Study of the quality of peaches, nectarines and apricots based on morphological characteristics

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Abstract. Fresh fruits (FFs) are nutritionally valuable and are a major part of consumers' daily diets. The requirements towards quality of FFs have been increasing in recent years, and this is provoked by the need to add FFs with certain characteristic of the respective type/variety, properties and nutritional value in the diet. The purpose of this study is to present the morphological characteristics and specific results of the experimental study, linking them with the requirements reflected in the regulatory documents and determining quality of FFs. The object of this study is stone FFs from three harvests 2021, 2022 and 2023: peaches (*Prunus persica*) - Red Haven variety, O'Henry variety; nectarines (*Prunus persica var. Nucipersica*) - Sun grand variety, Golden Grand variety; apricots (*Prunus armeniaca*) - Hungarian variety, Delmas variety, Roxana variety and Silistra compotna variety. The morphological characteristics - shape, weight and dimensions (length, height and width) of the fruits, stones and petioles separated from them are determined according to an established methodology. The results obtained from the measurements were averaged and the diameter of the largest cross-section was calculated. The result is compared with the requirements reflected in Ordinance 16, 2010 and Regulation 543/2011, and quality class of FFs is determined. The following conclusions are drawn on the basis of FFs morphological characteristics: 1. the weight, sizes of fruits, stones and petioles of each variety are determined.; 2. the FFs quality was determined: peaches variety Redhaven and variety O'Henry are *quality class Extra*; nectarines variety Sungrand and variety Goldengrand are *quality class Extra*; the apricots variety Hungarian, variety Roxana, variety Delmast and variety Silistra Compotna are *quality class Extra*. The focus of future work may be directed at: calculation of the number of wastes from the certain fruit variety that will be generated after their processing.; introduce the possibility to manage and use the separated wastes obtained after processing FFs.

Key words: stone fruits, dry fruits, frozen fruits, morphological characteristics, quality fruits
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1. Introduction

Fresh fruits are nutritionally valuable and are a major part of consumers' daily diets. They are used both for fresh consumption and for processing: drying, freezing, production: fruit (compotes) and fruit-sugar preserves (jams, jams, marmalades and jellies); fruit juices, nectars and mousses; highly alcoholic beverages (brandy, liqueurs, etc.) and as an additive to pastry, sugar and confectionery products. The composition of fresh fruits contains in balanced quantities, sugars, organic acids, phenolic substances, mineral salts, vitamins, aromatic and dyeing substances, which are specific to the individual representatives of the fruit, and their amount is determined by the variety, soil and climatic conditions, the proposed cultivation technology, etc.

The requirements of consumers for the quality of fresh fruits have been increasing in recent years, and this is provoked by the need to include fruits with characteristic of the respective type, properties and balanced nutritional value in their daily diet. The dynamic modern conditions, the competition of fresh fruits offered to consumers produced in Bulgaria and abroad, as well as the increased requirements for them on the markets in Europe and globally pose the current problems related to the quality, ecological and biological purity of fruits. The growing requirements for the quality of fresh fruits, as well as their increased consumption in conditions of global changes and crises, pose various problems related to investing more funds in the perennial crops sector in order to expand the scope of the sector, the production of fresh fruits and the development of an effectively working system for their qualification. This necessitates the presentation of modern approaches to the methodology for research and evaluation of fruit quality.

In the scientific literature, there are separate studies in which the morphological characteristics of some varieties of apricots are presented, no similar studies have been found for peaches and nectarines. The researchers do not discuss and link the results of the studies of the morphological characteristics of fruits with the quality of fruits, mechanical composition and technological suitability of fruits for their intended use. There are no publications presenting a relationship between the results obtained after applying the morphological characteristic and the regulated requirements in the normative documents summarizing the quality of peaches, nectarines and apricots.

Therefore, the purpose of this study is to present the morphological characteristics and specific results of the experimental study, linking the results with the requirements reflected in the regulatory documents and determining the quality of the studied fruits.

