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Physicochemical properties and sensory evaluation of early ripening peach and nectarine varieties

Физико-химични показатели и сензорна оценка на ранно зреещи сортове праскови и нектарини

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ABSTRACT

The present study was carried out to determine some physicochemical, composition and sensory attributes of early-ripening peach varieties: "Filina" (peach), "Gergana" (nectarine), and "Ufo-4" (flat peach). Fruit weight, shape and size, as well as color and firmness were evaluated. Image analysis was used to describe properties such as length, width, thickness, etc. Skin hue ranged from 33.45±10.70 to 42.75±29.87. Dry matter (%), ash content (%), total soluble solids, pH, titratable acidity, total sugar content, and protein content were employed to characterize the studied varieties. Results showed differences in all properties of the types. Ash content varied from 0.45±0.04% to 0.96±0.12% and pH from 3.95 to 4.46. "Gergana" had the lowest total soluble solids. A trained descriptive sensory panel evaluated the peach varieties in five categories with a total of twenty-five attributes. The fruit attributes were evaluated by a 15-point ascending scale. The panellists detected differences between varieties in each of the categories (aroma, texture, taste, internal and external appearance). These results offer and highlight new data in terms of early-ripening peach variety properties.

Keywords: firmness, peaches, sensory profile, total soluble solids, varieties, weight

АБСТРАКТ

Настоящото проучване е проведено с цел определяне на някои физикохимични, химични и сензорни качества на ранно зреещи сортове праскови: „Филина" (праскова), „Гергана" (нектарина) и „Уфо-4" (плоска праскова). Оценени са теглото, формата и размерът на плодовете, както и цветът, и твърдостта. За описание на свойства като дължина, ширина, дебелина и др. е използван анализ на изображения. Оттенъкът на прасковената обелка варира от 33,45±10,70 до 42,75±29,87. Сухо вещество (%), съдържание на пепел (%), общо разтворими твърди вещества, pH, титруема киселинност, общо съдържание на захар и съдържание на протеин характеризират изследваните сортове. Резултатите показват разлики във всички свойства на сортовете. Съдържанието на пепел варира от 0,45±0,04% до 0,96±0,12%, а pH от 3,95 до 4,46. Гергана има най-ниските стойности на общо разтворими твърди вещества. Обучен сензорен панел оцени сортовете праскови в пет категории с общо двадесет и пет характеристики. Характеристиките на плодовете се оценяват по 15-степенна скала, в която 15 е максималната стойност. Дегустаторите откриват разлики между сортовете във всяка от категориите (аромат, текстура, вкус, вътрешност и външен вид). Получените резултати предлагат и подчертават нови данни по отношение на свойствата на ранно зреещи прасковени сортове.

Ключови думи: твърдост, праскови, сензорен профил, общи разтворими вещества, сортове, тегло

INTRODUCTION

Peach fruit have high economic and nutritional value. Peaches (*Prunus persica* L. Batsch) belong to the *Rosaceae* family and are a species of many crops commonly grown around the world. The fruit of *Prunus persica* is stone shaped, suitable for direct consumption and an interesting material for processing and analysis. Over the years, it has generated increased interest among consumers and food processors not only for its attractive sensory characteristics, but also because of its chemical composition and health-promoting properties (Chang et al., 2016). The quality of fresh fruits is due to a combination of physical and biological characteristics (Kader, 1999). Fruit quality indicators include appearance, sugar and acid content. However, fruits also contain innumerable phytochemicals, which, although at relatively low concentrations, play a key role in overall quality. Some of these substances can be major factors for determining their colour and aroma (Olsson et al., 2004). Sensory analysis is an important tool in order to determine how the consumer perceives fruit's physicochemical attributes (Belisle et al., 2017; Felts and Worthington, 2019).

Peach fruit can be classified as flat or round, and with season progression, fruit quality improves. Colour, firmness, shape, and size are some of the fruit characteristics that have to meet certain minimum quality standards. Considering the attachment of the pit to the flesh, peaches can be freestone, semi-freestone or clingstone (Ramina et al., 2008). Flesh types vary from melting to non-melting, depending on the fruit's enzymatic ability to degrade pectin while ripening (Tanou et al., 2017).

