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Studies on quality characteristics after fruit storage in some cherry varieties

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Abstract
In the process of cultivar promotion, in addition to the fruit ripening period and yield level, fruit quality represents a key evaluation criterion. Biometric, physiological, and biochemical characteristics play a decisive role in the selection of parent genotypes and, consequently, in assessing their breeding value. The aim of the present study was to identify and characterize the valuable traits of several cherry cultivars after storage at 4°C for a period of 14 days. For this purpose, three cherry cultivars originating from Caraș - Severin County were analyzed: Van, Stella, and Rubin. Among these, the Van cultivar exhibited the largest fruit dimensions, followed by Rubin and Stella. Throughout the storage period, a progressive decrease in fruit firmness was observed, most pronounced in the Stella cultivar after 14 days, while Van showed a less significant reduction, indicating a superior capacity for quality preservation during storage. Determinations of the maturity stage, expressed through the Brix index, revealed that the Rubin cultivar had the highest soluble sugar content after 14 days of storage at 4°C, followed by Van and Stella. The results obtained after 7 and 14 days of storage at 4°C indicated an increase in soluble carbohydrate content due to the enzymatic conversion of starch into glucose. At the same time, a reduction in juice acidity, fruit firmness, and dry matter content was recorded. In conclusion, the analysis of the physical and biochemical characteristics of the studied cherry cultivars demonstrated that all genotypes can be considered valuable both for fresh consumption - due to their high pulp percentage (over 91%) - and as promising genetic material for breeding programs.

Keywords: diameter, height, pH, content of glucids, firmness, dry matter

Introduction

The cherry (*Prunus avium* L.) is a very important fruit species due to the nutritional characteristics of the fruit [14, 26, 11, 5].

The world produces about 2.3 million tonnes of cherries. Most of the fruit comes from Asia (43%), Europe (37%) and America (18%). The largest producers are Turkey (535,000 t), the USA (345,000 t) and China (220,000 t) [8]. In Romania, the area of cherries has increased in the last five years by about 1,000 ha being 7,058 ha with 90,837 t as total production [10].

Cherries are perishable fruits characterized by high tissue water content, thin skin and high respiration intensity [29].

They are sweet cherries appreciated by consumers due to their very good taste and high nutritional value and are mainly consumed as fresh fruit [6]. The beneficial properties of cherries are due to their high nutrient content. Cherries contain not only a high number of vitamins (C and E, provitamin A), of the B complex (B1, B2, B6), mineral elements such as phosphorus, calcium, magnesium, potassium, iron [17], but also organic acids: citric, malic, succinic, salicylic [22].

Cold storage technology is often applied to expand the supply of fruit on the market. However, cherries can be stored for a relatively short time (up to 8 weeks) under optimal storage conditions [1, 16, 12].

Research on plants for climate change has a great influence on the development of phenological stages [3]. Salazar-Gutierrez et al. observed that deterioration of cherry cultivars due to low temperatures in early spring is dependent on floral bud development stages.

Fruit ripening is a key factor in determining quality. Cherries should be picked when fully ripe to ensure good fruit quality [28]. The timing of cherry harvest varies by variety, but there is a range of up to 5 days for harvesting the best quality fruit [4].

Consumers rely on external quality traits of cherries, such as colour, fruit size, freshness, absence of defects [23]. Flavour, acidity, sweetness and texture are also essential characteristics [25,7]. Fruit colour is the main quality trait [18]. Colour has been studied as a function of variety, ripening stage and storage conditions [9, 13, 21].

The choice of variety can limit the quality of fruit in the orchard, throughout its life. Also, excess nitrogen during preharvest can reduce soluble solids content (SSC) and firmness [6, 25].

Material and methods

The biological material

In this experiment we studied the influence of temperature, as well as the storage duration on biometric, physiological and biochemical indices of three cherries fruits cultivars 'VAN', 'STELLA' and 'RUBIN'. These varieties are sourced from the commune of Ticvaniu Mare, in Caras-Severin County. The fruit was stored for 14 days at a temperature of 4°C.

