Method of increasing the mixed fodder nutritional and energy value

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Abstract. The use of local raw materials in the mixed fodder formulations for broiler chickens, including non-traditional raw materials, allows to expand the range of manufactured feeds possessing high nutritional properties and biological value. In order to improve the quality and to reduce the production costs of the mixed fodder due to the cheap raw materials use and the reduction of the premix use share, the mixed fodder formulation for broiler chickens was developed. The nutritional and energy value, safety of mixed fodder are determined. It is established that the nutritional and energy value of the mixed fodder with extruded mixture of non-crushed wheat, peat and cones meets the requirements of the current standard for complete feed for poultry and is obtained in accordance with the rules of the production technological process organization and supervision in the mixed fodder industry. The obtained mixed fodder with the use of non-traditional additives is non-toxic. There is no pathogenic microflora. Replacement of the expensive premix with peat, cones and introduction of non-crushed wheat grain into the mixture before extrusion helps to reduce the cost of finished products. In the production of extrudate from non-crushed wheat (98.8 %), peat (0.6 %) and cones (0.6 %), grinding and mixing with other components of the mixed fodder, the proportion of premix P5-1 decreased to 0.52%. The mixed fodder quality improvement is due to the enrichment with vitamins, essential amino acids and vegetable protein by adding cones and peat.

1. Introduction
One of the development directions for modern mixed fodder production is the development of promising energy-resource-saving technologies that contribute to increasing the nutritional value of the finished feed [1, 2].

Currently, the efforts of scientists and manufacturers are aimed at solving the issues of feed rational use, as well as the use of unconventional feed and additives [3, 4]. The reserve for obtaining high-energy mixed fodder is the extrusion of grain (wheat, barley, corn, peas, soybeans) and other components included in the formulation of poultry feeding and subsequent mixing with premixes. The extrusion process involves the impact of high temperature and pressure on feed, as a result of which the mixture structural and mechanical properties change [5, 6, 7].

The high-moor peat [8, 9] and pine cones [10] containing a large amount of biologically active substances are the promising components for use in fodder production.

The development of mixed fodder formulations based on local raw materials, including non-traditional raw materials will expand the range of manufactured feed possessing high nutritional properties and biological value.
The purpose of research is to improve the quality and to reduce the cost of mixed fodder production through the use of cheap raw materials and reducing the premix use share.

The tasks of the research are to develop the mixed fodder formulation for broiler chickens; to determine the mixed fodder nutritional and energy value and safety; to assess the economic efficiency of mixed fodder production according to the proposed formulation.

2. Objects and methodology of research
The initial components in the research work were composed of Novosibirskaya wheat grown in the conditions of the educational farm “Minderlinskoye” of FSBEI HE “Krasnoyarsk state agrarian university” of the Sukhobuzimsky district; high-moor peat from the Kozulsky field (Krasnoyarsk territory); covering scales and rods of Siberian pine cones (Pinus sibirica), as well as substandard cones from the Emelyanovsky district (Krasnoyarsk territory); vermiculite from the Tatar field (Krasnoyarsk territory).

Raw materials and finished products according to the developed formulation were studied according to accredited methods in the Federal state budgetary institution “Krasnoyarsk reference center of Rosselkhoznadzor” and in the Federal state budgetary institution state center of agrochemical service “Krasnoyarsky”.

3. Results and discussions
Experimental studies were conducted in the Engineering center of the FSBEI HE “Krasnoyarsk state agrarian university”.

The analysis has shown that peat and pine cones have a high nutritional and energy value (table 1) and are promising raw materials for use in the mixed fodder production.

| Table 1. Nutritional and energy value of peat and cones. |
|----------------------------------------------------------|
| **Indicators**                                           | **Cones** | **Peat** |
| Exchange energy (poultry), kcal/100 g                    | 110.88    | 86.60    |
| Raw protein, %                                           | 6.11      | 18.25    |
| Raw fat, %                                               | 9.19      | 0.99     |
| Raw cellulose, %                                         | 31.60     | 33.60    |
| Raw ashes, %                                             | 3.40      | 19.50    |
| Nitrogen-free extractive substances, %                   | 49.70     | 27.66    |
| Dry substance, %                                         | 71.60     | 72.70    |
| Lysine, %                                                | 0.16      | 0.32     |
| Methionine, %                                            | 1.29      | 1.55     |
| Methionine + Cystine, %                                  | 1.64      | 1.95     |
| Calcium, %                                               | 0.25      | 6.83     |
| Total phosphorus, %                                      | 0.14      | 0.11     |
| Sodium, %                                                | 0.06      | 0.04     |

For the extruded mixture production, the following ratio of components (by weight) was used: non-crushed wheat – 98.8 %; peat – 0.6 %; cones – 0.6 %.

The technological process of preparing the mixed fodder for broiler chickens consisted of the following stages (figure 1). Peat and cones were crushed to a powdery state and mixed with non-crushed wheat grain in a mixer.
The technological process scheme for the mixed fodder obtaining with the use of peat and pine cones.

