The Influence of Postharvest Calcium Application in Hydrocooling Water on Physiological and Biochemical Parameters of Sweet Cherries of Regina Varieties

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Abstract

The short harvesting season together with the soft texture, limit the availability of high-quality sweet cherries on the market for longer period. An essential element that builds up the structure and the resistance of cell wall and is calcium. To have high quality fruits, it should be applied by farmers in the orchard, but has a higher absorption rate while application in the postharvest hydro-cooling water. The aim of following study was to investigate the influence of calcium chloride ($CaCl_2$) added to hydro-cooling water on physiological and biochemical parameters of Regina sweet cherry varieties. The research was carried out in 2020. The tested $CaCl_2$ concentration in water at 0ºC was 0.2%; 0.5%; 1.0% and 2.0% where the sweet cherries were immersed during 5 min. After hydro-cooling, fruits were stored in modified atmosphere packages produced by Stepac, Israel for 2 and 4 weeks. It was established the gases and atmosphere balances in packages and the organoleptic, physiological and biochemical parameters of fruits. The increase of Ca content in hydro-cooling water in comparison to control showed improvements in weight stability, acidity, firmness, soluble solid content and vitamin C with the best results at 0.5% and 1.0% $CaCl_2$ content. Pedicel browning was reduced by $CaCl_2$ at 0.2% and 0.5%, but presented higher effect at 1.0% and 2.0%.

Keywords: sweet cherry, postharvest, hydro-cooling, calcium content, shelf life, fruits quality, stem browning

Introduction

Because of the special taste and small size of fruits together with the early availability on the market, sweet cherries are demanded in both northern and southern hemisphere and are situated in the top 7 fruit species of the temperate zone according to production after apple, peach (and nectarine), pear, plum, strawberry and apricot. According to the FAO data, in 2019 it was produced 2,595.8 thousand tons of sweet cherries on a surface of 443.8 thousand ha. From the total yield 45% were produced in Asia, 30% in Europe and 13% in North America. Turkey is the biggest producer cropping about 25% of all sweet cherries globally reaching 664 thousand tons in 2019 (FAO database).

The short harvesting season as well as the soft texture of sweet cherries limits their availability on the market for longer period than 2-3 weeks. Additionally, these fruits are not available for consumers in the optimal condition after transporting at longer distances (Amarowicz, 2008, Quero-Garcia, 2017). The fresh appearance of skin, green stem and specific aroma and texture are the main physiological characteristics of sweet cherries. During transportation they are susceptible to physical damage that lead to modifications of sugar/ acidity content, shrivelling, pitting and stem browning (Bernalte, 1999, 2003). To have high quality fruits and in the end profit, farmers should take into consideration the technology of harvesting, post-harvest manipulation, storage and distribution (Goncalves, 2007).

In this chain very important role calcium plays an essential role. It contributes to the cell wall structure and strength, plasma membrane and integrity and cellular signalling responses (Poovaiah, 1993, Wang, 2014). The level of Ca in cell walls affects fruit firmness, physiological disorders and decay, while its presence in cell membranes determines respiration activity and even flavor. Fruit Ca levels are directly proportional to fruit firmness; the higher the Ca, the higher the firmness. In addition, fruit with higher Ca levels have reduced respiration levels, less stem browning and decay, greater resistance to pitting, better luster and higher acidity.

It is applied by farmers in orchards in different stages of fruits using calcium chloride ($CaCl_2$), calcium hydroxide ($Ca(OH_2)_2$), calcium nitrate ($Ca(NO_2)_2$ etc. (Erogul, 2014). $CaCl_2$ can be injected as well into the irrigation line or the microsprinkler system having an effect of reducing the rain-induced fruit cracking. Higher Ca concentrations in fruit result in potentially less cracking and heat stress, longer storage capacity, and improved flavour after prolonged cold storage (Long, 2020).

