Bulgarian Chemical Communications, Volume 56, Special Issue D2 (pp. 143-147) 2024 DOI:10.34049/bcc.56.D.S2P63

Evaluation of preliminary physico-chemical parameters and biometric characteristics of the "Stendesto" plum-apricot hybrid with reference to its parental lines

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Received: November 3, 2023; Revised: April 11, 2024

Prunus spp. are economically important stone fruits with hybrid potential. The "Stendesto" is the only successful plum-apricot hybrid registered in Bulgaria. Information about its features is rather scarce in the available scientific databases. The "Stendesto" comes from the "Modesto" apricot and the "Stanley" plum. In this study, classical methods were used in order to provide preliminary knowledge about the hybrid, with reference to its parental lines. The color parameters, as well as total soluble solids, pH, ash and moisture contents, water activity, and biometric data (weight, size, thickness, length, and width) were evaluated. The results show that the moisture content is comparable between the three fruits, and the fruit weight had the highest values for the "Modesto" apricot, while the "Stendesto" stood in the middle. Microscopic images of the fruits were also provided for better evaluation. The results show that physically the "Stendesto" is more similar to the "Stanley" plum than to the "Modesto" apricot. This study considered a pilot on the topic of plum-apricot hybrids in Bulgaria and sets ground for further research on their phytochemical composition and related biological activities.

Keywords: *Prunus* spp., physico-chemical parameters, plumcot

INTRODUCTION

Stone fruits, and fruits in general, are important health and nutrition contributors due to their phytochemicals [1]. Phenolic compounds are major bioactive providers in stone fruits [2]. It is well-known that a diet rich in fruit and vegetables may contribute to the prevention of non-communicative diseases (hypertension, diabetes, obesity, several types of cancer, among others) [3]. However, consumers evaluate and make buying decisions based on primary physical characteristics like size, weight, shape, color, aroma. Fruit size is a qualitative feature that strongly influences consumer's preferences [4]. It can be partially controlled by water and nutrient availability, light and temperature [5]. The morphological description is recognized as a first important step in fruit characterization [6]. Additionally, the variability of the color parameters may determine appropriate maturity and fruit attractiveness in terms of the market selection [7]. Furthermore, the total soluble solids (TSS)/titratable acidity (TA) ratio gives important information about the fruit taste, and the possible content of sugars and organic acids. Higher TSS/TA ratios are associated with a higher eating quality [8].

Genus *Prunus* comprises important and well accepted fruits, *e.g.* peaches, plums, cherries, sour cherries, among others. Hybridization is recognized as a vital process in plant evolution [9]. Plum-apricot hybrids may result in plumcots, pluots, and apriums depending on the resemblance to their parent (plum or apricot, respectively) [10]. Globally, plum-apricot hybrids are not new [11] but to date, only one plum-apricot hybrid is registered in Bulgaria, and this is the "Stendesto".

Consequently, the present work aims at characterizing the "Stendesto" in terms of color parameters, total soluble solids, pH, ash and moisture contents, water activity, and biometric data (weight, size, thickness, length, and width), also making reference to its parental lines. This study is considered a pilot on the topic of plum-apricot hybrids in Bulgaria and sets ground for further research on their phytochemical composition and related biological activities.

MATERIALS AND METHODS

The fruits (apricots, plumcots, and plums) were harvested on three dates, at optimal ripeness, from the fields of the Fruit Growing Institute, Plovdiv, Bulgaria (lat. 42.10384828045957 and long.

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24.72164848814686). A total of sixty fruits were transported in pulp trays in an air-conditioned vehicle to the University of Food Technologies, where the fruits were randomly placed in new trays in order to minimize the differences in fruit quality and further analyses were applied. Twenty extra fruits per variety were selected in case there was decay or damage during/after the harvest.

Ash content was determined according to AOAC Official Method 940.26 [12]. The moisture content of the studied samples was measured using an infrared moisture analyzer PMB 53 (Adam Equipment Inc., Oxford, UK). The water activity (a_w) was measured using a LabSwift-aw, Novasina AG, Lachen, Bassersdorf, Switzerland. TSS (%) were evaluated using a digital handheld refractometer (Opti Brix 54, Bellingham + Stanley, Kent, UK). The pH was determined using an Orion 2 Star pH Benchtop (Thermo Scientific, Singapore) with the electrode standardized with pH 4.0 and 7.0 buffers (Sigma-Aldrich, Darmstadt, Germany). A PCE-CSM 2 (PCE-CSM instruments, Meschede, Deutschland) with a measuring aperture of 8 mm was used to analyze the color parameters (L, a, b, c, h) of the skin and flesh.

