Influence of Cultivation Systems on Physical and Chemical Composition of Strawberry Fruits cv. Elsanta

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

Summary

The aim of this research was to determine differences in physical and chemical composition of strawberry fruits cv. Elsanta, grown in three different cultivation systems, open field, high tunnel and soilless culture. Experiment was conducted in Zagreb area. Fruits were harvested at the same time in all three cultivation systems, after which physical and chemical parameters were determined. Obtained data showed that fruits grown in open field had the lowest fruit mass (17.0 g) compared to the ones grown in high tunnel (20.0 g) and soilless (21.0 g), however fruits grown in field had the highest fruit firmness (0.76 kg cm^{-2}). Values obtained by color analysis for light (L) ranged from 37.52 for fruits in soilless cultivation to 41.94 for fruits grown in open field. Intensity (C) ranged from 24.71 in soilless to 31.65 in open field and values obtained for angle of coloring (H) ranged from 47.44 in high tunnel to 54.77 in soilless culture.

Values obtained for ^{0}Brix ranged from 6.23 in soilless to 7.25 in high tunnel cultivation system. Total acidity (TA) was 7.35 g L^{-1} in soilless cultivation, while it was somewhat higher in fruits grown on open field (7.39 g L^{-1}) and in high tunnel (7.64g L^{-1}). Ratio ^{0}Brix/TA was aligned in fruits cultivated in soilless culture and open field (0.85), while it was somewhat higher in the ones grown in high tunnel (0.95). Quantity of ascorbic acid (AA) ranged from 58.32 mg/100g in soilless culture to 68.58 mg/100 g in high tunnel. Values of pH ranged from 3.70 on open field to 3.91 in soilless culture. Physical and chemical analysis showed alignment in fruit quality cultivated in three different systems; however fruits grown in high tunnel showed slightly better properties.

Key words

Fragaria x *ananassa* Duch; high tunnel; soilless culture; field; physical-chemical composition

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

Received: May 15, 2006 | Accepted: September 15, 2006

Introduction

Strawberries (*Fragaria x ananassa* Duch.) have unique, highly desirable taste and flavour and are one of the most popular summer fruits. Consumers mainly purchase strawberries for an enjoyable eating experience. Media reports have indicated increasing consumer dissatisfaction with the flavour and inconsistent quality of strawberries (Sturm et al., 2003). The components of quality can be sensory and nutritional. Implicit in the use of single and multiple physical or chemical characteristics to determine optimum maturity is that changes in the selected parameter correlate with the attainment of the general composite of quality characteristics of the product (Kays, 1991; Sturm et al., 2003).

Strawberries are a good source of ascorbic acid (vitamin C; AA) which is a very important nutrient, being essential, e.g. for the synthesis of collagen. Ascorbic acid is also a natural antioxidant used in foodstuff formulations in order to prevent browning, discolouring and to enhance shelf life (Castro et al., 2004). Many authors have found a very poor correlation value for total soluble solids (TSS) and total sugars, titratable acid (TA) and total organic acids, therefore those parameters are not good enough for the evaluation of strawberry quality. The use of TSS and TA should be limited to comparative studies in which variations by genotype and environment are low. Of the many factors that can affect the taste quality of a product, ripeness, maturity, cultivar, irrigation, and fertilisation are especially important (Kays, 1991; Sturm et al., 2003). The cultivation of strawberries in plastic tunnels decreased the dependency of the yield quality and quantity on the climatic and soil conditions. Furthermore, it increasingly equalised the conditions during the ripening time due to better control of water regime, sunlight, and temperature. Harvesting at the proper stage of maturity is essential for optimum quality and often for the maintenance of this quality after harvest (Sturm et al., 2003).

Strawberry is non-climacteric fruit and it must be harvested at full maturity to achieve the maximum quality in relation to flavour and colour. The main changes in fruit composition, which are usually associated with ripening, take place when the fruit is still attached to the mother plant. Consequently, strawberries should be harvested ready for consumption. This means there is very short period of fruit at its best quality (Manning, 1996; Cordenunsi et al., 2003).

