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Assessment of sweet cherry fruit quality according to the requirements of the modern market

Abstract. Assessment of commercial properties of sweet cherry fruit determines the competitiveness of fresh fruit in the modern market. The selection of cultivars with the highest number of high-quality fruits to meet the preferences of all stakeholders is relevant. The purpose of this study was to substantiate the commercial indicators for assessing the quality of sweet

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cherry fruit of three ripening periods and to select the most competitive cultivars for sustainable supply of fresh fruit to the modern market. The methods used in the study were field, laboratory, and comparative. The commercial properties of 33 sweet cherry cultivars of early, middle, and late ripening were determined. The sweet cherry fruits of the cultivars under study were divided into two commercial classes according to fruit size and defects. The fruits were analysed for the following defects: cracked, scarred, and browned skin. The amount of non-standard sweet cherry fruit production for each cultivar was determined. For each ripening period of sweet cherry varieties, the average value of the volume of fruits of classes I-II and non-standard products was established. A general trend towards an increase in the amount of high-quality fruit raw materials for late-ripening cultivars was identified. The most valuable cultivars of early (Skazka and Zabuta), medium (Uliublenytsia Turovtseva and Temp) and late (Anons) ripening were identified, which provided the maximum number of class I fruits. The maximum production was determined in the Merchant (early ripening), Cordia (medium ripening) and Karina (late ripening) cultivars. The lowest volume of non-standard products was found in cultivars of different ripening periods – Skazka, Prostir, and Anons. The fruit classification into commercial classes can be used to evaluate the fruit of sweet cherry cultivars and determine the possibility of using them fresh, for long-term chilled storage and for various further processing methods

Keywords: *Prunus avium* L.; cracking; fruit diameter; cultivars; commercial classes; fruit browning; non-standard products

INTRODUCTION

The sustainable development of horticulture is essential for ensuring food security in Ukraine, as fruit is an indispensable component of a healthy diet (Dogbe & Revoredo-Giha, 2021; Janda *et al*., 2022). Growing sweet cherries helps diversify the diet and extend the period of fresh fruit consumption due to the early ripening of the fruit. Sweet cherries are characterised by a pleasant taste, juicy pulp, and a dark red colour. The study of fruit quality is becoming increasingly important due to the value of sweet cherry fruit as a food product and as a raw material for the processing industry.

Sweet cherry (*Prunus avium* L.) is the leader in the cultivation of fruit plantations, which is a priority in many countries (Ivanova *et al*., 2023). This culture is of tourist importance for the regions where it is recognised as a geographical brand (Trusova *et al*., 2020). According to research by scientists, sweet cherry fruits are rich in natural antioxidants (vitamins and polyphenols), which has a beneficial effect on human health, as they neutralise harmful radicals and reduce the risk of some diseases. The sweet cherry fruits are characterised by the presence of an increased amount of monosaccharides and have a low calorie content. The content of organic acids, vitamins, minerals, and biologically active substances enhances the nutritional, medicinal, and dietary value of sweet cherries (Vignati *et al*., 2022).

The demand for sweet cherry consumption leads to an increase in fruit production and the study of commercial parameters of fruits of varieties of different ripening periods. This stimulates researchers to analyse fruit raw materials on the world market to divide them into commercial classes. The quality parameters of sweet cherries are determined by the preferences of consumers who are willing to pay high prices for fruit with the desired characteristics. To meet the needs of consumers, researchers have focused on identifying the most important fruit quality parameters (López *et al*., 2023).

Scientists in many countries have conducted online surveys to identify the most attractive external quality indicators for consumers. The survey determined the respondents' attitudes towards the size and hardness of the fruit, and the presence of a stalk, depending on their place of residence. The following dominant characteristics of sweet cherry fruit have been identified: fruit size and shape, fruit damage, and stalk length (Paunović *et al*., 2022). Consumers prefer sweet cherry fruit without external defects, not damaged by pests and not affected by diseases from pests and diseases.

