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CORRELATION BETWEEN SWEET CHERRY QUALITY TRAITS AND FRUIT CRACKING INDEX AT THREE ROMANIAN VARIETIES

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Abstract

Cracking in sweet cherry is often mentioned as a serious problem in many commercial orchards. Research was conducted on reducing the phenomenon of cracking and keeping in mind that cheap, easily accessible, effective solutions for farmers in the specific climatic conditions of our country, is of particular importance. Fruit quality is the target of every farmer. In an attempt to obtain higher quality fruit, it is possible that sometimes, especially if significant rainfall occurs during the ripening period, producers neglect the cracking susceptibility of their varieties. In 2023 we evaluated three Romanian sweet cherry cultivars from the perspective of fruits quality parameters as follows: weight, firmness, pH, total soluble solids, colour. `Special`, `Tentant` and `Severin` cvs. grafted on `IP-C8` rootstock have been quantitatively assessed by the cracking index. `Severin` recorded the largest fruits while `Special` registered the highest content of total soluble solids and these traits represent ones of the most important quality attributes in relation with the intensity of sweet cherry fruit cracking.

Key words*: sweet cherry, cracking index, fruit quality, spray treatments.*

INTRODUCTION

In recent years, Romania has consistently maintained in the first top 10 countries ranked in terms of sweet cherries production in Europe (Faostat, 2022). Due to an extensive favourable geographical conditions for growing (many hilly areas with altitudes of 600-700 m) and a long traditions of sweet cherry cultivation, considering also the economic efficiency of the crop that can generate important incomes for fruit growers, the cherries are in the main attention for farmers and investors too.

Nevertheless sweet cherry production faces a lot of challenges. Certainly the most important ones are spring frosts and fruit cracking. Spring frosts is a threat of a high risk for the production of sweet cherries in temperate climate regions through cold climate regions, especially when the bacterial canker infection follows this low temperature wave (Demirsoy et al., 2022), and its severity is determined by many factors, such as the cultivar, the pruning intensity, the duration of the freeze and the stage of bud dormancy (Webster and Looney, 1996). Such accidents are quite often and become more often due to the climate change in all areas where sweet cherry is cultivated in Romania. If occurs during the blooming period, between 10 to 90% of the flowers can be affected (Chitu et al., 2020).

On the other hand, the unpredictable weather specific to the sweet cherries ripening period (May-June) causes big problems for farmers in many years. In a multi-year characterization (1961-2023) of Romania's climate, the National Meteorological Administration indicates that May and June are the months characterized by periods of sunny and warm days (sometimes too hot) that alternate with periods of cold and rainy days. The rains have many times torrential feature. In addition, June is the richest month in precipitation among all the months of the year. In terms of cracking susceptibility, fruit of all cultivars cracks, but some differences between the sweet cherry cultivars exist (Knoche and Winkler, 2019). Research should be conducted towards the use of less susceptible cultivars to cracking and their selection for the establishment of new orchards, especially in areas where the rain risk is present during the picking time. These sweet cherry varieties that prove to be tolerant to cracking, can be a valuable source of genes for the sweet cherry breeding programs.

MATERIALS AND METHODS

The biological material used in the present research was represented by three Romanian sweet cherry varieties grafted on IP-C8 vegetative rootstock and established in a non-irrigated eight years old orchard of the Research Institute for Fruit Growing Pitesti - Maracineni (Figure 1).

Figure 1. Eight years old orchard at RIFG Piteşti - Mărăcineni

The main traits of the sweet cherry cultivars are as follows:

Special - is a bitter-sweet taste variety, specially bred for processing as jam and for alcoholic beverages, a better alternative to the varieties used for 'kirschwasser' or older similar varieties present in the official ISTIS assortment list.

Figure 2. 'Special' fruit

The fruit is medium-sized (6 g), with a deep stylar point, dark red to black skin, good firmness of the flesh, dark red flesh and juice (Figure 2).

Tentant – is a variety for fresh consumption, with a very firm purple-red pulp and sweet taste. Flowering is starting late and the tree is medium as vigour, with upright or semi-upright habit and high productivity. It is tolerant to *Monilia* sp. and *Blumeriella jaapii* (Rehm Arx.) and can be a good substitute for 'Kordia' in a high density orchard (Figure 3).

Figure 3. 'Tentant' sweet cherry variety fruits

Severin – variety bred for fresh consumption, with large fruits (9g), dark red skin, firm pulp and sweet taste (Figure 4). The productivity is medium and the tree is tolerant to *Monilia* sp. and *Blumeriella jaapii* (Rehm Arx.).

Figure 4. 'Severin' sweet cherry variety fruits

The cracking susceptibility of the varieties was assessed by calculating the cracking index, using the Verner (1957) method revised later by Christensen (1972).

