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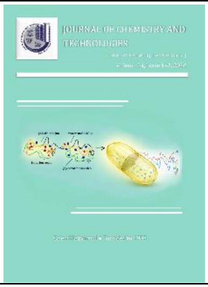

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THE EFFECT OF PRE-TREATMENT WITH CHITOSAN AND SALICYLIC ACID COMPOSITION ON CHANGE IN THE QUALITY OF SOUR CHERRIES DURING STORAGE

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Abstract

Cherry fruits are valued for their anthocyanin content, but their shelf life is short. Therefore, it is necessary to extend the shelf life of the fruit by developing new storage technologies. To this end, Alpha and Pam'yat Artemenka sour cherry varieties were sprayed with a solution of chitosan and salicylic acid and stored in a refrigerator at a temperature of 1±0.5 °C and a relative humidity of 95±1 %. The results of the studies showed that spraying cherry fruits with a 1 % chitosan solution with the addition of 100 mg/l of salicylic acid had a beneficial effect on the preservation of ascorbic acid, tannins, and pigments. Their content decreased by 18.3–19.8 % and 8.2–9.5 %. At the same time, the loss of antioxidant activity was 25–26 %. A strong correlation was found between antioxidant activity and the content of tannins and pigments (r = 0.93±0.00).
Keywords: cherry fruits; tannins and pigments; antioxidant activity; chitosan; antioxidant activity.

ВПЛИВ ПОПЕРЕДНЬОЇ ОБРОБКИ СКЛАДОМ З ХІТОЗАНУ ТА САЛІЦИЛОВОЇ КИСЛОТИ НА ЗМІНИ ЯКОСТІ ВИШНІ ПІД ЧАС ЗБЕРІГАННЯ

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Анотація

Плоди вишні цінуються за вміст антоціанів, але термін їх зберігання дуже короткий. Тому необхідно подовжувати термін зберігання плодів шляхом розробки нових технологій зберігання. З цією метою сорти кислих вишень «Альфа» та «Пам'ять Артеменка» обприскували розчином хітозану та саліцилової кислоти й зберігали в холодильнику за температури 1±0.5 °C та відносній вологості 95±1 %. Результати досліджень показали, що обприскування плодів вишні 1 %-вим розчином хітозану з додаванням 100 мг/л саліцилової кислоти сприятливо вплинуло на збереження аскорбінової кислоти, дубильних речовин та пігментів. Їхній вміст зменшився на 18.3–19.8 % та 8.2–9.5 %. Водночас втрата антиоксидантної активності становила 25–26 %. Була виявлена сильна кореляція між антиоксидантною активністю та вмістом танінів і пігментів (r = 0.93±0.00).
Ключові слова: плоди вишні; таніни та пігменти; антиоксидантна активність; хітозан; антиоксидантна активність.

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Introduction

Phenolic compounds, which are responsible for taste and colour and include phenolic acids (hydroxybenzoic acids) and flavonoids (anthocyanins and flavan-3-ols), are concentrated in the skin and less so in the flesh of cherries. Polyphenols play an important role in the prevention of cardiovascular disease, cancer, diabetes and obesity (Wojdyło et al., 2014; Picariello et al., 2016). Flavonoids protect against ultraviolet radiation, prevent the effects of toxic substances and provide resistance to pathogens (Serradilla et al., 2017).

The anthocyanin content is the main indicator of cherry ripeness. Studies have shown that the season and harvest period, variety, and climatic conditions affect the composition and concentration of anthocyanins. The anthocyanin content in fruits, particularly cherries, depends on the ecotype and region of cultivation (Oancea et al., 2016; Pissard et al., 2016; Goncalves et al., 2017; Lien et al., 2020).

The total amount of anthocyanins in cherry fruits averages 40–297 mg/100 g and sometimes reaches 994 mg/100 g. For dark-coloured fruits, their content is 82–297 mg/100 g, and for light-coloured fruits, it is 2–41 mg/100 g. The main anthocyanins are cyanidin-3-glucorutin (89–227 mg/100 g) and cyanidin-3-rutinoside (16–22 mg/100 g), which account for 63–94% of the total anthocyanin content (Blando et al., 2004; Goncalves et al., 2007; Capanoglu et al., 2011).

Anthocyanins exhibit a wide range of biological properties, including antioxidant, antimicrobial, anti-inflammatory, anticarcinogenic activity, and neuroprotective effects (Wojdyło et al., 2014; Stan et al., 2015; Pissard et al., 2016). The main property of anthocyanins is their antioxidant activity in metabolic reactions and their ability to absorb oxygen radicals in cells, which prevents oxidative stress (Serradilla et al., 2017).