According to scientists, it has been found that the weight of the fruit and its size, as well as the degree of fruit cracking, depends on the cultivar (Pereira *et al.*, 2020). In sweet cherry production, fruit cracking is one of the priority issues, depending on the amount of precipitation during the ripening period. The fruit cracking defect causes high economic losses. Therefore, such fruits were inspected depending on the presence of cracks in the fruit. The emphasis was on damage in the cheeks of the fruit (lateral cracks), the lateral scar area or the stem cavity. Cracking of juicy fruits such as sweet cherries poses a genuine issue in production and is associated with massive commercial losses worldwide.

A study of nine cultivars of sweet cherries over four years of research revealed the dependence of the type of cracks on the fruit on varietal characteristics. The cause of deep cracks in the fruit was determined. According to scientists, the degree and type of fruit cracking depends on the cultivar, season, and load on the fruit tree. Diurnal rhythms and environmental conditions play a role in the development of cracking (Grimm *et al.*, 2019).

The study of the degree of cherry fruit cracking is important because it predicts the depth of tissue destruction of fruit crops. Microcracks on cherry fruits lead to destruction at the cuticle level. Macrocracks destroy the skin, cuticle, and inner cell layers of the fruit (Knoche & Lang, 2017). Research has shown that an important cause of cracking is the rapid absorption of water by the fruit's skin or the plant's vascular system (Brinkmann *et al.*, 2022). In addition to the elements of cultivation technology (variety/rootstock combination, tree spacing, irrigation and pruning), fruit characteristics such as size, firmness, and maturity are also factors that can increase fruit cracking. S. Correia *et al.* (2018) found a low correlation between cracking and fruit size, shape, and firmness.

The market season for fresh sweet cherries is short. The fruit is perishable and has a short shelf life (Wu *et al.*, 2018). Therefore, the study of sweet cherry fruits of different cultivars according to their commercial properties will enable the distribution of raw materials for fresh consumption, selection of samples for long-term storage and identify cultivars that are more suitable for different types of processing.

The purpose of this study was to assess the quality of fruits according to commercial parameters of early, medium, and late ripening sweet cherry cultivars and to identify the most valuable ones for sustainable supply of fresh fruit to the modern market. The objectives of this study were as follows: to describe in detail the methodology used to assess commercial quality parameters of sweet cherry fruit according to current market requirements; to assess the feasibility of effectively distinguishing sweet cherry fruit of different ripening periods into commercial classes; to identify the best sweet cherry cultivars in each ripening group according to selected commercial fruit quality parameters to meet the preferences of all stakeholders and promote food security.

MATERIALS AND METHODS

The study was conducted in 2008-2019 in the laboratories of the Research Institute of Agrotechnology and Ecology of the Dmytro Motornyi Tavria State Agrotechnological University. Cultivars of three ripening periods were selected for inspection of sweet cherry fruits and division into classes I-II and non-standard products according to commercial indicators: 1st (early) – Svit Erliz, Merchant, Bigaro Burlat, Rubinova early, Valerii Chkalov, Skazka, Zabuta; 2nd (medium) – Cordia, Octavia, Vynka, Pervistok, Temp, Uliublenytsia Turovtseva, Talisman, Dilemma, Melitopolska black, Orion, Chervneva early, Dachnytsia, Prostir; 3rd – late – Karina, Regina, Mirage, Krupnoplidna, Udivitelna, Zodiac, Surprise, Kolkhoznytsia, Kosmichna, Prazdnychna, Anons, Temporion, Meotida.

For the study, fruits were selected from typical trees for each pomological cultivar of the same age with an average fruiting intensity. Commercial evaluation of sweet cherries was performed during the period of consumer ripeness. During this period, the fruit flesh was still quite dense, with a taste and colour inherent in the pomological cultivar under study. To determine the diameter of one sweet cherry fruit, a sample of 100 fruits was taken from 3-5 typical trees during the period of consumer ripeness. The repetition of the experiment was threefold. (Serdiuk *et al.*, 2020). The fruit should be selected in such a way that the sample is characteristic of the quality of the harvest of the given season. The fruits from the trees of the cultivars under

study were removed completely. If the fruit ripened unevenly, they were partially removed in proportion to the location of the crop on the tree.

