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Quality evaluation of strawberries grown in the region of Lavras, Minas Gerais State

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ABSTRACT. The study determined the quality parameters of three cultivars of strawberries, aiming to provide support to the producers as to the choice of the best cultivar at planting time. The studied parameters were: physical characterization, mass loss, pH, soluble solids, titratable acidity, total, reducing and non-reducing sugars and vitamin C. Fruit of the cv. Oso-Grande presented higher values of pH and mass loss and lower values of titratable acidity, soluble solids, total and reducing sugars and vitamin C, presenting a good quality and can thus be used by producers.

Keywords: storage, strawberry, postharvest.

Avaliação da qualidade de morangos cultivados na região de Lavras, Estado de Minas Gerais

RESUMO. O trabalho determinou parâmetros de qualidade de morangos de três cultivares, com o objetivo de dar suporte aos produtores na escolha da melhor cultivar na hora do plantio. Os parâmetros estudados foram: caracterização física, perda de massa, pH, sólidos solúveis, acidez titulável, açúcares totais, redutores e não-redutores e vitamina C. Concluiu-se que os frutos da cv. Oso-Grande apresentaram maiores pH e perda de massa e menores acidez titulável, sólidos solúveis, açúcares totais e redutores e vitamina C, apresentando boa qualidade, podendo ser utilizada pelos produtores.

Palavras-chave: armazenamento, morango, pós-colheita.

Introduction

The change of the eating habits of modern society leads consumers to constantly seek to products with quality and convenience, such as: appearance, flavor, aroma and texture; nutritional value, based on caloric, protein, mineral, vitamin and fiber level values and the presence or absence of cholesterol and even safety, related to toxic natural and/or added compounds and microbiological, which can compromise consumer health (VILAS BOAS, 2003; VILAS BOAS et al., 2004).

Currently, the expectation regarding food has undergone a series of modifications. Those that were used at first, fundamentally for survival, as a function of their nutritional composition, are consumed today according to a broad concept of quality, besides possible convenience at preparation and/or consumption time and economical value (NUNES, 2004).

In cultivars destined for processing, the quality refers to good flavor. This means pleasant combinations of flavor and texture, flavor resulting from taste and sense of smell and the texture perceived orally. The appearance refers to the visible attributes of the product, including color, shape and size. The objective during storage is to maintain the product with harvest-time quality as long as possible. In Lavras, Minas Gerais State, the strawberry crop is being implemented. As there are many cultivars, the present study examined some quality parameters of three cultivars, in order to provide subsidies to producers in the choice of cultivar for fresh and semi-processed consumption.

Material and methods

Raw material

The strawberry cultivars Oso-Grande, Toyorrinho and Tudla came from a commercial orchard in the region of Itutinga, Minas Gerais State, at 910 m of altitude, and at the geographical coordinates of 21°18'45" S and 44°41'15" W. Gr. (IBGE, 1959).

Three-hundred fruit were picked out and taken to the Biochemistry Laboratory of the Chemistry Department of UFLA, in Lavras, Minas Gerais State, where 80 of each cultivar were selected as to size, maturity stage and absence of physiological disorders or diseases.

Experimental design

The design was completely randomized (CRD), the treatments were arranged into a factorial scheme (3 x 2), being 3 cultivars and 2 analyses days, corresponding to days 0 and 5, with 4 repetitions of 10 fruits for each treatment.

Sample preparation and experimental setup

After selecting 80 fruit of each cultivar, they were divided into 2 groups:

- 1st group: 40 fruit of each cultivar, for the analyses at the harvest;
- 2nd group: 40 fruit of each cultivar were stored on a bench in the UFLA Biochemistry Laboratory, at room temperature (17°C and 69% (RH), for five days.

Statistical analysis

The results were subjected to analysis of variance, using the software SISVAR (FERREIRA, 2003) and, when significant, the mean values were compared by the Tukey's test to 5% of probability.

