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EFFECTS OF 1-METHYL-CYCLOPROPENE ON THE PHYSICO-CHEMICAL PROPERTIES OF CHERRY FRUIT DURING STORAGE

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Abstract

This study examined the effects of 1-methylcyclopropene (1-MCP) on basic physico-chemical characteristics of sweet cherry fruits, ‘Burlat’ cultivar. The fruits were exposed to 1-methylcyclopropene at concentrations of 0.05, 0.1 and 0.5 ppm, for 20 hours at 5°C. After treatment, the fruits were stored in the cold room (3°C) with normal atmosphere for 15 days, followed by 5 days storage at room temperature (shelf life). The average fruit weight, fruit firmness and total soluble solids in the fruit juice were determined and compared to the average values of these parameters before treatment. The obtained results indicate that 1-methylcyclopropene has an impact on the studied parameters. Fruit weight loss was the lowest in samples treated with 0.05 ppm 1-MCP and the highest at 0.5 ppm 1-MCP. The average fruit firmness was the lowest in the fruits treated with 0.05 ppm 1-MCP, and the highest in the non-treated fruits. The average value of the soluble solids content in the fruit juice was the lowest in fruits treated with 0.05 ppm, and the highest at 0.1 ppm.

Keywords: cherry ‘Burlat’, 1-methylcyclopropene, fruit storage

Introduction

One of the important factors that influence fruit preservation is gaseous phytohormone ethylene, which at low concentrations activates the process of senescence (aging) of fruit, ultimately leading to deterioration of stored products. Negative impact of ethylene in fruit storage environment can be reduced or eliminated by using different alkene cyclic derivatives such as 2,5-norbornadiene; 3,3-dimethylcyclopropene; diazocyclopentadiene and 1-methylcyclopropene (Sisler et al., 1990). These compounds have the ability to inhibit ethylene action by binding to the ethylene receptors faster than ethylene itself (Sisler & Serek, 1997, 1999). Only 1-methylcyclopropene is used for commercial purposes so far (commercial formulations SmartFresh^{TM} and EthylBlock^{TM}) in order to control ethylene level in the cold rooms where horticultural products are stored. Previous studies have shown that 1-methylcyclopropene has a significant impact on the biochemical processes in climacteric fruits during ripening and storage, while the impact of this compound on non-climacteric fruits is contradictory (Porat et al., 1999; Mullins et al., 2000; Tian et al., 2000; Jiang et al., 2001). Cherry fruits are non-climacteric fruits (Biale, 1960; Blanpied, 1972) characterized by a low level of endogenous ethylene production (Biale and Young, 1981). Influence of 1-methylcyclopropene on the physico-chemical characteristics of cherry is not well documented. Yiping et al. (2002) reported that treatment with 1-methylcyclopropene did not affect respiration rate, fruit skin color, stem color and fruit firmness of the Bing and Rainier cherry cultivars. On the other hand, Yang et al. (2011) reported that treatment of cherry with 1-methylcyclopropene (EthylBlock formulation) is an effective method for fruit quality preservation during storage. Obviously, there is a need for further evaluation of the effects of 1-methylcyclopropene on cherry fruit preservation. The aim of this study was to investigate the influence of 1-methylcyclopropene on basic physico-chemical characteristics of cherry fruit during storage in the cold room with normal atmosphere.

Materials and methods

Fruits of the ‘Burlat’ cultivar were harvested from the Jablanica orchard, Gradiska. Trees from which the fruit was harvested were previously grafted on Gisela 5 and they were in the sixth year of cultivation. After harvesting at the consumption maturity stage the fruits were pomologically analyzed, determining the average fruit weight, soluble solids content in the fruit juice and fruit firmness. Soluble solids content was determined using a digital Atago refractometer. Fruit firmness was determined using a digital dynamometer (piston width of 1.5 cm and vertical path of 2 mm). Fruit skin was not removed and the fruit resistance to piston pressure was measured, rather than piston penetration into the fruit flesh. After the initial analysis, the fruits were exposed to 1-MCP at three different concentrations: 0.05, 0.1, and 0.5 ppm. SmartFresh formulation with 0.14% 1-MCP was used in the following way: 80 mg/m^3 (for 0.05 ppm concentration), 160 mg/m^3 (for 0.1 ppm) and 800 mg/m^3 (for 0.5 ppm concentration). 1-MCP solution was prepared by dissolving adequate amount of 1-MCP in 2 ml of distilled water at 25°C. The fruits were kept in a sealed container with 1-MCP for 20 hours at 5°C. After treatment, the fruits were stored in a chamber with normal atmosphere at 3°C and relative humidity of 95% for 15 days, and then kept at room temperature for 5 days (shelf life). The average fruit weight, soluble solids content and fruit firmness were determined and compared to the average values prior to the treatment.