The object of this study are fresh fruits - peaches, nectarines and apricots from three harvests 2021, 2022 and 2023: peaches (*Prunus persica*) with representatives of the Red Haven variety, the O'Henry variety; nectarines (*Prunus persica var. Nucipersica*) with representatives of the Sun grand variety, the Golden Grand variety; apricots (*Prunus armeniaca*) with representatives of the Hungarian variety, the Delmas variety, the Roxana variety and the Silistra compotna variety. This choice is dictated by the fact that these are fruit species with traditions in cultivation on the territory of our country, of great importance for the domestic and foreign markets, and the processing industry. Some of the studied varieties of the different representatives of peaches, nectarines and apricots are well known and preferred by consumers. The fruits in botanical ripeness, with typical size, shape, color and taste properties, were taken during the three years from the same producers from Northeastern Bulgaria, guaranteeing their variety. The fruits are well developed, without damage and have a satisfactory degree of ripeness.

The implementation of the formulated research goal presupposes the implementation of the following tasks:

1. To study the theoretical aspects regarding the origin, distribution, production, import and export of peaches, nectarines and apricots.
2. To study the quality of some important varieties of peaches, nectarines and apricots, grown in our country and offered to consumers based on the morphological characteristics of the fruits.

Fresh fruits, depending on their structure, are divided into the following groups: seed fruits, stone fruits, berry berries, walnut fruits. The stone fruits of the genus *Prunus i*nclude the following: cherries (*Prunus avium L.*), sour cherries (*Prunus cerasus L.*), plums (*Prunus domestica*), peaches (*Prunus persica*), nectarines (*Prunus persica var. nucipersica*) and apricots (*Prunus armeniaca L.*). A specific feature of this group of fruits is that they are true, simple fruits, formed only by the pistil of the flowers. The pistil is apocarpene, formed by joining of the ends of the carpel. As a result, an abdominal suture (depression) is formed and observed on the abdominal side of the fruit. In the core of the fruit, in place of the seed chamber, characteristic of seed fruits, there is a single-chambered stone in which the seed (nut) is located (Iliev, Vitanov, Yoncheva, Belyakov, 1977; Vasilev, Georgiev, Belyakov, 1982; Mihaylov, 2006; Donchev, Pashova, Zlateva, 2011; Manganaris, Crisosto, 2020).

2. Literature review

2. 1. Origin of some types of stone fruits

The origin of stone fruits is systematized and presented consistently for some of the most preferred representatives by consumers, such as: peach, nectarine and apricot.

Peach. The peach belongs to the genus *Persica*, this fruit species has been known since antiquity, and it is believed that its origin is from China, and not from Persia, where its Latin name originated. Initially, the fruits of the peach were brought to Central Asia and the Mediterranean, and now it is grown on all continents, with the exception of tropical zones. On the territory of our country, the peach was imported even before the New Era. As an industrial fruit crop in Bulgaria, the peach began to be grown after 1950, and over the years its areas have been dynamically expanding. Plantations are created in different regions of the country, with the exception of the higher semi-mountainous and mountainous regions, where the conditions are unsuitable for its cultivation. Bulgaria is located in the southern parts of the temperate climatic zone, where there are very good conditions for growing the peach, and it is an economically very important crop for our country (Petrov, Grigorov, 1981; Ferguson, Hldelorand, Hespendheild, 1987; Mikhailov, 2006).

Nectarine. Nectarine (Prunus persica var. nucipersica) is a variety of peach (Prunus persica) originating in China, which in the past was called the Persian plum. The fruit of the nectarine is smaller in size and mass than that of the peach, another characteristic feature of them is that they have a smooth, not hairy skin, which makes them a preferred fruit by consumers. In the scientific literature, there are two hypotheses about the origin of nectarine. According to the first, nectarine arose through a mutation from a common peach, and according to the second, they are a separate species, different from peaches (Zhivondov, 1985; Siddiq, Liavoga, Greiby, 2012; Manganaris, Crisosto, 2020).

Apricot. *Prunus armeniaca*, known as the *golden egg of the sun*, grows in colder and drier temperate climates around the world (Leccese, Bartolini, Viti, 2007; Hacıseferoğulları, Gezer, Özcan, MuratAsma, 2007). Information about the origin of the apricot is lost in the distant prehistoric eras. It is believed that the homeland of this fruit species is Southeast Asia with the center of Northern China. In addition to this region, apricot is widespread in wild state already in eastern Tibet, Alma Ata and Central Asia, and this gives scientists reason to believe that this is another center of its origin (Ivanova, 2006; Ali, Mehdi, Lakdan, Dolkar, Stanzen, Singh, Hussain, 2018). According to a group of researchers, the Japanese apricot (*Prunus mume Sieb. et. Zucc*.), also known as Ume, is used for food and as a medicinal product in East Asian countries (Horinishi, Toyama, Watanabe, Ayano, Ozaki, 2022). Apricot kernels found during excavations in Armenia, dating back to ancient times, are grounds to believe that Armenia is also one of the centers associated with the origin of this fruit species (Donev, 2015). This is the reason why the common apricot receives the Latin name Armenica. According to some sources, the traditions associated with the cultivation of apricots in Anatolia date back nearly 2000 years (Asma, 2015).

