Safety and quality of feed for piglets

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Abstract. The results of research on the safety and quality of compound feed of domestic producers for piglets have been presented in the article. The materials for the investigation were 4 samples of the starting complete feed for piglets of main domestic producers. Organoleptic characteristics of compound feed for piglets met the requirements of Federal standard 34109-2017. The assessment of the total bacterial contamination showed that sample No. 3 (the feed plant “VEGA”) has the maximum level of contamination, and the lowest level in sample No. 1 – new feeding technologies plant. The content of toxic elements in compound feed did not exceed their maximum permissible level and met the requirements of Federal standard 34141-2017. The level of radionuclides in compound feed did not exceed their maximum permissible level and corresponded to the standards provided for in the instructions on radiological quality control of feed of the Ministry of Justice No. 831 on 14.04.1995. Thus, the analysis of samples of the starting compound feed of domestic producers for piglets on organoleptic, physic and chemical, bacteriological and sanitary-mycological indicators, for the presence of toxic elements and radionuclides showed that all samples meet the requirements of safety and quality.

1. Introduction

At the present step of agricultural development one of the priority tasks is to obtain biologically complete, environmentally safe products of crop production and animal husbandry. An effective method of solving it is the use of safe and high-quality raw materials produced under conditions that exclude the ingress of harmful or undesirable components from the environment [1].

According to Petukhov V L et al., Konovalova T V et al., this is especially important for the content of heavy metals and sizes of particles of compound feed [2,3]. Feed production and the feed base are the basis for the sustainable development of highly productive animal husbandry. The creation of a single effective system of animal husbandry and feed production will make it possible to realize the genetic potential of the animal, to provide its high and sustainable productivity. The development of feed production in the Russian Federation is a strategic direction in the rapid development of all agriculture. It is extremely necessary in order to ensure the self-sufficiency of the
production of livestock products. Also feed production is extremely important for the rational use of natural resources, the improvement of the environment and the overall health of the nation [4]. The main indicators of safe and high-quality feed are general toxicity, microbiological indicators (total bacterial contamination, the presence of opportunistic and pathogenic microflora), the content of toxic elements, pesticides, mycotoxins, harmful impurities [5-8].

The purpose of the work is to study some indicators of safety and quality of compound feed of different producers for piglets.

2. Materials and methods

The materials for the investigation were 4 samples of the starting compound feed for piglets CFP-3 (complete feed for piglets) of domestic producers: the 1st sample – Limited liability company (LCC) “NFT” (New feeding technologies, Krasnodar Territory), the 2nd sample – Limited liability company “Athens-Volga” (Volgograd region), the 3rd – sample of the feed plant “VEGA” (Novosibirsk), the 4th – sample of CJSC “Tosnensky compound feed plant” (Leningrad region).

Complete feed CFP-3 is intended for piglets aged from 10 to 42 days. The peculiarity of CFP-3 compound feed is that piglets fed with this product spend a minimum amount of energy on getting used to new food and digesting it, so all the energy goes into the live weight. Thus, the result is achieved for getting the maximum growth of the animal in a short time. At the same time, this complete feed contains all the necessary elements, which are very important for their health and influence on growth and normal development.

The experimental part of the work was carried out in the laboratory of veterinary expertise at the compound feed plant LCC “Athens-Volga”. Safety and quality control of the raw materials and finished products is provided here by our own production and technological laboratory equipped with modern equipment.

For the study of compound feed an average sample was taken from each sample, separating from the combined sample using a hand scoop according to Federal standard 13496.0-2016 Compound feeds, feed raw materials. Methods of sampling [9].

The evaluation of the starting compound feed CFP-3 for piglets on organoleptic and physic and chemical parameters was carried out in accordance with the requirements of Federal standard 34109-2017 Complete mixed feeds for pigs. General specifications [10] and Federal standard 13496.4-93 Fodder, mixed fodder and animal feed raw stuff. Methods of nitrogen and crude protein determination [11].

Methods for determining the content of nitrogen and crude protein were according to Federal standard 32040-2012 Feed, compound feed, feed raw materials. For determining the content of crude protein, crude fiber, crude fat and moisture we used the method near-infrared spectroscopy [12].

Microbiological research was carried out according to Federal standard 31708-2012 (ISO 7251: 2005) Microbiology of food and stuffs. Method for the detection and enumeration of presumptive Escherichia coli. Most probable number technique [13].

Determination of the content of smut fungi spores was carried out according to Federal standard 13496.10-74 [14]. Determination of ergot content in compound feed and grain processing products was carried out according to Federal standard 13496.5-70 [15].

