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THE EFFECT OF SODIUM ALGINATE ON THE STORAGE LIFE OF SOUR CHERRY FRUITS

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ABSTRACT

The article shows the effect of sodium alginate solution on the quality and duration of storage of cherry fruits. For research purposes, cherry fruits of the Alfa variety were selected. The selected fruits were washed with water, immersed in sodium alginate solutions according to the options with 3% and 5%. The processed fruits were dried for 30 minutes by blowing air created artificially by a fan, packed in polyethylene bags and stored at a temperature of 0±0.5°C and a relative humidity of 95±1%. By the content of dry soluble substances, ascorbic acid, tanning and coloring substances, antioxidant activity. Using Harrington's method, the optimal concentration of sodium alginate solution for pre-treatment of cherry fruits before storage was determined - 5%. A technological scheme for storing cherry fruits treated with sodium alginate solution has been developed.

1.Introduction

Edible films and coatings are classified by type of material. The components used for the preparation of edible films are classified into three categories: hydrocolloids, which include proteins, cellulose derivatives, polysaccharides, kappa-2-carrageenan, alginates, pectins, starch; lipids including fatty acids, acylglycerol, waxes and composites containing lipids and hydrocolloid components (Maftoonazad & Badii, 2009; Nayik et al., 2015; Lopez-Rubio et al., 2017; Pereira, 2017).

Polysaccharides are long-polymer biopolymers formed from mono- or disaccharide repeating units connected by glycosidic bonds. Being hydrophilic in nature, polysaccharide films create a barrier to carbon dioxide and oxygen and thereby delay fruit respiration and ripening. On the other hand, their polarity determines a weak
barrier to both water vapor and general sensitivity to moisture.

Alginate is a polysaccharide used as an effective biopolymer film or coating component due to its characteristic colloidal properties such as thickening, gelling, film forming and emulsion stabilizer (Hassan et al., 2018).

Polysaccharide alginate coatings reduce moisture loss in garlic, extend shelf life and preserve freshness of sliced pineapple (Radev & Dimitrov, 2017), strawberry (Li et al., 2017; Aitboulahsen et al., 2018), nectarine (Chiabrando & Giacalone, 2013) pistachios (Hashemi et al., 2020), cherries (Zapata et al., 2017). Mixing sodium alginate with agar-agar in water as a common solvent resulted in two-component edible films (Po Huo et al., 2015).

According to G. Giacalone, V. Chiabrando (2013), J. Alonso, R. Alique (2004), the use of biodegradable films was beneficial for the preservation of cherry and sweet cherry quality by delaying color changes, loss of firmness and acidity.

Based on polysaccharides, sodium alginate, carbomethylcellulose and glycerin, a film-forming coating has been developed for the mechanical protection of the meat surface, as well as the creation of favorable conditions for

the development of lactic acid bacteria (Kishenya, 2016).

Analysis of the use of edible coatings in various food products shows that they effectively preserve their quality (color, appearance, texture, moisture loss, etc.) during storage.

Despite the great advantages of using edible coatings, the commercial application of this technology in a wide range is still very limited. Improving the water resistance, mechanical and barrier properties of biopolymer films still needs improvement. In addition, a key issue is the acceptability of coverage to consumers, the ultimate cost. There is also a large question regarding the effects of coatings and films on fruit metabolites (Nayik et al., 2015).

Future research can be directed in several directions:

- study of the influence of edible coatings on fresh fruits;
- study of carefully researched fresh fruits with new edible coatings applied to the surface;
- characteristics of physical and chemical solutions for coatings;
- characteristics of films, their gas and vapor permeability;
- study of metabolic reactions, in particular breathing (Radev & Dimitrov, 2017; Vasylyshyna, 2018; 2022)

The purpose of the study was to evaluate the effect of post-harvest treatment of sodium alginate solution on the quality of cherry fruits during storage.

2. Materials and methods

For this purpose, cherry fruits of the Alfa variety were selected during 2016−2018 years at the research station of pomology named after L.P. Simyrenko 2-3 days before the consumer stage of ripeness. They were sorted by size, shape and color. The selected fruits were washed with water. After that, the cherry fruits were immersed in sodium alginate solutions for 1−2 minutes to ensure the uniformity of the coating according to the options: without treatment (control) and treated with sodium alginate solutions of 3 and 5% concentration.

Fruits treated with sodium alginate were dried for 30 minutes by blowing air created artificially by a fan at 25°C. They were packed in polyethylene bags 0.5 kg and stored at a temperature of 0±0.5°C and a relative humidity of 95±1%.

