

Antioxidant Potential and Storage Stability of Sweet Cherries (*Prunus Avium* L.) Depending on the Use of 1-Methylcyclopropene

Dorota Wichrowska

wichrowska@pbs.edu.pl

Bydgoszcz University of Science and Technology

Andrzej Wolan

Nicolaus Copernicus University of Toruń

Tim Malefyt

Fresh Inset S.A, Chief Technology Officer

Article

Keywords:

Posted Date: June 17th, 2025

DOI: <https://doi.org/10.21203/rs.3.rs-6546955/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at Scientific Reports on March 14th, 2026. See the published version at <https://doi.org/10.1038/s41598-026-42369-3>.

Abstract

Plant growth regulator 1-methylcyclopropene (1-MCP) delays the ripening of many climacteric fruits and vegetables. However, the effect of 1-MCP has been studied to a lesser extent on non-climacteric fruit, showing variable results in delaying their ripening. In the present experiment the effects of using different doses: 1, 2, 4 μ L of 1-MCP per liter in the form of Vidre + stickers (Fresh Inset) compared to control (without 1-MCP) on the quality parameters and shelf life of cv. Kordia and Regina was evaluated. One Liter clamshells of freshly picked sweet cherries were placed into a plastic bag for 24 hours. After that, all clamshells were placed into a storage chamber (2–3°C, 90–95% relative air humidity). The best results in terms of weight loss, stem browning, firmness and fruit quality after storage was obtained with samples treated with 1-MCP. Similar relationships were obtained with regard to the concentration of Vitamin C, total polyphenols, anthocyanins and the antioxidant activity FRAP.

Introduction

Sweet cherries (*Prunus avium* L.) are a premium product with high market prices, whose seasonality is increasing in the face of global climate change. These fruits are highly appreciated for their excellent organoleptic properties and are also rich in bioactive compounds with antioxidant properties, mainly phenols and ascorbic acid, which are responsible for their beneficial effects on health, i.e. anti-inflammatory, antidiabetic, antibacterial and anticancer properties, and also cardiovascular and neuroprotective effects^{1–8}. Moreover, an increasing percentage of consumers pay attention to aspects related to the sustainable development of the entire production chain in terms of the balance between resource input and crop efficiency, environmental impact, nutritional value of products⁹. As reported by FAO¹⁰, more than 460 million tons of fruits and vegetables go to waste every year. Much of this fresh produce waste occurs due to quality loss in the supply chain. Therefore, resources used to produce the food and ship the food are wasted for every kilo of produce that is never eaten. Therefore, wasted food is an important contributor to wasted resources causing harm to our natural environment and an economic drain on state budgets and households. The development of technologies that enable longer preservation of fruit freshness is the subject of interest of many scientific and research centers. The goal for any sustainable technology for produce should be to reduce this waste and improve shelf life to allow for safe distribution, sale and storage of food all the way to the consumer's home.

Sweet cherry has become one of the most important non-climacteric fruits worldwide. Anon-climacteric fruit is one that does not continue to ripen after harvesting^{11–12}. However, after harvesting it can age, soften and decay due to respiratory activity and other physical and environmental factors which can shorten post-harvest lifespan¹³. Cherry spoilage includes softening of the flesh followed by skin color change and bruising, browning of the stem, dehydration of the fruit and loss of acidity^{14–17}. Unlike other fruits, there are unique aspects cherry fruit aging¹⁸. Failure to comply with the recommended storage requirements leads to loss of taste, darkening of the skin of the fruit, browning of the stalks and decay caused by common plant pathogens, in particular *Monilinia laxa*, *Botrytis cinerea*^{19–20}, *Alternaria alternat*, *Penicillium expansum*, *Rhizopus stolonifera* and *Cladosporium* spp.²¹. It has been widely recognized that preserving cherries for fresh consumption, even for short periods of time, requires very sophisticated techniques that include rapid removal of heat from the field after harvest and low temperatures throughout the distribution chain. In addition, keeping cherries firm is a key quality factor to consider during transportation²². It is well known that fruit softening is partly regulated by ethylene^{23–28}; however, the effect of exogenous ethylene on non-climacteric fruit remains unclear. It is well known that the plant

growth regulator 1-methylcyclopropene (1-MCP) delays the ripening of many fruits and vegetables during the climacteric period ²⁹. However, the effects of 1-MCP have been studied to a lesser extent on non-climacteric fruits, showing variable effects of slowing post-harvest ripening.

Therefore, the aim of the work is to present the possibility of reducing food losses and waste through the use of an innovative technology that extends the shelf life of selected sweet cherry varieties through the use of 1-methylcyclopropene (1-MCP). The application, in the form of a sticker from which 1-MCP is gradually released, does not have to be used in a closed warehouse or cold store. This new technology means that 1-MCP can be used to extend the freshness of many highly perishable fruits and vegetables, including those transported immediately after harvest from the packhouse or field directly to retailers.

Results and discussion

Weight loss and fruit firmness during storage

Weight loss and firmness were two important predictors of vegetable shelf life, and softening was one of the most ethylene-sensitive ripening processes ³⁰. Both varieties of sweet cherries were characterized by good shelf life, measured, among others, by the amount of weight loss, firmness, color of the stems and fruit quality in the planned period of storage, i.e. 21 days. Figure 1 shows and Table 1 present that cultivar and 1-MCP dose had significant ($p < 0.05$) effect on weight loss of sweet cherries. Regina varieties showed significantly lower weight loss during storage than Kordia varieties. Weight loss of storage samples was 31.6% lower in the fruit treated with 1-MCP compared to the fruit without the application of 1-MCP. This can be attributed to the function of ethylene in regulating the metabolic activity associated with softening and weight loss ^{31–32}. Similar effects of 1-MCP on delaying the softening and maintaining fruit weight have been observed for tomato, avocado, kiwifruit and apple ^{30, 33–35}.

Table 1
Weight loss (%) after storage depending on the cultivar and 1-MCP dose (mean for cultivars and 1-MCP concentration).

Factors		Storage time						
		After 1 day	After 3 days	After 6 days	After 9 days	After 13 days	After 17 days	After 21 days
1-MCP conc.	Control	1.44 a	3.34 a	4.41a	5.37 a	5.58 a	6.60 a	7.98 a
	1 ppm	0.22 b	1.75 d	2.76 b	3.71 d	4.19 c	4.94 d	6.45 b
	2 ppm	0.22 b	2.03 b	2.85 c	4.08 c	4.70 b	5.50 b	5.94 c
	4 ppm	0.18 c	1.86 c	2.71b	4.43 b	4.59 b	5.25 c	5.87 c
Cultivar	Kordia	1.44 A	1.58 B	3.20 A	5.20 A	5.55 A	6.26 A	7.52 A
	Regina	0.75 B	2.91 A	3.17 A	3.59 B	3.97 B	4.88 B	5.60 B
Mean		0.51	2.25	3.18	4.40	4.76	5.57	6.56

a, b, c, d, A, B. Means noted with the same letter in column are not significantly different ($p < 0.05$).

LSD—least significant difference.

In the following days of storage, the weight loss was the lowest after application 1-MCP (Table 1). The smallest weight losses after 21 days of storage were in the samples treated with 2 and 4 ppm 1-MCP (5.94 and 5.87%), the largest losses in untreated sweet cherries (7.98%).

Table 2
Firmness [N] after storage depending on the cultivar and 1-MCP dose (mean for cultivars and 1-MCP concentration).