Fruit quality was assessed in the sorting room. All selected fruits were calibrated by diameter, and then the diameter of one fruit was determined by dividing the total weight by their number (100 pcs). Fruit samples were taken in fourfold repetition. One pack unit was taken as a repetition. To evaluate the quality of the fruit according to the indicators of classes I and II, an average sample of 5% of each package was taken. The weight of the package was 12 kg. The commercial properties of sweet cherry fruits were determined per the current regulatory and technical document DSTU 8153:2015 "Fresh sweet cherry. Technical specifications" (2017). Commercial characterisation and division of fresh sweet cherry fruits into classes I and II was performed according to the following quality indicators: fruit size, number of cracked fruits, number of fruits with fresh and scarred mechanical damage, number of fruits with browning of the skin in the form of spots (Table 1).

Table 1. Commercial characteristics of fresh cherry fruit class and permissible deviations of quality indicators

Indicator	Class characteristics	
	I	II
Fruit size according to largest transverse diameter, mm not less than	20	17
Permissible quality deviations, % not more than		
Cracked fruit	2	4
Fruits with mechanical damage: - scarred - fresh	 4 2	 10 4
Fruits with browned skin in the form of spots with an area of 0.2 cm^2, no more than	4	8

Source: compiled by the authors of this study

The distribution of the sample of fresh sweet cherry fruit into classes was determined in percentage. Fruit diameter yield was determined as a percentage of the total number of fruits.

RESULTS AND DISCUSSION

The competitiveness of fruit products in the modern European market is determined according to a number of important commercial properties of fruit. Among the most important parameters of cherry fruit quality are the size of the fruit and its cracking. Fruit cracking leads to a deterioration in the quality of sweet cherry fruit and causes large economic losses for producers (Santos *et al.*, 2023). Cracking of sweet cherry fruit depends on the cultivar, growing conditions, rootstock, size, amount of free and bound water in the cells, elasticity of the skin cuticle and ripening stage (Pereira *et al.*, 2020).

According to the size of the fruit, sweet cherry varieties of three ripening periods were divided into commercial classes I and II and non-standard products. The inspection of fruits for commercial properties allowed to determine the percentage of fresh sweet cherry fruits of I and II classes for the early cultivars under study 92.8-94.8% (Table 2).

Table 2. Commercial characteristics of early ripening sweet cherry fruits of classes I and II, non-standard products (2008-2019)

Cultivar	**Fruit size by largest transverse diameter, mm not less than:**										Classes I and II total, %	Non-standard products, % by fruit size
	Class I, %					Class II, %						
	fruit size (20 mm and larger)	cracked fruits, up to 2%	scarred fruits, up to 4%	fruits with browning of the skin, up to 4%	total, %	fruit size (17 mm and smaller)	cracked fruits, 2-4%	scarred fruits, up to 10%	fruits with browning of the skin, up to 8%	total, %		
Rubinova early	83.5	0.8	1.0	0.8	86.1	3.9	2.4	1.1	0.4	7.8	93.9	6.1

Table 2. Continued

Cultivar	Fruit size by largest transverse diameter, mm not less than:										Classes I and II total, %	Non-standard products, % by fruit size
	Class I, %					Class II, %						
	fruit size (20 mm and larger)	cracked fruits, up to 2%	scarred fruits, up to 4%	fruits with browning of the skin, up to 4%	total, %	fruit size (17 mm and smaller)	cracked fruits, 2-4%	scarred fruits, up to 10%	fruits with browning of the skin, up to 8%	total, %		
Valerii Chkalov	86.5	0.5	0.4	0.2	87.6	2.4	2.1	2.0	0.0	6.5	94.1	5.9
Svit Erliz	82.9	0.5	0.3	0.2	83.9	2.4	2.4	4.1	0.0	8.9	92.8	7.2
Merchant	82.5	0.7	0.4	0.3	83.9	7.3	2.0	0.0	0.8	10.1	94.0	6.0
Kazka	88.4	0.6	0.3	0.1	89.4	3.3	2.0	0.0	0.1	5.4	94.8	5.2
Bigaro Burlat	86.8	0.6	0.5	0.3	88.2	0.0	4.0	0.0	1.1	5.1	93.3	6.7
Zabuta	88.2	0.6	0.4	0.2	89.4	2.9	2.0	0.0	0.0	4.9	94.3	5.7
Average value	**85.5**	**0.6**	**0.5**	**0.3**	**86.9**	**3.2**	**2.4**	**1.0**	**0.3**	**7.0**	**93.9**	**6.1**

