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Effect of bacterial lysate-based bioactive supplement on immunological blood parameters in grower pigs

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ABSTRACT

Introduction. Modern pig farming in Russia is showing steady growth, which is accompanied by the introduction of new technologies aimed at increasing productive performance and reducing dependence on antibiotics. This causes increased interest in biologically active products with immunostimulatory and immunomodulatory properties. Multiple studies confirm their positive effect on the intestinal microflora, immune status and overall productive performance of animals. However, the morphofunctional and biochemical aspects of the action of these agents remain understudied, which highlights the necessity of further research in this field.
Objective. To justify the expediency of using immunomodulatory drug Immbaclys C for pigs during grower stage based on the analysis of the published resources and experimental data.
Materials and methods. Sixty biological samples (blood) collected from grower pigs on the commercial pig farm in Kolomna Municipal Okrug, Moscow Oblast in April – July 2024 were studied. The samples were tested using enzyme-linked immunosorbent assay, flow cytometry, and microscopy. The data was processed using the statistical analysis software Statistica v.13.0.
Results. Course administration of Immbaclys C to grower pigs (22–113 days old) induced statistically significant enhancements in cellular and humoral immunity markers, including elevated T- and B-lymphocyte counts, neutrophil phagocytosis, and IgG/IgM levels, demonstrating activation of immune defense pathways.
Conclusion. The dynamics of the parameters throughout the study period indicate a cumulative effect of the drug, particularly with respect to the relative count of B-lymphocytes and the level of IgM, which may suggest its prolonged action upon repeated administration. These findings position Immbaclys C as an effective immunoprophylactic agent with potential for incorporation into veterinary health programs to control and prevent immunodeficiency in intensively reared young pigs.

Keywords: replacement gilts, immunity, immunomodulators, immunostimulators, Immbaclys C, T- and B-lymphocytes, immunoglobulins, phagocytosis

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Изменение иммунологических показателей крови у поросят на доращивании под воздействием биологически активной добавки на основе лизата бактерий

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РЕЗЮМЕ

Введение. Современное свиноводство в России демонстрирует стабильный рост, который сопровождается внедрением новых технологий, направленных на увеличение продуктивности и снижение зависимости от антибиотиков. Это вызывает повышенный интерес к биологически активным препаратам, обладающим иммуностимулирующими и иммуномодулирующими свойствами. Множество исследований подтверждают их положительное влияние на кишечную микрофлору, иммунный статус и общую продуктивность животных. Однако морфофункциональные и биохимические аспекты действия этих средств остаются недостаточно изученными, что подчеркивает необходимость дальнейших исследований в этой области.
Цель исследования. На основе анализа существующей литературы и экспериментальных данных обосновать целесообразность использования препарата «Иммбаклиз С», обладающего иммуномодулирующими свойствами, для поросят в период их доращивания.
Материалы и методы. Исследовали 60 образцов биологического материала (крови), полученного от поросят на доращивании в апреле – июле 2024 г. на свиноводческом комплексе промышленного типа, расположенном на территории Коломенского городского округа Московской области. Исследования

проводились методами иммуноферментного анализа, проточной цитометрии, микроскопии. Обработка данных осуществлялась с использованием пакета статистического анализа Statistica v.13.0.

Результаты. Курсовое введение препарата «Иммбаклиз С» поросятам на доращивании в возрасте 22–113 сут обусловило статистически значимое повышение показателей клеточного и гуморального звеньев иммунной системы, включая увеличение абсолютного и относительного содержания Т- и В-лимфоцитов, фагоцитарной активности нейтрофилов, а также концентрации иммуноглобулинов классов G и M, что указывает на активацию специфических и неспецифических механизмов иммунной защиты.

Заключение. Динамика показателей в течение исследуемого периода свидетельствует о накопительном эффекте препарата, особенно в отношении относительного содержания В-лимфоцитов и уровня IgM, что может указывать на его пролонгированное воздействие при многократном применении. Полученные данные позволяют рассматривать «Иммбаклиз С» как эффективное средство иммунопрофилактики, потенциально пригодное для включения в ветеринарные схемы оздоровления и профилактики иммунодефицитных состояний у молодняка свиней, выращиваемого в условиях интенсивных технологий.