Factors		Storage time						
		After 1 day	After 3 days	After 6 days	After 9 days	After 13 days	After 17 days	After 21 days
1-MCP conc.	Control	3.22 a	3.21 a	3.20 b	3.18 c	3.18 d	3.15 c	3.14 c
	1 ppm	3.22 a	3.21 a	3.21 a	3.20 b	3.19 c	3.18 b	3.18 b
	2 ppm	3.22 a	3.21 a	3.21 a	3.20 b	3.20 b	3.18 b	3.18 b
	4 ppm	3.22 a	3.21 a	3.21 a	3.21 a	3.21 a	3.20 a	3.20 a
Cultivar	Kordia	3.16 B	3.16 B	3.16 B	3.14 B	3.14 B	3.12 B	3.12 B
	Regina	3.27 A	3.26 A	3.26 A	3.25 A	3.25 A	3.23 A	3.23 A
Mean		3.22	3.21	3.21	3.19	3.19	3.17	3.17

Fruit firmness is a critical fruit quality parameter for consumers, where consumers prefer firm rather than soft fruit ³⁶. However fruit firmness often changes during storage and shipping. The mechanism for sweet cherry fruit softening is not clear, indeed it is not always consistent that fruit always softens during storage and marketing. The phenomenon of fruit softening during storage is contentious ²⁰ (Zoffoli et al., 2017). Excessive softening is described as a common problem during long-term storage in some cultivars, but varies depending on the season ³⁷. Studies on the effect of 1-MCP on maintaining the firmness of cherries are few and rather contradictory ^{38–40}. In present study instrumental methods were used to characterize the physical characteristics of the fruit - the force needed to pierce the fruit with a pin was measured and the deformation of the fruit under the action of compressive force was measured. The results showed that the use of 1-MCP had a beneficial effect on maintaining fruit firmness (Fig. 2). Cultivar Regina was better in terms of the tested feature than cultivar Kordia (Table 2). Significantly, the best results in firmness after storage were obtained in samples treated with 4 uL of 1-MCP per liter (Table 2). 1-MCP has been reported to delay softening avocado, custard apple, mango and papaya ⁴¹.

Fruit quality

Quality is an elusive concept that depends on the product itself and on consumer preferences ⁴². Quality does have many meanings, but can often be defined in objective measures that are related to the consumer's experience of eating ⁴³. The quality of cherry fruit is also determined by features that influence the market attractiveness of the fruit and consumer satisfaction with consumption ⁴⁴. In present research the best results in

terms of fruit quality after storage were obtained for samples treated with 4 cm²/L (Table 3). CV. Regina was better in terms of the tested feature than CV. Kordia.

Table 3
Fruit quality (scores) after storage depending on the cultivar and 1-MCP dose (mean for cultivars and 1-MCP concentration).

Factors		Storage time						
		After 1 day	After 3 days	After 6 days	After 9 days	After 13 days	After 17 days	After 21 days
1-MCP conc.	Control	4.00 a	4.00 a	4.00 a	3.80 b	3.80 c	3.60 b	3.50 c
	1 ppm	4.00 a	4.00 a	4.00 a	4.00 a	3.90 b	3.90 a	3.60 a
	2 ppm	4.00 a	4.00 a	4.00 a	4.00 a	4.00 a	3.90 a	3.55 b
	4 ppm	4.00 a	4.00 a	4.00 a	4.00 a	4.00 a	3.90 a	3.60 a
Cultivar	Kordia	4.00 A	4.00 A	4.00 A	3.95 A	3.93 A	3.80 B	3.48 B
	Regina	4.00 A	4.00 A	4.00 A	3.95 A	3.93 A	3.85 A	3.65 A
Mean		4.00	4.00	4.00	3.95	3.93	3.83	3.56

Scores: 1–4 with 4 = excellent eating quality, 3 = good eating quality, 2 = moderate eating quality, 1 = poor eating quality

a, b, c, d, A, B. Means noted with the same letter in column are not significantly different ($p < 0.05$); LSD—least significant difference.

Steam browning

Although sweet cherry stems are not eaten, the quality of the stems (particularly color and freshness) greatly influences consumers' perception of the quality of cherries. Both water loss and mechanical damage to the stem cause browning, which is highly undesirable. Fruits have a thick waxy skin that protects them against water loss⁴⁵, while the stems have a much thinner epidermis, which increases sensitivity during storage, especially water loss⁴⁶. The resistance to water vapor penetration in the stem is much lower than in the fruit. Therefore, cherry fruit stems can exhibit up to eight times greater water loss, regardless of whether they are separated from the fruit or still attached to it⁴⁶. Therefore, green stems are often used as indicators of the overall freshness of cherry fruit. These types of indicators are very helpful and important for consumers when making purchasing decisions⁴⁷. However, this also makes it more important for the supply chain and retailer to maintain the quality of the stems. Significantly, the best results in terms stem browning after storage were obtained in samples treated with 2 and 4 cm²/L (Fig. 3). After 21 days of storage, steam browning of the Regina CV. were less than those of the Kordia CV (Table 4).

Table 4

Steam browning [scores] after storage depending on the cultivar and 1-MCP dose (mean for cultivars and 1-MCP concentration).

Factors		Storage time						
		After 1 day	After 3 days	After 6 days	After 9 days	After 13 days	After 17 days	After 21 days
1-MCP conc.	Control	4.00 a	4.00 a	3.90 b	3.75 c	3.65 c	3.30 d	2.58 c
	1 ppm	4.00 a	4.00 a	4.00 a	3.95 b	3.90 b	3.65 c	3.48 b
	2 ppm	4.00 a	4.00 a	4.00 a	4.00 a	4.00 a	3.75 b	3.65 a
	4 ppm	4.00 a	4.00 a	4.00 a	4.00 a	4.00 a	3.80 a	3.65 a
Cultivar	Kordia	4.00 A	4.00 A	3.95 B	3.88 B	3.83 B	3.38 B	3.10 B
	Regina	4.00 A	4.00 A	4.00 A	3.98 A	3.95 A	3.88 A	3.58 A
Mean		4.00	4.00	3.98	3.93	3.89	3.63	3.34

Scores: 1–4 with 4 = bright green, 3 = light green/slightly yellow, 2 = beginning browning, 1 = mostly brown

a, b, c, d, A, B. Means noted with the same letter in column are not significantly different ($p < 0.05$); LSD—least significant difference.

Dry matter

Dry matter and total soluble solids content increase during fruit development^{48–49}, which becomes significantly sweeter during ripening due to increased sugar concentration, while acids (malic acid) remain relatively constant or decrease⁵⁰. The tested cherry varieties differed significantly in terms of dry matter content, both after harvest and after storage. The use of different doses of 1-MCP had a significant impact on the dry matter content after storage. Significantly, the untreated samples had the highest amount of dry matter, and the highest amount of dry matter among those treated with 1-MCP was found in fruits after a dose of 1 ppm, both after 9 and 21 days of storage (Table 5), and this content increased after storage. Research by Ross, K. A. et al.⁵¹ has shown that dry matter is a better indicator of quality than color. Adopting dry matter as a primary parameter would ensure higher product quality, increasing consumer satisfaction and export value. In addition, monitoring dry matter can facilitate the adoption of more targeted storage practices.

Table 5
Dry matter content [%] after harvest and storage depending on the cultivar and 1-MCP dose (mean for cultivars and 1-MCP concentration).

		Storage time		
Factors		After harvest	After 9 days	After 21 days
1-MCP conc.	Control	20.54 ± 0.03 a	20.89 ± 0.10 a	21.08 ± 0.04 a
	1 ppm	20.54 ± 0.03 a	20.79 ± 0.09 b	20.97 ± 0.08 b
	2 ppm	20.54 ± 0.03 a	20.66 ± 0.16 c	20.76 ± 0.08 c
	4 ppm	20.54 ± 0.03 a	20.59 ± 0.15 d	20.69 ± 0.01 d
Cultivar	Kordia	20.37 ± 0.03 B	20.66 ± 0.22 B	20.87 ± 0.23A
	Regina	20.70 ± 0.07 A	20.80 ± 0.06 A	20.88 ± 0.15 A
Mean		20.54	20.73	20.87
LSD $p \leq 0.05$ Interaction 1-MCP conc./Cultivar		n.s.	*	*

Vitamin C

Cherries are appreciated by consumers for their good taste, but also for their many healthy nutritional properties, such as high vitamin C content ⁵². In research Mineat,ă, I. et al. ⁹ fully ripe fruit had more than twice the vitamin C content compared to unripe ones. In the present study, the Kordia variety contained significantly more vitamin C, both after harvest and after storage, respectively 9.74 and 9.19, but its content decreased during storage. Samples treated with 1-MCP, especially at the 4 ppm and 1 ppm dose, contained the highest amount of vitamin C after 21 days of storage (Table 5). In other studies⁵³ the average content of vitamin C in sweet cherries ranged from 5.3 to 20.3 mg 100 g⁻¹ f.m. and depending on the variety and meteorological conditions of the year of study.