The analysed biometric, physiological and biochemical indices

Sampling

For all analysis, 25 fruits of each variety were used. Height and diameters were measured with the digital caliper and expressed in mm.

Determination of fruit mass

The mass of the fruit was determined individually for each cherry variety, by using an electronic balance (KERN ABS) with an accuracy of 0.001 g.

Total soluble solids

The total soluble solids content was determined by a digital refractometer (Kruss DR 201-95) at room temperature (25°C) using samples from the fruit pulp.

pH

The pH was determined by measurements with a digital pH meter (CONSORT C933) from 25 homogenized samples at 25°C.

Firmness

To measure firmness, the fruit was peeled (very thin layer) in 2 different places in the equatorial region of cherries. Firmness was measured with a penetrometer (FORCE GAUGE PCE-FM 200) and expressed in libres.

Dry matter

Dry matter content was determined with thermobalance Kern MLS in percent units.

For each genotype, observations and determinations were carried out regarding the main fruit characteristics, in accordance with the established objectives. The average fruit weight was determined by weighing 25 fruits collected as a representative sample, followed by calculating the mean weight per fruit.

The fruit size was evaluated using the Fruit Size Index (Im), calculated according to the following formula:

$$Im = \frac{H + D + d}{3}$$

where:

- D = maximum fruit diameter (mm)
- d = minimum fruit diameter (mm)
- H = fruit height (mm)

Based on the obtained size index values, the fruit size was classified as follows:

- greater than 30 – very large fruits.

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- between 21–30 – large fruits.
- between 11–20 – medium fruits.
- between 9–10 – small fruits.
- less than 9 – very small fruits [30].

The fruit shape was determined by measuring the fruit dimensions (height, maximum diameter, and minimum diameter), followed by calculating the Shape Index according to the method described by Ionică, M.E. (2014), using the formula:

$$If = \frac{H}{(D+d)/2}$$

where:

- H = fruit height (mm)
- D = maximum fruit diameter (mm)
- d = minimum fruit diameter (mm)

Values between 0.90 and 1.00 indicate a round fruit shape, values below 0.90 correspond to an elongated fruit, and values above 1.00 describe a flattened (compressed) fruit.

The stone percentage was determined as the ratio between the average stone weight and the average fruit weight, multiplied by 100, according to Ancu S.I. (2005):

$$\text{Stone percentage (\%)} = \frac{Gs}{Gf} \times 100$$

where:

- Gs = stone weight
- Gf = fruit weight

The pulp percentage (Cp%) was calculated by weighing the pulp using an analytical balance and applying the following formula:

$$Cp(\%) = \frac{Gp}{Gf} \times 100$$

where: Gp = pulp weight
Gf = fruit weight [30].

These biometric parameters provided essential information for the comparative characterization of cherry genotypes and for assessing their potential suitability for breeding and post-harvest storage studies.

Results and discussions

Fruit weight and equatorial diameter are traits influenced by climatic conditions, applied technology, rootstock and biological peculiarities of each variety. The mean cherry fruit weight and equatorial diameter varied between 5.9 g and 9.2 g and between 22.4 mm and 25.8 mm grown in the northeastern part of Romania in the Moldavian area [5].

Fruit size is an important characteristic for commercial value. Pérez-Sánchez et al. have shown that fruit weight is the most important physical inset on which fruit price depends. Dry periods during certain growing seasons and climatic conditions could also affect fruit size. But a strong influence on fruit size is given by variety and rootstock.

According to some authors [20] a fruit diameter between 25.1 mm and 27.5 mm was recorded. Concerning fruit weight, the results were between 7 and 11.1 g, depending on variety and rootstock.