For each sweet cherry variety, 50 fruits at full maturity were picked, without any disorders, cracks or bumps and were placed in distilled water at 20˚C for 6 hours. Every 2 hours the fruits have been checked, and those that were found cracked have been removed from the water and counted (Figure 5).

Figure 5. Immersing sweet cherry fruits in distilled water for 6 hours

The cracking index (CI) was calculated according to the formula below:

$$CI = (5a + 3b + c) / 250) \times 100$$

where a, b and c represent the number of fruits cracked after 2, 4 and 6 hours of immersion, total number of fruits immersed = 50, maximum cracking 50 × 5 = 250

The quality traits of the sweet cherry fruits have been evaluated considering the following items (Figure 6):

- weight – measured with a high precision electronic scale;
- fruit firmness – using a non-destructive penetrometer, Bareiss Qualitest HPE, with 0.25 cm^2 plate and cylindrical tip;
- the skin color - was assessed using the Konica Minolta CR 400 Chroma Meter;
- total soluble solids (TSS) – was measured by refractometric method using a Hanna HI 96801 portable refractometer;
- pH of the fruit juice - was determined using the Mini Lab pH meter.

For the evaluation of the fruit's skin colour, we used the CIELAB system. The colour is represented using coordinates in a uniform colour space consisting of the brightness variable L* and the chromaticity indices a* and b*. Thus, if the L* coordinate provides information regarding the brightness, the positive values of a* are located on the red axis and the negative ones on the green axis, and the positive values of b* are located on the yellow axis and the negative ones on the blue axis.

Figure 6. Sweet cherry fruit measurements

Statistical analysis of data was done using analysis of variance (one way-ANOVA), followed by post hoc Duncan's Multiple Range Test (DMRT) to measure specific differences between samples means.

The relationships between parameters were also performed in order to determine, above all, the relationships between fruit quality parameters and CI, by Pearson's correlation.

The aim of the researchwas to emphasize the relationship between some quality traits of three sweet cherry Romanian varieties and their susceptibility to cracking.

RESULTS AND DISCUSSIONS

Sweet cherry fruit quality is closely related with the cultivar, but also with the specific environmental conditions of the current year, and is decisively affected when abundant precipitation is recorded before or during harvesting. In 2023, 12th of June was considered the harvesting day for full ripen stage of 'Tentant' and 'Special' varieties and two days later, on June 14, for 'Severin'. In setting up the experiment, we considered very relevant for an objective evaluation, to choose sweet cherry varieties that have the same or very close harvesting time. One week behind the harvest date, no precipitation occurred (Figure 7), and even that 7.2 mm of precipitation fell on the eve of the harvest, it wasn't affect the fruits. As a result of this environmental condition, in the field we counted only 2.5% of cracked fruits.

According to the data registered for each variety (Table 1) in terms of **fruit weight**, 'Severin' presented the largest fruits (7.67 g), very closed followed by 'Tentant' (7.56 g) with no statistic differences.

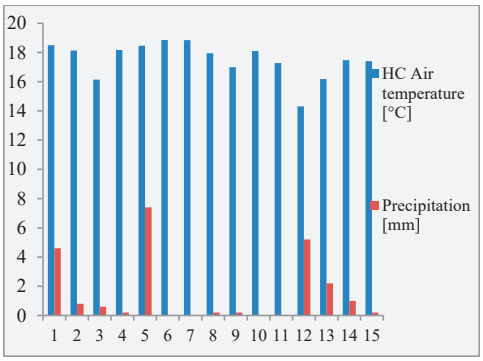

Figure 7. Environmental conditions during the harvest time (1-15 June, 2023)

Table 1. Analyzed quality parameters of the sweet cherry varieties

Cultivar	Weight (g)	Firmness (HPE)	pH	TSS (°Brix)
Special	5.57[b]	32.1[b]	3.53[b]	21.70[a]
Tentant	7.56[a]	51.2[a]	3.62[a]	16.21[b]
Severin	7.67[a]	34.1[b]	3.44[c]	11.78[c]

*Values followed by the same letter are not statistically different according to DMRT (P<0.05).

The lowest cracking index (Table 2) of 'Severin' variety (6.4) did not support the results obtained by Perreira et al. (2020) in case of cultivar 'Lapins' and 'Early Bigi' that showed a higher CI correlated with the bigger size of the fruits. In other particular cases and varieties, as results obtained by Stojanović et. al. (2013) the late ripening varieties are less susceptible to cracking and not the heaviest ones.

In our research, we noticed a significant negative correlation between weight and the cracking index (Table 3). The same conclusion was indicated in the experiments initiated by Demirtaş and Aydinli (2020) who could not demonstrated a strong connection between the fruit size and the cracking index in 16 sweet cherry early ripening genotypes.