The "Filina" variety was officially recognized in Bulgaria in 2008. It is a combination of the varieties "July Lady" and "Maycrest" and is created by the Fruit Growing Institute in Plovdiv, Bulgaria. The tree is moderately growing, with a semi-upright crown. Flowering is early and the flowers are bell-shaped, large, dark pink, with a diameter of 31.6 mm. The variety enters fruiting early and has a good fertility. It is moderately resistant to low winter temperatures and spring frosts. It is resistant to powdery mildew.

The fruit of the "Filina" variety ripen early, and are large, round, and symmetrical. Their skin is thin, completely covered with an intense dark red colour. The flesh is yellow, very tender, and juicy, with moderate acidity, sweet, with a good aroma and excellent taste. "Filina" is a clingstone variety. The first Bulgarian nectarine variety created by a combination of "Goldengrand" and "Aureliogrand" varieties is "Gergana". It was officially recognized in 2009. Its fruits ripen early and are still clingstone. The fruit has an average weight of 120-130 g, and the colour of the skin is intensely red and covers the entire surface of the fruit. The flesh is yellow, with a delicate texture, fragrant, with a very good sour-sweet taste. The "Ufo-4" peach is a relatively new variety that is grown in many European countries (main variety in Italy and Greece). It is a so-called "doughnut" shape variety. The fruit flesh is yellow, juicy, and sweet, with a pleasant aroma.

The objective of the present study was to evaluate certain physicochemical (color, firmness, shape, size) attributes and composition (titratable acidity, total soluble solids, pH, sugar content, protein content, ash, dry matter) of three different types early-ripening peach varieties. A descriptive sensory method evaluated how aroma, taste, texture and appearance were perceived.

MATERIALS AND METHODS

Plants and culture

Three early-ripening peach and nectarine genotypes were evaluated. "Filina" (peach, clingstone), "Ufo-4" (peach, clingstone), and "Gergana" (nectarine, clingstone) participated in the study. Fruit was harvested from trees at the Fruit-growing Research Institute, Plovdiv, BG (lat. 42.10384828045957 and long. 24.72164848814686). Fruit was harvested from tree ranging from 5 to 8 years old that were spaced 3 m apart. No bactericides were applied to plantings during testing. The Agricultural University, Plovdiv, Bulgaria, performed soil tests and made recommendations about fertilizers according to the test's results.

Harvest

Peaches and nectarines were hand harvested in the morning between 6 am and 8 am on two harvest dates 22 June and 29 June 2020 at optimal ripeness. They were free from major damages such as blemishes, flaws, etc. "Filina" was harvested on 22 June and "Ufo-4" and "Gergana" on 29 June 2020. No rain events within 24 h of harvesting have been registered. Sixty peaches per variety were harvested and transported in pulp trays in an air-conditioned vehicle to the University of food technologies, where the fruit was randomly places in new trays in order to minimize the differences in fruit quality. Extra fruit was harvested in case there was decay or damage during/after the harvest. The fruit was evaluated for physicochemical and sensory attributes at harvest.

Physicochemical analysis

All analysis was performed in triplicates for each variety. Physicochemical attributes included fruit weight, colour, and firmness.

Fruit and pit weight

Fruit and pit were measured on a digital scale (KERN, EMB 500-1). Fruit was weight intact; afterwards the pit was extracted and evaluated.

Image analysis of shape and size

Thirty peaches/nectarines of each genotype were divided into three groups, and were positioned in three orientations as described by Ercisli et al. (2012). A Nikon D5600 digital SLR camera with 30 mm focal length and shutter speed 1/160 sec. was used to capture the area. In order to calibrate length, a transparent plastic ruler with intervals of 0.5 mm was placed beside the peach (Figure 1). The image resolution was 3000x4496 p with 300 ppi pixel depth. Photos were saves as colored .tiff image files. The obtained images were processed and analyzed with ImageJ software. The software automatically determined the length, width, and thickness of the selected object. The geometric mean diameter and sphericity were calculated following the equations of Mohsenin (1986). Surface area was calculated according to McCabe et al. (1986).

