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VACUUM COOLING OF BISCUIT SEMI-FINISHED PRODUCTS

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Abstract: *The paper reviews advanced cooling method of biscuit semi-finished products under vacuum. It is established that the duration of cooling of biscuit products is reduced from 30-40 minutes to a few minutes, at cooling with a temperature of 20°C and relative humidity φ 75%. Also there is no need to use its standing. The influence of the regime parameters of the vacuum cooling on humidity, temperature and structural-mechanical parameters of biscuit semi-finished products has been investigated. During storage of finished biscuit products for 72 hours, the loss of moisture by blanks cooled by vacuum evaporation method was 0.7% less than the cooled by convection method and after standing for 8 hours. Pressure plays an important role in the quality of the cookie semi-finished product. In particular, reducing the pressure under dilution conditions to 3 kPa leads to a decrease in the cooling temperature of the finished biscuit semi-finished product to 24 ° C, reducing the time during which it cools from 480 to 2-5 minutes, increasing the elastic deformation by stabilizing the structure of the finished product. Samples cooled by the vacuum evaporation method had better structural and mechanical quality indicators compared to the samples cooled by the convection method and after standing for 8 hours.*

Keywords: *Vacuum cooling, Biscuit, Physico-chemical parameters of quality, Heat-mass transfer.*

INTRODUCTION

Advanced way of intensifying the technological process of food production, including biscuit semi-finished products, is the use of vacuum evaporative cooling (VEC). The principle of which is to cool the moist material with high vacuum and vapor permeability due to moisture evaporation during adiabatic boiling as a result of reducing the pressure of the environment.

Cooling in vacuum conditions occurs when the pressure of the working environment of the vacuum cooler decreases, the value of which depends on the amount of moisture removed from the biscuit semi-finished product and its final temperature.

The purpose of the research is to determine the regime parameters of vacuum evaporative cooling, which provides the required humidity, temperature and structural and mechanical characteristics of the quality of biscuit semi-finished products for their further processing.

EXPOSITION

Laboratory installation and experimental procedure

Investigation of the vacuum-evaporative cooling process was carried out on laboratory plant (Fig.1), which consists of an oven with radiation convection heating, which loaded biscuit dough billets 2 with height-adjustable copper-constantan thermocouples. Tensometric scales 3 were used to determine the value of moisture loss. The values of the temperatures in the blanks and weights were determined using the analog module ICP CON I-7018 6 and the data conversion module ICP CON I-7520 7 in the baking process they were registered at computer 5.

The freshly baked biscuits, together with thermocouples, were loaded into a vacuum evaporator cooler 8, where a vacuum was created by a vacuum system consisting of a vacuum pump 9, a receiver 10, a condenser 11, and a corresponding shut-off and adjusting armature.

Experiments were carried out at these values of the final pressure of the medium vacuum chamber - 3, 5, 10 kPa. The vacuum value was set and maintained by an electrically contact vacuum manometer 12. The change in the mass of the workpiece after vacuum evaporative cooling was determined on the laboratory strain gauge weights 3.

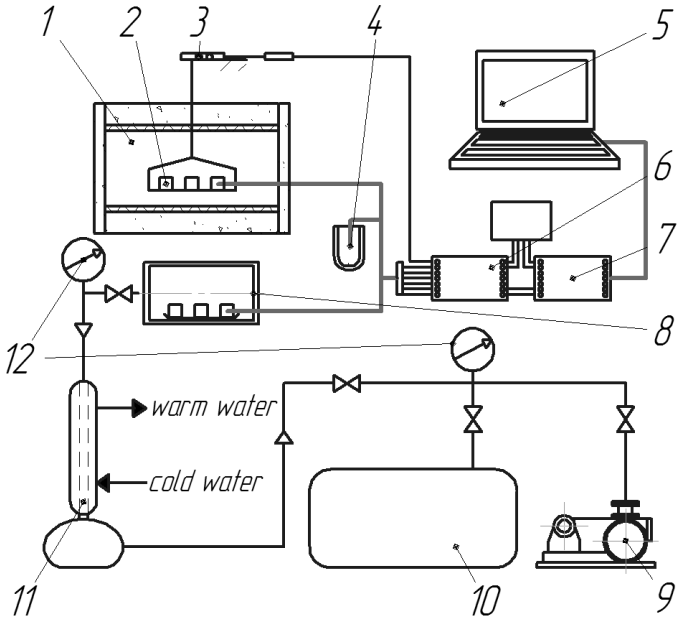

Fig. 1. Laboratory installation for vacuum evaporative cooling of biscuit wares:
1 – oven; 2 - biscuit billets; 3 - strain gauge scales; 4 - Dewar vessel; 5 – computer; 6 - ICP CON I-7018 analog module; 7 - ICP CON I-7520 data conversion module; 8 - vacuum evaporative cooler; 9 – vacuum pump; 10 - receiver; 11 - capacitor; 12 - electrocontact vacuum gauge.