Toxic elements were determined according to Federal standard 34141-2017 Food products, feed, food raw. Determination of arsenic, cadmium, mercury and lead by the method of inductively coupled plasma-mass spectrometry [16].

Determination of residual amounts of organochlorine pesticides such as: alpha-isomer of hexachlorocyclohexane (α-HCCH), the gamma isomer of hexachlorocyclohexane (γ-HCCH), 4,4’-dichlorodiphenyltrichloroethane (DDT) and its metabolites such as: 4,4’-dichlorodiphenyldichloroethane (DDC) and 4,4’-dichlorodiphenyl dichloroethylene (DDE) were performed using gas-liquid chromatography according to Federal standard 31481-2012 [17].
Radiological study of the content of radionuclides Cs-137 (Caesium-137) and Sr-90 (Strontium-90) was carried out in accordance with the Instructions on radiological control of feed quality (Ministry of Justice N 831 14.04.1995).

3. Results and discussion

In the result of research we have made the organoleptic parameters of 4 samples of compound feed CFP-3 of domestic producers for piglets were as follows. The appearance of all samples met the requirements of Federal standard: cylindrical granules with a glossy surface without foreign impurities and traces of mold. The color was light brown and corresponds to the color of the loose feed from which the pellets were prepared. The smell was characteristic of the set of ingredients included in the recipe without musty, moldy and other foreign odors. The granularity of all compound feed samples ranged from 5.9% to 16.1%, the length of the granules was not more than 6 mm (from 4.1±0.4 mm in sample No. 3 to 5.9±0.6 mm in sample No. 4) with a diameter of not more than 4 mm (from 2.8±1.1 mm in sample No. 3 to 3.5±0.4 mm in sample No. 4). The content of the metal and magnetic impurity did not exceed the permissible norms. The largest number of particles up to 2 mm (inclusive) in size 2.8±0.7 mg/kg was detected in sample No. 3 (the permissible norm according to Federal standard was up to 10 mg/kg). There were no particles more than 2 mm with sharp edges in the studied samples.

In samples No. 3 and No. 4 pests of grain stocks were detected in the amount of 2 and 3 copies per 1 kg, respectively, which did not exceed the permissible norms (up to 5 per 1 kg).

Chemical analysis of feed provided information about the content of nutrients, minerals and biologically active substances as well as harmful substances and impurities, so it could serve as a basis for characterizing its nutritional properties. The results of the physic and chemical research are presented in table 1.

Table 1. Physical and chemical parameters of the starting complete feed for piglets CFP-3.

| Parameter                                      | According to Federal standard | Samples       |
|-----------------------------------------------|-------------------------------|---------------|
| Metabolic energy, MJ/kg, not less             | 14.3                          | 14.8          |
| Mass fraction of moisture, %, not more        | 13.5                          | 10.4          |
| Mass fraction of crude protein, %, not less   | 19.9                          | 21.4          |
| Mass fraction of crude fiber, %, not more     | 3.6                           | 2.5           |
| Mass fraction of lysine, %, not less          | 1.1                           | 1.5           |
| Mass fraction of methionine and cystine (in total), %, not less | 0.7 | 0.9 | 0.8 | 0.7 | 0.8 |
| Mass fraction of calcium, %                   | 1.5                           | 1.3           |
| Mass fraction of phosphorus, %                | 0.9                           | 1.2           |
| Mass fraction of sodium, %                    | 0.4                           | 0.4           |
| Mass fraction of chlorides, %                 | 0.16                          | 0.4           |
| Mass fraction of crude fat, %                 | 2.1                           | 3.8           |
| Mass fraction of ash, insoluble in hydrochloric acid, %, not more | 0.4 | 0.1 | 0.3 | 0.4 | 0.3 |
It was revealed according to the results of the physic and chemical research of the starting compound feed for piglets CFP-3 of domestic producers that all feed samples comply with Federal standards.

Samples from the studied compound feed samples for microbiological analyses were taken before sampling for physic and chemical analyses in an aseptic manner, excluding microbial contamination of the products from the environment. The requirement for the weight of the analyzed sample for microbiological analyses, which must be at least 400 g, was met.

Mycological research aims to identify toxic or pathogenic fungi that develop during the growing season and feed storage. The investigation of feed is carried out for diagnostic purposes and aimed at preventing diseases. These diseases usually occur when animal feeding by feed affected by toxigenic or pathogenic microscopic fungi as well as to find out the causes of poisoning of livestock. Sanitary-indicative phytopathogenic fungi are ergot and smut fungi [18].

The main reason for the destruction of feed by mold fungi remains non-compliance with the technology of growing crops, violation of the harvesting process and storage conditions of the feed base. All these factors contribute to the spread of fungal spores in the environment and their further contamination of environmental objects.

