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Research of Vacuum Honey Drying Processes

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***Abstract* — The article is devoted to the effective mode selection for vacuum honey drying. There were studied an impact of the drying layer thickness and heat flux density on the efficiency of vacuum honey dehydration. Experiments on vacuum drying of honey were carried out at a heat flux density from 2 to 10 kW/m^2. The dependences of the relative product mass on the vacuum drying process duration were obtained. If a heat flux density increases, the drying time reduces: when a heat flux density was 2, 4 and 6 kW/m^2, the drying time lasted for 270±10, 240±10 and 225±10 min respectively; while at a heat flux density of 8 and 10 kW/m^2, the time was 210±10 and 195±10 min, respectively. At the same time, the moisture content of the dehydrated product also changes: an increase in the heat flux density from 2 to 10 kW/m^2 leads to the moisture content changes from 4.5 to 5 %. Experimental studies were carried out on vacuum honey drying at a product layer thickness of 5 to 20 mm. It was established that an increase in the layer thickness entails an increase in the drying time, an increase in the moisture content of the dehydrated product, and a decrease in its quality. However, this increases the productivity of the drying unit. Based on the studies, the following effective modes of vacuum honey drying were determined – heat flux density – 4 kW/m^2, product layer thickness – 15 mm. It is advisable to dehydrate honey at a residual pressure of 4±0.5 kPa and at a temperature of 40 °C in the drying chamber. Under these conditions, the drying time is 275±10 minutes, and the organoleptic evaluation of the dry product is 34 points out of 40.**

***Keywords* — vacuum honey dehydration, mode selection, vacuum drying process.**

I. Introduction

Bee honey is a biologically active product, the advantage of which is not only high energy value (on average it is about 300–340 kcal per 100 g), but also it obtains a large number of valuable minerals, enzymes, vitamins, organic acids, aromatic and antimicrobial substances causing its healing properties [1, 2].

One of the advantages of this product is the fact of its 100 % absorption by the body, unlike most other sweet foods. Ripe honey contains not more than 21 % water, about 35 % glucose, 40 % fructose, 1.3 % sucrose, 0.45 % protein, 0.1 % organic acids and 0.2 % minerals [3].

Honey always contains pollen, which enters nectar during the movement of a bee and additionally enriches the product with vitamins, minerals and proteins. Honey contains all B vitamins, as well as vitamins A, H, nicotinic acid and biotin. About 40 micro and macro elements were found in this product, including potassium, calcium, cobalt, iron, phosphorus, honey, magnesium, manganese, aluminum, iodine, zinc, etc. Moreover, the concentration and ratio of some micro elements in honey corresponds to those in human blood, which defines its rapid assimilation [4–6].

For technological reasons, or to avoid biochemical changes that occur in honey due to the presence of a certain amount of moisture, there is a need for dehydration of this product.

The traditional method of honey dehydration is a convective method, which involves direct contact of the product with heated air. It is not recommended to exceed a temperature of 40 °C to preserve biologically useful components.

An alternative method of drying is vacuum dehydration. As a result of lowering the pressure, the boiling point decreases and the rate of moisture removal increases [7].

II. Purpose and objectives of research

The purpose of this research was to study the processes of vacuum honey drying under various conditions.

Within the aim framework, the following objectives were set:

- kinetics analysis of the process of vacuum honey drying;
- study of the influence of technological parameters on the efficiency of vacuum honey drying process;
- selection of effective modes of vacuum dehydration of honey.

III. Methods and Objects of Research

The object of the carried research was natural buckwheat honey produced by Bashkir Honey Company. Organoleptic characteristics of the studied object are shown in Table 1.

TABLE I. ORGANOLEPTIC CHARACTERISTICS OF HONEY

Indicator	Characteristics
Taste	Sweet, pleasant, lack of extraneous tastes
Color	Light Amber
Odor	Particular, odorless
Consistency	Syrupy consistency

To carry out these experimental studies, a vacuum drying unit was used, the scheme of which is shown in Figure 1.

All the experiments were conducted in the vacuum chamber at the following conditions: temperature – 40±2 °C, residual pressure – 4±0.5 kPa. Every experiment was carried out in triplicate to obtain more reliable results. Data was processed in Microsoft Excel software.