Later, the apricot was brought to Greece, and from there it spread to other Mediterranean countries and parts of Europe (Malinov, 2003; Khadari, Krichen, Lambert, Marrakchi, Audergon, 2006). In America, apricot became famous in the XVII-XVIII centuries. It was brought by colonizers to South Africa and South America, but did not spread to these areas. It is believed that the apricot penetrated into Bulgaria from Greece (Iliev, Tsolov, Nikolov, Marinov, Babayashev, Belyakov, Karov, Angelova, 1983; Mihaylov, 2006; Manganaris, Crisosto, 2020).

Apricots are an important fruit crop and nutritionally valuable for humans. They are fruits of high nutritional value, as they are rich in polyphenols, vitamins and carotenoids. The fruit is consumed fresh or dried, but is used to make fruit juices, nectars and preserves (Moustafa, Cross, 2019; Dragovic-Uzelac, Levaj, Mrkic, Bursac, Boras, 2007; Taylor, 2008).

a. **Distribution, production, import and export of peaches, nectarines and apricots**

In recent years, there has been an increase in the production and consumption of peaches, nectarines and apricots, and this is probably due to the awareness of consumers about their nutritional value and their beneficial effect on human tone and health, as they are rich in useful substances polyphenols (anthocyanins and hydroxy acids), sugars, vitamins, minerals, etc. (Manganaris, Crisosto, 2020).

The main producers of peaches, nectarines and apricots worldwide are: peaches and nectarines - China, Spain and Italy, apricots - Turkey, Uzbekistan and Iran (Agry.bg, 2018; Moustafa, Cross, 2019; FAO, 2023; Ricardo-Rodrigues, Laranjo, Elias, Agulheiro-Santos, 2023). In recent decades, Turkey has been among the first producers of fresh and dried apricots in the world (Money.bg, 2018; FAO, 2023).

In the EU, the largest producers of peaches, nectarines and apricots are: peaches and nectarines – Spain, Italy and Greece, apricots – France, Italy and Spain (Ivanova, Popov, 2017; FAO, 2023, Cirillo, De Luca, Izzo, Cepparulo, Graziani, Ritieni, Romano, Di Vaio, 2023).

In Bulgaria, separate fruit growing regions are located, which are in different districts, and only the total area of the plantations varies. The state of fruit growing in the country depends on many natural and socio-economic factors, among them are the lack of sufficient funds and investments for consolidation, the introduction of new production technologies, as well as the obsolescence of existing plantations and insufficient funds for the creation of new plantations (Djouvinov, Vitanova, 2002; Mladenova, Georgieva, Serbezova, 2017; Kabadzhova, 2022).

On the territory of our country the soil and climate conditions are favorable for the cultivation and production of high-quality peaches, nectarines and apricots, competitive both on the domestic market and for export. The production of *peaches and nectarines* is concentrated in the following regions: Southeastern, North Central, Northeastern and Southwestern. In the regions presented, the average yield of peaches from the 2022 harvest is 10 537 kg/ha, 8 815 kg/ha, 7 699 kg/ha and 7 535 kg/ha, respectively. The concentration of apricot and zarzales production in Bulgaria is localized in the following regions: North Central, Southeast, Northeast and Northwest. In the presented regions, the average yield of apricots from the 2022 harvest is respectively – 6,517 kg/ha, 6,444 kg/ha, 4,975 kg/ha and 4,609 kg/ha (Fruit production in Bulgaria – harvest, 2022; Slavova, Ivanova, 2022).

In 2021, 202,579 tons of fruit were produced on farms, which is 13.6% less on an annual basis. Compared to 2019, in 2020 and 2021 there was a decrease in the produced quantities of peaches, nectarines, apricots and zarzales, in tons. Compared to 2020, in 2021 there was a significant increase in the produced quantities of apricots and zarzales. The harvested quantities of peaches and nectarines were also significantly higher by 958 tons in 2021 (Agrarian Report, 2020; Agrarian Report, 2021; Agrarian Report 2022; Agrarian Report, 2023) (table 1).

Table 1.