Information about the physical properties of cherries is very important for understanding the behaviour of the fruit during harvesting, transport, sorting, packing and storage operations. According to Naderiboldaji et al., these dimensions ranged from 20.18 to 24.72 mm in length, 18.93 - 22.87 mm in width, 17.04 - 20.54 mm in thickness and 4.51-7.40 g fruit weight.

After 14 days of storage, all varieties showed a slight decrease in height, most pronounced in Stella (2.44 mm), suggesting a loss of fruit turgidity associated with the natural dehydration process. The *Van* variety best maintained its dimensions, indicating superior firmness and stability during storage.

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Both the large and small diameters followed a similar pattern of reduction, with the *Van* variety proving the most stable, maintaining almost constant dimensions after the first week of storage.

Fruit weight decreased significantly in all genotypes. After 14 days, a general reduction in weight was observed, more pronounced in Van (1.36 g) and less pronounced in Rubin (0.29 g). The most significant decrease occurred in Van between the first day (7.301 g) and the seventh day (6.048 g), which may be attributed to water loss through transpiration and respiration - physiological processes typical during storage.

Overall, the Van *v*ariety demonstrated the greatest ability to maintain its morphometric parameters during storage, followed by Rubin*,* whereas Stella showed the most rapid dimensional degradation (Fig. 1).

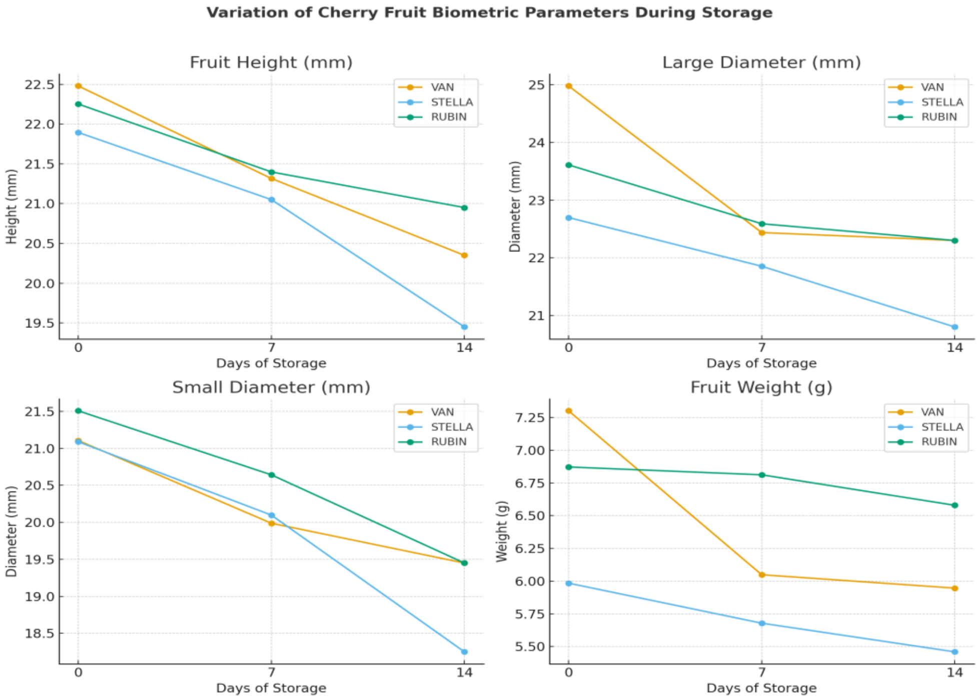

Figure 1. Biometric parameters of cherries stored at 4°C for 14 days

Analysing the varieties based on fruit size, calculated using the size index (expressed in millimetres), it was found that all varieties recorded size index values above 21 mm: Van (22.854 mm), Rubin (22.456 mm), and Stella (21.893 mm), thus being classified as large fruits (Fig. 2).