The obtained mixture was moistened with water to a moisture content of 15-16% for the extrusion process optimal flow and was kept in the bunker for 1 hour to evenly distribute moisture throughout the mixture volume. Further, the resulting mixture was processed on a screw extruder at a temperature of 140-145°C and a pressure of 4-5 MPa.

After cooling, the extrudate was crushed to a particle fraction not exceeding 2.5 mm and was mixed with the rest of the mixed fodder components in a mixer.

The resulting extrudate was analyzed for nutrient content. The nutritional and energy value of the extrudate is presented in Table 2. On the basis of the obtained data, the ratio calculation and selection of the mixed fodder components were made. They were based on the poultry needs according to State standard 18221-99.

**Table 2.** Nutritional and energy value of extrudate.

| Indicators                                    | Value  |
|-----------------------------------------------|--------|
| Exchange energy (poultry), kcal/100 g         | 267.81 |
| Raw protein, %                                | 18.37  |
| Raw fat, %                                    | 0.92   |
| Raw cellulose, %                              | 2.90   |
| Raw ashes, %                                  | 2.20   |
| Nitrogen-free extractive substances, %        | 75.61  |
| Dry substance, %                              | 84.60  |
| Lysine, %                                     | 0.22   |
| Methionine, %                                 | 0.21   |
| Methionine + Cystine, %                       | 1.18   |
| Calcium, %                                    | 0.13   |
| Total phosphorus, %                           | 0.50   |
| Sodium, %                                     | 0.45   |
The mixed fodder components were mixed in the following ratios: extruded mixture – 23.06%; corn – 22.79%; toasted soybean meal – 20%; barley – 10.0%; peas – 10%; sunflower oil – 6.43%; meat and bone flour – 4%; fish flour – 3%; vermiculite – 0.01%; salt – 0.1%; premix P5-1 – 0.52%.

The obtained mixed fodder was studied according to a set of indicators characterizing its nutritional properties and energy value (table 3).

| Name of indicators | Mixed fodder | According to the proposed method | The norm for broilers aged 1-4 weeks (State standard 18221-99) |
|--------------------|--------------|----------------------------------|-------------------------------------------------------------|
| Mass fraction of moisture, % | 12.27        | 13.0                             |                                                              |
| Raw protein, %      | 22.01        | 22.0 - 23.5                      |                                                              |
| Raw cellulose, %    | 3.51         | not more than 4.5                |                                                              |
| Lysine, %           | 1.11         | 1.10 - 1.15                      |                                                              |
| Methionine + Cystine, % | 0.85      | 0.82 - 0.85                      |                                                              |
| Calcium, %          | 0.92         | 0.9 - 1.2                        |                                                              |
| Phosphorus, %       | 0.79         | 0.75 - 0.85                      |                                                              |
| Sodium, %           | 0.23         | 0.22 - 0.32                      |                                                              |
| Exchange energy, kcal/100 g | 310     | not less than 310                |                                                              |

The data on the mixed fodder nutritional and energy value with extruded mixture of non-crushed wheat, peat and cones indicates that the resulting feed meets the requirements of the current standard for the poultry complete feed and is obtained in accordance with the rules of organization and supervision of the production technological process in the mixed fodder industry.

The mixed fodder obtained in accordance with the developed formulation was studied for the following safety indicators: toxicity, mycotoxin content, heavy metal salts, nitrates and nitrites, microbiological indicators (table 4).

| Safety indicators | Value |
|-------------------|-------|
| Toxicity          | non-toxic |
| Pathogenic, including Salmonella | absent |
| Coliform bacteria | absent |
| Total bacterial semination, CFU / g | 9.6·10³ |
| Aflatoxin B1, mg/kg | less than 0.004 |
| Nitrates, mg/kg | 126 |
| Nitrites, mg/kg | less than 2 |
| Lead, mg/kg | 0.72 |
| Cadmium, mg/kg | 0.21 |
| Copper, mg/kg | 3.21 |
| Zinc, mg/kg | 12.70 |

It is noted that the obtained mixed fodder with the use of non-traditional additives is non-toxic. The content of lead, cadmium, mercury, arsenic, copper, zinc, nitrates, nitrites, aflatoxin B₁ does not exceed the maximum permissible norms. There is no pathogenic microflora.

The calculation of the economic efficiency of the mixed fodder production according to the proposed formulation showed that the replacement of the expensive premix with peat, cones and the
introduction of non-crushed wheat grain into the mixture before extrusion helps to reduce the finished product cost. The production cost of 1 ton of the mixed fodder reduces by 3526.91 rubles with adding peat and cones compared to the formulation that uses crushed wheat grain instead of extrudates.

4. Conclusion
The conducted research has proved the economic efficiency of using non-traditional sources of raw materials in the mixed fodder production. The proportion of premix P5-1 decreased up to 0.52% in the extrudate production from non-crushed wheat (98.8 %), peat (0.6 %) and cones (0.6 %), grinding and mixing with other mixed fodder components.

The mixed fodder quality improvement is due to the enrichment with vitamins, essential amino acids and vegetable protein by adding cones and peat. The obtained research results give grounds to recommend the use of non-traditional sources of raw materials in the mixed fodder production.

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