Age-related dynamics and interrelationships of biochemical blood parameters in landrace and duronco pigs

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Abstract. The article presents the study results of the breed features and age dynamics of the enzyme activity - aspartate aminotransferase, alanine aminotransferase and urea in gilts of the Landrace and Duroc breeds. Significant breed differences in the biochemical status were revealed. The gilts of the Landrace breed have a relatively stable and high enzyme activity. The average alanine aminotransferase activity in Landraces was 43.8 U/L, which is 36.0% more than in Durocs. The aspartate aminotransferase content in the blood serum of Landrace gilts varied within a narrow range of 25.9 U/L to 44.0 U/L, while the Duroc showed a pronounced amplitude of changes from 42.3 U/L to 15.0 U/L, with a sharp decrease by the end of the study. The serum urea concentration increased in both breeds by the end of the study, but the dynamic pattern was different: Landrace gilts showed a smooth increase to a maximum of 5.1 mmol/L at week 16, while Duroc gilts showed a sharp decrease to 1,2 mmol/L at week 17. The average urea level in Landrace gilts was 23.3% higher. Significant breed differences in metabolism have been established. In Landrace pigs, a moderate positive correlation between transaminases (r = 0.48), no correlation between alanine aminotransferase and urea (r = 0.05), and a negative correlation between aspartate aminotransferase and urea (r = -0.33) were found. In Duroc pigs, by contrast, a single positively correlated biochemical complex was revealed: a strong correlation between alanine aminotransferase and aspartate aminotransferase (r = 0.86), as well as moderate positive correlations of both enzymes with urea (r = 0.55 and r = 0.47, respectively). The revealed features reflect breed-specific metabolic processes formed as a result of selection. The obtained data should be used in the development of biochemical markers in breeding programs.

1 Introduction

Pigs have a number of biological features that favorably distinguish them from other types of farm animals. This is primarily a good reproductive ability and high growth rate. For the full realization of these important economically useful traits, pigs need adequate nutrition, balanced in terms of nutrition elements [1-3]. The animal's body is a complex biochemical

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laboratory. Numerous chemical reactions are constantly taking place here at great speed, and many simple and complex chemical compounds are being destroyed and re-created.

Average indicators (taking into account the type, age, and physiological condition of animals) can serve as a starting material for determining proper nutrition and animal welfare conditions [4].

Since the main part of the diet of farm animals consists of concentrated food, the main source of energy in animal organisms, apart from lipids, are carbohydrates and proteins, which cereals are rich in. For example, 41 grams of fat can be formed from 100 grams of starch, and 51 grams of fat can be formed from the same amount of protein. The fat synthesis from macronutrients requires the presence of intermediate compounds common to fat, protein, and carbohydrate metabolism, such as pyruvic, acetic, and other acids. The cofactors, such as macro- and microelements and vitamins are required for these acids. Fats can partially compensate for the lack of carbohydrates, but this interchangeability often leads to ketosis and increased stress on the animal liver.

In industrial pig breeding complexes, the combined effects of industrial stresses, pathogenic agents and feed risks (nutrient imbalance, mycotoxicosis) inevitably affect the condition of the internal organs of animals. The liver, as the main metabolic and detoxification center of the body, is the most vulnerable in this chain. This explains the high proportion of its pathologies in the structure of non-contagious diseases, which, according to the research, reaches 10-20%. The liver synthesizes various organic substances: proteins, glycogen, fats, phosphatides, and other compounds. Protein is synthesized in the liver from amino acids supplied with blood. It produces fibrinogen and prothrombin, which play an important role in blood clotting [5, 6].

Among the substances that make up all animal tissues and organs, proteins are of particular importance. Proteins are involved in the regulation of metabolism, in contractile processes, and in reactions that protect higher organisms from pathogenic agents. Thus, the copper-containing protein ceruloplasmin participates in oxidation reaction processes, regulates iron metabolism and also has an antioxidant effect. It is also involved in the development of the acute phase of inflammation. Cytokines are polypeptide mediators of intercellular interaction. They are necessary in the modulation process of the defensive mechanisms of the body and regulation of normal physiological functions, etc. [7-9].

