Rational feeding as the basis for the efficiency of pork production (on the example of the Krasnoyarsk Territory)

N I Pyzhikova, A N Lazarevich, Yu I Koloskova and E Yu Vlasova
Krasnoyarsk State Agrarian University, Krasnoyarsk, Russia

E-mail: pyzhikova@kgau.ru

Abstract. Modern technologies in pig breeding allow in a short time not only to quantitatively increase the volume of domestic pork production, but also to significantly reduce its cost. The profitability of fattening pigs depends on the value of the average daily gain and the cost of feed for the increase in live weight and the quality of the carcass. These indicators are associated with the genetic characteristics of animals, the composition and amount of feed they consume. Lack of feed and imbalance in diets leads to a decrease in the productivity of animals, therefore, their genetic potential is used in farms only by 60-70% of the possible. Feeding costs account for up to 60% of the total cost of pork production. Fodder production is the main area of innovative activity in animal husbandry, which determines the efficiency of pork production today. The efficiency of feeding is determined primarily by the cost of feed per unit of production. All other things being equal, a better feed payment rate always corresponds to a lower production cost. The use of the technology proposed by the authors allows to reduce the cost of feed in the cost of 1 ton of pig meat by 7.3-12.0%, as a result, to reduce the production cost of manufactured products by 15.5-25.5%.

1. Introduction
The production of livestock products depends primarily on the level of provision of livestock enterprises with feed of appropriate quality, since lack of feed and imbalance in diets lead to a decrease in the productivity of farm animals, while the genetic potential of animals is used in farms by no more than 60-70% of their capabilities [1,2]. The search for fundamentally new ways and economic substantiation of technological solutions in the field of production of new types of feed products based on crop and food production wastes is of current importance for providing a forage base for an agricultural livestock complex [3]. The use of biotechnology in agriculture is focused on the stable development of agricultural production, obtaining high-quality and environmentally friendly food products and recycling agricultural waste. In this direction, the most priority is the production of new feed products for farm animals with a low cost, the use of which makes it possible to increase the biological value and productivity of the action of feed, as well as the efficiency of their use in the diet of farm animals to reveal their genetic potential [4]. The use of innovative technologies in the production of feed and fodder products makes it possible to maximize the use of cheap vegetable sources of fodder protein of local production and obtain high-quality products in farms with different production volumes and forms of ownership at low production costs [5]. In modern conditions, the expansion of the feed base is becoming increasingly important in animal husbandry, in particular, through the use of feed products obtained from by-products of food production [6], which, in terms of zootechnical parameters and cost, can occupy their own segment in the feed market, both in the region and countries [7].
Based on the analysis of the state of production of pig meat, the raw material base and the use of fodder at livestock enterprises of the Krasnoyarsk Territory, the conditions and sources of innovation were determined [8]. The basis for the choice of the object of research was the economic problems of these enterprises in terms of providing the population of the region with high quality livestock products with low cost. All of the above determined the relevance of the study. The purpose of the study is to determine the cost of production of feed products obtained by biofermentation from by-products of food production (bran and brewer's grains) and to show the economic efficiency of their use using the example of livestock enterprises for the production of pork in the Krasnoyarsk Territory.

2. Conditions, materials and research methods
The objects of research are feed products obtained by biofermentation from wheat bran and brewer's grains, and livestock enterprises of the Krasnoyarsk Territory for the production of pork. Zootechnical analysis of the feed product was carried out at the Regional Veterinary Laboratory, Krasnoyarsk.

When analyzing the technological process of the production and use of feed products, as well as identifying the priority direction of use, a computational and constructive research method was applied. When developing predictive scenarios for the use of a feed product, the predictive scenario method was used. The method of economic and mathematical modeling based on linear programming was used in the development of a set of models that make it possible to establish optimal rations and feed mixtures, taking into account the satisfaction of the entire complex of animal needs according to the criterion of minimization of costs, which contributes to an increase in the efficiency of the use of feed products at various levels of their implementation.

