FRI–ONLINE-1-BFT(R)-04

GAS PERMEABILITY OF BREAD

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Abstract: *The article presents the results of the study of the permeability of the crust and the central layers of bread products on the gases formed and transported from the workpiece to the environment by vacuum cooling. The scheme of experimental installation and a technique of research of permeability of layers of bread are offered. The influence of temperature and humidity of samples on the value of permeability was investigated. The values of the permeability of the bread crust to gases in different areas of the workpiece surface were found. The specific flow rates of gas through the surface of the products during vacuum cooling are found. The obtained results can be used to determine the modes of creating a vacuum in which the integrity of the samples is ensured.*

Keywords: *Gas permeability, Bread, Vacuum cooling.*

INTRODUCTION

During the production of bread, a significant portion of time and effort is spent on cooling the finished product, which entails many inconveniences and additional costs. In practice, the most common are two methods of cooling: natural and air conditioning. But these two methods of cooling require large production areas, and in the first case, significant time and additional manual labor.

An innovative way to cool food, including bread, is to use a vacuum evaporative method of cooling, its advantages include the speed of the cooling process, compact equipment and a positive impact on product quality.

Studies of vacuum evaporative cooling method have been conducted for several decades by scientists such as McDonald K., Sun, D.-W, Everington, D., Sluimer, P., Cauvain, S.P. and others. (McDonald K., 2001; Everington, D., 2003; Primo-Martín C., H. de Beukelaer, Hamer R.J., T. van Vliet, 2008).

The process of vacuum evaporation cooling has a positive effect on the physicochemical and organoleptic quality of bakery products, increases porosity, specific volume, reduces the time spent on cooling the product, prolongs their storage time due to the absence of microorganism infection during prolonged cooling.

However, the use of the proposed method in the cooling of bakery products requires additional research to establish the mode parameters of cooling, because due to too intense pressure reduction due to the fact that the crust creates resistance to steam from the workpiece into the environment, there is a pressure gradient between steam in the workpiece and the environment, which is accompanied by the destruction of the workpiece. Therefore, it is advisable to study the gas permeability of the crust and the inner layers of bread and the effect of the duration of aging of the blanks after baking on the value of permeability (Lytvynchuk A.A., Komarova O.V., Arnaut S.A., 2014).

EXPOSITION

Laboratory installation and experimental procedure

To determine the gas permeability of the products of bakery enterprises (crust and inner layers of bread), an experimental installation was created, the scheme of which is p resented on Fig. 1.

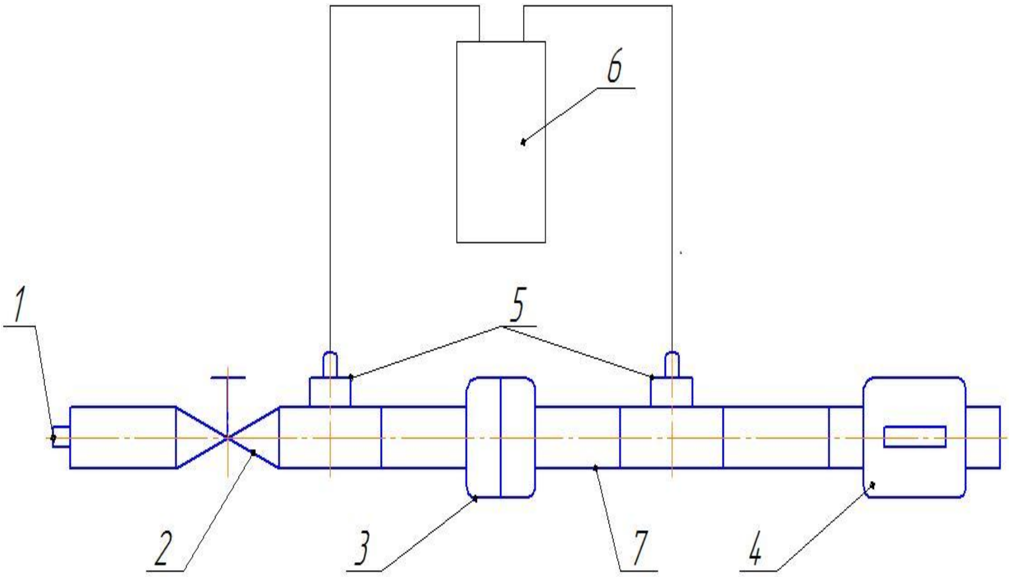

Fig. 1 The scheme of laboratory installation:

1 – The union for connection of the vacuum pump; 2 – the crane for regulation of speed of creation of vacuum; 3 – clamp segment of the workpiece; 4 – gas flow meter; 5 – tees with fittings for differential connection of the manometer; 6 – differentially connected manometer; 7 – pipeline.

