Theoretical Basis of Optimal Regime Regulation for Sausage Drying

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SUMMARY: For development of packet of programs, ensuring optimum drying regimes for different types of sausages, it is necessary to create mathematical model of interrelation between thermodynamic and heat-and-moisture exchange characteristics of sausages and regime parameters of drying chamber medium. On the basis of experimental curves of desorption, temperature fields and moisture distribution along radius of a sausage long loaf, the fllowing parameters are determined: distribution of water activity (a_w), wet bulb chamber medium (t_m) and surface temperature, ratio of moisture-exchange (β), value of boundary layer of vapour-air medium, moisture-exchange criterion by Nusselt(Nu_m). Besides, method of regulation of regime parameters of chamber medium was developed, ensuring optimal drying regime with the account of sausage properties.

Principle of control and regulation of regime parameters is based on experimental dependence $T = f(a_w, \varphi, Wp)$, where φ - is relative moisture of medium, Wp -equilibric moisture content in a loaf.

Drying conditions: for period of constant drying rate $a_w \leq 1$, $T = T_m - T_{s.w} > 0$, where Tm is wet bulb temperature of chamber mediumn; $T_{s \cdot w}$ - wet bulb temperature of loaf surface. For period of decreasing drying rate: $0 \leq a_w \leq 1$ $\Delta T > 0$. Drying is stopped at $a_w = \varphi$, $\Delta T=0$.

INTRODUCTION: Characteristic feature of modern sausage production in USSR and abroad is intensificatioh of technological processes and creation of heavy duty equipment. For development of packet of programms, ensuring optimum drying regimes for all types of sausages, it is necessary to have mathematical model of interrelation between thermodynamic and heat-and-moisture echange characteristics of sausages with regimic parameters of drying chamber medium.

MATERIALS AND METHODS: As a physical essence of moisture transfer in a sausage loaf, the law of water activity (a_w) distribution was adopted, and temperature curves of wet bulb temperature (t_w) along radius of sausage loaf were taken into consideration. Uniformity of moisture distribution and evaporation of water from loaf are limited by a_w and t_w, mass-exchange criterion of Nusselt (Nu_m), ration of moisture-exchange with medium and value of boundary layer $\delta\varphi$ of vapour-air medium define not only external moisture exchange, but also possibility of "hardening" on loaf surface. Thus, the main aim of researches in this field is development of equipment, of control devices and of process control system on this basis.

RESULTS AND DISCUSSION: Using experimental desorption curves, temperature and moisture content curves, and also diagram of Jd dependence, $a_w=f(R)$ $t_m=f''(R)$ is found. From curves of a_w distribution along loaf radius and values of relative humidity of drying chamber, and also using graphic (analytical) method $\delta_{,}\varphi$, depth of evaporation zone φ and masstransfer criterion by Nusselt are determined.

$$Nu_m = \frac{R}{\delta\varphi} \qquad (1),$$

where: R - is radius of long sausage loaf.

By formula (1) and by known ratio of moisture transfer (determined from the tables) in boundary layer, moisture-exchange ratio is determined:

$$\beta = \frac{\lambda m}{\delta\varphi} \qquad (2).$$

Nusselt criterion and moisture-exchange ratio characterize external moisture-exchange. In the boundary layer during laminar effect of air flow on sausage loaf, Nu_m falls, when relative humidity of environment is reduced.

The principle of control and regulation of regimic parameters is created on the basis of experimental dependencies $\Delta T = f(a_w, \varphi, Wp)$, where:

Wp - is equilibric moisture content;

$$\Delta T = T_w - T_{sw} \qquad (3)$$

T_w - is wet bulb temperature of medium;

T_{sw}- wet bulb temperature of loaf surface.

In the process of drying, as a result of decrease of average integral moisture of a loaf and of a_w on loaf surface, ΔT changes. At ΔT of lower value, as determined by mathematical model of optimal drying regime? "disaccordance" signal appears. Optimal value is limited by technological requirements for sausage manufacture. When $\Delta T = 0$ and $a_w = \varphi$, drying is completed.

Drying conditions. For the first period of constant rate of drying $a_w \leq 1$, $\Delta T = T_w - T_{sw} > 0$, where: T_w - is wet bulb temperature of chamber medium;

T_{sw}- wet bulb temperature on loaf surface.

For the second period of decreasing rate of drying: $0 < a_w < 1$, $\Delta T > 0 = const.$

<u>CONCLUSIONS</u>: Automatic regulation of T_w and φ means, that drying process bears interruptive character, consisting of a range of subsequent "on" and "off" cycles. Time duration of cycle depends on sausage properties (moisture-exchange criteria and characteristics).

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