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FATTENING AND MEAT QUALITY TRAITS OF YOUNG PIGS WITH DIFFERENT GENOTYPES OF THE MELANOCORTIN RECEPTOR GENE (MC4R) AND THEIR RELATIONSHIP WITH PROTEIN METABOLISM INDICATORS AND SERUM AMINOTRANSFERASE ACTIVITY

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The paper presents the results of studies on the fattening and meat qualities of Large White pigs of different genotypes for the melanocortin receptor gene (MC4R), as well as the biochemical parameters of blood serum. Based on the obtained data, the levels of correlations between quantitative traits were calculated. The study was conducted within the framework of Scientific Research Program No. 31 of the National Academy of Agrarian Sciences of Ukraine, "Genetic Improvement of Farm Animals, Their Reproduction and Biodiversity Conservation" (Genetics, Conservation, and Reproduction of Biological Resources in Animal Husbandry).

It was established that the biochemical parameters of blood serum (total protein content, g/L; urea concentration, mmol/L; aspartate aminotransferase (AST) activity, U/L; alanine aminotransferase (ALT) activity, U/L) in Large White pigs of Hungarian origin were within the physiological range characteristic of clinically healthy animals. Analysis of performance testing and slaughter data demonstrated that Large White pigs of Hungarian origin were characterized by relatively high fattening and meat quality traits. In terms of age at reaching 100 kg body weight, backfat thickness measured at the level of the 6th–7th thoracic vertebrae, and chilled carcass length, the animals exceeded the minimum requirements of the elite class by an average of 13.76%. A statistically

significant difference between animals of Group I (MC4RAG) and Group II (MC4RAA) was found for average daily gain (41.5 g; td = 4.18), age at reaching 100 kg body weight (3.8 days; td = 2.45), backfat thickness at the level of the 6th–7th thoracic vertebrae (1.8 mm; td = 3.00), chilled carcass length (1.9 cm; td = 3.45), maximum (anterior) carcass width (2.0 cm; td = 2.46), and minimum (posterior) carcass width (1.2 cm; td = 2.30). The difference between the experimental groups according to B. Tyler's index amounted to 17.63 points (td = 4.65). The pairwise correlation coefficients between blood serum biochemical parameters, fattening and meat quality traits of Large White pigs of Hungarian origin, as well as animals of different genotypes for the melanocortin receptor gene (MC4RAA and MC4RAG), ranged from –0.854 to +0.821. The proportion of significant correlations was 29.16%, 54.16%, and 25.00%, respectively.

Keywords: piglets, breed, genotype, gene, blood serum biochemical parameters, fattening and meat quality traits, variability, correlation.

ВІДГОДІВЕЛЬНІ І М'ЯСНІ ЯКОСТІ МОЛОДНЯКУ СВИНЕЙ РІЗНИХ ГЕНОТИПІВ ЗА ГЕНОМ РЕЦЕПТОРА МЕЛАНОКОРТИНУ (MC4R) ТА ЇХ ЗВ'ЯЗОК З ПОКАЗНИКАМИ БІЛКОВОГО ОБМІНУ ТА АКТИВНІСТЮ АМІНОТРАНСФЕРАЗ СИРОВАТКИ КРОВІ

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В роботі наведено результати досліджень відгодівельних і м'ясних якостей молодняку свиней великої білої породи різних генотипів за геном рецептора меланокортину (MC4R), а також біохімічних показників сироватки крові; на основі одержаних даних розраховано рівень кореляційних зв'язків між кількісними ознаками. Роботу виконано згідно програми наукових досліджень Національної

академії аграрних наук України №31 «Генетичне поліпшення сільськогосподарських тварин, їх відтворення та збереження біорозмаїття». (Генетика, збереження та відтворення біоресурсів у тваринництві).

