



## MATHEMATICAL APPARATUS FOR THE CRYOPROCESSING OF PLANT MATERIALS

**Karimova Zilola Makhmudovna**

Assistant of Bukhara Engineering and Technological Institute, Bukhara, Uzbekistan

**Oripov Azizbek Anvarovich**

Student of Bukhara Engineering and Technological Institute, Bukhara, Uzbekistan

### ABSTRACT

*The article provides mathematical formulas for controlling the processes of cryo-treatment of plant objects. Methods for calculating quality indicators and factors affecting the technological processes of cryoprocessing, namely, cryoseparation and cryo-grinding of plant products, are discussed.*

**KEY WORDS.** *Mathematical apparatus, cryoprocessing, plant materials, cryoseparation, quality indicators. Key words: mathematical apparatus, cryoprocessing, plant materials, cryoseparation, quality indicators.*

### INTRODUCTION

Cryoprocessing of plant raw materials and products is accompanied by mathematical processing of the experimental results obtained, which is important in determining the technological parameters of the process and drawing up its regulations. The purpose of this work is to consider the mathematical apparatus of the processes of cryoprocessing of plant objects. Thus, the quality of cryoseparation is determined by the following formula [1]:

$$Q=(m_1-m_2)/M \cdot 100\%$$

M- total mass of the fraction obtained  $\Gamma$

$m_1$ - mass of target fraction,  $\Gamma$

$m_2$ - mass of non-target fraction  $\Gamma$

Organoleptic indicators are determined by a tasting-examination based on a comparison of assessments (points) of the analyzed products in accordance with the requirements of state standards. The average score (score) is determined from the formula:

$A=E/K$ , где – E sum of all points, K- number of experts.

The heat (kJ) removed from the product during cooling depends on the size of the heat capacity C and the temperature difference between the product at the beginning and at the end of the cooling process  $\Delta t \cdot C$ .

$Q=M \cdot C \cdot \Delta t$ , M- mass of the cooled product.

Specific heat is a value equal to the amount of heat that must be removed from the product to cool the body weight by 1 K;

$$C = \frac{dQ}{dm \Delta t} = \frac{Q}{m \Delta t}$$

Q- quantity of heat, Дж;

m- body mass, кг,  $\Delta t$ - temperature difference, °K.

It is believed that the mass and volumetric specific heat are equal to each other.

The heat capacity of ice formation processes (J/kg, K) for products with a low fat content, taking the heat capacity of water equal to 4.19, for dry substances 0.71-1.36, vegetable substances 1.38-1.68, is found from the formula :

$$C_0=C_c W+C_b(1-W)$$

$C_b$ ;  $C_c$ - specific heat capacity of water and dry matter, W, (1-W), mass fraction of water and dry matter.

Transforming this equation, we obtain the following equation for plant raw materials



$$C_0 = 4,19W + 0,9(1-W)$$

## RESULTS

The heat capacity after ice formation, or the calculated specific heat capacity of the product to be calculated, since at negative temperatures, part of the water in the raw material does not turn into ice, the heat capacity of which  $C_L$  is calculated from the equation:

$$C_{\Pi} = C_w \cdot W(1-W) + C_{\Pi} \cdot W_w + C_x(1-W)$$

W- mass fraction of water in products,,

W- relative amount of frozen water:

$$W = 1 - \frac{t_{kp}}{t_3}$$

$t_{kp}$  critical temperature;  $t_3$ - product temperature, °C

Transforming the last equation and taking into account the previous equation, we obtain:  $C_w = C_0 - (C_w - C_x)W_w$

Thermal conductivity (W/m s) can be calculated as heat capacity, taking the thermal conductivity coefficient of water and dry substances as 0.6 and 0.26.

$$\lambda = 0.6W + 0.26(1 - W)$$

The cooling rate, which mainly depends on temperature, product thickness and cooling method, is found from the formula:

$$\frac{dx}{d\tau} = \frac{(t_{kp} - t_0)}{gf \left[ \frac{x}{\lambda} + \frac{1}{\alpha} \right]}$$

$t_{kp}$  и  $t_0$  cryoscopic product and ambient temperature, respectively

q- specific heat removed from raw materials during cooling, кДж\кГ

$\gamma$ - product density, кг\м<sup>3</sup>

X- product size, м;

$\lambda$ - product thermal conductivity coefficient, Вт \кГ\К°

$\alpha$ - heat transfer coefficient.

The cooling rate is understood as the amount of frozen water in the product for a certain period of time, % min.

The amount of frozen water W is found from the ratio of moisture converted to ice to its total amount

$$W = \frac{G_{\Pi}}{(G_x + G_0)}$$

$G_{\Pi}$  и  $G_0$  – the amount of ice and water at a given temperature, unit fractions.

Otherwise, the amount of frozen moisture can be depicted as the ratio of the mass of ice G at a given temperature to the total mass of ice and moisture equal to the initial mass of water  $G_b$  ;

$$D = \frac{G_{\Pi}}{G_b} = 1 - \frac{G_b - G_{\Pi}}{G_b}$$

Cooling of food raw materials and products is a complex physical and chemical process. In refrigeration practice, the most important parameter is the duration of cooling, which is understood as the total duration of freezing and cooling of an object to a given temperature. To determine this, the most widespread was the Planck formula, which is applicable for bodies of simple shape with the constancy of the physicochemical properties of the product. [2]: This formula has a simple form for application and understanding of heat and mass transfer processes during cooling and for fixing the initial and final temperature of the object. The heat of ice formation is represented as the sum of heat removed from a unit of product during cooling from the initial temperature  $t_n$  to the temperature of the onset of freezing of water  $t_{cr}$  of the heat of ice formation and heat when the temperature of the frozen product decreases from  $t_{nz}$  to the final  $t_k$



$$Q = c(t_c - t_{kp}) + \alpha W \omega + C_H(t_H - t_k)$$

$C_M$ - the heat capacity of the frozen product.

