On the use of feed supplements in the system of livestock technological modernization

M Prokopieva*, O Nesterova and N Sereda

Federal State Budgetary Educational Institution of Higher Education, Chuvash State Agricultural Academy, 29 K Marx Street, Cheboksary 428003, Russian Federation

*E-mail: maria64pr@edu.academy21.ru

Abstract. When feeding of pigs is organized it is necessary to take into account physiological patterns of development that affect both productivity and reproductive qualities which are based on metabolism. This study considers and investigates the use of Provimi protein-vitamin-mineral supplements (PVMS) in the system of livestock technological modernization. Morphological and biochemical parameters of blood were studied in the control and experimental groups using generally accepted standardized methods. The results were processed using the program STATGU1.XLS. In the course of experimental work, the composition and nutritional value of feeding pigs within 60 days after weaning and 210 days of fattening were evaluated. The influence of Provimi products on their growth, development and metabolism was studied, which is judged by the state of morphobiochemical parameters of blood in the dynamics of growth of animals. The use of PVMS of the aforementioned company has had a positive effect on the growth dynamics as evidenced by an average daily body-weight increase of animals of the experimental group compared to the test one by more than 30%.

1. Introduction

One of the main directions of the priority project for the technological modernization of animal husbandry all over the world, as well as in Russia, is its accelerated development, involving the production and consumption of ecologically clean meat. This implies an increase in pork production both through the selection of boars with certain genotypes of blood groups with dams of certain genes [1], and due to the average daily gain in live weight during growing and fattening, and a decrease in feed consumption per unit of production. Lack of protein, mineral elements and vitamins in the ration of farm animals leads to a decrease in productivity, an increase in feed consumption per unit of products and ultimately to an increase in the cost of products [2, 3].

The diet of animals and the conditions for their maintenance determine the production of high quality products, depending on the optimal content of each feed component [4]. Food used in farms is not always balanced with biologically active substances [5].

The scientific studies related to the enrichment of pig diets with amino acids show a significant average daily body-weight increase of animals up to 607-634 g [6]. It was found that during the entire experiment, ducklings additionally fed with enzyme agents as supplements demonstrated increased growth energy [7]. There is evidence that the activity of enzymes depends on the nutritional phases of piglets [8]. Thus, the activity of enzymes in the jejunum tissues is directly related both to the phases of development of piglets and to a change in the composition and percentage of feed components [9]. A mixture of such enzyme agents in domestic feed as amilosubtilin and cellux (celloviridine),
amilosubtilin and protosubtilin, allows you to realize the biological resources of animals, which optimally affects the profitability of meat production, quantitative and qualitative indicators of meat productivity due to the full use of feed nutrients [10].

The amino acid lysine has a positive effect on mineral metabolism, promotes the absorption of calcium and phosphorus, activates the hematopoietic function of the bone marrow and the state of the nervous system. Feed additives also have a positive effect on the palatability of livestock products [11, 12], immunological status and productivity of newborn animals [13], improving pregnancy outcomes [14] and increasing economic profitability [15].

Studying the issue of intensification of pork production, science and practice solve promising problems associated with the use and search for synthetic and natural complex chemicals [16].

Objective of the Study – investigation of the effect of feeds containing Provimi PVMS on the growth and development of young pigs and morphobiochemical parameters of blood during systemic technological modernization of the livestock.

2. Materials and methods
The scientific and economic experience was conducted on large white pigs (20 heads per each control and experimental groups selected on the basis of pairs – analogues) in the period of postweaning and growing, aged 60 to 210 days, in the farming conditions of the Chuvash Republic. The animals of both experimental and control groups were maintained identically.

The mass of weaned piglets at the beginning of the experiment made up 15-16 kg both in the control and in the experimental groups.

The household diet of the control group of piglets represents a structure consisting of 40% of wheat, 40% of barley, 20% of fodder yeast during the observation period from 60 to 90 days; 45 of barley, 40 of wheat, 15 of fodder yeast in the period from 90 to 140 days; 45 of barley, 45 of wheat, 10 of fodder yeast in the period from 141 to 210 days. Additionally, in accordance with the norms of the All-Russia Institute for Animal Husbandry [4], sodium chloride and dicalcium phosphate were added.

