Productive qualities and quality of large white pigs' meat using vitamin feed additive

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Abstract. In 2015-2016, OJSC Lynevsky Plemazavod in Smolensk District of Altai Territory studied the use of LipoCar vitamin feed additive on large white breed pigs. The experiment was carried out on pregnant sows and then on piglets obtained from them. In the control group and 2 experimental groups the sows received the main ration of the farm, and the sows of 1 and 3 experimental groups were additionally fed the feed additive "LipoCar" in a dose of 2.1 g per head per day for 20 days. After weaning the piglets during the growing period 4 groups of young animals were formed. In the control and 1 experimental group young animals were fed only the main ration of the farm. In addition to the basic diet, piglets from groups 2 and 3 received the feed additive "LipoCar" from the age of 60 days for 40 days. The use of the feed additive contributed to an increase in the live weight of 2 and 3 experimental groups at the age of 5 and 6 months by 4.8-11.7% (p≤0.05-0.001). Pigs in groups 1, 2 and 3 in the age group 4 to 5 months had higher average daily increases of 10.3-15.8% (p≤0.05-0.001) compared to controls. The live weight of 100 kg of young animals in groups 2 and 3 with a difference of 5.5-7.9% (p≤0.05-0.01) in relation to control was reached more quickly. Animals of all experimental groups had a higher slaughter yield by 1.6-3.1%. Pigs in the 3 experimental groups had a 15.2% (p≤0.01) lower fat thickness than in control variant. There is a tendency to increase the moisture-bonding ability of pigs of the first experimental group by 1.8% as opposed to the control group. The tendency to a higher content of dry matter by 1.9-5.2% and protein by 1.7-2.2% in the meat of pigs of experimental groups is established.

1. Introduction

To further improve the genetic productivity potential of pigs, it is necessary to move to new theoretical positions based on modern scientific achievements [1].

Currently, the use of biologically active substances of natural origin is increasingly important for increasing the overall resistance of the animal body and normalizing reproductive function [2].

The use of herbs in fattening pigs has a positive effect on the improvement of slaughter qualities and quality of meat, animal health, appetite and use of feed nutrients. The use of carvacrol, capsaicin and zincamaldehyde during the fattening period did not have a significant effect on the slaughter quality of carcasses. However, these supplements reduce lipid metabolism in animals [3].
Nabicate and glauconite supplements, including vitamins, have completely different effects on the growth and development of pigs [4].

Feed additive "Polysol Omega-3" consists of a complex of unsaturated fatty acids and liposomal beta-carotene, hepatoprotector, a complex of spores of bifida and lactic acid bacteria, as well as components of nutrients, enzymes, vitamins and mineral salts. The use of "Omega-3 Active" and "Polysol Omega-3" feed additives in pigs' diets contributes to the optimization of lipid metabolism and metabolic processes in the body, which has a positive effect on their growth, development and early maturity [5].

Vitamin A should come with feed; it forms beta-carotene in the animal's body. Beta-carotene can saturate an animal's body with vitamin A, prevent oxidation, increase animal productivity, vitality, stimulate growth and improve commercial production. Animals' need for vitamins increases during pregnancy, farrowing, lactation, suction and weaning of piglets. The vitamins used are chemically or microbiologically synthesized. Oily solutions are difficult to mix with feed, they quickly oxidize, their shelf life is limited, so the attention of researchers is attracted by dispersed drugs that are easy to set with water or feed. The study of betacinaol and betaviton containing beta-carotene on pregnant and lactating sows and piglets born from them showed that under the influence of the drugs in pregnant sows there is the use of lipids and reserves from the fat as an energy source in the development of the fetus. Betacinaol had a normalizing effect on lactating sows. A feed additive betaviton had a stimulating effect, increasing the level of lipid metabolism. Lipid and carbohydrate metabolism increased in piglets and young animals under the influence of preparations containing beta-carotene [6].

The use of the complex of "LipoCar" + "Oxymethyluracil" preparations with immunomodulating, adaptive, antioxidant effect normalizes the functional activity of endocrine glands, increases metabolism, improves the gastrointestinal tract, which leads to improved growth, development, adaptation, productivity and reproductive properties of animals [7].