3. Analysis and discussion of results
On the basis of the research carried out and the available experience in the field of biofermentation of plant raw materials, we have determined the technology of industrial production of a feed product by biofermentation using Lesnov's starter culture [9]. The proposed technology for the production of high-quality feed products, which is based on by-products of food production (bran and brewer's grains), is shown in figure 1 [10]. It is fully consistent with the comprehensive program for the development of biotechnology in the Russian Federation for the period up to 2020. Where the main goal is to enter Russia into a leading position in the development of biotechnology, including in certain areas of agrobiotechnology, industrial biotechnology and bioenergy. This makes it possible to create a globally competitive bioeconomy sector, which, along with the nanoindustry and information technologies, should become the basis for modernization and building a post-industrial economy. The technology, in our opinion, is simple and inexpensive, therefore it can be applied both at industrial livestock enterprises and in peasant farms.

This technology is similar to cicatricial digestion of an animal with the help of a complex of microorganisms that are similar in physiological composition, located in the rumen. Lesnov's leaven is a microbiological preparation obtained under laboratory conditions on the basis of the rumen liquid of ruminants, as well as extracts of some specific plants, the juices of which have high biological activity. Thus, we, as it were, recreate an artificial stomach, in which hard-to-digest carbohydrates (fiber) are broken down into easily digestible sugars. The effect of the starter culture is based on the fact that it introduces potent microorganisms into the food environment that are capable of processing fiber, and also prevents the rapid development of the food's own microflora, which mainly decomposes starch with the release of organic acids. High rates of microbiological synthesis create conditions for obtaining high quality feed products. In accordance with the requirements that apply to biological products used as part of the diets of farm animals, the products of which are used for human consumption, they must be non-toxic and harmless. Lesnov's leaven meets these requirements.
Along with the above qualities of solid-phase fermentation based on Lesnov's starter culture, there is one more important circumstance. In accordance with the decision of the Interdepartmental Commission of the Ministry of Agriculture (dated 07/08/2011) to prevent the spread of African swine fever in the territory of the Russian Federation, heat treatment of raw materials is required. The technological process provides for a biofermentation temperature in the range of 50-55 °C, and the process itself lasts at least 6 hours, depending on the amount of fiber in the feedstock. At this temperature, the African plague pathogen dies within three hours, which may be one of the important elements in antiepizootic measures to prevent infection through feed prepared for feeding to animals, and does not require additional material costs. All raw materials of the technological process have an organic basis, which ultimately ensures full biological compatibility at all stages of the production of a feed product and its consumption by animals. This technology gives the maximum economic effect only at a high-tech livestock enterprise, where a wet type of animal feeding is used, since the technological process provides...
for the moisturizing of raw materials up to 55%. Drying and granulation of the resulting feed product, as a result of which we receive feed concentrate, increase its cost by 1.5-2 times.

Table 1 shows the zootechnical parameters of the fodder product (FP-1) obtained from wheat bran, the fodder product (FP-2) obtained from wheat bran and brewer’s grains (wet), and the fodder product (FP-3) obtained from brewer’s grains (wet) by solid phase biofermentation for use in pig diets.

Table 1. Chemical composition and nutritional value of feed products.

| Indicator             | Unit | fodder product (FP-1) | fodder product (FP-2) | fodder product (FP-3) |
|-----------------------|------|-----------------------|-----------------------|-----------------------|
| ECE                   | rev. | 1.41                  | 1.45                  | 1.54                  |
| Exchange energy       | MJ   | 14.1                  | 14.5                  | 15.4                  |
| Dry substance         | g    | 850                   | 852.1                 | 860.0                 |
| Crude protein         | g    | 200.0                 | 238.3                 | 308.0                 |
| Digestible protein    | g    | 177.6                 | 205.9                 | 257.5                 |
| Raw fiber             | g    | 20                    | 31.1                  | 51.0                  |
| BEV                   | g    | 506                   | 471.0                 | 410.7                 |
| Raw fat               | g    | 42                    | 50.0                  | 64.7                  |
| Calcium               | g    | 2.0                   | 2.3                   | 2.9                   |
| Phosphorus            | g    | 9.6                   | 8.4                   | 6.4                   |
| Potassium             | g    | 4.3                   | 3.3                   | 1.6                   |
| Magnesium             | g    | 10.9                  | 7.6                   | 1.8                   |
| Iron                  | g    | 170                   | 209.5                 | 281.2                 |
| Copper                | mg   | 11.3                  | 14.6                  | 20.7                  |
| Zinc                  | mg   | 81                    | 89.4                  | 104.7                 |
| Manganese             | mg   | 117                   | 87.9                  | 36.5                  |
| Cobalt                | mg   | 0.1                   | 0.1                   | 0.2                   |
| Iodine                | mg   | 1.75                  | 1.2                   | 0.1                   |
| Carotene              | mg   | -                     | 2.0                   | 5.6                   |
| Vitamin E (tocopherol)| mg   | 97.0                  | 74.4                  | 34.5                  |
| Vitamin B₁ (thiamine) | mg   | 15.0                  | 10.0                  | 1.2                   |
| Vitamin B₂ (riboflavin)| mg  | 8.0                   | 5.4                   | 0.9                   |
| Vitamin B₃ (pantothenic acid)| mg | 103.0                 | 65.9                  | -                     |
| Vitamin B₄ (choline)  | mg   | 2500.0                | 2051.5                | 1260.4                |
| Vitamin B₅ (nicotinic acid)| mg | 490.0                 | 326.1                 | 34.9                  |

