

# POSTHARVEST QUALITY OF STRAWBERRY FRUITS GROWN IN CONVENTIONAL SYSTEM

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## ABSTRACT

The objective of the study was to evaluate some postharvest parameters of fruit quality at seven strawberry cvs., ('Alba', 'Clery', 'Coral', 'Magic', 'Premial', 'Queen Elisa', 'Record') grown at RIFG Pitești, Romania in open field, in the 2016-2018 period. The storage method included three days in normal refrigeration condition (2-4°C) followed by one day at room temperature (22-24 °C). The following parameters were determined before and after storage: fruit weight (g), fruit firmness (kgf/cm<sup>2</sup>), four color indicators (L\*, a\*, b\*, ΔE) and percent of damaged fruits caused by pathogen. Statistically assured differences were recorded between cultivars. 'Premial' cv. proved the lowest fruit weight loss (0.27 g) and also the lowest fruit firmness loss (0.09 kgf/cm<sup>2</sup>) after storage. 'Alba' cv. had the highest percentage of healthy fruits after storage (86.4%). After four days storage both early cvs.were marketable.

**Keywords:** *Fragaria x ananassa*Dutch.,cultivars, weight,firmness,color,storage.

## INTRODUCTION

Strawberries are a highly perishable fruits because of their vulnerability to mechanical damage and sensibility to pathogens, requiring a rapid initial cooling for storage and distribution to the market. Some of fruit qualities traits as general appearance, size, shape, firmness and color can influence the consumer's decision on market (Battino et al., 2019, Temocico et al., 2019, Mazzoni et al, 2020). For example red bright is favorite (Kader 1999; Moshir Rahman et al., 2014; Moshir Rahman et al. 2015, Temocico et al., 2017). Because of high metabolic activity, strawberry fruit quality decreases rapidly after harvest (Olias et al., 2000). Fruit storage at ambient temperature makes the management of post-harvest strawberries to be very difficult (Asrey et al., 2004, Ayala-Zavala et al., 2004). Storage of fruits in cold conditions is used on large scale for prolonging the quality. The objective of this study was to evaluate the post harvest quality parameters of seven strawberry cultivars.

## MATERIALS AND METHODS

The study was conducted between 2016-2018, on a sample of 500 g of fruit for each studied cultivar 'Alba', 'Clery', 'Queen Elisa', 'Record' (Italian origin) 'Coral', 'Magic', 'Premial' (Romanian origin), at the third harvest of the each year. The field trials were grown in conventional and perennial system, and before planting the following quantities were applied 40kg ha<sup>-1</sup> N, 40 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> and 60 kg ha<sup>-1</sup> K<sub>2</sub>O, as basic fertilization.

Straw were used as mulch and the irrigation system used was the sprinkler irrigation type. Soil type prevailing in the field a trial has medium-textured and the heavy-clay soils: clayey-

illuvial luvisols, all showing medium and low humus content. The strawberry fruits were harvested at commercial maturity and the fruits samples were analyzed immediately after picking. The optimum moment for harvesting strawberries was considered when the entire surface was red (Voca et al., 2008).

The fruits were kept for three days in the refrigerator (2-4°C) and one day at room temperature (22-24° C). The following parameters were determined before and after storage: fruit weight (g), fruit firmness (kg/ cm<sup>2</sup>), and four color parameters: L\*(brightness-darkness), a\*(green-red), b\*(blue-yellow), ΔE (color evolution during storage) and the percentage of damaged fruit caused by pathogenicmicroorganisms. The fruit weight was determined by measuring the individual fruit with HL-400 digital balance. The fruit firmness was determined on each fruit for each sample with a non-destructive Bareiss HPE II Fffpenetrometerwith a measurement area of 0.50 cm<sup>2</sup>.

The color of the fruit was determined by Konica Minolta CR 400 colorimeter, based on HunteL system L\*, a\*, b\* on both sides of the fruit. The color space is organized as a cube. The axis L\* represents the brightness, where the maximum value 100 represents white color and the minimum value 0 represents black. a\* and b\* axes have no specific numerical limits. The positive values for a\* indicates red color and the negative values, green color.