At inclusion in the diet of pregnant sows of the vitamin feed additive "LipoCar" in dosages of 1.1 and 2.1 g per head per day the content of vitamin A and carotene in the blood serum was higher than in the animals of the control group by 17.1% (p≤0.01) and 60.3% (p≤0.05), respectively [8].

The aim of our work was to study the fattening, meat quality and the quality of pig meat when using the feed additive "LipoCar" in diets.

The study was aimed at:
1) Determine the effect of the vitamin feed additive on the fattening qualities of young pigs.
2) Examine the meat quality of pigs when including a feed additive in the diet.
3) Identify the impact of the use of sows and the feed additive obtained from them on the quality of pig meat.

2. Materials and methods
Studies were carried out at Linevsky Tribal Farm in the Smolensk District of the Altai Territory in 2015. The scheme of experience is presented in Table 1.

| Group                  | Control variant | 1 experimental                               | 2 experimental                          | 3 experimental                          |
|------------------------|-----------------|----------------------------------------------|-----------------------------------------|-----------------------------------------|
| Sows                   | Basic diet      | "LipoCar" 2.1 g per head per day             | Basic diet                              | "LipoCar" 2.1 g per head per day        |
| The piglets that are   | Basic diet      | Basic diet                                   | Basic diet+ "LipoCar" 0.8 g per head    | OR+ "LipoCar" 0.8 g per head per day   |
| growing                |                 |                                              | per day                                 |                                         |

"LipoCar" feed additive is produced by "Karaton-LAD" organization, St. Petersburg, Russia. It is used as a microencapsulated powder to normalize metabolism, increase resistance and productivity of
livestock, birds and fish. Provides animals with beta-carotene, starts the mechanism of synthesis of vitamins of group B and C, promotes activation of microflora of the gastrointestinal tract. "LipoCar" contains beta-carotene (provitamin A) - 20.0 g/kg, vitamin C (ascorbic acid) - 2.5 g/kg, vitamin E (tocopherol) - 5.0 g/kg, as well as auxiliary components: vegetable phospholipid soya lecithin - 60 g/kg and sugar powder filler - up to 1 kg.

According to the scheme of experience (Table 1), the studies were conducted on pregnant sows (in the last 30 days of pregnancy), and then on piglets obtained from them. Sows of the control group and 2 experimental groups received the main ration of the farm. In addition to the basic diet, sows of 1 and 3 experimental groups were fed a vitamin feed additive at a dosage of 2.1 g per head per day once a day for 20 days. The drug was mixed with food and given to animals in dry form. The second experiment was conducted on young pigs from sows in the first experiment. 4 groups of young pigs were formed for experience. Each group included 8 heads of weaning piglets (4 pigs and 4 boars). The piglets of the control group and 1 experimental group received only the main ration. The animals of the 2 and 3 experimental groups were fed LipoCar in a mixture with dry food in the amount of 0.8 g per head per day for 20 days starting from the age of 60 days. After a break in the use of the drug (10 days) it was given to piglets again for 20 days.

The main diet - mixed fodder used to feed young pigs during the period of growing, included: barley 40%, oats 27%, peas 10%, wheat bran 10%, fishmeal 5%, herbal flour Vico-Oat 5%, chalk fodder 1.5%, salt 0.5%, premix 1%.

2.1. Feeding properties of pigs

During the period of control cultivation, the live weight of young pigs was taken into account and they were individually weighed once a month and the feed eatability was taken into account. On the basis of the obtained results, the average daily increase was calculated and the age of achievement of the live weight of 100 kg was determined.

2.2. Meat properties of pigs

When each animal reaches 100±10 kg live weight, a control slaughter was carried out (4 heads from each group). The following indicators of pig meat quality have been studied: pre-slaughter weight, kg (weighing after 12 hours of hungry aging); weight of paired carcasses (with skin, without head, legs and kidney fat). Before the carcasses were measured, they were placed in a refrigerating chamber at 4°C for 24 hours. The length of the carcasses was measured from the leading edge of the first cervical vertebrae to the bone of the pelvic bones; the thickness of the backbone was measured by a ruler over the 6-7 thoracic vertebrae; the area of the "muscular eye" was determined on the transverse section of the longest back muscle between the first and second lumbar vertebrae.