To prepare the solution, sodium alginate was dissolved in distilled water at a temperature of 45°C with a concentration of 3 and 5%. After cooling, 10% glycerol was added to the solution.

2.1.Analytical methods.

Soluble substances – refractometer (PAL-3 (ATAGO), Japan). The content of *titrated acids* was determined by titration with a solution of 0.1 M NaOH.DSTU 4957:2008.

Ascorbic acid was determined using the modified Tillman's method. Ascorbic acid was titrated with 2.6-dichloroindophenol under acid conditions (Naichenko, 2001). *Tanning and coloring substances* - by Neubauer and Leventhal (Naichenko, 2001), titrated with potassium permanganate (0.1n $KMnO_4$).

Antioxidant activity - by FRAP (Khasanov et al, 2004). Measurements were performed on the millivoltmeter (MP 511 Lab pH Meter "Ulab", China) (mV). FRAP values were expressed as mmol 100g of dry matter, as mean value ± standard deviation (N = 3 replicates).

Fruit weight loss. At the end of storage was noted natural weight loss mass by weighting. The boxes of fruit were weighted initially and before and after sampling at each evaluation date. Weight loss was expressed as percentage loss of original weight. Criteria at the end of fruit storage − weight loss no more than 6%.

Fruits were homogeneous in degree of maturity, not overripe and no smaller than 16 mm in size. The number of fruits without a peduncle and with healed damages was not higher than 4%. The fruits were of the same size, color and shape without damages (average diameter is about 15.51 ±0.05mm) (DSTU 8325:2015). Tasting rating on a 5-point scale.

To generalize the research results, the generalized Harrington function (Koltunov & Belinska, 2010; Hayova, 2019) was used, which is the geometric mean of the desirability function.

$$D = \sqrt[q]{d1 \cdot d2 \cdot \dots dq} \quad (1)$$

tod_1, d_2, d_q– is the desired level (desirability function of the 1st, 2nd, etc. optimization parameter); q is the number of optimization parameters.

Dependency (1) allows you to replace several optimization parameters with one.

The following one-sided restrictions were imposed on the optimization parameters: the content of dry soluble substances (y_1); of titrated acids (y_2); vitamin C (y_3); tannins and dyes (y_4); antioxidant activity (y_5); output of commercial products (y_6); mass loss (y_7); tasting evaluation (y_8).

In the case of one-sided restrictions on the optimization parameters, the desirability function has the form:

$$di = (\exp(-exp(-yi)) \quad (2)$$

Where y' is some dimensionless quantity related to the optimization parameter and linear dependence:

$$y = b0^{\cdot} + b1y\iota \quad (3)$$

to b_0, b_1 – are coefficients that can be determined if, for two values of the optimization parameters y_i, the corresponding values of the desirability function (d) are set.

3. Results and discussions

Table 1 shows the existing values of cherry fruits of Alfa varieties before and after storage.

Table 2 shows the value of the coded scale, which was taken from 3 to 6 and from 0 to − 0.5, which correspond to certain values for the content of dry soluble substances, etc., which are set intuitively. For example, on the coded scale, a value of 0.89 corresponds to 0.94 in terms of the content of dry soluble substances.

Based on the complex coding matrix of table 2, we set natural responses to the coded scale and calculate the desirability functions based on it. For example: for cherry fruits of the Alpha variety, after treatment with a 3% solution of sodium alginate (the first feedback is the content of dry soluble substances, we find that:

$$y = 1+(1-1)/((0.82-0.94)*(0.89-0.94)) \quad (4)$$

From here, according to the formula, $d_i = (\exp(-\exp(-y_i'))$ the responses of the conversion on the scale of desirability will be equal to 0.351 and 0.704 of Tables 3 and 4. From here we find the generalized feedback D, which gives an estimate of the scale of desirability.

Because on the coding scale from 0 to −1.5 – "bad" from 0.77 to 1.5 − "good" from 1.5 to 3 "very good". According to the content of dry soluble substances, these values are in the range of 0.56−0.97; of titrated acids − 0.46−0.89; vitamin C - 5.4-6.8; tannins and dyes − 0.09−0.91; antioxidant activity - 4.0-8.3; yield of marketable products - 87.9-92.3, mass loss - 1.5-3.8; change in the tasting score - by 0.2-0.4 points.

