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QUALITY OF SOME STRAWBERRY CULTIVARS IN RELATION WITH CONSUMER PREFERENCES

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Abstract

Strawberries (Fragaria x ananassa) are among the first fruits consumed in Romania, being appreciated for their flavour and special nutritional qualities. In the evaluation of the quality of the strawberry fruit, consumers appreciate the fruit appearance, taste and aroma. The aim of this paper was to analyse fruit quality of some strawberry cultivars in relation with consumer preferences. The research took place out at Small Fruit Department of Research Institute for Fruit Growing, Pitesti on 10 strawberry cultivars with different origin. The data were collected for: fruit weight, length, diameter, firmness, the soluble solids, acidity, five colour indicators, and sensory evaluation. The results showed significant differences between cultivars regarding the shape index, the fruit firmness and the highest value of content in total soluble solids was recorded by 'Vibrant' followed by 'Clery'. Regarding the panel test of the fruits the general score ranged between 5.58 ('Vibrant') to 8.22 ('Matis'). 'Sarom' had the highest weight, dark red fruit colour and balanced taste.

Key words*: Fragaria x ananassa, fruit quality, panel test, cultivars.*

INTRODUCTION

Strawberries are among the most appreciated fruits worldwide due to their exceptional flavour and high levels of bioactive compounds with strong antioxidant properties. Consumers appreciate their distinctive sweet and aromatic notes. Main chemical components contributing to the fruit's flavour include sugars, organic acids, phenolic compounds and various volatile organic copounds (Klee & Tieman, 2018). Strawberry aroma is determined by over 360 volatiles low molecular-weight compounds produced during ripening (Ulrich et al., 2018; Fan et al., 2021). Previous studies have shown significant correlations between these volatile compounds and the intensity of sweetness and flavour in strawberries (Tieman et al., 2012; Klee & Tieman, 2018; Fan et al., 2021) as observed by consumer panels evaluating different strawberry genotypes.

However, the visual impression and texture are also crucial for complex sensory perception. When choosing fresh fruits, shoppers consider colour and appearance as important quality factors (Ragaert et al., 2004; Lewers et al., 2020). Also, sensory quality often limits the shelf life of fresh fruits. (Jacxsens et al., 2002; Jacxsens et al., 2003; Ares et al., 2009). The sensory quality of strawberries relies on both the fruit's sensory characteristics and how consumers perceive them (Costell, 2002; Ares et al., 2009). Therefore, the evaluation of strawberry sensory quality has focused solely on their sensory characteristics (Van der Steen et al., 2002; Pelayo - Zaldivar et al., 2003; Péneau et al., 2007; Kim et al., 2020) using a trained assessor panel.

The aim of this paper was to analyse fruit quality of various strawberry cultivars and to understand consumer preferences for cultivars available to grow in Romania. The goal is to assist growers in selecting the most suitable strawberry cultivars based on marketability, sensory quality, and physicochemical measurements.

MATERIALS AND METHODS

The experiment was conducted during 2021-2023 at Small Fruit Department of Research Institute for Fruit Growing Pitești, Romania on ten strawberry cultivars of different origin: two Romanian ('Premial', 'Sarom'), five French ('Daroyal', 'Darselect', 'Dona', 'Matis', 'Magnum'), one Italian ('Clery'), one