2.3. Physical and chemical properties and chemical composition of pig meat

Samples of the longest back muscle above the 9-12 thoracic vertebrae were taken. In the muscle tissue the moisture content was studied by drying the hanger to a constant mass in the drying cabinet at the temperature of 103°C; the fat content was determined on the Soxhlet extraction apparatus; the nitrogen and protein content was determined by the Kjeldahl method; the ash content was determined by burning the hangers in the muffle furnace at the temperature of 500°C. Moisture binding capacity of muscle tissue was studied by the press method according to R. Grau and R. Hamm, the pH value of the meat was set using the potentiometric method using the pH meter "Anion-7000".

3. Results and Discussion

3.1. Feeding properties of pigs

The results of live weight studies of young pigs are presented in Table 2.
### Table 2. Living weight of young pigs

| Group         | Living weight at the age of 3 months (kg) ± SD | Living weight at the age of 4 months (kg) ± SD | Living weight at the age of 5 months (kg) ± SD | Living weight at the age of 6 months (kg) ± SD |
|---------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| control group | 30.8±0.73                                     | 46.2±1.16                                     | 66.8±1.12                                     | 89.7±1.92                                     |
| 1 experimental| 30.3±2.20                                     | 46.1±2.44                                     | 68.8±2.20                                     | 94.7±2.83                                     |
| 2 experimental| 31.1±0.48                                     | 46.9±0.72                                     | 70.0±0.81 **                                  | 93.4±1.12 **                                 |
| 3 experimental| 32.1±2.45                                     | 49.2±2.24                                     | 73.1±1.54 ***                                | 100.2±0.98 ***; 3*                           |

*1 - in comparison with the control group, ** - in comparison with 2 experimental groups, the difference is reliable:* * - p≤0.05, ** - p≤0.01, *** - p≤0.001.

At the age of 5 and 6 months, piglets of the first experimental group tended to have a higher live weight by 3.0-5.6%, as opposed to control ones (Table 2). Piglets in 2 experimental groups at 5 and 6 months of age were 4.8% (p≤0.05) and 7.5% (p≤0.05) ahead of control group analogues by live weight, respectively.

At the age of 5 and 6 months, the young pigs of the 3 experimental groups had an advantage over their peers in the control group by live weight by 9.4% (p≤0.01) and 11.7% (p≤0.001), respectively.

### Table 3. Average daily live weight gains of young pigs

| Group         | Average daily increase in the age of 2-3 months (d) ± SD | Average daily increase in the age of 3-4 months (d) ± SD | Average daily increase in the age of 4-5 months (d) ± SD | Average daily increase in the age of 5-6 months (d) ± SD |
|---------------|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|
| control group | 395.4±17.34                                              | 512.5±25.14                                              | 687.5±13.36                                              | 762.5±54.06                                              |
| 1 experimental| 400.0±61.35                                              | 525.0±35.48                                              | 758.3±23.08 **                                           | 862.5±50.14                                              |
| 2 experimental| 412.5±18.97                                              | 525.0±31.41                                              | 770.4±8.40 ***                                           | 879.2±20.13                                              |
| 3 experimental| 408.8±49.23                                              | 570.8±15.70                                              | 795.8±44.89 1**                                          | 904.2±20.69 1**                                          |

*1 - compared to the control group, the difference is significant: * - p≤0.05, ** - p≤0.01, *** - p≤0.001.

