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ARTICLE

OVERVIEW OF ROUGHAGE FEEDS PROCUREMENT TECHNOLOGY

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ABSTRACT

A study of the drying process by means of active ventilation carried out by the authors allows concluding that the patterns of water-yielding capacity in cut plants and changes in the quality of the dried mass at individual stages of drying depend on the properties of the plants themselves and the methods of drying. Knowing these patterns allows choosing the best drying conditions, as well as technological tools for various climatic conditions and various types of crops. The criterion for the process of removing moisture from the dried material by means of active ventilation includes obtaining high-quality conditioned feed at the maximum performance of the equipment while maintaining its nutritional value. When drying with heated air or with gas-air mixture, thermal and moisture conductivity provides additional resistance to moisture movement. To eliminate this resistance, it is necessary to apply low temperatures and an increased speed of the drying agent at the beginning of drying; this ensures faster and more uniform heating of the product. Modern drying methods are characterized by intensification of heat and mass transfer processes, which is achieved in various ways: by increasing the contact surface between the dried product and the drying agent; decrease in relative humidity of the drying agent; the use of combined heat supply; increasing the speed of movement of the dried material and drying agent; a combination of dehydration with various technological processes, etc. Therefore, taking into account the influence of all the objective laws, during research, special attention should be paid to the improvement of the technology and necessary equipment for procurement of roughage feeds using cheap sources. In connection with the foregoing, the task was to study the uniformity of the distribution of the air agent through the air distribution channel to stabilize the forces of aerodynamic resistance to air flow that arose in the dried mass when using infrared burners as thermal energy, which made it possible to substantiate the design of the dryer and optimize the design and technological parameters of the drying.

INTRODUCTION

KEY WORDS
humidity, moisture exchange, drying, herbs, dehydration

In modern conditions, the main task of agricultural producers should be the procurement of high-quality feed containing maximum nutrients used by the body of the animal to produce meat, fat, milk, etc. [1-9]. Currently, the need for animal feed is not fully satisfied. Production of feed per one conditional head of cattle had been 21.5 - 23.5 cwt of feed units per year during the last twenty years, which was significantly lower than the normative indicator (35-40 cwt of feed units), and their consumption during this period was 71-80% of the norm. Therefore, special attention should be paid to the intensification of feed production [2, 4, 5, 7, 10]. However, at present not all farms have the necessary equipment and technologies [5-14], therefore, it is necessary to prepare appropriately the feed maintaining high level of vitamins. As a consequence, the cost of feed production per unit of the final product is increased by 1.5–2 or more times, as well as the cost of feed itself [5-9]. From studies carried out at different times [1-9], we know that vitamins play the role of unique biological catalysts in animals.

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The experience of livestock breeders in Holland, Switzerland, and other countries shows that grazing of dairy cows on grass is the cheapest method of producing milk. Farmers and researchers invest large amounts of money in the improvement of technologies for production and cultivation of crops [5-9]. Costs pay off with interest. Some farmers obtain even more milk in the winter than in the summer by feeding their livestock with roughage. Concentrates are used sparingly, especially since grain prices are quite high. The most used are green grass, haylage, silage, and hay obtained from cultivated land. In other words, today, it is possible to increase the production of milk and meat at least by a factor of 1.5, if a natural forage field is used. The potential of Russian meadows is very high. Russian lands are able to feed herds in the summer and significantly replenish feed supplies for the winter, but their rich potential is poorly used. [5-9].

Therefore, the research was aimed at increasing the quality of feed preparation by improving the technological process and technical means of their drying in the farm [5-7, 9, 12, 13].

ORGANIZATION OF THE TECHNOLOGICAL PROCESS OF FEED PREPARATION

Factors influencing the feed preparation technology

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Haymaking at farms of various forms of ownership takes place in various climatic conditions, which affects both the amount of hay harvested and its quality. It should be remembered that high-quality hay is

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especially necessary for highly productive animals – dairy cows, beef cattle, etc. Therefore, in order for the productive potential of animals to be high, it is necessary to properly organize the technological process of the roughage procurement.

The complexity of solving the problem arising from the variety of factors causing losses during hay harvesting still does not allow developing a unified methodology for their accounting and applying it to determine the most accurate quantitative indicators under various conditions and methods of roughage procurement. Most researchers who analyze the causes of nutrient loss in procured feeds agree that the most valuable parts of plants are leaves, inflorescences, and the thin parts of stems that are of great nutritional value. However, they dry faster than the bulk of the stems and, unfortunately, when tedding, raking, and other manipulations with the hay during the harvesting process, they easily crumble and are permanently lost. Leaves contain 2-3 times more protein than stems [5, 8]. According to Shain and Borinevich, the leaves of various types of legumes contain 23.4-31.4% of protein, while the stems contain 9.05-11.2% [5, 8]. These parameters are lower for grasses and amount to 4-8%. If the plant mass is exposed to rain during harvesting the losses might increase sharply.

In the course of improving the drying methods, it turned out that moisture removal during drying takes place only in certain drying regime conditions, such as the rate of the air supply, the moisture absorption capacity of the air, and the loss of air pressure in the hay layer. Therefore, to obtain hay with high nutrient content, it is necessary to study the interrelation between the main structural and operational parameters of the equipment used for the procurement [5-9].

