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Defragmenting Processing of Collagen-Containing Wastes of Meat Processing Industry into Functional Feed Additives for Obtaining High-Quality Food

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Abstract: The authors developed a technology for obtaining feed additives from wastes of meat processing industry using physical, biochemical and biotechnological processing methods in comparison with the biotechnological method of obtaining a high-grade microbial protein for the production of high-quality food products based on meat raw materials.

Keywords: Collagen Waste, Meat Processing Industry, Lactic Acid, Hydrolysates, Probiotic Culture *Lactobacillus Plantarum*, Corn Seed Cake, Pre-starter Feed Additives

1. Introduction

One of the main factors of successful livestock development is the strengthening and expansion of the forage base, the creation of ecologically clean feed additives containing nutrients with high digestibility, stimulating normal growth and intensive development of animals [1-2].

Most of the feeds used for feeding farm animals do not contain enough high-grade proteins. This deficit is covered by an increase in the content in the rations of animals of plant protein contained in crops, primarily in grain [3].

In the recipes of modern mixed fodders, the share of cereals is 60-80%. The use of such a quantity of grain is irrational and leads to an imbalance in the protein and carbohydrate components of the rations and can contribute to the formation of ketosis, which causes a decline in productivity of up to 30-50%, loss of live weight, forced culling of animals, and infertility.

The solution to this problem is possible by reducing the use of grain components in feed and enriching the rations with animal protein or protein obtained by microbial synthesis [4].

At present, much attention has been paid to the rational use of low-value slaughter products and livestock processing to produce protein hydrolysates, which are used in the production of feed and microbiological media [5-7].

The most promising raw materials for obtaining fodder protein hydrolysates are collagen-containing wastes that are most difficult to process into nutrients: beef and veins beef, pork skin, collagen tendons [8]. The yield of such collagen-containing wastes with the slaughter of 1000 head of cattle or 1000 heads of pigs of different fatness is on the average 2-10% by weight for each batch of animals [9].

Most of the meat wastes have not yet been used rationally and are being exported to landfills, which, apart from material losses, leads to pollution of the environment, therefore studies aimed at solving the problem of high quality feed protein from animal processing waste are quite an actual but complex problem [10-12].

In connection with the foregoing, the task of our research was primarily to develop a method for processing collagen waste that would preserve the biological value of protein products and ensure high digestibility in feeding animals, and also obtain a high protein feed supplement with probiotic and prebiotic properties.

As the object of research, the collagen products of the veins of meat were used. (Vein), beef split, veined mass of cr. With tendons, as well as pork skin.

Theoretical and experimental studies were carried out using conventional, standard and original methods of biochemical, physico-chemical, structural-mechanical analysis [13-15].

The calculation and processing of the results were carried out by statistical, regression analysis methods.

2. Experimental

As the object of research, collagen products of veins of cattle meat (vein), beef cuts, veined mass of cattle (SM) with tendons, as well as pork skin were used.

Theoretical and experimental studies were carried out using conventional, standard and original methods of biochemical, physico-chemical analysis [13-15].

The calculation and processing of the results were carried out by statistical, regression analysis methods.

Determination of the total nitrogen of the protein was performed with the Kjeltec 8200, Foss (Denmark) analyzer.

Determination of amine nitrogen was carried out by spectrophotometric method using 2, 4, 6-trinitrobenzenesulfonic acid (TNBS). The amount of amine nitrogen in the hydrolysates studied was determined from a calibration plot constructed for standard dilutions of a known substance. The degree of hydrolysis was determined as the ratio of amine nitrogen to total.

The mass fraction of amino acids was determined on the amino acid analyzer Biotronic 6001 (Germany) by the method of distribution chromatography after acid hydrolysis of proteins.

