Results of comparative studies of grain syrup quality

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Abstract. This paper presents the results of analysis of the chemical composition of molasses obtained in the conditions of agricultural organizations from locally produced grain. The research was carried out on wheat and barley taken from one of the farms in Russia. The prepared grain molasses is a homogeneous mass. In the finished product, moisture, energy feed unit, exchange energy, crude and digestible protein, crude fiber, sugar, and starch were determined by standard methods. The chemical composition in the finished grain product was determined at natural moisture and air-dry condition. Grain syrup obtained from wheat contains exchangeable energy of 9.56 MJ, crude protein 12.57 %, digestible protein 93.00 g kg⁻¹ and crude fiber 2.33 %. In addition, 1 kg of the product contains 299.0 and 133.0 g, respectively, of sugar and starch. The finished product obtained from barley contains 73.6 % moisture, 2.48 MJ of exchangeable energy, 30.3 and 22.7 g kg⁻¹ of raw and digestible protein, respectively, 1.37 % of fiber, 69.3 and 46.7 g sugar and fiber, respectively. Thus, according to the results of the material obtained, it was concluded that it is possible to prepare grain feed syrup under the conditions of a farm from local grain raw materials, in particular from barley and wheat.

1. Introduction

At present, traditional methods of feed preparation [1-4] do not always satisfy and correspond to the state of the livestock problem. A balanced diet is important in feeding highly productive dairy cows. In this case a special role belongs to the exchange of protein and sugars [5, 6]. In most agricultural enterprises, the animal’s need for protein is almost completely satisfied. But due to a sharp reduction in the production of root and field crops, the amount of easily digestible carbohydrates in the diet of farm animals decreased. It is known that the absence or lack of individual elements of feeding, as well as their incorrect ratio in the diet often leads to disruption of the metabolic processes in the body, reducing the average daily milk yield of cows [7, 8].

Many enterprises add sugar molasses and hydrolytic molasses to the diet of animals. However, the use of these additives is rational at their low cost and easy availability. In addition, these products have a high content of nitrates and nitrites, residual concentrations of heavy metals, pesticides and herbicides [9-11]. An alternative for sugar molasses and molasses, the hydrolysis may be the corn syrup [12-18].

The use of fodder molasses from grain raw materials in diets of highly productive animals makes it possible to increase milk productivity, fat and lactose content in milk [10, 11]. However, the quality of
the molasses produced in industrial plants, with the time of its storage, transportation, and distribution of animals may deteriorate. The solution to this problem can be the preparation and distribution of fresh grain syrup obtained in the conditions of agricultural organizations from its own grain. This requires a preliminary assessment of the quality of the feed. In this regard, the purpose of the research is to determine the quality of molasses obtained in the conditions of agricultural organizations from locally produced grain.

2. Materials and methods
The research was conducted in the laboratory of the Nizhny Novgorod State University of Engineering and Economics. Barley grain varieties ‘Ataman’ and wheat varieties ‘Moskovskaya 39’, taken from the agricultural production cooperative ‘Bolsheandreevsky’, Knyagininsky district of the Nizhny Novgorod region (Russia) were used as the raw materials.

The preparation of a liquid grain feed syrup was carried out at a facility developed at the Nizhny Novgorod State University of Engineering and Economics, a state budgetary educational institution of higher education, whose working process is focused on hydromechanical destruction of grain.

The ‘Multienzyme Composition-3’ preparation obtained on the basis of hydrolytic and lyase enzymes - xylanase, beta-glucanase, and pectinlyase was used as an enzyme [18].

For the preparation of grain molasses, one part of the grain raw materials and two parts of water were used. Grain raw materials were gradually poured into a bunker with water previously heated to 30 °C, and a portion of the preparation ‘Multienzyme Composition-3’ was added to starch saccharification. Then the grain mixture was circulated until it reached a temperature of 60 °C. For the accumulation of simple sugars, the finished liquid feed molasses was kept for at least 1 h. After that, the selected point samples were joined together in a bucket, thoroughly mixed and formed a combined sample weighing at least 2 kg and poured into clean, dry, tightly closed plastic cans.