The liver plays an important role in the carbohydrate metabolism. Glucose carried from the intestine through the portal vein is converted into glycogen in the liver. Due to its high glycogen content, the liver is the central carbohydrate depot of the body, and the process of gluconeogenesis also occurs in the liver [10].

Urea is the main end product of nitrogen metabolism excreting in urine. The formation of urea occurs in the liver as a result of the ornithine cycle [11]. The synthesis of cholesterol which is an important structural component of nervous and other tissues takes place mainly in the liver. It is found in all animal cells and it is necessary for the formation of bile acids, calciferol, hormones of the adrenal cortex and sex hormones. With a decrease in synthetic liver function, cholesterol synthesis may also decrease [12].

Numerous studies have demonstrated that pig breed and sex exert a significant influence on metabolism, thereby affecting growth rate, feed conversion efficiency, and final product quality. Sows exhibit marked intergroup variations in hormonal profiles, which in turn impact biochemical parameters as a consequence of growth rate and the functional maturation of internal organs [13].

The main problem is that the lack of breed-specific biochemical standards for Landrace and Duroc pigs limits the possibility of early diagnosis of metabolic disorders, optimization of feeding, and selection. The purpose of this scientific study is to determine the activity of alanine aminotransferase, aspartate aminotransferase, and serum urea concentrations in

Landrace and Duroc pigs, and to identify correlations: to analyze the correlations within each breed and the correlations between different breeds.

2 Conditions, materials, and methods

The scientific study was conducted on clinically healthy gilts belonging to two genetically different breeds: Landrace and Duroc. All the animals were raised using intensive industrial fattening technology. To ensure maximum comparability of experimental data, an analogue group formation scheme was applied. The gilts were kept in standardized machines under identical conditions of the pig breeding complex. For biochemical analysis, blood samples of gilts were taken in the morning, before feeding. Measurements of the studied blood parameters of gilts were carried out on an automatic biochemical analyzer Chem Well 2910. In the course of the research, test systems manufactured by Vector BEST (Russia) were used. Statistical processing of the obtained digital arrays was carried out using variation analysis tools in Excel.

3 Results and discussion

The age dynamics of the alanine aminotransferase content in the blood serum of gilts of the Landrace and Duroc breeds is presented in Figure 1.

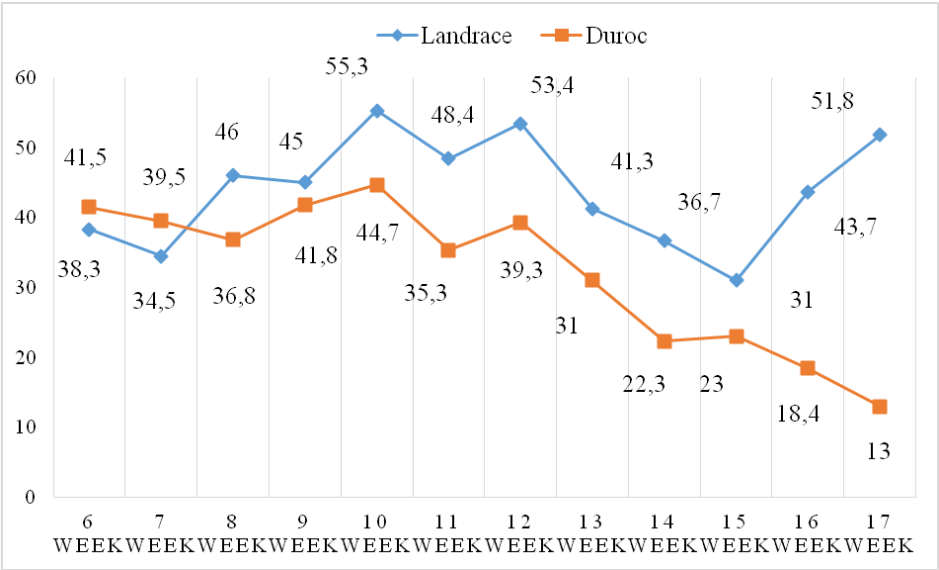

Figure 1. Alanine aminotransferase content in blood serum of gilts of the Landrace and Duroc breeds, U/L.