Materials and methods

Strawberry fruit (*Fragaria x ananassas* Duch., cv. Elsanta) was grown as soilless culture, in high tunnel and in field at Sveta Nedjelja near Zagreb. Researched fruits were grown in conventional way. Samples were harvested in optimal harvest time for each cultivation system. Harvested fruits were delivered to laboratory. Fruit samples were analysed initially after harvest. In laboratory physical parameters were determined (mass, firmness and colour) and after that fruits were blended into mash from which chemical parameters were determined. Three replicates were used per analyse.

Analysed for external skin colour (opposite sides) and internal flesh colour were measured using a ColourTec colourimeter and expressed as L, a, b, C, H, colour values CIE *L a b* mode under CIE Standard Illuminant C. L defines the lightness, and a and b define the red-greenness and blue-yellowness, respectively. Hue angle (H) was calculated as H = arc tan b/a (deg).

Total soluble solids (TSS) expressed as ^{0}Brix, were measured with an Abbe refractometer (A. Krüss, Germany) calibrated against sucrose. Titritable acidity (TA) was measured according to AOAC method 942.15 (1995) and expressed as g L^{-1} citric acid. pH was measured with a pH metar (Mettler- toledo, Switzerland). Ascorbic acid (AA) was determined using 2.6-Dichloroindophenol Titrimetric methode according to AOAC method 967.21 (2002) and expressed as mg $100g^{-1}$ fresh weight (f.w.). Firmness was measured with a penetrometer (Effegi FT 327), using an 8-mm tip and expressed as kg cm^{-2}. Sample mass was determined by weighing them on Sartorius scales (d=0.1g).

Statistical analysis

Data were analysed using the statistical Analysis System (SAS, version 8.0, SAS Institute Inc. Cary, NC, USA). Analyses of variance were performed by the ANOVA procedure. Each value is the mean ± SD of three determinations (replicates). Mean values were considered significantly different when $p \leq 0.05$.

Results and discussion

Results of physical and chemical analysis in fruit samples of strawberry cv. Elsanta grown in three different systems are shown in Table 1-3.

Results of chemical analysis of fruits cv. Elsanta grown in three different systems are shown in Table 1. Based on obtained data highest values for soluble solids were determined in fruits grown in high tunnel (7.25^{0}Brix), while somewhat lower values were noted in fruits grown in open field (6.27 ^{0}Brix) and in soilless culture (6.23 ^{0}Brix). At the same time, values for total acidity were also higher in fruits grown in high tunnel (7.64 g L^{-1}) compared to fruits grown on open field (7.39 g L^{-1}) and soilless (7.35 g L^{-1}). For this reason the best soluble solids/total acidity (^{0}Brix/TA) ratio was obtained in high tunnel (0.95)

Table 1.
The chemical content of strawberry fruit cv. Elsanta grown in three different systems

Cultivation system	°Brix	Total acidity (g L^{-1})	°Brix/Total acidity	Ascorbic acid (mg/100g f.w.)	pH
High tunnel	7.25a±0.25	7.64a±0.04	0.95a±0.04	68.58a±0.24	3.80b±0.01
Soilless	6.23b±0.25	7.35b±0.05	0.85b±0.04	58.32c±0.02	3.91a±0.01
Open field	6.27b±0.25	7.39b±0.02	0.85b±0.03	64.41b±0.56	3.70c±0.01

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

Table 2.
Colour of strawberry fruit cv. Elsanta grown in three different systems

Cultivation system	L	a	b	C	H
High tunnel	38.70b±0.07	20.03a±0.88	22.85a±0.72	30.76a±0.95	47.44b±1.17
Soilless	37.52b±0.20	13.29c±0.72	19.96b±0.40	24.71b±1.18	54.77a±1.25
Field	41.94a±0.88	17.89b±0.74	25.91a±0.62	31.65a±0.90	54.67a±1.93

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

cultivation system, while ^{0}Brix/TA ratio in other two cultivation systems had identical value 0.85. Values for ascorbic acid ranged from 58.32 mg/100g f.w. for fruits grown in soilless cultivation system, 64.41 mg/100g f.w. for fruits grown in open field, to 68.58 mg/100g f.w. for fruits grown in high tunnel. Chemical parameters showed somewhat higher values in fruits grown in high tunnels, and only pH value was higher in soilless cultivation system. Based on chemical analysis results strawberry fruits grown in high tunnels attained the highest quality, this is consistent with the previous investigations of other researches (Sturm et al., 2003; Cordenunsi, et al. 2005; Saied, et al., 2005). Statistical analysis showed significant difference among high tunnels, open field and soilless, while at the same time there are no significant differences between fruits grown in field and in soilless except in ascorbic acid content and in pH values, where significant differences between all three cultivation systems are noted.