Netherlands ('Elsanta') and one English ('Vibrant'). Three replications, 10 plants in each, were planted at distances of 0.3 × 0.90 m using black plastic mulch. The strawberry fruits were harvested at commercial maturity and the fruits samples were analysed immediately after picking. The indicators studied were recorded on a sample of 20 strawberry fruits. The average fruit weight was determined by weighing of each fruit using HL-400 digital balance. The fruit firmness was determined for each sample with a penetrometer Bareiss HPE II Fff non-destructive test, with a measuring surface of 0.50 cm^2. The length and diameter of the fruit were determined by measuring this using digital calliper. The shape index of the fruit was calculated as the ratio of these two dimensions (Tudor et al. 2014, Jamieson, 2016). The short-conic strawberries have length/width of about 0.9-1.1 and long-conic fruits 1.2-1.4. The soluble solids content was determined with digital refractometer PR Series. The pH values were measured in strawberry fresh juice using a pH meter (ISFET pH Meter, IQ 125, Japan). The external fruit colour was determined with a colorimeter Konica Minolta CR 400, based on system Huntel L*, a*, b* on both sides of the fruit by measuring the lightness or L* (+100 = white, −100 = black), a*(+60 = red, −60 = green), and b*(+60 = yellow, −60 = blue). Chroma index (colour intensity) was determined by the formula $C = (a^{*2} + b^{*2})^{1/2}$ and hue angle of the formula h° = arctangent (b*/a*), where 0° = red-purple, 90° = yellow, 180° = bluish-green and 270° = blue (McGuire, 1992; Lester & Saftner, 2008), Saftner and Lester, 2009). The sensory evaluation of fruits was recorded by open taste panels consisting of researchers and students from Faculty of Horticulture. Whole fruits were presented to members on platters (10 typical fruits of cultivars), to rate attractively and flavour, in points 1 to 5 (in which 5 designates the best performance) according to a questionnaire used by the Romanian breeders. The rating of fruit appearance was based on fruit size and shape, skin colour. The rating of intern characteristics of fruit was based on taste and aroma. The total point value was obtained by summing the scores for appearance and intern characteristics of fruit. The statistical analysis of the data was performed the SPSS 14.0 software and the Duncan comparison test was used to determine the difference between variants, with an error probability of ≤0.05.

RESULTS AND DISCUSSIONS

The study found significant differences in the investigated parameters among different strawberry cultivars. The quality of strawberries is influenced by factors such as their appearance (color intensity, size, and shape), firmness, and aroma. These attributes are affected by a combination of genetic factors, environmental conditions, and cultivation practices. This highlights the importance of considering these factors when evaluating and optimizing the quality of strawberries for commercial production.

The average fruit weight, an important commercial factor for fresh consumption, varied significantly among the cultivars, with 'Sarom' showing the highest average fruit weight of 28.73 g compared to other cultivars (Table 1). During this study, significant differences in fruit shape index were observed, ranging from 0.90 ('Premial') to 1.37 ('Clery'), with the latter exhibiting long-conic fruits (Table 1).

The study found a significant difference in fruit firmness between the cultivars and showed higher resistance value for the 'Dona' (48.49 N) and 'Magnum' (45.07 N) significantly big fruit compared to the other cultivars tested (Table 1).

The flavor of the fruit is influenced by its soluble solids content, as noted by Tomic et al. (2022). The quantitative variation in soluble solids content can be attributed to genetic factors, fruit ripeness, climatic conditions, and various other influences. These factors collectively impact the taste and sweetness of the fruit, emphasizing the importance of understanding and managing these variables for optimizing fruit quality.

The total soluble solids quantity of the studied cultivars ranged from 8.17 to 10.37 °Brix (Table 1), with 'Vibrant' and 'Clery' having the highest values. The pH values were highest for 'Darselect' and 'Vibrant' (4.15) and the lowest for 'Sarom' (3.51).

Table 1. Fruit size, firmness and total soluble solids characteristics and pH of strawberry cultivars (average ± SD; 2021-2023)

Cultivar	Fruit weight (g/fruit)	Fruit shape index	Fruit firmness (N)	Total soluble solids (°Brix)	pH
	19.25±3.60^{b*}	1.37±0.07^{a}	30.8±7.28^{cd}	10.27±0.50^{a}	3.56±0.06^{bc}
'Daroyal'	20.64±1.71^{b}	1.17±0.10^{bc}	31.33±11.87^{c}	8.17±1.16^{d}	3.90±0.08^{ab}
'Darselect'	20.26±2.51^{b}	1.15±0.14^{bc}	33.53±3.46^{bc}	10.37±0.64^{a}	4.15±0.12^{a}
'Dona'	21.37±1.81^{b}	1.28±0.03^{ab}	48.49±3.13^{a}	8.50±0.20^{cd}	3.84±0.41^{abc}
'Elsanta'	18.49±2.50^{b}	1.01±0.03^{cd}	25.00±7.60^{cde}	8.40±0.54^{cd}	3.82±0.23^{abc}
'Matis'	21.12±2.48^{b}	0.97±0.05^{d}	33.23±9.98^{bc}	8.50±0.50^{cd}	4.07±0.23^{a}
'Magnum'	17.55±1.42^{b}	1.18±0.17^{bc}	45.07±9.07^{a}	9.42±0.35^{abc}	3.80±0.14^{abc}
'Premial'	18.2±2.41^{b}	0.90±0.05^{d}	17.90±1.97^{e}	9.17±0.50^{bcd}	3.58±0.13^{bc}
'Sarom'	28.73±4.44^{a}	1.21±0.07^{ab}	26.97±7.35^{cde}	10.03±0.06^{ab}	3.51±0.07^{c}
'Vibrant'	17.4±0.35^{b}	1.15±0.14^{bc}	33.53±3.46^{bc}	10.37±0.64^{a}	4.15±0.12^{a}