Free amino acids were determined in the product after its treatment by adding 10% trichloroacetic acid to precipitate the proteins, neutralizing to pH 2.0, by filtration through a Millipore membrane filter with a nominal pore diameter of 0.22 μm, followed by dilution of the filtrate in sample dissolution buffer pH 2.2. Quantitative estimation of the content of individual amino acids was carried out by comparing the areas of peaks on the aminogram calculated using the Winpeak integrating system of Eppendorf-Biotronic (Germany) for the areas of peaks obtained by analyzing a standard mixture of amino acids containing 2.5 μmol of each amino acid in 1 ml of standard solution.

Mass fraction of ash was determined in accordance with State standard of the Russian Federation GOST 53642-2009 "Meat and meat products. Method for determining the mass fraction of total ash". The method is based on drying, charring, ashing the sample for testing and then determining the mass fraction of total ash.

The mass fraction of fat was determined by the accelerated method in accordance with GOST 23042-86 "Meat and meat products. Methods for determining fat". The method is based on the extraction of total fat contained in meat and meat products with a mixture of chloroform and ethyl alcohol in a filtering funnel.

Carbohydrate content was determined by a method based on the ability of carbohydrates to form with anthrone colored complexes absorbing in the visible part of the spectrum at a given wavelength [13].

Kinetic measurements during acid hydrolysis were carried out as follows. All kinds of substrates before hydrolysis were subjected to drying and grinding on a disintegrator. Weighed portions of crushed substrates weighing 1 g were placed in glass ampoules, 4 ml of an acid solution of the required concentration were introduced, purged with argon for 3 minutes, sealed and placed in a thermostat for hydrolysis. Hydrolysis was carried out with solutions of lactic acid at concentrations of 10, 20, 30, 40% for 0.5-8.0 hours at a temperature of 95-105°C, measuring the concentration of nitrogen of the amino end groups of amino acids and lower peptides by formal titration and the content of free amino acids in hydrolysates at the end of the process. The optimum concentration was the acid, at which the maximum degree of hydrolysis of the protein was observed in 6 hours of the process in combination with the minimum possible destruction of labile amino acids [14].

The obtained hydrolysates were used in liquid form with the content (%): protein – 18.4; fat – 5.5; ash – 1.6; carbohydrates – 4,5; moisture – 70, amine nitrogen – 365 mg%; As well as in the form of dry form obtained in a spray dryer containing (%): protein – 55.2; fat – 16.5; ash – 4.4; carbohydrates – 13,5; moisture – 10, amine nitrogen – 1033 mg%.

The producer of *Lactobacillus plantarum* ATCC 8014 lactobacilli was used as the object for obtaining the microbial protein. Cultivation of the producer was carried out in nutrient medium containing (g /1 liter): peptone or lactic acid hydrolyzate of animal collagen–20, yeast extract–14, K_2HPO_4–6, KH_2PO_4–3, NaCl–5, $MgSO_4$–5, initial pH 6.8. The inoculum was grown in Erlenmeyer flasks with a capacity of 0.75L containing 0. L of this medium into which 10g / 1 liter of a sterile glucose solution was additionally applied once.

The flasks were cultivated at 200 rpm on a shaker at 37°C for 16 hours until the optical density exceeded the optical density by 6-8 times at 546 nm against the starting medium. The sowing culture was used to seed the nutrient medium in an amount of 20% of the volume of 10 L of the Ankum 2M fermenter with a filling factor of 0.65. Temperature 37°C, sterile air flow 3 L / min L, stirring speed 200-350 rpm, pH 6.5-6.8 was maintained by adding 25% ammonia solution and 10% sterile glucose solution. The grown cells were separated by centrifugation and drying on a spray dryer. A protein preparation with a moisture content of 10% and a protein content of 55-65% was obtained.

3. Results and Discussion

The raw materials used were high collagen meat products (vein), beef split, veined mass with tendons, and also pigskin, the amino acid content of which is given in Table 1.