Because of the slow mobility in the plant as well as the unidirectional movement in the plant to areas of higher transpiration, such as leaves, Ca is often in deficiency in fruits. That's why one of the most efficient ways of calcium intake is the post-harvest application directly of harvested fruits. Fruit Ca levels can be enhanced by adding calcium chloride or calcium hypochorite ($Ca(OCl)_2$) in the hydrocooling water (Wang, 2014). In the research of Wang (2014) with adding calcium salt to the hydrocooling water, this experiment showed an increase in fruit firmness, reduced pitting susceptibility and respiration rate that maintains acid and flavour levels, and an overall reduction in fruit decay.

Hydrocooling is one of the most common fast cooling methods in which the exchange of heat from the fruit is achieved by direct contact with cold water (Quero-Garcia, 2017). Hydrocooling contributes to fast and uniform cooling as well, in this process fruits are washed and can be disinfected. To reduce the respiration rate and to maintain the fruit and stem quality it is essential to achieve at the temperature of 5ºC from 20-28ºC in maximum 4 hours (Alique, 2005). The research of Manganaris (2007) concluded that hydrocooled sweet cherries after one week of storage were of higher quality through reduced rate of stem browning and pitting.

The aim of my research is the influence of $CaCl_2$ applied in hydrocooling water on fruit quality and stem colour of sweet cherries of Kordia variety on Gisela 6 rootstock.

Materials and Methods

The research took place in 2020. The sweet cherries were harvested at ripening stage from the orchard of the Farm Prod company. It was planted with Regina variety trees grafted on Gisela 6 rootstock. Trees were 7 years old. The plantation was maintained according to the technology recommended for sweet cherry production. Fruits were harvested in the morning and transported to the Technical University of Moldova laboratory, where they were sorted by size, lack of defects and the presence of the stems.

The study included 5 variants of three repetitions, each repetition constituting of 5 kg. Treatments included immersing fruits in cold water at 0 °C for 5 minutes, in which the $CaCl_2$ content was at 0.0%, 0.2%, 0.5%, 1.0% and 2.0%. Fruits were then dried, packed in StePac modified atmosphere packages produced in Israel and stored in refrigeration condition at -0.5ºC. The packages producer recommends storage of sweet cherries in these bags until 60 days at -0,5…0ºC with the shelf life of 4 days at 10ºC (www.stepac.com).

Scheduled determinations were performed after 3-4 hours at 20°C in the laboratory when removed from the refrigerator.

The calcium content in the tissue was determined using the spectrophotometric method. The fruit samples were washed, oven-dried at 65°C and ground to pass through a 1 mm sieve. The samples were then treated in a CEM MARS Express microwave oven using nitric acid and hydrogen peroxide. The prepared samples were analysed for Ca content by a device called: Thermo 6500 duo ICP. The calcium content in the tissue is related to the dry mass (mg/kg). Each sample included the pulp of 30 fruits.

The firmness of sweet cherries was measured in 25 fruits using a penetrometer (Delta TRAK, Model 12226) with a cylinder diameter of 4 mm, the results were expressed in kg/ cm^2. Stem browning was investigated visually by selecting randomly 20 stems and comparing to other variants.

The average weight of the cherries was determined by the weighing method (RADVAG PS 4500 C/2 scale).

Results and Discussions

Calcium has a significant impact on fruit storage. In sweet cherries, it accumulates in bigger quantitates the first weeks after fruit setting, in the phases of cells multiplication, preharvest and postharvest before storage (Jamba, 2002). A significant increase of fruit tissue calcium content was recorded determined after dipping in cold water with $CaCl_2$. In the control variant the calcium ions content of the fruit tissue was 85.7 mg/kg, but showed an increase of 25%, 41%, 65% and 89% by using 0.2 to 2.0% of CaC_2 (fig. 1).

After storing sweet cherries of Regina variety for 2 and 4 weeks in modified atmosphere packages, the weight loss was limited to 0.7-1.1% and 1.2-1.6% respectively. The calcium treatment didn't influence much this parameter even though there is a positive trend of weight stability while increased calcium content (fig. 2).