Based on the data records presented in Figure 1, it can be seen that at weeks 6 and 7 the alanine aminotransferase content in the blood serum of Duroc gilts was higher than of Landrace gilts, and amounted to 41.5 U/L and 39.5 U/L, which exceeded their values by 8.4% and 14.5% respectively. From week 8 to week 17 the content of ALT in the blood serum was higher in Landrace gilts than in the Duroc gilts.

For gilts of the Landrace breed, the alanine aminotransferase variability from 31 U/L at week 15 to 55.3 U/L at week 10 being a characteristic feature. Whereas Duroc gilts have a minimum alanine aminotransferase value of 13 U/L at week 17 and a maximum value of

44.7 U/L at week 10. It should be noted that enzyme content in Landrace gilts at week 10 was 23.7% higher than that of the Duroc gilts during the same period. The average alanine aminotransferase content in the blood serum of Landrace gilts over the entire study period was 43.8 U/L, which is 36.0% more than in Duroc gilts.

The greatest interbreed difference was observed at week 17 when the alanine aminotransferase activity in Landrace gilts was 51.8 U/L, that was 3.9 times higher than in Duroc gilts. A significant intergroup difference was found at week 16 which was 2.4 times greater in Landrace gilts. The closest alanine aminotransferase values in the blood serum of gilts were established at week 9 which amounted to 45.0 U/L in Landrace gilts and 41.8 U/L in Duroc gilts.

The age dynamics of aspartate aminotransferase content in the blood serum of Landrace and Duroc gilts is presented in Figure 2.

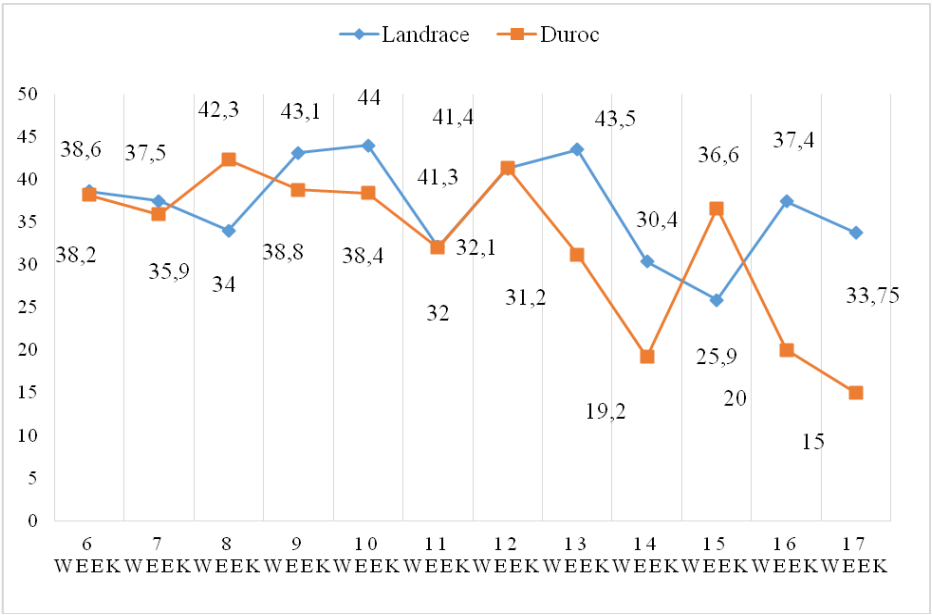

Figure 2. Aspartate aminotransferase content in the blood serum of Landrace and Duroc gilts, U/L.

