The scientific and practical rationale for the inclusion of enzyme preparations in the feed of young pigs

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Abstract. Studies on growing young pigs for rearing and fattening using a mixture of enzyme preparations were carried out on animals aged 2 to 7 months in the dynamics of their growth and development. The animals receiving compound feed used in the economy served as control. The compound feed of the first experimental group was enriched with a mixture of additional enzyme preparations amylosubtilin G3x and cellolux-F, and the second experimental group – a mixture of amylosubtilin G3x and protosubtilin G3x. The use of a mixture of amylosubtilin G3x and cellolux-F increases the average daily growth by 13.6 %, reduces feed costs by 11.8 % compared to the control group's pigs, a mixture of amylosubtilin G3x and protosubtilin G3x - an average daily increase of 8.7 %, a decrease in feed costs by 7.9 % compared to the control group's pigs. The highest content of muscle tissue in the half-carcasses was observed in animals in the first experimental group (58.5 %) and in the second experimental group (58.17 %), which is higher in the control group by 0.93 and 0.6, respectively. The results of research in the technology of pork production reveal new possibilities of using a mixture of enzyme preparations.

1. Introduction

The world experience of animal husbandry shows that full-fledged feeding is the basis for the manifestation of the genetic potential of animal productivity and effective conversion of feed nutrients into animal products [1, 2].

The main way to increase meat resources is the accelerated growth of pork production. To this end, it is necessary to organize a full and balanced feeding, which will significantly increase the productivity of animals and contributes to the better manifestation of their genetic potential and improve product quality [3-6].

It is revealed and established that animal diets are deficient in protein and mineral substances, which leads to a deterioration in the reproduction of the herd, reducing the volume of livestock products, reducing the level of profitability of production. Along with the strengthening of the forage base and its expansion at the expense of traditional types of feed, there is a need to use non-traditional feed products containing protein, other nutrients and mineral elements in animal feeding [4, 5].

At the same time, the practical application of new sources of protein, especially unconventional feed, minerals, vitamins, probiotics and enzyme preparations has so far received insufficient attention, although numerous studies have proven zootechnical feasibility and economic efficiency of the use of these substances in the feeding of farm animals [7-9].
Enzymes increase the digestibility of hard-to-digest cereals, why their feed value even exceeds the value of easily digestible cereals. At the same time, for feed producers, this action of enzymes allows to reduce the difference between good and bad batches of cereals, in addition, the nutrient content of cereals with the addition of enzymes is higher than without addition, as a result of which the nutritional value of the diet increases. Enzymes break down NSPs, reduce intestinal viscosity, and subsequently improve nutrient uptake by improving bowel function [10, 11]. Enzymes cause disruption of the integrity of the plant cell wall and, as a consequence, release of nutrients encapsulated by the cell wall [12]. Similar results were obtained by other authors [13, 14].

The use of enzyme technologies is the main justification for improving the nutritional value of feed [15].

In this regard, studies on the effect of a mixture of enzyme preparations of domestic production of amylosubtilin G3x, cellolux –F and protosubtilin G3x in the cultivation of young pigs are very relevant and of scientific and practical interest [16-18].

The aim of the research is the theoretical and practical justification of increasing pork production by introducing a mixture of enzyme preparations of domestic production of amylosubtilin G3x and cellolux-F, amylosubtilin G3x and protosubtilin G3x into the feed for young pigs.

2. Materials and methods

Experimental studies on the rearing and fattening of young pigs were carried out on young pigs of large white breed at the age of 2 to 7 months in a pig farm Yalchiksky district of the Chuvash Republic. The effectiveness of feeding a mixture of enzyme preparations amylosubtilin G3x and cellolux-F, as well as amylosubtilin G3x and protosubtilin G3x was studied.

Pigs of all groups were in the same conditions of feeding and keeping, and they were fed feed in accordance with the detailed feeding standards. The animals receiving compound feed used in the economy at the feeding of young pigs served as control. The compound feed of the first experimental group was enriched with a mixture of additional enzyme preparations amylosubtilin G3x and cellolux-F, the second experimental group – a mixture of amylosubtilin G3x and protosubtilin G3x. The control group of pigs was on the economic diet: 45% barley, 40% wheat, 5% sunflower meal, 5% corn, 5% protein vitamin-mineral concentrate. Nutrients in the preparation of compound feeds were normalized taking into account age, live weight, and average daily live weight gain.

The feed was taken into account the total nutritional value, amount of protein, mineral content, fiber, vitamins. According to the content of energy, nutrients, macro- and microelements, vitamins of compound feed, the needs of animals in these nutrients were met. The duration of experiment was 150 days.