In animals of 1, 2 and 3 experimental groups aged 4 to 5 months, the average daily gain was higher than in control peers by 10.3% (p≤0.05), 12.1% (p≤0.001) and 15.8% (p≤0.05), respectively (Table 3). At the age of 5 to 6 months, pigs in the 3 groups had 18.6% (p≤0.05) higher average daily gains than the control animals. Individuals of 1 and 2 experimental groups had a tendency to higher average daily growth with a difference in relation to the analogues of the control group by 13.1-15.3%. In general, higher average daily increases were typical for animals of groups 2 and 3. The results show that the feed additive "LipoCar" provides optimal intake of vitamins into the body of young pigs, which have a positive effect on their exchange by improving digestion and digestion of incoming feed.

### Table 4. Feeding qualities of young pigs

| Group        | Age at which the live weight of 100 kg (days) ± SD | Feed costs per 1 kg of live weight gain (kg) ± SD |
|--------------|--------------------------------------------------|--------------------------------------------------|
| control group| 195.0±3.75                                       | 3.76±0.17                                        |
| 1 experimental| 187.0±3.50                                      | 3.60±0.21                                        |
| 2 experimental| 184.3±1.37 *                                   | 3.46±0.23                                        |
| 3 experimental| 179.6±1.06 **; 3*                              | 3.39±0.20                                        |

*1 - in comparison with the control group, ** - in comparison with 2 experimental groups, the difference is reliable: * - p≤0.05, ** - p≤0.01, *** - p≤0.001.
Individuals of 1 experimental group reached slaughter conditions more quickly by 8 days (4.1%) and spent less forage per 1 kg of live weight gain by 4.3% than representatives of the control group (Table 4). Young adults in the 2 experimental groups were more mature for 10.7 days (5.5%, p≤0.05) and were better paid by 8.0% live weight gain compared to control. The piglets of the 3 experimental groups reached a live weight of 100 kg faster than those of the control groups and 2 experimental groups by 7.9% (p≤0.01) and 2.6% (p≤0.05), respectively. They also had the lowest feed consumption per 1 kg of live weight gain (3.39 kg), which was 2.0-9.8% lower than in the animals of other groups under study.

3.2. Meat properties of pigs

The results of pig meat quality studies are presented in Table 5.

| Group          | Slaughter output (%) ± SD | Carcass length (cm) ± SD | Muscle peephole area (cm²) ± SD | Square of "muscle eye" (cm²) ± SD |
|----------------|---------------------------|--------------------------|--------------------------------|----------------------------------|
| control group  | 68.7±2.77                 | 97.8±0.97                | 32.3±2.35                      | 26.3±0.84                        |
| 1 experimental | 70.3±1.48                 | 97.3±4.91                | 36.5±1.26                      | 26.1±0.51                        |
| 2 experimental | 71.3±1.21                 | 96.9±1.10                | 35.1±3.41                      | 25.1±0.84                        |
| 3 experimental | 71.8±1.06                 | 97.11±4.37               | 31.4±3.22                      | 22.3±0.98                        |

1 - compared to the control group, the difference is significant: **- p≤0.01.

As a result of researches it is established (tab. 5) that application of the vitamin fodder additive in a diet of pigs of experimental groups promoted increase in their slaughtering yield on 1.6-3.1 %. In the 1 and 2 experimental groups, the area of the "muscle eye" was the largest and deviated by 8.7-13.0% from the considered indicator of the control group animals. In pigs of the second experimental group the tendency to decrease the thickness of fat by 3.8-4.6% was observed in contrast to the animals of the control and the first experimental groups. The thinnest fat layer were in animals of 3 experimental groups, which was less than in pigs of 1 experimental group, 2 experimental groups and control groups by 14.6%, 11.2% and 15.2% (p≤0.01), respectively.

Similar results of increase of pigs meat productivity are received at use of fodder additives "Tetra+" and "Glimalask" in diets of fattening pigs. Young pigs of experimental groups exceeded the control group by weight of chilled carcasses by 5.58 and 3.11 kg, by meat yield by 1.39 and 0.82%, by meat index by 0.18 and 0.07% [9].

3.3. Physical and chemical properties and chemical composition of pig meat

The main nutritional value of meat is the muscle tissue, which is the richest in proteins and contains a sufficient amount of amino acids. The results of the physical and chemical analysis of meat (colour, acidity, moisture retention capacity) give a more complete picture of the quality of pork and depend on various factors [10].

