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Product Quality and Safety

Dynamic biometric data, total soluble solids, ash content, firmness, and color characteristics of two peach varieties

S. Pandova[1], D. Mihaylova[2], A. Popova[3], S. Savchovska[1], A. Zhivondov[1]

[1]Department of Breeding and Genetic Resources, Fruit Growing Institute, 4000 Plovdiv, Bulgaria
[2]Department of Biotechnology, Technological Faculty, University of Food Technologies, 4002 Plovdiv, Bulgaria
[3]Department of Catering and Nutrition, Economics Faculty, University of Food Technologies, 4002 Plovdiv, Bulgaria

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Abstract. *The present study tracks changes in the development of two native peach varieties (“Laskava” and “Evmolpiya”) from fruit formation to full ripening within five calendar weeks. In search for a non-destructive method for maturity assessment, the parameters firmness, color, size, weight, dry weight, ash content, and TSS values were evaluated. It was found that a 30% increase in size and a 1.8-2 times increase in weight occurred during the ripening period. The TSS data did not change radically, which shows that the main nutrients of the peach accumulate in the early stages of development. The color indicators change in the following trend: a decrease in the “L”, “h” and “b” values, and a tendency of increase in the “c” values. The stone size does not change drastically during the evaluation time. The moisture content also does not change significantly, although in the initial stage of fruit growth it cannot be characterized by juiciness. Firmness progressively decreases.*
The obtained results show grounds for the creation of a database of expected markers which may indicate the onset of maturity without the fruit being pulled from the tree or damaged.

Keywords: maturity assessment, peaches, *Prunus persica* (L.) Batsch

Introduction

Prunus trees can be seen in orchards and urban areas. Flowers are white or pink, usually with 5 petals. The peach (*Prunus persica* (L.) Batsch) is mentioned as the third most economically important fruit crop grown in temperate zones, but is also used as a model species along with apple and diploid strawberry based on the unique characteristics, making it very suitable for targeted genomic research (Shulaev et al., 2008). The peach tree most probably originated from China, and then extensively spread throughout Europe and some parts of Asia (Zheng et al., 2014).

Fruit quality is directly related to the consumer’s expectations and to the relationship between climate and characteristics such as size, shape, color, chemical composition of the fruit. Ripening is a complicated process that involves changes in the color, texture, flavor, and aroma of fruits (Begheldo et al., 2008). One of the indicators used and accepted by many scientists to monitor climate change is the phenology of fruit trees (Rötzer and Chmielewski, 2001).

Phenology originates from Greek, meaning “to show”, “to bring light”, which corresponds well to the main task of this research field, to follow and record the visible changes in the biological development. Phenology is the ideal way to demonstrate the effects of global warming on the living world (Sparks and Menzel, 2002). Knowledge about the

*e-mail: popova_aneta@yahoo.com

phenological cycles provides invaluable information about the specific geographic and climatic descriptors of an area (Jensen, 2000). The ability to create phenological models greatly supports breeding programs' success. Different methods of observation can be applied including a monthly estimation of each phenophase through a visual inspection of ten target plants or a monthly monitoring of all the leaves, buds, flowers and fruits borne on five tagged branches throughout an annual cycle. Regardless of the method, a calendar of the leaf production and shedding, development of inflorescence and flower buds, flowering, fruit setting and seed dispersal is drawn (Castro-Díez et al., 2003). Plant phenology is not equipment costly, and lays on specific observations of the plants' development (Li et al., 2021). Camera-based phenology allows an immediate observation of specific vegetations from various habitats worldwide and provides data that can be linked to ecosystem structural and functional measurements (Alberton et al., 2017). Scientists are encouraged to produce long-term phenological records since they give valuable information not only about climate change consequences, but also about plants' adaptability in the environment.