Ключевые слова: ремонтные свинки, иммунитет, иммуномодуляторы, иммуностимуляторы, «Иммбаклиз С», Т- и В-лимфоциты, иммуноглобулины, фагоцитоз

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Конфликт интересов: Федотов С. В. является членом редколлегии журнала «Ветеринария сегодня», но никакого отношения к решению опубликовать эту статью не имеет. Рукопись прошла принятую в журнале процедуру рецензирования. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

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INTRODUCTION

Modern commercial pig farming in Russia is showing steady growth, which is accompanied by the introduction of new technologies aimed at increasing productive performance and reducing dependence on antibiotics. This causes increased interest in biologically active products with immunostimulatory and immunomodulatory properties [1, 2]. Multiple studies confirm their positive effect on the intestinal microflora, immune status and productive performance of pigs [3, 4, 5]. However, the morphofunctional and biochemical aspects of the action of these agents remain understudied, and the differences in the formulations of the products call for a systematic method of their administration [6].

Russia holds a leading position in global pork production: by the end of 2023, the increase in live weight on the commercial farms reached 340 ths tons, which is 6.5% higher than in the previous year [1]. The industry's development is being driven by vertically integrated holdings and environmentally focused technologies implemented by the largest agricultural establishments [7]. A significant role is played by the state support program implemented since 2018 and aimed at modernizing production, reducing the environmental burden and increasing efficiency [1, 2].

The prospects of the industry are associated with the introduction of environment-friendly technologies, expansion of export markets and support for small-scale farming [2, 8]. Of particular relevance is the development and introduction of antibiotic-alternative products with immunostimulatory and immunomodulatory effects, including immunostimulating and other biologically active compounds [4, 9].

The aim of the present study is to justify the efficacy of the immunomodulator Immbaclys C for grower pigs, based on the analysis of the published data and experimental material. The objectives of the study involve experimental assessment of the immunomodulatory effect of Immbaclys C and determination of its effect on the immunological parameters of pig blood.

MATERIALS AND METHODS

The study was conducted on the commercial pig farm in the Moscow Oblast, Kolomna Municipal Okrug, Industria settlement, from April to July 2024. Sixty grower pigs were included in the experiment. The pigs were selected using the matched-pairs method according to the following parameters: Landrace and Large White cross-breeds, females, 22–113 days of age, 7–48 kg body weight. All animals were raised at agricultural cooperative "Mashkino"; they were not moved during the study and stayed in the standard housing conditions. The animals were divided into two groups of 30 animals: control and experimental groups. Pigs in both groups were housed under identical conditions, with standardized management of environmental factors, feeding, veterinary monitoring, and light cycles [10]. The diet of the experimental group was supplemented with Immbaclys C, a bioactive additive demonstrating expressed immunomodulatory and probiotic properties.

Immbaclys C (rights holder; registration certificate holder: NITA-FARM) is an immunotropic agent and immunomodulator (pharmacotherapeutic group; ATC code recommended by the World Health Organization: other immunomodulators). It is

formulated as a modified-release coated granules for oral administration. Each 1 g of the product contains a protein-lipopolysaccharide complex of antigens derived from lysate of *Bordetella bronchiseptica*, *Haemophilus parasuis*, *Streptococcus suis* – 10 mg, as well as the following excipients: monosodium glutamate, D-mannitol, propyl gallate, macrogol cetostearyl ether (polyethylene glycol-25-cetostearyl ether), sugar, povidone K-30, quinoline yellow food colorant (E104), and chalk.

The substance was administered in accordance with the manufacturer's instructions (0.6 g per 1 kg of feed) in a dosage calculated for the body weight of the animal, daily throughout each course of treatment. The control group received a standard diet without any additional supplements. The experiment design included three recurring courses: course I: April – May, course II: May – June, course III: June – July 2024. Each course lasted 14 days with 21-day intervals. In each of the three courses, four blood samples were collected from the jugular vein: day 0 – before the start of the product administration, day 8 – at the stage of the immune response formation, day 15 – at the peak of the therapeutic effect, day 22 – at the end of the course. Laboratory blood tests were performed at the Department of Veterinary Medicine, Russian State Agrarian University – Moscow Timiryazev Agricultural Academy.