Fruit firmness is a very important quality parameter sweet cherries, as it determines how fruits will be handled, transported, stored and then appreciated by customers. The enzymes responsible for texture modifications during ripening are pectin methylesterase (PME), polygalactoronase (PG) and β-galactosidase (β-Gal). Fruit softening is caused by growing solubility of cell walls determined by the activity of PME and PG. In the control variant average firmness was 7.4 kg/ cm^2 which qualifies sweet cherries for good storage. After dipping in hydrocooling water with calcium solution there is a high increase of firmness from 9.2 to 16.4% with higher value by applying 2.0% $CaCl_2$ (tab. 2). After storage during 4 weeks firmness decreased with 16.4%, but was much more stable while calcium application presenting 9.9 to 5.1% firmness depreciation.

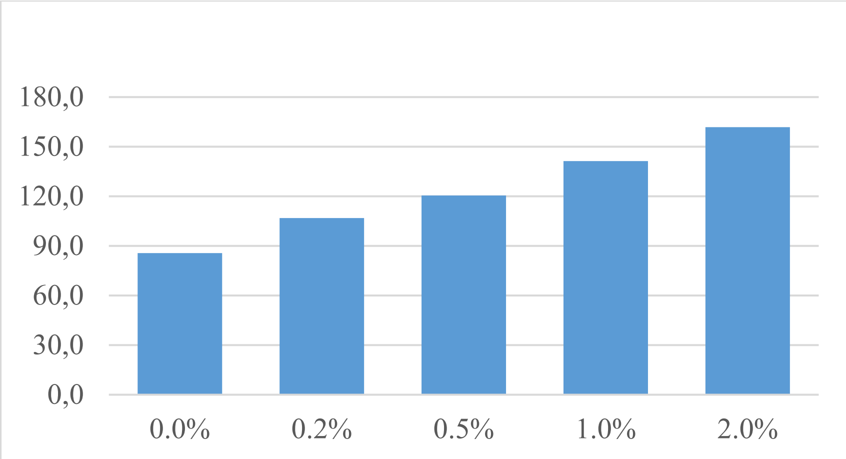

Figure 1. Influence of $CaCl_2$ content in hydrocooling water on calcium ions content in fruit tissue, mg/kg, year 2020

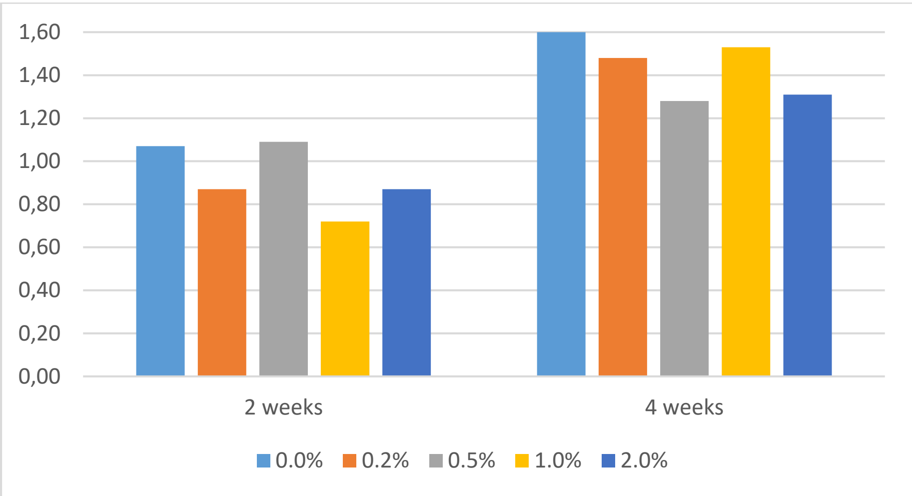

Figure 2. Fruit weight loss after sweet cherry storage depending on $CaCl_2$ concentration in hydrocooling water calculated in percent, year 2020

Higher firmness resulting from higher calcium content is due to formation of calcium pectate, which increases rigidity of the middle lamella and cell walls, leading to increased resistance of PME, PG and β-Gal.