The analysis of the presented data allows us to conclude that, in terms of nutritional value, the feed product is a complete feed with a high concentration of metabolic energy, ready for use. For piglets and fattening pigs, the optimal metabolic energy content in the feed is from 12.5 to 13.5 MJ [11]. A higher energy level does not automatically lead to better absorption by animals and thus to higher productivity. Pigs eat feed until they are mechanically or physiologically saturated. Mechanical saturation works up to 12.5 MJ of exchange energy, and physiological saturation above 13.5 MJ [12]. This means that feed intake limits overall energy consumption. That is, animals eat significantly less food if it is very energy-rich. As the production experiments carried out by the authors show, it can be fed to pigs during growing and fattening from 50% to 70% of the nutritional value of the diet, depending on their productivity and genetic potential.

An approximate calculation of the cost of 1 ton of feed product (FP-1), obtained from wheat bran, is presented in table 2. Feed product (FP-2), obtained from wheat bran and brewer's grains (wet) in table 3. Feed product (FP-3) obtained from brewer’s grains (wet) in table 4.
### Table 2. Calculation of the cost of feed product (KP-1).

| Indicator               | %   | Weight, Kg | Price 1 kg, rub.* | Cost, rub. |
|-------------------------|-----|------------|-------------------|------------|
| Seed material:          |     |            |                   |            |
| - wheat bran            | 0.25| 5.0        | 4.0               | 20.0       |
| - leaven                | 0.005| 0.005     | 30000.0           | 150.0      |
| - water                 | 0.25| 5.0        | 0.05              | 0.3        |
| Bran                    | 50.51| 995.0     | 4.0               | 3980.0     |
| Water                   | 47.97| 945.0     | 0.05              | 47.3       |
| Chalk feed              | 0.61| 12.0       | 20.0              | 240.0      |
| Monocalcium Phosphate   | 0.15| 3.0        | 35.0              | 105.0      |
| Salt                    | 0.25| 5.0        | 15.0              | 75.0       |
| Additional expenses**   |     |            |                   | 550.0      |
| Total                   | 100.0| 1970.0    |                   | 5167.5     |
| Overheads               | 24.0|            |                   | 1240.2     |
| TOTAL                   |     |            |                   | 6407.7     |

*Note: * The calculations use the market value in 2019 prices. ** The cost of electricity, water heating costs, additional salary, tax deductions and other costs. Hereinafter.

### Table 3. Calculation of the cost of feed product (FP-2).

| Feed composition       | %   | Weight, Kg | Price 1 kg, rub.* | Cost, rub. |
|------------------------|-----|------------|-------------------|------------|
| Seed material:         |     |            |                   |            |
| - wheat bran           | 0.3 | 5.0        | 4.0               | 20.0       |
| - leaven               | 0.3 | 0.005      | 30000.0           | 150.0      |
| - water                |     |            | 0.05              | 0.3        |
| Bran                   | 32.8| 600.0      | 4.0               | 2400.0     |
| Beer grains            | 65.6| 1200.0     | 0.50              | 600.0      |
| Chalk feed             | 0.66| 12.0       | 20.0              | 240.0      |
| Monocalcium Phosphate  | 0.16| 3.0        | 35.0              | 105.0      |
| Salt                   | 0.27| 5.0        | 15.0              | 75.0       |
| Additional expenses**  |     |            |                   | 550.0      |
| Total                  | 100.0| 1830.0    |                   | 4140.3     |
| Overheads              | 24.0|            |                   | 993.7      |
| TOTAL                  |     |            |                   | 5134.0     |