The volume of blood collected in one sample did not exceed 10 mL, which is within the permissible norms and has no adverse effect on the physiological state of the animals [11]. The use of the test product Immbaclys C concurrently with routine vaccinations and antibiotics was not allowed in order to avoid distortion of the study results. The following indicators were analyzed: concentration of IgG and IgM using enzyme-linked immunosorbent assay (ELISA); relative and absolute count of T- and B-lymphocytes using flow cytometry; phagocytic activity using microscopy. The data was processed using the statistical analysis software Statistica v.13.0. To assess the reliability of the differences, Fisher's exact test and the Mann – Whitney U test were used. The level of statistical significance was assumed to be $p \leq 0.05$.

The study procedure was approved by the local ethics committee. All procedures involving animals adhered to ethical standards for humane treatment [12]. During the entire experiment, no behavioural or physiological deviations were reported in any animal.

The selection of the analytical parameters was based on the sensitivity of T- and B-cell-mediated immunity to the immunomodulatory agent [13]. The studies show that when biologically active substances are used, an increase in immunoglobulin titres and activation of phagocytosis are reported [6]. Biologically active substances also contribute to the normalization of the intestinal microbiota and suppression of inflammatory processes [14]. According to the preliminary data, Immbaclys C, can be classified as a prolonged-action supplement. Its efficacy may increase when administered in courses with 30-day intervals.

The physiological characteristics of growing pigs aged 22–113 days involve active morphogenetic restructuring of the intestines [15]. At this time, the crypts form and the villi lengthen in the small intestine, while the lymphoid tissue matures [16]. Biologically active additives administered during this period improve the body resistance to opportunistic microflora. This fact is supported by the experimental data on increased production of protective mucus and activation of small intestine epithelial cells [17].

The repeatability of experimental conditions was ensured through the automated feed and water supply systems [18]. Temperature, humidity, and ammonia levels were monitored daily. The feed lots were standardized and tested for mycotoxins [19]. Such control of external factors excluded any influence on the immune response [8], which corresponded to the reproducibility principles in veterinary research [20].

The trial design incorporated a comprehensive approach integrating immunological, physiological, and hygiene control parameters. At each stage, not only laboratory parameters were monitored, but also such factors as behavior, productive performance, and feed intake. The pigs from both groups were provided with equal opportunities for physical activity. The animals were housed in individual pens. This allowed minimizing the variability within the groups.

The study protocol complied with the internationally recognized guidelines for the use of farm animals in research [13]. Herewith, both daily and seasonal changes in physiological functions were recorded [21]. All the animals were kept in the same room throughout the experiment. The animal handlers had no information about which group was the control one, which eliminated potential bias. The use of this blinded design contributed to increased objectivity of the obtained results.

RESULTS AND DISCUSSION

To analyze the immune status indicators of the replacement gilts after Immbaclys C course treatment, data obtained by calculating group means (control and experimental groups) were used, based on individual animal health assessments. Based on these data, mean values for each immunological parameter were calculated, and tables were prepared to enable comparative analysis between the groups. Dynamics of the product's action within each course, as well as summary data, were analyzed.

Following the first course of Immbaclys C administration, pigs in the experimental group demonstrated a significant increase in T-lymphocyte levels (Table 1). The absolute cell count of this population was 5.20×10^9/L compared to 4.55×10^9/L in the control group (an increase of 14.29%, $p < 0.001$). The relative count of T-lymphocytes also increased – 25.12% compared to 20.10% in control animals (a difference of 5.02 percentage points (pp), $p < 0.001$). These changes indicate activation of the cellular immune response, which is consistent with the results obtained for immunomodulators capable of enhancing T-cell activity in farm animals [11, 18]. Immbaclys C, as a drug with pronounced immunostimulatory properties, aids to the enhancement of the functional activity of the lymphocyte immunity and formation of strong cellular protection.