Two phases characterize the annual cycle of the genus Prunus: hibernation (dormancy) and shoot growth. Dormancy is divided into three phases: paradormancy, endodormancy and ecodormancy (Prudencio et al., 2021). Endodormancy (accumulation of chill hours) in temperate fruit trees like *Prunus* is a protector state that allows the trees to survive in the adverse conditions of autumn and winter. A certain amount of chill hours is required (chilling requirements) for the flower buds to release from endodormancy. The global warming and temperature change greatly endangers the fulfillment of the chilling requirements, which is a vital step for the proper flowering and fruit set (Guillamón et al., 2022). That is why temperature is seen as the most important factor when it comes to the duration of the hibernal period. The chilling hour requirements cannot be seen as a constant value because plants adapt to the geographical zone they grown in. For example, low chilling requirements are documented for *Prunus persica* located in the subtropical zones (Sawamura et al., 2017). A thorough study (Fadón et al., 2020) of the chilling and heat requirements of *Prunus* spp. reveals that statistical models can aid the prediction of different phases, but still different methodologies exist which makes it harder to standardize and unify results.

When dormancy ends, different external phases, known as phenological stages, occur. The phenological changes have been intensely studied and classified according to their development from dormancy to fruit set. Changes in climatic conditions have the strongest impact on the annual seasonal dynamics of perennial plants, especially at the beginning of their vegetation (Wielgolaski, 1999; Menzel et al., 2008). Persistence of flowers on trees for a longer time is a positive characteristic of cultivar's adaptation to unfavorable conditions for pollination, a longer duration of flowering, including a higher number of days that are favorable to the flight of bees and securing the pollination (Cosmulescu et al., 2010). Floral bud development is affected by the plant genotype, age, health, position and density in the shoot, climatic conditions, geographical region, agrotechnical methods, pesticide application (Szalay, 2006).

The non-destructive on-plant assessment of fruit ripeness offers a number of positive characteristics and is gaining scientific interest (Li et al., 2018). Most often the color, firmness, total soluble solids (TSS) content, ethylene concentration, changes in shape and size are chosen as attributes for evaluation. The color is an important characteristic in agricultural produce since consumers judge the maturity of the product by its external color and overall appearance. Research teams have focused on different approaches for non-destructive detection of fruit maturity usually relying on spectroscopy methods (Uwadaira et al., 2018).

The objective of this study was to assess the maturity of two peach varieties through the parameters firmness, color, size, weight, dry weight, ash content, and TSS values in search for an inexpensive and effective non-destructive method for evaluation.

Material and methods

Fruit sample collection

Fruit samples from two native peach varieties were objects of this study: „Laskava“ and „Evmolpiya“. Samples of each variety were collected at the last five weeks prior to full ripening (season 2021) based on phenology observations. Samples were taken from two specific trees per variety grown in the same plantation of the Fruit Growing Institute-Plovdiv, Bulgaria (42°0607.0N 24°4330.7E), each week, on Friday morning, between 6 and 8 am.

Size, weight

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

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 parameters

A PCE-CSM 2 (PCE-CSM instruments, Deutschland) with a measuring aperture of 8 mm was used to analyze the color parameters of the flesh and skin. Fruit flesh was measured immediately after cutting the peach. The L* (lightness; ranging from 0 to 100), a (representing red-green opponent colors), b (representing blue-yellow opponent colors), chroma (color saturation), and hue angle (color tone) were estimated.

Moisture and ash content

Total moisture content of the samples was determined according to the procedure described in AACC method 44-15.02 (Analysis, n.d.) and the ash content of the samples was determined according to the AOAC Official Method 942.05 (Cunniff and Washington, 1997).

Total soluble solids

Total soluble solids (TSS) expressed as % were measured using a digital handheld refractometer (Opti Brix 54, Bellingham + Stanley, United Kingdom).

Statistical analysis

Data were analyzed using MS Excel software. Results were presented as mean ±SD (Standard Deviation). Relevant statistical analyses of the data were performed using one-way ANOVA and a Tukey–Kramer post hoc test (α = 0.05), as described by Assaad et al. (2014) The Pearson's correlation coefficients between moisture content, biometry, ash, TSS, and color parameters have been plotted with the use of Excel STAT Cloud function in Microsoft Excel 365 software.