The fruits and pits were measured on a digital scale (KERN, EMB 600-2). Fruit was weight intact; afterwards the pit was extracted and evaluated. Fruit's and pit's sizes (length, width, thickness) were measured using a digital caliper. The microstructure of the fruit samples was examined with a Celestron LCD Digital II microscope. Micrographs were made by means of an 8MP digital camera, and further analyzed by ImageJ software [13].

MS Excel software was used for data analysis. All assays were performed at least in triplicate. Results are presented as mean ± SD (standard deviation). The additional statistical analyses of the data were presented using one-way ANOVA and a Tukey–Kramer post hoc test ($\alpha = 0.05$), as described by Assaad *et al.* [14].

RESULTS AND DISCUSSION

Information about the moisture and ash contents, TSS values, pH, and a_w is presented in Table 1.

The moisture content varied from 65.53±6.18 to 74.55±4.49 %. The lowest values belonged to the "Stanley" plum. Other authors reported 10% higher moisture content for apricot cultivars and comparable ash content [15]. Higher moisture content is also documented in papers about plums [16].

The TSS values of apricots range from 10 to 20 ºBrix as established in another research [17]. The current result of 14.55 ºBrix ("Modesto") is comparable to the ones established in ripe apricots [18]. European plum are characterized in literature with 8.2 to 18.4 ºBrix values [19]. The "Stanley" plum shows much higher TSS. The plum-apricot hybrid had a TSS of 19.3 ºBrix which was more similar to the plum than to the apricot. This is consistent with the morphological similarities of plumcot to plums compared to apricots [20]. A TSS report of plumcots [21] showed lower values which were more similar to the currently reported "Modesto" results.

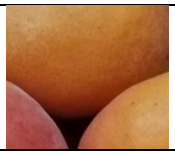
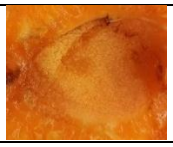
As fruit acidity is important to quality, it is related to two parameters, namely titratable acidity and pH value. Fruit acidity is mainly due to the organic acids and mineral cations in the vacuole [22]. Considering the pH values, the studied hybrid had the lowest values, while the apricot had the highest. The "Modesto" values are consistent with other reported in literature ranging from 3.90 to 4.70 [23]. Nicolas-Almansa *et al.* [11] reported lower pH values (3.08 to 3.75) for several plum-apricot hybrids. Information about the water activity of fresh fruit is scarce. Research teams report a_w of 0.966 ± 0.002 for plums [24] and showed an initial which is higher than the currently established results for "Stanley" plums.

Table 1. Physico-chemical characteristics of investigated fruit samples (n=3)

Fruit sample/ characteristic	"Modesto" apricot	"Stendesto" hybrid	"Stanley" plum
Moisture - fruit, %	72.95±0.11^{a}	74.55±4.49^{a}	65.53±6.18^{a}
Moisture – stone, %	5.18±1.51^{ab}	5.91±1.69^{a}	2.24±0.94^{b}
Ash - fruit, %	0.80±0.15^{a}	0.66±0.15^{a}	0.58±0.24^{a}
Ash – stone, %	2.90±0.57^{a}	1.27±0.64^{b}	1.59±0.60^{ab}
pH - fruit	4.50±0.01^{a}	2.55±0.01^{c}	3.80±0.00^{b}
TSS - fruit	14.55±0.21^{b}	19.3±1.99^{a}	20.55±0.63^{a}
a_w - fruit	0.875±0.007^{b}	0.895±0.007^{a}	0.905±0.007^{a}
a_w - stone	0.85±0.01^{a}	0.87±0.01^{a}	0.785±0.02^{b}

Different letters in the same row indicate statistically significant differences ($p<0.05$), according to ANOVA (one-way) and the Tukey test.