Source: compiled by the authors of this study

The largest number of fruits with a size of more than 20 mm in transverse diameter was determined in samples of early-ripening cultivars Zabuta (88.2%) and Kazka (88.4%). The minimum percentage of fruits with a size of more than 20 mm in transverse diameter was determined in the sample of Merchant (82.5%) and Svit Erliz (82.9%) cultivars. Variations in fruit size depending on varietal characteristics have been investigated previously. Fruit size is a variety trait that can vary depending on climatic conditions and agricultural practices (Lanauskas *et al.*, 2023). Furthermore, the size of the fruit plays a vital role in assessing the quality of the fruit and influences consumer perception. According to A. Wojdyło *et al.* (2014), most of the sweet cherry cultivars studied in Poland formed fruits with a diameter ranging from 13.71 (Fortuna) to 25.96 mm (Stevensbaer). The average fruit diameter of the 33 cherry cultivars under study was 18.2 mm. Among them, 8 cultivars had an average fruit diameter of more than 20 mm – Lucyna (20.07 mm), Morina (21.98 mm), Nana (21.31 mm), Wilena (21.33 mm), Wilga (20.37 mm), Wisok (20.69 mm), Stevensbaer (25.96 mm), Wołyńska (20.88 mm).

It was found that the maximum amount of class I products for early ripening cultivars was produced by the fruits of the Kazka and Zabuta sweet cherry cultivars – 89.4%. This indicator was 1.5% higher than the average value (86.9%) of the number of fruits of the first class of early ripening cultivars. The lowest number of class I products was found in the sample of Merchant and Svit Erliz cultivars – 83.9%, which is 3% less than the average value in the group of early ripening cultivars. The largest amount of class II products was found in the sample of sweet cherry fruit of the Merchant cultivar (10.1%), which is 3.1% more than the average value (7.0%). In the sample of sweet cherries of the Zabuta cultivar, the lowest number of class II fruits was found (4.9%), which is 2.1% less than the average in the group of early ripe cultivars. The yield of non-standard products in terms of fruit size was highest in the Svit Erliz cultivar (7.2%), which is 1.1% higher than the average (6.1%). The lowest number of non-standard products was observed in the Kazka variety (5.2%), which is 0.9% lower than the average value of the early ripening group.

In the study, one of the parameters that increases the yield of non-standard products is fruit cracking. The publication by G. Fischer *et al.* (2021) highlighted that fruit cracking is caused by external (agronomic and environmental) and internal factors. According to the authors, the frequency of cracking varies substantially depending on climatic conditions during fruit development, different types and cultivars of fruit, place of cultivation and crop care. This physiological defect is exacerbated by an increase in the intensity of precipitation, especially after the dry season or in regions

with hot temperatures. The publication of M. Corneanu *et al.* (2020) presents the results of the evaluation of sweet cherry cultivars according to resistance to cracking. Eight varieties with low values of fruit cracking (1.3-9.3%) were identified. A high resistance to cracking was observed in the fruits of the cultivars "Iaşirom" (1.3%) and "Paulică" (3.3%) compared to the cultivars "Van" (46.8%) and "Stella" (74%).

The presence of physiological disorders, especially fruit cracking, severely limits fruit production and quality (Ramteke *et al.*, 2017). This defect affects the appearance of the fruit, reduces shelf life, and limits uses, causing considerable commercial losses for producers (Ginzberg & Stern, 2016; Yu *et al.*, 2020). The cracking resistance of the fruit peel, transportation, storage, and quality of fruit products during storage play a crucial role (Wang *et al.*, 2021).

In the studies conducted, the places where fruit cracks were detected was not detailed. In M. Ur. Rehman *et al.* (2015), three forms of cherry fruit cracks are described: cuticular cracks at the stem ends, cracking at the apical (cone) end of the fruit, and lateral cracks at the cheek seam. According to scientists, the first two forms are shallow cracks that appear at both ends of the cherry fruit and are called "stem" and "nose or apical" cracks, respectively. These small cracks form at an early stage of fruit development, leading to a decrease in the market price of fruit. The third type starts from the cheeks and spreads over the bulk of the fruit, causing the greatest physical and economic damage. As a result of commercial fruit evaluation, the percentage of fresh sweet cherry fruits of classes I and II for the cultivars under study with an average ripening period of 93.5-94.5% was determined (Table 3).