Comparative analysis of the humoral immunity parameters also revealed positive dynamics in pigs from the experimental group. The absolute B-lymphocyte count reached 4.01 × 10^9/L compared to 3.39 × 10^9/L in the control group (an increase of 18.30%, $p < 0.001$), and the relative count was 18.77% compared to 15.15% (a difference of 3.62 pp, $p = 0.0102$). An increase in the B-cell count indicates the activation of antibody production, which is especially important in the context of early immunoprophylaxis in pigs. According to the published data, immunomodulators activate the humoral immunity by stimulating B-lymphocyte differentiation and enhancing immunoglobulin synthesis [22, 23, 24]. Such agents enable the formation of the functionally complete humoral response already at the early stages of rearing [17, 25].

The neutrophil phagocytic activity in the experimental group was 64.88% compared to 56.98% in the control group (a difference of 7.90 pp, an increase of 13.86%, $p < 0.001$). This indicates an increase in nonspecific resistance and activation of the innate immune response. An increase in phagocytic function indicates the systemic effect of Immbaclys C on non-specific protection, including activation of the lysosomal apparatus and cytokine secretion [9, 10]. Immunostimulating substances also enhance the expression of phagocyte surface receptors thus increasing their antigen recognition capacities [9, 25].

The immunoglobulin levels confirm the overall trend towards the increase of the specific immune response in pigs from the experimental group. The IgG level was 7.58 mg/mL compared to 6.25 mg/mL in control animals (an increase of 21.28%, $p < 0.001$), and IgM level reached 2.82 mg/mL compared to 2.40 mg/mL in the control group (an increase of 17.50%, $p < 0.001$). These changes are interpreted as activation of the primary and secondary humoral responses, especially under repeated immunostimulatory exposures. Literature sources emphasize that immunomodulators enhance IgG and IgM synthesis through activation of B-cells and improved cooperation between T- and B-lymphocytes [21, 26]. Such dynamics allows for the formation of stable and balanced humoral immunity in young animals [12, 16].

During the second course of the experiment, the positive dynamics of changes in immunological parameters in pigs from the experimental group continued compared to the control group (Table 2). The absolute T-lymphocyte count was 5.42 × 10^9/L, whereas in the control group it was at the level of 4.58 × 10^9/L (an increase of 18.34%, $p < 0.001$). The relative T-cell count reached 32.63% compared to 20.23% in control animals (the difference was 12.40 pp, $p < 0.001$). These data indicate the cumulative activating effect of Immbaclys C on the cellular component of the immune system. According to the literature sources, prolonged use of immunostimulators promotes enhanced T-lymphocyte differentiation and strengthens the population immune response in young pigs [4, 14, 15].

A similar trend of changes was reported for B-lymphocytes. Their absolute count in the experimental group was 3.87 × 10^9/L compared to 3.62 × 10^9/L in the control group (an increase of 6.90%, $p = 0.0149$), and their relative count was 28.76% compared to 15.31% (a difference of 13.45 pp, $p < 0.001$). This may indicate the continued activation of the humoral immune system, which promotes the specific antibody production. As demonstrated in a number of studies, the immunostimulators activate B-cells, increase effectiveness of their antigen-presenting function, and stimulate the immunoglobulin production [22, 23, 24]. These mechanisms are important at the stage of adaptive immunity formation and increase the young animals' resistance to infectious agents [17, 25].

Phagocytic activity in the experimental group reached 65.80%, while in the control group it was 55.41% (a difference of 10.39 pp, an increase of 18.75%, $p < 0.001$). The data indicate a sustained enhancement of the innate immune response following repeated administration of Immbaclys C. Immunostimulators can increase the activity of neutrophils and macrophages, as well as enhance their capacities for pathogen recognition and destruction [10, 27]. According to literature sources, the use of immunomodulating agents is accompanied by stimulation of phagocytosis due to the activation of receptor complexes and production of innate immunity mediators [9, 18].

Table 1
Mean immunological parameters in pigs of control and experimental groups after course I (April – May 2024)

Indicator	Experimental group	Control group
T-lymphocytes, 10^9/L	5.20 ± 0.11	4.55 ± 0.05
T-lymphocytes, %	25.12 ± 0.68	20.10 ± 0.18
B-lymphocytes, 10^9/L	4.01 ± 0.08	3.39 ± 0.03
B-lymphocytes, %	18.77 ± 0.35	15.15 ± 0.13
Phagocytic activity, %	64.88 ± 0.30	56.98 ± 0.17
IgG, mg/mL	7.58 ± 0.17	6.25 ± 0.13
IgM, mg/mL	2.82 ± 0.10	2.40 ± 0.08

Fisher's exact test $p \leq 0.005$.