Table2. CIE lab color parameters of the studied samples, (n=5)

Fruit sample/ parameter	"Modesto" apricot	"Stendesto" hybrid	"Stanley" plum
	fruit skin		
			
L	54.35 ± 4.38[a]	44.86 ± 5.27[b]	23.84 ± 3.59[c]
a	24.14 ± 1.97[a]	- 0.56 ± 2.34[b]	1.25 ± 0.96[b]
b	39.15 ± 5.97[a]	- 7.58 ± 2.03[b]	- 1.94 ± 0.91[b]
c	46.26 ± 4.15[a]	7.94 ± 1.76[b]	2.50 ± 0.80[c]
h	57.92 ± 6.30[c]	269.01 ± 21.34[b]	304.44 ± 21.54[a]
	fruit flesh		
			
L	45.40 ± 5.19[a]	31.61 ± 3.78[a]	39.71 ± 17.56[a]
a	11.34 ± 2.23[a]	6.61 ± 6.55[a]	-2.35 ± 4.53[b]
b	41.67 ± 4.01[a]	30.42 ± 4.01[b]	27.46 ± 2.11[b]
c	43.21 ± 4.33[a]	30.79 ± 4.15[b]	27.86 ± 1.99[b]
h	74.83 ± 1.98[b]	77.33 ± 11.85[b]	94.92 ± 9.52[a]

Different letters in the same row indicate statistically significant differences ($p<0.05$), according to ANOVA (one-way) and the Tukey test.

Canakapalli *et al*. [25] have documented a water activity of 0.68 for pluots. These results are substantially lower that those currently reported about the "Stendesto" hybrid.

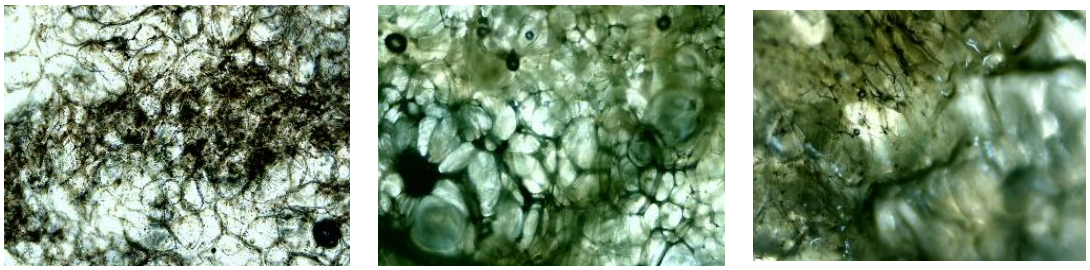
The plum-apricot hybrid has a water activity more similar to the plum than to the apricot. Lower water activity is usually associated with limited microbial growth. The results considering the fruit stones from the three studied samples are regarded as new data since information in the vastly available literature is not found.

Color is an important attribute especially when food is being evaluated. Table 2 holds information about the L*, a, b, c, and h parameters of the studied fruit skins and fleshes. ΔE between the hybrid and its parents was calculated in order to demonstrate the differences in color perception. The calculated hybrid-plum (21.84) and hybrid-apricot (53.70) ΔE revealed that the "Stendesto" is more similar to the "Stanley" plum. However, color is not perceived as similar or is difficult to differentiate.

Visually the plum-apricot hybrid is more resemblant to the plum (Figure 1). This is supported by the established "a" values of the fruit skin corresponding to a blue coloration. The lightness of the samples' skin varied between 23.84 ± 3.59 and 54.35 ± 4.38. The apricot's skin was the lightest. The same trend was observed for the fruit flesh. The color parameters of the "Modesto" apricot are comparable to other available in published papers [26, 27]. Vivid colors are desired for fruit. Plum peels can vary in color [28]. However, similarities to other results in established color attributes are present [29]. The great difference in the chroma of the fruit skin is due to the initial color of the fruit. High chroma values are associated with the change from green to yellow which is relevant to the "Modesto".

The microscopic images of the three studied fruits shed more light about their similarities. The plant cell is comprised of polysaccharides (cellulose, hemicellulose, pectin, among others) and proteins [31]. The dimensions (diagonal diameter) of the cells varied from 110.6±35.61 μm ("Stendesto") to 121.62±6.08 μm ("Stanley"). No statistically significant difference between the studied samples was established. Other authors have reported no correlation between cell size and attributes like firmness between fruit cultivars [32] although research papers had pointed out that cell size may be responsible for some textural differences (juiciness) [33].

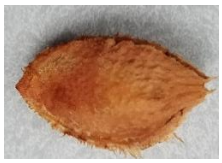
The biometric data of the studied fruits are given in Table 3. Information about the weight of the fruit and stone, the dimensions of the fruit (length, width, thickness) and stone is used to better evaluate the differences and similarities between the hybrid and its parental lines.