In the experimental group, the diet was balanced according to the Provimi program feeding standards due to the inclusion of PVMS in the amount of 20% of ‘Starter’ 1,505, 15% of ‘Grower’ 2,065 and 10% of ‘Finisher’ 2,064 taking into account the age. At the same time animals were group-fed with constant supply of clean water. During the experiments, the pigs were kept in the pens with the same microclimate.

Protein, vitamin and mineral supplements of the company Provimi (Holland) being on the Russian market since the end of the 20th century contain protein, fiber, lysine, methionine+cystine which are ingested with feed. Along with this, lysine and methionine are essential aminocarboxylic acids, and cystine is interchangeable with methionine, which is involved in metabolic processes. They affect the metabolism of proteins, carbohydrates and contribute to the formation of substances, detoxification of intestinal poisons, activation of insulin, and participate in the synthesis of bile acids in the liver. Moreover, the supplement composition includes all the necessary vitamins, macro- and microelements, other amino acids and enzymes. The feed consumption rate with the help of the ‘Finisher’ PVMS was maintained within 2.10 kg during the entire growing season. The average daily body weight gain of reared heads did not exceed 600-650 g. The recommended daily feed consumption rate is 2.20-2.80 kg with an average daily body weight gain of 750 g. Such an increase can lead to their obesity, which is very unacceptable for reared heads with a moderate level of feeding.

The studies took into account the dynamics of live weight of animals, their safety and physiological condition. Animals in all groups were weighed at the beginning and at the end of the experiment as well as with a change in PVMS. During the experiment, blood parameters were monitored.

All the studied indicators were checked in the following periods: 60-90 days with the PVMS ‘Starter’ 1,505, 91-140 days with the PVMS ‘Grower’ 2,065, 141-210 days with the PVMS ‘Finisher’ 2,064.

Previously, in order to study the usefulness of diets, the feed of piglets was analyzed by nutrients during weaning and growing pigs to a live weight of 110 kg.
Throughout the experiment, a live weight and an average daily body-weight increase of piglets were monitored, the clinical condition was recorded.

The following serum biochemical parameters were studied: enzymes: aminotransferases – alanine aminotransferase, aspartate aminotransferase; alkaline phosphatase; total protein, protein fractions, total calcium, inorganic phosphorus, reserve alkalinity, microelements – cobalt, manganese, copper. The morphological composition was determined in the blood: the number of red blood cells, white blood cells, hemoglobin.

To carry out biochemical analyzes, we used a semi-automatic biochemical analyzer with a built-in thermostat for 10 tubes, a laboratory medical photometer of the Biochem SA model (High Technology, USA, 2009) and biochemical reagents HighTechnology, USA.

ALT (Alanine Aminotransferase) and AST (Aspartate Aminotransferase) were determined by the IFCC enzymatic kinetic method at a wavelength of 340 nm using the HT-A306-120 reagent. The essence of the method: ALT catalyzes the transfer of amino groups from L-alanine to α-ketoglutarate with the formation of pyruvate and L-glutamate. Lactate dehydrogenase catalyzes the reduction of pyruvate and simultaneously the oxidation of NADH to NAD+. The rate of decline in NADH concentration, measured photometrically, is directly proportional to the ALT activity present in the sample. AST catalyzes the transfer of an amino group between L-aspartate and 2-oxoglutarate. The oxaloacetate formed in the first reaction reacts with NADH in the presence of malate dehydrogenase (MDH) to form NAD+. The rate of decline in NADH concentration, measured photometrically at 340 nm, is directly proportional to the AST activity present in the sample.

Alkaline phosphatase – by enzymatic kinetic method at a wavelength of 405 nm using reagent HT-A305-120. Method principle: alkaline phosphatase accelerates the transfer of phosphate from p-nitrophenyl phosphate to 2-amino-2-methyl-1-propanol (AMP), forming p-nitrophenol. The rate of formation of p-nitrophenol, measured photometrically, is proportional to the enzymatic activity of alkaline phosphatase, which allows the concentration to be determined.

Total protein – by the endpoint biuret method at a wavelength of 540 nm using the HT-T251-125 reagent. The principle of the method: whey protein in an alkaline medium, when interacting with copper ions, forms a violet complex. The absorption of the formed complex is directly proportional to the protein concentration in the test sample.