Table 2
Mean immunological parameters in pigs of control and experimental groups after course II (May – June 2024)

Indicator	Experimental group	Control group
T-lymphocytes, 10^9/L	5.42 ± 0.39	4.58 ± 0.26
T-lymphocytes, %	32.63 ± 6.59	20.23 ± 1.09
B-lymphocytes, 10^9/L	3.87 ± 0.51	3.62 ± 0.16
B-lymphocytes, %	28.76 ± 9.89	15.31 ± 0.80
Phagocytic activity, %	65.80 ± 1.26	55.41 ± 0.81
IgG, mg/mL	7.42 ± 1.10	6.61 ± 0.34
IgM, mg/mL	3.05 ± 0.41	2.73 ± 0.51

Fisher's exact test $p \leq 0.005$.

The immunoglobulin indicators demonstrate further strengthening of humoral immunity. The IgG level in the experimental group was 7.42 mg/mL compared to 6.61 mg/mL in the control group (an increase of 12.25%, $p = 0.0005$), and IgM was 3.05 mg/mL compared to 2.73 mg/mL (an increase of 11.72%, $p = 0.0097$). This reflects activation of both the primary and secondary immune responses and indicates a sustained immunostimulating effect of Immbaclys C. According to the published data, immunomodulators enhance expression of genes responsible for IgG and IgM synthesis, as well as promote the interaction between T- and B-lymphocytes, which contributes to the comprehensive activation of the immune system [21, 26]. These observations are supported by the experimental results of the current study and emphasize the effectiveness of the course-based administration of the agent.

During the third course of Immbaclys C biologically active supplement administration, a consistently positive dynamics of immunological parameters was reported in pigs in the experimental group as compared to the control group (Table 3). The absolute T-lymphocyte count in the experimental group was 5.56×10^9/L, which exceeds the value in the control group (4.55×10^9/L) by 22.20% ($p < 0.001$). The relative T-cell count was also higher: 33.10% compared to 19.94% in the control animals (the difference was 13.16 pp, $p < 0.001$). This confirms the continued stimulatory effect of Immbaclys C on the cellular compartment of the immune system. Similar data were obtained with prolonged use of immunomodulatory agents that promote enhanced differentiation of T-lymphocytes and maintain their functional activity [4, 14, 15].

The B-lymphocyte counts in the experimental group also demonstrated an increase. The absolute count was 3.94×10^9/L compared to 3.49×10^9/L in the control group (an increase of 12.90%, $p < 0.001$), and the relative count was 29.00% compared to 15.06% (a difference of 13.94 pp, $p < 0.001$). This indicates the continued activation of the humoral immune system. Such shifts are typical for the course-based use of immunostimulators that enhance production of the antibodies and increase the functional maturity of the B-cells [22, 23, 24]. According to the published data, the effect of immunomodulators on adaptive immunity is manifested in enhanced activation of B-lymphocytes and increased immunoglobulin levels [17, 25].

Phagocytic activity in the experimental group was 67.11% compared to 57.23% in the control

Table 3
Mean immunological parameters in pigs of control and experimental groups after course III (June – July 2024)

Indicator	Experimental group	Control group
T-lymphocytes, 10^9/L	5.56 ± 0.37	4.55 ± 0.57
T-lymphocytes, %	33.10 ± 7.15	19.94 ± 1.40
B-lymphocytes, 10^9/L	3.94 ± 0.41	3.49 ± 0.27
B-lymphocytes, %	29.00 ± 10.13	15.06 ± 0.47
Phagocytic activity, %	67.11 ± 2.39	57.23 ± 1.56
IgG, mg/mL	7.88 ± 0.83	6.48 ± 0.27
IgM, mg/mL	3.17 ± 0.54	2.21 ± 0.41

Fisher's exact test $p \leq 0.005$.

group (a difference of 9.88 pp, an increase of 17.26%, $p < 0.001$). These data indicate the maintenance of a high level of nonspecific resistance, which is one of the indicators of the immunostimulator action. Immbaclys C promotes the activation of neutrophils and macrophages, as well as an increase in the expression of molecules responsible for the pathogen destruction [3, 9, 18, 27].