Results and discussion

The development of two native peach varieties ("Laskava" and "Evmolpiya") from fruit formation to full ripening within six calendar weeks was tracked through several destructive and non-destructive methods (Figure 1).

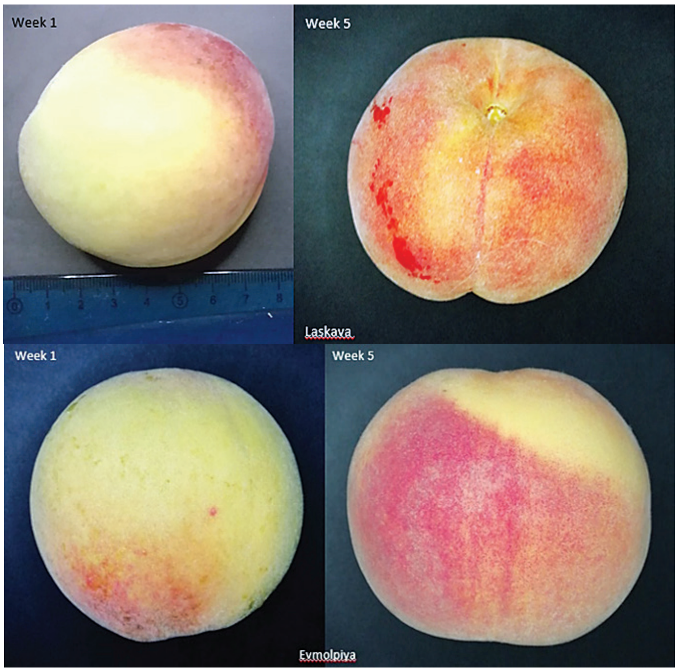

Figure 1. Fruit samples at week 1 and week 5

At week 6 both varieties have reached their full ripeness on August 6th („Laskava") and September 14th („Evmolpiya"), respectively. The „Laskava" variety is usually characterized with a shorter harvest time (136-139 days after full bloom) compared to „Evmolpiya" (169-176 days after full bloom) (Zhivondov et al., 2021). Table 1 visually represents the size and weight changes during the period of evaluation, starting July 9th, 2021 („Laskava") and August 6th, 2021 („Evmolpiya").

Table 1. Weight and size development of fruit samples (T – thickness, W – width, L – length)

Sample	Fruit weight, g	Pit weight, g	Fruit size, mm			Pit size,mm		
			T	W	L	T	W	L
„Laskava“								
Week 1	113.51±1.83^{b}	13.21±1.89^{a}	60.22±4.51^{a}	61.24±5.40^{a}	62.75±4.03^{a}	43.17±0.05^{a}	31.13±0.17^{a}	26.11±0.14^{b}
Week 2	178.82±4.50^{ab}	15.01±1.56^{a}	68.27±2.39^{a}	70.78±1.26^{a}	70.78±0.52^{a}	27.11±0.55^{bc}	34.14±0.25^{a}	45.16±0.65^{a}
Week 3	189.46±13.11^{ab}	16.27±0.97^{a}	68.77±1.23^{a}	72.28±1.26^{a}	70.22±4.03^{a}	30.11±0.36^{b}	34.14±0.47^{a}	45.18±0.29^{a}
Week 4	175.81±7.29^{ab}	14.35±0.76^{a}	68.84±1.45^{a}	73.36±1.06^{a}	70.33±0.47^{a}	N/A	N/A	N/A
Week 5	169.33±2.91^{ab}	12.62±0.05^{a}	69.09±1.39^{a}	69.63±3.68^{a}	63.24±7.81^{a}	N/A	N/A	N/A
Week 6	298.13±99.87^{a}	11.64±2.83^{a}	90.10±27.45^{a}	90.68±23.29^{a}	83.09±19.11^{a}	23.25±3.53^{bc}	31.10±4.05^{a}	39.97±4.03^{a}
„Evmolpiya“								
Week 1	128.43±6.42^{b}	13.21±2.31^{a}	63.74±7.50^{a}	64.88±8.20^{a}	63.06±2.69^{a}	N/A	N/A	N/A
Week 2	122.11±12.72^{b}	15.10±2.62^{a}	59.35±1.33^{a}	62.93±1.66^{a}	63.77±3.01^{a}	26.89±0.89^{bc}	33.95±0.47^{a}	44.67±0.16^{a}
Week 3	216.66±6.55^{ab}	14.84±0.67^{a}	73.97±4.95^{a}	78.01±5.51^{a}	68.04±3.70^{a}	29.08±0.19^{bc}	30.73±0.98^{a}	43.56±2.40^{a}
Week 4	247.36±32.04^{ab}	15.07±1.83^{a}	80.69±9.25^{a}	84.22±3.12^{a}	76.24±3.51^{a}	27.29±3.16^{bc}	33.45±3.17^{a}	46.00±2.75^{a}
Week 5	199.36±40.11^{ab}	11.23±0.01^{a}	68.01±9.05^{a}	70.76±2.92^{a}	67.25±3.05^{a}	22.39±0.01^{c}	29.78±0.48^{a}	41.63±2.75^{a}
Week 6	213.68±39.34^{ab}	11.07±1.16^{a}	72.05±11.26^{a}	80.23±19.25^{a}	75.61±19.33^{a}	23.43±2.26^{bc}	29.59±1.06^{a}	41.96±1.28^{a}