"Modesto" apricot "Stendesto" hybrid "Stanley" plum

Figure 1. Microscopic images of studied samples

Table 3. Biometric data of studied samples, (n=25)

Fruit sample/ parameter	"Modesto" apricot	"Stendesto" hybrid	"Stanley" plum
Fruit			
Weight, g	72.84 ± 6.55[a]	47.84 ± 6.40[b]	36.02 ± 3.54[c]
Length, mm	53.18 ± 1.10[b]	58.79 ± 2.65[a]	48.09 ± 2.36[c]
Width, mm	56.79 ± 2.83[a]	41.01 ± 1.73[b]	34.17 ± 1.59[c]
Thickness, mm	48.75 ± 8.51[a]	42.79 ± 2.15[b]	36.01 ± 1.81[c]
Stone			
Weight, g	3.28 ± 0.59[a]	2.94 ± 0.56[b]	2.22 ± 0.20[c]
Length, mm	29.85 ± 1.53[b]	33.34 ± 3.55[a]	26.03 ± 1.83[c]
Width, mm	23.58 ± 1.12[a]	9.17 ± 0.88[c]	14.61 ± 0.89[b]
Thickness, mm	13.97 ± 1.07[b]	15.51 ± 0.76[a]	8.42 ± 0.64[c]

Different letters in the same row indicate statistically significant differences ($p<0.05$), according to ANOVA (one-way) and the Tukey test.

The heaviest of the three fruit is the apricot with an average of 72.84 ± 6.55 g. These measurements are in accordance with other published data about apricots from different cultivars [34]. The established biometry of the "Stanley" plum is comparable to the data published by Dimkova *et al*. [35] about nine cultivars, including "Stanley", which was used as a standard. The hybrid fruit had values for length, width, and thickness that are greater than those of the plum, and smaller than the same of the apricot. The same trend did not apply for the stones. The hybrid stone was visually more similar to the plum stone. The stone weight was comparable to the data published about apricot hybrids [36]. Some authors highlighted that very often plum-apricot hybrids were falsely regarded as plums due to the visual similarity [11].

CONCLUSION

The present study is considered a pilot on the topic of plum-apricot hybrids in Bulgaria. To date, the "Stendesto" is the only successful plum-apricot hybrid registered in Bulgaria. The color parameters, as well as total soluble solids, pH, ash and moisture contents, water activity, and biometric data (weight, size, thickness, length, and width) were evaluated. The studied plum-apricot hybrid showed more similarities to the plum than to the apricot, especially in terms of color. The hybrid fruit had values for length, width, and thickness greater than those of the plum, and smaller than the same of the apricot. Visually there was a greater resemblance to the plum. The current results set ground for further research on the phytochemical composition and related biological activities of plum-apricot hybrids.

Acknowledgement: *We acknowledge the financial support by the Bulgarian National Science Fund, project КП06-Н67/2.*