The analysis of the data records in Figure 2 allows us to conclude that at the beginning of rearing the animals, the aspartate aminotransferase content in the blood serum of gilts had no significant deviations, with the predominant aspartate aminotransferase content in Landrace gilts. At week 7 the highest level of aspartate aminotransferase was found in the blood serum of the Duroc gilts. At week 8 the aspartate aminotransferase in Duroc pigs was 42.3 U/L, which exceeded the same indicator in Landrace gilts by 24.4%. From week 9 to week 11 the highest aspartate aminotransferase content was found in the blood serum of Landrace gilts which exceeded the indicators of the Duroc gilts by 11.1%, 14.6% and 0.3%, respectively. At week 12 the AST content in the blood serum of Duroc gilts exceeded the one of Landrace gilts by 0.2%. During weeks 13 and 14 Landraces exhibited the highest aspartate aminotransferase levels, showing a difference of 39.4% and 58.3% compared to Durocs, respectively. At week 15 the aspartate aminotransferase level superiority in the blood serum of Duroc gilts was 41.3% and amounted to 36.6 U/L. By the end of the scientific research, serum aspartate aminotransferase levels in Landrace gilts exceeded those of Duroc gilts. So, at week 16 the difference was 87%, and at week 17, the aspartate aminotransferase content in the blood serum exceeded by 2.3 times. The data on alanine

aminotransferase and aspartate aminotransferase levels can vary greatly depending on the metabolic rate from low to high values, depending on the animals'protein supply, the burden on the urea cycle, liver, and the animals' growth rates.

Summarizing the dynamics of changes in the aspartate aminotransferase content in the blood serum of gilts, it should be noted that the aspartate aminotransferase activity in Landrace gilts was more stable throughout the entire fattening period, with moderate fluctuations in the range from 25.9 to 44.0 U/L. Durocs were characterized by a more pronounced amplitude of changes, from a maximum value of 42.3 U/L at week 8 to a minimum of 15.0 U/L by week 17. A particularly sharp decrease in enzyme activity was observed in Durocs during the final rearing period, between weeks 15 and 17, which may indicate specific breed-related metabolic characteristics during this growth phase. Moreover, it is precisely in these weeks that gilts undergo intensive oogenesis, a process that undoubtedly leaves its mark on the metabolic profile.

The age dynamics of the urea content in the blood serum of the Landrace and Duroc gilts breeds is presented in Figure 3.

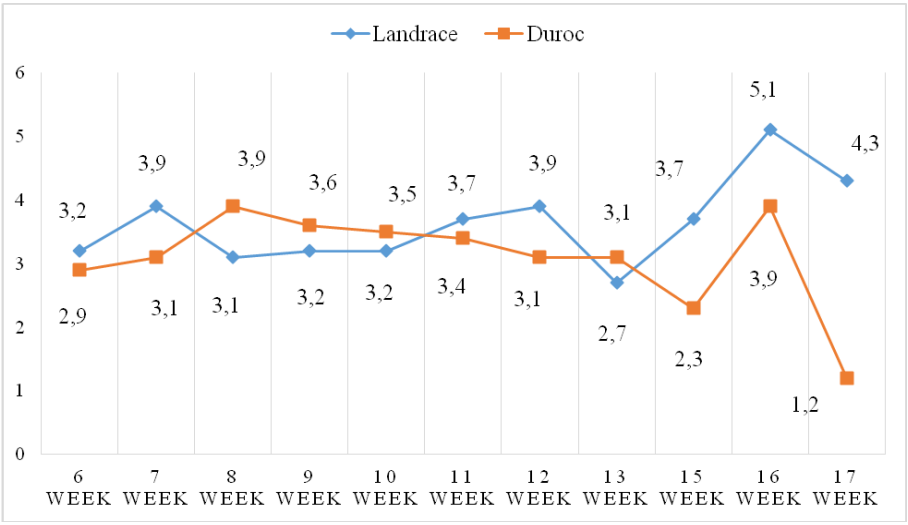

Figure 3. Urea content in the blood serum of Landrace and Duroc gilts, U/L.