Production of some stone fruits
from harvest 2019, 2020, 2021 and 2022

№	Fruit crops	Average yield (kg/ha)				Production (tons)			
		2019	2020	2021	2022	2019	2020	2021	2022
1.	Peaches and nectarines	10 541	7 474	8 117	9 547	33 878	20 740	21 698	24 182
2.	Apricots and zarzales	6 957	5 177	6 754	6 245	20 244	9 516	20 701	19 040

Source: Annual Report on the State and Development of Agriculture (Agrarian Report '2020; Agrarian Report '2021; Agrarian Report '2022; Agrarian Report '2023), Ministry of Agriculture and Agriculture, Agrostatistics Department

The South-Eastern and South-Central regions have the highest share in the quantity of fruits produced, forming 26,5% and 23,3% of the total production for 2021, respectively, with the production of peaches and nectarines prevailing in the South-Eastern region (65,5%). In the North Central region, 84,7% of the apricots in our country are produced. In 2021, an increase in the average yields of apricots and zarzals by 30,5% was reported, and for peaches and nectarines it was by 8.6% (Agricultural Report, 2022).

The average yields from the 2022 harvest of peaches and nectarines are higher by 17,6% compared to the 2021 harvest. A total of 97% of the fruits produced from the 2022 harvest were sold, with the highest share of production intended for direct sales, including export and in the commercial network - 52%, and the directed quantities for processing were 41%. The lowest is the share of production for own consumption on the farm – 7% (Fruit production in Bulgaria – harvest 2022; Situation on the market of fresh fruits and vegetables in Bulgaria, 2023).

A significant part of the stone fruits produced in Bulgaria are intended for sale and export outside the country. In this regard, in order to provide a quality product to consumers, it is necessary to comply with the requirements for manufacturers, traders and economic operators. Studies have shown that the consumption of imported peaches is decreasing significantly worldwide, mainly due to consumer dissatisfaction, according to which the fruits offered commercially are tasteless and have an uncharacteristic consistency. The main reason for this is that the fruits are harvested before they are fully ripe so that the properties of the fruits can be preserved during logistics operations (Minas, Tanou, Molassiotis, 2018).

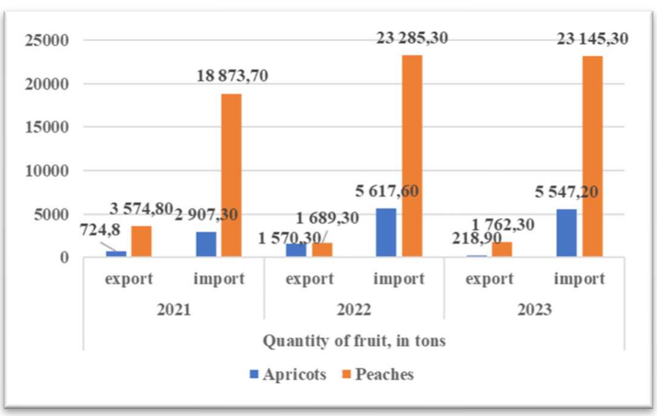

Figure 1. Import and export of peaches and apricots, in tones, to/from Bulgaria in the period 2021-2023

Source: Reference "Import/export of basic fresh fruits and vegetables to Bulgaria in the period 2021 – February 2023; Reference "Import/export of basic fresh fruits and vegetables in Bulgaria in the period 2022 – January 2024

In the period 2021-2023, the quantity, in tons, of imported peaches and apricots in our country is higher than that of exported fruits of domestic production (fig. 1). The highest share of peaches exported from Bulgaria was in 2021, and they were mainly destined for the market of Romania, Belarus, Italy, Spain, Poland and the Netherlands. In 2022, the export of peaches decreased by 1,885.5 tons, and in 2023 the decrease in exports was by 1,812.50 tons.

Imports of peaches and apricots were highest in 2022, with imported fruits coming from Greece, Turkey, North Macedonia, Germany and Spain. In 2021 and 2023, imports of peaches and apricots were lower compared to 2022 (fig. 1) (Reference Import/export of basic fresh fruits and vegetables in Bulgaria in the period 2021 – February 2023, by products and countries; Bulgarian Industrial Association, 2023; Situation on the market of fresh fruits and vegetables in Bulgaria, 2023; Beltramo, Bast, Diliën, de Boer, 2023).