Amylosubtilin G3x is a bacterial enzyme preparation of hydrolytic action, produced by the strain Bacillus subtilis. Contains in its composition a complex of amylolytic enzymes, as well as related enzymes: β-glucanase, xylanase, glucoamylase, protease.

The main enzyme amylosubtilin - α-amylase with endogenous mechanism of action catalyzes the hydrolysis of α-1,4-glycoside bonds of starch, which leads to a rapid decrease in the viscosity of gelatinized starch solutions. The final products of the action of bacterial α-amylase on starch are low molecular weight soluble dextrins with a low content of mono- and disaccharides (glucose and maltose).

Due to the complex effects of amylosubtilin enzymes, there is a stepwise splitting of native forms of plant feed.

The general effect of amylosubtilin is associated with the combined effect of all the enzymes included in the preparation, including beta-glucanase, xylanase, and cellulase, catalyzing the cleavage of hard-to-digest polysaccharides of barley, wheat and rye, hydrolysis of which gives an additional amount of sugars.

Cellolux-F - multi-enzyme product of new generation, balanced xylanases, β-glucanases and cellulose activities. The enzyme complex provides stepwise cleavage of cellulose, xylans, β-glucans of plant cells. Increased availability of protein, starch, fat for the effects of digestive tract enzymes,
improved digestibility of feed and absorption of nutrients in the small intestine. The intestinal microbiological environment is improved by reducing viscosity and increasing the level of monosaccharides.

Control over the growth of piglets was carried out by means of individual control monthly weighing and calculations of absolute and average daily weight gain. The dynamics of changes in live weight of young pigs was established by individual weighing at the beginning and at the end of the experiment. The growth rate was characterized by absolute and relative indicators. The absolute gain for the entire experiment was calculated by subtracting the live weight at the end and at the beginning of the growing period. The average daily gain was estimated as the absolute increase in live weight in one day.

The development of animals, except the determination of live weight, was evaluated from the measurements. Measurements were taken of the length of the torso, chest girth behind the shoulder blades, height at the withers, chest width, the girth of the heel. The length of the torso is measured with a measuring tape from the occipital crest to the root of the tail at the moment when the pig's head is raised from the ground, and the lower line of the trunk is horizontal. The chest girth behind the shoulder blades is measured with a measuring tape along an imaginary plane perpendicular to the body, tangent to the rear corners of the blades. The height at the withers is determined by a measuring stick at the highest point of the withers at the moment of calm standing of the animal on a flat plane. The chest width behind the shoulder blades is measured with a measuring stick between the outer mounds of the shoulder joints. The girth of the heel is measured with a measuring tape at the lower end of the upper third of the pastern.

In order to study the slaughter and meat qualities, the development of the internal organs of experimental animals, a controlled slaughter was conducted at the end of the scientific and economic experiment. For the controlled slaughter 3 heads (young gelded pigs) from each group were selected, characterized by the average values of their live weight. At the same time, the removable live weight and the pre-slaughter mass were taken into account, after a 12-hour fasting period, to which all subsequent calculations of outputs were carried out.

During the controlled slaughter, the pre-slaughter live weight, the mass of the steam carcass, the mass of the cooled carcass, the mass of the lungs, heart, liver, kidneys, spleen, as well as the slaughter yield were taken into account.

The thickness of the fat was determined by measuring, the area of the "muscular eye". The area of the "muscular eye" was determined between the last thoracic and first lumbar vertebrae by transferring the contours of the "muscular eye" to the tracing paper and the subsequent measurement with a polar planimeter, and the thickness of the fat was measured with a metal ruler over 6-7 thoracic vertebrae.

3. Research results

Successful rearing and fattening are determined, first of all, by the quality of young animals, the conditions of keeping and feeding, the breed of animals. The comparative test of fattening and meat qualities of animals in the same conditions of the maintenance allows estimating the considered signs more precisely.

When studying the growth and development of pigs, the most interesting for the study is the dynamics of live weight – a generally recognized complex indicator characterizing the development of the body during ontogenesis.