Physical analysis

The physical characterization of the fruit was carried out through evaluations of the weight (g), obtained on semi-analytical scale, length and diameter (mm), measured with a caliper. The mass loss was determined by the difference in fruit mass at the moment of the experiment installation (day zero) and on the fifth day, expressed as percentage of mass loss, with reference to the initial value. For this experiment, a Precision semi-analytical M/NUCLEO scale, model PR1000 was used.

Chemical analysis

The pH and the total soluble solids were determined according to the AOAC (2005) technique. The titratable acidity was determined according to the Instituto Adolfo Lutz (IAL, 1985) technique. The total and reducing sugars were extracted by the Lane-Enyon method, mentioned by AOAC (2005) and levels determined according to the Somogyi technique adapted by Nelson (1944), mentioned by Oliveira et al. (2006), with readings performed with the aid of a computerized spectrophotometer Varian Cary model 50. The ascorbic acid content was extracted and determined by the colorimetric method according to the Strohecker and Henning (1967) technique, described by Corrêa et al. (2004), readings were performed in spectrophotometer with computerized system, Varian Cary model 50.

Results and discussion

Physical characterization

Fruit of the Tudlla cultivar have obtained the highest value in length (52.04 mm), followed by the cultivars Oso-Grande and Toyorrinho (Table 1). Fruit of cultivar Toyorrinho presented a larger diameter, followed by the cultivars Tudlla and Oso-Grande, although the cultivar Tudlla has not presented the largest diameter, the difference in relation to Toyorrinho is little, which was not observed for the length, where the difference between the two cultivars was 10 mm. This result showed that the fruit of Tudlla cultivar are larger in size and can vary according to cultivar, planting site, fertilization, etc.

Table 1. Mean lengths and diameters of strawberry of three cultivars from the region of Lavras, Minas Gerais State.

Cultivar	Length (mm)	Diameter (mm)
Oso-Grande	44.65 B	29.54 C
Tudlla	52.04 A	31.08 B
Toyorrinho	42.59 C	32.08 A

Mean values followed by different letters are significantly different by Tukey's test at 5% probability.

Villela Júnior et al. (2004) presented data relative to the average length and diameter of Campinas and Sweet Charlie strawberry cultivars, ranging from 29.73 to 33.92 mm length and 24.03 to 31.73 mm diameter. The mean values of length in the present study are higher than found by Villela Júnior et al. (2004), varying from 42.59 to 52.04 mm, but the cultivars are different. However, the diameter values are quite similar, varying from 29.54 to 32.08 mm.

Mass loss

The mass loss values of the cultivars studied are listed in the Table 2, which were higher in the Oso-Grande cultivar (21%) followed by 'Tudlla' (17.81%) and 'Toyorrinho' (16.70%).

The mass loss is related to the loss of water as water vapor, which is one of the main causes of deterioration, resulting not only in quantitative losses but also in the appearance (causing shriveling and wrinkling in the fruit), textural qualities (causing softening, loss of coolness and succulency) and in the nutritional quality (KADER, 2002).

Mass losses between 3% and 6% are enough to cause reduction in the quality of many products, while others, even losing 10% or more of moisture, are still marketed (CHITARRA; CHITARRA, 2005).

Fruit of the three cultivars after 5 days of storage, even having lost on average 18% moisture, were still appropriate for consumption.

Table 2. Mass loss (%) in strawberry of three cultivars stored at room temperature for five days.

Cultivar / Days	Oso - Grande	Tudlla	Toyorrinho
0	0	0	0
5	21.00 a	17.81 b	16.70 c

Mean values followed by different letters are significantly different by Tukey's test at 5% probability.

In an experiment using modified atmosphere in the conservation of postharvest 'Oso-Grande'strawberries, Calegaro et al. (2002) found mass loss values of 17.1%, after 7 days of storage at room temperature. The average mass loss of this work is superior, varying from 16 to 21%, after 5 days at room temperature. This can be because the present experiment had not used a modified atmosphere, therefore the fruit lost more water, and also due to the temperature and the humidity of the storage atmospheres.

The Toyorrinho cultivar presented the lowest mass loss in relation to the other cultivars.

pH and titratable acidity

For the pH, there was no significance for the interaction between the studied factors ($p < 0.01$), however, the cultivars and the storage days were significant (Table 3).