Different letters in the same column indicate statistically significant differences ($p < 0.05$), according to ANOVA (one-way) and the Tukey test.; N/A – not available

It can be seen that both samples have increased in weight, but a clear ascending week-trend cannot be observed. When the size measurements are taken into account, the thickness value shows a steady increase only for the „Laskava“ variety. Significant changes are observed at week 6 of the evaluation where all three size parameters have increased. When the pit size was evaluated, samples from the „Laskava“ variety at weeks 4 and 5 could not be obtained due to breakage (not splitting) of the stone and an inability to correctly measure the size. The same event was observed with the „Evmolpiya“ variety at week 1 of its evaluation. Fruit size is seen as a factor affecting firmness in a lot of research papers (Ehsani-Moghaddam and DeEll, 2013).

Fruit softening, an important part of the ripening, is due to changes in the cell wall structure. At week four of the samples observation, the firmness values have significantly decreased (Table 2) which most often suggests that ripening has occurred. During this process, the accumulation of pigments and volatile compounds is present in most agricultural produce. The softening of the fruit tissue is possible thanks to a series of complex biochemical and physiological changes.

The sugar content is a good predictor for the sugar content measurement through the soluble solids concentration. It is also an easy approach for the overall peach fruit quality estimation. TSS reaches its peak at week 2 of evaluation and slightly decreased until week 6. The EU has recognized a minimum of 8º Brix for the peach market (Commission Regulation No. 1861/2004), which the „Evmolpiya“ and „Laskava“ peaches fulfill prior to their full maturity. Depending on the season's peculiarities and the cultivar itself, the TSS may vary between 9 and 17º Brix. Research has found that individual fruit difference by 4° Brix may occur (Golding et al., 2012), which can explain the differences in the currently established results. Table 2 represents data obtained by destructive techniques for evaluation (ash and moisture content, firmness and TSS).

The ash content of the „Laskava“ peaches is higher not only compared to „Evmolpiya“ but also to other documented data concerning ash content of different cultivars (Zhong et al., 2021). The decline in moisture content can be associated with an early event in fruit ripening (Frenkel and Hartman, 2012) which is further supported with the current results.