Total calcium – by OCP endpoint at 570 nm using HT-C216-250 reagent. Principle of the method: calcium reacts with o-cresolphthalein in the presence of 8-hydroxyquinoline with the formation of a colored complex (purple color) with absorption at a wavelength of 570 nm (550-580 nm). The color intensity is proportional to the calcium concentration. Phosphorus – by the end-point method of ammonium molybdate at a wavelength of 340 nm using the HT-P344-125 reagent.

The HT-C500-CTL reagent is used to calibrate quantitative tests on automatic and semi-automatic analyzers.

Determination of the alkaline reserve in blood plasma was carried out by the diffusion method. In one half of the double flask, the blood plasma is treated with sulfuric acid, thereby releasing carbon dioxide, which is part of the bicarbonates. The released carbon dioxide is absorbed by the sodium hydroxide solution, which is in the other half of the flask. An excess of caustic soda, which has not entered into a reaction with carbon dioxide, and half of the sodium carbonate formed during the absorption of CO₂ are titrated with a solution of sulfuric acid. By the amount of caustic soda bound, the amount of carbon dioxide released from the plasma is determined, which is equivalent to the content of bicarbonates.

Protein fractions, cobalt, manganese and copper were investigated using a KFK-2 device (ZOMZ, Russia, 1989).

Protein fractions in blood serum were determined by the nephelometric method. The principle of the method is that individual protein fractions are capable of precipitating phosphate solutions of a certain concentration.

The method for the determination of cobalt is based on obtaining a colored complex of cobalt with 2-(2-peredylazo) -5-diethylmethaaminophenol (PAAP) at pH = 5, its extraction with chloroform and
measurement of the optical density of the medium. To eliminate the influence of other trace elements that react with PAAF, their colored complexes are decomposed with 10 N sulfuric acid solution.

The manganese content in the blood was determined by the periodate method. The principle of the method is that potassium periodate in an acidic medium is capable of oxidizing manganese to MnO₄²⁻. Interfering substances are removed or destroyed during ash handling.

Copper was determined according to Sindel's method, where a trace element with diphenylcarbazone forms a colored compound at pH 4-5. PCE-90Vet (High Technology, USA, 2009) was used for hematological analyzes. The following parameters were determined: erythrocytes (RBC), leukocytes (WBC), hemoglobin (HGB).

Hemoanalyzer PCE 90 Vet is a fully automatic hematology analyzer for 18 parameters for the study of animal blood samples, including the differentiation of leukocytes in three subpopulations and the construction of histograms. Instrument status, measurement and graphing are displayed on a large LCD display. The device is controlled using the built-in keyboard. The analyzer automatically draws a blood sample, dilutes, mixes, lyses, delivers and rinses. Measurement methods: conductometric, colorimetric.

The morphological and biochemical parameters of blood were studied with the use of generally accepted standardized methods. The obtained statistical results were processed with variation statistics methods of the program STATGU1.XLS.

3. Results and discussion

The analysis of the pig rations after weaning showed the availability of digestible protein, lysine, methionine + cystine, calcium, phosphorus and some vitamins but did not meet the animals’ mineral requirements, in %: Fe – 36.7-46.3; Cu – 42.7-53.2; in vitamins – carotene – 10-11; vitamin E – 70-93; B₂ – 18-46; B₃ – 42-70; B₄ – 81-97. In modernizing the technology for growing pigs, taking into account the unbalanced ration, we used PVMS produced by Provimi.

Such clinical indicators as temperature, pulse and respiration for the entire observed period were within normal limits, respectively, in all tested animals.

For piglets of the experimental group, the activity of alanine aminotransferase was 218.20±6.02 at the beginning of the observation period. An increase was observed with the growth of piglets, and at the end of the experiment the activity made up 234.90±7.81 nmol/s·L (P<0.05) which was statistically significant and by the end of the observation period was higher than in animals of the control group by 9.8%.

The quantitative content of aspartate aminotransferase was more constant during the experiment and increased by the end of the experiment by 8.9%. And piglets in the control group showed changes but downwards. The levels of aspartate aminotransferase in the blood of animals of the compared groups had a significant difference. At the end of the experiment, the activity indicator of Aspartate aminotransferase in piglets of the experimental group prevailed over the control one by 10%.

In the period from weaning to the end of the research, when growing piglets with the use of protein, vitamin and mineral supplements the content of transaminases was higher than in the control group as was the content of alkaline phosphatase. Transaminases are involved in transamination reflecting protein metabolism and transport amino groups to form new amino acids.