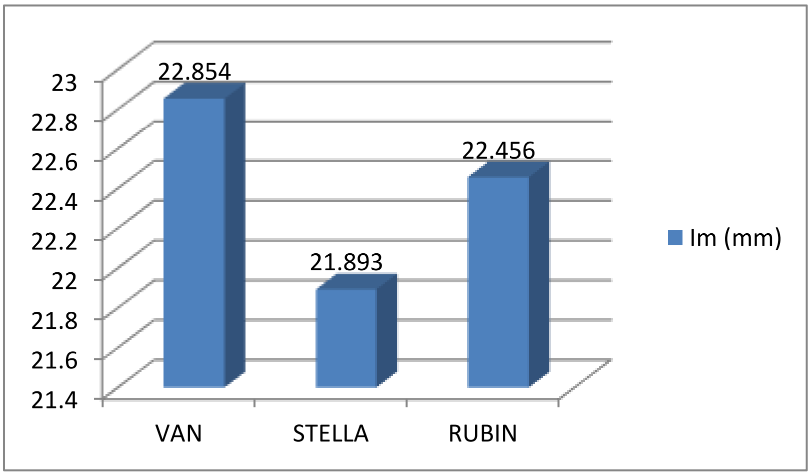

Figure 2. Experimental results on the size index of the studied cherry varieties (mm)

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Regarding the shape index, it can be observed that all tested cherry varieties exhibited a round shape (IF = 0.9–1.0) (Fig. 3).

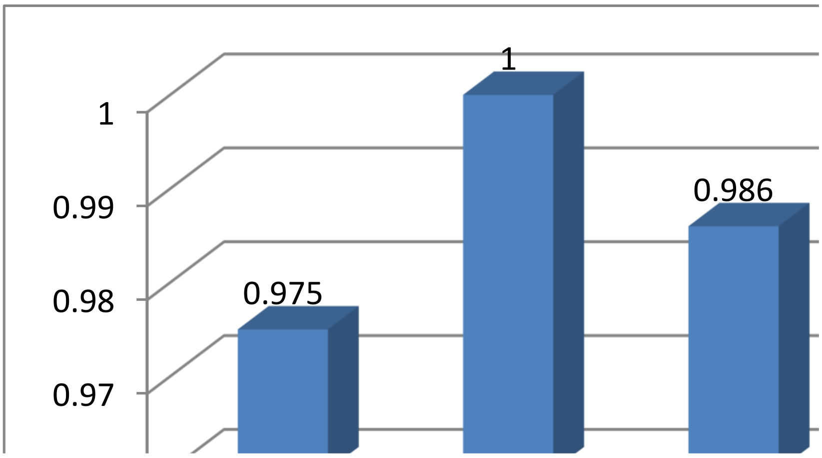

Figure 3. Experimental results on the shape index of the studied varieties

In terms of technological value related to pulp and stone content, all three varieties showed high values, with pulp percentages ranging from 91.38% to 93.62% and stone percentages from 6.38% to 8.62%. The Van variety stood out, exhibiting the highest pulp content (93.62%) (Fig. 4).