Table 3. Commercial characteristics of medium-ripening sweet cherry fruits of classes I and II, non-standard products (2008-2019)

Cultivar	Fruit size by largest transverse diameter, mm not less than:										Classes I and II total, %	Non-standard products, % by fruit size
	Class I, %					Class II, %						
	fruit size (20 mm and larger)	cracked fruits, up to 2%	scarred fruits, up to 4%	fruits with browning of the skin, up to 4%	total, %	fruit size (17 mm and smaller)	cracked fruits, 2-4%	scarred fruits, up to 10%	fruits with browning of the skin, up to 8%	total, %		
Vynka	88.4	0.5	0.4	0.1	89.4	4.4	0.0	0.0	0.3	4.7	94.1	5.9
Pervystok	87.3	0.4	0.6	0.7	89.0	4.6	0.0	0.0	0.6	5.2	94.2	5.8
Temp	89.6	0.3	0.2	0.4	90.5	3.5	0.0	0.0	0.4	3.9	94.4	5.6
Uliublenytsia Turovtseva	88.8	0.4	0.3	0.3	89.8	2.0	2.1	0.0	0.2	4.3	94.1	5.9
Talisman	87.1	0.3	0.4	0.2	88.0	1.9	0.0	4.0	0.0	5.9	93.9	6.1
Dylema	87.7	0.5	0.3	0.2	88.3	5.2	0.0	0.0	0.1	5.3	94.0	6.0
Melitopolska black	87.5	0.3	0.1	0.1	88.0	6.1	0.0	0.0	0.0	6.1	94.1	5.9
Cordia	82.9	0.6	0.3	0.6	84.4	8.6	0.0	0.0	0.5	9.1	93.5	6.5
Octavia	85.8	0.4	0.2	0.2	86.6	5.4	0.0	2.1	0.0	7.5	94.1	5.9
Orion	88.4	0.3	0.3	0.4	89.4	4.8	0.0	0.0	0.1	4.9	94.3	5.7
Chervneva early	86.1	0.7	0.4	0.7	87.9	5.3	0.0	0.0	0.8	6.1	94.0	6.0
Dachnytsia	88.1	0.6	0.3	0.3	87.5		4.0	0.8	0.2	6.8	94.3	5.7
Prostir	87.9	0.5	0.4	0.3	89.1	3.4	2.0	0.0	0.0	5.4	94.5	5.5
Average value	**87.4**	**0.4**	**0.3**	**0.3**	**88.3**	**4.2**	**0.6**	**0.5**	**0.2**	**5.8**	**94.1**	**5.9**

Source: compiled by the authors of this study

The maximum number of fruits with a size of more than 20 mm in transverse diameter was determined in samples of the mid-season cultivar Temp (89.6%), which is 2.2% more than the average value of the group (87.4%). The minimum percentage of class I fruits with a size of more than 20 mm in transverse diameter was determined in the sample of cultivars Cordia (82.9%) and Octavia (85.8%), which is 1.6 and 4.5% less than the average value of the medium-ripening group. The results of the study suggest that the sweet cherry cultivars under study differ in fruit size. This conclusion is confirmed by the data obtained by other scientists. In the study by M. Corneanu *et al.* (2020), the sweet cherry cultivars with the largest fruit sizes were noted – "Andreiaş", "Bucium", "Ştefan", "Paulică", "Golia", "Van", and "Stella". The average fruit diameter ranges from 22.4 mm (George) to 25.8 mm (Paulică). The largest amount of class I products was found in samples of mid-season cultivars Uliublenytsia Turovtseva (89.8%) and Temp (90.5%). This figure was 1.5% and 2.2% higher than the average value (88.3%) of the number of fruits of the first class of varieties of medium-ripening period.

The lowest number of class I fruits was found in the sample of sweet cherry cultivars Cordia (84.4%) and Octavia (86.6%), which is 1.7 and 3.9% less than the group average. The largest amount of class II products was found in the sample of cherry fruit of the Cordia cultivar (9.1%), which is 3.3% more than the average value (5.8%).

