



Biometric data of peach and nectarine fruit and stones

A. Zhivondov¹, S. Savchovska¹, S. Pandova¹, D. Petkova^{2*}, P. Doykina³, I. Manolov⁴

¹Department of Breeding and Genetic Resources, Fruit Growing Institute, 4000 Plovdiv, Bulgaria

²Department of Biotechnology, Technological Faculty, University of Food Technologies, 4002 Plovdiv, Bulgaria

³Department of Catering and Tourism, Economics Faculty, University of Food Technologies, 4002 Plovdiv, Bulgaria

⁴Department of Agrochemistry and Soil Science, Faculty of Agronomy, Agricultural university, 4000 Plovdiv, Bulgaria

(Manuscript received 3 June 2021; accepted for publication 26 July 2021)

Abstract. The article presents a three-year traceability (2018, 2019, 2020) of biometric results of the fruits of eight peach and nectarine varieties. The study covers the fifth, sixth and seventh vegetation period from the period of full fruiting. Varieties included in this investigation were "Filina" (peach, clingstone), "Gergana" (nectarine, clingstone), "July Lady" (peach, semi-clingstone), "Ufo 4" (flat peach, semi-clingstone), "Laskava" (peach, freestone), "Morsiani 90" (nectarine, freestone), "Flat Queen" (flat peach, freestone), and "Evmolpiya" (peach, freestone). The experimental collection plantation was created in the spring of 2014 on the territory of the Fruit Growing Research Institute, Plovdiv, (lat. 42.10384828045957 and long. 24.72164848814686). The data analysis shows that the varieties "Laskava" and "Evmolpiya" produce fruits with the highest weight - 319.60 g and 303.60 g, respectively. Medium weight is registered in the "Morsiani 90" variety (226.07 g) and the "July Lady" variety (193.87 g). "UFO 4" is characterized with the smallest fruits – an average of 143.83 g and the highest flesh yield. Considering the fact that the "Filina" variety is very early ripening, its fruits can be treated as large for the season - 170.21 g. The stones of the "July Lady", "Morsiani 90" and "Evmolpiya" varieties have the largest average mass.

Keywords: fruit biometrics, fruit stones, fruit weight, nectarines, peaches, *Prunus persica* (L.) Batsch

Introduction

Peaches and nectarines are among the most profitable fruit crops grown in Bulgaria (MAFF, 2019). The second half of the XX and the first two decades of the XXI century mark a historically unique, qualitative leap in the development of the peach and nectarine assortment. Today, the dynamics of the varieties is extremely high. This is determined by the significantly shorter life of peach orchards compared to those of other fruit species and, above all, by the large supply of newer varieties. Consequently, arises the need for rapid comprehensive studies of varieties in order to introduce the best in the new peach and nectarine plantations. (Zhivondov et al., 2020).

The great diversification of peach varieties is mainly due to the long history of breeding programs (Cantin et al., 2010). Today, there are many worldwide breeding programs targeting to improve the physical and chemical qualities of the peach and nectarine varieties. Breeding studies are long known in the field of horticulture. They usually aim at quality improvement, alternation of ripening period, disease control, chilling properties, etc. (Küden et al., 2018). The two best-developed tasks in almost all programs are the calendar ripening period of the fruits and the low temperature impact for varieties intended for cultivation in areas with a Mediterranean climate (Fideghelli,

2002; Bellini, 2005; Sansavini et al., 2006; Zhivondov, 2009; Zhivondov et al., 2020). Frost damage is one of the main limiting factors in the production and distribution of fruits worldwide, despite the numerous research efforts to reduce it.

Representatives of the genus *Prunus* are of great agricultural importance in Bulgaria, and in particular the *Prunus persica* L. Batsch varieties. In Bulgaria, there is a certain lag with the introduction of new varieties in production. In the 1960s, after the initial partial enrichment of genetic resources, by introducing new for the period varieties from abroad, a significantly higher level selection, pomological and genetic research on peach and nectarine varieties started (Petrov and Grigorov, 1981; Zhivondov, 2009).

The first organized and official breeding program for improving the peach and nectarine assortment in Bulgaria was launched in 1989 at the Fruit Growing Institute - Plovdiv. As a result of this program, 5 new dessert varieties ("Flavia", "Filina", "Puldin", "Laskava", "Evmolpiya"), 1 canned ("Spasena") and 1 nectarine ("Gergana") were created, four of which are included in the current study (Zhivondov, 2009, 2010a,b; Zhivondov and Dabov, 2010; Zhivondov et al., 2015). Initial pomological studies of newly introduced peach and nectarine varieties with a flat shape were conducted in order to accelerate their introduction in the agricultural production (Zhivondov et al., 2019).

