Differences in Fruit Quality of Strawberry cv. Elsanta Depending on Cultivation System and Harvest Time

Sandra VOĆA [1](✉)
Nadica DOBRIČEVIĆ [1]
Martina SKENDROVIĆ BABOJELIĆ [2]
Jasmina DRUŽIĆ [2]
Boris DURALIJA [2]
Jasmina LEVAČIĆ [1]

Summary

The aim of this research was to determine differences in chemical composition of strawberry cv. Elsanta fruit in three different cultivation systems and at three harvest times. The cultivation systems were: open field, high tunnel and hydroponics, all located in the Zagreb area. The harvest times were: the beginning, the middle and the end of strawberry harvest season.

In the harvested fruit following parameters were determined: dry matter, total soluble solids (°Brix), total acid (TA), Brix/TA, pH, L-ascorbic acid, natural invert and total invert. There were significant differences between high tunnel, open field and hydroponics cultivation. Chemical parameters were somewhat highest for fruit grown in high tunnel, and only values of total invert were higher in open field at second and third harvest time. Based on statistical analysis fruit grown in high tunnel had good quality at all three harvest times.

Key words

Fragaria x ananassa Duch, cultivation system, chemical composition, harvest time

[1] University of Zagreb, Faculty of Agriculture,
Department of Agricultural Technology, Storage and Transport,
Svetosimunska 25, 10000 Zagreb, Croatia
✉ e-mail: svoca@agr.hr
[2] University of Zagreb, Faculty of Agriculture, Department of Pomology,
Svetosimunska 25, 10000 Zagreb, Croatia

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Introduction

Strawberries (*Fragaria* X *ananassa*) have unique, very pleasant taste and aroma, and are considered the most popular fruit. Research showed that there is considerably growing dissatisfaction with aroma and non-uniform quality of strawberry fruit. By the term quality we usually consider sensory attributes (colour, taste, smell, crispness), also nutritive characteristics (sugar/ acid ratio, quantity of soluble solids, vitamin C, total acids and anti-oxidative compounds) (Cordenunsi et al., 2003; Sturm et al., 2003).

Strawberry is a non-climacteric fruit and it must be harvested at full maturity to achieve the maximum quality in relation to flavor and color. The main changes in fruit composition which are usually associated with ripening, take place when the fruit is still attached to the mother plant. As a consequence, strawberries should be harvested when they are ready for consumption. This means there is a very short period when fruit is at its best quality (Cordenunsi et al., 2003*)*

Cultivar Elsanta has high content of total acids and low content of total sugars. For this reason it has low sugar/ acid ratio compared to other strawberry cultivars (Saied et al., 2005).

Many factors influence fruit quality. One of the main factors is cultivation system. Growing strawberries in high tunnels decreases dependence of fruit quality on climate conditions and soil. This cultivation system also enables better control of water relations, light and temperature. The difference is shown in quality between technological and full ripeness of some strawberry cultivars (Sturm et al., 2003).

One of the problems in open field strawberry cultivation is a very short harvest period. In selection of assortment and cultivation technology, harvest dynamics have very important role, because quality and quantity of yield depend on them. Besides cultivar and planting time, other factors have direct influence on harvest dynamics, for example: selection of mulch, air temperature and humidity at the maturation time, irrigation and plant protection. Because maturation dynamics and consequently harvest are under influence of numerous factors, there are significant differences between cultivation years (Stapleton et al., 2002).

The intention of this work was to test the hypothesis that at different harvest times and cultivation systems strawberry quality is changing, and according to this, some fruit will not be acceptable for consumption as fresh but should be transferred to processing. Therefore, with right selection of ripening stage for harvesting and cultivation system we can extend sale of fresh and high quality strawberries and also eliminate the most pronounced objection to the fresh strawberry sale, which is non-uniform quality.

Material and methods

In our research strawberry cv. Elsanta fruit was grown in the Zagreb area in three different cultivation systems: hydroponics, high tunnel and open field. Strawberries cultivated in open field and in high tunnel were grown in the same type of the soil (alluvium), with planting density of 40 000 plants/ha. High tunnels and hydroponics were covered with plastic folium, and hydroponics cultivation was in the plastic bags with the substrate characteristic for strawberry cultivation. Fertirigation system was in sync with cultivation systems. Experiment was set as random block design with three repetitions in each cultivation system. Repetitions comprised 50 plants each.

