# Comparison of characteristics of sweet cherry varieties grown in Georgia and their changes during the storage

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## Abstract

**Introduction.** The aim of this research was to study the changes in the quality of sweet cherries grown in Georgia during their storage.

**Materials and methods.** Characteristics of sweet cherry varieties such as weight loss, titratable acidity, and content of total soluble solids, total phenolic compounds and anthocyanins, as well as the antioxidant activity were monitored at the beginning and after 21 and 42 days of storage in the fridge chamber at the temperature of 0–1 ºC and the relative humidity of 90–95%.

**Results and discussion.** Three commercially produced varieties of sweet cherry, particularly, Cordia, Regina and Sweetheart, were chosen for study. Cherry variety Cordia contained the highest amount of total phenolic content (TPC), 213.95mg100g$^{-1}$, and anthocyanins, 145.7mg100g$^{-1}$, compared to the other varieties, meanwhile variety Sweetheart contained the lowest amount of TPC, 116.0mg100g$^{-1}$, and anthocyanins, 29.75mg100g$^{-1}$. A positive correlation between the phenolic content and antioxidant activity for studied varieties was observed. The best correlation was found for Regina cherry ($R^2$=0.98), meanwhile for Cordia and Sweetheart it was 0.88 and 0.83, respectively. The physico-chemical properties of sweet cherries changed during the storage: content of total soluble solids, titratable acidity, total phenolic content, anthocyanins content, and antioxidant activity decreased gradually.

The total decrease in fruit mass after 42 days was measured together with the microbiological losses. Sweetheart has the highest weight loss compared to the others.

Based on the three-year data, total weight loss in Cordia was 10.13% at the end of the storage period (42 days) at temperature 0–1 ºC and relative humidity 90–95%. This value was 13.51% for Regina and 14.49% for Sweetheart variety.

**Conclusion.** The studied three sweet cherry varieties are close by their chemical composition. However, it can be concluded that Cordia is the best in terms of the content of valuable substances and storage stability.

## Introduction

Sweet cherries (*Prunus avium* L.) are one of the most popular seasonal fruit, which is highly appreciated by consumers for its taste, attractive appearance and nutritional quality (Antognoni et al., 2022; Faniadis at al., 2010; Gabriele et al., 2013; Pirog et al., 2022; Usenik et al., 2005; Wani et al., 2002). According to FAO the world's total sweet cherry production was estimated as 2,609,550 metric tons, and in Georgia sweet cherry production is increased by almost 31% in 2016-2020 (FAO, 2020).

Attractive colour, sweetness, sourness, firmness, high content of antioxidants and nutrients are the main characteristics for cherry quality (Esti et al., 2002; Gabriele et al., 2013; Nunes et al., 2021; Usenik et al., 2005). The health benefits of cherry intake are linked mainly to strong antioxidant activities (Nunes et al., 2020; Yoo et al., 2010), supporting the potential preventive health benefits in relation to several chronic diseases including cardiovascular disease, diabetes, and arthritis (Ferretti et al., 2010; Jacob et al., 2003; Mamani-Matsuda et al., 2006; Mc Cune et al., 2011; Wani et al., 2002). Sweet cherries are also rich in phenolic acids such as hydroxycinnamic acid derivatives (neochlorogenic acid, p-coumaroylquinic acid and chlorogenic acid) (Liu et al., 2011; Usenik et al., 2010). These components are important for their potential contribution to the colour of the cherry fruits through co-pigmentation with anthocyanins (Mazza & Brouillard, 1990; Mozetic et al., 2002). Moreover, strong correlations were found between the phenolic content and antioxidant activity of fruits (Serra et al., 2011; Tobar et al., 2019; Usenik et al., 2008).

Commercial cultivation and storage of sweet cherries is generally difficult and expensive. High levels of care in transportation and storage should be taken to achieve premium quality fresh fruit for serving in the market (Looney & Jackson, 2011). Cherry is highly perishable with a limited shelf life of 7–10 days (Wani et al., 2002). Low temperature is the basic parameter for storing; it keeps the fruit firm longer and reduces the color loss (Shick and Toivonen, 2002). Reported as recommended conditions to store cherries is the temperature range 0 to 2 °C and the relative humidity of 90 to 95% (Crisosto et al., 1993; Looney et al., 1996; Suran et al., 2019). The narrow harvest season together with sweet cherry soft texture limits availability of this fruit in the market over a longer period (Yoo et al., 2010), and in conventional storage conditions, the shelf life of cherries is very short.