Table 5

Vitamin C concentration [$\text{mg} \cdot 100^{-1} \text{ g FW}$] after harvest and storage depending on the cultivar and 1-MCP dose (mean for cultivars and 1-MCP concentration).

Factors		Storage time		
		After harvest	After 9 days	After 21 days
1-MCP conc.	Control	$9.47 \pm 0.06 \text{ a}$	$9.09 \pm 0.10 \text{ d}$	$8.59 \pm 0.06 \text{ c}$
	1 ppm	$9.47 \pm 0.06 \text{ a}$	$9.34 \pm 0.04 \text{ b}$	$9.08 \pm 0.03 \text{ ab}$
	2 ppm	$9.47 \pm 0.06 \text{ a}$	$9.14 \pm 0.03 \text{ c}$	$8.94 \pm 0.05 \text{ b}$
	4 ppm	$9.47 \pm 0.06 \text{ a}$	$9.39 \pm 0.21 \text{ a}$	$9.12 \pm 0.01 \text{ a}$
Cultivar	Kordia	$9.74 \pm 0.11 \text{ A}$	$9.50 \pm 0.10 \text{ A}$	$9.19 \pm 0.02 \text{ A}$
	Regina	$9.19 \pm 0.02 \text{ B}$	$8.98 \pm 0.09 \text{ B}$	$8.67 \pm 0.05 \text{ B}$
Mean		9.47	9.24	8.93
LSD $p \leq 0.05$ Interaction 1-MCP conc./Cultivar		*	*	*

Total polyphenols

Sweet cherry fruits are considered to be a very good source of phenolic compounds, which are beneficial in the human diet because they have antioxidant and free radical scavenging properties⁵². In addition to their organoleptic properties, these compounds are also responsible for the red color and tartness of sweet cherries. In present studies the Kordia variety contained significantly more polyphenols than the Regina variety. The content of these compounds decreased during storage. The 1-MCP used, regardless of the dose used, stabilized the level of these compounds in the fruit compared to untreated samples (Table 6).

Table 6

Total polyphenols concentration [TPC] [$\text{mg GAE} \cdot 100\text{g}^{-1} \text{ FW}$] after harvest and storage depending on the cultivar and 1-MCP dose (mean for cultivars and 1-MCP concentration).

Factors		Storage time		
		After harvest	After 9 days	After 21 days
1-MCP conc.	Control	$140.80 \pm 0.14 \text{ a}$	$134.54 \pm 0.21 \text{ c}$	$131.19 \pm 0.12 \text{ b}$
	1 ppm	$140.80 \pm 0.14 \text{ a}$	$136.43 \pm 0.14 \text{ a}$	$133.57 \pm 0.08 \text{ a}$
	2 ppm	$140.80 \pm 0.14 \text{ a}$	$135.44 \pm 0.09 \text{ b}$	$133.37 \pm 0.05 \text{ a}$
	4 ppm	$140.80 \pm 0.14 \text{ a}$	$135.26 \pm 0.08 \text{ b}$	$133.12 \pm 0.11 \text{ a}$
Cultivar	Kordia	$153.00 \pm 0.04 \text{ A}$	$144.15 \pm 0.04 \text{ A}$	$139.47 \pm 0.08 \text{ A}$
	Regina	$128.60 \pm 0.08 \text{ B}$	$126.69 \pm 0.08 \text{ B}$	$126.16 \pm 0.06 \text{ B}$
Mean		140.80	135.42	132.81
LSD $p \leq 0.05$ Interaction 1-MCP conc./Cultivar		*	*	*

Anthocyanins

Anthocyanins, belonging to the subclass of water-soluble flavonoids, are one of the main phenolic compounds in sweet cherries and are responsible for the red colouring of the fruit epidermis and pulp ⁵⁴ and associated with the high antioxidant potential of sweet cherry fruits ^{55–56}. In present studies the anthocyanin content increased during the first 9 days of storage and then decreased. The Kordia variety contained the most tested anthocyanin compounds, both after harvest and after storage (51.99 and 53.17–53.33 mg 100 g – 1 f.w.). The Regina variety contained 43.16 after harvest and 44.90–45.32 mg 100 g – 1 f.w. after storage. Ferretti et al. ⁵³(2010) showed that the fruits of the Regina variety contained 41.0 mg 100 g – 1 f.w. of anthocyanins, and in another study ⁵², an average of 54.0 mg 100 g – 1 f.w. of anthocyanins were detected in red sweet cherry fruits. In turn, after 21 days of storage, the untreated samples and those treated with 2 ppm of 1-MCP contained significantly more anthocyanins, and the samples treated with a dose of 1 ppm 1-MCP contained significantly the lowest amount (Table 7), which indicates the influence of 1-MCP on the inhibition of fruit ripening.

Table 7

Anthocyanins concentration [mg · 100 g⁻¹ FW] after harvest and storage depending on the cultivar and 1-MCP dose (mean for cultivars and 1-MCP concentration).

Factors		Storage time		
		After harvest	After 9 days	After 21 days
1-MCP conc.	Control	47.58 ± 0.02 a	49.85 ± 0.04 a	49.42 ± 0.06 a
	1 ppm	47.58 ± 0.02 a	49.20 ± 0.01 ab	48.69 ± 0.02 c
	2 ppm	47.58 ± 0.02 a	49.29 ± 0.02 ab	49.04 ± 0.01 ab
	4 ppm	47.58 ± 0.02 a	48.96 ± 0.01 b	48.99 ± 0.01 b
Cultivar	Kordia	51.99 ± 0.04 A	53.33 ± 0.01 A	53.17 ± 0.05 A
	Regina	43.16 ± 0.01 B	45.32 ± 0.03 B	44.90 ± 0.02 B
Mean		47.58	49.33	49.04
LSD _{p ≤ 0.05} Interaction 1-MCP conc./Cultivar		*	*	*

Total soluble solids, reducing and total sugars concentration

Total soluble solids (TSS), mainly estimating the level of dissolved sugars (sucrose, glucose and fructose) in fruit juice, but also including a small number of other compounds such as organic acids, soluble amino acids and minerals, is an important quality parameter that has a significant impact on fruit flavour⁵⁴. In present study the total soluble solids concentration significantly depended on the variety - the Regina variety accumulated more TSSC. As for the effect of 1-MCP, similar relationships were obtained as in the case of sugars, because they mainly (apart from organic acids) constitute the compounds which are part of the general extract (Table 8). The content of reducing sugars, i.e. glucose, fructose and total sugars (including sucrose) in the fruit depended significantly on the variety, the Regina variety was sweeter. The sugar content increased during storage, especially in control samples, and among treated samples in which the lowest dose of 1-MCP was used (1 ppm) (Table 9, 10).

Table 8

Total soluble solids concentration (TSSC) [°Brix] after harvest and storage depending on the cultivar and 1-MCP dose (mean for cultivars and 1-MCP concentration).

Factors		Storage time		
		After harvest	After 9 days	After 21 days
1-MCP conc.	Control	16.70 ± 0.02 a	17.75 ± 0.04 a	18.05 ± 0.05 a
	1 ppm	16.70 ± 0.02 a	17.45 ± 0.01 b	17.65 ± 0.01 b
	2 ppm	16.70 ± 0.02 a	17.20 ± 0.02 d	17.45 ± 0.02 c
	4 ppm	16.70 ± 0.02 a	17.30 ± 0.03 c	17.45 ± 0.03 c
Cultivar	Kordia	16.20 ± 0.05 B	16.83 ± 0.04 B	17.13 ± 0.02 B
	Regina	17.20 ± 0.05 A	18.03 ± 0.01 A	18.18 ± 0.01 A
Mean		16.70	17.43	17.65
LSD $p \leq 0.05$ Interaction 1-MCP conc./Cultivar		*	*	*

Table 9

Reducing sugars concentration [g · 100g⁻¹ FW] after harvest and storage depending on the cultivar and 1-MCP dose (mean for cultivars and 1-MCP concentration).