In accordance with the specified processing modes of the original grain, six samples of wheat and barley grain, obtained in a laboratory setup, were investigated. Laboratory studies were carried out in accordance with the guidelines [19]. Quality assessment of grain syrup was carried out on the basis of studies of the federal state budgetary institution ‘Center of Agroecological Service Nizhegorodsky’, as well as in the accredited testing laboratory center of the federal state budgetary educational institution of higher education ‘Chuvash State Agricultural Academy’. Standard methods were used to determine the quality of grain and finished grain products. The moisture content and dry matter content, the exchange energy, crude and digestible protein, crude fiber, sugar, starch, phosphorus and calcium were analyzed according to the protocols of the state standards (GOST).

The significance of differences in group means was estimated by the Student's t-test [20].

3. Results and discussion
Lots of wheat and barley, from which samples were taken for research, in terms of quality assessment met the requirements of regulatory documents. The organoleptic evaluation showed that the original grain was benign, had a light yellow color, no green films, not rancid, no foreign flavors. Analysis of table 1 suggests that the grain of wheat and barley meets the requirements of state standard (GOST) and can be used for research and development of the finished grain product.

The chemical composition and nutritional value of prepared grain syrup are shown in tables 2 and 3. According to data received enzyme mixture had a different effect on the cleavage of starch and sugar in the prepared molasses. We assume that this is due to the presence of inhibiting substances in the grain, which act on enzymes and reduce the hydrolytic properties of enzymes.
**Table 1** Chemical analysis of raw materials.

| Indicators                              | Grain types |          |          |
|-----------------------------------------|-------------|----------|----------|
|                                        | Barley      | Wheat    |
| Humidity, %                             | 11.9±0.02   | 10.7±0.02|
| Mass fraction of dry substances, %      | 88.24±0.002 | 89.3±0.01|
| Mass fraction of crude protein, %       | 10.9±0.01   | 12.6±0.01|
| Mass fraction of crude fat in recalculation on absolute dry substance, % | 2.06±0.06   | 2.23±0.008|
| Mass fraction of crude fiber in dry matter, % | 3.60±0.05   | 1.70±0.08|
| Mass fraction of starch, g              | 568.4±4.0   | 600±4.8  |
| Mass fraction of sugar, g               | 27.5±0.07   | 21.1±0.07|

**Table 2.** Chemical composition and nutritional value of grain molasses at natural humidity.

| Indicator                              | Type of whole grain |          |          |
|-----------------------------------------|---------------------|----------|----------|
|                                        | Barley              | Wheat    |
| Moisture, %                             | 73.6±0.35           | 70.9±0.47|
| Energy feed unit, kg                    | 0.21±0.006          | 0.24±0.003|
| Exchange energy, MJ                     | 2.48±0.4            | 2.78±0.04|
| Crude protein, gkg⁻¹                   | 30.3±0.06           | 36.3±0.06|
| Digestible protein, gkg⁻¹               | 22.7±0.3            | 27.0±0.57|
| Crude fiber, %                          | 1.37±0.22           | 0.66±0.03|
| Sugar, g                                | 69.3±7.44           | 98.3±3.93|
| Starch, g                               | 46.7±3.3            | 43.3±3.33|

**Table 3.** Chemical composition and nutritional value of grain molasses in the air-dry state.

| Indicator                              | Type of whole grain |          |          |
|-----------------------------------------|---------------------|----------|----------|
|                                        | Barley              | Wheat    |
| Moisture, %                             | 73.58±0.35          | 70.9±0.47|
| Energy feed unit, kg                    | 0.80±0.003          | 0.80±0.003|
| Exchange energy, MJ                     | 9.40±0.04           | 9.56±0.003|
| Crude protein, %                        | 11.47±0.16          | 12.57±0.03|
| Digestible protein, gkg⁻¹               | 85.0±0.001          | 93.0±0.001|
| Crude fiber, %                          | 5.23±0.9            | 2.33±0.09|
| Sugar, g                                | 261.3±24.9          | 299.0±50.3|
| Starch, g                               | 180.0±17.3          | 133.0±8.8|

Preparation for feeding is crucial for the rational use of feed. The cooked grain syrup, ready to be fed to animals, is an opaque, viscous, good flowable, sweet-tasting liquid without any visible mechanical impurities, of a gray or gray-brown color with a fragrant odor. This suggests that after the heat treatment of the feedstock, the palatability of the feed mixture has improved since aromatic substances are formed.