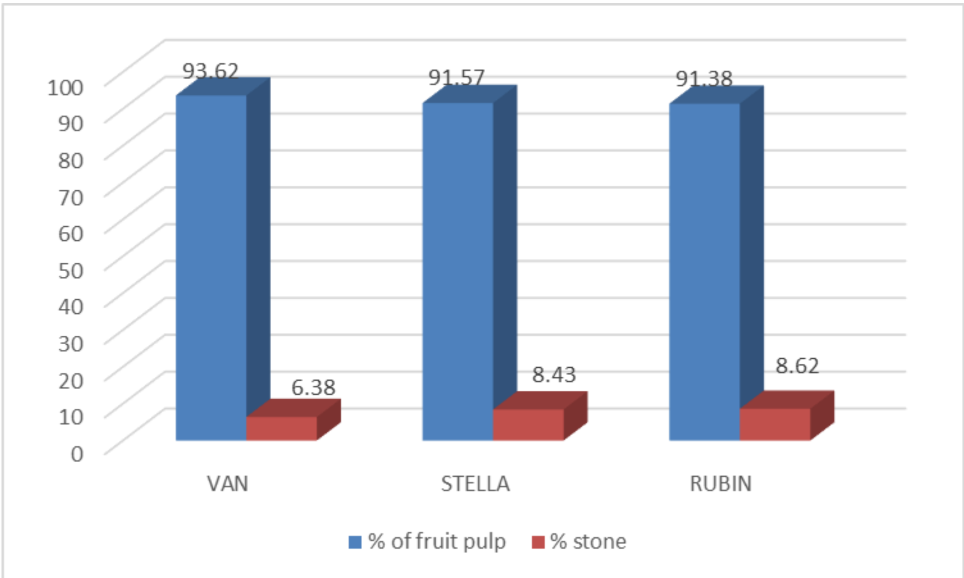

Figure 4. Experimental results on the pulp and stone percentages in the studied cherry varieties

The study monitored the evolution of the soluble solids content (% BRIX) and pH in three cherry cultivars - Van, Stella, and Rubin - during postharvest storage at 4°C for 14 days. These parameters are essential indicators of the biochemical and physiological changes occurring in fruits during cold storage and directly influence their organoleptic quality and storability.

At harvest, the highest soluble solids content was recorded in the Rubin cultivar (17.9%), followed by Van (16.9%) and Stella (15.75%). After 7 days of storage, all cultivars showed a moderate increase in soluble solids content, reaching 18.63% for Rubin, 17.45% for Van, and 16.23% for Stella. After 14 days, this upward trend continued, with the highest final value observed again in Rubin (19.57%), followed by Van (17.9%) and Stella (16.5%) (Fig. 5).

This increase in % BRIX during storage is primarily attributed to enzymatic hydrolysis of polysaccharides, such as starch and pectic substances, into simple sugars (glucose and fructose), combined with moisture loss through transpiration. These processes concentrate the carbohydrates in the fruit tissues.

The gradual rise in soluble solids content indicates a continuation of ripening processes under low-temperature conditions, improving the sweetness and flavor profile of the cherries. The Rubin cultivar displayed the highest accumulation of soluble carbohydrates, suggesting a more intense metabolic activity and better postharvest biochemical resilience.

The total soluble solids content (TSS) is related to the taste of cherries and is used to determine optimal fruit quality and postharvest. Initially TSS (15.75 - 17.9%) of fresh cherries indicated good ripeness, which increased to 16.5% and 19.566%, respectively, after 14 days of storage.

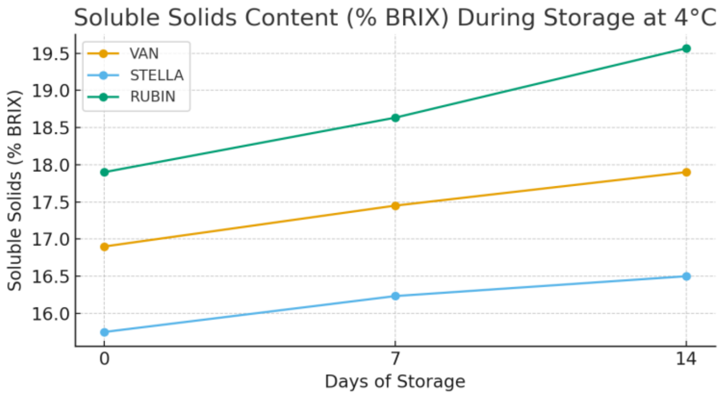

Figure 5. Experimental results regarding the soluble carbohydrate content in cherries

At the beginning of the experiment, pH values ranged from 3.45 in Van to 3.66 in Stella, indicating a moderate acidity level typical of fresh sweet cherries.