Table 2. Ash (%), moisture content (%), firmness (N) and total soluble solids (TSS, %)

Sample	Moisture content	Ash content	TSS	Firmness
„Laskava“				
Week 1	87.71±0.51^{ab}	1.03±0.50^{ab}	8.20±0.00^{e}	9.70±0.42^{a}
Week 2	86.05±0.60^{ab}	0.47±0.02^{bc}	14.10±0.00^{ab}	8.7±0.98^{ab}
Week 3	88.11±0.86^{a}	1.34±0.01^{a}	13.80±0.84^{ab}	6.83±0.15^{bc}
Week 4	82.57±0.98^{acd}	0.98±0.01^{ac}	13.75±0.21^{ab}	4.73±0.64^{c}
Week 5	83.72±1.54^{ac}	0.95±0.08^{ac}	13.70±0.14^{ab}	2.03±0.47^{d}
Week 6	79.65±0.36^{ce}	0.83±0.05^{ac}	12.83±0.72^{bc}	1.40±0.07^{d}
„Evmolpiya“				
Week 1	83.25±0.96^{ac}	1.21±0.39^{c}	8.80±0.00^{e}	10.00±1.05^{a}
Week 2	76.82±0.52^{de}	0.94±0.01^{ac}	14.90±0.28^{a}	10.36±0.65^{a}
Week 3	81.97±3.23^{bcd}	0.55±0.16^{bc}	14.70±0.28^{a}	9.53±0.41a
Week 4	76.75±3.02^{de}	0.96±0.02^{ac}	12.15±0.35^{c}	6.70±0.30^{bc}
Week 5	84.55±0.98^{ac}	0.62±0.19^{ac}	10.45±0.07^{d}	5.46±0.41^{c}
Week 6	74.43±1.07^{e}	0.45±0.01^{bc}	15.00±0.00^{a}	1.90±0.10^{d}

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

Fruit color is an important quality attribute (Gonzali and Perata, 2021). The evident green shade of the peach skin (weeks 1 to 3) can be associated with increased firmness (Table 3). Some authors have found a correlation between the presence of chlorophyll in the skin and the flesh firmness (Ziosi et al., 2008; Shinya et al., 2013). Pigment manifestation is connected to some quality attributes (soluble solid contents and firmness, for example) (Zhong et al., 2021).

Table 3. Color parameters (flesh, skin) dynamics of studied samples

Sample	L	a	b	c	h
„Laskava“ - skin					
Week 1	58.69±10.63^{ab}	4.19±14.23^{a}	43.24±8.49^{ab}	45.78±3.69^{ab}	82.84±21.74^{abc}
Week 2	57.16±12.81^{ab}	7.31±15.97^{a}	41.14±12.90^{ab}	45.45±4.71^{ab}	76.85±28.10^{abd}
Week 3	54.00±9.56^{ab}	18.51±5.93^{a}	35.44±7.12^{ab}	40.65±4.41^{b}	61.59±11.54^{abd}