The determination of the pH of the fruit is important for defining the manner of use of the cultivar. The acidic pH (lower than 3.5) is a property of strawberries for industrial use and the consumer market for fresh fruit prefers slightly acidic strawberries. The pH characteristic makes difficult the development of dual purpose cultivars, since the requirements for industrial use and fresh consumption are opposite.

The strawberries of the cv. Oso-Grande presented a higher pH value followed by 'Toyorrinho' and 'Tudlla' (Table 3), all are within the pH range for the fresh fruit market.

Table 3. Mean levels of titratable acidity (mg citric acid/100 g pulp) and mean values of pH of strawberry of three cultivars.

Cultivar	Titratable acidity	pH
Oso Grande	0.73 B	3.81 A
Tudlla	1.10 A	3.61 C
Toyorrinho	1.02 A	3.73 B
0 day	0.99 A	3.51 B

Mean values followed by different letters are significantly different by Tukey's test at 5% probability.

Silva et al. (2011) have evaluated the quality of Oso-grande strawberries treated with 1-methylcyclopropene and found pH values varying from 3.73 to 3.80, for the treated fruit and from 3.73 to 3.86 for the control fruit, on days 0 and 6, respectively, stored at room temperature. Fruit of the mentioned experiment presented a pH variation similar to that observed in this study, which was 3.51, on day 0 and 3.93, on day 5, independent of cultivar.

During storage, the tendency of the pH was to increase for the three cultivars studied. That might have occurred because the organic acids were being used in the respiratory metabolism of fruit.

Silva et al. (2011) also observed that with the ripening of fruit, the pH value increased from the 6th storage day onwards. Fruit of the cv. Oso-Grande presented an increase in the pH from 3.63 to 4.01, followed by 'Toyorrinho' (3.49 to 3.95) and 'Tudlla' (3.42 to 3.81).

Conti et al. (2002), studying the production and the quality of strawberry in assays conducted in Atibaia and Piracicaba, found pH values of the order of 3.77, for the cv. Campinas; 3.66 for the cv. Dover; 3.58 for the cv. Guarani; 3.84 for the cv. Princess Isabel and 3.77 for the cv. AGF 080, on the harvest day. These values are higher than those of this work, which were 3.42 for the cv. Tudlla; 3.48 for cv. Toyorrinho and 3.63, for cv. Oso-Grande, on the harvest day. This can be due to different cultivars.

The titratable acidity (TA) was significantly affected by the cultivar and the storage duration, without a significant interaction between these two factors ($p < 0.01$). The strawberries of the cultivars Tudlla and Toyorrinho presented mean levels of titratable acidity higher than that of the cv. Oso-Grande, coinciding with the lowest pH (Table 3).

It is expected a reduction in the acidity during the ripening, therefore the organic acids are used in the fruit metabolism, being converted into sugars or serving as substratum for the respiration process (CHITARRA; CHITARRA, 2005). During the storage there was a decrease in the titratable acidity, for all analyzed cultivars, coinciding with the pH increase, during the storage period. The values obtained for the titratable acidity, between 0.73 and 1.10 mg 100 g^{-1} are inferior to those described in the literature by Françoso et al. (2008), between 1.14 and 1.68 mg 100 g^{-1}. However, the discrepancies observed can be associated with differences among cultivars and different treatments (control and irradiated with doses of 0.5, 1.0, 1.5 and 2.0 kGy).

Vieites et al. (2006) examined the preservation of strawberries stored under modified atmosphere, and verified a reduction in the titratable acidity levels during the storage for the control fruit, this value being 0.81 for day 0 and 0.78 mg of acid 100 g^{-1} for the 12nd day.

Soluble solids

The soluble solid levels are used as indicative of maturity and also determine the fruit quality,

playing an important role in the flavor. The soluble solids represent the content of soluble sugars, organic acids and other minor constituents (CHITARRA; CHITARRRA, 2005).

The statistical analysis evidenced significant differences for the cultivar and storage days. There was no significant interaction between these two factors ($p < 0.01$). The strawberries of the cv. Toyorrinho presented higher soluble solid levels (11.13 ºBx), followed by 'Tudlla' (10.06 ºBx) and 'Oso-Grande' (9.84 ºBx) (Table 4).