Установлено, що біохімічні показники сироватки крові (вміст загального білка, г/л; вміст сечовини, ммоль/л; активність аспартатамінотрансферази (АсАТ), од/л; активність аланінамінотрансферази (АлАТ), од/л) молодняку свиней великої білої породи угорського походження відповідають фізіологічній нормі клінічно здорових тварин. Аналіз даних контрольної відгодівлі та забою свідчить, що молодняк свиней великої білої породи угорського походження характеризується достатньо високими показниками відгодівельних і м'ясних якостей, а за віком досягнення живої маси 100 кг, товщиною шпику на рівні 6-7 грудних хребців і довжиною охолодженої туші переважають мінімальні вимоги класу еліта в середньому на 13,76 %. Достовірну різницю між тваринами I ($MC4R^{AG}$) і II ($MC4R^{AA}$) піддослідних груп установлено за середньодобовим приростом живої маси (41,5 г; t_d=4,18), віком досягнення живої маси 100 кг (3,8 доби; t_d=2,45), товщиною шпику на рівні 6-7 грудних хребців (1,8 мм; t_d=3,00), довжиною охолодженої туші (1,9 см; t_d=3,45), найбільшою (передньою) шириною охолодженої туші (2,0 см; t_d=2,46), найменшою (задньою) шириною охолодженої туші (1,2 см; t_d=2,30). Різниця між тваринами піддослідних груп за індексом Б. Тайлера становить 17,63 бала (t_d=4,65). Коефіцієнти парної кореляції між біохімічними показниками сироватки крові, відгодівельними і м'ясними якостями молодняку свиней великої білої породи угорського походження, а також тварин різних генотипів за геном рецептора меланокортину ($MC4R^{AA}$, $MC4R^{AG}$) коливаються у межах від –0,854 до +0,821, а кількість достовірних зв'язків відповідно становить 29,16, 54,16 і 25,00 %.

Ключові слова: молодняк свиней, порода, генотип, ген, біохімічні показники сироватки крові, відгодівельні і м'ясні якості, мінливість, кореляція.

Introduction. The acceleration of breeding progress in pig production is achieved through the importation of animals of foreign genetic origin and the implementation of modern genetic and zootechnical methods for the evaluation and selection of highly productive breeding boars, sows, and replacement gilts (Pelykh & Shevchenko, 2020; Povod et al., 2021; Berezovskyi et al., 2022).

An important zootechnical approach for the evaluation and selection of highly productive sows and breeding boars is the assessment of the fattening and carcass traits of their offspring (Berezovskyi & Khatko, 2005), as well as the application of marker-assisted selection (MAS) methods (Balatskyi et al., 2018; Hyria et al., 2018; Kozyr et al., 2019).

The results obtained by Budakva E.O. (Budakva, 2022) indicate that mtDNA haplotypes exert a positive effect on growth rate during the fattening period up to slaughter in pigs of Asian origin (haplotype N) and European origin (haplotypes C and O). The age at reaching a body weight of 100 kg was 144 days for animals with haplotype C, 141 days for haplotype N, 156 days for haplotype O, and 165 days for haplotype G, with differences of 13 and 22 days, respectively. Pigs carrying haplotypes C and N were characterized by a uniform average daily gain throughout the fattening period, averaging 851 g, which exceeded the values recorded for haplotypes O and G by 76 g. The author also reported that animals with haplotypes C (0.696 kg), G (0.605 kg), O (0.642 kg), and N (0.715 kg) exhibited relatively low average daily gains throughout the entire growing period, from birth to the completion of fattening.

Kirovych N. et al. (2023) reported that when establishing breeding herds of Pietrain

pigs, replacement stock should be selected according to their genotypes for the RYR-1 and MC4R genes. Such selection contributes to an increased proportion of favorable farrowings, improved litter size, and greater litter weight at weaning at 28 days of age. Under a targeted breeding strategy, preference should be given to replacement gilts carrying the heterozygous AGNn and GGNn genotypes for the MC4R and RYR-1 genes, respectively.

The relevance and practical significance of this area of research are confirmed by numerous studies conducted by both Ukrainian and international scientists (Lykhach et al., 2022; Khalak et al., 2024; Prudyus, 2024).

The aim of the study was to investigate the fattening and meat quality traits of Large White pigs with different genotypes of the melanocortin receptor gene (MC4R), as well as the biochemical parameters of blood serum, and, based on the obtained data, to determine the level of correlation between quantitative traits.

Materials and Methods. The study was conducted under the conditions of the industrial pig production complex of LLC "Druzhba-Kaznacheivka" (Dnipropetrovsk region, Ukraine), the "Jazz" Meat Processing Plant, the Research Center for Biosafety and Environmental Control of Agricultural Resources of the Dnipro State Agrarian and Economic University ("Biosafety-Center"), and the Animal Husbandry Laboratory of the State Institution Institute of Grain Crops of the National Academy of Agrarian Sciences of Ukraine.

DNA genotyping of young pigs for the melanocortin receptor gene (MC4R) was performed in the Genetics Laboratory of the Institute of Pig Breeding and Agro-Industrial Production of the National Academy of Agrarian Sciences of Ukraine (Kim et al., 2006; Dai & Long, 2015).