The aim of the present research was to characterize the chemical compositions of sweet cherries grown in Georgia and their changes during sweet cherry storage.

## Materials and methods

### Chemicals

Ascorbic acid, sodium hydroxide, Folin-Ciocalteu reagent, TPTZ-2,4,6-Tris (2-pyridyl)-s-triazine, sodium carbonate, ethyl acetate, ferric (III) chloride and ethanol were purchased from Sigma-Aldrich (Steinheim, Germany), (Sigma-Aldrich, Switzerland), hydrochloric acid was provided by Merck (Darmstadt, Germany). All other reagents were commercially available at the local market and were of analytical grades.

### Sweet cherry samples

Three commercially produced sweet cherry (*Prunus avium* L.), Cordia, Regina and Sweetheart, grown in the village of Jighaura (Farming of Scientific Research Center of

Agriculture), west Georgia, municipality of Mtskheta (WGS84 41° 55′ 25″ N, 44° 46′ 35″ E 41.923611, 44.776389) were selected for study. The sweet cherry samples for the experiment were harvested at the end of June and in early July. The test samples were kept in the fridge chamber at the temperature of 0–1 °C and the relative humidity of 90–95 %. Initially, during and at the end of storage the physico-chemical and antioxidant properties of sweet cherry fruit of each variety were examined and compared.

**Determination of quality parameters**

Quality parameters such as weight loss, total soluble solids (TSS), titratable acidity (TA), total phenolic content (TPC) and anthocyanin content (AC), as well as the antioxidant capability were monitored at the beginning, after 21 and 42 days of storage at 0–1 °C. The samples were prepared for TPC and antioxidant analysis: about 40 g of cherry fruits were squashed and weighed (5g), 70% ethanol was added to the sample. The extract was left at room temperature for 30 min and then filtered. The extracts were stored in the refrigerator at 5 °C.

To determine weight loss fruit, 15 pieces of fruit were taken in triplicate and weighted. The loss of weight was expressed as the percent from the original weight.

To measure the microbiological loss, 10 kg of cherry samples were tested in triplicates. Microbial spoilage was monitored at intervals of 5 days. Microbiological changes were observed after 21 and 42 days of storage. Samples were weighted then, and the weight loss percentage was determined compared to the original weight.

Content of total soluble solids was determined using a digital refractometer (WAY, 2S, China) according to ºBrix reading.

Titratable acidity was determined by titration with 0.1 N NaOH to a pink color using 1% phenolphthalein as indicator and expressed as g 100 $g^{-1}$ malic acid (Morris et al., 1985).

The total phenolic compound content was determined using the Folin–Ciocalteu method Bond et al., 2003). 1.0 mL of extract was diluted with 10 mL distilled water, mixed thoroughly with 1.0 mL of Folin-Ciocalteau reagent for 8 min, followed by the addition of 4 mL of 7.5% ($w \cdot v^{-1}$) sodium carbonate. The samples and standards (dilute gallic acid standard working solutions: 10-50 μg/mL) were allowed to stand at room temperature for 60 minutes in the dark, and absorbance was measured spectrophotometrically (UV/Vis spectrophotometer, A&E Lab Co LTD, UK) at 765 nm with a 10 mm path length cell, and the total phenolic compound content was calculated as mg of gallic acid equivalents per 100 gram of fresh fruit.

Determination of total anthocyanins was conducted by the pH differential method (Giusti et al., 2001). Samples were diluted 1:150 in pH 1.0 and pH 4.5 buffers, and the absorbance was measured at 520 nm and 700 nm in a UV-visible spectrophotometer (A & E Lab Co LTD, UK), based on a cyanidin 3-glucoside molar extinction coefficient of 26,900 ΔE/mol and a molecular weight of 449.2 g $mol^{-1}$. The resulting values were expressed in terms of mg of anthocyanin per 100 g of fresh fruit.

The ferric reducing ability of plasma (FRAP) assay was carried out as previously described by (Benzie and Strain, 1996). The experiment was carried out at 37 °C and pH 3.6 with a blank sample in parallel. In the FRAP assay, the reductants ("antioxidants") in the sample reduce the Fe(III)/tripyridyltriazine complex to the blue ferrous form, with an increase in absorbance at 593 nm. The results were expressed as mg ascorbic acid equivalents (AAE) per 100 gram fresh fruit (mg AAE100 $g^{-1}$ FW) (Dziadek et al., 2019).