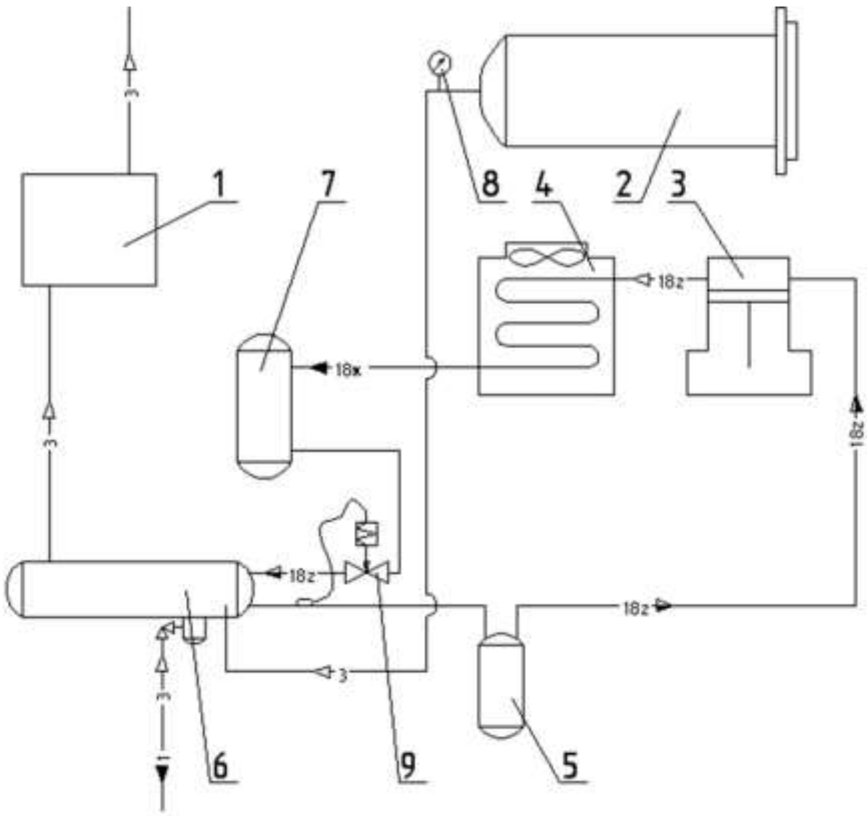

Fig. 1. Scheme of an experimental vacuum drying unit: 1- vacuum pump; 2 – a drying chamber; 3 – compressor; 4 – capacitor; 5 – liquid separator; 6 – desublimator; 7 – receiver; 8 – a vacuum gauge; 9 – thermostatic valve

IV. Results and Discussions

Initially, vacuum drying process was carried out at different heat flux densities. This parameter was varied in the range from 2 to 10 kW/m^2 in increments of 2 kW/m^2. The thickness of the drying layer was 10 mm.

Figure 2 shows graphs of changes in the relative mass of honey during the vacuum drying process at different heat flux densities, and Figure 3 presents the rate of relative mass changes.

The entire vacuum drying process can be conveniently divided into three periods – a) period of the vacuum drying unit entering the needed mode, when there is a gradual increase in the rate of moisture removal, b) period of constant drying rate, at which most of the moisture is removed and c) period of the falling drying rate. With an increase in heat flux density, the drying time decreases: with a heat flux density of 2, 4 and 6 kW/m^2, the drying time was 270±10, 240±10 and 225±10 min, and with a heat flux of 8 and 10 kW/m^2 the drying time was 210±10 and 195±10 min, respectively. At the same time, the moisture content of the dehydrated product changes as well: with an increase in the heat flux density from 2 to 10 kW/m^2, it rises from 4.5 to 5 %.

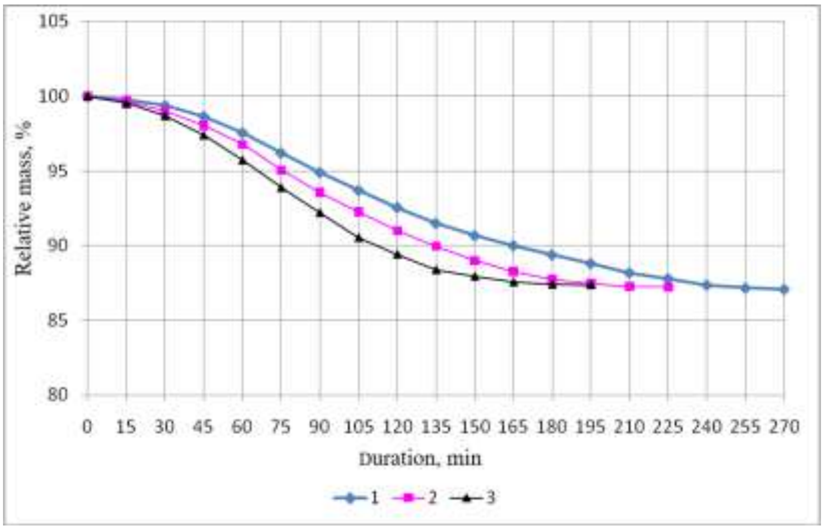

Fig. 2. Graphs of honey relative mass changes during the vacuum drying process at a heat flux density of: 1 – 2 kW/m^2; 2 – 6 kW/m^2; 3 – 10 kW/m^2