Factors		Storage time		
		After harvest	After 9 days	After 21 days
1-MCP conc.	Control	12.37 ± 0.01 a	13.70 ± 0.03 a	14.94 ± 0.04 a
	1 ppm	12.37 ± 0.01 a	13.36 ± 0.01 b	14.18 ± 0.02 b
	2 ppm	12.37 ± 0.01 a	13.21 ± 0.01 c	13.63 ± 0.01 c
	4 ppm	12.37 ± 0.01 a	13.19 ± 0.01 c	13.44 ± 0.02 d
Cultivar	Kordia	10.08 ± 0.01 B	11.71 ± 0.05 B	12.80 ± 0.05 B
	Regina	14.65 ± 0.02 A	15.02 ± 0.02 A	15.30 ± 0.04 A
Mean		12.37	13.36	14.05
LSD $p \leq 0.05$ Interaction 1-MCP conc./Cultivar		*	*	*

Table 10

Total sugars concentration [$\text{g} \cdot 100\text{g}^{-1}\text{FW}$] after harvest and storage depending on the cultivar and 1-MCP dose (mean for cultivars and 1-MCP concentration).

Factors		Storage time		
		After harvest	After 9 days	After 21 days
1-MCP conc.	Control	13.01 $\pm$ 0.01 a	13.81 $\pm$ 0.03 a	15.18 $\pm$ 0.02 a
	1 ppm	13.01 $\pm$ 0.01 a	13.63 $\pm$ 0.01 b	14.41 $\pm$ 0.00 b
	2 ppm	13.01 $\pm$ 0.01 a	13.49 $\pm$ 0.01 c	13.97 $\pm$ 0.01 c
	4 ppm	13.01 $\pm$ 0.01 a	13.38 $\pm$ 0.00 d	13.71 $\pm$ 0.01 d
Cultivar	Kordia	10.81 $\pm$ 0.01 B	11.82 $\pm$ 0.02 B	13.20 $\pm$ 0.01 B
	Regina	15.21 $\pm$ 0.02 A	15.33 $\pm$ 0.02 A	15.43 $\pm$ 0.04 A
Mean		13.01	13.58	14.32
LSD $p \leq 0.05$ Interaction 1-MCP conc./Cultivar		*	*	*

Antioxidant capacity – FRAP

Antioxidant capacity is an important fruit quality parameter⁵⁵. Total antioxidant capacity of sweet cherries was measured by FRAP assays. Antioxidant capacity varied both in terms of variety and the use of 1-MCP. Fruits of the Kordia variety had a significantly higher antioxidant capacity, and the highest dose of 1-MCP (4 ppm) stabilized the tested parameter to the greatest extent, which decreased during storage (Table 11).

Table 11

Antioxidant capacity – FRAP [$\mu\text{mol Fe}^{2+} \cdot 100\text{g}^{-1}\text{FW}$] after harvest and storage depending on the cultivar and 1-MCP dose (mean for cultivars and 1-MCP concentration).

Factors		Storage time		
		After harvest	After 9 days	After 21 days
1-MCP conc.	Control	2182.3 $\pm$ 12.20 a	1525.3 $\pm$ 15.61 d	1412.2 $\pm$ 11.25 d
	1 ppm	2182.3 $\pm$ 12.20 a	1756.3 $\pm$ 18.41 b	1534.3 $\pm$ 12.51 c
	2 ppm	2182.3 $\pm$ 12.20 a	1690.9 $\pm$ 15.63 c	1613.4 $\pm$ 14.32 b
	4 ppm	2182.3 $\pm$ 12.20 a	2029.5 $\pm$ 16.81 a	1751.5 $\pm$ 10.51 a
Cultivar	Kordia	2317.8 $\pm$ 18.65 A	1568.5 $\pm$ 18.21	1371.9 $\pm$ 14.89 B
	Regina	2046.9 $\pm$ 14.25 B	1932.5 $\pm$ 14.56	1783.8 $\pm$ 15.65 A
Mean		2182.3	1750.5	1577.9
LSD $p \leq 0.05$ Interaction 1-MCP conc./Cultivar		*	*	*

Pearson's correlations

The tested compounds were also correlated (Table 12). Polyphenols, anthocyanins, sugars and extract with vitamin C content showed a very strong correlation, while the weakest correlation was the antioxidant capacity with dry matter content and vitamin C. Vitamin C is a very labile compound, so this could have contributed to obtaining such a result, in turn polyphenols and anthocyanins had the greatest impact on the antioxidant capacity. A positive correlation between the amount of phenolic and anthocyanins compounds in samples and antioxidant capacity is supported by findings of other researchers ^{57–59} .

Table 12

Peaeson's correlations between the tested components in cherries

	Dry matter	Vitamin C	Polyphenols	Anthocyanins	Reducing sugars	Total sugars	TSSC	FRAP
Dry matter	-	-0.760	-0.654	-0.606	0.747	0.744	0.756	-0.172
Vitamin C	-	-	0.935	0.901	-0.951	-0.953	-0.945	-0.275
Polyphenols	-	-	-	0.995	-0.991	-0.953	-0.967	0.536
Anthocyanins	-	-	-	-	-0.979	-0.980	-0.950	0.587
Simple sugar	-	-	-	-	-	0.999	0.978	0.436
Total sugar	-	-	-	-	-	-	0.974	0.438
TSSC	-	-	-	-	-	-	-	0.446
FRAP	-	-	-	-	-	-	-	-

< 0.2 weak correlation; 0.3–0.5 correlation sufficient; 0.6–0.7 moderate correlation; 0.8–0.9 very strong correlation;1 perfect correlation

Methods

The study was carried out with sweet cherries purchased from a commercial orchard Galster of the ‘Kordia’ and ‘Regina’ cultivar, located in Wierzchucice near Bydgoszcz (53°15'36"N 17°47'08"E). Trees were subjected to standard fertilizer, herbicide, and pesticide practices. Research cultivars are firm and have a medium-sized stem, heart shape, dark red skin, and pale red flesh. Sweet cherries were manually harvested in the early morning at commercial ripeness, stage 4 according to scale CTIFL, and transported at 5 °C to the laboratory within 2 h. About 24 kg of cherries homogeneous in colour, size and without visual defects were selected and randomly grouped in 4 batches of 6 kg each., which corresponds to control and three different Vidre + sticker sizes (Fresh Inset) of: 1, 2, and 4 cm²/Liter of package in a completely sealed chamber, this area of sticker would release a total of 1 uL of 1-MCP over the 24 hour release period. Theoretically, if there was no 1-MCP escape from the chamber, these sticker areas would relate to a maximum concentration of 1, 2, and 4 ppm. Actual concentrations of 1-MCP inside the clamshell packages were not measured. Freshly picked sweet cherries were put into 1 L clamshells with or without stickers and placed into a plastic bag for 24 hours, and then into cold storage. After 24 hours, bags were removed and all clamshells stored at 2–3°C and 90–95% relative air humidity. Both varieties of sweet cherries were evaluated for the amount of weight loss, firmness, color of the stems and fruit quality over 21-day storage period. All analyses were performed in triplicate and were shown as mean values standard error (SE).

The cultivation and collection of research material was in accordance with the guidelines contained in national standards and international regulations.

Quality tests

Weight loss

Weight loss was calculated as the difference between the initial weight (after harvest) and after 1, 3, 6, 9, 13, 17, 21 days after storage and expressed as a percentage (Serradilla et al 2019).

Stem browning

After harvest, after 1, 3, 6, 9, 13, 17, 21 days - evaluated 20 cherries from each clamshell for stem color on a scale of 1–4 grade with 4 = bright green, 3 = light green/slightly yellow, 2 = beginning browning, 1 = mostly brown;

Fruit quality

For quality analysis 20 cherries were selected after harvest, after 1, 3, 6, 9, 13, 17, 21 days- evaluated the same 20 cherries for defects / brown spots / pitting and give them a quality rating on a scale of 1–4 with 4 = excellent eating quality, 3 = good eating quality, 2 = moderate eating quality, 1 = poor eating quality;

Fruit firmness

Flesh firmness was determined on opposite peeled cheeks of the fruit using a Fruit Firmness Tester-GY-4, equipped with a 3,5-mm plunger tip after harvest, 3, 6, 9, 13, 17, 21 days of storage. The force necessary for the piston to penetrate the fruit to a depth of 3,5 mm was expressed in N. Twenty fruits were analyzed per treatment in each replicate and two readings per fruit were recorded; a new fruit set was used each time.

