DEGRADATION KINETICS OF ANTHOCYANINS IN SOUR CHERRY DEPENDING ON THE DRYING TEMPERATURE

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Introduction

Among the domestic fruit species, sour cherries belong to the most popular fruits. In the fruit processing industry, they are canned in their own juice or syrups, processed to concentrates, juices, preserved by drying, etc. Republic of Moldova currently exports more than 500 tons of dried cherries with a perspective to increase this amount [1].

However, no detailed information is available about the effect of drying on the degradation of anthocyanins, which are an important component of cherries and cherry products and plays a critical role in color quality of them [2–4]. Cyanidin–3–glucoside is the major anthocyanin present in sour cherry [5], which is not stable similar to all anthocyanins and could be decolorized or degraded by many factors, for example, temperature, oxygen, enzyme, light and time, during processing and storage [6–9].

Our objectives were to determine the impact of drying temperatures on the anthocyanin stability and evaluate the kinetics of anthocyanin degradation in the sour cherries drying process.

Materials and methods

Sample preparation. Fresh sour cherries (*Cerasus vulgaris Miller*) from local market,

17,7°Brix, with fruit size corresponding to 27 pcs per 100 g, were used in this study. The fruits were washed, detached from stalks and stoned. Stoned fruits were placed onto perforated stainless steel trays and dried in a laboratory chamber air drier at different temperatures of 45 (1.0 m/s), 60, 75, 85 ºC and air velocity of 3.5 m/s. Samples were dried to approximately 13% final moisture. One tray was connected to a balance to measure fruit weight during drying. Product temperature was measured by thermocouples introduced inside of three fruits at 1 min intervals. Average temperature was automatically registered. During drying, 4–6 portions of fruits at different moisture (i.e. *ca* 75%, 65%, 55%, 45%, 25% and 13%) were removed from the dryer and later analyzed.

Moisture determination. Moisture of fresh and dried cherries was determined by drying in a vacuum oven at 70 ºC for 6 h (10).

A*nthocyanins content determination.* Total Monomeric Anthocyanins were measured by the pH–Differential Method using UV–Visible Spectroscopy [11].

Results and discussion

The drying kinetics of stoned sour cherries at four different constant temperatures are shown in Fig.1 and Fig.2. There is no heating period in the all obtained drying curves and no constant–rate drying period at 45°C. The results obtained of drying curves at the temperatures 60, 75 and 85 °C reveal the constant rate drying period with a duration of 20 to 40 min, representing, respectively, 2.4%, 8.9% şi 8.7% of the total drying time. The strong linear correlation exists between the maximum drying rate (MDR) and air temperature. The air temperature raising in the ratio of 1 to 1.33 to 1.67 to 1.89 (45, 60, 75, 85 °C) is resulted in the MDR value increasing almost in the same ratio 1 to 1.43 to 1.83 to 2.34 times. The drying time is dependent on the drying temperature and is the 47.5, 600, 1170 min and 264 h, relatively to 85, 75, 60 and 45 °C.