In the sample of sweet cherries of the Temp cultivar, the lowest number of class II fruits was found (3.9%), which is 1.9% less than the average in the group. The number of non-standard products in terms of fruit size was highest in the Talisman cultivar (6.1%). The minimum amount of non-standard products is set for the Prostir cultivar (5.5%). As a result of the analysis of commercial indicators of fruits in samples of late-ripening cultivars, it was found that the amount of fresh sweet cherry fruits of I and II classes was 94.1-96.2% (Table 4).

Table 4. Commercial characteristics of late-ripening sweet cherry fruits of classes I and II, non-standard products (2008-2019)

Cultivar	Fruit size by largest transverse diameter, mm not less than:										Classes I and II total, %	Non-standard products, % by fruit size
	Class I, %					Class II, %						
	fruit size (20 mm and larger)	cracked fruits, up to 2%	scarred fruits, up to 4%	fruits with browning of the skin, up to 4%	total, %	fruit size (17 mm and smaller)	cracked fruits, 2-4%	scarred fruits, up to 10%	fruits with browning of the skin, up to 8%	total, %		
Krupnoplidna	91.3	0.3	0.1	0.2	91.9	1.9	2.0	0.0	0.0	3.9	95.8	4.2
Karina	85.9	0.4	0.3	0.2	86.8	7.2	0.0	0.0	0.1	7.3	94.1	5.9
Regina	87.7	0.2	0.2	0.2	88.3	5.5	0.0	0.7	0.0	6.2	94.5	5.5
Mirage	90.3	0.2	0.3	0.2	91.0	4.1	0.0	0.0	0.1	4.2	95.2	4.8
Udivitelna	90.4	0.4	0.2	0.1	91.1	3.8	0.0	0.0	0.2	4.0	95.1	4.9
Zodiak	90.9	0.5	0.3	0.2	91.9	3.3	0.0	0.5	0.0	3.8	95.7	4.3
Surprise	89.4	0.4	0.3	0.8	90.9	4.4	0.0	0.0	0.6	5.0	95.9	4.1
Kolkhoznytsia	89.9	0.4	0.2	0.7	91.2	4.1	0.0	0.0	0.7	4.8	96.0	4.0
Kosmichna	89.7	0.3	0.2	0.8	91.0	4.3	0.0	0.0	0.6	4.9	95.9	4.1
Prazdnichna	90.7	0.4	0.3	0.1	91.5	4.1	0.0	0.4	0.0	4.5	96.0	4.0
Anons	92.4	0.2	0.2	0.2	93.0	3.2	0.0	0.0	0.0	3.2	96.2	3.8
Temporion	92.0	0.2	0.3	0.1	92.6	3.2	0.0	0.3	0.0	3.5	96.1	3.9
Meotida	90.7	0.4	0.4	0.1	91.6	3.7	0.0	0.0	0.0	3.7	95.3	4.7
Average value	**90.1**	**0.3**	**0.3**	**0.3**	**91.0**	**4.1**	**0.2**	**0.1**	**0.2**	**4.5**	**95.5**	**4.5**

Source: compiled by the authors of this study

The maximum number of fruits with a size of more than 20 mm in transverse diameter was determined in samples of late-ripening cultivars Temporion (92.0%) and Anons (92.4%). Samples of cultivars Karina (85.9%) and Regina (87.7%) had a minimum number of fruits with a size of more than 20 mm in cross diameter. The dependence of sweet cherry fruit diameter on the genetic characteristics of the cultivar is also confirmed by studies by other authors (Lanauskas *et al.*, 2023). As a result of studies of 45 cultivars of sweet cherry by A. Khadivi *et al.* (2019) in Iran, it was found that the diameter of sweet cherry fruit ranged from 18.88 to 28.45 mm. According to E. Iurea *et al.* (2019), the evaluation of sweet cherry fruits by size revealed that the fruit diameter of the cultivars under study ranged from 21.8 (Cetăţuia) to 24.0 mm (Cătălina).