At the beginning of the experiment, in all groups, the average live weight of the pigs was almost the same and ranged from 17.8 to 18.1 kg. During the experiment, a certain discrepancy was observed on this indicator between groups (table 1).
Table 1. Dynamics of body weight and average daily gain of test pigs.

| Group       | Live weight, kg | Average daily gain, g |
|-------------|-----------------|-----------------------|
|             | 60-90 days      |                       |
| control     | 17.8±0.6        | 31.3±0.6              |
| I experimental | 18.1±0.8    | 33.3±1.6              |
| II experimental | 17.9±0.6   | 32.5±1.0              |
|             | 91-120 days     |                       |
| control     | 31.3±0.6        | 46.1±0.74             |
| I experimental | 33.3±1.6    | 50.1±0.81*            |
| II experimental | 32.5±1.0   | 48.7±0.65*            |
|             | 121-150 days    |                       |
| control     | 46.1±0.74       | 65.9±0.53             |
| I experimental | 50.1±0.81*   | 73.6±0.64*            |
| II experimental | 48.7±0.65*  | 70.8±0.57*            |
|             | 151-180 days    |                       |
| control     | 65.9±0.53       | 88.1±1.66             |
| I experimental | 73.6±0.64*   | 100.1±1.68*           |
| II experimental | 70.8±0.57*  | 96.3±1.65*            |
|             | 181-210 days    |                       |
| control     | 88.1±1.66       | 112.0±1.8             |
| I experimental | 100.1±1.68*  | 125.1±1.49*           |
| II experimental | 96.3±1.65*  | 120.3±1.94*           |

There was a positive effect of the mixture of enzyme preparations on the dynamics of live weight gain (figure 1).

Figure 1. Changes in live weight of experimental animals, kg.

Thus, for the period of 60-90 days, the live weight of pigs of the first experimental group was higher by 6.4 %, from 91-120 days – by 8.7 %, from 121-150 days – by 11.7 %, from 151-180 days – by 13.6 %, from 181-210 days – by 11.7 %, than in the control group. The second experimental group was also ahead of the control group, respectively: over a period of 60-90 days – 3.8 %, 91-120 days – 5.6 % 121-150 days – 7.4 % 151-180 days – by 9.3% and with day 181-210 of 7.4 %. The difference between the first and second experimental groups was respectively for the period of 60-90 days – by 2.5 %, from 91-120 days – by 2.9 %, from 121-150 days – by 4.0 %, from 151-180 days – by 4.0 % and from 181-210 days – 4.0 % in favor of the first experimental group. In the period from 60-120 days, the live weight of experimental animals of the first experimental group exceeded the indicators
in the control group by 13.1 %, from 121-210 days – by 13.8 %; in the second experimental group respectively – by 8.8 % and 8.6 %.

Table 2 presents the data on changes in body weight and average daily gain in groups for the entire period of scientific and economic experiment. The average daily gain for the entire accounting period was: in the control group 627.8 g; in the first experimental group – 713.3 g; in the second experimental group – 682.7 g. Thus, as a result of the experiment, the average daily gain was higher in the first experimental group by 13.6 % (P<0.05), and in the second experimental group by 8.7 % than in the control group. And the difference between the first and second experimental groups was 4.48 % in favor of the first experimental group. The absolute increase in the control group was 94.2 kg, in the first experimental group this figure was higher by 12.8 kg and in the second experimental group – by 8.2 kg. The difference between the first and second experimental groups was 4.6 kg.

**Table 2. Dynamics of live weight gain and average daily growth of experimental animals.**

| Indicators | Control | Group I experimental | Group II experimental |
|------------|---------|----------------------|-----------------------|
| Average live weight of 1 head, kg: | | | |
| at the beginning of the experiment | 17.8±0.6 | 18.1±0.8 | 17.9±0.6 |
| at the end of the experiment | 112.0±1.8 | 125.1±1.49* | 120.3±1.94* |
| The absolute gain in live weight of 1 head, kg | 94.2 | 107.0 | 102.4 |
| The average daily gain for the period of the experiment, g | 627.8±20.3 | 713.3±27.5* | 682.7±22.4 |
| % over control | 100 | 113.6 | 108.7 |
| The age of reaching live weight 100 kg, days | 191 | 175 | 180 |

*P<0.05

Studying the dynamics of live weight of young pigs found that, in general, for the experiment, the absolute gain in live weight of piglets from the experimental groups was 107 and 102.4 kg, respectively, against 94.2 kg in the control group, respectively, by 12.8 and 8.2 kg or by 13.6 and 8.7% more compared with the control group.

The development of animals, in addition to determining by live weight, was also evaluated by exterior measurements. The results of the studies are presented in table 3. Against the background of the use of a mixture of enzymatic preparations, the body length index of pigs in the experimental groups, compared with the control group, was higher by an average of 4.5 cm in the first experimental group and 1.8 cm in the second experimental group.