The levels of soluble solids increased during storage as a consequence of the transformation of the fruit reserves into soluble sugars, as well as due to the loss of pulp water vapor by transpiration, leading to a higher concentration (higher level) of those solids.

Table 4. Mean levels of reducing sugars (mg glucose 100 g pulp^{-1}) and soluble solids (°Bx) in strawberry of three cultivars.

Cultivar	Soluble solids
Oso-Grande	9.84 B
Tudlla	10.06 B
Toyorrinho	11.13 A
0 Day	9.31 B

Mean values followed by different letters are significantly different by Tukey's test at 5% probability.

Silva et al. (2011) analyzed the quality of Oso-grande strawberries treated with 1-methyl-cyclopropene, found soluble solid level values varying from 7.5 to 9.3 °Bx, for the treated fruit and from 7.5 to 10.5 °Bx for the control fruit, on days 0 and 6, respectively, stored at room temperature. The mean values observed herein were higher, ranging from 9.31 °Bx to 11.38 °Bx, after 5 days at room temperature. This result can be due to different cultivars. Silva et al. (2011) also observed that during the fruit ripening the soluble solid level values have increased, starting from the first day of storage.

Total, reducing and non-reducing sugars

The cultivar and days of storage factors were significant for the total, reducing and non-reducing sugar variables, without significant interaction between these two factors for the reducing sugars variable.

The strawberries of the three cultivars have not presented significant differences in the total sugars on the harvest day. However, at the end of storage, the cultivar Toyorrinho presented higher levels of that sugar compared with the other cultivars (Table 5), coinciding with the highest soluble solids level (Table 4).

The total soluble sugars present in the fruit are carbohydrates of low molecular weight, responsible for the sweetness, flavor and aroma, the attractive color and the texture. These constitute most of the soluble solids of the strawberries and come mainly in the form of glucose and fructose (4.5%) and sucrose (0.9%) (CHITARRA; CHITARRA, 2005).

Oliveira et al. (2005) reported that sugar levels usually increase with the fruit ripening, through biosynthesis processes or by polysaccharide degradation. The variations within a same species are due to several factors, such as cultivar, soil type, climatic conditions and cultivation practices. The mean sugar values in this work have increased during storage. This behavior is in agreement with that observed for the soluble solids, once the values have increased during the 5 days of storage.

Table 5. Mean levels of total sugars (mg glucose 100 mg pulp^{-1}) in strawberry of three cultivars stored at room temperature for five days under ambient conditions.

Cultivar / Days	Oso -Grande	Tudlla	Toyorrinho
0	4.54 aB	4.84 aA	4.85 aB
5	5.28 bA	4.82 bA	6.00 aA

Mean values followed by different lowercase in the rows and uppercases in the columns are significantly different by Tukey's test at 5% probability.

In an experiment with strawberries, Silva et al. (2011) found total sugar values varying from 3.3 to 6.2%, for treated fruit and from 4.09 to 7.2% for control fruit, on days 0 and 6, respectively, stored at room temperature. Those fruits presented a total sugar variation similar to that observed in this study, from 4.54 to 4.85%, on day 0 at room temperature. The increase of total sugars by the 5th day can be due to the loss of water by the fruit.

The strawberries of the cv. Toyorrinho presented a higher level of reducing sugars, followed by 'Tudlla" and 'Oso-Grande' (Table 7).

There was an increase in the levels of reducing sugars, during the 5 storage days. This significant increase can be related to the fruit water loss during storage, which might have contributed to the increase of sugar concentrations, as well as non-reducing sugar degradation (Table 6).

The accumulation of reducing sugars was also observed in pineapple of the cv. Smooth Cayenne L (THÉ et al., 2001) and in 'Diamante' peach (*Prunus persia* (L) Batsch) (OLIVEIRA et al., 2005).

Strawberries of the cv. Toyorrinho presented a higher mean level of non-reducing sugars, followed by 'Oso-Grande' and 'Tudlla'.