### Table 4. Calculation of the cost of feed product (FP-3).

| Feed composition       | %   | Weight, Kg | Price 1 kg, rub.* | Cost, rub. |
|------------------------|-----|------------|-------------------|------------|
| Seed material:         |     |            |                   |            |
| - wheat bran           | 0.1 | 5.0        | 4.0               | 20.0       |
| - leaven               | 0.1 | 0.005      | 30000.0           | 150.0      |
| - water                |     |            | 0.05              | 0.3        |
| Beer grains            | 99.2| 3500.0     | 0.5               | 1750.0     |
| Chalk feed             | 0.34| 12.0       | 20.0              | 240.0      |
| Monocalcium Phosphate  | 0.08| 3.0        | 35.0              | 105.0      |
The efficiency of animal feeding is determined primarily by the cost of feed per unit of production [13]. All other things being equal, the best indicator of payment for feed always corresponds to a lower cost of production [14]. Table 5 shows the calculation of the cost of 1 EKE of a feed product (FP-1) from wheat bran.

**Table 5. Calculation of the cost of 1 EKE of feed product (FP-1).**

| Indicator                                      | Unit rev. | Number  |
|------------------------------------------------|-----------|---------|
| Bran - fermented, moisture 14%                 | kg        | 1000.0  |
| Cost price                                    | rub       | 6407.7  |
| Cost of 1 EKE                                 | rub       | 4.41    |
| For reference:                                |           |         |
| Cost of 1 EKE in the region for pork production in 2019 | rub | 9.63    |

The data obtained indicate that the cost of 1 EKE of a feed product is 2.19 times cheaper than the cost of 1 EKE in the region in the production of pork in agricultural organizations in 2019.

Table 6 shows the calculation of the cost of 1 EKE of feed product (FP-2) from wheat bran and brewer's grains.

**Table 6. Calculation of the cost of 1 EKE of feed product (FP-2).**

| Indicator                                      | Unit rev. | Number  |
|------------------------------------------------|-----------|---------|
| Bran + brewer's grains - fermented, moisture content 14% | kg        | 1000.0  |
| EKE, (pig)                                     |           | 1454.8  |
| Cost price                                     | rub       | 5462.2  |
| Cost of 1 EKE                                  | rub       | 3.76    |
| For reference:                                |           |         |
| Cost of 1 EKE in the region for pork production in 2019 | rub | 9.63    |

The data obtained indicate that the cost of 1 EKE of a feed product (FP-2) is 2.56 times cheaper than the cost of 1 EKE in the region in the production of pork in agricultural organizations in 2019.

Table 7 shows the calculation of the cost of 1 EKE of feed product (FP-3) from brewer's grains.

**Table 7. Calculation of the cost of 1 EKE of feed product (FP-3).**

| Indicator                                      | Unit rev. | Number  |
|------------------------------------------------|-----------|---------|
| Beer grains - fermented, moisture content 14%  | kg        | 1000.0  |
| EKE, (pig)                                     |           | 1540.0  |
| Cost price                                     | rub       | 3320.2  |
| Cost of 1 EKE                                  | rub       | 2.16    |
| For reference:                                |           |         |
| Cost of 1 EKE in the region for pork production in 2019 | rub | 9.63    |
The data obtained indicate that the cost of 1 EKE of a feed product is 4.47 times cheaper than the cost of 1 EKE in the region for the production of pork in agricultural organizations in 2019.

Let us consider the economic efficiency of using a feed product on the scale of the Krasnoyarsk Territory [8]. The results of the production and sale of agricultural products (pig meat) in 2019 and the forecast for the introduction of 50% of the feed product (FP-1), (FP-2) and (FP-3) of the nutritional value of the diet are presented in Table 8.