Table 1. *Amino acid composition of protein raw materials.*

Amino acid	Split	Vein	Pig's skin	Stem mass with tendons
Asp	1.58	1.33	2.83	1.47
o-Pro	0.36	0.63	6.08	6.42
Thr	0.44	0.39	0.95	0.88
Ser	0.8	0.56	1.79	1.74
Glu	2.6	1.77	4.66	4.29
Pro	3.18	1.93	6.01	6.14
Gli	3.91	1.38	11.08	10.75
Ala	2.08	0.74	4.23	3.11
Cys	–	0.12	0.1	0.14
Val	0.73	0.53	1.04	1.22
Met	0.06	0.34	0.33	0.41
Ile	0.44	0.28	0.79	0.6
Ley	0.89	0.64	1.54	1.02
Tyr	0.16	0.19	0.08	0.17
Phe	0.57	0.49	1.06	0.97
His	0.6	0.50	0.39	0.43
Lys	0.98	0.88	1.62	1.45
Arg	1.96	1.8	3.41	1.68
The sum of amino acids (equal to the protein content)	21	14	48	43

In collagen raw materials there are no amino acids such as cysteine and tryptophan, and histidine, methionine and tyrosine are in very small quantities.

The amino acid composition of the raw material shows that, depending on the type and amount of tendons, the total protein content of an inferior amino acid composition is 15-45%. Moreover, the protein content increases with the growth of the specific content of the cartilaginous tissue of the tendons, ligaments and other highly collagen-containing tissues. The increased protein content is a plus from the point of view of the potential protein reserve, but this protein can not be used directly without biochemical processing in the composition of feed compositions because of known causes - stiffness of the cartilaginous tissue and a negative effect on the taste characteristics of the feed.

Since the feedstock can contain 20 to 90% of the protein itself in terms of dry matter, one of the possible ways of processing it is hydrolysis with food acid, which allows the hydrolyzable collagen proteins to be cleaved with a high degree of conversion [13-15].

Previous studies have shown that the use of proteinases with collagenase activity (crab, microbial and animal origin) allows partial transformation of the raw material to produce protein peptide, amino acid mixtures that have high biological value. The yield of this processing is, depending on the type of raw materials, an average of 5-45%, however, a significant fraction of the raw material in the presence of enzymes is not completely processed [14, 16-18].

The content of lipids used collagen raw materials differed significantly and was in the range from 3 to 25%.

The total content of carbohydrates in the feed is given in Table 2.

Table 2. *The total content of carbohydrates in raw materials of animal origin,%.*

	Beef1 category	Split	Skin	Vein	Stem mass with tendons
Total content of sugars,% of sample weight	1.2	1.8	1.9	2.3	>3.5

It is known that in the mature animal tissue of muscles, the total content of carbohydrates is 0.7-1.3% depending on the location, and in cartilaginous tissues their content can exceed 3% of the mass of the raw material. And, if we consider the fleshy tissues, then the typical composition of carbohydrates is: lactic acid 0.9%, glucose-6-phosphate 0.15%, glycogen 0.1%, glucose 0.05% [2, 14].

In the cartilaginous tissue the main carbohydrate component is chondroitin sulfates A, B, C, partly hyaluronic acid and their combinations in protein complexes. So strong that in the biochemical analysis, part of the carbohydrates can be destroyed with an underestimation of the observed results [15].

The study of the chemical composition of collagen-containing raw materials allows a positive assessment of the potential capabilities of these protein resources.

Thus, for the production of fodder functional hydrolysates, there is a mixture composition of raw materials of animal origin, containing on the average 15-45% protein, 3-25% fat, 1-3% carbohydrates, the rest (up to 70%) water.

It is known that acid hydrolysis leads to the destruction of some amino acids, so it was of interest to evaluate the kinetics of the release process of individual amino acids during hydrolysis for subsequent use as feed.

In the work hydrolysis of raw materials was studied, for example, veined mass with tendons of lactic acid solutions. As a result of experiments on the selection of the optimal concentration of lactic acid, it was found that the greatest total yield of free amino acids was observed upon exposure to a protein of 20% $CH_3CH(OH)COOH$. Therefore, kinetic studies were carried out using lactic acid of the indicated concentrations.

The kinetic dependences of the accumulation of most amino acids on the duration of hydrolysis at 95, 100, and 105°C had the form characteristic of pseudo-first order reactions, for example, for leucine (Figure 1a).

