Study of drying conditions effect on the quality of products based on grain stillage

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Abstract. Actual alcohol production technology provides full processing of grain stillage into food and feed products: dietary fiber, dried distillers grains, fodder yeast. The quality of these products is significantly affected by the parameters of the drying process. Using the example of grain stillage, the authors studied the effect of temperature on the content of its composition: protein, carbohydrates, fiber, etc. It is shown that with an increase in temperature, the destruction of grain stillage components occurs. To minimize quality loss, the drying process must be carried out at a temperature of 100 - 150 °C.

1. Introduction
Actual ethyl alcohol technologies provide integrated grain processing, including stillage treatment into food and feed products: dietary fiber, dried distillers grains (DDG), fodder yeast, etc. [1,2] The final stage of product obtaining in a marketable state is the drying process. In real practice, pre-concentrated dispersed cake with a moisture content of 68-72% is exposed to drying. In the process of drying, due to thermal action, moisture is removed to the required values of 10 - 12%, which guarantees a product shelf life of at least six months [3-5]. The qualitative composition of products based on grain stillage is shown in table 1.

The drying process can be carried out in dryers of various designs in a wide temperature range (90-500 °C) and duration from 10 seconds to 1.5 hours or more. For drying process, the product moisture content must be reduced without reducing its quality. Unfortunately, it is practically impossible to avoid the negative impact of drying parameters on the components contained in the dispersed cake of grain stillage (culture liquid).

According to the research in this field, increasing temperature and increasing duration of heating changes the degree of coagulation proteins. At high heating, the destruction of dissolved proteins and amino acids can occur with the accumulation of amino nitrogen. Destruction of amino acids, including essential at high temperatures for excessive time, reduces the feed and food product value.

High-temperature heating also results in fat oxidation and thermal polymerization. The resulting carbonyl compounds have toxic properties [6,7].
Table 1. Composition of stillage processing products.

| Indicators                     | Dietary fiber | DDG   | Feed yeast |
|--------------------------------|---------------|-------|------------|
| Solids content, %              | 10-11         | 10-11 | 10-11      |
| Crude protein, g/absolutely dry matter | 34 - 39       | 27 - 34 | 43 - 48   |
| True protein, g/absolutely dry matter | 32 - 38       | 25 - 31 | 32 - 41   |
| Carbohydrates, %               | 0.4 - 0.8     | 4 - 6 | 0.1 - 0.15 |
| Cellulose, %                   | 52 - 54       | 12 - 15 | 5.5 - 11.5 |
| Fat, %                         | 5.5 - 7.5     | 5 - 7 | 1.3 - 1.8  |
| Ash, %                         | 8 - 9         | 5 - 6 | 1.9 - 3.6  |
| Amino acids, g/absolutely dry matter |             |       |            |
| Lysine                         | 1.7           | 0.85  | 1.91       |
| Methionine                     | 0.81          | 0.7   | 1.93       |
| Threonine                      | 1.49          | 1.16  | 2.28       |
| Vitamins, mg/100g:             |               |       |            |
| B1 (thiamine)                  | 0.24          | 0.79  | 1.82       |
| B2 (riboflavin)                | 0.64          | 15.56 | 10.52      |
| B6 (free pyridoxine)           | 0.51          | 1.12  | 1.64       |
| Macronutrients, mg/100g        |               |       |            |
| Calcium                        | 194           | 130   | 205        |
| Potassium                      | 516           | 90    | 611        |
| Magnesium                      | 501           | 195   | 232        |

The process of changing taste and smell is also significantly influenced by the formation of aldehydes, volatile fatty acids, and other compounds. The rate of the melanoidin formation reaction is accelerated, both due to the high temperature and due to the increase in the number of free amino acids and glucose.

The destruction of vitamins when heated can be different. The least stable are vitamins C, D, thiamine, nicotinic and pantothenic acids. Vitamins A, E, K, B are more heat-resistant.