Alkaline phosphatase is an enzyme responsible for the separation of phosphoric acid molecules from the compounds entering the body which ensures that phosphorus enters the cells for normal metabolism. Alkaline phosphatase is responsible for the state of mineral metabolism and, in particular, calcium–phosphorus one. Monitoring of the activity of alkaline phosphatase in piglets of the control and experimental groups showed that the enzyme activity was within the physiological norm. In the control group, with advancing aging of piglets, alkaline phosphatase activity decreased by 6.5%, in the experimental group there was a slight increase towards the end of the observed period (2%). The enzyme level at the end of the experiment was higher in the blood of piglets of the experimental group by 8%.
The level of total protein and protein fractions in the blood under the influence of protein, vitamin and mineral supplements was altered with a change in composition by 6%. By the end of the observation it decreased by 8% and was at a level of 66.67±1.05 g/l in pigs in the control group. In the group representing control, during all observed periods of the scientific study, compared with the experimental ones, it was lower and made up from 1.9 to 2.9% which was also lower than the accepted standards. Such changes are evidence of physiological tension during the period of intensive growth of animals and indicates a completely favorable course of physiological processes in a living organism and the formation of its nonspecific protective forces. The activation of protein metabolism is also evidenced by an increase in β-globulins by 5-6%, γ-globulins by 12-13% relative to the control.

Some biochemical parameters (Ca, P, Co, Mn, Cu, AR) are presented in the table.

### Table. Some biochemical indicators of blood of pigs in the experiment (Groups n = 20).

| Indicators        | Control, days | Experimental | P   |
|-------------------|---------------|--------------|-----|
|                   | 60-90         | 91-140       | 141-210       | 60-90 | 91-140 | 141-210 |     |
| Total Ca, mmol/l  | 1.85±0.05     | 2.04±0.08    | 2.69±0.05     | 1.90±0.06 | 2.14±0.07 | 2.32±0.11 | <0.01 |
| P, mmol/l         | 1.13±0.08     | 1.33±0.07    | 1.38±0.06     | 1.15±0.06 | 1.24±0.08 | 1.30±0.07 | <0.01 |
| Ca:P              | 2.17          | 1.98         | 2.50          | 2.13      | 2.22      | 2.30      | <0.01 |
| Co, µmol/l        | 0.42±0.03     | 0.40±0.04    | 0.38±0.04     | 0.43±0.04 | 0.44±0.03 | 0.53±0.04 | <0.05 |
| Mn, µmol/l        | 1.55±0.07     | 1.72±0.07    | 1.97±0.07     | 1.56±0.08 | 1.69±0.06 | 1.80±0.05 | <0.05 |
| Cu, µmol/l        | 9.42±0.31     | 10.30±0.35   | 10.20±0.30    | 10.20±0.20| 11.33±0.43| 11.80±0.30| <0.01 |
| Alkaline reserve, vol. % CO₂ | 47.25±1.11 | 48.50±0.74 | 41.17±1.16 | 49.67±0.88 | 52.00±1.61 | 44.75±0.92 | <0.05 |

During the study period, sixty-day-old piglets – in the control and experimental groups – showed insignificant deficiencies of calcium with phosphorus while the calcium-phosphorus ratio was within 2.13 (experience) and 2.17 (control). The addition of a protein, vitamin and mineral supplement to the diet of animals of the experimental group normalized the calcium-phosphorus ratio up to 2.30 while in the control group of piglets it was wide and equal to 2.50. The data obtained indicate that during the period of active growth and development, the content of Ca and P in the blood of piglets changes and normalizes when a protein, vitamin and mineral supplement is included in the feed, which is actively used both for weight gain in piglets and for enhanced bone formation. They also affect the completion of the structural and functional formation of internal organs and humoral defense mechanisms. The reserve alkalinity of blood serum of piglets in the experimental group during the observation period was in the range of 49.67±0.88 against 44.75±0.92 at the end of the experiment. In the control group, it was lower and ranged within 47.25±1.11-41.17±1.16 vol.% CO₂ from the beginning to the end of the experiment. It means acidosis in piglets of the control group.

The change in the content of Co, Mn and Cu according to the table data in the blood of the experimental group during the study period was higher than in the control one. The change in the amount of cobalt was dynamic and by the end of the experiment its content increased by 18.9% which corresponded to the standards. In the control group of animals in all studied periods, hypocobalaltosis was observed. In the blood of the pigs of the compared groups, the difference in cobalt content at the beginning was 2.30%, and at the end it was 28.30 (P<0.05).