RESULTS AND DISCUSSION

From literature sources it is known that the process of vacuum-evaporative cooling (VEC) positively affects the physico-chemical and organoleptic quality characteristics of biscuit semi-finished products, increases porosity, specific volume, reduces the time spent on putting the product, extends the time of their storage due to absence of infection by microorganisms at cooling.

To substantiate the rational parameters of the VEC process, we carried out a comparative analysis of the qualitative parameters of the biscuit products cooled by the proposed method with biscuit products manufactured by traditional furnishing, which involves cooling the products at t = 20 ℃, relative humidity of about φ = 75%, and subsequent standing up to 8 hours to stabilize the product structure.

One of the main qualitative indicators of biscuit products that must be provided for the further processing of baked biscuit semi-finished products are: the value of the temperature of the batch and the corresponding values of structural and mechanical parameters, which depend on the humidity and porosity of the products.

Cooling in the traditional way to supervise the lower humidity of biscuit semi-finished products.

The most intense evaporation of moisture occurs during the cooling of oil biscuit semi-finished products, as there is a temperature gradient that facilitates the movement of moisture from the center to the surface of the product. With the decrease of the temperature gradient, the intensity of the moisture output decreases. It is known that the shell layer near the crust loses moisture much faster than its central part. The total moisture loss is 4 – 5% for 8 hours.

In the vacuum-evaporative cooling method, a decrease in the temperature of the central layers of the workpiece is proportional to the decrease in the pressure of the medium of the working chamber (Fig. 2).

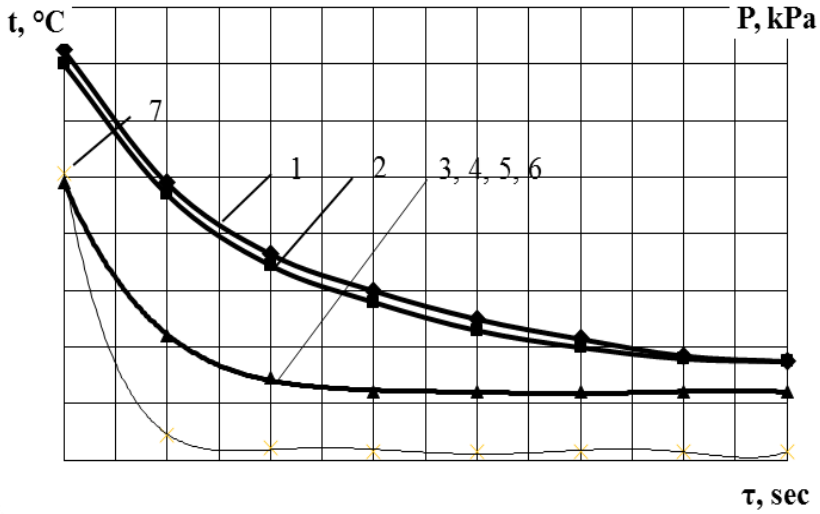

Fig.2. Temperature curves for the biscuit semi-finished product cooling process and the pressure curve of the operating chamber:
1 - Upper axis; 2 - lower spine; 3 - 14 mm from the top of the spine; 4 - 20 mm from the top of the spine; 5 - 20 mm below the speed; 6 - center of the workpiece) 7 - the curve of changing the pressure of the medium in the cooling chamber.

At the beginning of the process of vacuum evaporative cooling, the gradient of the surface temperature of the workpiece and the central layers is about 40 ºC until the end of the cooling (τ = 120 s) decreases to 15 ºC, which can be explained by the low humidity of the crust and accordingly the cooling of the workpiece surface is mainly due to the cooled transit steam moving from the middle and heat transfer from the central layers of the workpiece.

Consequently, this testifies that, at VEC, the final temperature and humidity of a biscuit semi-finished product is determined by the value created by the vacuum and the humidity and temperature of the product layers.

Since the vacuum evaporation method of cooling is due to the removal of heat by evaporation of the moisture from the material, and considering that one of the indicators of the quality of the biscuit products is their humidity, we, in order to avoid excessive loss of moisture by the half-finished product, the effect of the final pressure of the medium of the vacuum evaporator on the amount of evaporated moisture from the workpiece. Results of studies on the influence of the final pressure of the medium of the vacuum chamber on the temperature inside the billets and moisture content ready-made biscuit wares are presented in Fig. 3.