The data analysis in Figure 3 allows us to conclude that in the initial period of the study, namely at weeks 6 and 7 the urea content in the blood serum of Landrace gilts was higher than that of Duroc gilts, which made up a difference of 10.3% and 25.8%, respectively. From week 8 to week 11 of rearing, urea levels in Duroc gilts exceeded those of Landrace gilts. The maximum value for this period in Duroc gilts was recorded at week 8 at the value of 3.9 mmol/L, which was 25.8% higher than the Landrace figure.

From week 12 to the end of the scientific research, with the exception of week 13 the urea content in blood serum in Landraces was higher. Pronounced interbreed differences were observed during the final period of the research. At week 16 the urea content in the blood serum of Landraces reached a maximum value of 5.1 mmol/L, which is 30.8% more than in Durocs. At week 17 the urea content in Landraces was 4.3 mmol/L, while in Durocs it sharply decreased to a minimum value of 1.2 mmol/L, which is an indicator of depletion of liver resources. Thus, the Landrace indicator at this age was 3.6 times higher than that of the Duroc.

Table 1 shows the interbreed correlations of biochemical parameters: alanine aminotransferase, aspartate aminotransferase, urea.

Table 1. Interbreed correlations of indicators.

Indicator	Landrace - Duroc
Alanine aminotransferase	0.19
Aspartate aminotransferase	0.32
Urea	-0.16

The conducted analysis of interbreed correlational relationships revealed a multidirectional nature of the association between biochemical blood parameters in Landrace and Duroc gilts. Specifically, a positive yet weak correlation was found between the breeds regarding alanine aminotransferase levels (r = 0.19). For aspartate aminotransferase, the association was also positive but stronger, achieving moderate strength (r = 0.32). The positive sign of the correlations suggests that the variability is unidirectional. This may indicate similar genetically determined mechanisms of protein metabolism regulation and liver function in the compared breeds, despite their genetic differentiation. The stronger link observed for aspartate aminotransferase (0.32) relative to alanine aminotransferase (0.19) could indicate higher conservatism and breed-specific stability of this enzyme, given its greater association with energy metabolism and the urea cycle.

A weak negative correlational link was identified for serum urea levels (r = -0.16). As the end product of protein metabolism, urea levels are closely associated with the effective utilisation of feed nitrogen. A negative correlation may indicate the presence of specific physiological and biochemical features in nitrogen utilization and the intensity of catabolic processes. For the Landrace breed, known for its high meat qualities, and the Duroc, valued for the quality of meat, the nature of nitrogen metabolism may differ due to differences in metabolism inherent in genetics.

Table 2 shows the interbreed correlational link between traits.

Table 2. Interbreed correlational links between traits.

Indicator	Alanine aminotransferase	Aspartate aminotransferase
Landrace		
Aspartate aminotransferase	0.48	1
Urea	0.05	-0.33
Duroc		
Aspartate aminotransferase	0.86	1
Urea	0.55	0.47

The analysis of interbreed correlational links revealed significant differences in the structure of metabolic interrelationships in gilts, which indicating the breed-specific regulation of biochemical processes.

