# Heat cost calculation of the process of zucchini fruits saturation with sucrose from an aqueous solution.

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***Abstract – This work deals with experimental studies of zucchini fruits saturation were conducted in static and dynamic modes. Specific heat consumption of the studied modes of saturation of zucchini fruits in sugar syrup was theoretically calculated. The total heat consumption is lower in dynamic mode compared to the static one, at the same medium temperatures.***

Keywords – kinetics, static and dynamic modes, heat consumption

## Introduction

Processes of sucrose diffusion inside plant fruits and their generalization require special attention, namely theoretical generalization of experimental data and organization of energy-saving production of candied fruits while preserving the quality of the finished product [1]. The aim of this work is an experimental study of the kinetics of zucchini fruits saturation with sucrose in static and dynamic mode, determination of the specific heat consumption.

## Results and discussion

Fig. 1. shows the kinetic curves of changes in the sucrose concentration in zucchini fruits under two modes of saturation: static and dynamic. Static mode (steady state) is represented by curves 3, 4, and 6 (Fig. 1). Dynamic mode (bubble state) is represented by curves 1, 2, and 5 under conditions of an air supply rate of 6.6 m/s. The intensity of this process will depend on the medium temperature and the rate of air supply.

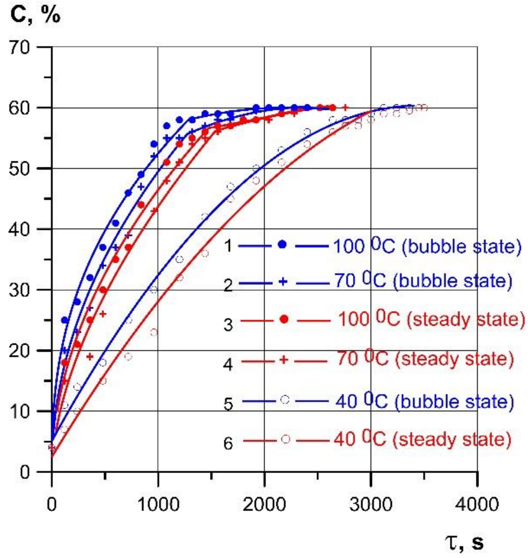


Fig. 1 Kinetic curves of changes in sucrose concentration in zucchini fruits over time

1 – kinetic curve of saturation in dynamic mode at a temperature of 100°C;

2 – kinetic curve of saturation in dynamic mode at a temperature of 70°C;

3 – kinetic curve of saturation in static mode at a temperature of 100°C;

4 – kinetic curve of saturation in static mode at a temperature of 70°C;

5 – kinetic curve of saturation in dynamic mode at a temperature of 40°C;

6 – kinetic curve of saturation in static mode at a temperature of 40°C.

Thus, in order to establish the most effective mode of saturation, it is necessary to calculate the specific heat consumption (MJ/kg of syrup) for the process. Heat consumption for heating the syrup to the defined temperature and for the reaching equilibrium of the saturation process (Q), is calculated according to Eq. (1). The heat consumption of the fan for supplying air ($Q_{fan}$) is calculated according to Eq. (2). Heat consumption for air heating ($Q_{heater}$) is calculated according to Eq. (3). Total heat consumption (ΣQ) is calculated according to Eq. (4):

$$Q = c_s \cdot (t_2 - t_1) \cdot \frac{\tau_2}{\tau_1} \cdot 10^{-6} \tag{1}$$

$$Q_{fan} = V_{air} \cdot \Delta p \cdot \tau_2 \cdot 10^{-6} / m_s \tag{2}$$

$$Q_{heater} = V_{air} \cdot c_{air} \cdot (t_2 - t_1) \tau_2 \cdot 10^{-6} \tag{3}$$

$$\sum Q = Q + Q_{fan} + Q_{heater} \tag{4}$$

where

$t_2$ is the saturation temperature, °C; $t_1$ is the initial temperature of the syrup, 20°C; $\tau_2$ is the time of zucchini fruits saturation to the equilibrium concentration, s; $\tau_1$ is the time of syrup heating to saturation temperature, s; $V_{air}$ is a volumetric flow rate of air for bubbling, m3/s; $c_{air}$ is a specific heat capacity of air, J/kg·degree; Δp is a pressure of air for bubbling, Pa; $m_s$ is a syrup weight, kg; $c_s$ is a specific heat capacity of syrup, J/kg·degree.

The obtained numerical values of the specific heat consumption for all studied modes are shown in Table 1.

*Table 1*

Specific heat consumption of the studied modes of saturation of zucchini fruits in sugar syrup

| Mode | $t_2$,°C | $\tau_1$, s | $\tau_2$, s | Q, MJ/kg | $Q_{fan}$, MJ/kg | $Q_{heater}$, MJ/kg | Σ Q, MJ/kg |
|---|---|---|---|---|---|---|---|
| Static | 100 | 480 | 2330 | 1.113 | 0 | 0 | 1.138 |
| Dynamic | 100 | 480 | 1920 | 0.938 | 0.128 | 0.020 | 1.085 |
| Static | 70 | 300 | 2400 | 1.172 | 0 | 0 | 1.172 |
| Dynamic | 70 | 300 | 2000 | 0.977 | 0.133 | 0.013 | 1.123 |
| Static | 40 | 75 | 3450 | 2.532 | 0 | 0 | 2.696 |
| Dynamic | 40 | 75 | 3120 | 2.438 | 0.207 | 0.008 | 2.653 |

As can be seen from Table 1, the total heat consumption is lower in dynamic mode compared to the static one, at the same medium temperatures. Moreover, the heat consumption in dynamic mode at 70°C (1.123 MJ/kg) is lower than the heat consumption in static mode at 100°C (1.138 MJ/kg). Based on the experimental results, it is recommended to produce candied fruits in dynamic mode at temperatures of 70-100°C. Under such conditions, the lowest heat consumption is observed (Table 1).

## Conclusions

The specific heat consumption of the studied modes was determined. It is proved that the lowest heat consumption (Σ Q = 1.123 MJ/kg syrup) is for the saturation process conducted under dynamic conditions at a syrup temperature of 70°C.

## References

[1] Atamanyuk V., Huzova I., Gnativ Z. (2017). Study of diffusion processes in pumpkin particles during candied fruits production. Food Science and Technology, 11(4), pp. 21–28. https://doi.org/10.15673/fst.v11i4.727