Research methodology.

– At the same temperature in the oven baked 2 pieces of oval hearth bread weighing 0.5 kg, moisture content of 44% from wheat flour;

– To determine the resistance of different parts of the workpiece surface, we made a "surface map" (Fig. 2)

Fig. 2 "Surface map" of the workpieces

– In order to study the influence of the duration of aging of the blanks after baking on the value of permeability of the workpiece was divided into "hot" and "cold";

– According to the proposed "surface map" cut the workpiece and separate the crust from the crumb (for "hot" workpiece – immediately after baking, for "cold" workpiece – 60 minutes after baking) (Figure 3)

Fig. 3 Workpieces in accordance with the "surface map"

– Cut a segment of bread crust approximately 5 mm thick (Fig. 4);

Fig. 4 Segments of crusts

– The obtained segments were clamped in the clamp of the workpiece segment, the vacuum pump was turned on. The accounting of the amount of gas passing through the segment was determined by a gas meter, and the pneumatic resistance of the segment was determined by a differential pressure gauge (Kononchuk S.V., 2019; Smislov V.V.,1971).

– The gas permeability of the workpiece crumb was similarly studied. For their study, samples were taken from the central layer of the workpiece, the upper and lower zones under the crust.

During the study of gas permeability of the crust and the inner layers of bread, the following parameters were measured:

1) initial and final mass of segments (g)

2) the duration of the experiment (s.)

3) pressure gradient with time (kPa.)

4) change in gas consumption over time (m3)

RESULTS AND DISCUSSION

The obtained results of changes in air flow for the segments taken from the crust and the inner layers of bakery products over time show that the maximum flow is characteristic of the central layer of the crumb, and the minimum for the central part of the crust surface (Fig. 5).

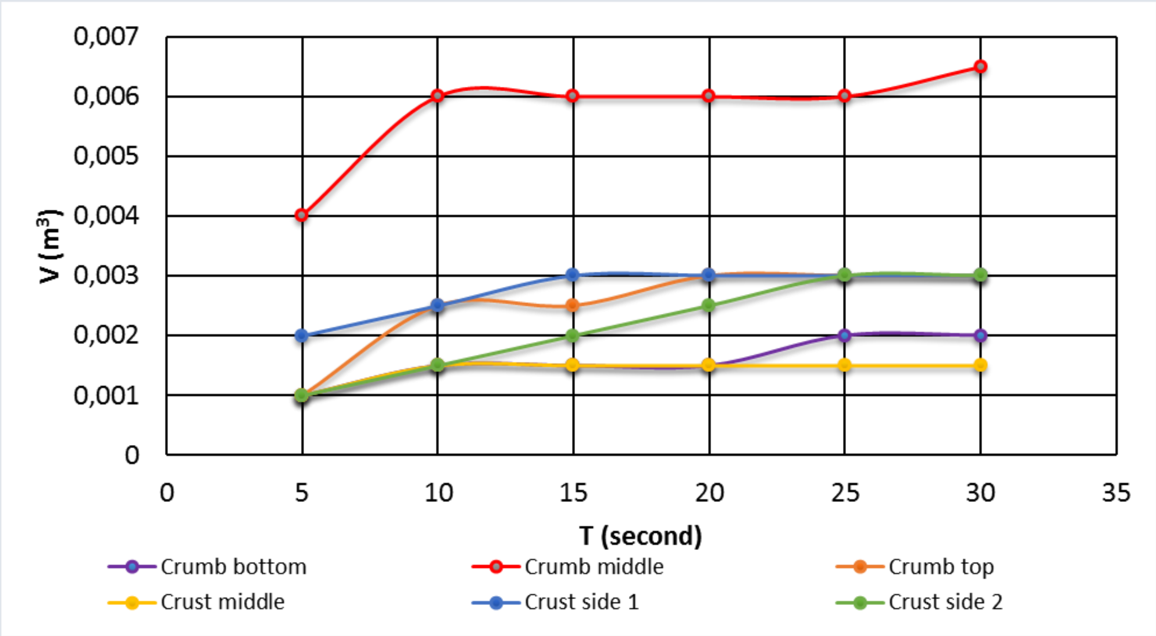

Fig. 5 Changes in air losses over time for segments taken from the crust and the inner layers of bakery products

It was found that the central part of the upper crust has the highest resistance, which is in the range of 70-80 kPa, and the lowest resistance (10-12 kPa) has the central part of the crumb (Fig. 6).