One of the important indicators that characterize the sanitary condition of feed is the number of micromycete spores in 1 g of feed. When taking compound feed the number of spores of pathogens of smut fungi and ergot is determined. The number of spores of these phytopathogenic micromycetes that secrete specific mycotoxins should not exceed the established standards according to Federal standard 13496.5-70 [15] and Federal standard 13496.6-2017 [19]. The content of ergot and smut spores in the compound feed for piglets is not allowed. No spores of smut fungi and ergot were detected in the studied samples of mixed feed.

Among the numerous feed pollutants, mycotoxins – aflatoxins are particularly dangerous: B₁, B₂, G₁, G₂, M₁ and others. The greatest danger to the animal body is represented by feed contaminated with fungal waste products as mycotoxins belonging to two groups. The first group of Aspergillus and Penicillium the so-called storage fungi, intensively develop in the mass, especially when storage conditions are violated. The second group includes field mushrooms. These fungi include species of the genus Fusarium their toxins are most dangerous to animals. About 100 species of fungi are known to form toxic substances. Some of them cause mycotoxicoses, which are observed in natural conditions in animals.

The results of the research showed the absence of mycotoxins such as aflatoxin B₁, ochratoxin A, sterigmatocystin, T-2 toxin, deoxynivalenol (vomitoxin), zearalenone, fumonisin B₁ in the compound feed of all four samples and compliance with Federal standard 13496.6-2017 [19], Federal standard 13496.10-2017 [20].

The microflora of compound feed was represented by epiphytic microorganisms. The degree of contamination of feed by microorganisms increases during transportation, storage and depends on humidity, temperature, aeration, the physiological state of the feed and its morphological structure. During long-term storage of feed the total number of microorganisms decreased sharply with a simultaneous change in the ratio of different groups of microorganisms. The specific and quantitative composition of spore-forming bacteria in comparison with other microorganisms increased by 60-90% during the storage of feed in the winter-spring period.

The main factor that contributes to the development of the microflora of the feed is humidity, the level of which depends on the air temperature. The generalized results of bacteriological studies of compound feed of the starting complete feed for piglets CFP-3 were presented in table 2. The results of the assessment of the total bacterial contamination showed that the sample of compound feed No. 3 had the maximum level of contamination, and the lowest level in compound feed No. 1.

During the storage of the feed the total bacterial contamination increased to a certain level of total acidity, after which the bacterial contamination decreased significantly with an increase in total acidity. Under production conditions the total acidity was determined when evaluating the quality of grain feed and compound feed.
Table 2. Results of bacteriological studies of compound feed for piglets (thousand CFU/g*).

| Parameter                              | According to Federal standard | Samples |
|----------------------------------------|------------------------------|---------|
|                                        |                              | 1      | 2      | 3      | 4      |
| Total bacterial contamination          | 5×10⁴                        | 1.5×10⁴| 1.9×10⁴| 4.2×10⁴| 3.8×10⁴|
| Salmonella in 50 g                     | not allowed                  | missing| missing| missing| missing|
| Pathogenic escherichia in 50 g         | not allowed                  | missing| missing| missing| missing|

*Note: CFU – colony forming unit.

The determination of total acidity reflected the total content of weak organic polybasic acids and did not cover the entire list of compounds that determine the total acidity of the analyzed feed. It was true only when it is used for compound feed, which included only grain, oil cake, animal feed and traditional mineral additives.

Recently, new types of raw materials have appeared, which themselves have high acidity. These are preservatives that are purposefully introduced into the feed in order to increase the acidity for longer preservation of wet feed. They based on low-molecular organic acids increase the acidity of the stomach of animals, promote a higher level of protein digestion, thanks to the activation of pepsin, and limit the development of enteropathogenic microflora in the intestine. Such preservatives increase the total acidity of feed, which for compound feed should not be higher than 8 °H.

The acidity of compound feed in the range from 7.6 °H to 8.7 °H indicates the beginning of microbiological processes that lead to spoilage. Compound feed with an acidity of up to 7.6 °H are of good quality and they are subject to long-term storage and feeding to all animals according to existing standards without restrictions.

The total acidity was most expressed in sample No. 3 and was 6.7 °H. The lowest index of total acidity was found in sample No. 1-4.5 °H. All the obtained indicators did not exceed the standards of Federal standard 13496. 12-98 Mixed fodder, raw mixed fodder. Method for determination of total oxidability [21]. Thus, the obtained results of the study of total bacterial contamination, total acidity of compound feed did not violate the existing standards of Federal standard 31708-2012 [13]; Federal standard ISO 7218-2015 [22] and Federal standard 13496.12-98 [21].