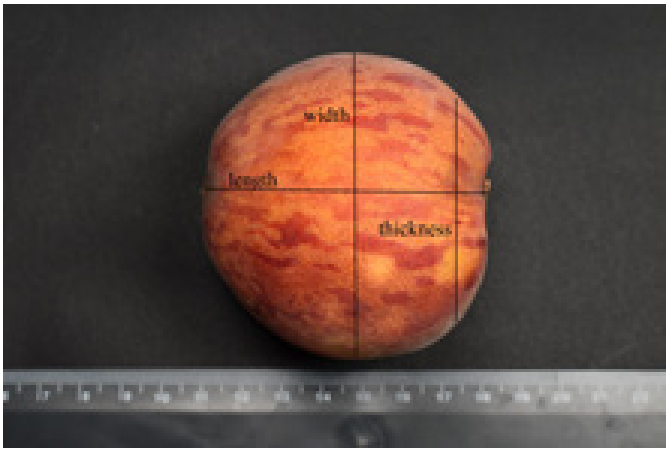

Figure 1. Determination of length, width, and thickness in peach fruit

Firmness

Firmness of the fruit was measured using a FT 327 fruit pressure tester, TR Turoni, Italy. Force to penetrate was expressed in Newtons (N). Firmness was evaluated at 90, 180, and 270 degrees to the right of the suture.

Colour

The colour of the flesh and skin was analysed with the use of PCE-CSM 2, PCE-CSM instruments, Deutschland. The L^*, chroma, and hue angle were evaluated. Skin colour was evaluated on three locations (90, 180, and 270 degrees to the right of the suture) for each peach/nectarine. Fruit flesh was measured immediately after cutting the peach using the same technique as for the fruit skin.

Composition

Composition was evaluated by freezing peaches, which have been cut, immediately after measuring the inner color and pit. Each fruit was macerated for 3 min in a porcelain mortar then strained through a cheesecloth. Each experimental unit was an individual peach or nectarine. Composition analysis included total soluble solids, pH, titratable acidity, sugars and proteins.

Dry matter

Total moisture content of the samples was determined according to the procedure described in AACC method 44-15A (2000).

Ash content

Ash content of the samples was determined according to the AOAC Official Method 942.05 (2003).

Total soluble solids (TSS)

TSS expressed as % were measured using ABBE refractometer (Carl Zeiss Abbe Laboratory Refractometer).

pH

The pH was measured using Orion 2 Star pH Benchtop (Thermo Scientific) with the electrode standardized to pH 4.0 and 7.0 Sigma buffers.

Titratable acidity (TA)

Titratable acidity was measured with the use of the potentiometric method, using a pH meter Orion 2 Star pH Benchtop (Thermo Scientific).

Maturity index (MI)

The sugar/acid ratio was calculated following the equation:

$$MI = TSS/TA$$

Sweetness index (SI) and Total sweetness index (TSI) were calculated after HPLC analysis of individual sugars for determination of the fruit sweetness perception (Akšić et al., 2019). SI was calculated, based on the fact, that fructose and sucrose are 2.30 and 1.35 times sweeter than glucose. TSI is expressed with the contribution of each sugar estimated relative to sucrose.

Sugars

The total soluble carbohydrate content was estimated by phenol-sulphuric acid method (Dubois et al., 1956). The absorbance was measured at 490 nm against blank with distilled H_2O.

Proteins

Total protein content in samples was determined by dye-binding method (Bradford, 1976) where 100 µl of sample was mixed with 100 µL Bradford reagent (Biorad, USA). Distilled water was used as blank. The mixture was incubated at room temperature for 5 min before measuring the absorbance at 595 nm.

Sensory evaluation – Sensory analysis was performed at the University of food technologies. The ten panellists (three male, seven female) were trained to use a modified Sensory Spectrum method, and objective method for describing the intensity of attributes using references. A lexicon of attributes was developed for the needs of the evaluation. Each panellist evaluated one fruit per variety in duplicates. The fruit was served at room temperature (24 °C) on plates labelled with 3-digit codes in a randomized design. Panellists cleansed their palates between samples (using water and crackers). The panel evaluated the fruit for external appearance (n=8), internal appearance (n=6), basic taste (n=3), texture (n=4), and aroma (n=4). The fruit attributes were evaluated by a 15-point ascending scale.