*e-mail: dorina.petkova95@gmail.com

The recent revival in the introduction of new peach and nectarine varieties, as well as the new Bulgarian varieties, necessitate a rapid study of their pomological characteristics and economic qualities. As a result of such research, the best varieties will be recommended in the varietal structures of the new plantations. When evaluating new cultivars and varieties, it is important to gain knowledge about the aspects of production, potential breeding, as well as some quality indicators. This situation determines the purpose of the present study - to establish the biometric parameters of peach and nectarine fruit varieties, object of this investigation.

Material and methods

The present study comprised of eight varieties from three different pomological groups, covering a long period of the country's peach ripening season. The dessert peach group is covered by the very early "Filina", the mid "July Lady", the late "Laskava" and the very late "Evmolpiya" varieties. Nectarines are represented by the early Gergana and the late Morsiani 90 varieties. The early "Ufo 4" and late "Flat Queen" varieties, which have a flat fruit shape, were also included in the study.

The research was conducted during the period 2018-2020, when the trees were in the fifth, sixth and seventh vegetation periods, respectively, from their full fruiting. The collection plantation was established at the Fruit Growing Institute in Plovdiv BG (lat. 42.10384828045957 and long. 24.72164848814686) in the spring of 2014 at planting distances 5 m between rows and 3 m between trees in a row (Figure 1). All varieties are grafted on a peach seed rootstock and are grown by the system of free-growing crown. The plantation is

grown using standard peach and nectarine technology, the black fallow system, and the conventional plant protection.



Figure 1. Peach orchard, Fruit Growing Institute, Plovdiv

Biometric measurements of the fruits and stones (height, width, thickness) of the monitored varieties were made with a digital caliper connected to a data logger at the specialized laboratory for breeding, selection and pomology of the Fruit Growing Institute, Plovdiv. Fruit and stone weight were established with the use of Kern 572 digital scale (Kern & Sohn GmbH). For this purpose, randomized samples of 25 fruits per variety were measured, after having been collected in full maturity from all parts of the tree crowns.

Xlstat Pro software was used to statistically analyze the data.

Results and discussion

The peach fruit development period is highly dependent on the variety (Rodriguez et al., 2019). The harvest date may change every year depending on the climatic conditions and especially temperature. Table 1 is a brief presentation of the studied varieties.

Table 1. Peach varieties characteristics, object of analysis

Variety	Type	Flesh colour	Harvest date			Harvest time (days after full bloom)		
			2018	2019	2020	2018	2019	2020
"Filina"	P	Y	12 June	21 June	20 June	91	83	88
"Gergana"	N	Y	19 June	6 July	30 June	95	107	106
"Ufo 4"	FP	W	27 June	11 July	3 July	133	110	109
"July Lady"	P	Y	12 July	17 July	15 July	117	116	117
"Laskava"	P	Y	1 August	9 August	5 August	138	139	136
"Evmolpiya"	P	Y	9 Sept	16 Sept	15 Sept	173	176	169
"Flat Queen"	FP	W	1 Sept	4 Sept	3 Sept	165	164	164
"Morsiani 90"	N	Y	17 Sept	25 Sept	23 Sept	180	186	184

*P- peach; N- nectarine; FP- flat peach; Y- yellow; W- white.

All of the studied varieties have a very predictable harvest time. The early ripening varieties are ready after approximately 83 to 100 days after full bloom. The late ripening varieties have a harvest time of 165-186 days after full bloom. The year 2020 is marked with the shortest harvest times with the exception of the early ripening variety "Filina" where a delay of 5 days is registered.

The data analysis from the three-year biometric studies undoubtedly shows that the fruits of the peach varieties "Laskava" - 319.60 ± 66.22 g and "Evmolpiya" - 303.60 ± 25.46 g are the biggest in weight, and in size compared to the other varieties (Table 2).

