and fisheries management. *Blue Biotechnology*, 1, 3. https://doi.org/10.1186/s44315-024-00004-8

Rodenburg, T. B., & Turner, S. P. (2012). The role of breeding and genetics in the welfare of farm animals. *Animal Frontiers*, 2(3), 16–21. https://doi.org/10.2527/af.2012-0044

Qiao, J., Li, K., Miao, N., Xu, F., Han, P., Dai, X., Abdelkarim, O. F., Zhu, M., & Zhao, Y. (2024). Additive and dominance genome-wide association studies reveal the genetic basis of heterosis related to growth traits of Duhua hybrid pigs. *Animals*, 14(13), 1944. https://doi.org/10.3390/ani14131944

Sanz-Fernández, S., Díaz-Gaona, C., & Simões, J. (2024). The impact of herd age structure on the performance of commercial sow-breeding farms. *Porcine Health Management*, 10, Article 56. https://doi.org/10.1186/s40813-024-00406-5

Singh, P., Ali, S. A. (2021). Impact of CRISPR-Cas9-based genome engineering in farm animals. *Veterinary Sciences*, 8(7), 122. https://doi.org/10.3390/vetsci8070122

Tishchenko, O. S., & Moysey, I. S. (2024). Productivity of hybrid pigs of English origin under dry and combined feeding systems in conditions of industrial production. *Bulletin of Sumy National Agrarian University. Series: Livestock*, 3, 96–105. https://doi.org/10.32782/bsnau.lvst.2024.3.12

Thoma, G. J., Baker, B., & Knap, P. W. (2024). A life cycle assessment study of the impacts of pig breeding on the environmental sustainability of pig production. *Animals*, 14(16), 2435. https://doi.org/10.3390/ani14162435

Tsiouni, M., Kountios, G., Kousenidis, K., Kousenidis, D., Tzamaloukas, O., & Simitzis, P. (2023). Financial ratio analysis as an advisory tool for sustainable pig farm management in Greece. *Sustainability*, 15(21), 15536. https://doi.org/10.3390/su152115536

Vashchenko, O. V. (2017). Economic efficiency of using heterosis in industrial crossbreeding of pigs. *Collection of Scientific Papers "Technology of Production and Processing of Livestock Products"*, 1(134), 32–37.

Voloshynov, V. V., & Povod, M. H. (2023). Productive qualities of sows of Danish and Canadian breeding under industrial technology conditions. *Bulletin of Sumy National Agrarian University. Series: Livestock*, 4, 3–9. https://doi.org/10.32782/bsnau.lvst.2023.4.1

Voshchenko, I. B., & Povod, M. G. (2024). The effectiveness of different methods of breeding pigs of maternal and paternal lines under the conditions of an industrial enterprise. *Bulletin of Sumy National Agrarian University. Series: Livestock*, 1, 33–47. https://doi.org/10.32782/bsnau.lvst.2024.1.5

Zhu, S., Zhao, H., Han, M., Yuan, C., Guo, T., Liu, J., Yue, Y., Qiao, G., Wang, T., Li, F., Gun, S., & Yang, B. (2020). Genomic prediction of additive and dominant effects on wool and blood traits in Alpine Merino sheep. *Frontiers in Veterinary Science*, 7, 573692. https://doi.org/10.3389/fvets.2020.573692