When feeding, the prepared product is evenly distributed over the mass of feed, thereby increasing the palatability of raw food by animals, increasing the digestibility of dry and organic matter of the diet. Grain molasses is energy and highly digestible feedstock with a dry matter content ranging from...
to 27%. The analysis of the prepared molasses obtained the main indicators characterizing the quality of the prepared product (tables 2 and 3).

The chemical composition of grain syrup obtained from barley grain at natural moisture is as follows. Thus, the highest nutrient yield (EFU) of dry matter of grain syrup at a humidity of 70.9% was obtained in the variant from wheat, which was 0.03 kg higher than in the syrup from barley grain. 1 kg of barley feed syrup contains 0.21 energy feed units.

The results demonstrate the superiority of wheat as a feedstock over barley grain.

In the conditions of intensification of animal husbandry, the productivity of animals largely depends on the concentration of exchange energy in the unit of dry matter of the feed produced. A significant difference was established between the indicators of the content of exchangeable energy. It was recorded that the amount of exchangeable energy per unit of dry matter was higher in the molasses from wheat grain by 0.3 MJ than in the molasses from barley (table 2).

The difference in the concentration of raw and digestible protein is 6 and 4.3 g kg⁻¹, respectively, in barley and wheat molasses.

As a result of assessing the quality of the finished product, it was found that the content of crude fiber in barley molasses is 0.71% higher than in the finished wheat product. The initial barley grain contained about 6% of crude fiber, therefore it is introduced into the ration with other types of grain with low fiber content.

Easily digestible carbohydrates (sugar, starch) are of great importance in the nutrition of dairy cows, due to which up to 70% of energy needs are replenished and which are the main precursors of milk. The quality of the molasses feed largely depends on the amount of sugar in it. It was established that the sugar content in wheat cereal syrup under the action of the hydrolysis of polysaccharides was higher by 29 g than in the barley grain product.

When using molasses as a source of sugar, it should be borne in mind that its excess in the diet of ruminants, especially dairy cows, is undesirable. The content of simple sugars in the crushed grain does not exceed 1.5%.

According to the recommendations of A. P. Kalashnikov [21], sugar-protein ratio should not be lower than 0.8:1.0. However, N. V. Kurilov [22] notes that the nutrients of the diets of highly productive animals are used better when the sugar ratio is 1.2-1.5:1.0. Reducing it to 0.4-0.6, as well as an increase to 2.4, leads to a significant deterioration in the absorption of nutrients.

The amount of starch was 46.7 and 43.3 g kg⁻¹ in the finished product from barley and wheat, respectively, which is 3.4 g kg⁻¹ lower. This is probably due to the fact that during enzymatic activity starch breaks down into simpler components. The sugar content in cooked cereal syrup directly depends on the starch content in the original grain.

Our findings suggest that wheat grain is more suitable for the production of grain syrup from it. However, in terms of the usefulness of protein, palatability, and productive action, the grain of barley exceeds the grain of wheat (raw material).

The chemical composition of grain syrup obtained from barley grain in an air-dry state is as follows: exchange energy of 9.40 MJ, crude and digestible protein 11.47% and 85.0%, respectively. The crude fiber content is 5.23% (table 3).

The chemical composition of grain syrup derived from wheat: metabolic energy 9.56 MJ, crude protein 12.57%, digestible protein 93.0 g kg⁻¹ and crude fiber 2.33%. In addition, 1 kg of the product contains 299.0 and 133.0 g, respectively, of sugar and starch. Thus, the content of basic nutrients in wheat cereal is significantly higher than in the finished product from barley. These indicators show an active enzymatic effect on the chemical composition of wheat compared to barley grain.

4. Conclusions

On the basis of the conducted research, it is possible to recommend the preparation of grain syrup in the conditions of an economy from local grain raw materials. Strict observance of technological modes of preparation of grain molasses provides high safety of nutrients in it and their availability. In terms of feed value, the finished wheat product in basic nutrients is superior to molasses prepared from
barley grain. It is recommended to feed the prepared cereal from feed grains of cereals to farm animals without additional processing (sterile and safe product). In addition, the prepared molasses can be mixed with the main diet in a mixer-feeder, as well as poured into roughage. It is necessary to reduce the grain portion of the diet. The results of the research can be useful for specialists working in livestock complexes.

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