**Statistical Analysis**

The data represents the mean of three replicates±standard deviation (SD). Data were subjected to the t-test. All calculations were performed with Microsoft Excel (Version 4, statistical functions, Microsoft Corp., Redmond, WA, USA).

## Results and discussion

The mean three-year indicators show that Cordia has a high content of dry soluble solids (20.50%) and Sweetheart has the lower (18.25%) followed with Regina (17.10%). Cordia has the highest titratable acidity (0.50%), Sweetheart is the second (0.46%) followed by Regina (0.40%) (Table 1).

**Table 1**

**Chemical characteristics of fresh cherry fruit**

| Varieties | TSS, % | TA, % | TPC, $mg100g^{-1}$ | AC , $mg100g^{-1}$ | AAE, $mg\ 100g^{-1}$ |
|---|---|---|---|---|---|
| Cordia | 20.50±1.36 | 0.50±0.10 | 213.95±6.44 | 145.70±4.35 | 288.33±7.78 |
| Regina | 17.10±1.02 | 0.46±0.15 | 122.69±5.11 | 51.52±2.87 | 127.13±5.62 |
| Sweetheart | 18.35±1.58 | 0.40±0.10 | 116.00±5.02 | 29.75±2.10 | 93.33± 4.51 |

The data represents the mean of three replicates±SD

The total polyphenols were analyzed, and Cordia was found to have 213.95 $mg100g^{-1}$, while Sweetheart has only half of this amount and Regina has 122.69 $mg100g^{-1}$. Cordia has high content of anthocyanins and high level of antioxidant activity: 145.7 $mg100g^{-1}$ and 288.33 AAE $mg100g^{-1}$, respectively, and for Sweetheart these values are much lower: 29.75 $mg100g^{-1}$ and 93.33 AAE $mg100g^{-1}$, respectively. Thus, Cordia is a cultivar with the highest content of useful substances while Sweetheart has the lowest.

The changes in the chemical characteristics during the storage were also studied. The research showed that studied cultivars differed in terms of change of their chemical composition during the storage (Figures 1–5).

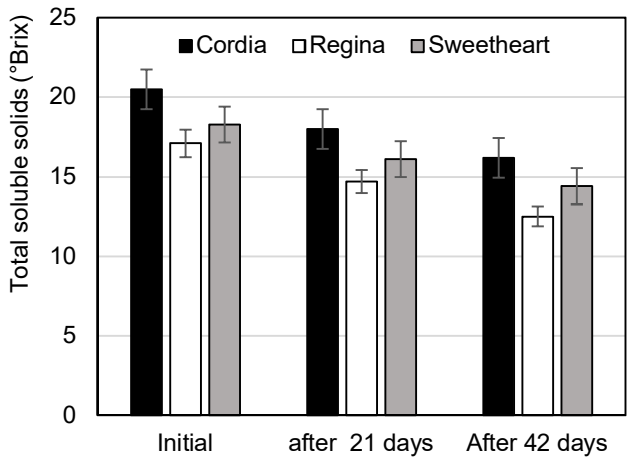


**Figure 1. Change of total soluble solids (%) in cherry varieties during the storage.**

The content of total soluble solids gradually decreased for all three varieties during the storage. However, the level of this decrease was different for each variety. For example, after 42 days of storage, the dry soluble solids in Cordia decreased from origin 20.5 to 16.2%, and the percentage of decrease was 20.9%. Whereas the same values for Regina and Sweetheart were 26.9 and 21.3 %, respectively.

The change in titratable acidity in the studied varieties also occurred in different ways (Figure 2).

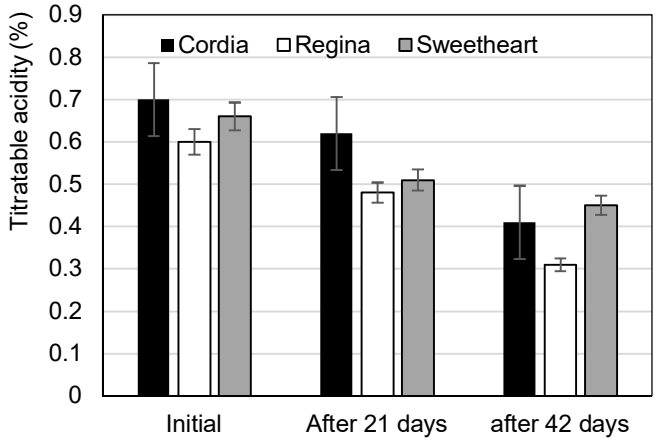


**Figure 2. Change of titratable acidity (%) in cherry varieties during storage.**

The reduction of sweet cherry titratable acidity during storage has been shown (Horak et al., 2016). In our case, at the end of storage period titratable acidity was reduced by 41.4% in Cordia, by 31.8% in Sweetheart and by 48.3% in Regina.