Component composition of dietary fiber and dry grain stillage mainly depends on the starting materials, modes of its processing, and yeast biomass synthesized in the fermentation process. Fodder yeast is additionally enriched with the biomass of the microorganism strain used for protein cultivation, and the its metabolism products.

The main components that determine the nutritional and energy value are protein substances, primarily amino acids, as well as vitamins, fiber, carbohydrates. In the studied products, the qualitative composition of the main nutritional components is practically the same, the difference lies in their quantity [1,2,8,9].

The objective of the research work was to study the effect of drying temperature on the quality indicators in products of grain stillage treatment.

2. Materials and methods

Taking into account the homogeneity of the component composition in the analyzed products, the studies were carried out on wheat stillage, since this raw material and the dry grain stillage obtained on its basis are the most widely-distributed in alcohol production. As already noted, the optimal mode of the drying process should preserve the nutritional value of the product, while reducing the moisture content to 10 - 12%.

After distillation of alcohol, samples of grain stillage were concentrated to a moisture content of 68 - 70% and then subjected to heat treatment (drying) in the temperature range - 100 - 250 °C and bringing the moisture content to 10 - 11%. At the end of the drying process in the test samples, the quantitative
and qualitative composition of the main components was monitored: crude protein and true protein by the Kjeldahl method. The carbohydrate content was determined by the colorimetric anthrone method, fat by high-performance liquid chromatography, ash by ashing, fiber by removing acid-alkali-soluble substances.

3. Results and discussion
The research results are shown in table 2.

| Indicators                        | Initial grain stillage | Dried distillers grains |
|----------------------------------|------------------------|-------------------------|
|                                  |                        | Drying temperature, °C  |
|                                  |                        | 100 | 150 | 200 | 250 |
| Dry matter                       | 7.8                    | 89.2 | 89.6 | 90.0 | 90.1 |
| Crude protein, % on absolutely dry matter | 34.6                   | 34.1 | 33.5 | 32.8 | 28.4 |
| True protein, % on absolutely dry matter | 31.2                   | 30.7 | 29.8 | 28.7 | 24.2 |
| Carbohydrates                    | 0.6                    | 6.57 | 6.4  | 5.6  | 4.2  |
| Cellulose                        | 1.16                   | 13.16 | 12.9 | 12.5 | 11.8 |
| Fat                              | 0.47                   | 5.4  | 5.3  | 4.9  | 4.5  |
| Ash                              | 0.48                   | 5.5  | 5.6  | 5.8  | 6.2  |
| Color                            | Light brown            | Light brown | Yellow brown | Brown | Dark brown |

A number of factors affect the drying process of the wet cake of distillery stillage and the quality of the resulting product: temperature, duration, rate of mass transfer. Temperature is the most effective parameter determining the speed of the process and simultaneously negative impact on the quality of the product - Dried distillers grains. Research results show that at a temperature of 100 °C the main quality indicators - protein and true protein change insignificantly, by 1.5 - 2%. An increase in the drying temperature to 150 °C reduces these indicators by 3.2 - 4.5%. With increasing temperature, the destruction process increases. At 200 °C, the losses are 5.2 - 8.0%, and at 250 °C: 18 - 22.5%. A similar trend, but to a lesser extent, occurs with carbohydrates and fiber. It increases the ash content at 250 °C by 12%. At the same time, the color of the dry product changes. At 100 - 150 °C it has a light and yellow-brown color, and at 250 °C, it becomes dark brown with the presence of a burnt odor.

4. Conclusion
In the drying process of products received on the basis of grain stillage, destructive processes occur, which negatively affect its quality. The negative influence degree increases with temperature rising, especially in the range of 200 - 250 °C. According to the results of the studies, in order to preserve the quality of products obtained of grain stillage, the drying process should be optimally carried out in the temperature range of 100 - 150 °C. Exceeding the drying temperature will be accompanied by the destruction of useful components. The drying temperature at 200 °C should be considered the limiting one. An important reserve for reducing the loss of useful components is drying process duration reducing. Research on this issue is continuing.

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