The immunoglobulin level in the experimental group was also higher than in the control group. IgG was 7.88 mg/mL compared to 6.48 mg/mL (an increase of 21.60%, $p < 0.001$), and IgM was 3.17 mg/mL compared to 2.21 mg/mL (an increase of 43.44%, $p < 0.001$). These parameters indicate a powerful stimulation of both the primary and secondary humoral immune responses. Long-term administration of immunomodulators contributes to the sustainable synthesis of immunoglobulins, as reported by a number of authors who note increased expression of IgG and IgM genes in animals after repeated administration of the immunostimulating agents [21, 26].

A comparative analysis of the mean immunological parameters between the experimental and control groups based on the results of three courses of Immbaclys C administration revealed significant differences in favor of the experimental group (Table 4). The absolute T-lymphocyte count was 5.39×10^9/L compared to 4.56×10^9/L (an increase of 18.20%, $p < 0.001$), and the relative count was 30.29% compared to 20.09% (a difference of 10.20 pp, $p < 0.001$). The resulted data indicate maintenance of the agent's activating effect on the cellular immunity and support its prolonged effect when administered course-based. The immunomodulatory action of Immbaclys C contributes to the maintenance of the functional activity of T-lymphocytes and their sustained circulation in peripheral blood [4, 14, 15].

B-lymphocyte counts also demonstrated higher levels in the experimental group. The absolute count was 3.94×10^9/L compared to 3.50×10^9/L in the control group (an increase of 12.57%, $p < 0.001$), and the relative count was 25.51% compared to 15.17% (a difference of 10.34 pp, $p < 0.001$). This indicates an increased humoral immune response associated with the B-cell proliferation and activation against the background of the agent's systematic exposure. Immunostimulators, including Immbaclys C, promote activation of the B-cell immunity and stimulate the immunoglobulin synthesis at all stages of the immune response [22, 23, 24].

The phagocytic activity of neutrophils in the experimental group was 65.93% compared to 56.54% in the control group (a difference of 9.39 pp, an increase of 16.60%, $p < 0.001$). This confirms the enhancement of the innate resistance under the agent's effect. Immbaclys C demonstrates the ability to sustain the activation of non-specific immune defense mechanisms, including the stimulation of phagocytosis and the expression of functional receptors on innate immune cells [3, 9, 18, 27].

Analysis of the immunoglobulin content revealed an increase in IgG levels up to 7.62 mg/mL in the experimental group compared to 6.45 mg/mL in the control group (an increase of 18.14%, $p < 0.001$), and IgM levels up to 3.01 mg/mL compared to 2.45 mg/mL, respectively (an increase of 22.86%, $p < 0.001$). These data indicate high activity of the humoral immunity of the immune system and maintenance of the immunostimulatory effect throughout the entire period of exposure to the agent. The immunomodulators activate the antibody production by enhancing the interaction between T- and B-lymphocytes and expression of genes responsible for the immunoglobulin synthesis [21, 26].

CONCLUSION

Course-based administration of the immunomodulatory agent Immbaclys C to grower pigs aged 22–113 days resulted in a statistically significant growth of the cellular and humoral components of the immune system, including an increase in the absolute and relative T- and B-lymphocyte counts, phagocytic activity of neutrophils, as well as IgG and IgM concentration, thus indicating activation of specific and nonspecific immune defense mechanisms.

The differences between the experimental and control groups across all key immunological parameters in all three courses were of high statistical significance ($p < 0.05$–0.001), which confirms the reliability of the results obtained and enables confident assessment of the pronounced immunostimulatory effect of the agent under commercial use.

Table 4
Generalized mean immunological parameters in pigs from the control and experimental groups over the entire experimental period

Indicator	Experimental group	Control group
T-lymphocytes, 10^9/L	5.39 ± 0.33	4.56 ± 0.33
T-lymphocytes, %	30.29 ± 6.36	20.09 ± 0.94
B-lymphocytes, 10^9/L	3.94 ± 0.35	3.50 ± 0.19
B-lymphocytes, %	25.51 ± 8.92	15.17 ± 0.50
Phagocytic activity, %	65.93 ± 1.72	56.54 ± 1.25
IgG, mg/mL	7.62 ± 0.75	6.45 ± 0.28
IgM, mg/mL	3.01 ± 0.39	2.45 ± 0.41

Fisher's exact test $p \leq 0.005$.