For late-ripening cultivars, the largest amount of Class I products was produced by the Anons sweet cherry cultivar – 93%. This figure is 2% higher than the average number of class I fruits in the group of late-ripening cultivars (91%). The minimum amount of class I products was determined in the sample of sweet cherry cultivars Karina (86.8%) and Regina (88.3%), which is 2.7% and 4.2% less than the average value in the group of late-ripening cultivars. The largest amount of class II products was found in the sample of sweet cherry fruit of the Karina cultivar (7.3%), which is 2.8% higher than the average value (4.5%). In the sample of sweet cherries of the Anons cultivar, the lowest number of class II fruits was found (3.2%), which is 1.3% less than the average in the group of late-ripening cultivars. The number of non-standard products in terms of fruit size was highest in the Karina variety (5.9%), which is 1.4% higher than the average (4.5%). The lowest number of non-standard products was observed in the Anons cultivar (3.8%).

The number of the class I fruits for early, medium-, and late-ripening varieties is 86.9%, 88.3%, 91.0%, respectively. A comparative analysis of the quantity of class I fruit products revealed a tendency to increase the quality of raw materials depending on the ripening period. The volume of class II products for early, medium, and late ripening varieties is 7.0%, 5.8%, and 4.5%, respectively. The number of non-standard products in terms of fruit size for early, medium, and late ripening varieties is 6.1%, 5.9%, and 4.5%, respectively. There is a gradual increase in the size of class I fruits and, conversely, a decrease in the volume of non-standard products from early to late ripening cultivars.

A comparable tendency to reduce the number of cracked fruits is observed in late-ripening cultivars compared to medium- and early-ripening cultivars. According to scientists, cultivars with higher skin tensile strength and elasticity are more resistant to fruit cracking (Brüggenwirth & Knoche, 2017).

Late-ripening, mid-ripening and early-ripening cultivars in class I products had average values of cracked fruit – 0.3%, 0.4%, and 0.6%, respectively. The sweet cherry cultivars Valerii Chkalov and Svit Erliz (early-ripening), Talisman, Orion, Temp, and Melitopolska black (medium-ripening), Mirage and Regina (late-ripening) had the lowest cracking levels. In class II products, the average values of cracked fruits in the groups of late-ripening, medium-ripening, and early-ripening cultivars were 0.2%, 0.6%, and 2.4%, respectively. The dependence of sweet cherry fruit cracking on varietal characteristics is also confirmed by the studies of other authors (Measham *et al.*, 2014). According to their data, over 4 years of research, as a result of monitoring the cracking of sweet cherry fruits of different varieties, it was found that the lowest level of crack development was demonstrated by the varieties 'Sylvia', 'Summit', and 'Van'. Cracked fruit loses its commercial value for the fresh market and can only be sold locally or for processing. Cherry fruit cracking is an unpredictable and economically important problem for growers worldwide.

The publication by A. Khadivi-Khub (2015) highlights that the most resistant cultivars to cracking and with better fruit quality can be recommended for further cultivation and obtaining a sustainable economic effect. These findings are important for the development of future management strategies for sweet cherry fruit cracking. This reduces economic risks for regions where sweet cherries are a priority fruit crop (Trusova *et al.*, 2018).

It is known that early-ripening fruits have a more delicate flesh texture and can deteriorate more than fruits of medium and late ripening cultivars. Late-ripening bigaro cultivars with a dense texture and harder skin are less damaged

during fruit formation (Ivanova *et al*., 2023). This trend may be due to the influence of weather conditions on the quality of raw materials when early-, medium-, and late-ripening sweet cherry cultivars ripen. This trend may also be influenced by the genetic characteristics of cultivars of these ripening periods.

The evaluation of early-, medium-, and late-ripening sweet cherry cultivars by commercial classes will allow the fruit to be divided into categories, which will enable the selection of raw materials for further use in fresh form, long-term storage, freezing, and manufacturing of processed products by heat sterilisation. Forecasting the volume of fruit products by commercial classes, having information on the suitability of raw materials for table and technical use, and the optimal choice of fruit processing methods will help processing companies coordinate their work according to a rational technological scheme with maximum economic effect.