The levels of non-reducing sugar have decreased during the 5 storage days for the studied cultivars except for the cultivar Toyorrinho (Table 6). This result pointed out that cultivar was still undergoing sucrose synthesis in storage (Table 7).

Table 6. Mean levels of non-reducing sugars (mg glucose 100 mg pulp^{-1}) in strawberry of three cultivars stored at room temperature for five days, under ambient conditions.

Cultivar / Days	Oso -Grande	Tudlla	Toyorrinho
0	1.43 aA	1.40 bA	1.04 cB
5	0.61 bB	0.49 cB	1.81 aA

Mean values followed by different lowercase in the rows and uppercases in the columns are significantly different by Tukey's test at 5% probability.

Table 7. Mean levels of reducing sugars (mg glucose 100 mg pulp^{-1}) in strawberry of three cultivars stored at room temperature for five days, under ambient conditions.

Cultivar	Means
Oso-Grande	3.80 B
Tudlla	3.88 AB
Toyorrinho	4.24 A
0 Day	3.59 B

Mean values followed by different letters are significantly different by Tukey's test at 5% probability.

Vitamin C

A significant effect of the cultivar and the storage time was detected for the vitamin C, but no significant interaction between these two factors was registered ($p < 0.01$). The cv. Toyorrinho has obtained the highest value of ascorbic acid in comparison with other cultivars studied (Table 8).

Table 8. Mean levels of vitamin C (mg ascorbic acid 100 g acid pulp^{-1}) in strawberry of three cultivars.

Cultivar	Means
Oso-Grande	46.88 B
Tudlla	44.13 B
Toyorrinho	52.746 A
0 Day	43.22 B

Averages followed by different letters differ by the Tukey test at 5% probability.

The vitamin C level was higher on the 5th day of storage. The natural vitamin C content of several fruit depends on many factors, including variety, maturity stage, cultivation conditions and harvest time. Also, the postharvest duration and storage conditions can influence the content of this constituent in a decisive way.

In an experiment with strawberries of the cv. Oso-Grande stored under modified atmosphere for 12 days, Vieites et al. (2006) found vitamin C levels from 44.6 mg 100 g^{-1}, on the harvest day to 49.4 mg 100 g^{-1}, on the 12nd day, for the control fruit.

Malgarim et al. (2006), studying harvest and storage systems and conditions on the quality of strawberries of the cv. Camarosa, and registered 54.47 mg of ascorbic acid in 100 g of pulp on the harvest day.

The cv. Oso-Grande strawberries after 7 storage days presented 57.0 mg of ascorbic acid in 100g of fruit pulp, for control fruit (CALEGARO et al., 2002).

Conclusion

The cultivar Toyorrinho presented the best results for the quality parameters studied, nevertheless the other cultivars were also within the standards required for fresh consumption.

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References

AOAC-Association of Official Analytical Chemists. **Official methods of analysis of the association of official agriculture chemistry**. 18th ed. Mayland: AOAC, 2005.

CALEGARO, J. M.; PEZZI, E.; BENDER, R. J. Utilização de atmosfera modificada na conservação de morangos em pós-colheita. **Pesquisa Agropecuária Brasileira**, v. 37, n. 8, p. 1049-1055, 2002.

CHITARRA, M. I. F.; CHITARRA, A. B. **Pós-colheita de frutos e hortaliças**: fisiologia e manuseio. 2. ed. rev. e ampl. Lavras: UFLA, 2005.

CONTI, J. H.; MINAMI, K.; TAVARES, F. C. A. Produção e qualidade de frutos de morango em ensaios conduzidos em Atibaia e Piracicaba. **Horticultura Brasileira**, v. 20, n. 1, p. 10-17, 2002.

CORRÊA, A. D.; SANTOS, S. R.; ABREU, C. M. P.; JOKL, L.; SANTOS, C. D. Remoção de polifenóis da farinha de folhas de mandioca. **Ciência e Tecnologia de Alimentos**, v. 24, n. 2, p. 159-164, 2004.

FERREIRA, D. F. **SISVAR**. Sistema de análise de variância, versão 4. 6. Lavras: Dex/UFLA, 2003.