The results of studies of physical and chemical parameters of pig muscle tissue are presented in Table 6. Our studies do not show any reliable differences in the quality of meat in animals of control and experimental groups. It is necessary to note a tendency to decrease pH of meat in pigs of experimental groups by 2.1-3.8%. The acidity of meat in all groups of young animals met the technological requirements for good quality meat (5.60-5.75).

Pigs with pH values below 5.2 are known to be pale, flabby and watery (PSE) with a loose consistency. Meat from pigs with pH greater than 6.2 dark, coarse and dry (DFD) with coarse fiber and sticky [11].

In our studies, there were no defects in the quality of pork when using the feed additive. At the same time, there was a tendency to increase the moisture-bonding capacity of muscle tissue (as a percentage of total moisture) in pigs of the experimental group 1 by 1.8% as opposed to control.
Table 6. Physico-chemical indicators of the quality of pig muscle tissue

| Group            | pH (acidity units) ± SD | Dehumidifying capacity (% to meat suspension) ± SD | Dehumidifying capacity (% of total moisture) ± SD |
|------------------|-------------------------|---------------------------------------------------|--------------------------------------------------|
| control group    | 5.75±0.204              | 64.52±0.977                                       | 85.71±1.384                                       |
| 1 experimental   | 5.53±0.146              | 62.32±2.010                                       | 87.52±1.390                                       |
| 2 experimental   | 5.63±0.226              | 62.18±3.338                                       | 84.97±5.330                                       |
| 3 experimental   | 5.60±0.224              | 61.45±1.089                                       | 85.47±1.709                                       |

The results of studies of the chemical composition of pig muscle tissue are presented in Table 7.

Table 7. Chemical composition of pig muscle tissue

| Group            | Total moisture (%) ± SD | Protein (%) ± SD | Fat (%) ± SD | Ash (%) ± SD                     |
|------------------|-------------------------|------------------|--------------|----------------------------------|
| control group    | 75.28±0.243             | 19.61±0.237      | 3.98±0.329   | 1.13±0.059                       |
| 1 experimental   | 71.28±2.036             | 21.63±0.303      | 5.69±2.133   | 1.40±0.040                       |
| 2 experimental   | 73.35±1.398             | 21.29±0.744      | 4.15±1.886   | 1.21±0.177                       |
| 3 experimental   | 70.10±3.969             | 21.80±0.829      | 6.66±3.689   | 1.44±0.058                       |

Meat of experimental groups is characterized by higher concentration of dry matter and protein by 1.9-5.2% and 1.7-2.2%, respectively (Table 7). Pigs in groups 1 and 3 were 1.7 and 2.7% higher than the control pigs in terms of fat content in meat and 0.3% higher in terms of ash content. In general, pig meat of experimental groups was characterized by higher caloric value by 7.2-28.8%.

Similar results were obtained in studies by Manokhin A.A., Reznichenko L.V. and Noskov S.B. (2017). In the piglet meat of experimental groups receiving vitamin-enzyme complex, the dry matter content in the meat was 2.0-1.2% higher than in the control. The use of vitamin-enzyme complexes in piglets' diets has led to the improvement of the chemical composition of meat and its taste properties in most cases [12].

In Volynkina M.G. research. (2016) the use of a protein-vitamin-mineral supplement in the diet of experimental pigs led to the optimization of metabolic processes, increased dry matter content, caloric content and moisture retention of meat, but reduced the pH of meat. Meat of experimental groups was more suitable for technological processing, which is connected with high quality of received production [13].

When Tetra+™ and "Glimalask" feed additives were used in fattening pigs, in the meat of young pigs of experimental groups, in comparison with the control group, the content of dry matter was higher by 0.88 and 0.72%, protein - by 0.78 and 0.58%, fat - by 0.08 and 0.11% [9].

4. Conclusion

The use of LipoCar feed additive had a more significant impact on animals of groups 2 and 3, which exceeded the control group's live weight and average daily gain by 4.8-11.7% (p≤0.05-0.001) and 15.3-18.6% (p≤0.01), respectively, in terms of live weight and average daily gain of the control group's peers in 5 and 6 months of age.