Laboratory analysis (after harvest, after 9 and 21 days of storage):

Determination of Dry Matter

About 100 g of sweet cherries were homogenized in a laboratory mixer until homogenous pulp was obtained. About ten grams of the pulp (the exact weight was recorded) was poured into a Petri dish and then heated at 60°C for 15 h using the Sup-100 convection dryer; afterwards, the oven temperature was raised to 105°C for 3 h and then Petri dish with dry matter of sweet cherries was cooled down to room temperature in desiccators and weighed. The total dry matter was calculated according to the following formula:

$$DM = D/M \times 100,$$

where DM—dry matter (%), D—weight of dry sample (g), W—weight of fresh sample (g).

Determination of Sugars

Carbohydrate analyses were made according to procedures in ⁶⁰. For a reducing sugar content assessment, ten grams of fresh material sample was placed in 250 mL bottle, 150 mL of distilled water was added and vigorously shaken. One milliliter of the filtrate was mixed with 3 mL of DNP (2,4-dinitrophenol) (Sigma-Aldrich, Darmstadt, Germany) reagent in a test tube and then heated in a water bath at 95°C for 6 min. Absorbance of the mixture was measured using the spectrophotometer at a wavelength of 600 nm using a Shimadzu UV-spectrophotometer,

(Shimadzu, Kyoto, Japan). The reducing sugar content was estimated using the standard curve of glucose. The total soluble carbohydrate was determined after hydrolysis of sugars. After filtration, 40 mL of the filtrate was taken, a few drops of concentrated HCl (POCH Gliwice) were added. The samples were warmed up for 30 min in a water bath. After cooling, the mixture was neutralized using a few drops of concentrated NaOH (POCH Gliwice). Next, 1 mL of the filtrate was mixed with 3 mL of DNP (Sigma-Aldrich, Darmstadt, Germany) reagent and the procedure for determining the content of reducing sugars was followed.

Determination of Ascorbic Acid

The ascorbic acid content was assessed according to Kapur et al.⁶¹. Ten grams of fresh sweet cherries were homogenized with 25 mL of metaphosphoric acid solution (Sigma-Aldrich) and quantitatively transferred into a 50 mL volumetric flask and gently shaken to homogenize the solution. Then it was diluted up to the mark with the metaphosphoric acid solution. The solution was filtered and centrifuged at 4000 rpm for 15 min, the supernatant solution was used for spectrophotometric determination (Shimadzu UV-1800, UV Spectrophotometer System, Japan) of ascorbic acid concentration in samples. Ascorbic acid is oxidized to dehydroascorbic acid by adding bromine water. After that, L-dehydroascorbic acid reacts with 2,4-DNPH (Sigma-Aldrich, Darmstadt, Germany) and produces an osazone, which, treated with 85% H₂SO₄, forms a red-colored solution. A typical calibration plot was made and used to determine the concentration of ascorbic acid in the samples.

Total soluble solids concentration (TSSC)

Total soluble solids concentration (TSSC) determination of the juice was measured using an Abbe Mark refractometer and expressed as °Brix. Ten fruits were analyzed per treatment per replicate, and two readings were recorded per fruit using juice from the fruit pericarp; a new set of fruits was analyzed on each assessment date.

Titrateable acidity (TA)

Titrateable acidity (TA) of 10- mL sample of juice was measured using titrator and is expressed as milliliters of 0,1 N NaOH required to bring the pH 8,1. Titrateable acidity (TA) was calculated as g L⁻¹ of in a Mettler Toledo DL50 titrator (Coslada, Madrid, Spain), with results expressed as % malic acid.

Total polyphenol concentration (TPC)

TPC was determined using the Folin–Ciocalteu reagent (Sigma-Aldrich, Darmstadt, Germany) according to the method of Singleton and Orthofer⁶². A volume of 0.5 mL of Folin–Ciocalteu reagent previously diluted with distilled water (1:10) was mixed with 0.1 mL of each sample. The solution was allowed to stand for 5 min at 25 °C before adding 1.7 mL of sodium carbonate solution (20%). Then, 10 mL of distilled water was added to the mixture and the absorbance was measured at 735 nm after 20 min of incubation with agitation at room temperature. Results were expressed in mg of gallic acid equivalents (GAE) per kg of fresh sample.

Total anthocyanins (TA)

Total anthocyanins (TA) were determined by the spectrophotometric method, which consists in determining the difference in absorbance of anthocyanin solutions at pH 1 (oxonium form) and pH 4.5 (pseudo-base form). The results of the determinations are given expressed as cyanidin-3-glucoside/100 g fresh weight (FW)⁶³.

Antioxidant capacity

Determination of the antioxidant capacity by the FRAP method (Ferric Reducing Antioxidant Power) was conducted using the method developed by Benzie and Strein⁶⁴. Immediately before the assay, a FRAP working solution was prepared, i.e. 250 mL of acetate buffer with a pH of 3.6, 25 mL of the 2,4,6-Tri(2-pyridyl)-s-triazine solution (TPTZ, 10 millimoles in 40 mmol HCl) and 25 mL of iron (III) chloride hexahydrate solution (20 mmol) were mixed (all provided by Sigma-Aldrich, Darmstadt, Germany). The solution was incubated at 37°C and assays were then performed. For this purpose, 6 mL of the FRAP solution was taken and 200 µL of the sample and 600 µL of H₂O were added. After 4 min, absorbance was measured at a wavelength of 593 nm. Based on the conducted measurements, a curve of dependence of the absorbance value on the sample concentration was plotted. Based on the curve, the absorbance value was determined at a concentration equal to the mean of the dilutions used and the antioxidant capacity was calculated at the same absorbance value based on the standard curve determined for Fe²⁺ ions. To remove solid parts, the samples were centrifuged for 5 min on a Rotina 420R centrifuge (Hettich, Vlotho, Germany) at 2250× *g* RCF before the assay. Each value in graphs is mean and standard deviation.

Statistics

The results were statistically analyzed by means of one factor analysis of variance after harvest and storage where the factor was cultivar, and also a two-factor analysis of variance, treating as variables the cultivar model and 1-MCP dose- stickers and without 1-MCP (control). The results were statistically analyzed, an analysis of variance (ANOVA) of data from each experiment and the synthesis from three repetitions were made. The significance of differences was evaluated using the Tukey multiple confidence intervals for the significance level of $\alpha = 0.05$. Calculations were made independently for each storage time using Statistica® 13.1.

Declarations

Funding

This research received no external funding.

Author Contribution

Conceptualization, D.W., A.W., T.M.; methodology, D.W., A.W., T.M.; research and development of research results D.W.; wrote the main manuscript text D.W. All authors reviewed the manuscript.

Data Availability

All data generated or analysed during this study are included in this published article

References

1. Faienza, M. F. et al. Childhood obesity, cardiovascular and liver health: a growing epidemic with age. *World J. Pediatr.* **16** (5), 438–445. 10.1007/s12519-020-00341-9 (2020).