During storage, a slight decrease in pH was observed across all cultivars. After 14 days, the lowest pH was recorded in Van (3.406), followed by Stella (3.45) and Rubin (3.51) (Fig. 6).

This small but consistent decline suggests a maintenance of organic acid levels, mainly malic and citric acids, which play a key role in flavor stability and microbial resistance. The decrease may also result from oxidation of certain organic compounds and conversion of acids into sugars through metabolic adjustments.

The overall reduction in pH reflects the stability of the fruit's acid-base balance and indicates that refrigeration successfully preserved the natural acidity and freshness of the cherries. The Van cultivar maintained the lowest pH throughout the storage period, suggesting greater physiological resistance and slower degradation, while Stella exhibited the smallest variation, implying high biochemical stability.

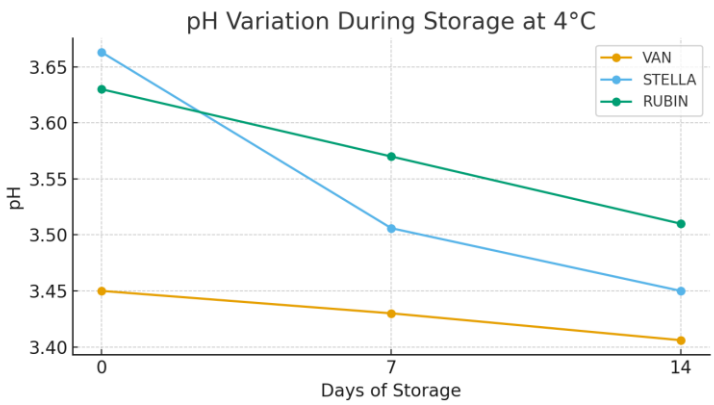

Figure 6. Experimental results regarding pH in cherry fruits

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The evolution of dry matter content during storage revealed noticeable differences among the three cherry cultivars (Van, Stella, and Rubin).

At the beginning of storage, the highest value was observed in Rubin (27.85%), followed by Stella (22.13%) and Van (21.18%). After seven days, a gradual decline occurred across all cultivars, reaching 22.10% in Rubin, 21.58% in Stella, and 20.97% in Van. At the end of the 14-day storage period, dry matter content further decreased to 19.40% in Rubin, 21.07% in Stella, and 19.44% in Van.

This downward trend indicates a progressive loss of soluble solids and dry mass, likely caused by respiration and transpiration processes during storage. Even at 4°C, metabolic activity continues, leading to the conversion of carbohydrates and organic acids into energy, which gradually reduces the total solid content of the fruit.

Among the studied cultivars, Stella exhibited the smallest decrease in dry matter, suggesting better stability of tissue composition and reduced dehydration rate, while Rubin showed the most pronounced reduction, reflecting a higher respiration intensity and faster postharvest metabolism (Fig. 7).

Fruit firmness is a critical indicator of postharvest quality and consumer acceptability, as it reflects the mechanical resistance of fruit flesh.

At harvest, the Van cultivar had the highest firmness (1.10 lbr), followed by Rubin (0.84 lbr) and Stella (0.72 lbr). Over time, all cultivars exhibited a steady decline in firmness: after 7 days, firmness values decreased to 0.97 lbr in Van, 0.64 lbr in Rubin, and 0.60 lbr in Stella. After 14 days, firmness dropped further to 0.82 lbr in Van, 0.56 lbr in Rubin, and 0.45 lbr in Stella (Fig. 7).

The loss of firmness is primarily attributed to enzymatic degradation of cell wall polysaccharides, particularly pectin and cellulose, as well as water loss leading to reduced turgor pressure. Enzymes such as polygalacturonase, pectin methyl esterase, and cellulase are known to play major roles in the softening process.