The negative values for b\* indicates blue color and the positive values, indicates yellow color. The small values of the color indicators L \*, a \*, b \* generally show the darker fruits (Zorrilla-Fontanesi et al. 2011).

The color difference at harvest versus the end of the storage period was determined by the formula:  $\Delta E = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$  (Faedi et al., 2002). Degradation of the fruits appearance at the attack by the pathogens during storage was visually determined after the storage period. The strawberries where was developed mycelium on the surfaces were considered decayed.

The results were expressed as the percentage decay incidence of the strawberry. Statistical processing of data was conducted using analysis of variance and was used to calculate was Duncan multiple range test, for a probability of error ≤0.05.

## RESULTS AND DISCUSSIONS

### Weight loss of fruit

The highest values of the fruit weight wereobtainedfor'Record' (17.73 g harvest and 17.24 g after storage, respectively) and the lowest for'Coral'. (10.93 g at harvest and 10.53 g after storage, respectively) Table 1. After the published data by Lovatti and Nuzzi (2009), in Cesena (Italy) 'Alba'showed a fruit weight of 26.0 g at harvest and 24.0 g after storage, consequently a weight loss of 2 g. Even if in our study 'Alba' cv. provedto have a smaller fruit weight because of environment conditions and culture technology, the fruit weight loss of this cv. after storage was 0.48 g (Table 1).

The analysis of fruit weight variation between the two moments of recording data (before and after storage), showed a decrease in the values between cultivars from 0.40% 'Coral' to 1.73% 'Magic' (Table 1).

### Firmness loss of fruit

At harvest 'Record'cv.showed the highest value (2.38 kgf/cm<sup>2</sup>) of the fruit firmness which is not significantly different versus the others studied cultivars (from 0.12 kgf/cm<sup>2</sup> to 0.62 kgf/cm<sup>2</sup>). Table 2 illustrates the value of fruit firmness before and after the storage period and it has found that there were not significant differences between cultivars. The average values recorded for all cultivars decreased with 0.33 kgf/cm<sup>2</sup>.

Table 1. Fruit weight of strawberry cultivars

| Cultivar    | Fruit weight (g) at harvest | Fruit weight (g) after storage | Weight loss (g) |
|-------------|-----------------------------|--------------------------------|-----------------|
| Alba        | 12.83 c*                    | 12.35 c                        | 0.48            |
| Clery       | 12.23 c                     | 11.59 c                        | 0.64            |
| Coral       | 10.93 d                     | 10.53 c                        | 0.40            |
| Magic       | 16.63 ab                    | 14.90 b                        | 1.73            |
| Premial     | 16.33 b                     | 16.06 ab                       | 0.27            |
| Queen Elisa | 16.13 b                     | 15.33 b                        | 0.80            |
| Record      | 17.73 a                     | 17.24 a                        | 0.49            |
| Average     | 14.69                       | 14.00                          | 0.69            |

\*Means within each row followed by different letters are significantly different according to LSD test ( $P \leq 0.05$ ).

Table 2. Fruit firmness of strawberry cultivars

| Cultivar    | Fruit firmness (kgf/cm <sup>2</sup> ) at harvest | Fruit firmness (kgf/cm <sup>2</sup> ) after storage | Firmness loss (kgf/cm <sup>2</sup> ) |
|-------------|--|---|--------------------------------------|
| Alba        | 1.90 ab*   | 1.72 ab   | 0.18                                 |
| Clery       | 1.90 ab  | 1.83 ab   | 0.07                                 |
| Coral       | 1.76 b   | 1.58 ab   | 0.18                                 |
| Magic       | 2.07 ab  | 1.30 b  | 0.77                                 |
| Premial     | 2.00 ab  | 1.91 ab   | 0.09                                 |
| Queen Elisa | 2.26 ab  | 2.10 a  | 0.16                                 |
| Record      | 2.38 a   | 1.54 ab   | 0.84                                 |
| Average     | 2.04   | 1.71  | 0.33                                 |

\*Means within each row followed by different letters are significantly different according to LSD test ( $P \leq 0.05$ ).

### Surface color stability after storage and decay incidence of strawberry

The color is an important indicator for determining the quality of fresh products and the changes of the L\* a\* b\* after the storage period are noted in Table 3.