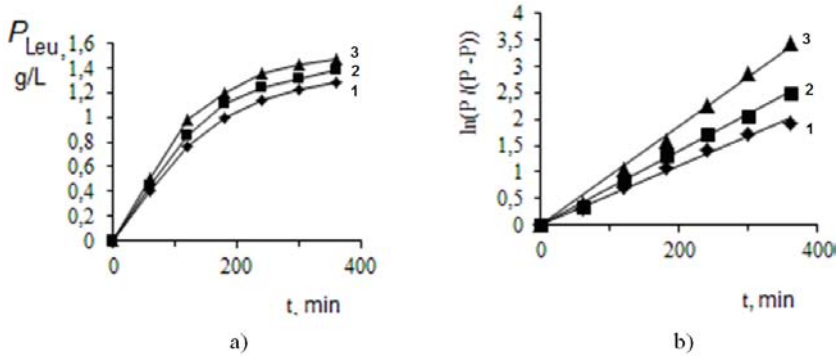

Figure 1. *Dependence of the accumulation of leucine on the duration of hydrolysis by 20% lactic acid (a) and its anamorphosis in semilogarithmic coordinates (b) at temperatures,°C: 1 – 95, 2 – 100, 3 – 105.*

The macroconstant of the reaction rate k_{eff} (sec^{-1}) was found graphically from the equation $\ln(P_\infty - P) = \ln P_\infty - k_{eff}\, t$, as the tangent of the slope of the line in the coordinates $\{\ln[P_\infty / (P_\infty - P)], t\}$, calculated by the method of least squares, where P is the concentration of the reaction product at time t, g / L; P_∞- concentration of the reaction product after completion of the reaction, g / L (Figure 1b).

For the kinetic curve of the first-order reaction, the initial period of which was not fixed, the macroconstant reaction rate can be found graphically from the following expressions: $\ln(P_\infty - P) = \ln P_\infty - k.\, t$, where P is the concentration of the reaction product at time t, and P_∞ is the concentration of the reaction product after completion of the reaction [14].

This expression shows that in the case of a first-order reaction, the absolute value of the effective rate constant does not depend on the units in which the concentrations of reaction products are expressed. Therefore, any physical quantities proportional to the concentrations can be used to calculate the effective rate constant.

Such a value in this case is the nitrogen content of amino groups of amino acids and lower peptides, determined by the method of titration, nitrogen of amino groups was measured, measured after 24 hours of hydrolysis with 20% lactic acid.

The graphs of dependences $\ln [P_\infty / (P_\infty - P)] = f(t)$, presented in Figure 1, had the form of a straight line, which proves the correctness of the assumption made earlier about the hydrolysis reaction in the pseudo-first order.

The effective reaction rate constants were found graphically from the tangent of the slope of the straight line in the coordinates $\{\ln [P_\infty / (P_\infty - P)], t\}$ by the least squares method. The activation energy of the process was found from the Arrhenius equation. The effective total reaction rate constants and the effective activation energy of the process are shown in Table 3.

Table 3. *Kinetic characteristics of the hydrolysis of the feedstock by 20% lactic acid solution and determination of the total apparent activation energy of the process of acid hydrolysis of the protein.*

Temperature,°C	The effective rate constant, $k_{eff} \times 10^4$, sec^{-1}	Apparent total activation energy, kJ / mol
95	1.24 ± 0.02	
100	1.53 ± 0.04	23.9±0.7
105	1.81 ± 0.08	

In Table 4 shows some macrokinetic constants of accumulation of amino acids that do not undergo oxidative degradation during acid hydrolysis.

Table 4 shows that in the process of hydrolysis of the studied types of raw materials, the accumulation of aspartic and glutamic acids, glycine, alanine, tyrosine and phenylalanine was most rapid.