In cherry fruits, antioxidant activity is associated with the presence of ascorbic acid, phenolic compounds and anthocyanins. In terms of oxygen radical absorbance capacity (ORAC), the antioxidant activity of 33 cherry varieties ranges from 8130 to 38110 μmol TE per 100 g. According to the analysis of the content (FRAP), the antioxidant activity is 1.9–13.0 mmol TE/100 g·dm (Wojdyło et al., 2014).

Antioxidant compounds (polyphenols and vitamin C), terpenes and organic acids play a major role in disease prevention due to their synergistic and additive (biological) effects. Modern practice in disease prevention consists of combining the main biologically active compounds, called ‘markers’. Important flavonols (markers) in cherry fruits are quercetin (11.86±2.36 mg/100 g Fwt), hyperoside and rutin. It has been established that the antioxidant activity of cherry fruit correlates with the content of polyphenols (Donno et al., 2018).

Therefore, due to the high polyphenolic composition and anthocyanin content, consumption of cherry fruit reduces the risk of cardiovascular disease, has an anti-inflammatory effect, and inhibits the development of cancer cells. Studies have shown that for the prevention of inflammatory diseases, cyanidin (aglycone) in sour cherries has shown better anti-inflammatory activity than aspirin (Blando et al., 2004; Capanoglu et al., 2011; Vasylyshyna et al., 2016).

During storage, the colour change in cherry fruits is the result of an increase in the level of anthocyanins, predominantly cyanidin-3-rutinoside and cyanidin-3-glucoside. The level of anthocyanins in fruits is inversely correlated with colour parameters and hue angle. Studying colour changes during cherry storage provides a complete assessment of anthocyanin level changes in different cherry varieties (Goncalves et al., 2007).

Treating stone fruits with salicylic and acetylsalicylic acid before storage reduced the loss of phenolic compounds by 10–15 %, anthocyanins by 15–20 %, and preserved antioxidant activity by 40–60 %.

The use of sodium alginate coating (1–5 %) maintains colour, prevents acid loss, reduces respiration and promotes the preservation of phenolic compounds (Valero et al., 2013).

The aim of the study was to determine the effect of treatment with chitosan and salicylic acid on the chemical parameters and antioxidant activity of sour cherries during storage.

Experimental

Preservation of the quality of cherries grown at the L. P. Simirenko Pomology Research Station of the IS NAAS, with preliminary treatment with polysaccharide compositions: salicylic acid, chitosan.

The study was conducted during 2016–2024 with cherry fruit of the Alfa and Pam'yat Artemenka varieties. The trees were kept under black steam.

The fruits from 5 trees of each variety and type of treatment were sprayed the day before harvesting according to the following options: no treatment (control); 100 mg/l salicylic acid

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solution; 1 % chitosan solution with 100 mg/l salicylic acid; 1 % chitosan solution.

The fruits were picked from trees at four different points of the crown at the consumer stage of ripeness for each variety and type of treatment, after which they were placed in boxes No. 5 weighing 5 kg each for storage at a temperature of 1±0.5 °C and relative humidity of 95±1 %. The experiment was repeated three times.

The following contents were determined in fresh cherries:

For chemical analysis of the fruit, a sample weighing at least 2 kg was formed and the indicators were determined using standard methods:

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 all., 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).

Statistical analysis. The data were statistically processed using a two and three factor analysis of variance (ANOVA) method at significance level P<0.05 on the PC program Statistica.

Mathematical data processing was performed according to V. O. Yeshchenko, P. G. Kopytko, V. P. Opryshko, P. V. Kostogryz et al. (2014).

Results and discussion

The anthocyanin content in cherries varies significantly from 40–297 to 994 mg/100 g (Blando et al., 2004; Goncalves et al., 2007). They have antioxidant activity and the ability to absorb oxygen radicals in cells, which prevents oxidative stress (Serradilla et al., 2017). In cherry fruits, antioxidant activity is determined by the presence of ascorbic acid, phenolic compounds and anthocyanins (Wojdyło et al., 2014). Therefore, determining its content in fruits is important for establishing antioxidant status.

According to the results of studies, the content of ascorbic acid in the fruits of the Alpha and Pam'yat Artemenka cherry varieties was 19.1–19.2 mg/100 g (Fig. 1). In the control variant, its content decreased by 41.0–47.4 %, and in the variant treated with chitosan solution, by 33.3–36.1 %. However, the smallest losses in the vitamin C content of cherry fruits were observed when they were treated with a solution of chitosan with salicylic acid – 18.3–19.8 %.