On average for the three years of study and the seven studied cultivars the analysis of the color indicators showed that there were significant differences between the values recorded at harvest and after the storage period.

For L\* and a\* parameters the differences between the two moments of evaluation (at harvest and after storage) were 0.01 units and 0.05 units, respectively. As average for the three years of study and the two moments of evaluations 'Premial' showed the highest values for three indicators of color, significantly different from all the other cultivars.

Table 3. Fruit colour of strawberry cultivars

| Cultivar    | Color at harvest |           |         | Color after storage |          |         |            |
|-------------|------------------|-----------|---------|---------------------|----------|---------|------------|
|             | L*               | a*        | b*      | L*                  | a*       | b*      | $\Delta E$ |
| Alba        | 31.56 ab*        | 28.13 b   | 12.25 b | 31.38 ab            | 28.08 b  | 12,18 b | 2.00 a     |
| Clery       | 31.60 ab         | 28.08 b   | 12.63 b | 31.58 ab            | 28.03 b  | 12,76 b | 0.16 b     |
| Coral       | 30.19 b          | 25.12 cd  | 11.55 b | 30.37 b             | 25.18 bc | 11,71 b | 0.87 ab    |
| Magic       | 31.30 ab         | 24.01 d   | 11.96 b | 31.38 ab            | 24.08 c  | 11,99 b | 0.92 ab    |
| Premial     | 32.42 a          | 32.73 a   | 14.54 a | 32.33 ab            | 32.74 a  | 14.42 a | 1.43 ab    |
| Queen Elisa | 32.28 a          | 27.05 bc  | 12.59 b | 32.26 ab            | 26.90 bc | 12.52 b | 0.60 ab    |
| Record      | 32.40 a          | 25.89 bcd | 12.44 b | 32.39 a             | 25.75 bc | 12.41 b | 0.63 ab    |
| Average     | 31.68            | 27.30     | 12.57   | 31.67               | 27.25    | 12.57   | 0.94       |

\*Means within each row followed by different letters are significantly different according to LSD test ( $P \leq 0.05$ ).

The lowest values of L\* and b\* color indicators were registered by 'Coral' for both moments of evaluation (Table 3). 'Coral' were worse noted than 'Premial' according with fruit brightness.

Even if after storage the color evolution ( $\Delta E$ ) showed close values, nevertheless some statistical differences between cultivars occurred, 'Alba' having the highest value ( $\Delta E = 2.00$ )

Table 4. Color stability and fruit decay after storage

| Cultivar    | Color stability after storage | % of marketable fruits | Dried calyx % |
|-------------|-------------------------------|------------------------|---------------|
| Alba        | medium                        | 86.4                   | 11.4          |
| Clery       | medium                        | 75.0                   | 24.1          |
| Coral       | medium                        | 56.4                   | 66.3          |
| Magic       | medium                        | 50.0                   | 70.2          |
| Premial     | high                          | 54.0                   | 62.4          |
| Queen Elisa | medium                        | 78.4                   | 22.1          |
| Record      | medium                        | 70.7                   | 44.2          |

'Premial' was also noted with higher color stability indicators after storage (Table 4). 'Alba' cultivar was evaluated as having the most marketable fruits (86,4%), taking account also of the lowest percent of dried calyx (11,4%), followed by Queen Elisa with 78,4% and 22,1%, respectively (Table 4).

### The nature and intensity of the correlations between the fruit quality indicators

In Table 5 are presented the correlations between studied indicators.

According to the ten indicators studied  $\Delta E$  was significantly and positively correlated with eight of them, representing color and firmness indicators both at harvest and after storage moments and was negatively correlated with fruit weight (g) for both moments.

The firmness registered at harvest is negatively correlated with three quality indicators studied, and only firmness after storage was negatively correlated with the average fruit weight at harvest.

The fruit weight recorded at harvest was negatively correlated with two fruit quality indicators ( $\Delta E$  and firmness registered after storage) and was highly significantly positive

with fruit weight measured after storage ( $r = 0.967$ ). The fruit weight recorded after harvest was negatively correlated only with  $\Delta E$  ( $r_h = -0.19$ ) and positively correlated with all the other quality indicators.