Among the three cultivars, Van maintained the highest firmness throughout storage, demonstrating greater structural integrity and potential for extended cold storage. In contrast, Stella showed the most rapid softening, indicating lower mechanical resistance and shorter storage potential, while Rubin displayed intermediate behavior.

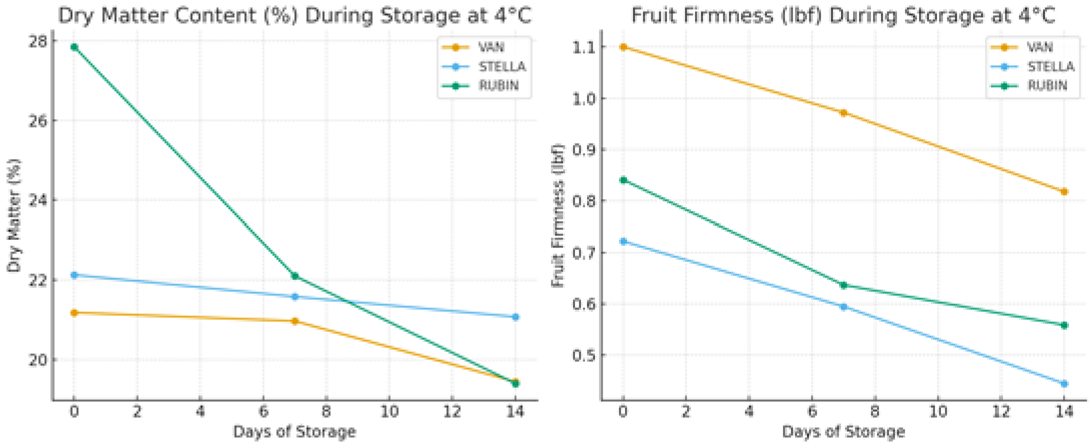

Figure 7. Results regarding dry matter content (%) and firmness (lbr) in the cherries studied

Conclusions

All cultivars exhibited significant reductions in size and weight during storage at 4°C. Among them, the Van cultivar maintained superior size and weight throughout the experimental period, indicating a greater capacity to preserve its physical quality attributes. The Stella cultivar experienced the most substantial decreases in both height and weight, reflecting a lower tolerance to storage conditions. In contrast, Rubin displayed intermediate behaviour, characterized by moderate stability in mass and size parameters.

During storage at 4°C, the soluble solids content increased steadily, while the pH decreased slightly, reflecting the natural processes of ripening and biochemical preservation.

The ‘Rubin’ variety showed the highest soluble carbohydrate content at the end of the storage period, making it the most suitable for fresh consumption or processing. The Van variety maintained a constant acidity and firm texture, being recommended for longer storage.

The Stella variety exhibited a moderate evolution of these parameters, suggesting a balance between sweetness and acidity, with good potential for immediate consumption.

Both dry matter content and fruit firmness decreased significantly during 14 days of storage, confirming the continuation of metabolic and enzymatic processes even under refrigeration.

The Van cultivar demonstrated superior firmness retention, suggesting suitability for longer cold storage and transport to distant markets.

The Stella cultivar showed higher stability of dry matter but lower firmness, making it better suited for short-term consumption.

The Rubin cultivar exhibited the highest initial dry matter but also the greatest loss over time, reflecting high respiration rate and accelerated postharvest ripening

Overall, the results demonstrate that both dry matter content and fruit firmness decrease progressively during cold storage, even under controlled low-temperature conditions. The Van cultivar showed the best overall storage performance, maintaining both higher firmness and acceptable dry matter levels, making it suitable for longer storage and transport. The Stella cultivar, although more stable in dry matter, was more susceptible to softening, while Rubin exhibited high initial dry matter but a more rapid decline in both parameters, suggesting faster metabolic and ripening processes.

These findings confirm that physiological and biochemical differences among cultivars significantly affect their postharvest behaviour and storage potential, and such parameters should be carefully considered in breeding programs and commercial storage strategies.

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