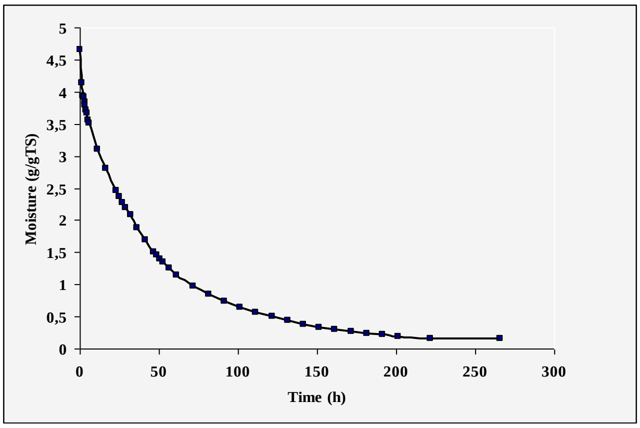

Fig. 1. Drying kinetics at 45°C

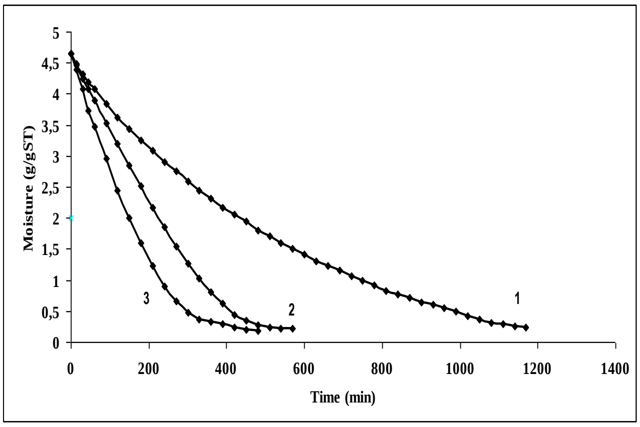

Fig. 2. Drying kinetics at different constant temperatures: 1 – g 60°C; 2 – 75°C; 3 – 85°C

Heat load on the product during its drying can be expressed as a definite integral following type:

$$\int_a^b f(x)dx \tag{1}$$

Where a and b are drying time interval boundaries, $f(x)$ is function of product temperature during drying; x – drying time.

The functions of product temperature during drying at different air temperatures are expressed graphically. Figure 3 shows, as the example, the temperature modifications of the product during its drying at 75 ºC. The corresponding definite integral is represented by the area below the temperature curve and above the interval [0, 600 min].

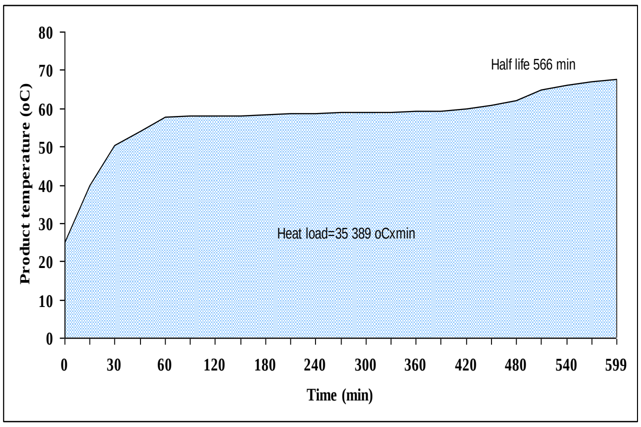

Fig. 3. Temperature modifications of product during drying at 75ºC

The weighted product temperature in the drying process is calculated by the formula:

$$S/x = t_W \tag{2}$$

Where S is the heat load (°Cxh); x is the drying time (h); t_W is the weighted product temperature (°C).

The determined values of heat loads and weighted temperatures are given in Table 1.

Table 1. The values of heat loads and weighted temperatures at different drying temperatures

Air temperature (°C)	Drying time (h)	Heat load (°Cxh)	Weighted product temperature (°C)	Half–life (h)
45	260	11629,65	44,73	102,13
60	21,25	1150,525	54,14	10,247
75	9,98	589,81	59,08	9,2717
85	7,98	540,91	67,75	5,7783

Change of total anthocyanin content during drying at differed air temperatures is presented in Fig. 4 and Fig. 5 in the form of $\ln C = f(x)$. Where C is the total anthocyanin content expressed as mg/100g of total solids; x is the drying time (min or h).

The experimental curves show stright lines and the antocyanin degradation follows a first order reaction at all evaluated temperatures, similarly to the heat sterilization [12].