Table 5. Correlations between fruit quality indicators at harvest and after storage (simple Pearson correlation coefficient- r)

| The studied character                               | L* (brightness-darkness) at harvest | a* (green-red) at harvest | b* (blue-yellow) at harvest | L* (brightness-darkness) after storage | a* (green-red) after storage | b* (blue-yellow) after storage | $\Delta E$ | Fruit firmness (kgf/cm <sup>2</sup> ) at harvest | Fruit weight (g) at harvest | Fruit firmness (kgf/cm <sup>2</sup> ) after storage | Fruit weight (g) after storage |
|---|-------------------------------------|---------------------------|-----------------------------|--|------------------------------|--------------------------------|------------|--|-----------------------------|---|--------------------------------|
| L* (brightness-darkness) at harvest                 | 1                                   | 0.374                     | 0.664 (**)                  | 0.910 (*)                              | 0.339                        | 0.567 (**)                     | 0.063      | 0.391  | 0.519 (*)                   | 0.403   | 0.550 (**)                     |
| a* (green-red) at harvest                           | 0.374                               | 1                         | 0.843 (**)                  | 0.350                                  | 0.975 (**)                   | 0.836 (**)                     | 0.332      | -0.211   | 0.028                       | 0.300   | 0.141                          |
| b* (blue-yellow) at harvest                         | 0.664 (**)                          | 0.843 (**)                | 1                           | 0.596 (**)                             | 0.814 (**)                   | 0.931 (**)                     | 0.209      | 0.026  | 0.329                       | 0.329   | 0.409                          |
| L* (brightness-darkness) after storage              | 0.910 (**)                          | 0.350                     | 0.596 (**)                  | 1                                      | 0.365                        | 0.623 (**)                     | 0.061      | 0.335  | 0.485 (*)                   | 0.350   | 0.516 (*)                      |
| a* (green-red) after storage                        | 0.339                               | 0.975 (**)                | 0.814 (**)                  | 0.365                                  | 1                            | 0.868 (**)                     | 0.365      | -0.207   | 0.029                       | 0.304   | 0.139                          |
| b* (blue-yellow) after storage                      | 0.567 (**)                          | 0.836 (**)                | 0.931 (**)                  | 0.623 (**)                             | 0.868 (**)                   | 1                              | 0.190      | -0.069   | 0.283                       | 0.267   | 0.370                          |
| $\Delta E$  | 0.063                               | 0.332                     | 0.209                       | 0.061                                  | 0.365                        | 0.190                          | 1          | 0.015  | -0.060                      | 0.127   | -0.019                         |
| Fruit firmness (kgf/cm <sup>2</sup> ) at harvest    | 0.391                               | -0.211                    | 0.026                       | 0.335                                  | -0.207                       | -0.069                         | 0.015      | 1  | 0.592 (**)                  | 0.536 (*)   | 0.576 (**)                     |
| Fruit weight (g) at harvest                         | 0.519 (*)                           | 0.028                     | 0.329                       | 0.485 (*)                              | 0.029                        | 0.283                          | -0.060     | 0.592 (**)                                       | 1                           | -0.015  | 0.967 (**)                     |
| Fruit firmness (kgf/cm <sup>2</sup> ) after storage | 0.403                               | 0.300                     | 0.329                       | 0.350                                  | 0.304                        | 0.267                          | 0.127      | 0.536 (*)  | -0.015                      | 1   | 0.065                          |
| Fruit weight (g) after storage                      | 0.550 (**)                          | 0.141                     | 0.409                       | 0.516 (*)                              | 0.139                        | 0.370                          | -0.019     | 0.576 (**)                                       | 0.967 (**)                  | 0.065   | 1                              |

## CONCLUSIONS

'Premial' and 'Alba' cvs. (early season) were distinguished from all, as follows: 'Premial' cv. showed the lowest fruit weight loss (0.27 g) and the lowest fruit firmness loss (0.09 kgf/cm<sup>2</sup>) after storage period.

The highest percentage of marketable fruits after storage (86.4%) was recorded by 'Alba'.

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