Fruit was harvested at the beginning, in the middle and in the end of strawberry harvest season, during May and June of 2005, for each cultivation system. For each harvest time there were three repetitions with 50 plants. Fruit was harvested in full maturity (full red color). From each repetition 500 g of fruit was taken by random choice.

In harvested fruit we determined the following quality parameters: dry matter, total acid, soluble solids, pH value, directly reducing sugars, vitamin C and soluble solids/acid ratio. Determination of total dry matter was conducted with etalonic method by drying at 105°C until constant mass (AOAC, 1995). Determination of total soluble solids was conducted by reading of soluble solids directly from the refractometer scale (AOAC, 1995). Determination of pH value was conducted using pH-meter, by immersing combined electrode in the homogenized sample and reading the values (AOAC, 1995). Determination of total acidity (percentage of citric acid) was based on potentiometric titration with the solution of sodium hydroxide. This method is used for determination of total acidity of fruits and vegetables and products of fruits and vegetables (AOAC, 1995). Determination of vitamin C (L-ascorbic acid) was conducted by titrimetric method with 2,6-p-dichlorphenolindophenol. Method is based on L-ascorbic acid oxidation by 2,6-p-dichlorphenolindophenol into dehydroascorbic acid, until color of reagent turns into colorless leucobasis, so at the same time it serves as indicator of this reaction. This method is used for determination of ascorbic acid in products of fruits and vegetables (AOAC, 2002). Determination of directly reducing sugars by Luff solution is based on the principal that in determined conditions reducing sugars (natural invert) convert $CuSO_4$ from the Luff solution into Cu_2O. Unspent amount of cupric ion is re-titrated with tyosulfate solution. From difference of consumption for blind trail and sample, quantity of sugars is read from the tables. Unreduced disaccharide (sucrose) first must be inverted (hydrolyzed) into reducing monosaccharides by acid, and then it is determined by Luff solution. This is how we get data on total amount of sugar in analyzed sample (total invert). Difference between obtained

Table 1.
Chemical composition of strawberry cv. Elsanta fruit from three different cultivation systems and at three harvest times.

Cultivation system	Harvest time	Dry matter (%)	Total acid (%)	Soluble solids (°Brix)	Soluble solids/ Total acidity	pH	Vitamin C (mg/100g)	Reducing sugars (%)	Sucrose (%)
Hydroponics	09.05.	7.02c ± 0.27	0.73b ± 0.03	5.17c ± 0.12	7.03a ± 0.09	3.63a ± 0.03	32.42c ± 0.71	2.31c ± 0.01	0,31a ± 0,49
	19.05.	6.65c ± 0.05	0.64b ± 0.01	4.20c ± 0.10	6.53c ± 0.20	3.72c ± 0.01	44.97c ± 0.47	3.61c ± 0.01	0,32c ± 0,12
	07.06.	7.59c±0.04	0.81a ± 0.04	6.00c ± 0.10	7.44c ± 0.11	3.55c ± 0.01	44.51b ± 0.01	3.00c ± 0.12	0,26c ± 0,12
High tunnel	24.05.	9.47a ± 0.02	0.89a ± 0.02	6.83a ± 0.31	7.70a ± 0.53	3.70a ± 0.07	67.37a ± 0.03	5.88a ± 0.12	0,72a ± 0,02
	02.06.	13.16a ± 0.09	0.81a ± 0.01	10.10a ± 0.10	12.46b ± 0.04	3.92a ± 0.01	83.07a ± 0.31	11.30a ± 0.53	0,97a ± 0,13
	10.06.	13.19a ± 0.03	0.71b ± 0.01	11.97a ± 0.06	16.83a ± 0.07	4.03a ± 0.01	64.54a ± 0.31	10.84a ± 1.40	0,74a ± 0,24
Open field	31.05.	8.51b ± 0.49	0.75b ± 0.02	6.03b ± 0.12	8.03a ± 0.12	3.65a ± 0.01	56.17b ± 3.81	5.31b ± 0.48	0,64b ± 0,12
	10.06.	8.49b ± 0.02	0.46c ± 0.003	6.03b ± 0.06	13.17a ± 0.11	3.82b ± 0.02	67.17b ± 0.25	5.72b ± 0.02	0,65b ± 0,02
	17.06.	12.09b ± 0.01	0.61c ± 0.003	10.03b ± 0.06	16.45b ± 0.17	3.81b ± 0.01	37.89c ± 0.18	7.50b ± 0.03	0,68b ± 0,02