The analyzed cultivars differ in terms of decrease in total polyphenols. The Figure shows that at the end of the storage period the total polyphenols decrease by 52.6%, while in Regina this indicator is 46.7% and in Sweetheart it is 45.8%. The data illustrates that in terms of the decrease in total polyphenol there is only a little difference between the cultivars (Figure 3).

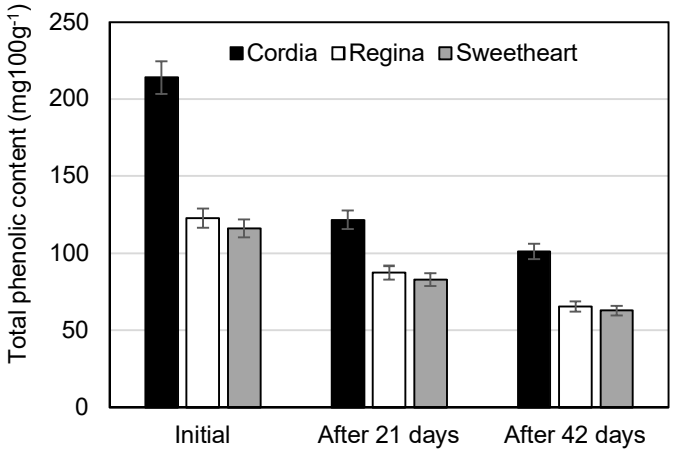


**Figure 3. Change of total phenolic content (mg100g$^{-1}$) in cherry varieties during storage.**

The analysis of the change in the anthocyanins content showed its decrease during the storage. The change was most noticeable for Sweetheart (decrease by 36.13%). The least decrease occurred in Regina. For Cordia the decrease in anthocyanins amounts to 22.92% after 42 days of storage was detected (Figure 4).

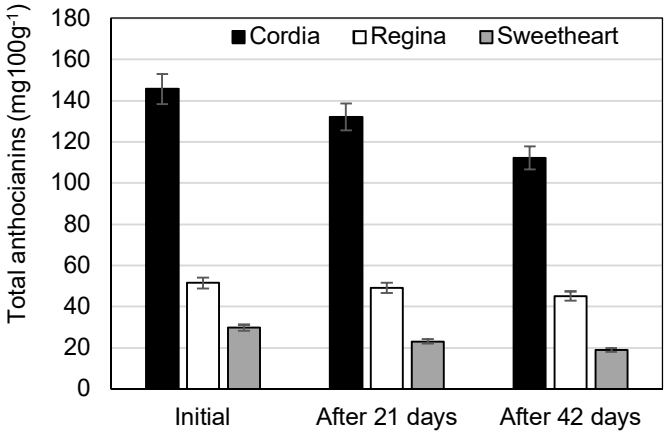


**Figure 4. Change of anthocyanins content (mg100g$^{-1}$) in cherry varieties during storage.**

The change in antioxidant activity showed that it decreased in all three varieties. The higher decrease, 36.4%, was observed in Cordia, the lowest, 14.9%, in Sweetheart, and in Regina it was 31.8% (Figure 5).

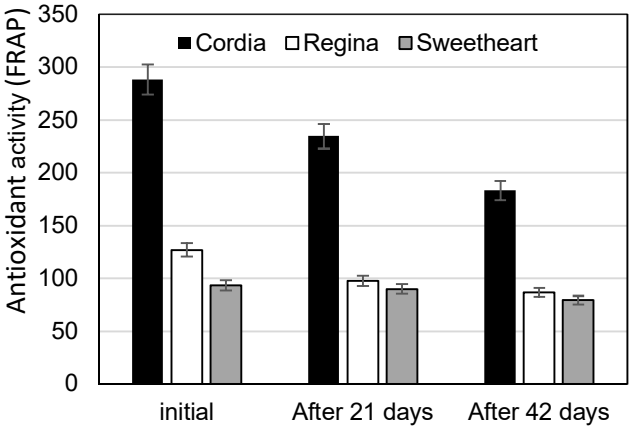


**Figure 5. Change of an (FRAP) in cherry varieties during storage.**

A positive correlation between the phenolic concentration and antioxidant activity of sweet cherry fruit has been shown by Tobar et al. (2019). For studied cherry varieties correlation of total phenolic content and antioxidant activities was different for studied cherry varieties. Thus, high correlation ($R^2$=0.98) was found for Regina cherry, meanwhile it was lower for the other varieties: in the case of Cordia $R^2$=0.88 and Sweetheart $R^2$=0.83 (Figure 6).