Thus, in Landrace gilts, a positive correlational link of average strength (r = 0.48) between the content of alanine aminotransferase and aspartate aminotransferase was established. This indicates the presence of a general regulation of transamination enzymes, which is physiologically justified by their participation in transamination reactions. There is practically no correlation between the alanine aminotransferase level and urea content (r = 0.05). This indicates that alanine aminotransferase levels, primarily marking cytoplasmic transamination, are functionally dissociated from the final stage of protein catabolism. In the Landrace breed which is characterized by a high growth potential, the activity of alanine aminotransferase seems to be more related to the processes of tissue synthesis than to the intensity of amino acid catabolism. A negative correlation of average strength (r = -0.33) was established between the aspartate aminotransferase level and urea content. A negative

correlation with urea may indicate higher aspartate aminotransferase activity in Landraces which is associated with less nitrogen excretion from urea, that is, with its more effective retention in the body for plastic needs.

Duroc gilts have revealed a slightly different, closer interrelationship. Thus, a strong positive correlational link was established between the content of aspartate aminotransferase and alanine aminotransferase (r = 0.86). A strong correlation could suggest targeted breed selection focused on enhancing meat quality. A moderate positive correlation (r = 0.55) was found between alanine aminotransferase and urea. Unlike the Landraces, the Durocs have an increase in alanine aminotransferase activity associated with an increase in urea levels. A moderate positive correlation (r = 0.47) has also been established between the aspartate aminotransferase and urea content, which is logical due to the aspartate's role in the Krebs-Hanseleit cycle. This also confirms the general trend for the Duroc breed, when all three indicators form a single, positively related complex. The activity of enzymes and the level of the final metabolite change unidirectionally, which indicates a high degree of integration of protein-energy metabolism.

4 Conclusions

Biochemical markers represent a pressing research topic across all branches of animal husbandry. Researchers link the effects of species identity and genotype to blood serum indicators as a basis for selecting superior animals to achieve high economic efficiency [14,15]. Thus, based on the analysis of the age dynamics of pig blood serum biochemical parameters significant breed differences were noted. The gilts of the Landrace breed are characterized by relatively stable and high activity of the studied enzymes and the urea level. This fact may reflect the specific character of their metabolic processes. Thus, the average alanine aminotransferase activity for the entire period in Landraces was 43.8 U/L, which exceeded the same activity in Durocs by 36.0%. The aspartate aminotransferase activity in the blood serum of Landrace gilts was more stable throughout the entire fattening period, with moderate fluctuations in the range from 25.9 to 44.0 U/L. Durocs were characterized by a more pronounced amplitude of changes: from a maximum value of 42.3 U/L at week 8 to a minimum of 15.0 U/L by week 17. The general trend for both pig breeds was an increase in urea level in the blood serum by the end of the scientific research, but the dynamics of this increase was different. For Landraces the growth rate was smoother and more stable, reaching a maximum by week 16, which amounted to 5.1 mmol/L. The urea content in Durocs, on the contrary, was characterized by a sharp decrease to a minimum value of 1.2 mmol/L by week 17, which led to a maximum interbreed difference of 3.6 times. The average urea level of the Landrace was 23.3% higher than that of the Duroc. Thus, the interrelationships between the biochemical parameters of pigs and their breed characteristics have been established.

In general, the identified correlation coefficients (both positive and negative) range from weak to moderate values. This points to the absence of rigid genetic determination that completely matches in the two breeds. Patterns found (similarity in transaminases and difference in urea) reflect both the general physiological bases of metabolism inherent in pigs and the breed-specific features of the biochemical status formed as a result of breeding.

A comparative analysis of interbreed correlations revealed clear breed differences. The gilts of the Landrace breed are characterized by a less integrated metabolic system with the presence of multidirectional connection (positive between enzymes, negative between aspartate aminotransferase and urea levels, and the absence of a connection between alanine aminotransferase and urea levels). This may be the physiological basis for the high efficiency of nitrogen use for growth which is typical for specialized meat breeds. Duroc gilts are characterized by a high positive correlation of all the studied indicators. The

identified variations in the of phenotypic correlation structure likely represent the different metabolic adaptation pathways developed through prolonged selection of these breeds for economically beneficial traits. These factors should be taken into account when developing breeding programs with employing biochemical markers.

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