Different letters within a column indicate significant differences at the 5% level by Duncan test.

total invert and natural invert gives quantity of reducing sugars developed by sucrose inversion (AOAC, 1995).

Obtained results are analyzed by SAS statistical program (SAS Institute, 1997).

Results and discussion

Obtained results of fruit chemical analysis are presented in Table 1.

Statistical analysis showed that there are significant differences in fruit quality between cultivation in high tunnel, in open field and in hydroponics. Quantity of dry matter had highest values in high tunnel cultivation system at all three harvest times, and ranged from 9.47 to 13.19 %. Lower values are noted in fruit form open field ranging from 8.49 % to 12.09 %, while the lowest values were noted in hydroponics ranging from 6.65 % to 7.59 %, which can be a consequence of earlier maturation of hydroponically grown fruit, while amount of sunny days was still not enough for satisfactory fruit development. Similarly total soluble solids of fruit were somewhat lower in hydroponics compared to the two other cultivation systems. The highest percentage of total acidity was noted in fruit grown in high tunnel, during all three harvest times. At the same time quantity of dry matter and soluble solids was the highest in high tunnel cultivation which resulted in good soluble solids/total acidity ratio. In hydroponics total acidity was relatively high compared to soluble solids, which resulted in lower soluble solids/total acidity ratio. Fruit from first harvest time in open field had somewhat higher acidity and lower soluble solids than in the second and third harvest time. Quantity of sucrose was also significantly lower in hydroponics in comparison to fruit grown in open field, and especially to fruit grown in high tunnel at second and third harvest. Ratio between soluble solids and total acidity was somewhat unfavorable in hydroponics, especially at harvest time two and three, while this ratio in fruit from open field and high tunnel was satisfying. The highest values of vitamin C were noted in fruit grown in high tunnel and ranged from 64.54 mg/100g to 83.07 mg/100g fresh mass. Quantity of vitamin C was somewhat lower in fruit grown in open field, while values of vitamin C of fruit grown in hydroponics was the lowest and ranged from 32.42 mg/100g to 44.97 mg/100g fresh mass. Generally chemical parameters showed highest values in fruit grown in high tunnel.

Table 2. Sum of average day temperature (°C) and sum of sunny hours (h) in May and June 2005.

Month	Decade	Sum of average day temperature (°C)	Sum of sunny hours (h)
May	1	140.1	59,1
	2	146.5	76,3
	3	224.2	122,9
	Average	20,4	258.3
June	1	155.8	71,6
	2	206.1	106,9
	3	235.1	108,2
	Average	23,5	286.7

Obtained results can be explained by climatic conditions. Fruit grown in hydroponics was harvested in May when quantity of sunny hours was lower than at the time when fruit from high tunnel and open field were harvested (Table 2). The average day temperature in May was 20.4 °C, and in June 23.5 °C (Table 2). At the same time sum of sunny hours was 258.3 h in May and 286.7 h in June. Statistical data showed that fruit grown in high tunnel had good quality at all three harvest times. Our results are consistent with work of other researchers (Sturm et al., 2003; Cordenunsi et al., 2005; Saied et al., 2005).

Conclusion

Considering obtained data, we can conclude that cultivation in all three systems showed good fruit quality. Strawberry fruit grown in high tunnels had somewhat better values of the examined parameters. We determined that throughout all three harvest times, we obtained fruit of uniform quality in the high tunnel system. With this research we confirmed precedence of closed cultivation systems, and precedence is in possibility of water relations, light and temperature control.

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