*The values in the table that do not have common letters differ significantly for a statistical assurance level of 5% ($p \leq 0.05$)

The colour of strawberries is a crucial factor as it directly impacts the fruit's commercial value. Consumers generally prefer strawberries the fruit with a vibrant, strong, red colour. The fruit's external colour is influenced by its genotype. The study observed statistically similar values for indicators L*, a*, b* C*, and h° among the different cultivars. Specifically, L* values from 26.09 ('Sarom') to 32.07 ('Elsanta'), C* from 24.06 ('Sarom') to 31.72 ('Elsanta') and h° from 21.8 ('Dona') to 25.38 ('Premial') (Table 2). In this colour spectrum, lower L* and h° values indicate a darker red colour, while the higher values represent the lighter, orange-red colour.

Table 2. Fruit quality colour characteristics of strawberry cultivars (average ± SD; 2021-2023)

Cultivar	Brightness (L*)	Chromaticity a*- axis (red-green)	Chromaticity b*- axis (yellow-blue)	Chroma Index (C*)	The angle (h°)
'Clery'	29.69±2.61^{ab*}	27.49±3.92^{a}	12.08±2.39^{ab}	30.03±4.50^{a}	23.62±1.83^{a}
'Daroyal'	29.31±1.12^{ab}	26.07±0.96^{a}	11.68±1.34^{ab}	28.59±0.63^{a}	24.15±3.07^{a}
'Darselect'	29.43±3.75^{ab}	27.77±5.46^{a}	12.57±2.60^{ab}	30.48±6.03^{a}	24.33±0.66^{a}
'Dona'	29.75±1.37^{ab}	28.64±2.71^{a}	11.42±2.37^{ab}	30.85±3.38^{a}	21.58±2.38^{a}
'Elsanta'	32.07±0.35^{a}	28.77±3.17^{a}	13.31±0.42^{a}	31.72±2.9^{a}	24.97±2.37^{a}
'Matis'	29.92±1.67^{ab}	26.62±4.91^{a}	12.16±1.45^{ab}	29.27±5.07^{a}	24.70±1.36^{a}
'Magnum'	30.19±2.59^{ab}	25.52±0.97^{a}	11.56±1.49^{ab}	28.04±1.08^{a}	24.34±2.92^{a}
'Premial'	26.48±3.63^{b}	27.27±2.15^{a}	12.97±1.82^{a}	30.21±2.54^{a}	25.38±2.36^{a}
'Sarom'	26.09±0.59^{b}	22.17±3.93^{a}	9.26±0.98^{b}	24.06±4.00^{a}	22.77±1.37^{a}
'Vibrant'	29.43±3.75^{ab}	27.77±5.46^{a}	12.57±2.60^{ab}	30.48±6.03^{a}	24.33±0.66^{a}

*The values in the table that do not have common letters differ significantly for a statistical assurance level of 5% ($p \leq 0.05$)

Sugars and organic acids, along with volatile and aroma compounds, are the primary factors that influence the sensory perception of fruits. These components collectively contribute to the taste, aroma, and overall sensory experience of the fruit. (Milosavljevi´c et al., 2023). Panel evaluations of whole strawberries revealed no significant differences between cultivars in terms of size, form, firmness, visual freshness, glossiness, colour uniformity, and calyx freshness (Table 3).