Table 1. Fruit firmness depending on $CaCl_2$ concentration in hydrocooling water as well as the storage period, year 2020

$CaCl_2$ content	Firmness at different periods of postharvest, (kg/cm^2)			Increase of firmness after dipping, %	Decrease of firmness compared to the initial one, %	
	Initial phase (after hydrocooling)	2 weeks	4 weeks		2 weeks	4 weeks
0.0%	7.4	6.8	6.2		8.1	16.2
0.2%	8.1	7.6	7.3	9.5	6.2	9.9
0.5%	8.3	7.9	7.6	12.2	4.8	8.4
1.0%	8.4	8.1	7.9	13.5	3.6	6.0
2.0%	8.6	8.4	8.2	16.2	2.3	4.7

Green stem is considered one of the most important indicators of sweet cherry quality and is associated with freshness. Its browning is a result of the loss of membrane integrity which allows polyphenol oxidase and polyphenol substances to mix in the damaged cells resulting in tissue browning (Wang, 2014).

Results in this research show small improvements of maintaining the stem green colour of sweet cherries of Regina variety taken from storage after 2 and 4 weeks while applying 0.2% $CaCl_2$ concentration in the hydrocooling water. While stored 2 weeks fruits proved better results of 10% stem browning in the case of 0.2% $CaCl_2$ in comparison to 1.5% $CaCl_2$ for control. For the 0.5%, 1.0% and 2.0% $CaCl_2$ concentrations after 4-weeks storage there were determined strong stem browning effect of 35%, 55% and 75% of the colour damaged (tab. 2).

The last 2 variants would be unacceptable for the fresh market. One of the reasons is the specific of Regina variety for storage in comparison to other varieties. In my researches with Kordia variety the best form of the green stems was in the cases of 0.2 and 0.5% (fig.3).

Table 2. Evolution of the colour of the sweet cherries stem depending on $CaCl_2$ concentration in hydrocooling water, year 2020

$CaCl_2$ content	Evolution of stem browning compared to 0% from the initial phase, %	
	2 weeks	4 weeks
0.0%	15	25
0.2%	10	20
0.5%	25	35
1.0%	45	55
2.0%	60	75

Figure 3. Stem colour state at 4 weeks of storage of sweet cherries of Regina variety

Wang, (2014) came with the result that after storing sweet cherries of Sweetheart and Lapins varieties for 4 weeks, fruits immersed in hydrocooling water with 0.2% and 0.5% $CaCl_2$ solution showed significant reduced incidence of stem browning compared to control. For example, 0.5% $CaCl_2$ reduced stem browning incidence of Sweetheart and Lapins up to 9% and 34%, respectively, after 4 weeks of storage (Wang, 2014).

Conclusions

Hydrocooling in a short time after harvesting is an important technological element in the value chain of sweet cherries used to eliminate the heat accumulated in the field.

Adding $CaCl_2$ with 0.2; 0.5; 1.0 and 2.0% concentration to the hydrocooling water increased the fruit tissue calcium ions content with 24.6; 40.6; 64.9 and 88.8%, respectively, compared to control of sweet cherries of Regina variety.

There was no significant impact in reducing the weight loss by adding calcium salt at postharvest period at sweet cherries of Regina variety.

Firmness is increased at the initial stage after dipping sweet cherries into the hydrocooling water with $CaCl_2$ and has a big impact in reducing firmness decrease after storage during 2 and 4 weeks.

For sweet cherries of Regina variety, adding 0.2% $CaCl_2$ to the hydrocooling water has a positive effect on maintaining green stems, but has a negative impact while adding higher concentrations (0.5 to 2.0%).

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