Table 8. Results of the production and sale of pork, and the forecast for the use of the feed product in the diet of pigs in 2019.

| Indicator                             | Fact 2019 | Forecast 2019 r. |
|---------------------------------------|-----------|------------------|
|                                       | FP-1      | FP-2             | FP-3             |
| Production cost of 1 ton              | 79.2      | 68.6             | 66.7             | 63.1             |
| Realizable cost of 1 ton, rub.        | 84.5      | 73.2             | 71.2             | 67.4             |
| Selling price of 1 ton, rub.          | 112.9     | 112.9            | 112.9            | 112.9            |
| The level of profitability (loss ratio) without subsidies, % | 33.6      | 54.3             | 58.6             | 67.6             |

4. Conclusion
The proposed technology for the production of a feed product by bio-fermentation is an innovative solution to the problem of producing high-quality feed products for pig breeding with a low cost, which is especially important in the production of competitive products in a market environment. It reveals a great potential for the use of by-products of the food industry in animal husbandry, which makes it possible to improve the quality of rations, increase the biological value and productivity of the action of feed and fodder. All this can make a significant contribution to the creation of a fodder base for agricultural enterprises, especially for areas of risky farming. When using feed products derived from wheat bran and brewer's grains in pig diets, livestock breeding enterprises for the production of pig meat can receive additional competitive advantages in relation to other producers, because the cost of final products will be significantly lower. The application of this technology at livestock breeding enterprises for the production of pork in the Krasnoyarsk Territory will allow:

1. Improve the quality of diets and increase the use of nutrients in it.
2. Reduce the cost of feed for pigs. The inclusion of a feed product in the ration in the amount of 50% of the nutritional value of the ration when growing and fattening pigs makes it possible to reduce the cost of feed in the cost of 1 ton of pig meat by 7.3-12.0%. And as a result, reduce the production cost of products by 15.5-25.5% or 10.6-16.1 thousand rubles.
3. Significantly increase the volume of input of feed by-products into the diet of animals.
4. To reduce the economic dependence of livestock enterprises on the prices of cereals in the region.

References
[1] Kalashnikov A P, Fisinina V I, Shecheglova V V and Kleimenova N I 2003 Norms and rations for feeding farm animals. Reference manual. 3rd edition revised and enlarged (Moscow: Rosselkhozakademiya) p 357
[2] Kabanov V D 2006 Intensive pork production (Moscow) p 377
[3] Gusakov V G et al. 2005 Creation of an effective fodder base - the basis for the intensive development of animal husbandry (Minsk: Institute of Agrarian Economics of the National Academy of Sciences of Belarus) p 24
[4] Lazarevich A N 2016 Analysis of the economic efficiency of the application of technology for the production of feed product in animal husbandry Vestnik NSAU 4(41) (Novosibirsk State Agrarian University) 157-67
[5] Lazarevich A N and Filipyev M M 2020 Economic efficiency of using a feed product in the diet of fattening pigs Food. Ecology. Quality. Proceedings of the XIII International Scientific and Practical Conference 5 179-85
[6] Rasskazova E B 2020 Management of costs and production costs based on assessing the level of innovative potential Vestnik of the Moscow Institute of Humanities and Economics 1 184-93

[7] ThePigSite 2008 Mike Tokach and his colleagues at Kansas state universitys applied swine nutrition team offered practical tips on feeding boars at the swine profitability conference

[8] Agro-industrial complex of the Krasnoyarsk Territory in 2019 2019 p 212

[9] Lesnov P A 1998 Method of using the leaven in the feed mixture, Lesnov's leaven for the preparation of feed: US Pat. 2122330 Rus. Federation No. 97101965 app. 02/10/97 publ. 11/27/98 Bul. 5

[10] Lazarevich A N, Lesnov A P and Tabakov N A 2014 Method of obtaining feed product and concentrate: US Pat. 2532452 RF Rus. Federation No. 2913128539 Appl. 06/21/13; publ. 10.11.14 Bul. 31

[11] Whittemore C T, Horrledine M L and Close W H 2003 Nutrient requirement standard of pigs British Society of Animal Science

[12] Whittemore C P, Green D M and Knap P W 2001 Technical review of the energy and protein requirements of pigs: Energy Animal Science 73 199-215

[13] Kochenkova N I 2018 Analysis of cost reduction methods In the collection: Actual problems of social and humanitarian research in economics and management materials of the IV All-Russian scientific-practical conference of the faculty and masters of the Faculty of Economics and Management pp 360-4

[14] Myasoedova V V 2018 The main directions of reducing the cost of production In the collection: Economics and management: key problems and development prospects Materials of the VII international scientific-practical conference pp 123-7

[15] Rzhavina Yu B 2003 Production cost and ways to reduce it In the collection: The interaction of science and society: problems and prospects Collection of articles on the results of the International Scientific and Practical Conference pp 120-1