2. Gonçalves, J. et al. In book: *Prunus avium L.: Composition, analysis and health benefits*. In *Prunus: Classification, Cultivation and Toxicity*, 1st ed.; Schneider, W., Ed.; Nova Publisher Inc.: New York, NY, USA, 1, 73–125, (2020).
3. Fonseca, L. R. S. et al. Sweet Cherries as Anti-Cancer Agents: From Bioactive Compounds to Function. *Molecules* **26**, 2941. <https://doi.org/10.3390/molecules26102941> (2021).
4. Kelley, D. S., Adkins, Y. & Laugero, K. D. A review of the health benefits of cherries. *Nutrients* **10**, 368. <https://doi.org/10.3390/nu10030368> (2018).
5. Girelli, C. R., De Pascali, S. A., Del Coco, L. & Fanizzi, F. P. Metabolic profile comparison of fruit juice from certified sweet cherry trees (*Prunus avium* L.) of Ferrovia and Giorgia cultivars: A preliminary study. *Food Res. Int.* **90**, 281–287. [10.1016/j.foodres.2016.11.014](https://doi.org/10.1016/j.foodres.2016.11.014) (2016).
6. Picariello, G., De Vito, V., Ferranti, P., Paolucci, M. & Volpe, M. G. Species-and cultivar-dependent traits of *Prunus avium* and *Prunus cerasus* polyphenols. *J. Food Compos. Anal.* **45**, 50–57. <https://doi.org/10.1016/j.jfca.2015.10.002> (2016).
7. Ballistreri, G. et al. Fruit quality and bioactive compounds relevant to human health of sweet cherry (*Prunus avium* L.) cultivars grown in Italy. *Food Chem.* **140**, 630–638 (2013).
8. Żurek, N., Karatsai, O., Rędownicz, M. J. & Kapusta, I. T. Polyphenolic Compounds of *Crataegus* Berry, Leaf, and Flower Extracts Affect Viability and Invasive Potential of Human Glioblastoma Cells. *Molecules* **26**, 2656. <https://doi.org/10.3390/molecules26092656> (2021).
9. Mineat,ă, I. et al. Effects of Ripening Phase and Cultivar under Sustainable Management on Fruit Quality and Antioxidants of Sweet Cherry. *Horticulturae* **10**, 720. <https://doi.org/10.3390/horticulturae10070720> (2024).
10. FAO. The State of Food and Agriculture 2024 – Value-driven transformation of agrifood systems. Rome, (2024). <https://doi.org/10.4060/cd2616en>.
11. Commisso, M. et al. Multi-approach metabolomics analysis and artificial simplified phytocomplexes reveal cultivar-dependent synergy between polyphenols and ascorbic acid in fruits of the sweet cherry (*Prunus avium* L.). *PLoS ONE*. **12** (7), e0180889. <https://doi.org/10.1371/journal.pone.0180889> (2017).
12. Mirto, A. et al. Dataset on antioxidant metabolites and enzymes activities of freshly harvested sweet cherries (*Prunus avium* L.) of Campania accessions. *Data Brief.* **15**, 522–527. [10.1016/j.dib.2017.10.020](https://doi.org/10.1016/j.dib.2017.10.020) (2017).
13. Rodríguez, E., Bettinazzi, S., Inwongwan, S., Camus, M. F. & Lane, N. Harmonizing protocols to measure *Drosophila* respiratory function in mitochondrial preparations. *Bioenerg Commun.* **3**, 1–25. <https://doi.org/10.26124/bec:20> (2023).
14. Wang, F. et al. Antioxidant activities of aqueous extracts from 12 Chinese edible flowers in vitro and in vivo. *Food Nutr. Res.* **61** (1), 1265324. [10.1080/16546628.2017.1265324](https://doi.org/10.1080/16546628.2017.1265324) (2016).
15. Serrano, M., Martinez-Romero, D., Castillo, S., Guille´n & Valero, F. The use of natural antifungal compounds improves the beneficial effect of MAP in sweet cherry storage. *Innovative Food Sci. Emerg. Technol.* **6**, 115–123. [10.1016/j.ifset.2004.09.001](https://doi.org/10.1016/j.ifset.2004.09.001) (2005).
16. Chockchaisawasdee, S., Golding, J. B., Vuong, Q. V., Papoutsis, K. & Stathopoulos, C. E. Sweet cherry: composition, postharvest preservation, processing and trends for its future use. *Trends Food Sci. Technol.* **55**, 72–83. <https://doi.org/10.1016/j.tifs.2016.07.002> (2016).
17. Correia, S., Schouten, R., Silva, A. P. & Gonçalves, B. Factors affecting quality and health promoting compounds during growth and postharvest life of sweet cherry (*Prunus avium* L.) *Front. Plant. Sci.* **8**, 1–15. <https://doi.org/10.3389/fpls.2017.02166> (2017).

18. Wani, A. A., Singh, P., Gul, K., Wani, M. H. & Langowski, H. C. Sweet cherry (*Prunus avium*): Critical factors affecting the composition and shelf life. *Food Packaging Shelf Life*. **1**, 1, 86–99. <https://doi.org/10.1016/j.fpsl.2014.01.005> (2014).
19. Adaskaveg, J. E., Forster, H. & Thompson, D. F. Identification and etiology of visible quiescent infections of *Monilinia fructicola* and *Botrytis cinerea* in sweet cherry fruit. *Plant Dis.* **84**, 328–333. 10.1094/PDIS.2000.84.3.328 (2000).
20. Zoffoli, J. P., Toivonen, P. & Wang, Y. Postharvest biology and handling for fresh markets. In 'Cherries: botany, production and uses' Eds. (eds Quero-Garcia, J., Lezzoni, A., Puławska, J. & Lang, G.) (2017). Chapter 19. CAB International, Cambridge, USA, 460–484, 461–485.
21. Romanazzi, G., Feliziani, E., Bautista Baños, S. & Sivakumar, D. Shelf Life Extension of Fresh Fruit and Vegetables by Chitosan Treatment, *Critical Reviews in Food Science and Nutrition*, (2015). 10.1080/10408398.2014.900474.
22. Wang, Y. & Long, L. E. Respiration and quality responses of sweet cherry to different atmospheres during cold storage and shipping *Postharvest Biology and Technology* **92**, 62–69, 0.1016/j.postharvbio.2014.01.003, (2014). (2014).
23. Blankenship, S. M. & Dole, J. M. 1-Methylcyclopropene: A review. *Postharvest Biol. Technol.* **28**, 1–25 (2003).
24. Watkins, C. B. The use of 1-methylcyclopropene (1-MCP) on fruits and vegetables. *Biotechnol. Adv.* **24**, 389–409. 10.1016/j.biotechadv.2006.01.005 (2006).
25. Wu, C. W. et al. Effect of 1- methylcyclopropene on postharvest quality of Chinese chive scapes. *Postharvest Biol. Technol.* **51**, 431–433. 10.1016/j.postharvbio.2008.08.005,((2009).
26. Valero, D. & Serrano, M. *Postharvest Biology and Technology for Preserving Fruit Quality*; CRC Press: Boca Raton. FL. USA. ISBN 9781439802670, (2010).
27. Iqbal, N. et al. Ethylene Role in Plant Growth. Development and Senescence: Interaction with Other Phytohormones. *Front. Plant. Sci.* **8**, 475. 10.3389/fpls.2017.00475 (2017).
28. Wichrowska, D., Kozera, W., Knapowski, T., Prus, P. & Ligocka, A. Assessment of the Interactive Effect of the Use of 1-Methylcyclopropene and Cultivars on the Nutritional Value of Broccoli during Storage. *Agronomy* **11** (12), 2575. <https://doi.org/10.3390/agronomy11122575> (2021).
29. Satekge, T. K. & Magwaza, L. M. Postharvest Application of 1-Methylcyclopropene (1-MCP) on Climacteric Fruits: Factors Affecting Efficacy. *Int. J. Fruit Sci.* **22** (1), 595–607 (2022).
30. Koukounaras, A. & Sfakiotakis, E. Effect of 1-MCP prestorage treatment on ethylene and CO₂ production and quality of 'Hayward' kiwifruit during shelf life after short, medium and long term cold storage. *Postharvest Biol. Technol.* **46**, 174–180. 10.1016/j.postharvbio.2007.05.002 (2007).
31. Guillén, F. et al. Efficacy of 1-MCP treatment in tomato fruit. Effect of cultivar and ripening stage at harvest. *Postharvest Biol. Tec.* **42**, 235–242. 10.1016/j.postharvbio.2006.07.005 (2006).
32. Jeong, J., Huber, D. J. & Sargent, S. A. Delay of avocado (*Persea americana*) fruit ripening by 1-methylcyclopropene and wax treatments. *Postharvest Biol. Technol.* **28**, 247–257 (2003). <http://www.sciencedirect.com/science/journal/09255214>
33. Fawbush, F., Nock, J. F. & Watkins, C. B. Antioxidant contents and activity of 1-methylcyclopropene (1-MCP)-treated 'Empire' apples in air and controlled atmosphere storage. *Postharvest Biol. Technol.* **52**, 30–37 (2009).