Based on the results of performance testing and slaughter evaluation, Large White pigs of Hungarian origin were assessed according to the following quantitative traits: average daily gain during the performance testing period (g); age at reaching 100 kg body weight (days); backfat thickness measured at the level of the 6th–7th thoracic vertebrae (mm); chilled carcass length (cm); maximum (anterior) width of the bacon side of the chilled carcass half (cm); and minimum (posterior) width of the bacon side of the chilled carcass half (cm) (Instructions for Pig Bonitation; Instructions for Breeding Record Keeping in Pig Production, 2003; Berezovskyi & Khatko, 2005; Voloshchuk et al., 2017).

A comprehensive assessment of the fattening and meat quality traits of young pigs was performed using the B. Tyler Index:

$$I_v=100 + (242 \times K) - (4{,}13 \times L)$$

where: I_v is the integrated index of fattening and meat quality traits; K is the average daily gain (kg); L is the backfat thickness measured at the level of the 6th–7th thoracic vertebrae (mm); 242 and 4.13 are constant coefficients (Berezovskyi, 1999; Vashchenko, 2019).

In the blood serum of 5-month-old pigs, the following biochemical parameters were determined: total protein concentration (g/L), urea concentration (mmol/L), aspartate aminotransferase (AST) activity (U/L), and alanine aminotransferase (ALT) activity (U/L) (Vlizlo et al., 2012).

Biometric processing of the experimental data was performed using generally accepted statistical methods described in the works of Ukrainian researchers (Kovalenko et al., 2011; Kramarenko et al., 2019).

Research results. Laboratory analyses of blood serum biochemical parameters in Large White pigs of Hungarian origin showed that the average total protein concentration was 83.46 ± 1.124 g/L, urea concentration was 5.15 ± 0.258 mmol/L, aspartate

aminotransferase (AST) activity was 59.38 ± 3.761 U/L, and alanine aminotransferase (ALT) activity was 44.38 ± 2.474 U/L (Table 1).

The obtained biochemical parameters were within the physiological range characteristic of clinically healthy animals (Vlizlo et al., 2012).

Table 1

Biochemical Parameters of Blood Serum in Large White Pigs of Hungarian Origin (n = 13)

Parameters	Biometrical indicators		
	$X \pm Sx$	$\sigma \pm X_\sigma$	$C_v \pm Sc_v$, %
Total protein concentration, g/L	83.46 ± 1.124	4.05 ± 0.795	4.86 ± 0.954
Urea concentration, mmol/L	5.15 ± 0.258	0.93 ± 0.182	18.06 ± 3.548
Aspartate aminotransferase (AST) activity, U/L	59.38 ± 3.761	13.56 ± 2.664	22.84 ± 4.487
Alanine aminotransferase (ALT) activity, U/L	44.38 ± 2.474	8.92 ± 1.752	3.97 ± 0.779

Analysis of the performance testing and slaughter data showed that the average daily gain of Large White pigs of Hungarian origin (n = 42) was 780.4 ± 5.91 g, the age at reaching 100 kg body weight was 177.5 ± 0.80 days, backfat thickness measured at the level of the 6th–7th thoracic vertebrae was 20.7 ± 0.34 mm, chilled carcass length was 96.6 ± 0.35 cm, the maximum (anterior) width of the bacon side of the carcass was 34.2 ± 0.44 cm, and the minimum (posterior) width of the bacon side of the carcass was 24.7 ± 0.35 cm. The B. Tyler index ranged from 170.55 to 229.89 points (Table 2).

Table 2

Fattening and meat quality traits of large white pigs of hungarian origin (n = 42)

Parameters	Biometrical indicators		
	$X \pm Sx$	$\sigma \pm X_\sigma$	$C_v \pm Sc_v$, %
Average daily gain, g	780.4 ± 5.91	38.35 ± 4.186	4.91 ± 0.536
Age at reaching 100 kg body weight, days	177.5 ± 0.80	5.24 ± 0.572	2.95 ± 0.322
Backfat thickness at the level of the 6th–7th thoracic vertebrae, mm	20.7 ± 0.34	2.21 ± 0.241	10.68 ± 1.165
Chilled carcass length, cm	96.6 ± 0.35	1.71 ± 0.186	1.77 ± 0.193
Maximum (anterior) width of the bacon side of the chilled carcass, cm	34.2 ± 0.44	2.30 ± 0.251	6.74 ± 0.735
Minimum (posterior) width of the bacon side of the chilled carcass, cm	24.7 ± 0.35	1.85 ± 0.201	7.52 ± 0.820
B. Tyler Index, points	201.38 ± 2.450	14.90 ± 1.626	7.40 ± 0.807

The coefficient of variation (Cv, %) for the biochemical parameters of blood serum, as well as for the fattening and meat quality traits of young pigs, ranged from 1.77% (chilled carcass length, cm) to 22.84% (aspartate aminotransferase (AST) activity, U/L) (Tables 1 and 2).