The loss in fruit weight is expressed as weight loss (spoilage, moisture loss) and it was measured after 15 days of storage and 5 days of shelf life. Fruit weight was measured on the composite sample in a container that contained 40 fruits. Fruit flesh firmness and soluble solids content in the juice 10^{th} and 15^{th} day of storage, and after 5^{th} day of shelf life. For the statistical analysis of data IBM SPSS Statistics 20 software was used. An analysis of variance with two factors (4×3) was done. Due to observed significant effect or interaction further analysis was performed using LSD test. Average values and standard error of arithmetic mean for the measured characteristics are also given.

Results and Discussion

Table 1. shows measured weight values of the composite samples of cherry prior to the treatment with 1-MCP and after the storage and shelf life, as well as fruit weight loss after the storage and shelf life, and the total weight loss during the research.

By examining data given in Table 1 we can see that the smallest total weight loss was observed in fruits treated with 0.05 ppm 1-MCP (28.40 g), and the highest loss was observed in fruits treated with 0.5 ppm 1-MCP (43.40 g). Based on tabular and graphical data (Graph 1), we can see that the ratio of fruit weight loss during storage and during the shelf life is different for examined concentrations. Higher weight loss was observed during the cold storage in compared to shelf life at fruits which were exposed to the concentrations of 0.1 and 0.5 ppm of 1-MCP as well as with untreated fruits. Contrary to this, the higher weight loss during the shelf life compared to the cold storage was observed at fruits exposed to concentration of 0.05 ppm of 1-MCP.

Table 1: Composite samples fruit wight loss (40 fruits in a container) during the storage and after shelf life for different 1-MCP concentrations

1-MCP	initial weight (g)	weight after 15 days of storage (g)	weight after shelf life (g)	weight loss during storage (g)	weight loss during shelf life (g)	total weight loss (g)
0.05 ppm	200.1	188.3	171.7	11.8	16.6	28.4
0.1 ppm	208.3	190.3	179.5	18.0	10.8	28.8
0.5 ppm	204.1	171.5	160.7	32.6	10.8	43.4
non-treated	216.5	198.6	185.6	17.9	13.0	30.9

Graph 1: Graphical representation of weight loss during storage and during shelf life of fruits exposed to different concentrations of 1-MCP

Table 2. shows average values and standard error of the soluble solids content in fruit flesh juice of examined cherry cultivar for differenet 1-MCP concentratios, before the treatment, after the cold storage and shelf life. Graph 2. shows graphical representation of examined paremeter.

Table 2: Average values and standard error of souluble solids content (Total soluble solids) (%Brix) in fruit flesh juice of examined cherry cultivar before, during and after the treatment at different concentrations of 1-MCP.

Storage period	1-MCP concentration [ppm]			
	0	0.05	0.1	0.5
	μ ± Sx	μ ± Sx	μ ± Sx	μ ± Sx
Initial	11.04 ± 0.31	11.04 ± 0.31	11.04 ± 0.31	11.04 ± 0.31
10 days after storage	11.77 ± 0.24	12.05 ± 0.18	11.48 ± 0.19	12.47 ± 0.16
15 days after storage	11.95 ± 0.19	12.24 ± 0.19	12.51 ± 0.16	12.17 ± 0.19
Shelf life	12.80 ± 0.31	12.64 ± 0.30	13.42 ± 0.28	13.18 ± 0.20

Graph 2. Graphical representation of the average soluble solids content values (%Brix) in fruit flesh juice of examined cherry before, during and after the treatment at different 1-MCP concentrations.

Based on data given in Table 2 and Graph 2, we can see that, as it would be expected, soluble solids content in fruit flesh juice increases with time. The smallest change for examined parameter was observed in cherry fruit which were treated with 0.05 ppm concetration of 1-MCP, and highest growth was observed in fruits treated with 0.1 ppm concetration of 1-MCP.