This suggests that strawberries from all cultivars were perceived as equally fresh, indicating that they are suitable for further evaluation.

The panel also did not detect significant cultivar differences in strawberry size acceptability (Table 3). 'Matis' and 'Sarom'

were found to be more acceptable in size (large enough than and 'Darselect' and 'Vibrant' (too small). While 'Sarom' was heavier than 'Vibrant' based on measurable observations, evaluations of form acceptability by the panel were not similar to any physical measurements. The measured length-to-width (l/w) ratio ranged from 0.90 ('Premial') to 1.37 ('Clery') and was not closely associated with the panel's perception of form acceptability, with ranged from 3.48 ('Elsanta') to 4.31 ('Matis').

The assessment of firmness by the panel did not correspond to the texture penetrometer's evaluation of skin toughness. The panel's ratings for firmness were similar to the overall quality. Research by Schwieterman et al. (2014) similarly found that firmer textures are preferred

Table 3. Results of strawberries sensory evaluation (average ± SD; 2021-2023)

Cultivar	Size	Form	Firmness	Color	Calyx freshness	Taste and flavour	General score
'Clery'	3.49±1.10^{a*}	3.86±1.21^{a}	3.50±0.76^{ab}	3.82±1.22^{a}	3.32±1.03^{a}	3.84±0.89^{a}	6.81±2.11^{a}
'Daroyal'	3.85±0.48^{a}	4.28±0.58^{a}	4.59±0.57^{a}	3.36±0.79^{a}	3.37±0.55^{a}	4.06±0.47^{a}	7.22±0.99^{a}
'Darselect'	3.23±0.59^{a}	3.80±0.50^{a}	3.30±0.89^{ab}	3.58±0.71^{a}	3.98±1.34^{a}	3.87±0.57^{a}	7.21±1.86^{a}
'Dona'	3.84±0.79^{a}	3.93±0.48^{a}	3.06±0.57^{b}	3.71±0.56^{a}	3.45±0.71^{a}	3.97±0.41^{a}	7.29±1.47^{a}
'Elsanta'	3.4±0.99^{a}	3.48±0.84^{a}	3.37±0.77^{ab}	3.27±0.79^{a}	2.97±1.04^{a}	3.04±0.44^{a}	6.36±2.03^{a}
'Matis'	4.37±0.77^{a}	4.31±0.86^{a}	3.50±0.76^{ab}	3.59±0.68^{a}	3.86±0.79^{a}	3.31±0.63^{a}	8.22±1.54^{a}
'Magnum'	3.83±0.95^{a}	3.74±0.89^{a}	4.36±0.67^{ab}	4.31±0.86^{a}	4.27±0.35^{a}	3.91±0.51^{a}	8.1±1.27^{a}
'Premial'	3.71±1.00^{a}	3.79±0.89^{a}	3.07±0.59^{b}	3.46±0.80^{a}	3.48±0.50^{a}	3.59±0.30	7.19±1.48^{a}
'Sarom'	4.09±0.94^{a}	3.79±0.97^{a}	4.10±0.88^{ab}	3.62±1.00^{a}	3.62±1.00^{a}	3.88±0.69	7.71±0.87^{a}
'Vibrant'	2.88±0.53^{a}	3.71±0.75^{a}	4.03±0.36^{ab}	3.65±0.57^{a}	2.69±0.63^{a}	3.34±0.18	5.58±0.93^{a}

*The values in the table that do not have common letters differ significantly for a statistical assurance level of 5% ($p \leq 0.05$)

The panel test did not detect significant differences in glossiness and visual colour intensity. The panels rated 'Elsanta' as having the lowest colour intensity score (Table 2), with the highest L* and C* values, indicating that these strawberries were lighter red and had the greatest colour intensity (Table 3). 'Sarom' was among the lowest for the colour parameters, L* and b*, indicating it was among the darkest and most blue (Table 3). The chroma index was also among the lowest (Table 3), suggesting a less shiny appearance compared to the other cultivars.