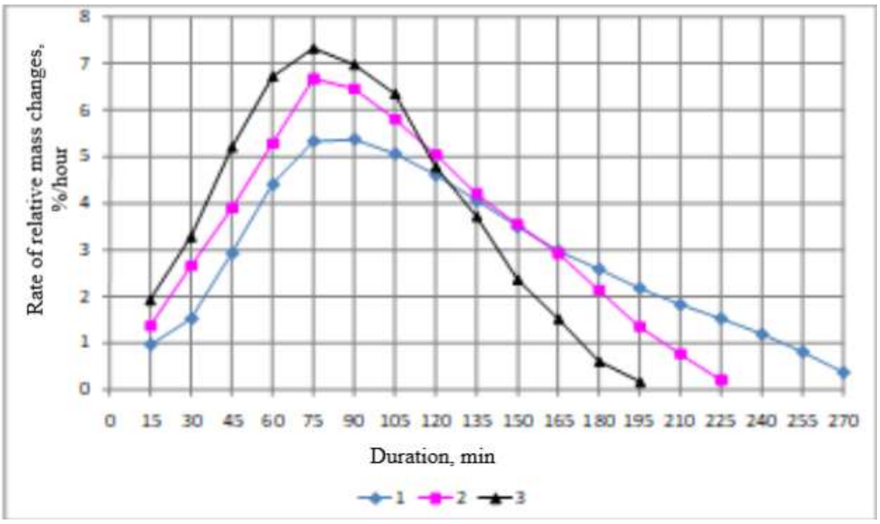

Fig. 3. Rate of relative mass changes during the vacuum honey drying process at a heat flux density of: 1 – 2 kW/m^2; 2 – 6 kW/m^2; 3 – 10 kW/m^2

Further, an organoleptic evaluation of dehydrated honey was carried out. The assessment included such indicators as taste, texture, smell and color; they were evaluated on a 10-point scale. Table 2 shows the results of this assessment.

TABLE II. RESULTS OF THE ORGANOLEPTIC EVALUATION OF DRY HONEY, POINTS

Indicator	Heat flux density, kW/m^2				
	2	*4*	*6*	*8*	*10*
Taste	8	8	7	7	7
Color	9	9	8	8	8
Odor	9	9	9	8	7
Consistency	10	9	9	8	6
Total score	36	35	33	31	28

The lower the heat flux density is, the more uniform the distribution of the temperature field in the product is ensured at the initial stage of drying, which is especially beneficial for such an indicator as consistency. At high values of the heat flux density, the consistency of the dehydrated product became heterogeneous; this fact was reflected in the quality indicators. Based on the above data, it is possible to conclude the feasibility of vacuum honey drying at a heat flux density of 4 kW/m^2, as this mode provides a relatively high organoleptic evaluation, the correct consistency of the final product and a short duration of dehydration (240 min).

At the following stage of the research, experiments were carried out on vacuum honey drying at different layer thickness: 5, 10, 15, and 20 mm. The other drying parameters remained unchanged, the heat flux density was 4 kW/m^2. Table 3 shows the indicators of vacuum drying of honey when selecting the layer thickness.

TABLE III. INDICATORS OF VACUUM HONEY DRYING WHEN SELECTING A LAYER THICKNESS

Indicator	Layer thickness, mm			
	5	*10*	*15*	*20*
Duration of drying, min.	180	240	275	300
Moisture content, %	4,3	4,6	4,9	5,4
Organoleptic evaluation, points	37	35	34	31

It was found that the increase in the layer thickness entails an increase in the drying time, an increase in the moisture content of the dehydrated product and a decrease in its quality. However, this increases the productivity of the drying unit, which is especially important for the organization of industrial production of dried honey. It is advisable to dry with a layer thickness of 15 mm. The moisture content of the product does not exceed 5 %, the organoleptic rating is 34 points out of 40, and the duration of dehydration is 275±10 minutes.

V. CONCLUSION

Thus, on the basis of the conducted studies, the following effective modes of vacuum honey drying were determined: the heat flux density – 4 kW/m^2, the product layer thickness – 15 mm. It is advisable to dehydrate honey at a residual pressure of 4±0.5 kPa and a temperature in the vacuum chamber of 40°C. Under these conditions, the drying time is 275±10 minutes, and the organoleptic evaluation of the dry product is 34 points out of 40.

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