The dynamics of the parameters over the study period demonstrates a cumulative effect of Immbaclys C, particularly in respect to the relative B-lymphocyte count and IgM level, which may suggest a prolonged action of the agent upon its repeated administration.

These findings position Immbaclys C as an effective immunoprophylactic agent, with a potential for incorporation into veterinary health programs to control and prevent immunodeficiency in intensively reared young pigs.

The limitations of the research included the use of animals of the same age category and homogeneous genotype, as well as conducting experiments within the same production facility. This necessitates a careful approach to the interpretation of the results and their extrapolation to other populations and housing conditions.

REFERENCES

1. Kovalev Yu. I. Current trends in pig husbandry of Russia in the new reality and medium-term prospects up to 2025. *Vsyo o myase*. 2023; (4): 8–13. https://doi.org/10.21323/2071-2499-2023-4-8-13 (in Russ.)

2. Bazhov G. M. Intensive pig farming: Textbook. Saint Petersburg: Lan'. 2021. 416 p. (in Russ.)

3. Ovchinnikov A. A. Productivity of sows at the use of probiotics in the ration. *Animal Husbandry and Fodder Production*. 2017; (1): 119–123. https://elibrary.ru/yhpsrd (in Russ.)

4. Belookov A. A., Belookova O. V., Chukhutin E. V., Gorelik O. V. The efficiency of probiotics in industrial pig breeding. *Agrarian Science*. 2022; (7–8): 98–101. https://doi.org/10.32634/0869-8155-2022-361-7-8-98-101

5. Moskalenko E. A., Zabashta N. N. Usage of the combined probiotics in pig. *Collected Scientific Papers of SKNIIZH*. 2016; 5 (3): 150–155. https://elibrary.ru/wxzdrj (in Russ.)

6. Danilenko V. N., Ilyasov R. A., Yunes R. A., Yanenko A. S., Kozlovsky Yu. E., Sverchkova N. V., Kolomiets E. I. Microbiome of animals: search for biologically active ingredients for the creation of probiotics and pharmabiotics. *Biology Bulletin Reviews*. 2022; 142 (4): 333–348. https://elibrary.ru/rmmmus (in Russ.)

7. Brovkina L. I., Tuov A. R. Vertical agroindustrial integration as the mechanism of the decision of financial problems of the agricultural enterprises. *Business in Law*. 2011; (5): 238–241. https://elibrary.ru/ogjvbn (in Russ.)

8. Plaksin I. E., Plaksin S. I., Trifanov A. V. Trends and prospects of pig breeding development in Russia. *AgroEkoInzheneriya*. 2022; (1): 155–168. https://doi.org/10.24412/2713-2641-2022-1110-155-168 (in Russ.)

9. Shkredov V. V. Improving productive quality of piglets during finishing with the use of probiotic Gallobact-F: Author's abstract of thesis for degree of Cand. Sci. (Biology). Ekaterinburg; 2022. 23 p. (in Russ.)

10. Kuznetsov A. F., Tyurin V. G., Semenov V. G., Holdoenko A. M., Rozhkov K. A. Animal management hygiene and technology. Saint Petersburg: Lan'; 2021. 380 p. (in Russ.)

11. Yuzhakov A. G., Zhukova E. V., Aliper T. I., Gulyukin A. M. Porcine reproductive respiratory syndrome: situation in Russia. *Pigbreeding*. 2022; (5): 32–35. https://doi.org/10.37925/0039-713X-2022-5-32-35 (in Russ.)

12. Polkovnikova V. I. Pig farming: study guide. Perm: IPTs "Prokrost"; 2022. 95 p. (in Russ.)

13. Orlova V. S., Orlova E. V., Timokhina A. S., Stanishevskiy Ya. M. The study of immunomodulating properties of the Vitanam. *Drug Development & Registration*. 2017; (4): 248–255. https://elibrary.ru/ztwvit (in Russ.)