The manganese content in the studied groups of piglets was increased. When comparing the two groups, the level of manganese in the blood of the piglets of the experimental group at the end of the experiment was 8.6% lower than that of the control one. The observed trend is positive since the
content of this microelement in the blood of piglets of the control group is higher than the accepted standards.

The copper level in the blood of piglets of the experimental group showed a steady upward trend with advancing aging (10.20±0.20-11.80±0.30); in the control till 120 days the copper content increased to 10.30±0.35 mcM/l, and by the end of the experiment its decrease was again observed (10.20±0.30).

At the beginning, the copper content in the blood of piglets of the compared groups differed 7.4%, while at the end of the experiment the copper level in piglets of the experimental group increased in blood and was already higher by 14% (P<0.01), and corresponded to the regulatory limits. It is believed that maintenance of the optimal level of copper in the blood of experimental piglets has been possible thanks to the positive effect of protein, vitamin and mineral supplements on absorption and intake of mineral substances.

The PVMS formula which provides for a high metabolic rate in piglets normalized the concentration of Ca, P, Co, Mn, Cu in the blood.

Monitoring of blood indicators showed that the number of red blood cells in piglets in the experimental group increased by 16% by the end of the study and amounted to 6.10±0.12ꞏ1012 l against 5.12±0.10ꞏ1012 l in sixty-day-old piglets, and in the control group changes during the experiment were less significant and amounted to 6% between the indicators of animals at the end of the experiment and sixty-day-old piglets. The obtained research results illustrate the hemostimulating effect of Provimi.

At the end of the experiment, the hemoglobin content in the experimental group of piglets increased by 1.3% compared with the beginning of the experiment and was within the accepted standards. In the control group, an increase of 4.4% was observed and the content was 2.6% higher than the accepted standards.

The number of leukocytes in both comparison groups was unstable: at the beginning of the study, 14.80±0.20 g/l in the experimental group, and by the end of the study it decreased by 16% while in the control group a decrease of 8% was observed. In the process of the experiment, the number of leukocytes in the blood of experimental pigs was within the accepted standards, and in the control group it was 11% higher than the experimental one by the end of the experiment (P <0.05).

The optimal conditions that are in full accordance with the nature of regulatory mechanisms for the development of animals with the use of Provimi PVMS are indicated by the number of red blood cells, white blood cells, and hemoglobin in the blood of tested animals characterizing the level of metabolic processes.

The experiments show that under the influence of PVMS the average daily body-weight increase indicators are significantly higher in piglets of the experimental group: 457.67±14.43-650.28±26.11 g whereas in the control group: 253.33±16.11-480.00±24.90 g as well as an absolute increase: 90 kg in the experimental against 61. In both groups, from 140 to 210 days the average daily body-weight increase was maximum and amounted to 650.28 g in the experimental group and 480.00 g in the control group.

Growing piglets with the use of full-feed mixed feeds allows them, after weaning (60-90 days), namely using the PVMS ‘Starter’, to achieve a high average daily body-weight increase rate of 457.67±14.43 of experimental pigs compared to 253.33±16.11 g in the control. In the period of 91-140 days with the use of the PVMS ‘Grower’ the average daily body-weight increase was 628.00±21.65 g against 399.60±27.54 g in the control group, 141-210 days – 650.28±26.11 g against – 480.00±24.90 g, respectively.

4. Conclusion

The study of the effect of feeds containing Provimi PVMS on the growth, development of young pigs and morphobiochemical blood parameters during systemic technological modernization of livestock showed a positive trend:

1. Enzymatic activity of aminotransferases and alkaline phosphatase was activated.
2. Provimi optimized the calcium-phosphorus metabolism and had a positive effect on the acid-alkali balance.

3. The concentration of cobalt and copper in the blood of the experimental group of piglets throughout the experiment was higher compared to the control one and was within the accepted standards.

4. In the experimental group of animals under the action of protein, vitamin and mineral supplements, protein metabolism was maintained at an optimal level compared to the control group which ensured enhanced growth and development.

5. The hematological blood parameters of piglets during the experiment were higher than in the control group but were within the accepted standards which ensured a more intensive growth.

6. Growing pigs using Provimi technology ensures an average daily body-weight increase of animals of the experimental group of over 30%.

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