The content of tannins and pigments (Fig. 2), together with the vitamin content, determines the biological value of cherry fruits.

In untreated (control) cherries of the Alfa and Pam'yat Artemenka varieties, the content of tannins and colouring substances was 0.74–0.85 % and decreased by 14.1–14.9 % at the end of storage. In fruits treated only with chitosan solution, the content of these substances decreased by 9.4–12.2 %, and when chitosan was used in combination with salicylic acid, the losses in content were the smallest – 8.2–9.5 %.

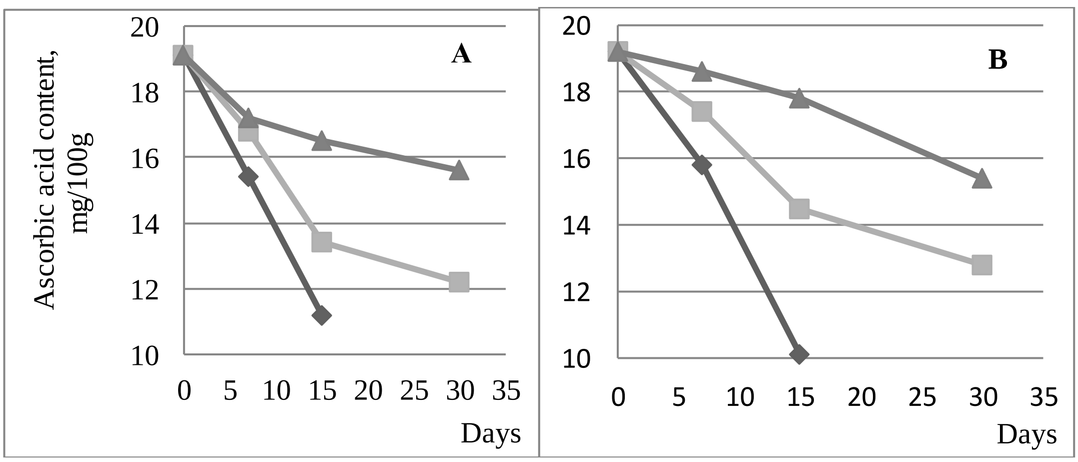

Fig. 1. Dynamics of ascorbic acid content in Alpha (A) and Pam'yat Artemenka (B) cherry fruits during storage (LSD_{05} = 1.6):

– without treatment (control); – 1%chitosan solution ;
– 1% chitosan and 100 mg/l salicylic acid solution.

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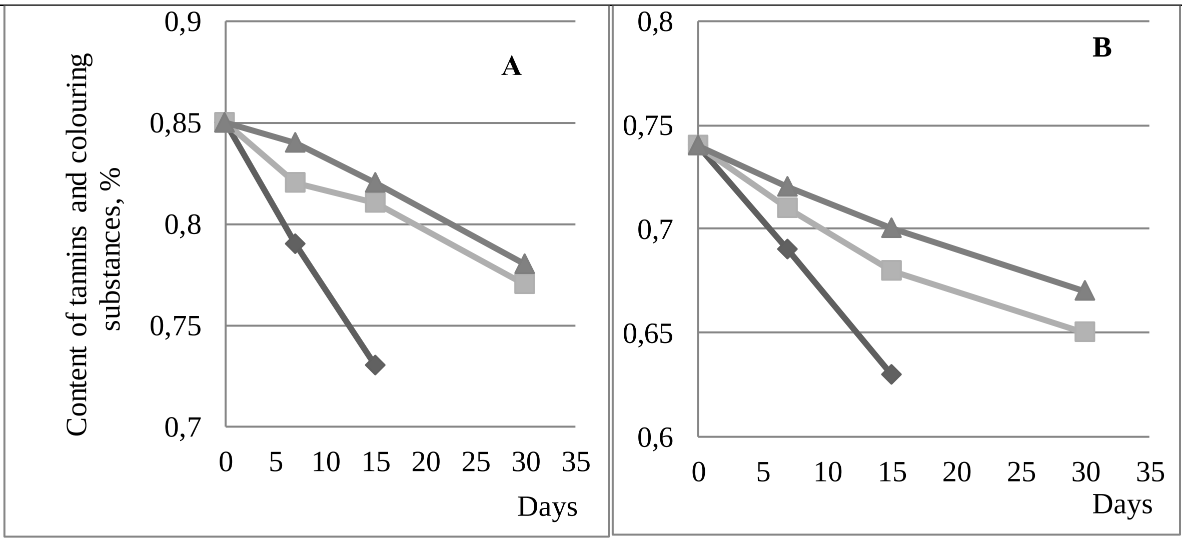

Fig. 2. Dynamics of tannin and pigment content in cherries of varieties (A) Alfa and (B) Pam'yat Artemenka during storage (LSD_{05} = 0.2):

– without treatment (control); – 1%chitosan solution ; – 1% chitosan and 100 mg/l salicylic acid solution.