14. Sepp A. L., Yashin A. V., Kotyleva M. P., Ermolenko E. I., Kavalionak Y. K., Dobrovolskiy S. A., Gromova L. V. Influence of the probiotic *Enterococcus* on the activity of digestive enzymes and the state of the intestinal microbiome in post-weaning piglets. *International Journal of Veterinary Medicine*. 2019; (3): 99–103. https://elibrary.ru/fpjeyb (in Russ.)

15. Levshin A. D., Kulmakova N. I., Latynina E. S. Metabolic processes in purebred and crossbred pigs at different age periods. *Pigbreeding*. 2022; (4): 50–52. https://doi.org/10.37925/0039-713X-2022-4-50-52 (in Russ.)

16. Kudryavtseva E. N., Kovzov V. V., Ostrovsky A. V., Motuzko N. S., Makovsky E. G., Vishnevets Zh. V., et al. Endogenous control of digestion in farm animals: study guide. Vitebsk: Vitebsk State Academy of Veterinary Medicine; 2023. 152 p. (in Russ.)

17. Pavlov A. V., Pavlova S. V. Relationship between growth energy and feed conversion. *Pigbreeding*. 2024; (5): 62–63. https://doi.org/10.37925/0039-713X-2024-5-62-63 (in Russ.)

18. Kletikova L. V., Ponomarev V. A., Yakimenko N. N., Pronin V. V. Morphostructure of the liver of pigs of the Vietnam bellow breed on the background of the application of a complex of biologically active substances. *Agrarian Journal of Upper Volga Region*. 2023; (2): 57–61. https://doi.org/10.35523/2307-5872-2023-43-2-57-61 (in Russ.)

19. Sysa L. V., Sysa S. A. The main factors negatively influencing the state of animals in the conditions of a series of pig farms. *Animal Agriculture and Veterinary Medicine*. 2022; (3): 26–29. https://elibrary.ru/tjgzmz (in Russ.)

20. Kang H., Tsoy Z. V., Nikulin Yu. P., Nikulina O. A. Waste from the fishing industry in pig feeding. *Pigbreeding*. 2023; (5): 32–34. https://doi.org/10.37925/0039-713X-2023-5-32-34 (in Russ.)

21. Abramov S. V., Gorlov I. F., Slozhenkina M. I., Mosolov A. A., Starodubova Yu. V., Khoroshevskaya L. V. Feed additives with acidifying effect in the diets of weaning piglets under conditions of thermal stress. *Pigbreeding*. 2024; (8): 50–54. https://doi.org/10.37925/0039-713X-2024-8-50-54 (in Russ.)

22. Bolotina E. N. Extruded feeds use for pigs fattening. *Bulletin Samara State Agricultural Academy*. 2014; (1): 118–122. https://elibrary.ru/saeykd (in Russ.)

23. Buyarov V. S., Mikhailova O. A., Buyarov A. V., Kreis V. V. Modern technology of pork production: study guide. Orel: Orel State Agrarian University; 2014. 184 p. https://elibrary.ru/uefnxt (in Russ.)

24. Popov V. S., Samburov N. V., Vorobieva N. V., Zorikova A. A. Secondary immunodeficiency swine:

clinical and immunological characteristics and principles of immunocorrection. *Vestnik of Kursk State Agricultural Academy*. 2016; (3): 57–61. https://elibrary.ru/uesubx (in Russ.)

25. Betin A. N., Frolov A. I., Filippova O. B. Biologically active additives in feeding suckling sows and piglets. *Pigbreeding*. 2022; (1): 15–17. https://doi.org/10.37925/0039-713X-2022-1-15-17 (in Russ.)

26. Gerasimovich A. I., Tuaeva E. V., Chabaev M. G. The use of biologically active additives in feeding sows. *Pigbreeding*. 2023; (2): 19–22. https://doi.org/10.37925/0039-713X-2023-2-19-22 (in Russ.)

27. Bibikov S. O. Effect of multidirectional biologically active substances on productivity and clinical-physiological status of pigs: Author's thesis for degree of Cand. Sci. (Agricultural Science). Volgograd; 2020. 133 p. (in Russ.)

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