Statistical analysis - Data were analysed using MS Excel software. All assays were performed in at least three repetitions. Results were presented as mean ±SD (standard deviation). Fisher's least significant difference test at a level of $P<0.05$ were used to determine the significance of differences between mean values.

RESULTS AND DISCUSSION

The three peach and nectarine varieties were evaluated for their physicochemical attributes (Table 1). "Filina" and "Gergana" were relatively the same in size approximately 135 g each, and "Ufo-4" (86 g) was the smallest. "Ufo-4" had the smallest pit (2.6 g) and "Gergana" had the largest (12.5 g). Differences in the firmness were registered among studied genotypes, with "Gergana" variety having the lowest firmness (1.5 ± 0.23 N) and "Ufo-4" the highest. Low firmness will shorten shelf life of fruit, indicating that the studied varieties cannot be stored for a long period.

Values of the dimensions and shape of peach varieties are presented in Table 2. Results show that "Filina" and "Gergana" varieties produce similar fruit in length, width and thickness. "Ufo-4", on the other hand, has quite different physical properties compared to the other varieties.

Although Alipasandi et al. (2013) have used image processing to classify peach varieties; their approach does no cover the currently evaluated characteristics.

Table 1. Physicochemical attributes of early-ripening peach varieties at harvest

Attribute/Variety	Filina	Gergana	Ufo-4
Fruit weight, g	135.51 ± 9.97ab	138.5 ± 17.99a	86.49 ± 23.4b
Pit weight, g	7.25 ± 2.00a	12.5 ± 1.00a	2.6 ± 0.50ab
Firmness, N	2.65 ± 0.81b	1.50 ± 0.22b	2.93 ± 1.43a
Fruit/pit ratio	3:1	2.5:1	3.5:1

*Means with different letter(s) for each attribute within effects are significantly different (P<0.05) using Fisher's least significant difference test

Table 2. Some physical properties of peach varieties

Attribute/Variety	Filina	Gergana	Ufo-4
Length, mm	61.14±3.33a	62.14±4.36a	32.28±4.26b
Width,mm	66.54±3.59a	66.28±5.52b	66.28±6.25a
Thickness, mm	61.22±2.79a	59.71±5.73b	65.57±5.66a
Geometric mean diameter, mm	62.92	62.65	51.96
Shpericity, %	102.91	100.82	160.95
Surface area, cm^2	124.30	123.26	84.79

*Means with different letter(s) for each attribute within effects are significantly different (P<0.05) using Fisher's least significant difference test

Thus, previous studies have not documented the shape and size of peach varieties in order to make comparison. The shape features of peach varieties are presented in Figure 2.

Perception of food is always a multisensory experience, and attributes such as colour, shape, variety and size, are important when it comes to food selection (Hoppu et al., 2018). Colour can be associated with many properties like spoilage, ripeness, sweetness, etc. (Foroni et al., 2016). Hue angle can be an indicator of ripeness (Shinya et al., 2013) ranging from 45 to 90° (orange to yellow) and 90 to 180° (yellow to green). Fruit ripe from green to yellow/red (McGuire, 1992). Table 3 visually presents the colour of the skin and flesh of the studied peach varieties.

For fruit skin "Ufo-4" had the highest L* value and "Filina" the lowest. Skin hue ranged from 33.45±10.70 to 42.75±29.87. The same tendency was observed considering the L* value of the flesh. The L* values of all studied varieties were in the midrange of transparent and opaque, with lower values for the skin and higher for the flesh. The hue angle ranged from 33.45±10.70 to 92.21±1.89. The flesh had higher hue values indicating a yellowish color, with "Ufo-4" having a yellow flesh, and "Filina" and "Gergana" tending for the red area (Figure 3). The "Ufo-4" variety corresponds to the color attributes of the Effie variety reported by Felts et al. (2019), and "Filina" resembles the color scheme of the Souvenirs variety studied by the same authors. Similarity in the L* values were also recorded by Zhang et al. (2017) where a peach (Xiahui 8) and a nectarine (Xiaguang) variety have been compared.