Just as we preserve tannins and pigments in stone fruits, the treatment with salicylic acid and chitosan was also noted in studies by M. J. Gimenez et al. (2016). Razavi et al. (2018) stored peaches treated with salicylic acid at a temperature of 1°C for 28 days. The content of phenols, flavonoids, and ascorbic acid in these fruits was higher than in untreated fruits.

The content of tannins and colouring substances, together with ascorbic acid, determines the antioxidant activity of cherry fruits.

During storage, it decreased and depended on the characteristics of fruit processing (Fig. 3). Thus, in the untreated control variant for the Alfa and Pam'yat Artemenka varieties, the antioxidant activity before storage was 28 and 27 mmol/dm^3, respectively, and by the end of storage it decreased by 39 and 41 %, respectively.

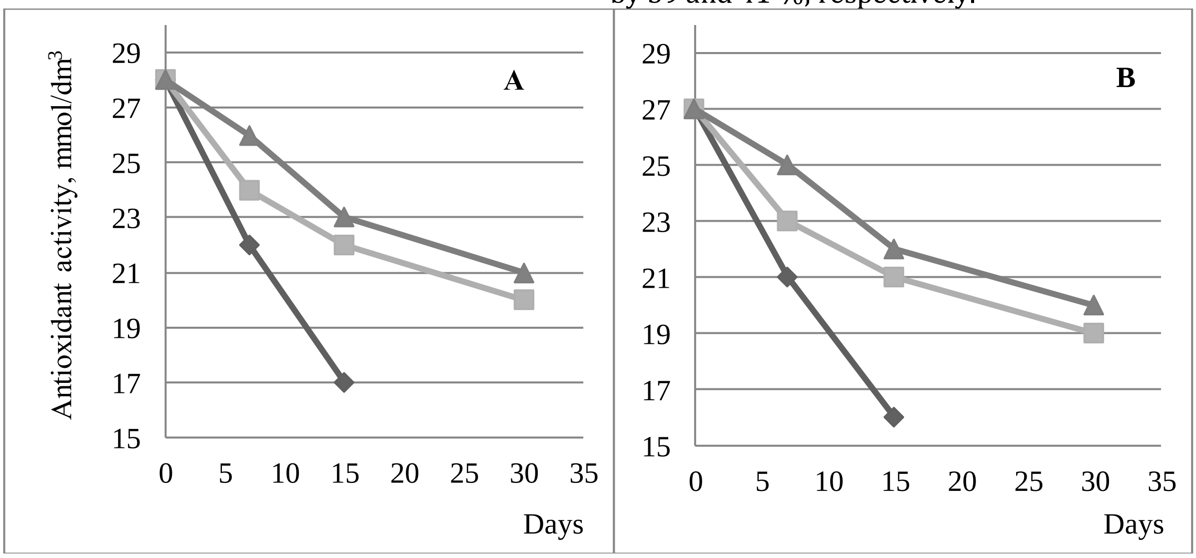

Fig. 3 Change in antioxidant activity of Alpha (A) and Pam'yat Artemenka (B) cherry varieties during storage (LSD_{05} = 4.2):

– without treatment (control); – 1%chitosan solution ; – 1% chitosan and 100 mg/l salicylic acid solution.

Pretreatment of cherries with chitosan solution contributed to their significant preservation – the reduction was only 28–30%. However, the most favourable for preserving antioxidant activity in cherries was treating them with a solution of chitosan and salicylic acid – losses were at the level of 25–26%. Similar preservation of antioxidant activity for stone fruits during their preliminary treatment with salicylic acid and chitosan was found in the works of M.I. Gimenez, M.I. Serradilla, and others (2016).