Week 4	57.63±5.88^{ab}	26.59±9.82^{a}	51.31±6.05^{a}	49.81±7.01^{ab}	57.80±10.36^{be}
Week 5	47.55±12.10^{bc}	34.23±7.40^{a}	36.40±11.60^{ab}	51.25±5.27^{ab}	45.86±14.44^{de}
Week 6	34.00±3.87^{c}	24.62±5.63^{a}	12.79±5.01^{c}	28.11±7.24^{c}	26.30±4.37^{e}
„Evmolpiya“ - skin					
Week 1	64.07±4.53^{ab}	-3.03±5.63^{a}	52.28±5.05^{a}	50.62±3.42^{ab}	93.36±6.33^{a}
Week 2	67.62±3.26^{a}	-0.26±7.12^{a}	52.61±1.92^{a}	53.00±1.65^{a}	90.22±7.85^{ab}
Week 3	69.50±4.31^{a}	0.44±6.36^{a}	51.16±3.54^{a}	51.09±3.86^{ab}	89.07±7.42^{ab}
Week 4	54.47±6.18^{ab}	29.29±6.30^{a}	36.44±5.43^{ab}	47.18±4.32^{ab}	51.20±8.71^{cde}
Week 5	62.18±4.91^{ab}	18.35±10.75^{a}	39.97±4.50^{ab}	45.11±3.24^{ab}	65.67±14.09^{abd}
Week 6	50.93±5.53^{ac}	29.26±3.55^{a}	32.74±3.53^{b}	44.08±3.57^{ab}	48.27±4.59^{de}
„Laskava“ - flesh					
Week 1	76.20±1.98^{a}	-0.36±2.20^{de}	42.25±3.00^{a}	42.29±3.00^{b}	90.54±2.96^{abc}
Week 2	70.37±1.05^{ab}	3.53±0.71^{ce}	44.97±3.23^{a}	45.11±3.25^{b}	85.51±0.84^{bd}
Week 3	69.54±3.54^{ab}	5.97±2.29^{bcd}	49.63±2.11^{a}	50.06±2.39^{ab}	83.21±2.36^{bd}
Week 4	67.81±2.57^{ab}	11.33±4.25^{ac}	45.81±5.56^{a}	47.59±4.36^{b}	75.73±6.46^{de}
Week 5	65.22±3.06^{ab}	15.03±3.21^{ab}	41.12±3.06^{ab}	44.04±1.73^{b}	69.82±5.30^{ef}
Week 6	54.13±3.32^{b}	21.56±4.49^{a}	41.99±7.13^{a}	47.51±6.37^{b}	62.61±7.14^{f}
„Evmolpiya“ - flesh					
Week 1	71.28±2.77^{a}	-6.49±1.35^{e}	43.34±3.08^{a}	43.88±3.01^{b}	98.54±1.91^{a}
Week 2	74.50±1.05^{a}	-2.40±4.99^{de}	49.14±3.34^{a}	49.40±3.37^{ab}	93.07±5.58^{ab}
Week 3	76.83±2.04^{a}	-0.97±5.22^{de}	45.66±2.44^{a}	45.87±2.53^{b}	90.95±6.55^{abc}
Week 4	75.29±2.46^{a}	1.71±1.27^{ce}	49.53±3.06^{a}	49.56±3.08^{ab}	88.16±1.40^{abc}
Week 5	77.66±0.74^{a}	0.16±1.39^{de}	42.76±1.05^{a}	42.78±1.10^{b}	89.77±1.86^{abc}
Week 6	71.92±1.11^{a}	7.45±0.89^{bcd}	55.65±1.91^{b}	56.15±2.01^{a}	82.38±0.64^{cd}