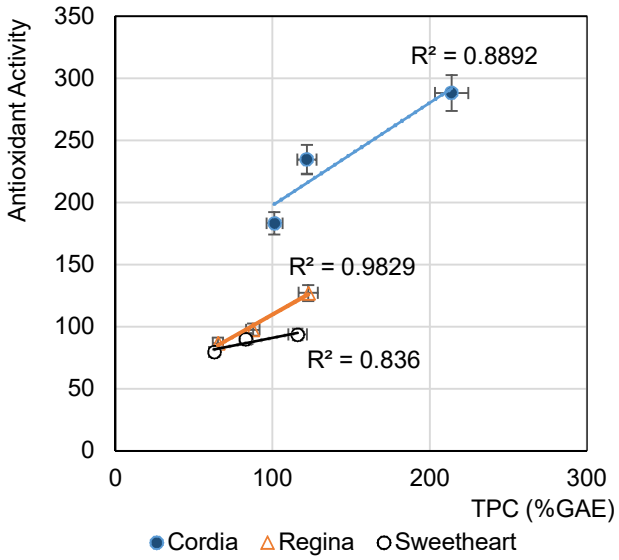


**Figure 6. Correlation between total phenolic content and antioxidant activity for studied cherry fruits varieties**

The cherries of the selected varieties were stored at 0–1 °C temperature and 90–95 % relative humidity. A total weight losses in fruit after 42 days was measured together with the microbiological postharvest losses. Microbiological postharvest loss is one of the major types of postharvest loss and it refers to losses caused by microorganisms like moulds, yeasts and bacteria (Bist and Bist, 2021). Based on the three-year data, the natural weight loss in Cordia was 5.83%, microbiological loss was 4.30%, and the total loss at the end of the storage period (42 days) was 10.13% (Table. 2).

**Table 2**

**Natural, microbiological and total weight losses on different stages of cherry fruit storage**

| Varieties | Natural weight losses, % | Microbiological losses % | Total weight loss, % |
|---|---|---|---|
| **21 days of storage** | | | |
| Cordia | 3.80±0.10 | 2.50±0.05 | 6.30±0.20 |
| Regina | 4.92±0.12 | 2.84±0.06 | 7.76±0.14 |
| Sweetheart | 6.12±0.17 | 4.38±0.01 | 10.50±0.23 |
| **42 days of storage** | | | |
| Cordia | 5.83±0.22 | 4.30±0.10 | 10.13±0.13 |
| Regina | 6.30±0.11 | 7.21±0.31 | 13.51±0.72 |
| Sweetheart | 8.23±0.78 | 6.26±0.50 | 14.49±0.36 |

The data represents the mean of three replicates±SD

The natural weight loss for Regina was 6.30%, microbiological losses was 2.84%, and the total loss was 13.51%. Sweetheart had the highest natural weight loss, 8.23%, compared to the others. Its microbiological loss was 6.26% and the total loss is 14.49%.

## Conclusions

Comparison of three cherry varieties grown in Georgia showed that:

1. Cherry variety Cordia contained the highest amount of total phenolic compounds and anthocyanins compared to the other varieties. This variety had also a higher antioxidant activity. Cordia variety can be stored under refrigerated conditions – 0–1 ºC and 90–95% relative humidity for 42 days with 10.13% total weight loss.
2. Regina variety had a lower content of total phenols and anthocyanins and a lower antioxidant activity compared to Cordia. Cherries of this variety can be stored at 0–1ºC and 90–95% relative humidity for 42 days with 13.5% total loss. Among the studied varieties, Sweetheart had the lowest total phenolic and anthocyanin contents and antioxidant activity. While storing sweet cherries of this variety under the refrigerated conditions for 42 days, total losses was 14.49 %.
3. Based on the obtained data, it can be concluded that among studied varieties Cordia was the best in terms of storage stability and content of valuable substances.

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