Detailed information about some chemical and physical properties of the studied early-ripening peach varieties is presented in Table 4. The average ash content of peach varieties documented in literature is 0.50 (Hajilou and Fakhimrezaei, 2011). Both "Gergana" and "Ufo-4" have an average ash content, while "Filina" characterizes with twice the ash content of the other varieties. Back in 1998, Moing et al. (1998) address peaches as high and low acidity.

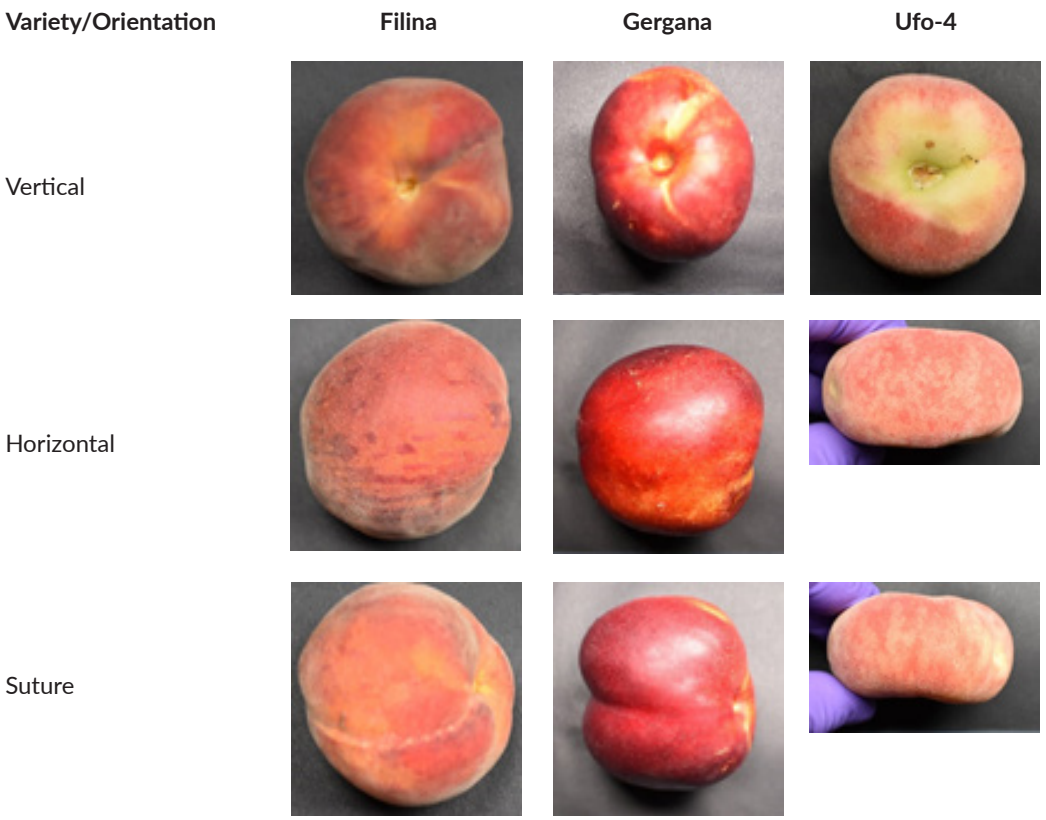

Figure 2. Peach variety samples

Table 3. Skin and flesh color attributes of early-ripening peach varieties

Attribute/variety		Filina	Gergana	Ufo-4
Flesh	L*	64.63±3.39a	65.13±6.33b	70.25±2.35b
	a	11.97±1.93b	14.13±5.59ab	0.76±0.72ab
	b	32.06±6.59ab	52.17±6.91b	18.16±2.65a
	h	69.20±6.75a	74.45±7.80b	92.21±1.89b
Skin	L*	39.39±9.77b	40.44±12.40a	48.63±18.36b
	a	26.84±4.84b	29.50±7.83b	19.63±12.55b
	b	19.63±10.22a	24.32±14.44ab	17.33±7.76a
	h	33.45±10.70b	36.08±16.00ab	42.75±29.87b