Table 3. shows average values and standard error for fruit flesh firmness in examined cherry cultivar at different concentrations of 1-MCP before the treatment, after the storage and shelflife, and Graph 3. gives grapchical representation of examined parameter.

Table 3. Average values and standars error for fruit flesh firmness (kg/2mm) of examined cherry cultivar before, during and after the treatment at different concentrations of 1-MCP

Measuring moment	1-MCP concentration [ppm]			
	0 μ ± Sx	0.05 μ ± Sx	0.1 μ ± Sx	0.5 μ ± Sx
Initial	0.32 ± 0.02	0.32 ± 0.02	0.32 ± 0.02	0.32 ± 0.02
10 days after storage	0.31 ± 0.02	0.33 ± 0.02	0.34 ± 0.02	0.36 ± 0.02
15 days after storage	0.25 ± 0.01	0.25 ± 0.02	0.29 ± 0.02	0.23 ± 0.02
Shelf life	0.21 ± 0.02	0.16 ± 0.01	0.18 ± 0.01	0.19 ± 0.01

Based on data from Table 3 and Graph 3, we can se that the smallest loss in fruit firmness was observed with untreated fruits, and the highest loss was observed at fruits treated with 1-MCP of 0.05 ppm concentration.

Graph 3. Graphical representation of average values of fruit flesh firmness (kg/2mm) of examined cherry cultvar before, druitng and after the treatment at different 1-MCP concentrations.

Table 4. Analysis of variance for totale soluble solids and fruit firmness, F values and p values (p<0,05*, p<0,01**)

Fruit characteristics	Factors		
	Storage period	1-MCP concentration	Interaction Time × MCP
TSS	25.45**	2.26	2.59*
Firmness	80.34**	0.97	1.65

The analysis of variance for soluble solids indicates statistically significant interaction between storage time and concentration of 1-MCP. By performing further breakdown of the factors and LSD test (p <0.05) it is indicated that fruits treated with 0.05 ppm showed no statistically significant difference in average values of total soluble solids between measurements in the 10^{th}, 15^{th} day and shelf life period. On the other hand, the fruits treated with 0.1 ppm expressed a statistically significant increase in the average values of total soluble solids in aforementioned measuring periods. At the 10^{th} day of storage smallest total soluble solids values had fruits treated with 0.1 ppm 1-MCP, which for the 10^{th} day is statistically significantly different only from fruits treated with 0.5 ppm. In the 15^{th} day of storage no statistically significant differences have been observed between the fruits treated with different 1-MCP concentrations. In the shelf life period fruits treated with 0.1 ppm have the highest average total soluble solids content compared to other fruits treated with other concentrations of 1-MCP, where significant difference between these fruits and fruits treated with 0.05 ppm and 0 ppm of 1 – MCP was observed. During the shelf life the lowest average total soluble solids content have fruits treated with 0.05 ppm where significant difference is observed only in comparison with fruits treated with 0.1 ppm. There was no significant difference between the periods from 10^{th} to 15^{th} day for all 1-MCP treatments except for the treatment with 0.1 ppm where there was a statistically significant increase. By performing the analysis of variance of the average value of the fruit firmness a significant impact of the storage duration was observed. There was no statistically significant effect of different concentrations of 1-MCP, or interactions between the studied factors. By further analysis of the factors of storage time with LSD test (p <0.05) it was observed that there was statistically significant difference between the average values of fruit firmness measured on the 10^{th}, 15^{th} day and shelf life period.

Conclusions

The research results of the effect of 1-MCP on basic physico-chemical characteristics of the cherry fruit, ‘Burlat’ cultivar, show that this agent has a certain influence on the fruit post-harvest physico-chemical characteristics during the storage process. It appears that the lower concentrations of 1-MCP (0.05 ppm) more strongly inhibit physiological processes compared to the higher concentrations. The fruits treated with low concentrations of 1-MCP showed reduced intensity of weight loss, as well as slower growth of total soluble solids during the storage. On the other hand, it seems that 1-MCP has no significant effect on the firmness of the fruit flesh, since the best results in this regard have shown untreated fruits. In this regard, it is necessary to study the impact of 1-MCP treatment on cherry fruits after the storage and prior to referral to the market. Indeed, research needs to be extended to other cherry cultivars that are present in our production area.

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