The use of vitamin feed additive contributed to faster achievement of 100 kg live weight by 5.5-7.9% (p≤0.05-0.01) by animals of 2 and 3 experimental groups and reduction of feed costs by 8.0-9.8% compared to the control group piglets.

The application of the drug under study resulted in a 15.2% reduction in the thickness of the fat in pigs of the third experimental group (p≤0.01) in comparison with the control group. There is a tendency to increase the slaughter yield in all experimental groups by 1.6-3.1%. It was determined that there is a tendency to a larger area of "muscle eye" in pigs of 1 and 2 experimental groups by 8.7-13.0%.
The pH of the pigs in the experimental groups tends to decrease by 2.1-3.8%. The moisture binding capacity of pig meat of the first experimental group was 1.8% higher than that of the control analogues. In experimental animals, the concentration of dry matter in the meat was higher by 1.9-5.2% and the protein content by 1.7-2.2%. Pigs in groups 1 and 3 were 1.7-2.7% fat and 0.3% more fat and 0.3% ash than the control group. The muscle tissue of pigs of experimental groups was characterized by higher caloric value by 7.2-28.8%.

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References
[1] Bekenev V A 2018 Ways to improve the gene pool of pigs of the Russian Federation Vavilov J. of Genetics and Breeding 22 (8) 912-21
[2] Narizhny A G, Anisimov A G and Dzhamoldinov A Ch 2015 Improving the reproductive characteristics of boars with introduction of biologically active substances to their diet Vestnik of Ulyanovsk State Agricultural Academy 1 (29) 77-80
[3] Kołodziej-Skalska A, Jacyno E, Plonka A, Pietruszka A, Matysiak B and KaweckaM 2014 The effect of active plant substances supplementation on fattening and slaughter performance and blood serum biochemical parameters in pigs Acta Sci.Pol., Zootechnica 13 (3) 67-74
[4] Bochkarev A K 2017 Efficiency of fodder additive "Nabikat" application in feeding of pregnant sows International research journal 11 (65) 107-10
[5] Semyonova Y V, Ulitko V E and Maslova T A 2016 Optimization of pigs lipid metabolism by using in its diets feed additives Vestnik of Ulyanovsk State Agricultural Academy 1 (33) 128-31
[6] Lyubin N A, Provorov A S, Provorova N A and Dezhatkina S V 2013 Change of indicators of lipid-carbohydrate metabolism in pigs while using beta-carotene preparation Bulletin of Ulyanovsk State Agrarian Academy 3 (23) 80-86
[7] Afanasyeva A I, Butz N Yu, Vasilkov A O 2016 The growth and development of young animals of hereford cattle of finnish breeding in the Altai region when using Lipokar and Oxymethyluracyl Bulletin of Altai state agricultural university 6 (140) 92-96
[8] Burtseva S V and Pushkarev I A 2015 The effect of liposomal form of vitamin A and beta-carotene on biochemical and morphological blood indices of pigs Bulletin of Altai State Agricultural University 8 (130) 99-103
[9] Serdyukova Y A 2016 Formation of meat productivity of pigs while insertion of feed additives «Tetra +» and «Glimalask» in the diet Vestnik of Ulyanovsk State Agricultural Academy 1 (33) 132-35
[10] Kosko I S 2016 Quality of meat and lard of hybrid young pigs Zootecniche Science of Belarus 51 98-104
[11] Poznyakovskiy V M, Corlov I F, Tikhonov S Land Shelepov V G 2015 About the quality of meat with pse and dfd properties Foods and Raw Materials 3 104-10
[12] Manokhin A A, Reznichenko L V and Noskov S B 2017 The influence of vitamin-enzymatic complex on pork quality Innovations in Agricultural Complex: problems and perspectives 4 (16) 130-33
[13] Volynkina M G 2016 The influence of protein-vitamin-mineral concentrate (PVMC) in diets of pigs on meat quality Russian Agricultural Policy 11 (59) 40-43