REFERENCES

1. M. Lara, C. Bonghi, F. Famiani, G. Vizzotto, R. Walker, M. Drincovich, *Front. Plant Sci*., **11**: 562252 (2020).
2. Y. Hong, Z. Wang, C. Barrow, F. Dunshea, H. Suleria, *Antioxidants*, **10**, 234 (2021).
3. D. Aune, E. Giovannucci, P. Boffetta, L. Fadnes, N. Keum, T. Norat, D. Greenwood, E. Riboli, L. Vatten, S. Tonstad, *Int. J. Epidemiol*., **46**: 1029 (2017).
4. C. Crisosto, G. Costa, D.R. Layne, D. Bassi (eds.), CAB International, Cambridge, 2008, p. 536.
5. M. Cerri, A. Rosati, F. Famiani, L. Reale, *Scientia Horticulturae*, **255,** 1 (2019).
6. M. Baji, H. Hanine, S. En-Nahli, R. Company O. Kodad, *Int. J. Fruit Sci.*, **21**(1), 52 (2021).
7. A. Cirillo, L. De Luca, L. Izzo, M. Cepparulo, G. Graziani, A. Ritieni, R. Romano, C. Di Vaio, *Horticulturae*, **9**(5), 546 (2023).
8. A. Hegedús, R. Engel, L. Abrankó, E. Balogh, A. Blázovics, R. Hermán, J. Halász, S. Ercisli, A. Pedryc, E. Stefanovits-Bányai, *J. Food Sci*., **75**: 722-730 (2010).
9. B. Kerbs, J.Ressler, J. Kelly, M. Mort, A. Santos-Guerra, M. Gibson, J. Caujapé-Castells, D. Crawford, *AoB Plants***, 9**, 043 (2017).
10. A. Popova, D. Mihaylova, S. Pandova, P. Doykina, *Horticulturae*, 9: 584 (2023).
11. M. Nicolás-Almansa, D. Ruiz, J. Salazar, A. Guevara, J. Cos, P. Martínez-Gómez M. Rubio, *Scientia Horticulturae*, **318,** 112131 (2023).
12. AOAC Official Method 940.26, Washington, DC, USA: AOAC International, 2003.
13. C. Schneider, W. Rasband, K. Eliceiri, *Nature Methods*, **9**(7), 671 (2012).
14. A. Hussein, A. El-Anssary, Plants Secondary Metabolites, Intech Open Limited; London, UK, 2019.
15. F. Khan, T. Khan, M. Arif, M. Tajudin, *Adv Food Technol. Nutr. Sci. Open J*., **2**(1), 3 (2016).
16. H. Polatci, *Pak. J. Bot.*, **53**(2), 579 (2021).
17. B. Velardo-Micharet, F. Agudo-Corbacho, M. Ayuso-Yuste, M. Bernalte-García, *Agriculture*, **11**(7): 639 (2021).
18. J. Ayour, M. Sagar, H. Harrak, A.Alahyane, M. Alfeddy, M. Taourirte, M. Benichou, *Sci. Hortic*., **215,** 72 (2017).
19. P. Roussos, N. Efstathios, B. Intidhar, N. Denaxa, A. Tsafouros, Nutritional Composition of Fruit Cultivars (19-48), M. Simmonds, V. Preedy (eds.), Academic Press, 2016, p. 639.
20. M. Szymajda, M. Studnicki, A. Kuras, E. Zurawicz, *S. Afr. J. Bot*., **146**: 624 (2022).
21. S-K. Jung, H-S. Choi, *Sustainability*, **13**(19), 10737 (2021).
22. A. Etienne, M. Génard, D. Bancel, S. Benoit, C. Bugaud, *Sci. Hortic. (Amsterdam)* , **162**,125 (2013).
23. E. Mratinić, B. Popovski, T. Milošević, M. Popovska, *Czech J. Food Sci*., **29**(2), 161–170 (2011).
24. M. Rodríguez, A. Rodriguez, R. Mascheroni, *J. Food Processing and Preservation*, **39**, 2647 (2015).
25. S. Canakapalli, L. Sheng, L. Wang, *LWT*, **154**, 112632 (2022).
26. C. Petrisor, *J. Horticulture*, **18**(4), 70 (2014).
27. J. Salazar, P. Martínez-Gómez, D. Ruiz, *Eur. J. Hortic. Sci*. 87(1), 1 (2022).
28. E. Rampácková, M. Göttingerová, T. Kiss, I. Ondrášek, R. Venuta, J. Wolf, T. Necas, S. Ercisli, *Eur. J. Hortic. Sci*, **86**, 453 (2021).
29. P. Drogoudi, G. Pantelidis, *Plants*, **11**, 1338 (2022).
30. A. Hegedüs, P. Pfeiffer, N. Papp, L. Abrankó, A. Blázovics, A. Pedryc, É. Stefanovits-Bányai, *Biol Res*, **44**, 339 (2011).
31. S. Uluisik, G. Seymour, *Food Chem*., **309**, 125559 (2020).
32. P. McAtee, I. Hallett, J. Johnston, R. Schaffer, *Plant Methods* **5**(5), (2009).
33. H. Mann, D. Bedford, J. Luby, Z Vickers, C. Tong, *Hort. Science*, **40**(6), 1815 (2005).
34. L. Septar, C. Moale, L. Tilinca, I. Stoli, *Current Trends in Natural Sciences*, **10**(19), 387 (2021).
35. S. Dimkova, D. Ivanova, S. Todorova, N. Marinova, *Bulgarian Journal of Agricultural Science*, **23**(6), 947 (2017).
36. M. Tufaru, D. Hoza, L. Chira, A. Peticilă, *Scientific Papers. Series B, Horticulture*, **LXV**(1), 270 (2021).