Taking into account the differentiation of pigs according to their genotype, it was established that animals of Experimental Group I (MC4RAG) exceeded their counterparts from Experimental Group II (MC4RAA) in serum urea concentration by 0.19 mmol/L (*td*

= 0.35; $P > 0.05$) and in aspartate aminotransferase (AST) activity by 5.98 U/L (*td* = 0.81; $P > 0.05$). In contrast, animals of Experimental Group II (MC4RAA) surpassed those of Experimental Group I (MC4RAG) in total serum protein concentration by 2.25 g/L (*td* = 1.06; $P > 0.05$) and in alanine aminotransferase (ALT) activity by 6.72 U/L (*td* = 1.44; $P > 0.05$) (Table 3).

Table 3

Biochemical parameters of blood serum, fattening and meat quality traits of young pigs with different melanocortin receptor gene (MC4R) genotypes

Trait	Statistical Parameter	Genotype	
		MC4R^{AG}	**MC4R^{AA}**
		Group	
		I	**II**
Total protein, g/L	*n*	*7*	*6*
	$X \pm Sx$	82.42 ± 1.937	84.67 ± 0.881
	$\sigma \pm X_\sigma$	5.12 ± 1.368	2.16 ± 0.624
	$C_v \pm Sc_v$, %	6.21 ± 1.660	2.55 ± 0.736
Urea, mmol/L	$X \pm Sx$	5.24 ± 0.388	5.05 ± 0.362
	$\sigma \pm X_\sigma$	1.02 ± 0.272	0.88 ± 0.254
	$C_v \pm Sc_v$, %	19.46 ± 5.203	17.42 ± 5.034
Aspartate aminotransferase (AST), U/L	$X \pm Sx$	62.14 ± 6.185	56.16 ± 4.020
	$\sigma \pm X_\sigma$	16.36 ± 4.374	9.84 ± 2.843
	$C_v \pm Sc_v$, %	26.32 ± 7.037	17.52 ± 5.063
Alanine aminotransferase (ALT), U/L	$X \pm Sx$	41.28 ± 3.649	48.00 ± 2.886
	$\sigma \pm X_\sigma$	9.65 ± 2.580	7.07 ± 2.043
	$C_v \pm Sc_v$, %	23.37 ± 6.248	14.67 ± 4.239
De Ritis ratio	$X \pm Sx$	1.50 ± 0.146	1.15 ± 0.103
	$\sigma \pm X_\sigma$	0.38 ± 0.101	0.25 ± 0.072
	$C_v \pm Sc_v$, %	25.82 ± 6.903	21.88 ± 6.323
Average daily gain, g	*n*	*20*	*22*
	$X \pm Sx$	802.2 ± 6.31	760.7 ± 7.66
	$\sigma \pm X_\sigma$	28.23 ± 4.466	35.93 ± 5.419
	$C_v \pm Sc_v$, %	3.52 ± 0.556	4.72 ± 0.711
Age at 100 kg body weight, days	$X \pm Sx$	176.0 ± 1.02	179.8 ± 1.18
	$\sigma \pm X_\sigma$	4.56 ± 0.721	5.55 ± 0.837
	$C_v \pm Sc_v$, %	2.59 ± 0.409	3.08 ± 0.464
Backfat thickness at the level of the 6th–7th thoracic vertebrae, mm	$X \pm Sx$	19.8 ± 0.32	21.6 ± 0.52
	$\sigma \pm X_\sigma$	1.47 ± 0.232	2.44 ± 0.368
	$C_v \pm Sc_v$, %	7.42 ± 1.174	11.29 ± 1.702
B. Tyler Index, points	$X \pm Sx$	212.36 ± 2.044	194.73 ± 3.204
	$\sigma \pm X_\sigma$	9.14 ± 1.446	15.03 ± 2.266
	$C_v \pm Sc_v$, %	4.30 ± 0.680	7.72 ± 1.164
Chilled carcass length, cm	*n*	*14*	*13*
	$X \pm Sx$	97.4 ± 0.44	95.5 ± 0.34
	$\sigma \pm X_\sigma$	1.65 ± 0.311	1.08 ± 0.212
	$C_v \pm Sc_v$, %	1.69 ± 0.319	1.13 ± 0.222