Therefore, in modern conditions, the technology should be as cost-effective as possible and contribute to the reduction of the costs per unit of the final product [5-9]. At the same time, the improvement of the existing technologies should ensure their cost-effectiveness.

Mechanical drying

An analysis of the studies shows that a decrease in the moisture content of the object being dried can be achieved in different ways. In the case of expression (mechanical method), the slightly expressed plant mass is laid out for 3-4 hours in a thin layer, which is constantly tedded and then stored. However, this method has a drawback. Nutrients are removed from the mass being dried along with the moisture. Absorption is a contact method, which uses a moisture-absorbing substance. The mass being dried is interlayered or mixed with any other (dry) moisture-absorbing substance. However, in this case, the quality of the procured product decreases.

Chemical dehydration

According to the literature, the chemical method of dehydration was tested with regard to the crop being procured, both directly at the grassroots and after cutting or harvesting. Published research data showed that no promising results were obtained.
This method involves the use of various chemicals. Their use does not lead to direct drying of the material, these substances only act as antiseptics that prevent the development of mold on the mass being dried.

Thermal drying

The most widely used method is thermal drying – thermal removal of moisture. It is simple and affordable for drying of various capillary-porous colloidal objects. Moisture, in this case, is removed in various ways. It can be done directly in the field by air drying and subsequent final drying at the farm using active ventilation. It can be done at the farm by using kiln-drying or final drying with the use of high temperature, using intensive drying with heated gas or other drying agents, using heat treatment of material by high-frequency currents or infrared rays, and by gas dehydration by cooling it below the dew point temperature.

The water-yielding capacity of a material, the quality of the resulting product, and its ability to maintain all its properties at different periods of drying and during further storage depends on the drying methods used [5, 8].

Analysis of these methods allows us to conclude that the drying of crops is subject to a number of requirements arising from the requirements for the finished product.

If we know technological features of the drying process, we can trace and investigate the patterns of moisture return in cut plants and changes in the quality of the dried mass at various drying stages with regard to the properties of the plants. This, in turn, will allow choosing the necessary dryer design, the best drying mode, as well as technological tools in various climatic conditions and for various types of crops.

An essential condition for high-quality hay production with the use of forced ventilation is the uniform passage of the drying agent through the layer of dried hay.

Therewith, it is reasonable to use enclosing structures (ground and subsurface trenches, etc.). This way the influence of wind can be eliminated. However, this causes a new problem of uneven airflow across the width and length of hay piled on the air channel [5, 8].

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Therefore, the experimental research methodology was as follows:
1. Obtaining experimental values for choosing the optimal power of the emitter and fan, depending on the thickness of the dried layer.
2. Determining the uneven temperature distribution of the drying agent on the surface of the grating depending on the different power of the IR emitters.
3. Determination of the optimal design of the device for the drying of crop products.
In accordance with the goals and methods of experimental studies, it was planned to conduct experiments in three stages: a laboratory experiment, a laboratory field and field (production) experiment.

QUALITY OF FEED PREPARATION DUE TO IMPROVEMENT OF THE TECHNOLOGICAL PROCESS

Theoretical substantiation of the possibility of improving the feed preparation quality

The mechanics of gases is the science of the laws of motion and equilibrium of gases. When transferring heat from combustion products to the objects being heated (when airflow heaters are used), it is necessary to take into account a large number of different factors, including the nature of the movement of combustion products. Therefore, one of the conditions for the effective operation of the drying assembly is the rational organization of the movement of gases. Knowing the laws of gas mechanics, it is possible to determine the resistance created by moving gases in the dryers, air distribution channels, etc. The fans are selected based on these calculations [5-9].

The laws of fluid motion help to study the movement of the gases in the dryer. The volume of liquid, in this case, in contrast to the volume of gas, is practically independent of temperature and pressure. The variation of gas motion (which obeys the laws of fluid motion) is low if the pressure and temperature of the moving gas are constant. The nature of the movement of the jets leaving the nozzles, burners, or air distribution ducts is determined by the nature of the movement of gases in the working space of the dryers (which operate on gaseous and liquid fuels), as well as air heated in electric heaters. Therefore, the main properties of the jets depend on the proper organization of the movement of gases or a drying agent in the dryers.

In other words, the movement that occurs due to the dynamic action of the jets is called streamline motion. Therefore, the movement of the drying agent inside the assembly is organized based on the properties of free and confined jets with regard to the requirements for the thermal operation of dryers.

However, the movement of gases in the working space of the dryers can be characterized as a channeled motion. In this case, the movement is made possible due to the potential energy of the flow. The movement of gases in the air distribution duct occurs in the horizontal channel due to a decrease in static pressure or due to a decrease in geometric pressure.