FRANÇOSO, I. L. T.; COUTO, M. A. L.; CANNIATTI-BRAZACA, S. G.; ARTHUR, V. Alterações físico-químicas em morangos (*Fragaria anassa* Duch.) irradiados e armazenados. **Ciência e Tecnologia de Alimentos**, v. 28, n. 3, p. 614-619, 2008.

IBGE-Instituto Brasileiro de Geografia e Estatítica. **Enciclopédia dos municípios brasileiros**. Rio de Janeiro: IBGE, 1959.

IAL-Instituto Adolfo Lutz. **Normas analíticas, métodos químicos e físicos para a análise de alimentos**. 3. ed. São Paulo: IAL, 1985. v. 1.

KADER, A. A. **Postharvest technology of horticultural crops**. 3rd ed. California: University of California, 2002.

MALGARIM, M. B.; CANTILLANO, R. F. F.; COUTINHO, E. F. Sistemas e condições de colheita e armazenamento na qualidade de morangos cv. Camarosa. **Revista Brasileira de Fruticultura**, v. 28, n. 2, p. 185-189, 2006.

NELSON, N. A. A photometric adaptation of Somogy method for the determination of glucose. **The Journal of Biological Chemistry**, v. 135, n. 1, p. 136-175, 1944.

NUNES, E. E. **Conservação de mandioquinha-salsa minimamente processada**. Lavras: UFLA/Faepe, 2004.

OLIVEIRA, S. M. A.; TERAO, D.; DANTAS, S. A. F.; TAVARES, S. C. C. H. **Patologia pós-colheita**: frutas, olerícolas e ornamentais tropicais. Brasília: Embrapa Informação Tecnológica, 2006.

OLIVEIRA, F. E. R.; ABREU, C. M. P.; ASMAR, S. A.; CORRÊA, A. D.; SANTOS, C. D. Firmeza de pêssegos 'diamante' tratados com 1-MCP. **Revista Brasileira de Fruticultura**, v. 27, n. 3, p. 366-368, 2005.

SILVA, P. A.; ABREU, C. M. P.; QUEIROZ, E. R.; CORRÊA, A. D.; SANTOS, C. D. Avaliação da qualidade de morangos 'Oso-Grande' submetidos ao 1-metilciclopropeno. **Revista Brasileira de Armazenamento**, v. 36, n. 1, p. 13-21, 2011.

STROHECKER, R.; HENNING, H. M. **Analisis de vitaminas**: metodos comprobados. Madrid: Paz Montalvo, 1967.

THÉ, P. M.; CARVALHO, V. D.; ABREU, C. M. P.; NUNES, R. P.; PINTO, N. A. V. D. Modificações na atividade enzimática em abacaxi 'Smooth Cayenne' em função da temperatura de armazenamento e do tecido de maturação. **Ciência e Agrotecnologia**, v. 25, n. 2, p. 364-370, 2001.

VIEITES, R. L.; EVANGELISTA, R. M.; SILVA, C. S.; MARTINS, M. L. Conservação do morango armazenado em atmosfera modificada. **Semina: Ciências Agrárias**, v. 27, n. 2, p. 243-252, 2006.

VILAS BOAS, E. V. B. **Extensão da vida de prateleira e manutenção da qualidade de frutos e hortaliças minimamente processados**. Lavras: UFLA/Faepe, 2003.

VILAS BOAS, B. M.; PRADO, M. E. T.; VILAS BOAS, E. V. B.; NUNES, E. E.; ARAUJO, F. M. M. C.; CHITARRA, E. B. Qualidade Pós-colheita de melão 'Orange Flesh' minimamente processado armazenado sob refrigeração e atmosfera modificada. **Revista Brasileira de Fruticultura**, v. 26, n. 3, p. 424-427, 2004.

VILLELA JUNIOR, L. V. E.; ARAUJO, J. A. C.; FACTOR, T. L. Análise do resfriamento da solução nutritiva para cultivo hidropônico do morangueiro. **Engenharia Agrícola**, v. 24, n. 2, p. 338-346, 2004.

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