Maximum (anterior) width of the bacon side of the chilled carcass, cm	$X \pm Sx$	35.1 ± 0.51	33.1 ± 0.63
	$\sigma \pm X_\sigma$	1.91 ± 0.361	2.30 ± 0.451
	$C_v \pm Sc_v$, %	5.44 ± 1.028	6.94 ± 1.363
Minimum (posterior) width of the bacon side of the chilled carcass, cm	$X \pm Sx$	25.2 ± 0.45	24.0 ± 0.28
	$\sigma \pm X_\sigma$	2.09 ± 0.395	1.38 ± 0.271
	$C_v \pm Sc_v$, %	8.29 ± 1.567	5.75 ± 1.129

The difference between animals of the experimental groups in average daily gain was 41.5 g (*td* = 4.18; *P* < 0.001), in age at reaching 100 kg body weight 3.8 days (*td* = 2.45; *P* < 0.05), in backfat thickness measured at the level of the 6th–7th thoracic vertebrae 1.8 mm (*td* = 3.00; *P* < 0.01), and in chilled carcass length 1.9 cm (*td* = 3.45; *P* < 0.01). Furthermore, the maximum (anterior) width of the chilled carcass exceeded that of the comparison group by 2.0 cm (*td* = 2.46; *P* < 0.05), while the minimum (posterior) width was greater by 1.2 cm (*td* = 2.30; *P* < 0.05). According to the B. Tyler Index, pigs of Experimental Group I outperformed their counterparts from Experimental Group II by 17.63 points (*td* = 4.65; *P* < 0.001).

The calculated pairwise correlation coefficients between blood serum biochemical parameters and the fattening and meat quality traits of Large White pigs of Hungarian origin indicated substantial variability in the strength and direction of the relationships. In the overall population, correlation coefficients ranged from –0.399 to +0.487 (Table 4). In animals with the MC4RAA genotype, the coefficients varied from –0.854 to +0.680 (Table 5), whereas in pigs carrying the MC4RAG genotype, they ranged from –0.703 to +0.821 (Table 6).

Significant correlations were identified between several biochemical parameters of blood serum and fattening and meat quality traits.

In the overall population of pigs, significant relationships were observed between the following pairs of traits: total protein concentration and average daily gain during the performance testing period (*r* = +0.312, *tr* = 2.24); alanine aminotransferase (ALT) activity and age at reaching 100 kg body weight (*r* = –0.344, *tr* = 2.53); urea concentration and backfat thickness at the level of the 6th–7th thoracic vertebrae (*r* = –0.399, *tr* = 3.08); aspartate aminotransferase (AST) activity and backfat thickness (*r* = –0.316, *tr* = 2.27); ALT activity and chilled carcass length (*r* = +0.293, *tr* = 2.08); urea concentration and maximum (anterior) width of the bacon side of the chilled carcass half (*r* = +0.487, *tr* = 4.14); and urea concentration and minimum (posterior) width of the bacon side of the chilled carcass half (*r* = +0.365, *tr* = 2.73).

In pigs carrying the MC4RAA genotype, significant correlations were found between total protein concentration and average daily gain (*r* = +0.680, *tr* = 4.15); urea concentration and average daily gain (*r* = –0.450, *tr* = 2.25); AST activity and average daily gain (*r* = –0.434, *tr* = 2.15); ALT activity and average daily gain (*r* = +0.495, *tr* = 2.55); total protein concentration and age at reaching 100 kg body weight (*r* = +0.620, *tr* = 3.53); urea concentration and backfat thickness (*r* = –0.854, *tr* = 7.32); AST activity and backfat thickness (*r* = –0.814, *tr* = 6.31); AST activity and chilled carcass length (*r* = +0.673, *tr* = 3.96); total protein concentration and maximum (anterior) width of the bacon side of the chilled carcass half (*r* = –0.523, *tr* = 2.75); AST activity and maximum width of the bacon side (*r* = +0.524, *tr* = 2.75); total protein concentration and minimum (posterior) width of the bacon side (*r* = –0.530, *tr* = 2.80); AST activity and minimum width of the bacon side (*r* = +0.680, *tr* = 4.15); and ALT activity and minimum width of the bacon side (*r* = –0.421, *tr* = 2.08).