**Table 3. Exterior measurements of pigs.**

| Indicators | Group | |
|------------|-------|----------|----------|
| Body length, cm | Control | Group I experimental | Group II experimental |
| Chest girth, cm | 116.8±1.43 | 121.3±1.39* | 118.6±1.44* |
| Height at withers, cm | 113.4±1.32 | 118.3±1.32* | 115.9±1.58* |
| Girth of pastern, cm | 65.5±0.57 | 68.1±0.28* | 66.8±0.60 |
| Girth of pastern, cm | 17.6±0.12 | 17.8±0.14 | 17.6±0.09 |

*P<0.05

Similar natural changes were observed in experimental animals and other exterior indicators. Thus, breast girth in experimental animals of the first group, in relation to control peers, was higher by 4.9 cm, in the second experimental group – by 2.5 cm; height at the withers – by 2.6 and 1.3 cm; girth of the pastern – by 0.2 cm, respectively.
As can be seen from the presented data, the exterior indicators in experimental animals of experimental groups characterizing the degree of intensity of animal growth, against the background of the mixture of enzyme preparations amylosubtiline G3x and celloluxe-F were slightly higher in the first experimental group than in the second experimental group, where a mixture of enzyme preparations amylosubtiline G3x and protosubtiline G3x was used when feeding young pigs.

Thus, the tested mixtures of enzyme preparations had a positive impact on the development of young pigs, which is confirmed by a significant increase in exterior performance in experimental animals.

In assessing any of the studied factors of feeding should pay attention not only to its impact on the quantity but also the quality of the products. In pig breeding, the main indicators are slaughter yield, the morphological composition of carcasses. Therefore, it is important to determine the effect of feeding diets with mixtures of enzyme preparations on the meat-sebaceous productivity of experimental animals. The dynamics of the formation of meat efficiency of hog pigs in groups was determined by the method of control slaughter at the end of fattening. The results of the controlled slaughter are shown in table 4.

### Table 4. Results of control slaughter of experimental animals.

| Indicators                     | Control          | I experimental | II experimental |
|-------------------------------|------------------|----------------|-----------------|
| Pre-slaughter live weight, kg | 111.7±0.58       | 123.0±0.58*    | 116.0±1.00*     |
| The steam mass carcass, kg    | 74.2±0.24        | 82.8±0.20*     | 77.6±0.22*      |
| Carcass weight after cooling, kg | 72.7±0.5        | 81.4±0.18*     | 76.1±0.85*      |
| Slaughter yield, %            | 65.1±0.24        | 66.2±0.18*     | 65.6±0.17       |
| The composition of the carcasses, % | 57.56±0.12     | 58.5±0.23*    | 58.17±0.19      |
| muscle tissue                 | 29.87±0.15       | 29.37±0.18     | 29.43±0.12      |
| adipose tissue                | 12.57±0.03       | 12.13±0.24     | 12.4±0.15       |
| bone tissue                   | 33.6±0.53        | 32.9±0.31      | 33.67±0.29      |
| Backfat thickness, mm         | 31.33±0.19       | 31.67±0.32*    | 31.53±0.07*     |

*P<0.05

One of the most important indicators characterizing the results of fattening pigs is slaughter yield, which is defined as the percentage of slaughter weight to pre-slaughter. The data in the table 4 show that there was no significant difference in slaughter yield between the groups, and it ranged from 65.1 to 66.2%.

The highest content of muscle tissue in the half-carcasses was observed in animals in the first experimental group (58.5%) and in the second experimental group (58.17%), which is higher in the control group by 0.93 and 0.6, respectively. The lowest thickness of lard was in experimental animals of the first experimental group of 32.9 mm, and in the control and second experimental group was almost the same – 33.6 mm. The area of the "muscle eye" was higher in the first experimental group (31.67 cm²), which is 0.34 cm² more than in the control group and 0.14 cm² more than in the second experimental group.

Consequently, feeding a mixture of enzyme preparations of amylosubtiline G3x and celloluxe-F, amylosubtiline G3x and protosubtiline G3x in the diet of experimental animals, compared with the control group, had a positive effect on meat-sebaceous productivity and muscle tissue development.

During the control slaughter, the internal organs of the animals were weighed. The data obtained are given in table 5.