The cold consumption for freezing an object is found by the formula:

$$Q_{kp} = G_{np} C(t_H - t_k)$$

$G_{np}$ - product weight,  $C$ - heat capacity of an object,  $t_H$  и  $t_k$  the initial and final temperature of the object.

Moreover, when freezing plant objects, the warmth of breath should be additionally taken into account

$$Q = q_g \cdot G_{np}$$

$q_g$ - warmth of breath  $BT/Kr$ , is from the reference book depending on the product and temperature.

The amount of heat removed from the object during cooling is found by the formula

$$Q_{ox} = G[C_0(t_0 - t_{kp}) + r \cdot \omega \cdot W + C_k(t_{kp} - t_c)]$$

$Q_{ox}$ - cold consumption for object cooling,  $KJ$

$G$ - product weight,  $Kr$

$C_0$ - specific heat capacity of an object at temperatures above its cryoscopic temperature  $KJ/Kr \cdot C$

$T_H$ - initial process temperature

$T_{kp}$ - cryoscopic temperature,  $C$

$W$ - mass fraction of water in the object, in fractions of a unit

$\omega$ - the proportion of frozen water at the average, final cooling temperature, in fractions of a unit

$\gamma$ - specific heat of ice formation,  $KJ/Kr$

$C_k$ - specific heat capacity of a frozen object at temperature

Average between cryoscopic and final,  $KJ/Kr$ .

$T_{ck}$ - average end temperature of the object,  $C$

The efficiency of using the method of cryo-separation of food raw materials can be assessed by the technological indicator [3]:

$$P = \frac{\gamma_0(\beta - \alpha)}{\alpha(100 - \alpha)}$$

$\gamma_0$ - split component output, %

$\alpha$ - content of the component to be separated in the original product, %.

$\beta$ - content of the component to be separated in the recovered product, %

The efficiency of the cryo-grinding process is determined by the following equation:

$$G = \frac{F[\alpha_1(F - G_0) - (F\alpha_1 - G_2)]}{\gamma(F_0 - G_0) - (F\alpha_1 - G_0)}; \quad \gamma = \exp\left[\frac{gV_\tau(1 - \alpha)}{F\alpha}\right]$$

$F$ - the mass of raw materials in the cryo-grinder,  $Kr$ ;  $G$ ,  $G_0$  – the mass of the selected component of the structure of the object located in the grinder at the moment of time  $\tau$  and before the start of grinding, respectively,  $kg$ .

$\alpha$ - content of minor components in the feedstock, units share.  $g$ -

specific, true productivity of the grinder for the selected component of raw materials,  $Kr/M^3 \cdot \text{чac}$ .

$V$ - cryo-grinder space volume,  $M^3$

True specific productivity of the cryo-grinder for the selected component  $G_o = \frac{J\psi}{S_o}$  or  $G_o = \frac{J}{S_{o,x}}$

$J$ - true specific productivity of the cryo-grinder at  $F=0$ ,  $1/M \cdot \text{чac}$ ,

$S_o, S_x$ - the specific surface area of accretion and the released component, respectively,

$\Psi$ - coefficient of intercomponent cryo-grinding, determined by the nature of accretion and connection between the components of the cooled object. [4]:

The main factors that determine the quality of refrigerated fruits, berries, vegetables and other plant objects are the nature of the cell structure, which depends on the speed and temperature of cooling, storage temperature, which should not exceed the freezing temperature in order to prevent the growth of ice crystals, the speed and conditions of defrosting. Freezing can cause damage to cell membranes and this can cause an imbalance in redox processes towards oxidative reactions during storage of a frozen object. The quality of a frozen object is determined by the completeness of inactivation of enzymes that accelerate these processes - oxidoreductases, polyphenol oxidases, and others. The main substrate for these enzymes is the water of the cell sap. The method of rapid cryopreservation allows you to quickly overcome the cryoscopic temperature in order to prevent the



formation of large ice crystals that damage the cell structure of the object, which causes a loss of cell juice output. As a result of damage to cellular structures at the stage of freezing after defrosting, irreversible structural-mechanical, physicochemical and organoleptic changes occur. [4,5]:

**Conclusion.** Thus, it can be concluded that it is recommended to use rheological parameters to establish the quality of frozen plant objects.

## REFERENCES

1. Касьянов Г.И. Сязин И.Ф. Кочерга А.В. “Инновационные технологии обработки сельскохозяйственного сырья”, Экоинвест, Краснодар, 2013.
2. Мухамадиева, К. Б., & Каримова, З. М. (2020). МАТЕМАТИЧЕСКИЙ АППАРАТ ПРОЦЕССОВ КРИООБРАБОТКИ РАСТИТЕЛЬНЫХ МАТЕРИАЛОВ. *Universum: технические науки*, (6-2 (75)).
3. Ломачинский В.В. Касьянов Г.И. “Технология криообработки пищевого сырья”, “Экоинвест”, Краснодар I, II, 2011,2012 г.
4. Б.Т.Мухамадиев “Использование криоопорошков, обогащенных CO<sub>2</sub> экстрактами в производстве пищевых продуктов”, *UNIVERSUM*: 2020.(в печати)
5. Архаров А.М.«Достижения и проблемы инженерной криологии. «Химическое и нефтяное машиностроение», № 7. Стр.27-33, 2007.