The panel observed an interaction between the estimated calyx freshness and the overall quality. Some cultivars were found to have higher calyx freshness than others (Table 3). No significant differences in strawberry flavour and taste were detected by the panel (Table 3).

In the panel test, the scores generally ranged between 5.58 to 8.22, , with the highest score found in the 'Matis' followed by 'Sarom' (7.71), 'Dona' (7.29) ,'Daroyal' (7.22) and 'Darselect' (7.21).

According to the panel test, the scores generally ranged between 5.58 to 8.22, with the highest score found in the 'Matis' followed by 'Sarom' (7.71), 'Dona' (7.29), 'Daroyal' (7.22), and 'Darselect' (7.21) Table 3.

CONCLUSIONS

The cultivars 'Matis' and 'Sarom' have been highly rated for their attributes, with 'Sarom' specifically standing out for its size and quality of fruits. This suggests that both cultivars would be well-suited for cultivation in the central region of Romania and other areas with similar environmental conditions. The positive ratings from panel evaluations and instrumental measures indicate that these cultivars have the potential to thrive in these regions and produce high-quality strawberries.

REFERENCES

Ares G., Barrios S., Lareo C., Lema P., (2009). Development of a sensory quality index for strawberries based on correlation between sensory data and consumer perception, *Postharvest Biology and Technology*, Volume 52, Issue 1, Pages 97-102, ISSN 0925-5214, https://doi.org/10.1016/j.postharvbio.2008.11.001.

Costell, E. (2002). A comparison of sensory methods in quality control. *Food Quality and Preference*. *13*, 341-353.

Fan Z., Hasing T., Johnson T. S., Garner D. M., Schwieterman M. L., Barbey C. R., Colquhoun T. A., Sims C. A., Resende M. F. R., Whitaker, V. M., (2021) Strawberry sweetness and consumer preference are enhanced by specific volatile compounds. *Horticulture Research* (2021) 8:66 https://doi.org/10.1038/s41438-021-00502-5.

Jacxsens L., Devlieghere F., Ragaert P., Vanneste E., Debevere J., (2003) Relation between microbiological quality, metabolite production and sensory quality of equilibrium modified atmosphere packaged fresh-cut produce, *International Journal of Food Microbiology*, Volume 83, Issue 3, Pages 263-280, ISSN 0168-1605, https://doi.org/10.1016/S0168-1605(02)00376-8.

Jacxsens L., Devlieghere F., Debevere J., (2002). Temperature dependence of shelf-life as affected by microbial proliferation and sensory quality of equilibrium modified atmosphere packaged fresh produce, *Postharvest Biology and Technology*, Volume 26, Issue 1, Pages 59-73, ISSN 0925-5214, https://doi.org/10.1016/S0925-5214(02)00004-2

Jamieson, A. R. (2016, August). Strawberry shape: phenotypic variation in length and width. In *VIII International Strawberry Symposium 1156* (pp. 135-140).

Kim S. Lewers, Michael J. Newell, Eunhee Park & Yaguang Luo (2020) Consumer preference and physiochemical analyses of fresh strawberries from ten cultivars, International Journal of Fruit Science, 20:sup2, 733-756, DOI: 10.1080/15538362.2020.1768617.

Klee HJ, Tieman DM. (2018). The genetics of fruit flavour preferences. *Nat Rev Genet*. 19(6):347-356. doi: 10.1038/s41576-018-0002-5. PMID: 29563555.

Lewers K. S., Newell M.J., Park E., Luo Y. (2020). Consumer preference and physiochemical analyses of fresh strawberries from ten cultivars, *International Journal of Fruit Science*, 20:sup2, 733-756, DOI: 10.1080/15538362.2020. 1768617, https://doi.org/10.1080/15538362.2020.1768617

Lester, G.E., and R.A. Saftner. (2008). Marketable quality and phytonutrient concentrations of a novel hybrid muskmelon intended for the fresh-cut industry and its parental lines: Whole-fruit comparisons at harvest and following long-term storage at 1 or 5 °C. *Postharvest Biol. Technol*. 48:248–253. doi: 10.1016/j.postharvbio.2007.10.009.

McGuire RG, (1992). Reporting of objective color measurements, HortScience 27,1254 -1255.