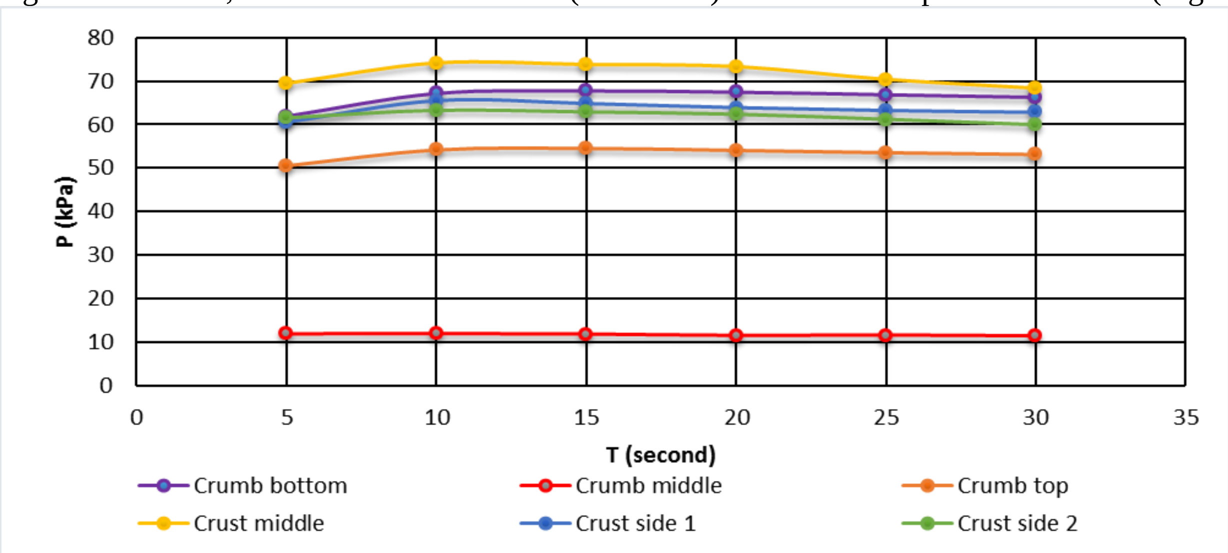

Fig. 6 Change in resistance over time for segments taken from the crust and inner layers of bakery products

For all samples, the results of the study show a gradual increase in air consumption over time to the end of the process, and a decrease in resistance over time, which in our opinion is associated with a decrease in sample moisture during air purging.

The values of the resistance of the crust of bread on the gases in different areas of the surface of the workpiece and constructed "maps" of the resistance of the crust of bread blanks (Fig. 7): 1- workpiece after baking; 2 – blanks completely cooled naturally.