Table 4

Correlation coefficients between blood serum biochemical parameters and fattening and meat quality traits of large white pigs of hungarian origin (n = 42)

Trait		Biometrical indicators		
x	***y***	**$r \pm S_r$**	**t_r**	**P**
Average daily gain during the performance testing period, g	Total protein, g/L	+0.312 ± 0.1393*	2.24	<0.05
	Urea, mmol/L	+0.088 ± 0.1531	0.57	>0.05
	Aspartate aminotransferase (AST), U/L	–0.049 ± 0.1539	0.32	>0.05
	Alanine aminotransferase (ALT), U/L	+0.281 ± 0.1421	1.98	>0.05
Age at reaching 100 kg body weight, days	Total protein, g/L	–0.010 ± 0.1543	0.06	>0.05
	Urea, mmol/L	–0.278 ± 0.1423	1.95	>0.05
	Aspartate aminotransferase (AST), U/L	+0.212 ± 0.1473	1.44	>0.05
	Alanine aminotransferase (ALT), U/L	–0.344 ± 0.1360*	2.53	<0.05
Backfat thickness at the level of the 6th–7th thoracic vertebrae, mm	Total protein, g/L	–0.076 ± 0.1534	0.50	>0.05
	Urea, mmol/L	–0.399 ± 0.1297**	3.08	<0.01
	Aspartate aminotransferase (AST), U/L	–0.316 ± 0.1389*	2.27	<0.05
	Alanine aminotransferase (ALT), U/L	+0.091 ± 0.1530	0.59	>0.05
Chilled carcass length, cm	Total protein, g/L	+0.176 ± 0.1495	1.18	>0.05
	Urea, mmol/L	+0.026 ± 0.1542	0.17	>0.05
	Aspartate aminotransferase (AST), U/L	+0.073 ± 0.1535	0.48	>0.05
	Alanine aminotransferase (ALT), U/L	+0.293 ± 0.1410*	2.08	<0.05
Maximum (anterior) width of the bacon side of the chilled carcass half, cm	Total protein, g/L	–0.232 ± 0.1460	1.59	>0.05
	Urea, mmol/L	+0.487 ± 0.1177***	4.14	<0.001
	Aspartate aminotransferase (AST), U/L	–0.058 ± 0.1538	0.38	>0.05
	Alanine aminotransferase (ALT), U/L	+0.169 ± 0.1499	1.13	>0.05
Minimum (posterior) width of the bacon side of the chilled carcass half, cm	Total protein, g/L	–0.122 ± 0.1520	0.80	>0.05
	Urea, mmol/L	+0.365 ± 0.1337**	2.73	<0.01
	Aspartate aminotransferase (AST), U/L	+0.179 ± 0.1493	1.20	>0.05
	Alanine aminotransferase (ALT), U/L	+0.097 ± 0.1528	0.63	>0.05

Note: P < 0.05; P < 0.01; P < 0.001.

Table 5

Correlation coefficients between blood serum biochemical parameters and fattening and meat quality traits of large white pigs of hungarian origin with the MC4r^{AA} genotype (n = 20)

Trait		Biometrical indicators		
x	***y***	**r±S$_r$**	**t$_r$**	**P**
Average daily gain during the performance testing period, g	Total protein, g/L	+0.680 ± 0.1639***	4.15	<0.001
	Urea, mmol/L	–0.450 ± 0.1996*	2.25	<0.05
	Aspartate aminotransferase (AST), U/L	–0.434 ± 0.2014*	2.15	<0.05
	Alanine aminotransferase (ALT), U/L	+0.495 ± 0.1942*	2.55	<0.05
Age at reaching 100 kg body weight, days	Total protein, g/L	+0.620 ± 0.1754**	3.53	<0.01
	Urea, mmol/L	+0.392 ± 0.2057	1.91	>0.05
	Aspartate aminotransferase (AST), U/L	–0.107 ± 0.2223	0.48	>0.05
	Alanine aminotransferase (ALT), U/L	–0.137 ± 0.2214	0.62	>0.05
Backfat thickness at the level of the 6th–7th thoracic vertebrae, mm	Total protein, g/L	+0.164 ± 0.2205	0.74	>0.05
	Urea, mmol/L	–0.854 ± 0.1167***	7.32	<0.001
	Aspartate aminotransferase (AST), U/L	–0.814 ± 0.1291***	6.31	<0.001
	Alanine aminotransferase (ALT), U/L	+0.001 ± 0.2236	0.01	>0.05
Chilled carcass length, cm	Total protein, g/L	–0.197 ± 0.2192	0.90	>0.05
	Urea, mmol/L	+0.295 ± 0.2136	1.38	>0.05
	Aspartate aminotransferase (AST), U/L	+0.673 ± 0.1673***	3.96	<0.001
	Alanine aminotransferase (ALT), U/L	–0.378 ± 0.2070	1.83	>0.05
Maximum (anterior) width of the bacon side of the chilled carcass half, cm	Total protein, g/L	–0.523 ± 0.1905*	2.75	<0.05
	Urea, mmol/L	+0.164 ± 0.2205	0.74	>0.05
	Aspartate aminotransferase (AST), U/L	+0.524 ± 0.1904*	2.75	<0.05
	Alanine aminotransferase (ALT), U/L	–0.397 ± 0.2052	1.93	>0.05
Minimum (posterior) width of the bacon side of the chilled carcass half, cm	Total protein, g/L	–0.530 ± 0.1896*	2.80	<0.05
	Urea, mmol/L	+0.312 ± 0.2124	1.47	>0.05
	Aspartate aminotransferase (AST), U/L	+0.680 ± 0.1639***	4.15	<0.001
	Alanine aminotransferase (ALT), U/L	–0.421 ± 0.2028*	2.08	<0.05