Significant differences were determined based on data for fruit color. L-values from fruits grown in the field (41.94) were higher than two other cultivations (soilless 37.52; high tunnel 38.70), between which there was no significant difference. Chroma (C) did not show significant difference between fruits grown in field (31.65) and high tunnel (30.76), while somewhat lower value was noted in fruits grown in soilless system (24.71). Hue value (H) was somewhat higher in soilless system (54.77) than in high tunnel (47.44) and in open field (54.67), where no significant difference was noted.

Obtained data for fruit mass and firmness of fruits grown in three different cultivation systems are presented in Table 3. There are significant differences between fruits grown in field and two other cultivation systems between which there is no significant difference. Mass is somewhat higher for fruits grown soilless (21.0 g) and in high tunnel (20.0 g) compared to field (17.0 g). Noted values for fruit firmness show significant differences in firmness of fruits grown soilless (0.64 kg cm^{-2}) compared to fruits grown in field (0.76 kg cm^{-2}) and in high tunnel (0.74 kg cm^{-2}); that is fruits grown in field and in high tunnel had higher fruit firmness than fruits in soilless production system.

Table 3.
The physical parameters of strawberry fruit cv. Elsanta grown in three different systems

Cultivation system	Mass (g)	Firmness (kg/cm^2)
High tunnel	20.0a±0.15	0.74a±0.12
Soilless	21.0a±0.16	0.64b±0.11
Field	17.0b±0.15	0.76a±0.10

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

Obtained data showed that cultivation in all three systems produces fruits of good quality, however based on chemical and physical analysis fruits grown in high tunnel system showed somewhat better results. Advantage of protected cultivation systems is in ability of control of water relations, sunlight and temperature.

Conclusion

We can conclude that difference in cultivation systems had a great influence on fruit colour and firmness. Due to higher temperatures in soilless and in high tunnel cultures better fruit colouring was obtained. Also it was interesting to notice that the lowest firmness was attained in soilless system. Further research on this subject is needed.

References

AOAC. (1995.). Official methods of analysis (16th ed.). Washington, DC: Association of Official Analytical Chemists.

AOAC. (2002.). Official methods of analysis (17th ed.). Washington, DC: Association of Official Analytical Chemists.

Castro I., Teixeira J. A., Salengke S., Sastry S. K., Vicente A. A. (2004). Ohmic heating of strawberry products: electrical conductivity measurements and ascorbic acid degradation kinetics. Innov. Food Sci. Emerg. Tech. 5: 27-36

Cordenunsi B. R., Nascimento J. R. O., Lajolo F. M. (2003). Physico-chemical changes related to quality of five strawberry fruit cultivars during cool-storage. Food Chem. 83: 167-173

Cordenunsi, B. R., Genovese, M. I., Nascimento, J. R. O., Hassimotto, N. M. A., Santos, R. J. Lajolo, F. M. (2005). Effects of temperature on the chemical composition and antioxidant activity of three strawberry cultivars. Food Chem. 91: 113-121

Kays S. J. (1991). Postharvest physiology of perishable plant products. AVI, New York

Manning K. (1996). Soft fruits. In G. B. Seymour, J. E. Taylor, & G. A. Tucker (Eds.), Biochemistry of fruit ripening, Chapman&Hall London: 347-373

SAS Institute (1990). SAS/STAT User›s Guide, version 8 edition. Vol. 2. SAS Institute, Cary, NC., USA.

Saied A. S., Keutgen A. J., Noga G. (2005). The influence of NaCl salinity on growth, yield and fruit quality of strawberry csv. "Elsanta" and "Korona". Sci. Hort. 103: 289-303

Sturm K., Koron D., Stampar F. (2003). The composition of fruit of different strawberry varieties depending on maturity stage. Food Chem. 83: 417-422

acs71_27