Table 2. Biometric data for fruits, averaged for the period 2018-2020

Variety	Fruit weight, g	Fruit sizes, mm			Flesh yield, %
		height	width	thickness	
"Gergana"	159.47±33.44 ^{de}	67.24±2.87 ^c	69.97±6.01 ^e	64.17±5.67 ^d	95.17
"July Lady"	193.87±61.30 ^c	35.83±7.64 ^c	72.77±8.89 ^{de}	70.43±5.78 ^c	95.01
"Evmolpiya"	303.60±25.46 ^a	78.49±2.96 ^a	86.52±1.49 ^a	81.57±3.48 ^{ab}	96.89
"Laskava"	319.60±66.22 ^a	76.75±6.55 ^a	86.44±5.30 ^a	84.47±3.90 ^a	97.48
"Morsiani 90"	226.07±65.90 ^b	72.23±9.17 ^b	75.77±7.25 ^{cd}	74.29±7.26 ^c	95.73
"Ufo 4"	143.83±19.22 ^e	38.32±3.16 ^e	78.04±5.33 ^{bc}	80.42±3.95 ^{ab}	97.98
"Filina"	170.21±27.06 ^{cd}	67.84±3.06 ^c	71.94±5.36 ^{de}	65.80±4.05 ^d	95.83
"Flat Queen"	178.05±14.88 ^{cd}	46.85±1.88 ^d	81.03±3.59 ^b	79.81±5.81 ^b	97.83

*Values followed by the same letter are not significantly different ($p>0.05$) by Duncan's multiple range test

The fruits of the nectarine variety "Morsiani 90" (226.07±65.90 g) are quite big, with statistical difference compared to the other studied varieties. The fruits of the "July Lady" variety (Figure 2), with average weight of 193.87±61.3 g, are large enough. The smallest fruits belong to the "Ufo 4" variety - 143.83±19.22 g. It is not uncommon for flat fruit varieties to have a lower average weight than the traditional round-shaped varieties (Cantin et al., 2010). Similar findings have been recorded in previous studies (Zhivondov et al., 2019). Unlike the "Ufo 4" variety, "Flat Queen", which is from the same pomological group of flat fruits, demonstrates a significantly higher mass per fruit - 178.05±14.88 g. This differentiation in fruit weight is due to the notable interval in the ripening period of the fruits. The "Ufo 4" variety is early ripening, while "Flat Queen" is a late season variety. It is known that late maturing varieties form larger fruits than those with an earlier ripening period. Similar assumptions can be found in the paper of Mihaylova et al. (2021b). An exception to this rule is the early ripening "Filina" variety, the fruit of which have an average weight of 170.21±27.06 g. Although its fruits ripen around June 20, the average fruit weight is comparable to that of the late "Flat Queen" variety and to some extent to that of "July Lady". According to this indicator, the "Filina" variety is superior to the nectarine variety "Gergana" and to the flat "Ufo 4", although the fruits of the last two varieties ripen about 20 days later than those of "Filina". Similar observations about the size and weight have been recorded in the paper of Mihaylova et al. (2021a) concerning the physical properties of mid-season peach varieties.

**Figure 2.** Fruit samples from the tested varieties

Varieties with a higher average fruit weight usually have larger size. In all studied varieties with round shape of the fruit, the largest size is the width of the fruit. In the varieties with flat fruits, the height of the fruit is the smallest. The average values of the height vary from 38.32±3.16 mm in "Ufo 4" to 78.49±2.96 mm in "Evmolpiya" (Table 2). The values of the fruit width are in the range from 69.97±6.01 mm ("Gergana" variety) to 86.52±1.49 mm ("Evmolpiya" variety). Fruit thickness is the smallest in the "Gergana" variety (64.17±5.67 mm) and the largest in the "Laskava" variety (84.47±3.90 mm). The results are comparable to the ones documented by Popova et al. (2021) where different physicochemical and sensory attributes of early ripening varieties are observed.

The lowest average yield was in 2018 when the fruit weight of the studied varieties was the smallest. The other two study years were marked with heavier fruits from the early ripening to the late ripening varieties, with 2019 being the year with the highest parameters. Higher yielding varieties proved to be those harvested in the mid-season, while early ripening nectarine varieties ("Gergana") are lower yielding. Fruit weight in the peach varieties ("Filina", "July Lady", "Laskava", "Evmolpiya") was considerably higher than the fruit weight in nectarine ("Gergana", "Morsiani 90") and flat peach ("Ufo 4", "Flat Queen") varieties.

"Morsiani 90" is marked with a 2/3 increase in the peach size, as well as an increase of the stone. Similarly, during the tested period "July Lady" doubles both its fruit and stone size. "Filina", an early ripening variety, is characterized with an increased yield because of its increasing size and decreasing stone. The studied flat peaches and nectarines are tending for a slightly decreasing yield due to the increased stone size and smaller weight.

The flesh yield is an important indicator of how much of the total mass of fruit is used for consumption. The smaller the stone, the larger the usable part of the fruit. Yield depends on the genetic background of the variety, and agronomic and environmental factors (Dirlewanger et al., 1999; Milatović et al., 2010). The data show that the highest flesh yield is in the "Ufo 4" variety - 97.98%. Over 97% is also the flesh yield of the varieties "Flat Queen" and "Laskava".