Table 1. Changes in the quality of cherry fruits of the Alfa variety, pre-treated with polysaccharide compositions during storage

Indicator	Type of processing		
	No processing (control)	3% solution sodium alginate	5% solution sodium alginate
Dry soluble substances* (%): to storage	15.89±0.2	15.89±0.2	15.89±0.1
after storage	14.48±0.2	15.00±0.1	15.30±0.2
losses	1.41	0.89	0.59
Titrated acids* (%): before storage	1.74±0.02	1.74±0.01	1.74±0.02
after storage	0.84±0.02	0.90±0.03	0.94±0.02
losses	0.90	0.84	0.80
Vitamin C* (mg/100 g): before storage	19.05±0.01	19.05±0.02	19.05±0.01
after storage	12.2±0.01	12.4±0.02	13.00±0.01

losses	6.85	6.65	6.05
Tanning and coloring substances * (%): to storage	0.85±0.01	0.85±0.01	0.85±0.01
after storage	0.72±0.02	0.78±0.02	0.80±0.01
losses	0.13	0.07	0.05
Antioxidant activity* (mmol/dm^3): to storage	28±2.0	28±2.0	28±1.0
after storage	17±2.0	21±1.0	22±1.0
losses	11	7	6
Product yield*,%	85.7±1.0	87.8±1.0	91.3±1.0
Mass loss*,%	4.2±0.5	3.8±0.3	3.4±0.2
Tasting evaluation (points) *: to storage	4.8±1.0	4.8±1.0	4.8±1.0
after storage	3.8±1.0	4.5±1.0	5.0±1.0
losses	1.0	0.3	0.2

*Values are displayed as the mean ± standard deviation (SR) of the three replications (P <0.05).

Table 2. Limit values of natural responses, displayed in a coded scale

Response	Boundary values of natural responses, *y*								
	−1.5	−1.0	−0.48	0	0.77	1.00	1.50	2.00	3.00
Loss of dry soluble substances	1.46	1.34	1.16	1.07	0.97	0.94	0.82	0.73	0.56
Loss of titrated acids	1.2	1.1	1.01	0.92	0.89	0.78	0.68	0.56	0.46
Loss of vitamin C	8.2	8	7.5	7.2	6.8	6.5	6.3	6	5.4
Loss of tannins and dyes	0.17	0.15	0.13	0.11	0.91	0.72	0.46	0.24	0.09
Loss of antioxidant activity	13.4	12.3	11.2	9.1	8.3	7.3	6.3	5	4
Output of commodity products	85.1	85.4	85.8	86.4	87.9	88.5	89.8	91.7	92.3
Loss of mass	6.3	5.7	5.1	4.4	3.8	3.2	2.8	2.1	1.5
Tasting assessment	1.24	1.04	0.84	0.64	0.4	0.35	0.3	0.25	0.2

Table 3. Reviews of the conversion on a scale of desirability

Conversion feedback for metrics	Type of processing		
	No processing (control)	3% solution sodium alginate	5% solution sodium alginate
Dry soluble substances	0.223	0.351	0.095
Titrated acids	0.972	0.899	0.493
Vitamin C	0.189	0.176	0.049
Tanning and coloring substances	0.171	0.064	0.037
Antioxidant activity	0.189	0.099	0.042
Output of commodity products	0.210	0.185	0.514
Loss of mass	0.479	0.109	0.008
Tasting assessment	0.449	0.001	0.001

According to the obtained calculations, we find that the treatment with a 5% solution of sodium alginate was the most effective for the fruits of cherry varieties of Alfa.

Reducing the concentration of sodium alginate to 3% or the complete absence of treatment turned out to be less effective - good and satisfactory, respectively.

Table 4. Transformed feedback and generalized feedback on the scale of desirability

Converted feedback for metrics, *d*	Type of processing		
	No processing (control)	3% solution sodium alginate	5% solution sodium alginate
Dry soluble substances	0.799	0.704	0.909
Titrated acids	0.378	0.407	0.611
Vitamin C	0.828	0.839	0.952
Tanning and coloring substances	0.843	0.938	0.963
Antioxidant activity	0.827	0.906	0.959
Output of commodity products	0.811	0.832	0.986
Loss of mass	0.619	0.896	0.993
Tasting assessment	0.638	0.999	0.999