The development of internal organs in pigs of all groups differed from each other. The weight of kidneys ranged from 307 to 315 g, spleen – from 212 to 219 g, liver – from 1.699 to 1.711 kg, heart – from 330 to 339 g, lungs – from 871 to 905 g.
Table 5. The ratio of the mass of the internal organs of experimental animals to the pre-slaughter body weight, %.

| Bodies      | Control | I experimental | II experimental |
|-------------|---------|----------------|-----------------|
|             | Weight, kg | %     | Weight, kg | %     | Weight, kg | %     |
| Kidneys     | 0.307±2.89 | 0.27  | 0.315±2.09 | 0.27  | 0.310±0.73 | 0.27  |
| Spleen      | 0.212±3.12 | 0.19  | 0.215±1.39 | 0.17  | 0.219±2.09 | 0.19  |
| Liver       | 1.704±11.33 | 1.51  | 1.699*±1.11 | 1.38  | 1.711*±3.48 | 1.48  |
| Heart       | 0.330±1.27 | 0.29  | 0.339*±1.82 | 0.28  | 0.335±3.42 | 0.29  |
| Lungs       | 0.871±1.54 | 0.78  | 0.883*±1.69 | 0.72  | 0.905*±1.00 | 0.78  |

*P<0.05

Research has shown that feeding a mixture of enzyme preparations amylolubtline G3x and cellolux -F in the diet of experimental animals had a positive effect on the development of the liver, heart, lungs, spleen, and kidneys.

Consequently, the use of a mixture of enzyme preparations of amylolubtline G3x and cellolux-F, amylolubtline G3x and protolubtline G3x in the diet of fattened pigs does not significantly affect the meat productivity of pigs, as well as the development of internal organs of experimental animals.

Currently, the efficiency of agricultural production is determined primarily by the economic effect of its implementation.

Feeding well-balanced diets for all nutrients using high-quality feed contributes to their rational use, increase metabolism in animals. This in turn has a positive impact on their productive qualities. With the improvement of production indicators, production costs are reduced.

The economic efficiency of inclusion in the diet of a mixture of enzyme preparations should be calculated through the main economic indicators. First of all, it is the consumption of feed for the formation of a unit of production and increase the profitability of livestock production, as well as obtaining an additional increase by one ruble of costs. Therefore, for a more complete assessment of the effectiveness of the use of a mixture of enzyme preparations amylolubtline G3x and cellolux -F, amylolubtline G3x and protolubtline G3x as part of the diet of young pigs, we calculated the economic efficiency.

The main indicators of the effective use of a mixture of enzyme preparations are given in table 6.

Table 6. Economic efficiency of using a mixture of enzyme preparations in animal feed.

| Indicators                        | Control | I experimental | II experimental |
|-----------------------------------|---------|----------------|-----------------|
| Live weight, kg                   |         |                |                 |
| at the beginning of the experiment| 17.8    | 18.1           | 17.9            |
| at the end of the experiment      | 112.0   | 125.1          | 120.3           |
| Live weight gain, kg              | 94.2    | 107.0          | 102.4           |
| Average daily gain, g             | 627.8   | 713.3          | 682.7           |
| The additional gain, kg           | ―       | 12.8           | 8.2             |
| Spent feed per 1 kg of gain:      |         |                |                 |
| EFU                               | 4.82    | 4.25           | 4.44            |
| The cost of the spent drug on 1 head for the accounting period, rub. | ― | 154.43 | 135.27 |
| Sale price 1 kg of live weight, rub. | ― | 100 | 100 |
| The cost of additional products, rub. | ― | 1280 | 820 |
| Products received for 1 RUB of additional costs, rub. | ― | 8.29 | 6.06 |
During the scientific and economic experiment, the farm sold its products at a price of 100 rubles per kg of live weight. As it was found, experimental animals of experimental groups had a higher growth rate and therefore a large absolute increase. As a result, the sale of one animal provided additional revenue in the amount of 1280 and 820 rubles, respectively, in the first and second experimental groups.

There were received products for 1 ruble of additional costs in the first experimental group for 8.29 rubles and at 6.06 rubles in the second experimental group.

On the basis of the results of studies, it can be concluded that the use of a mixture of enzyme preparations amylosubtiline G3x and celloluxe -F, amylosubtiline G3x and protosubtiline G3x in the feeding of young pigs is economically justified.

Thus, a comparative study of the use of a mixture of enzyme preparations when feeding pigs showed that the best economic indicators are obtained in animals, when feeding them a mixture of enzyme preparations of amylosubtiline G3x and celloluxe -F.

4. Conclusion
Feeding a mixture of enzyme preparations amylosubtiline G3x and celloluxe -F, amylosubtiline G3x and protosubtiline G3x in the compound feed contributes to an effective increase in live weight, average daily gains, meat productivity compared to the control group. In the technology of pork production in order to increase the productive action of animal feed for young pigs for rearing and fattening and more complete realization of the genetic potential of productivity, it is advisable to use in their composition a mixture of enzyme preparations of domestic production of amylosubtiline G3x and cellolux-F, amylosubtiline G3x and protosubtiline G3x. In this case, preference should be given to a mixture of amylosubtiline G3x and celloluxe -F.

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