*Means with different letter(s) for each attribute within effects are significantly different (P<0.05) using Fisher's least significant difference test

Filina Gergana Ufo-4

Figure 3. Skin flesh color of peach varieties

Table 4. Composition attributes of early-ripening peach varieties

Attribute/Variety	Filina	Gergana	Ufo-4
Dry content, %	15.88±3.18a	14.49±2.52b	12.89±2.81b
Ash, %	0.96±0.12c	0.47±0.03a	0.45±0.04a
TSS, %	10.04	10.00	11.50
TTA % (as malic)	0.44	0.38	0.23
pH	4.40	3.95	4.46
Total sugars, g/100g	2.67	1.84	2.49
Proteins, g/100g	1.05±0.34c	4.07±0.24c	2.18±0.47ab

*Means with different letter(s) for each attribute within effects are significantly different (P<0.05) using Fisher's least significant difference test

With reference to their findings, "Gergana" is considered a high acidity variety, and "Ufo-4" and "Filina" are low acidity with values above 4.0. TSS varied from 11.94 to 15.19 in a study conducted by Zhang et al. (2017). Those values are higher than the currently established results, which is due to the fact, that Zhang et al. (2017) evaluate late ripening varieties. All the variations in the composition attributes could be due to the fact, that the investigated varieties are early-ripening.

Cantin et al. (2010) have found out that flat peaches have the sweetest taste and the highest sugar content. The results from the present study show that the flat peach comes second when evaluating the total sugar content. Sugar content in fruit is predominantly sucrose, glucose, and fructose.

The "Gergana" variety is much similar to the Youtao 4 cultivar described by Wanpeng et al. (2017) when considering pH, total sugar content, titratable acidity and total soluble solids. "Ufo-4" is comparable to the Qingpan cultivar studied by the same authors.

Several indices are used to show the quality of fruit and vegetables. Table 5 presents the sweetness, and maturity indices of the studies peach varieties. "Filina" had the highest sweetness and total sweetness indices, while Ufo-4 possessed the highest maturity index.

Table 5. Quality indices of early-ripening peach varieties

Index/Variety	Filina	Gergana	Ufo-4
Sweetness index	36.90	25.70	33.80
Total sweetness index	26.90	18.60	24.80
Maturity index	22.82	26.32	50.00

In general, stone fruits are highly prized for their unique aesthetic and organoleptic characteristics. However, sensory evaluation gives a better explanation to variety characteristics (Delgado et al., 2013). In the field of food technology, product quality and its sensory evaluation are priority criteria for the consumer. When it comes to fruits, colour, shape, firmness and aroma are the main factors that influence choice. Based on this, panellists evaluated peach/nectarine varieties in five categories with a total of twenty-five attributes (Table 6, Table 7). The panellists detected differences between genotypes in each of the categories (aroma, texture, taste, internal and external appearance).

External colour uniformity ranged from 2.8 to 7.4, where "Gergana" had the highest uniformity. "Gergana" was also the variety with predominantly one colour of its skin. Fruit size was referenced with spheres of different diameters. "Ufo-4" was considered the smallest, and "Gergana" the biggest. Size is strongly correlated with meteorological factors (Wert et al., 2007). Shape was referenced with coloured pictures and according to the panellists' opinions, among the studied varieties; "Ufo-4" had a flat shape, and "Filina" and "Gergana" - an oval. Blemishes and deformities ranged from 1 to 3.5 where "Gergana" was the most compromised variety. Fuzziness between peaches was practically indistinguishable with

Table 6. Descriptive sensory external/internal appearance attributes of peach varieties

Attribute/ Variety	External appearance						Internal appearance			
	Color uniformity	Redness	Yellowness	Deformities	Size	Fuzziness	Color uniformity	Redness	Yellowness	Deformities
Filina	2.8d	2.5a	8.5a	2.0c	9.0b	6.3a	9.6b	9.2ab	1.3b	2.5c
Gergana	7.4ab	8.1ac	2.3ab	3.5a	9.4a	0.0b	8.6a	5.8abc	3.1cd	1.0b
Ufo-4	6.3ab	1.2b	10.6bc	1.0a	6.3b	5.9c	7.8ab	6.8bcd	2.4bcd	1.5c