34. Jeong, S. E., Rosenfield, C. L., Marsella-Herrick, P., Man You, K. & Knipple, D. C. Multiple acyl-CoA desaturase-encoding transcripts in pheromone glands of *Helicoverpa assulta*, the oriental tobacco budworm. *Insect Biochem. Mol. Biol.* **33** (6), 609–622 (2003).
35. Zhang, Z. K., Huber, D. J., Hurr, B. M. & Rao, J. P. Delay of tomato fruit ripening in response to 1-methylcyclopropene is influenced by internal ethylene levels. *Postharvest Biol. Technol.* **54**, 1–8. 10.1016/j.postharvbio.2009.06.003 (2009).
36. Crisosto, C. H., Crisosto, G. M. & Metheney, P. Consumer acceptance of 'Brooks' and 'Bing' cherries is mainly dependent on fruit SSC and visual skin color. *Postharvest Biol. Technol.* **28**, 1, 159–167. [https://doi.org/10.1016/S0925-5214\(02\)00173-4](https://doi.org/10.1016/S0925-5214(02)00173-4) (2003).
37. Zhou, L. et al. Determination of S-geotypes and self-fertility of sweet cherry in Summerland advanced selections. *J. Am. Pomol Soc.* **56**, 173–179 (2002).
38. Gong, Y. P., Fan, X. T. & Mattheis, J. P. Responses of 'Bing' and 'Rainier' sweet cherries to ethylene and 1-methylcyclopropene. *J. Am. Soc. Hort Sci.* **127**, 831–835. 10.21273/JASHS.127.5.831 (2002).
39. Mozetič, B., Simčič, M. & Trebše, P. Anthocyanins and hydroxycinnamic acids of Lambert Compact cherries (*Prunus avium* L.) after cold storage and 1-methylcyclopropene treatment. *Food Chem.* **97**, 2, 302–309. <https://doi.org/10.1016/j.foodchem.2005.04.018> (2006).
40. Yang, Q., Zhang, X., Wang, F. & Zhao, Q. Effect of pressurized argon combined with controlled atmosphere on the postharvest quality and browning of sweet cherries. *Postharvest Biol. Technol.* **147**, 59–67. <https://doi.org/10.1016/j.postharvbio.2018.09.007> (2019).
41. Hofman, P. J., Jobin Decor, M., Meiburg, G. F., Macnish, A. J. & Joyce, D. C. Ripening and quality responses of avocado, custard apple, mango and papaya fruit to 1-methylcyclopropene. *Aust J. Exp. Agric.* **41**, 567–572 (2001).
42. Sloof, M., Tijssens, L. M. M. & Wilkinson, E. C. Concepts for modelling the quality of perishable products. *Trends Food Sci. Technol.* **7** (5), 165–171. [https://doi.org/10.1016/0924-2244\(96\)81257-X](https://doi.org/10.1016/0924-2244(96)81257-X) (1996).
43. Walsh, K. B. Setting and meeting objective standards for eating quality in fresh fruit. *Acta Hort.* **712**, 191–201. 10.17660/ActaHortic.2006.712.19 (2006).
44. Predieri, S., Dris, R. & Rapparini, F. Influence of growing conditions on yield and quality of cherry: II. Fruit quality. *Food Agric. Environ.* **2** (1), 307–309 (2004).
45. Belge, B. et al. Lara I Characterization of cuticle composition after cold storage of 'Celeste' and 'Somerset' sweet cherry fruit. *J. Agric. Food Chem.* **62**, 8722–8729. 10.1021/jf502650t (2014).
46. Sekse, L. Respiration and storage potential in Norwegian-grown sweet cherries. *Acta Hort.* **410**, 357362. <https://doi.org/10.17660/ActaHortic.1996.410.56> (1996).
47. Linke, M., Herppich, W. B. & Geyer, M. Green peduncles may indicate postharvest freshness of sweet cherries. *Postharvest Biol. Technol.* **58**, 135–141. 10.1016/j.postharvbio.2010.05.014 (2010).
48. Magri, A. et al. Milena Petriccione. Agronomic, Physicochemical, Aromatic and Sensory Characterization of Four Sweet Cherry Accessions of the Campania Region. *Plants* **12**, 610, (2023). <https://doi.org/10.3390/plants12030610>
49. Kovács, E., Muskovics, G. & Perlaki, R. Relationship of colour and other quality parameters of sweet cherry during development and ripening. *Acta Aliment.* **38**, 415–426. 10.1556/AAlim.38.2009.4.2 (2009).
50. Habib, M., Bhat, M., Dar, B. N. & Wani, A. A. Sweet cherries from farm to table: A review. *Crit. Rev. Food Sci. Nutr.* **57**, 1638–1649 (2017).

51. Ross, K. A., DeLury, N. C., Fukumoto, L. & Forsyth, J. A. An assessment of the flavour quality attributes of Staccato, Sweetheart, and Sentennial sweet cherry cultivars in relation to maturity level at harvest. *Fruit Res.* **4**, e037. <https://doi.org/10.48130/frures-0024-0031> (2024).
52. Hallmann, E. & Rozpara, E. The estimation of bioactive compounds content in organic and conventional sweet cherry (*Prunus avium* L.). *J. Res. Appl. Agric. Eng.* **62**, 141–145 (2017).
53. Ferretti, G., Bacchetti, T., Belleggia, A. & Neri, D. Cherry Antioxidants: From Farm to Table. *Molecules* **15**, 6993–7005 (2010).
54. Rodrigues, R. S., Laranjoa, M. & Agulheiro-Santos, A. C. Methods for quality evaluation of sweet cherry. *J. Sci. Food Agric.* **103**, 463–478 (2023).
55. Liu, Y. et al. Comparative Study of Phenolic Compounds and Antioxidant Activity in Different Species of Cherries. *J. Food Sci.* **76**, C633–C638. 10.1111/j.1750-3841.2011.02150.x (2011).
56. Khoo, H. E., Azlan, A., Tang, S. T. & Lim, S. M. Anthocyanidins and anthocyanins: Colored pigments as food, pharmaceutical ingredients, and the potential health benefits. *Food Nutr. Res.* **61** 10.1080/16546628.2017.1361779 (2017).
57. Faniadis, D., Drogoudi, P. D. & Vasilakakis, M. Effects of cultivar, orchard elevation, and storage on fruit quality characters of sweet cherry (*Prunus avium* L.). *Sci. Hort.* **125**, 301–304. <https://doi.org/10.1016/j.scienta.2010.04.013> (2010).
58. Prvulović, D., Malenčić, D., Popović, M., Ljubojević, M. & Ognjanov, V. Antioxidant properties of 455 sweet cherries (*Prunus avium* L.) – Role of phenolic compounds. *International J of Biol. Life and Agric. Sci.* **5** (11), ISSN: 2415–6612 (2011).
59. Wichrowska, D. Antioxidant Capacity and Nutritional Value of Potato Tubers (*Solanum tuberosum* L.) as a Dependence of Growing Conditions and Long-Term Storage *Agriculture* **12**, **1**, 21, (2022). <https://doi.org/10.3390/agriculture12010021>.
60. Talburt, W. F. & Smith, O. *Potato Processing; Van Nostrand Reinhold Co.: New York* 371–474 (NY. USA, 1987). <https://doi.org/10.5962/bhl.title.69159>
61. Kapur, A. et al. Spectrophotometric analysis of total ascorbic acid content in various fruits and vegetables. *Bull. Chem. Technol. Bosnia Herzeg.* **38**, 39–42 (2012).
62. Singleton, V. L. & Orthofer, R. Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. In *Methods in ENZYMOLOGY*; Abelson. J.N. Simon. M.I. Sies. H. Eds.; Academic Press: Burlington. MA. USA. 299, 152–178, (1999).
63. Chaovanalikit, A. & Wrolstad, R. E. Total anthocyanins and total phenolics of fresh and processed cherries and their antioxidant properties. *J. Food Sci.* **69** (1), FCT67–FCT72. 10.1111/j.1365-2621.2004.tb17858.x (2004).
64. Benzie, I. F. & Strain, J. J. Ferric reducing/antioxidant power assay: Direct measure of total antioxidant activity of biological fluids and modified version for simultaneous measurement of total antioxidant power and ascorbic acid concentration. *Methods Enzymol.* **299**, 15–27 (1999).