The average three-year biometric data for the stones of the studied eight varieties of peaches and nectarines show that the highest average weight is that of "July Lady" - 9.68±3.14 g, "Morsiani 90" - 9.66±2.31 g and "Evmolpiya" - 9.44±1.62

g (Table 3). Their values have statistical differences ($p < 0.05$) compared to those of the other four studied varieties. The

smallest are the stones of both varieties with flat fruits “Ufo 4” - 2.90 ± 0.41 g and “Flat Queen” - 3.87 ± 0.73 g (Figure 3).

Table 3. Biometric data for stones - average values for the period 2018-2020

Variety	Weight of the stone, g	Stone dimensions, mm			Relative share of the stone, %
		height	width	thickness	
“Gergana”	7.71 ± 0.85^b	38.88 ± 2.89^{ab}	20.20 ± 1.56^{bc}	26.19 ± 1.74^c	4.83
“July Lady”	9.68 ± 3.14^a	36.05 ± 3.49^{bc}	21.40 ± 2.54^{ab}	26.66 ± 3.9^{bc}	4.99
“Evmolpiya”	9.44 ± 1.62^a	40.73 ± 2.61^a	21.89 ± 1.99^{ab}	29.08 ± 1.66^a	3.11
“Laskava”	8.06 ± 1.64^{ab}	35.98 ± 3.61^{bc}	19.18 ± 1.37^c	27.30 ± 2.31^b	2.52
“Morsiani 90”	9.66 ± 2.31^a	41.76 ± 7.23^a	22.70 ± 4.40^a	28.62 ± 4.47^a	4.27
“Ufo 4”	2.90 ± 0.41^c	12.86 ± 0.87^d	19.39 ± 1.57^c	21.47 ± 1.22^e	2.02
“Filina”	7.10 ± 1.66^b	35.78 ± 3.09^c	19.17 ± 1.36^c	25.07 ± 2.51^d	4.17
“Flat Queen”	3.87 ± 0.73^c	15.02 ± 0.81^d	21.97 ± 1.54^{ab}	22.37 ± 1.41^e	2.17

*Values followed by the same letter are not significantly different ($p > 0.05$) by Duncan’s multiple range test

The relative proportion of the stone to the whole fruit is a reciprocal indicator of the fruit flesh and shows what part of the whole fruit is unfit for consumption. The smaller the mass of the stone, on the one hand, and at the same time the greater the mass of the fruit, on the other, the smaller the relative share of the stone. This is one of the selection goals of the programs for creating new peach and nectarine varieties. In the study, the values of the relative proportion of the stone are in the range of 2.02% in “Ufo 4” variety, to 4.99% in “July Lady” variety.



Figure 3. Stone samples of peach varieties (1- “Flat Queen”; 2- “Filina”; 3- “Morsiani 90”; 4- “July Lady”; 5- “Ufo 4”; 6- “Gergana”; 7- “Laskava”; 8- “Evmolpiya”)

The relative share of the stone is also small in the varieties “Flat Queen”, “Laskava” and “Evmolpiya”. There are no varieties with a high relative share of the stone (8-10%) in the studied group. Stones, themselves, are an interesting research topic as the current scientific teams aim at repurposing waste, and green and circular economy. Peach stones can be used in the fields of food production (as flour, functional ingredient), cosmetics (functional ingredient), biotechnology, etc.

Conclusion

The studied diverse pomological samples of peach and nectarine varieties have distinct physical properties. The varieties “Laskava” and “Evmolpiya” have the fruits with the highest weight. Given the early ripening of the “Filina” variety, its fruits can be categorized as large for the season. Among the flat peach varieties, when it comes to proximate weight, “Flat Queen” and “Ufo 4” are at a ratio 1.2:1.0. Given the established low share of the stones, all of the studied varieties are with high flesh yield. The eight selected varieties can justifiably occupy a proper share of the areas in the newly established orchards demonstrating the value of traditional fruit growing by newly established recombination.

Acknowledgment

This work was partially supported by the Ministry of Education and Science Scientific Research Fund, Bulgaria, project KP-06-H37/23 – 2019.