In all cases destruction of histidine, serine and methionine was noted, and the degree of destruction of the latter was greatest. The kinetic curves of accumulation of cystine as a result of hydrolysis did not have a maximum. Probably, the rate of accumulation of cystine was higher than the rate of its destruction due to the high content of this amino acid.

Consideration of the kinetics of accumulation and destruction of amino acids during acid hydrolysis made it possible to determine the conditions for achieving the highest degree of protein conversion while preserving labile amino acids: temperature 100°C, time 6 h, lactic acid concentration 20%.

Table 4. *Effective values of the rate constants of accumulation of individual amino acids (k_{eff}), their yield (X) and effective values of activation energy in the process of hydrolysis by 20% lactic acid.*

Amino acid	Temperature 95°C		Temperature 100°C		Temperature 105°C		The effective activation energy, kJ / mol
	$k_{eff} \times 10^4$, sec^{-1}	X*, %	$k_{eff} \times 10^4$, sec^{-1}	X*, %	$k_{eff} \times 10^4$, sec^{-1}	X*, %	
Essential amino acids							
Ile	0.89 ± 0.02	50.8	1.02 ± 0.03	52.7	1.17 ± 0.01	59.1	18.1 ± 0.3
Leu	0.94 ± 0.02	51.2	1.16 ± 0.01	55.0	1.44 ± 0.02	57.3	30.6 ± 0.2
Lyz	0.98 ± 0.03	54.2	1.10 ± 0.03	58.7	1.48 ± 0.02	61.4	32.4 ± 0.1

Amino acid	Temperature 95°C		Temperature 100°C		Temperature 105°C		The effective activation energy, kJ / mol
	$k_{eff} \times 10^4$, sec^{-1}	*X**, %	$k_{eff} \times 10^4$, sec^{-1}	*X**, %	$k_{eff} \times 10^4$, sec^{-1}	*X**, %	
Phe	1.17 ± 0.02	42.3	1.34 ± 0.03	42.4	2.09 ± 0.04	44.6	32.5 ± 0.5
Tur	1.08 ± 0.01	71.4	1.41 ± 0.02	74.7	1.88 ± 0.03	80.3	33.6 ± 0.2
Tre	1.33 ± 0.03	63.2	1.69 ± 0.03	62.8	1.98 ± 0.02	66.5	21.9 ± 0.1
Val	0.96 ± 0.02	37.6	1.18 ± 0.03	41.6	1.43 ± 0.02	41.7	31.3 ± 0.2
Replaceable amino acids							
Ala	1.03 ± 0.02	49.4	1.12 ± 0.02	49.4	1.36 ± 0.01	54.3	18.8 ± 0.5
Arg	1.06 ± 0.01	59.8	1.27 ± 0.03	61.2	1.39 ± 0.02	61.4	21.4 ± 0.3
Asp	1.52 ± 0.02	61.0	1.78 ± 0.04	63.3	2.03 ± 0.02	66.3	21.1 ± 0.2
Gly	1.73 ± 0.02	44.7	1.88 ± 0.02	44.5	1.99 ± 0.02	48.1	10.1 ± 0.5
Glu	1.01 ± 0.03	74.2	1.40 ± 0.01	76.1	1.36 ± 0.02	80.1	23.2 ± 0.1
Pro	0.89 ± 0.03	31.7	1.07 ± 0.02	34.2	1.71 ± 0.03	34.2	17.3 ± 0.2

*) The yield was determined after 6 hours of hydrolysis with 20% acid.

Table 5. *The content of free amino acids in the samples of hydrolysates, g / 100 g of protein.*

Indicator	Hydrolyzate	Indicator	Hydrolyzate
Amount of amino acids, including:	51.1	Replaceable, including	31.9
		Ala	2.2
Irreplaceable, including	19.2	Arg	4.4
		Asp	4.4
Ile	1.3	His	1.6
Leu	4.2	Gly	3.0
Lyz	2.8	Glu	10.8
Met	0.9	Pro	1.8
Cys**	2.3	Ser	3.7
Phe	1.6	Ratio E/N	0.60
Tyr***	2.5		
Thr	1.9	Degree of conversion of protein, %	87.6
Val	1.7		

The amino acid composition of free amino acids in the hydrolysates obtained under these conditions is given in Table 5.