Note: P < 0.05; P < 0.01; P < 0.001.

Table 6

Correlation coefficients between blood serum biochemical parameters and fattening and meat quality traits of large white pigs of hungarian origin with the MC4R^{AG} genotype (n = 22)

Trait		Biometrical indicators		
x	***y***	**r±S$_r$**	**t$_r$**	**P**
Average daily gain during the performance testing period, g	Total protein, g/L	+0.050 ± 0.2354	0.21	>0.05
	Urea, mmol/L	+0.545 ± 0.1976*	2.76	<0.05
	Aspartate aminotransferase (AST), U/L	+0.352 ± 0.2206	1.60	>0.05
	Alanine aminotransferase (ALT), U/L	–0.179 ± 0.2319	0.77	>0.05
Age at reaching 100 kg body weight, days	Total protein, g/L	+0.227 ± 0.2295	0.99	>0.05
	Urea, mmol/L	–0.703 ± 0.5300	1.33	>0.05
	Aspartate aminotransferase (AST), U/L	+0.109 ± 0.2343	0.47	>0.05
	Alanine aminotransferase (ALT), U/L	–0.124 ± 0.2338	0.53	>0.05
Backfat thickness at the level of the 6th–7th thoracic vertebrae, mm	Total protein, g/L	+0.024 ± 0.2356	0.10	>0.05
	Urea, mmol/L	–0.296 ± 0.2251	1.31	>0.05
	Aspartate aminotransferase (AST), U/L	–0.338 ± 0.2218	1.52	>0.05
	Alanine aminotransferase (ALT), U/L	+0.454 ± 0.2100*	2.16	<0.05
Chilled carcass length, cm	Total protein, g/L	+0.157 ± 0.2327	0.67	>0.05
	Urea, mmol/L	–0.121 ± 0.2339	0.52	>0.05
	Aspartate aminotransferase (AST), U/L	–0.004 ± 0.2357	0.02	>0.05
	Alanine aminotransferase (ALT), U/L	+0.622 ± 0.1845**	3.37	<0.01
Maximum (anterior) width of the bacon side of the chilled carcass half, cm	Total protein, g/L	–0.336 ± 0.2219	1.51	>0.05
	Urea, mmol/L	+0.821 ± 0.1345***	6.10	<0.001
	Aspartate aminotransferase (AST), U/L	–0.217 ± 0.2300	0.94	>0.05
	Alanine aminotransferase (ALT), U/L	+0.300 ± 0.2248	1.33	>0.05
Minimum (posterior) width of the bacon side of the chilled carcass half, cm	Total protein, g/L	–0.176 ± 0.2320	0.76	>0.05
	Urea, mmol/L	+0.713 ± 0.1652***	4.32	<0.001
	Aspartate aminotransferase (AST), U/L	–0.024 ± 0.2356	0.10	>0.05
	Alanine aminotransferase (ALT), U/L	+0.430 ± 0.2117*	2.02	<0.05

Note: * - P < 0.05; ** - P < 0.01; *** - P < 0.001

In pigs with the MC4RAG genotype, significant correlations were established between urea concentration and average daily gain (r = +0.545, tr = 2.76); ALT activity and backfat thickness (r = +0.454, tr = 2.16); ALT activity and chilled carcass length (r = +0.622, tr = 3.37); urea concentration and maximum (anterior) width of the bacon side of the chilled carcass half (r = +0.821, tr = 6.10); urea concentration and minimum (posterior) width of the bacon side (r = +0.713, tr = 4.32); and ALT activity and minimum width of the bacon side (r = +0.430, tr = 2.02).