Milivojevi, J., Radivojević, D., and Nikolić, M. (2015). Proizvodna svojstva i kvalitet ploda sorti i novih selekcija jagode introdukovanih iz Italije. Zbornik radova sa 5. savetovanja „Inovacije uvoćarstvu“, Beograd, 65-75.

Milosavljevi´c, D., Maksimovi´c, V.; Milivojevi´c, J., Djeki´c, I., Wolf, B., Zuber, J., Vogt, C., Dragiši´c Maksimovi´c, J. (2023). Sugars and Organic Acids in 25 Strawberry Cultivars: Qualitative and Quantitative Evaluation. *Plants* 12, 2238. https://doi.org/10.3390/plants12122238.

Pelayo-Zaldívar, Clara & Ebeler, S.E & Kader, A.A. (2003). Postharvest life and flavour quality of three strawberry cultivars kept at 5 °C in air + kPa CO2. *Postharvest Biology and Technology.* 27. 171-183

Péneau S., Brockhoff P.B., Escher F., J. Nuessli, (2007). A comprehensive approach to evaluate the freshness of strawberries and carrots, *Postharvest Biology and Technology*, Volume 45, Issue 1, Pages 20-29, ISSN 0925-5214, https://doi.org/10.1016/j.postharvbio.2007.02.001.

Ragaert P., Verbeke W., Devlieghere F., Debevere J., (2004). Consumer perception and choice of minimally processed vegetables and packaged fruits, *Food Quality and Preference*, Volume 15, Issue 3, Pages 259-270, ISSN 0950-3293, https://doi.org/10.1016/S0950-3293(03)00066-1.

Saftner, R., and G.E. Lester. (2009). Sensory and analytical characteristics of a novel hybrid muskmelon fruit intended for the fresh-cut industry. *Postharvest Biol. Technol.* 51:327–333. doi: 10.1016/j.postharvbio.2008.09.008.

Schwieterman, M. L., Colquhoun, T. A., Jaworski, E. A., Bartoshuk, L. M., Gilbert, J. L., Tieman, D. M., ... & Clark, D. G. (2014). Strawberry flavor: diverse chemical compositions, a seasonal influence, and effects on sensory perception. *PloS one*, *9*(2), e88446.

Sturzeanu, M., Baruzzi, G., Sbrighi, P., and Calinescu, M. (2021). The evaluation of some Italian strawberry genotypes in Romania. Acta Hortic. 1309, 431–438 https://doi.org/10.17660/ActaHortic.2021.1309.62.

Tieman D, Bliss P, McIntyre LM, Blandon-Ubeda A, Bies D, Odabasi AZ, Rodríguez GR, van der Knaap E, Taylor MG, Goulet C, Mageroy MH, Snyder DJ, Colquhoun T, Moskowitz H, Clark DG, Sims C, Bartoshuk L, Klee HJ. (2012) The chemical interactions underlying tomato flavor preferences. *Curr Biol*. 5;22(11):1035-9. doi: 10.1016/j.cub.2012.04.016. Epub 2012 May 24. PMID: 22633806.

Tomić, J., Glišić, I., Milošević, N., Štampar, F., Mikulič-Petkovšek, M., & Jakopič, J. (2022). Determination of fruit chemical contents of two plum cultivars grafted on four rootstocks. *Journal of Food Composition and Analysis*, *105*, 103944.

Tudor, V., Asănică, A., & Neagu, T. (2014). First results of some day-neutral strawberry cultivars behavior in the Bucharest area conditions. *Uni. Agron. Sci. and Veterinary Medicine of Bucharest*, *58*, 101-106.

Ulrich, D., Kecke, S. & Olbricht, K. (2018). What do we know about the chemistry of strawberry aroma? J. *Agric. Food Chem*. 66, 3291–330.

Van den Steen PE, Dubois B, Nelissen I, Rudd PM, Dwek RA, Opdenakker G. (2002) Biochemistry and molecular biology of gelatinase B or matrix metalloproteinase-9 (MMP-9). *Crit Rev Biochem Mol Biol.* 37(6):375-536. doi: 10.1080/10409230290771546. PMID: 12540195.