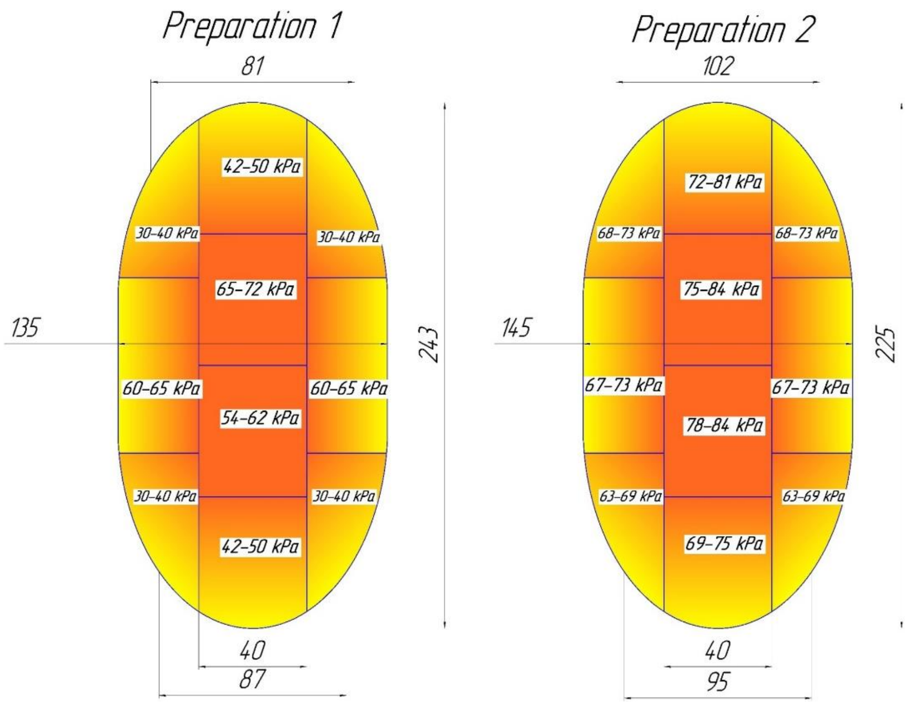

Fig. 7 Resistance maps of bread crust

From the obtained "maps" it is seen that the central part of the crust has 10-15 kPa greater resistance than the segments closer to the side surface, apparently due to the higher density, due to the more intense heat load during baking.

It was found that the crust of the workpiece completely cooled naturally has a higher resistance of 15-20 kPa than the crust of the workpiece after baking.

Also created a "resistance map" of the workpiece layers in cross section (Fig. 8).

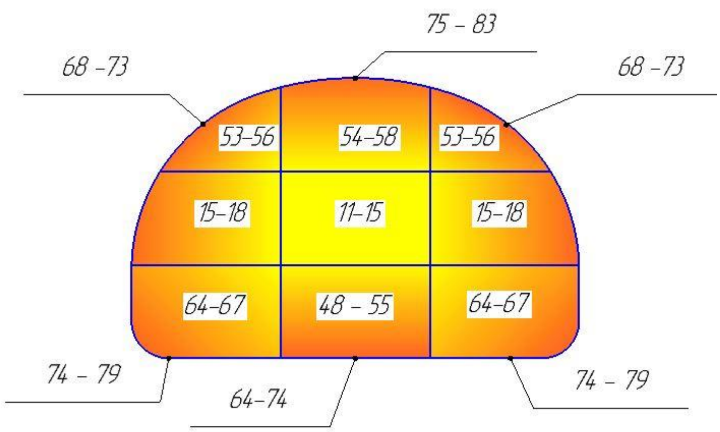

Fig. 8 Map of layer-by-layer resistance of the bakery billet (kPa)

As can be seen from the map of the resistance of the inner layers of the workpiece in cross section, the lowest resistance has the center of the crumb 11-15 kPa. As you approach the periphery, the resistance of the crumb increases: the resistance of the crumb layer near the lower crust is greater than the resistance of the crumb layer near the upper crust and is 64-67 kPa and 53-58 kPa, respectively.

The results can be explained by the fact that the central part of the crumb has the highest porosity and, accordingly, is well permeable to gases. As you approach the periphery, the porosity of the crumb decreases, leading to a gradual increase in resistance.

CONCLUSION

An experimental setup and research methodology for determining the gas permeability of bakery products has been developed, which allows to determine gas consumption per unit time and local crust supports on the plane of the workpiece, support and gas loss of crumb in the cross section of the workpiece.

The results of experiments show that different areas of the workpiece surface have different resistance and gas capacity. The highest resistance is in the upper crust in the area of greatest heat load during baking (75-83 kPa) and the lower crust (74-79 kPa). The resistance of the crumb, samples of which are taken from the layers of the workpiece, placed under the crusts are in the range from 53-56 kPa for the upper crust to 64-67 kPa for the lower crust. The resistance of the central layer of crumb is 5-6 times less than the resistance of the crust and is 10-15 kPa.

The resistance of the workpiece is influenced by such parameters as the recipe composition, baking conditions, duration of aging and others, which are the tasks of further research.

The obtained results allow to better understand the physical model of the process of vacuum evaporative cooling of bread in which moisture evaporates from the middle of the workpiece and its migration through the workpiece layers into the environment, and to establish a vacuum mode that will unit of time and pressure gradient in the middle of the workpiece preventing its destruction.

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