CONCLUSIONS

The results of twelve years of research suggest that the average stone weight of sweet cherries grown in the southern steppe zone of Ukraine was 8.41 grams, with an average stone weight of about 0.56 grams. The sweet cherry cultivars of three ripening periods were analysed and divided into commercial classes according to fruit size and degree of external damage. The maximum amount of class I products for the group of early ripening cultivars was produced by the fruits of the Kazka and Zabuta sweet cherry cultivars – 89.4%. The largest amount of products of the second class of early ripe cultivars was determined in the sample of sweet cherry fruit of the Merchant cultivar (10.1%), and the smallest – of the Zabuta cultivar (4.9%). The percentage of non-standard products in terms of fruit size was highest in the Svit Erliz cultivar (7.2%), and the lowest – in the Kazka cultivar (5.2%).

In the samples of medium-ripening cultivars Uliublenytsia Turovtseva (89.8%) and Temp (90.5%), the largest number of class I fruits was determined. The medium-ripening sweet cherry cultivars Cordia (84.4%) and Octavia (86.6%) had the smallest volume of class I fruit. The maximum percentage of class I fruits with a diameter of more than 20 mm was observed in the medium-ripening cultivar Temp (89.6%). The largest amount of class II products in medium-ripening cultivars was determined in the sample of cherry fruit of Cordia (9.1%), and the smallest – in the Temp variety (3.9%). The percentage of non-standard products in terms of fruit size was highest in the Talisman cultivar (6.1%), and lowest – in the Prostir cultivar (5.5%). The maximum percentage of class I fruits was determined in the late-ripening cultivar Anons – 93%. The largest amount of class II products was found in the sample of the Karina cultivar (7.3%), and the smallest amount – in the Anons cultivar (3.2%). The number of non-standard products in terms of fruit size was highest in the Karina cultivar (5.9%), and the lowest – in the Anons cultivar (3.8%). As a result of the division of fresh sweet cherries of early, medium, and late ripening into classes I and II and non-standard products by commercial properties, a general trend towards an increase in the number of high-quality fruits in late-ripening cultivars was established.

The prospect of further research is to evaluate the suitability of sweet cherries of early, medium, and late ripening for long-term storage in a chilled state and their suitability for the manufacture of processed products.

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CONFLICT OF INTEREST

The authors of this study declare no conflict of interest.

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Оцінювання якості плодів черешні відповідно до вимог сучасного ринку

Анотація. Оцінка комерційних властивостей плодів черешні визначає конкурентоспроможність свіжих фруктів на сучасному ринку. Виділення сортів з найвищою кількістю плодів високої якості для задоволення уподобань усіх зацікавлених сторін (стейкхолдерів) є актуальним. Метою дослідження було обґрунтування комерційних показників для оцінки якості плодів черешні трьох строків достигання та вибору найбільш конкурентоспроможних сортів для стійкого забезпечення свіжими фруктами сучасного ринку. У ході дослідження використано методи: польовий, лабораторний і порівняльний. Проведено визначення комерційних властивостей 33 сортів черешні раннього, середнього і пізнього строків достигання. Плоди черешні досліджуваних сортів за показниками розміром плоду і наявністю дефектів було поділено на два комерційні класи. Проведено аналіз плодів на наявність таких дефектів: розтріснуті, з рубцями, з побурінням шкірочки. Визначено кількість нестандартної продукції плодів черешні для кожного сорту. Для кожного строку достигання сортів черешні встановлено середнє значення обсягу плодів I-II класів і нестандартної продукції. Виявлена загальна тенденція щодо збільшення кількості якісної плодової сировини для сортів пізнього строку достигання. Було виділено найбільш цінні сорти раннього (Казка і Забута), середнього (Улюбленица Туровцева і Темп) і пізнього (Анонс) строків достигання, які забезпечили максимальну кількість плодів I класу. Максимальна кількість продукції була визначена у сортах Мерчант (ранній строк достигання), Кордія (середній строк достигання) і Каріна (пізній строк достигання). Найменший обсяг нестандартної продукції було виділено у сортах різних строків достигання – Казка, Простір і Анонс. Проведений розподіл фруктів на комерційні класи може бути використаний для проведення оцінки плодів сортів черешні та визначення можливості їх використання у свіжому вигляді, для тривалого зберігання в охолодженому стані і різних способів подальшої переробки

Ключові слова: *Prunus avium* L.; розтріскуваність; діаметр плоду; сорти; комерційні класи; побуріння плодів; нестандартна продукція