Table 2. Colour and Cracking Index of the three sweet cherry varieties

Cultivar	L*	a*	b*	CI
Special	23.25[c]	6.15[c]	1.16[c]	38.4[a]
Tentant	24.72[b]	13.00[b]	2.78[b]	35.6[b]
Severin	25.07[a]	15.86[a]	4.04[a]	6.4[c]

*Values followed by the same letter are not statistically different according to DMRT (P<0.05).

Although 'Special' and 'Severin' varieties showed similar **firmness** values (Table 1), their behaviour was totally differently once the fruits were introduced to water for 6 hours. These data are in line with other experiments that did not reveal a very strong correlation between firmness and the cracking index (Perreira et al., 2020). In our case, the correlation is significant at the 0.05 level and highlight big differences between the CI values of 'Special' and 'Tentant' varieties (Table 3).

Variations of **pH** can influence taste, flavour, consistency, fruit shelf life and depreciation of juice. Comparing to the finding of Kappel et al. (1996) where the pH was around 3,8 and those reported by Skrzyński et al. (2016), where 10 of the 14 sweet cherry genotypes had pH below 3.5 and only four cultivars had higher pH value than 3.8 our sweet cherry varieties significantly varied between 3.44 at 'Severin' to 3.62 at 'Tentant'.

Table 3. Correlations between cracking index and the biometric attributes of the sweet cherry varieties

	Cultivar	Weight (g)	Firmness (HPE)	pH	TSS (°Brix)	L*	a*	b*	CI
Cultivar	1	.821(**)	.070	-.262(*)	-.958(**)	.448(**)	.693(**)	.634(**)	-.905(**)
Weight (g)		1	.415(**)	-.027	-.817(**)	.452(**)	.651(**)	.565(**)	-.563(**)
Firmness (HPE)			1	.425(**)	-.097	.170	.169	.083	.250(*)
pH				1	.199	-.050	-.132	-.180	.440(**)
TSS (°Brix)					1	-.417(**)	-.661(**)	-.595(**)	.842(**)
L*						1	.885(**)	.921(**)	-.338(**)
a*							1	.972(**)	-.558(**)
b*								1	-.554(**)
CI									1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed)
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Under our specific experimental conditions, the increase in pH was positively correlated with the cracking index (Table 3).

Concerning the **total soluble solids**, the spectrum of values ranged from 11.78 °Brix at 'Severin' to 21.7 °Brix at 'Special' (Table 1). Even that Kappel et al. (1996) considered optimal a value of TSS = 15 for the harvest time, the specific color and the very balanced taste of the fruits assured us that the moment of harvesting for 'Severin' was the right decission. Similar values were also reported by Ruiz-Aracil et al. (2023), in the case of 'Early Lory' cultivar and after foliar applications of 0.5 mM MeJA.

Zheng et al. (2016) have shown that flavour and sweetness are main priorities in consumer acceptance, followed closely by colour, size and firmness of sweet cherry fruits. Also important we consider to research if there is any connection between the intensity of these attributes and the susceptibility to fruit cracking.

In our research, the correlation between TSS and CI is consistent and positive (Table 3) even that the differences between the varieties were statistically assured for both parameters.

Analyzing the 3 coordinates for **skin colour** of the fruits, we remarked that the bright red skin color of 'Severin' was the lightest one in contrast with 'Special' variety where the skin was darker (Table 2). Overall, 'Severin' cherries had recorded higher values than 'Special' and 'Tentant' cultivars in all parameters, and significant differences ($p < 0.05$) were found for all L*, a* and b* coordinates. We found significant negative correlation between skin colour and CI. Chełpiński et al. (2019) considered that the color measured with a spectrophotometer is a sufficient tool for appreciating the degree of ripening of the fruits. Low values of the coordinates L*, a* and b* generally assume darker and therefore over ripen fruits, correlated with higher CI values.

The lowest average value of **fruit cracking index** was recorded in the cultivar 'Severin' (6.4), while the highest value was fund for the cultivars 'Special' (38.4) and 'Tentant' (35.6). These values split the varieties in two out of the four groups established by Christensen (1972): 'Severin' in the group of low susceptible (CI < 10.0) and 'Special' and 'Tentant' in cracking susceptible group, were the cracking index values range between 30.1 and 50.0. We expect some differences in rankings and cracking index values depending on the year. For instance, Demirtaş and Aydinli (2020) found for one of the studied genotypes value of 5.7 for cracking index in the first year, and 43 for the 2nd year of experimentation.

CONCLUSIONS

Not all quality traits of the 'Severin', 'Special' and 'Tentant' Romanian sweet cherry varieties proved a strong correlation with the cracking index.

'Special' had the best coloured fruits, the highest TSS content and the lowest fruit firmness. The highest cracking index at the moment of the variety ripening time has to be connected to the rain fell on the eve of the harvest.

Some parameters such as the TSS content, better coloration of the fruit skin indicated a good correlation with the cracking index.

For the tested sweet cherry varieties, neither the firmness, nor the fruit weight did not confirm the expectation of a higher cracking index.

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