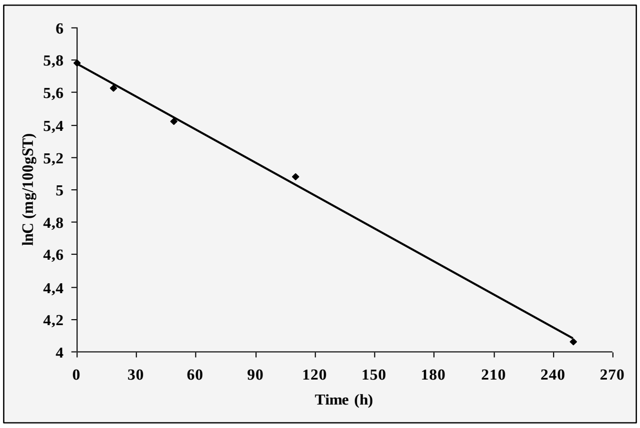

Fig. 4. Kinetics of anthocyanin degradation at 45 ºC

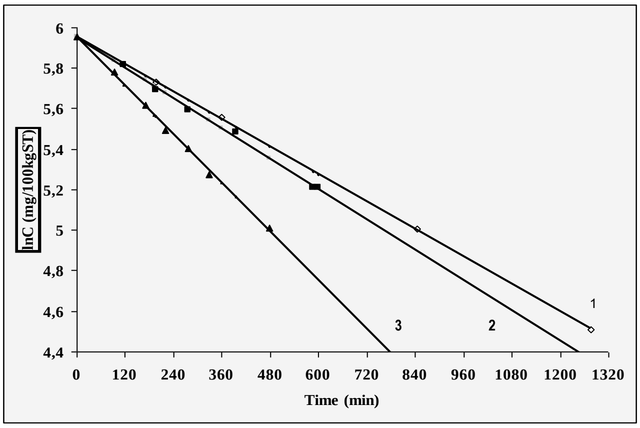

Fig. 5. Kinetics of anthocyanin degradation at different temperatures:
1 – 60 ºC, 2 – 75 ºC, 3 – 85 ºC

A first–order reaction rate constant is expressed as follows [13]:

$$\ln C = \ln C_0 - kx \qquad (3)$$

Where C and C_0 is the final and initial concentration (mg/100g of total solids), corresponding; K is rate constant (1/h).

Thus, the halflife of the reachion is:

$$x_{1/2} = (\ln 2)/k \tag{4}$$

The calculated values of halflife are included in Table 1.

The dependence of anthocyanin decreasing rate constant on air drying temperature and weighted product temperature is represented in Fig. 6. From the experimental data points in Fig. 6, it is observed that rate constant nonlinearly increases with increasing drying temperature. The model can be expressed as follows:

$$x = a \times \ln t + b \tag{5}$$

Where t is the air temperature (°C); a and b are the constant coefficients.

The resulting empirical coefficients and statistical characteristics of obtained models are given în Table 2. From Table 2 it becomes obvious that the application of weighted product temperature fits better than air temperature (R^2=0.98>0.92 and St =0.0067<0.0129).

Table 2. The values of empirical coefficients and statistical characteristics resulted by application of the equation (5)

Function of	Empirical coefficients		Statistical characteristics	
	a	b	Coefficient of determination	Standard deviation
air temperature:	0,1600821	– 0,5995011	0,9229	0,0129159
weighted product temperature:	0,2646917	– 0,9972325	0,9794	0,0066778

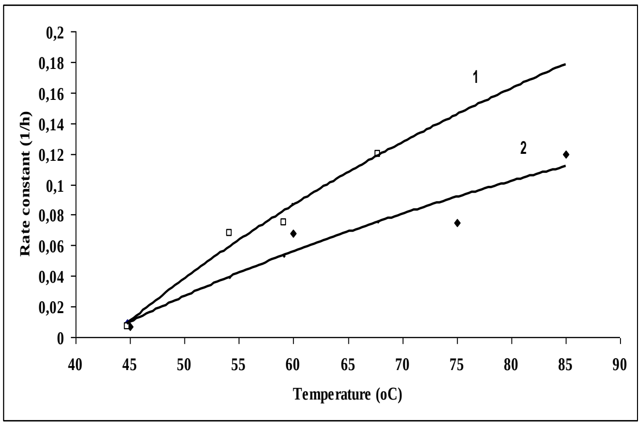

Fig. 6. Rate constant of anthocyanin concentration decreasing vs.:
1 – weighted product temperature; 2 – air temperature

Conclusions

In the process of drying the anthocyanin degradation in sour cherries is the first order reaction.

The empirical models to determine the constant rate of anthocyanin degradation according to the air drying temperature, and weighted product temperature (heat load on the product for the whole period of drying) were obtained.

It was found that weighted product temperature is better suited to evaluate the response of anthocyanin degradation than air drying temperature.

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