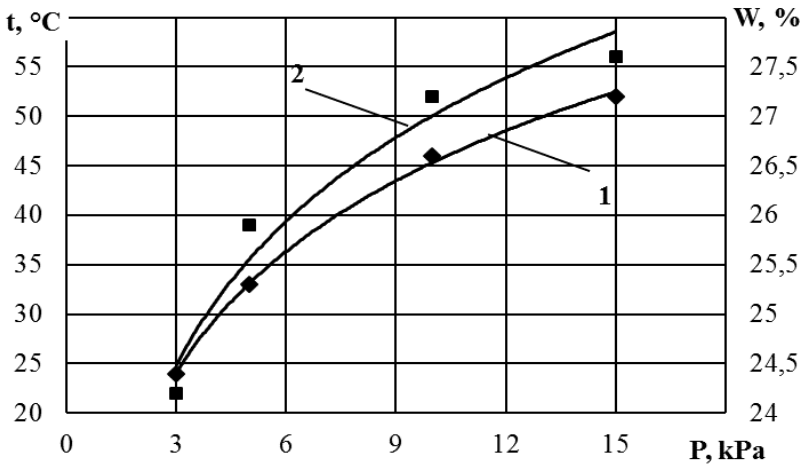

Fig.3 - Dependence of the final temperature of the center of the billet (1) and the moisture content of the finished products (2) on the pressure change.

From the obtained data it was established that the decrease in the absolute pressure of the medium of the vacuum chamber up to 3 kPa is accompanied by a decrease in the humidity of the products from 28,5% to 24,2%, which corresponds to the established requirements of the formulation 24,0 ± 1%. In the traditional way of cooling, this humidity is achieved in 6 ... 8 hours of resistance. In this case, the temperature of 24 ºC is also required to further process the biscuit semi-finished products.

Obviously, further decrease in absolute pressure of less than 3 kPa will lead to overcooling of products and excessive loss of moisture.

Also, it was interesting to compare the change in the moisture content of the finished biscuit products after cooling by a convection method (within 2 hours and for 8 hrs) and in the case of rarefaction (at a pressure of 3 kPa) (Fig.4). The change in the humidity of the biscuit during storage in a desiccator, at a relative humidity of φ 75% and a temperature of 20ºC, for 72 hours has been determined.

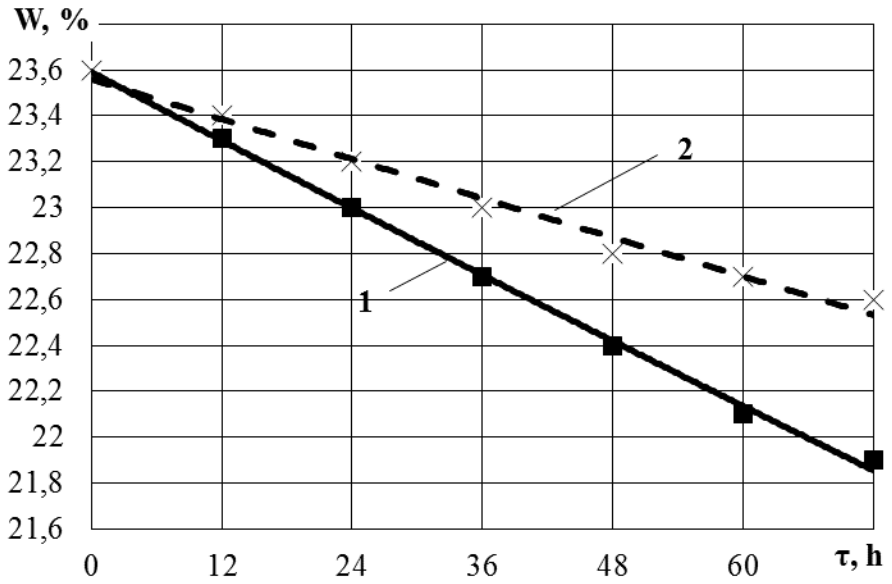

Fig. 4. Kinetics of drawing of biscuit semi-finished products during storage: 1 - convection cooling; 2 - VEC.

The moisture content of the products during their storage depends on the initial humidity of the samples and the method of their cooling. This dependence is linear. Biscuit products cooled by the vacuum evaporation method are characterized by less moisture loss during their storage compared to biscuit semi-finished products cooled in the traditional way, which makes it possible to assume the extension of their storage and realization due to the slowing of the worming process. This phenomenon can be explained by a change in the structural and mechanical properties of the biscuit cake.

CONCLUSION

Biscuit products cooled by the vacuum evaporation method are characterized by less moisture loss during their storage compared to biscuit semi-finished products cooled in the traditional way.

Cooling of biscuit semi-finished products in the conditions of rarefaction improves the quality of the finished biscuit semi-finished product and allows to reduce the technological process by 120 minutes, and completely exclude from it the stage of standing.

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