The main reason for the destruction of feed by mold fungi remains non-compliance with the technology of growing crops, violation of the harvesting process and storage conditions of the feed base. All these factors contribute to the spread of fungal spores in the environment and their further contamination of environmental objects.

Toxigenic mold fungi and their metabolites affecting feed cause complex poisoning in animals and poultry of varying severity such as acute and chronic. At the same time a decrease in the natural resistance of the immune status is noted. The result is the decrease in productivity, deterioration of the sanitary quality of products [23].

It is important to provide livestock with high-quality feed. Among the numerous feed pollutants the most dangerous are toxic elements such as copper, zinc, cadmium, lead, organochlorine and phosphorous, and other pesticides. The results of the determination of toxic elements and organochlorine pesticides in compound feed are presented in table 3.

It was found when considering the results obtained that the content of toxic elements in compound feed did not exceed their maximum permissible level and met the requirements of Federal standard. The results of the determination of radionuclides in compound feed were shown in table 4.

The content of radionuclides in compound feed did not exceed their maximum permissible level and corresponded to the standards provided for in the instructions on radiological quality control of feed of the Ministry of Justice No. 831 on 14.04.1995. According to the results obtained the content of Sr-90 (Strontium-90) was in the range of 25 to 52 Bq/kg (according to Federal standard no more than
65 Bq/kg), the content of Cs-137 (Caesium-137) was in the range of 12 to 61 Bq/kg (according to Federal standard no more than 600 Bq/kg).

Table 3. Results of the research of compound feed for piglets on the content of organochlorine pesticides and toxic elements, mg/kg.

| Parameters | According to Federal standard, mg/kg, not more | Samples |
|------------|-----------------------------------------------|---------|
| Aldrin (single or combined with dieldrin) | 0.01 | 0.002 | 0.003 | 0.007 | 0.005 |
| Hexachlorobenzene | 0.01 | 0.003 | 0.003 | 0.005 | 0.004 |
| Heptachlor (in total with heptachlorepoxide) | 0.01 | 0.004 | 0.005 | 0.006 | 0.004 |
| HCH (sum of isomers) | 0.2 | 0.1 | 0.1 | 0.2 | 0.1 |
| DDT (sum of metabolites) | 0.05 | 0.03 | 0.02 | 0.03 | 0.03 |
| Polychlorocamphene (toxaphene) | 0.1 | 0.05 | 0.06 | 0.07 | 0.05 |
| Thiodane (endosulfan) | 0.1 | 0.05 | 0.05 | 0.06 | 0.05 |
| Chlordane (sum of isomers) | 0.02 | 0.001 | 0.002 | 0.008 | 0.005 |
| Endrin | 0.01 | 0.002 | 0.003 | 0.007 | 0.005 |
| The content of herbicides of group 2, 4-D, not more | 0.6 | 0.1 | 0.3 | 0.3 | 0.1 |

Content of toxic elements, not more

| Parameters | Samples |
|------------|---------|
| Mercury | 0.1 | 0.002 | 0.005 | 0.007 | 0.004 |
| Cadmium | 0.4 | 0.005 | 0.007 | 0.01 | 0.008 |
| Lead | 5.0 | 0.005 | 0.008 | 0.01 | 0.004 |
| Arsenic | 1.0 | 0.002 | 0.005 | 0.007 | 0.004 |
| Fluoride | 50 | 8 | 10 | 35 | 20 |

Table 4. Results of studies of the initial complete feed for piglets on the content of radionuclides (Bq/kg).

| Parameters | According to Federal standard, Bq/kg, not more | Samples |
|------------|-----------------------------------------------|---------|
| Strontium-90 | 65 | 25 | 40 | 52 | 33 |
| Caesium-137 | 600 | 12 | 28 | 61 | 28 |
4. Conclusion
The investigation of some indicators of safety and quality of compound feed for piglets from different producers in the Russian Federation has shown that all of them corresponding to the requirements of pig breeding industry. The assessment of the total bacterial contamination of compound feed of different producers has shown that the sample of compound feed No. 3 had the maximum level of contamination, and the lowest level has been found in compound feed No. 1. The investigation of the content of radionuclides in compound feed has shown that content of Sr-90 was in the range of 25 to 52 Bq/kg, and the content of Cs-137 was in the range of 12 to 61 Bq/kg. It was in requirements of Federal standards.

It has been shown that for organoleptic, physics and chemical, bacteriological, sanitary and mycological indicators, for the presence of organochlorine pesticides, toxic elements and radionuclides that all feed met the safety and quality requirements and can be recommended for pig breeding industry. This should also be taken into account abroad, since compound feed from different producers have their own characteristics, which can affect the quality of the products produced.

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