References

- Bellini E, Natarelli L and Nencetti V**, 2005. Cultivar di pesco e nectarine diffuse e consigliate in Italia e risultati ed obiettivi del miglioramento genetico. *Il Pesco, Moderni indirizzi di allevamento, coltivazione, difesa, irrigazione, nutrizione, conservazione, trasformazione e mercato*. Bologna, 25-56 (I).
- Cantín CM, Gogorcena Y and Moreno MA**, 2010. Phenotypic diversity and relationships of fruit quality 487 traits in peach and nectarine [*Prunus persica* (L.) Batsch] breeding progenies. *Euphytica*, 171, 211-226.
- Dirlwanger E, Moing A, Rothan C, Svanella L, Pronier V, Guye A, Plomion C and Monet R**, 1999. Mapping QTLs controlling fruit quality in peach [*P. persica* (L.) Batsch]. *Theoretical and Applied Genetics*, 98, 18-31.
- Fideghelli C**, 2002. The Italian national peach breeding project. *Acta Horticulturae*, 592, 73-79.
- Küden A, Sarier A, Çömlekçioğlu S, İmrak B and Küden A**,

2018. Peach breeding studies in Turkey and the evaluation of peach and nectarine hybrids. IntechOpen Book: Breeding and Health Benefits of Fruit and Nut Crops, Jaya Soneji Madhugiri Nageswara-Rao, Editör, IntechOpen Book, Frankfurt, pp. 47-62.
- Mihaylova DS, Popova A, Dessev T and Petkova N**, 2021a. Mid-season peach varieties – physicochemical and sensory profile, IOP Conf. Series: Materials Science and Engineering, 1031, ISSN 1757-899X.
- Mihaylova DS, Popova A, Desseva I, Petkova N, Stoyanova M, Vrancheva R, Slavov AM, Slavchev A and Lante A**, 2021b. Comparative study of early- and mid-ripening peach (*Prunus persica* L.) varieties: biological activity, macro-, and micro-nutrient profile. Foods, 10, 1, ISSN 23048158.
- Milatović D, Nikolić D and Đurović D**, 2010. Variability, heritability and correlations of some factors affecting productivity in peach. Horticultural Science, 37, 79-87
- Ministry of Agriculture, Food and the Forestry (MAFF)**, 2019. Annual report on the state and development of agriculture, Sofia, Bulgaria (Bg). Available at: https://www.mzh.government.bg/media/filer_public/2020/02/11/agrarian_report_2019.pdf
- Petrov A and Grigorov Y**, 1981. Peach. Publishing house 'Hr. G. Danov', Plovdiv, Bulgaria (Bg).
- Popova A, Dessev T, Mihaylova DS and Petkova N**, 2021. Physicochemical properties and sensory evaluation of early ripening peach and nectarine varieties. Journal of Central European Agriculture, 22, 146-155.
- Rodriguez CE, Bustamante CA, Budde CO, Müller GL, Drincovich MF and Lara MV**, 2019. Peach fruit development: A comparative proteomic study between endocarp and mesocarp at very early stages underpins the main differential biochemical processes between these tissues. Frontiers in Plant Science, 10, 715. DOI:10.3389/fpls.2019.00715
- Sansavini S, Bassi D and Gamberini A**, 2006. Miglioramento varietale del pesco: genetica e genomica per nuove tipologie di frutto. Tendenze in California, Francia e Italia. Rivista di Frutticoltura e di Ortofloricoltura, 7/8, 16-28 (Sp).
- Zhivondov A**, 2009. Main results of the selection programs for stone fruit species in the Institute of Fruit Growing - Plovdiv. Plant science, 3, 195-200 (Bg).
- Zhivondov A**, 2010a. Filina - a new early peach cultivar. Voćarstvo (Pomology), 44(171/172), 83-86.
- Zhivondov A**, 2010b. Gergana - the first Bulgarian nectarine cultivar. Voćarstvo (Pomology), 44(171/172), 95-98.
- Zhivondov A and Dabov S**, 2010. 'Laskava' - a new peach cultivar resistant to powdery mildew disease (*Sphaerotheca pannosa* (Wallr.: Fr.). Acta Horticulturae, 940, ISHS (183-186).
- Zhivondov A, Dabov S and Bozhikova Y**, 2015. 'Evmolpiya' - a new Bulgarian peach cultivar resistant to leaf curl disease (*Taphrina deformans*). Acta Horticulturae, 1139, ISHS (67-70).
- Zhivondov A, Malchev S and Pandova S**, 2019. Biometric parameters of fruits and stones of newly introduced flat fruit peach cultivars-*Prunus persica* (L.) Batsch. F. Compressa. Journal of Agricultural, Food and Environmental Sciences, JAFES, 73, 12-16.
- Zhivondov A, Savchovska S and Pandova S**, 2020. Trends and dynamics in the development of the modern assortment of peach and nectarine. Plant protection, 2, 59-70.