The use of various coatings for pre-harvest treatment allows a physical barrier to be established on the surface of the fruit, reducing

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permeability to O_2, CO_2 and water vapour, which leads to a decrease in respiration and transpiration intensity and preserves fruit quality (Youwei at all., 2013). This has also been confirmed by other researchers: chitosan-based coatings for Chinese cherries improved fruit quality and extended their shelf life to 20 days (Xin at all., 2017).

Pre-treatment of fruit with salicylates prevents spoilage, reduces damage and improves appearance and quality (Razavi et al., 2018).

Based on the results obtained, it was established that the antioxidant activity of cherry fruits strongly correlates with the content of tannins and pigments (r = 0.93±0.00) and ascorbic acid (r = 0.98±0.00) (Fig. 4).

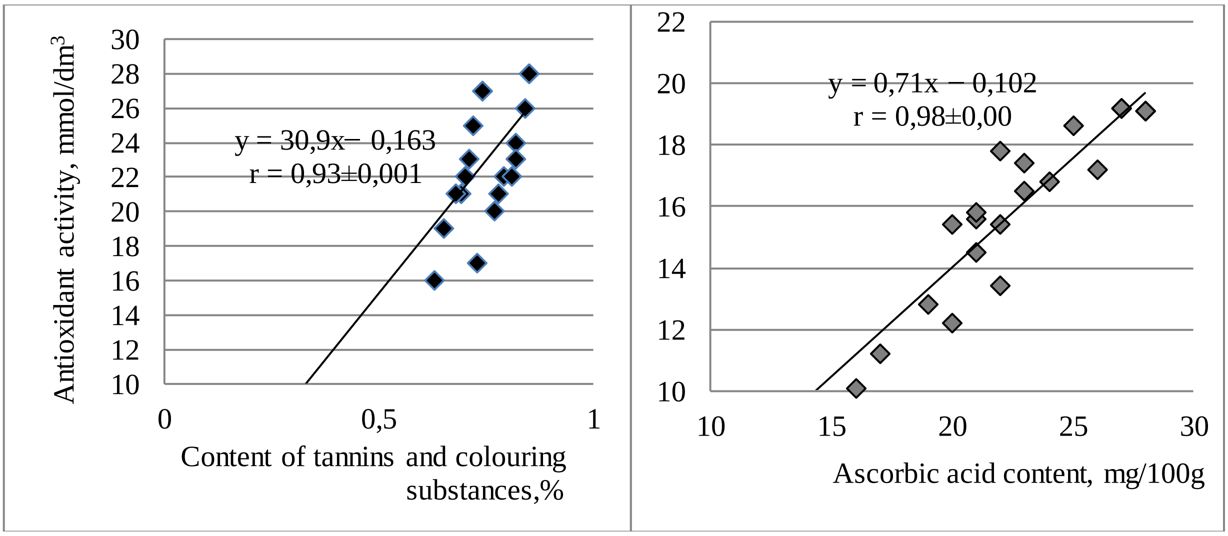

Fig. 4. Correlation between antioxidant activity and the content of tannins, pigments and ascorbic acid in cherries of the Alfa and Pam'yat Artemenka varieties

At the same time, a regression equation was derived between the antioxidant activity index and the content of tannins and colouring substances:

$$y=30.9x-0.163,$$

where x is the content of tannins and colouring substances, %;

between the antioxidant activity content and ascorbic acid: $y=0.71x-0.102$ (5.2), where x is the ascorbic acid content, mg/100 g.

The equations allow us to predict the antioxidant activity of cherries during storage based on the content of tannins and colouring substances or ascorbic acid.

Conclusions

1. Therefore, post-harvest treatment with salicylic acid can be a safe, environmentally friendly means of maintaining fruit quality. In contrast, fresh cherries lose 41.0–47.4 % of their ascorbic acid content and 14.1–14.9 % of their tannin and pigment content during storage, resulting in a significant 39–41 % decrease in their antioxidant activity. Treating cherries with a chitosan solution reduces the loss of ascorbic acid by 33.3–36.1 %, tannins and colouring substances by 9.4–12.2 %, and antioxidant activity by 28–30 %.

2. Pretreatment of cherry fruits with chitosan and salicylic acid helps to preserve the content of ascorbic acid, tannins and colouring substances with the least losses – 18.3–19.8 % and 8.2–9.5 %. The loss of antioxidant activity in cherry fruit during treatment with chitosan and salicylic acid is the lowest – 25–26 %.

3. A strong correlation (r = 0.93±0.00) was established between the antioxidant activity and the content of tannins and pigments in cherry fruit, and the regression equation

$$y = 30.9x-0.163$$ was derived.

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