*Means with different letter(s) for each attribute within effects are significantly different (P<0.05) using Fisher's least significant difference test

Table 7. Descriptive sensory texture, taste, and aroma attributes of peach varieties

Variety/Attribute		Filina	Gergana	Ufo-4
Aroma	Peachy	12.5c	10.7a	11.6a
	Unripe	0.0b	0.0b	1.0b
	Overripe	0.0b	0.0b	0.0b
	Earthy	0.0b	0.0b	0.0b
Taste	Sweet	6.5ab	11.7ab	10.2c
	Sour	0.0b	1.2a	1.0c
	Bitter	0.0b	1.1a	2.0c
Texture	Flesh hardness	12.3a	11.9ac	10.5bc
	Moisture release	7.4ac	13.6b	11.7ab
	Crispiness	9.8bc	12.2c	11.5bc
	Presence of fibres	3.2b	5.7cd	7.0ab

*Means with different letter(s) for each attribute within effects are significantly different (P<0.05) using Fisher's least significant difference test

the exception of "Gergana", a nectarine, where the score was a 0.0.

The panellists detected significant differences while evaluating the internal appearance of the varieties (Table 6). Uniformity of colour ranged from 7.8 to 9.6. Yellowness ranged from 1.3 to 3.1, and redness – from 5.8 to 9.2. "Filina" had the least yellowness and the most redness (Figure 2). All varieties were evaluated as such with a pit difficult to extract/separate. This is quite expected because all early-ripening varieties are clingstone. Pit size was also characterized, and varied from small ("Ufo-4") to medium ("Filina" and "Gergana"). Pit shape was described as round for "Ufo-4", elliptic for "Gergana", and leafy-like for "Filina". "Gergana" and "Filina"'s pits tend to split in half, and "Ufo-4"'s pit stayed intact.

Sweet, sour, and bitter were the basic tastes evaluated in the peach varieties (Table 7). Sourness ranged from 0 to 1.2 and bitterness - from 0 to 2.0. This showed that the panellists could not practically distinguish those two tastes in the peaches. "Gergana" was the sweetest of all varieties and "Filina" was considered the least sweet. These two varieties has quite similar TSS values (Table 4) and it is interesting that the panellists can state a difference in the intensity of the sweet taste.

Fruit texture was also evaluated. Flesh hardness, moisture release, crispiness, and fibre presence were the attributes described by the panellists. "Ufo-4" had the hardest flesh and "Filina" – the least moisture release. Moisture release is directly associated with the amount of liquid releasing in the mouth after one chew. This corresponds well to the results established about the fruit firmness (Table 1). Studies have shown that consumers prefer peaches that were sweet, juicy, round, and freestone peaches (Olmstead et al., 2015). Young consumers choose crisp, firm peaches, whereas older consumers search for sweet, melting-texture peaches (Delgado et al., 2013). In the current study, crispiness ranged from 9.8 to 11.5. "Gergana's" fruit meat was considered the softest and easiest to chew, while "Ufo-4" was the variety with the most present fibres between teeth after chewing the sample three to five times.

CONCLUSION

The present work provides new information about the physicochemical, composition and sensory attributes of three early-ripening peach varieties: "Filina", "Gergana", and "Ufo-4". This research evidenced that panellists considered the "Gergana" variety the sweetest, softest and easiest to chew from all evaluated early-ripening peaches. In terms of sugar content, "Filina" had the highest values and the highest sweetness index.

The current findings have also shown that "Filina" and "Gergana" varieties produce similar fruit in length, width and thickness. These results give a detailed profile of two understudied Bulgarian peach varieties, which can potentially lead to the diversification of daily diet and market availability. The present study could be considered as the first exhaustive information in respect of the abovementioned varieties. Both similarities and differences occurred in the intensity of attributes described by the trained panellists and the results obtained by scientific measurements. Further studies can look into a more thorough profile of the presented varieties.

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