As can be seen from Table 5, the acid hydrolyzate, like all the kinds of enzymatic hydrolysates we obtained earlier [14], contains an insufficient amount of methionine and cystine, however, it has a satisfactory amino acid composition that can be introduced into the food composition and used for balancing its amino acid composition. The resulting acid hydrolysates contain relatively many aspartic and glutamic acids, glycine, proline, and alanine are present in sufficient quantities.

As for the biological value of glutamic and aspartic amino acids, both of them play a major role in the metabolic processes of the animal body. According to the literature, it is known that such amino acids (individually and in various combinations) are the largest attractant activity, such as glycine, proline, alanine, etc. When added to the feed of their mixture in pigs, for example, food intake tripled. The facts cited show the important role of the three amino acids under consideration in the process of intensive growth of agricultural animals [1, 14].

In the feed industry, collagen additives can be used to produce granulated and extruded feeds in order to increase their biological value and the strength of the pellets. A sample of the hydrolyzate before and after drying is shown in Figure 2, 3.

Figure 2. *A sample of the collagen hydrolyzate prior to drying.*

Figure 3. *A sample of the collagen hydrolyzate after drying.*

The hydrolyzate of protein raw material after pasteurization and drying can be used both as a highly digestible protein supplement for piglets and as a protein base of a nutrient medium for cultivation of probiotic bacteria [16-19].

At present, Russia pays great attention to the use of new non-traditional types of raw materials in the composition of feed additives and mixed fodders, the use of which would improve the physiological and ecological status, productivity, preservation and reproduction of livestock and obtain high-quality and environmentally safe food.

To develop the technology of ecologically clean, biologically active feed additive of the new generation, the following components were chosen as the initial ones: secondary waste of meat processing industry (collagen hydrolyzate) and waste of oil extraction (corn cake germination). The results of chemical composition studies are presented in Table 6.

The selected ingredients of vegetable and animal origin are valuable food products, which is due to the high protein content in them and the favorable combination of proteins and fats, calcium and phosphorus, corresponding to the balance for these feed components. To increase the biological and nutritional value, the feed additive was subjected to hydrobarrothermal treatment.

Table 6. *Composition and properties of fodder additive.*

Indicators	Feed additive
Moisture content, %	8.7
Mass fraction of protein,%	25.3
Mass fraction of fat,%	8.5
Mass fraction of ash,%	7.4
Mass fraction of carbohydrates, %	50.0

As the technology of meat processing improves, the amount of waste will decrease, and the yield of food products from raw materials will increase. Therefore, there is no real reason to expect an increase in the rate of production of animal feed. Contradictions between the needs of the intensive livestock sector and the production of high-grade protein will be exacerbated in the future.

An alternative to animal feed may be a protein of microbiological origin.

The main producers of this protein are yeast, bacteria, low and higher fungi and unicellular algae [19]. If for cattle it takes 5 years to double the protein mass, for pigs –4 months, for chickens – 1 month, then for bacteria and yeast, 1-6 hours are enough. At the same time, microorganisms differ high (from 40 to 55% dry weight) protein content, balanced by amino acid composition, and also contain carbohydrates, lipids, vitamins, macro- and microelements [18]. Table 7 presents a comparative analysis of the most important amino acids in the obtained microbial protein.

Table 7. *The content of essential amino acids in proteins of microorganisms, in g per 100 g.*

Amino acid	Microbial protein from *Lactobacillus plantarum*	FAO Standard
Lysine	6.9	5.5
Tryptophan	1.3	1.0
Methionine	2.8	2.9
Threonine	4.6	4.0
Valine	5.4	5.0
Leucine	10.2	7.0
Isoleucine	6.1	4.0
Phenylalanine	3.8	3.0

Bacteria are much faster than yeast cells, build up biomass and, in addition, bacterial proteins contain more cysteine and methionine, which allows them to be classified as proteins with high biological value.