Discussion. The results obtained in the present study are consistent with the findings of other researchers. Thus, Hyria et al. (2018) reported that improvement of fattening performance in young pigs can be achieved through DNA testing of the PLIN and MC4R genes as an auxiliary criterion for animal selection and mating. According to the authors, this approach contributes to the production of pork that meets modern quality standards. They recommended selecting parental pairs to obtain offspring with the AG genotype for the PLIN 4119 A>G polymorphism, the CT genotype for the 7966 T>C polymorphism, as well as the GG genotype for the MC4R-1426 G>A polymorphism, with the aim of increasing lean meat content and reducing backfat thickness in domestic pig breeds.

Lykhach et al. (2022) established that the application of a mating scheme designed to produce offspring with the CTSFGC and MC4RAG genotypes in combinations of (Large White × Landrace) sows and terminal-line boars (Maxter and Maxgro) resulted in an increase in dressing percentage by 0.4–1.4%, loin eye area by 0.2–1.4 cm², ham weight by 0.3–0.6 kg, and carcass meat yield by 0.6–0.8%. At the same time, the authors found no significant effect of cathepsin and melanocortin genotypes on the chemical composition of pork. Based on their findings, they recommended breeding strategies aimed at obtaining pigs with the CTSFGC and MC4RAG genotypes to improve carcass meat characteristics.

According to the results reported by Prudius (2024), the concentration of total protein in the blood of piglets increased by 2.85% before weaning. Albumin concentration in the control group was 47.33%, whereas in the experimental group it reached 48.00%, exceeding the control value by 1.42%. Increases were also observed in the concentrations of α-, β-, and γ-globulins in the experimental group. After weaning, a significant increase in total protein and albumin concentrations was recorded in the experimental group, exceeding the control by 3.96% and 1.85%, respectively. At the beginning of the experiment, piglets from the control and experimental groups differed only slightly in body weight, with a 3.35% advantage in favor of the control group. However, by 28 days of age, piglets from the experimental group had a significantly higher body weight, exceeding the control by 6.58% ($P < 0.001$). During the 14-day post-weaning period, body weight gain in the experimental group increased significantly by 11.9% ($P < 0.01$), while the difference in body weight between the control and experimental groups reached 0.88 kg, or 8.15% ($P < 0.001$). Average daily gain also increased significantly in the experimental group by 11.8% ($P < 0.01$). In addition, feed conversion efficiency improved, with the difference between the control and experimental groups amounting to 0.19 kg, or 10.8%.

Conclusions:

1. The biochemical parameters of blood serum, including total protein concentration (g/L), urea concentration (mmol/L), aspartate aminotransferase (AST) activity (U/L), and alanine aminotransferase (ALT) activity (U/L), in Large White pigs of Hungarian origin were within the physiological range characteristic of clinically healthy animals.

2. Analysis of the performance testing and slaughter data demonstrated that Large White pigs of Hungarian origin were characterized by relatively high fattening and meat quality traits. In terms of age at reaching 100 kg body weight, backfat thickness at the level of the 6th–7th thoracic vertebrae, and chilled carcass length, the animals exceeded the minimum requirements for the Elite class by 6.57%, 31.00%, and 3.72%, respectively.

3. Significant differences between animals of Experimental Group I ($MC4R^{AG}$) and Experimental Group II ($MC4R^{AA}$) were established for average daily gain (41.5 g; *td* = 4.18), age at reaching 100 kg body weight (3.8 days; *td* = 2.45), backfat thickness at the level of the 6th–7th thoracic vertebrae (1.8 mm; *td* = 3.00), chilled carcass length (1.9 cm; *td* = 3.45), maximum (anterior) carcass width (2.0 cm; *td* = 2.46), and minimum (posterior) carcass width (1.2 cm; *td* = 2.30). The difference between the experimental groups according to the B. Tyler Index was 17.63 points (*td* = 4.65).

4. The pairwise correlation coefficients between blood serum biochemical parameters and the fattening and meat quality traits of Large White pigs of Hungarian origin, as well as animals with different melanocortin receptor gene genotypes ($MC4R^{AA}$ and $MC4R^{AG}$), ranged from –0.854 to +0.821. The proportion of statistically significant correlations was 29.16%, 54.16%, and 25.00%, respectively.

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