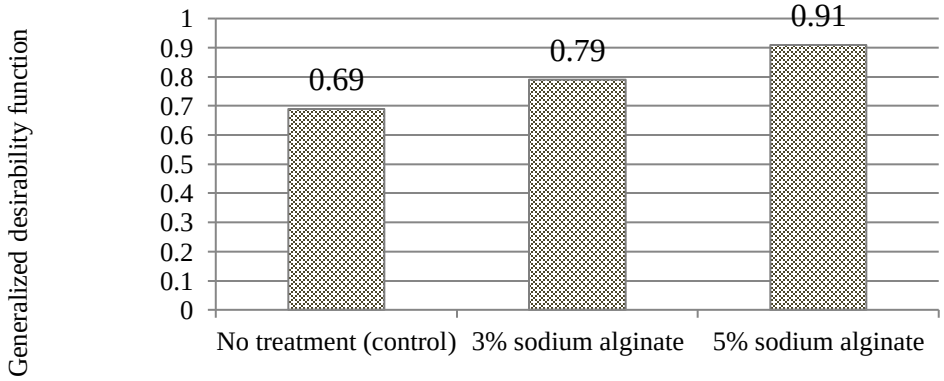


Figure 1. Ranking of pretreatment with sodium alginate on cherry fruits of Alfa varieties in order of decreasing value of the generalized desirability function

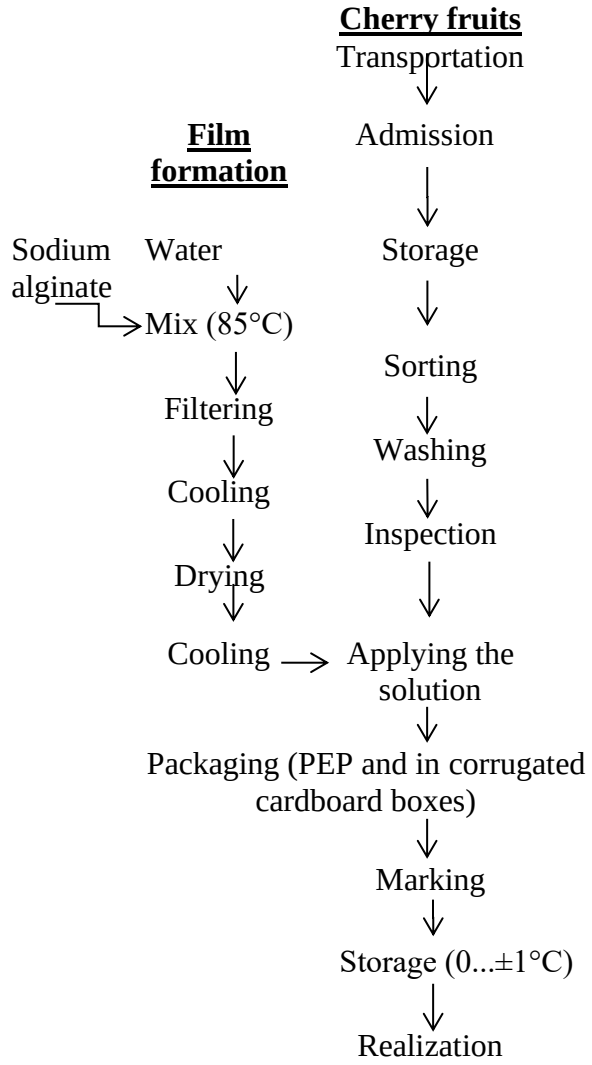
The ranking of samples in order of decreasing value of the generalized function is presented in Figure 1.

According to the ranking indicator, the most suitable for storage were the cherry fruits of the Alfa variety treated with a 5% solution of sodium alginate.

So, according to the technological scheme, after preliminary processing of cherry fruits, transportation, reception, storage in the garden (Figure 2), after unloading and receiving raw materials, sorting by quality, removing crumpled, damaged by agricultural pests, unripe and overripe fruits, the fruits are inspected, washed, and sodium alginate solution is applied.

To prepare a 5% solution, sodium alginate is dissolved in water and placed in a container for processing cherry fruits, after which they are

removed, dried, packed in boxes with a capacity of 5 kg and stored at a temperature of 0...±1°C and air humidity of 95± 1% up to 30 days.



Scheme 1. Technological scheme of storage of cherry fruits treated with sodium alginate solution

4. Conclusions.

Therefore, by carrying out research on the determination of commercial, physico-chemical indicators of cherry fruits of the common Alfa varieties pre-treated with sodium alginate solution during storage using the Harrington method, it was possible to establish the optimal concentration of sodium alginate solution - 5%. A technological scheme for preliminary processing of cherry fruits before storage has been developed.

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