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

Until week 3 of the evaluation, the „Laskava" variety had a distinct green color of the skin which may possibly be due to the presence of chlorophyll. On the contrary, the „Evmolpiya" peach had a more pronounced trend of green in the flesh. The decreasing "b" values reveal a less yellow shade on the skin which is visible in mature fruit. Lower "L" values are related to the accumulation of pigments in fruit and vegetables. Some authors have determined that the h-value (both skin and flesh) is a good predictor of maturity (Slaughter et al., 2006). The current results also point that the h-value can be a reliable tool for maturity evaluation. The increasing "a" values of the skin reveal the presence of a red pigmentation, which is related to maturity.

Pearson's correlation analysis revealed relationships with different strengths between the size attributes, firmness, TSS, moisture, and ash content (Table 4). Correlation analysis showed connections between peach size and color characteristics. All coefficients were positive, which means that a proportional dependence between variables exists.

Table 4. Pearson's correlation coefficients (R^2) of studied peach samples

„Laskava"	**Fruit Weight**	**TSS**	**Width**	**Thickness**	**Length**	**Firmness**	**Ash**	**Moisture**	**L**	**a**	**b**	**c**	**h**
Fruit Weight	**1**	0.202	0.985	0.976	0.891	0.477	0.029	0.360	0.769	0.171	0.717	0.688	0.714
TSS	0.202	**1**	0.196	0.128	0.124	0.210	0.033	0.964	0.040	0.314	0.007	0.000	0.176
Width	0.985	0.196	**1**	0.973	0.902	0.508	0.027	0.355	0.734	0.199	0.635	0.638	0.734
Thickness	0.976	0.128	0.973	**1**	0.841	0.544	0.039	0.272	0.853	0.191	0.756	0.674	0.771
Length	0.891	0.124	0.902	0.841	**1**	0.212	0.054	0.238	0.504	0.028	0.535	0.747	0.429
Firmness	0.477	0.210	0.508	0.544	0.212	**1**	0.002	0.348	0.660	0.829	0.326	0.090	0.924
Ash	0.029	0.033	0.027	0.039	0.054	0.002	**1**	0.028	0.007	0.053	0.004	0.000	0.004
Moisture	0.360	0.964	0.355	0.272	0.238	0.348	0.028	**1**	0.138	0.402	0.060	0.018	0.332
L	0.769	0.040	0.734	0.853	0.504	0.660	0.007	0.138	**1**	0.269	0.876	0.557	0.836
a	0.171	0.314	0.199	0.191	0.028	0.829	0.053	0.402	0.269	**1**	0.054	0.002	0.631
b	0.717	0.007	0.635	0.756	0.535	0.326	0.004	0.060	0.876	0.054	**1**	0.783	0.552
c	0.688	0.000	0.638	0.674	0.747	0.090	0.000	0.018	0.557	0.002	0.783	**1**	0.299
h	0.714	0.176	0.734	0.771	0.429	0.924	0.004	0.332	0.836	0.631	0.552	0.299	**1**
„Evmolpiya"	Fruit Weight	TSS	Width	Thickness	Length	Firmness	Ash	Moisture	L	a	b	c	h
Fruit Weight	**1**	0.047	0.920	0.909	0.738	0.343	0.320	0.040	0.289	0.595	0.524	0.401	0.553
TSS	0.047	**1**	0.095	0.015	0.110	0.028	0.349	0.460	0.001	0.009	0.010	0.011	0.020
Width	0.920	0.095	**1**	0.934	0.862	0.340	0.246	0.154	0.393	0.586	0.517	0.328	0.560
Thickness	0.909	0.015	0.934	**1**	0.713	0.187	0.111	0.048	0.279	0.479	0.388	0.243	0.436
Length	0.738	0.110	0.862	0.713	**1**	0.568	0.203	0.380	0.713	0.832	0.777	0.489	0.833
Firmness	0.343	0.028	0.340	0.187	0.568	**1**	0.411	0.157	0.729	0.776	0.879	0.901	0.801
Ash	0.320	0.349	0.246	0.111	0.203	0.411	**1**	0.026	0.048	0.182	0.233	0.284	0.193
Moisture	0.040	0.460	0.154	0.048	0.380	0.157	0.026	**1**	0.344	0.215	0.203	0.023	0.262
L	0.289	0.001	0.393	0.279	0.713	0.729	0.048	0.344	**1**	0.829	0.851	0.666	0.851
a	0.595	0.009	0.586	0.479	0.832	0.776	0.182	0.215	0.829	**1**	0.980	0.791	0.995
b	0.524	0.010	0.517	0.388	0.777	0.879	0.233	0.203	0.851	0.980	**1**	0.869	0.985
c	0.401	0.011	0.328	0.243	0.489	0.901	0.284	0.023	0.666	0.791	0.869	**1**	0.781
h	0.553	0.020	0.560	0.436	0.833	0.801	0.193	0.262	0.851	0.995	0.985	0.781	**1**

The studied size attributes showed good correlation coefficients (0.985 – 0.841). The TSS values were all poorly correlated to the other studied characteristics in both peach cultivars. Color values exhibit good correlations and confirm their potency to further research of the fruit maturity process. Results indicate that the color parameters obtained by a colorimeter can serve as a scale of the fruit's ripening status.

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Conclusion

The proposed non-destructive approach for assessing the maturity of peach fruits showed that the attributes chosen for evaluation are good predictors of ripening, especially color characteristics. The color indicators change in the following trend: a decrease in the "L", "h" and "b" values, and a tendency of increase in the "c" values. It was found that a 30% increase in size and a 1.8-2 times increase in weight occurred during the ripening period. When using a destructive approach, the TSS data, did not change radically, which show that the main nutrients of the peach accumulate in the early stages of development. Pearson's correlation analysis revealed relationships at different intensities between the size attributes, firmness, TSS, moisture, and ash content.

However, further large scale studies can aid in the verification of these findings and creating reliable statistical data sets for an estimated time of optimal fruit maturity.

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