Figures

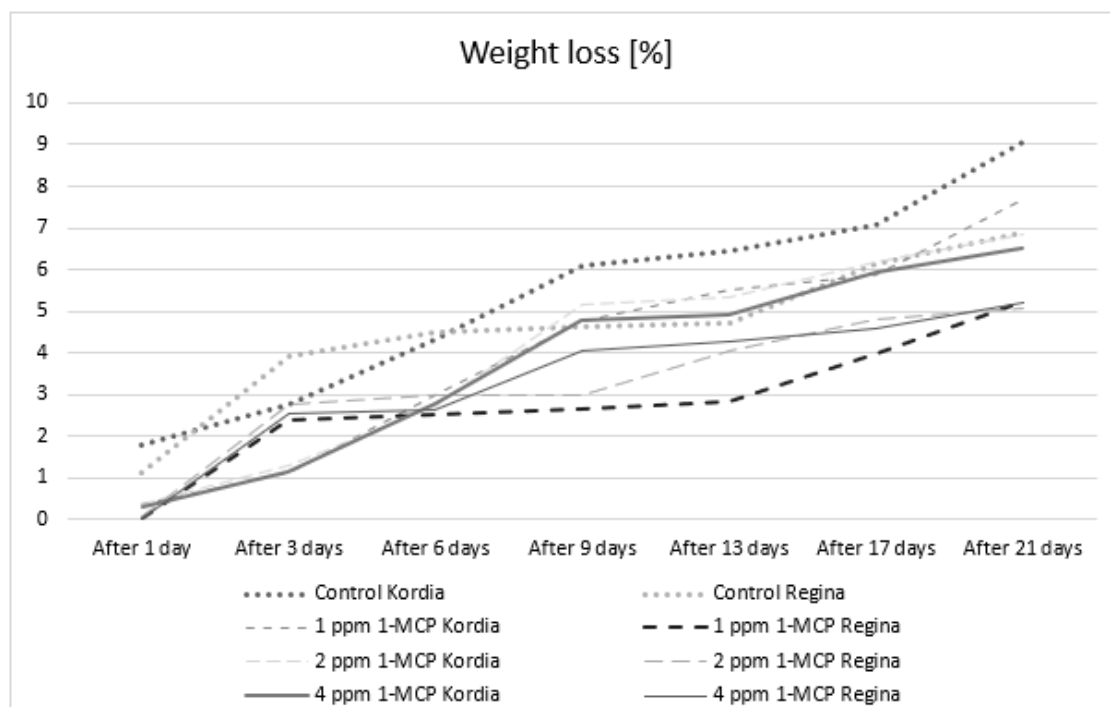


Figure 1

Weight loss (%) after storage depending on the cultivar and 1-MCP dose

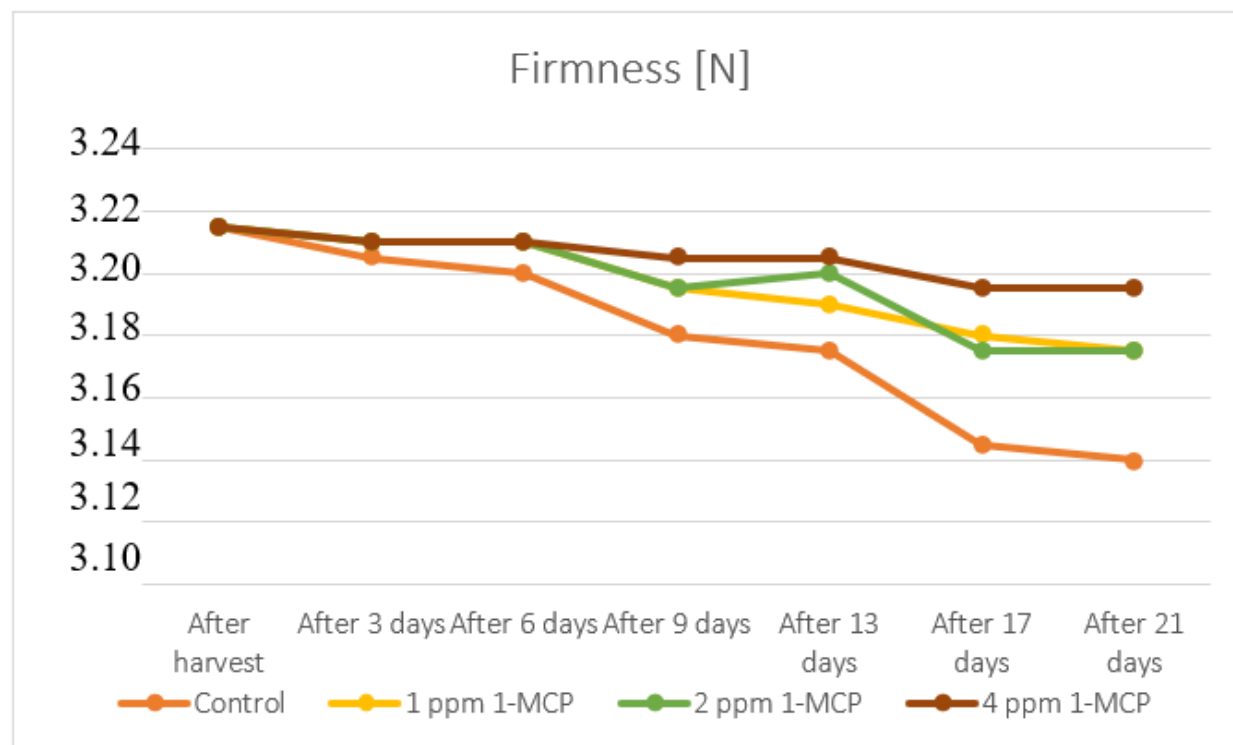


Figure 2

Firmness [N] after storage depending on the cultivar and 1-MCP dose

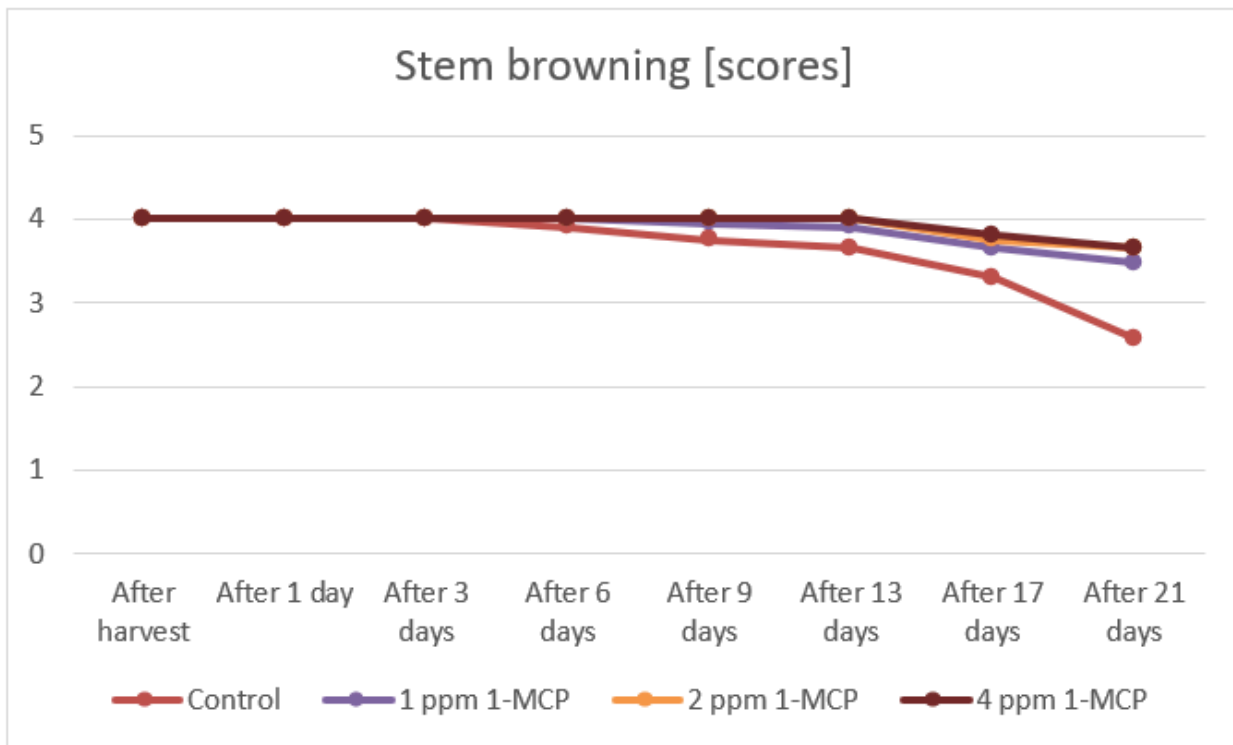


Figure 3

Stem browning [scores] after storage depending on the cultivar and 1-MCP dose