Table 8 presents the main microbiological indices of the hydrolysis protein supplement for piglets.

Table 8. *Microbiological indices of protein fodder additive for piglets,%.*

Name of indicator	Normatives	Result
The number of mesophilic, aerobic and facultative-anaerobic microorganisms, CFU per g, not more than	5.0×10^5	$7,5 \times 10^2$
Weight of product (g), in which enteropathogenic types of *E. coli* bacteria are not allowed	50.0	not detected
Mass of product (g), in which pathogenic microorganisms are not allowed, incl. *Salmonella*	50.0	not detected
Mass of product (g), in which toxin-forming anaerobes are not allowed	50.0	not detected
The product mass (g), in which *Proteus* is not allowed	1.0	not detected

As a result of the studies, the nutrient medium and the conditions for culturing lactic acid probiotic bacteria were selected, the amount and age of the seed material, the temperature regime and the duration of cultivation of the crop, the drying parameters of the additive were determined.

The results of studies of the microbiological parameters of the feed additive containing lactic acid bacteria are presented in Table 9.

Table 9. *Microbiological indices of protein fodder additive.*

Name of indicator	Normatives	Result
Titre of milk bacteria, CFU per 1 g	–	$8,0 \times 10^9$
The mass of the product (g), in which the bacteria of the *E. coli* group are not tolerated (enteropathogenic types)	50.0	not detected
Mass of product (g), in which pathogenic microorganisms are not allowed, incl. *Salmonella*	50.0	not detected
The product mass (g), in which anaerobes (toxin-forming) are not allowed,	50.0	not detected
The product mass (g), in which *Proteus* is not allowed	1.0	not detected

A fodder protein supplement of microbial origin obtained from processing animal proteins and used as a source of nitrogen for the cultivation of lactic acid probiotic bacteria contains about 55% protein and 16% fat, the number of living cells of lactobacilli is 8.0×10^9 CFU per 1 g.

The composition of the optimum feed formulation is

presented in Table 10.

Table 10. *Composition and nutrition of mixed fodders for piglets.*

Componentsand indicators, %	Control	Experienced
Wheat	26.92	26.9
Barley	44.14	44.14
Cuts made of wheat	10.1	10.0
Sunflower seed meal	5.0	5.0
Corn Gluten	3.0	3.0
Soybean meal	2.0	2.0
Flour	5.0	0.5
Collagen hydrolyzate		4.5
Lysine aft	0.11	0.11
Chalk aft	0.86	0.86
Salt	0.25	0.25
Phosphate defluorinated	1.70	1.70
Vitamin premix KS-3	1.0	1.0
Enzyme preparation based on endo-1,4-β-xylanase of the brand Natufos 5000	0.01	0.01
Vanilla	0.01	0.01
1 kg contains:		
Exchange energy, MJ	12.64	12.64
Crude protein, g	178.4	178.4
Lysine, g	8.3	8.3
Methionine + cystine, g	6.0	5.9
Raw fiber, g	50.1	50.0
Raw fat, g	23.1	23.1
Calcium, g	11.5	11.5
Phosphorus, g	7.6	7.6

The animals of the experimental group should receive a similar compound feed (control), but with the inclusion of 4.5% of the feed additive developed by us instead of fishmeal.

According to preliminary calculations, the use of a developed additive of microbial origin will increase the productivity of animals by 8-10% and reduce the feed costs for obtaining a unit of production by 6-8%.

4. Conclusion

Analysis of the kinetic data of the process of transformation of animal collagen into a nutritional component of feeds or nutrient media that is acceptable for nutritional value shows that the biotechnological method of growing a microbial protein in terms of the rate of production of a protein product greatly exceeds the traditional method of growing farm animals with the subsequent processing of secondary raw materials into a protein product. The carried out researches made it possible to obtain a high-protein feed supplement with probiotic and prebiotic properties for effective piglets' growth. Meat raw materials, obtained from the grown piglets, allowed to obtain pork of the highest quality for the production of meat products.

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