During the drying process, the drying zone constantly moves as the flow of the drying agent passes through the layer being dried. The speed, at which this zone moves, determines the kinetics of the drying process. Provided that there is equilibrium below and above the drying zone, the kinetics of the process are constant and can be determined by the amount of supplied air per unit of time (usually m3/h). The forces of aerodynamic resistance to airflow that occur in the dried mass due to the fact that it is porous and a certain laminar and turbulent airflow around a porous barrier is present can be calculated using the following formula [5, 8]:

$$F_{aero} = S_{lam} \times V + C_{turb} \times \cdot V2$$

where V is the air velocity (m/s) and Slam and Sturb are the aerodynamic coefficients for laminar and turbulent airflow, respectively.

Therefore, it is impossible to completely remove moisture from the mass being dried under normal drying conditions using the method of active ventilation. In addition, the residual humidity of the capillary-porous object depends on the humidity of the supplied drying agent (j). That is, if the theoretical drying agent humidity is j = 0, then the residual moisture content of the capillary-porous object will be W = 0, accordingly. However, in actual practice, j>0 and; therefore, W>0. Accordingly, the moisture value of the supplied drying agent should correspond to a very specific value of the residual moisture of hay in equilibrium. This moisture content of the plant mass is called equilibrium moisture content [5, 8].

The effect of fan power on high-speed air flow

Before starting experimental studies of the temperature distribution of the drying agent on the surface of the grating, it is necessary to find out the optimal speed regime. Acceleration of drying the sunflower is necessary as the higher the flow rate is, the faster the drying process is. However, it should be taken into account that the speed of air passing through the grating must be certain in order to prevent the drying of the sunflower lower layer out. Optimization of the air flow rate is achieved, as a rule, by regulating the fan motor power. By changing the power at any time, it is possible to achieve the optimal flow distribution rate on the surface of the grating. For this, experiments were carried out in a laboratory setup. Based on the obtained experimental data, dependencies were constructed.

Temperature distribution depending on the IR emitter power

Before starting experimental studies of the uniformity of the air temperature distribution on the surface of the grating, it is necessary to find out the influence of the IR emitter power, at which the heating of the air flow will be most optimal for seed sunflower drying, that is, the temperature of the air flow should not be more than 4000C. Therefore, experiments with IR emitters with different powers were carried out in a laboratory setup. As a result, emitters with the power of 1.5 kW, 2.3 kW and 3.6 kW were selected. The optimum air flow rate was set at 7.6 m/s and remained constant with each emitter of a certain power. On the basis of processed experimental data, the dependences of the uniformity of the temperature distribution on the emitter power were built.

PRACTICE AND PROSPECTS FOR IMPROVING AIR DISTRIBUTION SYSTEMS

Scientific studies in the field of improving air distribution systems, as well as the use of infrared radiation, were developed in the mid-forties and fifties of the last century [5-7, 9, 12, 13]. In addition, many researchers were engaged in improving the technology and technical means for drying [1, 3, 15-29]. The result of these studies was the creation of industrial plants for the heat treatment of bulk materials. Nowadays, various air distribution installations are produced by a number of companies, in particular, SOF Tech Service LLC (Moscow), OPKTB SibNIPTIZh (Novosibirsk region), Start LLC (Moscow region), Russian Food Corporation (Leningrad region), and even by artisan workshops. The infrared drying technology is actively developed by the following companies: in Ukraine - NPK BND LLC (Dnepropetrovsk), SPKB MeNas (Kiev); in Kazakhstan - Vibromash LLP (Ust-Kamenogorsk); in Uzbekistan - Keramika Syntez LLC (Tashkent); in Belarus –VAEM LLC (Minsk). By analyzing abstract publications and Internet data [10, 30-33], it can be concluded that there are few studies in the field of improving air distribution systems, as well as the use of infrared heating when drying feed. In any technological operation associated with the heating of the product, as a rule, all types of heat transfer (conductive, convective, and radiation) take place [5, 7]. In this case, the fraction of radiant heat transfer increases with temperature. An analysis of existing studies shows interest in this component and is present in many works [16, 21, 23, 28]. The use of distributors of the drying agent inside the installation and heat treatment of the dried material, including with IR energy supply, allows identifying promising areas for improving equipment and technology of drying aimed at maximizing the preservation of the original consumer or technological properties of the product.

These data are necessary to correctly apply the well-known I-d diagram in the calculations of the adiabatic drying process of plant material using active ventilation [5, 8].

CONCLUSION

According to numerous studies in various countries, during the development of new systems for the drying of agricultural products using active ventilation, it is essential to reduce dynamic pressure and increase static pressure. This can be achieved by reducing the speed of the drying agent in the air distribution channel by installing distributors in its path. This will reduce the air pressure as a result of mixing the flow of the drying agent and the aerodynamic impacts that occur when the flow direction changes.

Considering the above, it can be assumed that all technological methods that are used to maintain the quality of agricultural products of plant origin being procured should ensure the highest possible preservation of useful nutrients when choosing rational schemes for supplying and removing a drying agent. Improvement of the existing equipment that is used in the procurement of crop products is important. Moreover, the characteristics of the material as a drying object, the range of equipment produced, the features of modern agricultural production, and the operating modes of the equipment used for active ventilation should be taken into account, thereby reducing possible quality losses of procured products.

CONFLICT OF INTEREST
None.

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