In 2022, there was an increase in the production of peaches and nectarines by 2 484 tones and a decrease in the produced quantities of apricots and nectarines by 1 661 tones compared to 2021. in tones are the highest (table 1). The Bulgarian average annual export of stone fruits in tones is lower than the imports of these fruits (fig. 1). This is evidence of significant changes in production, logistics, trade and traditional ideas about the sector. It faces some important challenges related to the entry of new varieties and species, the opening of new markets, changes in consumer behavior and preferences, etc. Therefore, a critical analysis of the problems in the fruit growing sector is needed in order to identify specific activities aimed at developing and restoring the traditions in the cultivation and production of quality stone fruits intended for consumers in our country and abroad.

Until the onset of democratic changes, Bulgaria was popular as a producer and exporter of apricots, peaches and products from their processing. The economic changes that have taken place since 1990 have adversely affected their production. A major problem is the untimely settlement of the ownership and the way of management of the established plantations, and this leads to the abandonment of perennial crops. As a result, most of them are in poor condition, and another significant part is completely destroyed. The restoration of industrial production of these important fruit crops, which have been proven to have favorable soil and climatic conditions in different regions of our country, will be a very slow and lengthy process (Iliev, Tsolov, Nikolov, Marinov, Babayashev, Belyakov, Karov, Angelova, 1983; Mihaylov, 2006; Kabadzhova, 2022).

The study and analysis of the presented data are evidence that in recent years the production, in tons, of apricots, zarzals, peaches and nectarines has slightly increased. In the period 2021-2023, the number of imported peaches and apricots is higher than that of exported fruits produced in Bulgaria. This is proof that small quantities of fresh fruits produced in Bulgaria are exported, and consumers in our country are offered mainly fresh fruits from imports.

The presented literature review shows that in the studied studies in the field of use properties and quality of peaches, nectarines and apricots, one or a combination of some of the following methods are used: a method for studying plant resources (the morphological characteristic of fruits is determined by applying biometric indicators for fruits and stones), an organoleptic (sensory) method and physicochemical methods. It is noteworthy that most often the composition of the fruit or individual components of it is examined. The rich composition is the basis for their definition as fruits preferred by: consumers for fresh consumption, the processing sector as a raw material for the production of fruit and fruit and sugar preserves, for freezing, for drying and for export (Butac, 2020).

In the studied literature, studies of the composition of individual representatives of stone fruits are most often found. Another group of researchers established the relationship between: morphological and biochemical changes in the fruits of some varieties of stone fruits – apricots (Abbas, Bakhsh, Sumrah, Hussain, Akhtar, 2016; Karatas, Ercisli, Bozhuyuk, 2021); the mechanical and chemical composition of the fruits of some varieties of apricots (Hacıseferoğulları, Gezer, Özcan, MuratAsma, 2007). Some researchers have investigated: the influence of rootstock on the mechanical and chemical composition of some stone fruits (Herrero, 1975); the influence of fruit size on the quality and composition of fruits (Iliev, Vassilev, Georgiev, Grigorov, Petrov, Yoncheva, Mondeshka, Nikolov, 1985); some physical, pomological properties and the composition of specific varieties of stone fruits – apricots (Drogoudi, Vemmos, Pantelidis, Petri, Tzoutzoukou, Karayiannis, 2008; Ahmadi, Fathollahzadeh, Mobli, 2008; Moustafa, Cross, 2019; Karatas, Ercisli, Bozhuyuk, 2021); the influence of the composition on the taste and aromatic properties of stone fruits - peaches (Zhang, peng Xi, wen Wei, yuan Shen, Ferguson, song Chen, 2011; Farcuh, Hopfer, 2023), apricots (Baccichet, Tagliabue, Linge, Tura, Chiozzotto, Bassi, Cirilli, 2023); the relationship between the morphological and biological characteristics of some varieties of stone fruits – apricots (Taiti, Vivaldo, Masi, Giordani, Nencetti, 2023); the differences between domestic and foreign apricot varieties, using detailed analyses of physical, pomological characteristics and biochemical properties of the fruit (Sarıdaş, Ağçam, Ünal, Akyıldız, Kargı, 2024).

The presented literature review shows that there are separate studies in which the morphological characteristics of some varieties of apricots are studied and described. The described results of the conducted studies are very rarely related to the mechanical composition and technological suitability of the fruits for their intended use. There are no publications presenting a relationship between the results obtained after applying the morphological characteristic and binding the regulated requirements in the regulatory documents, deriving generalizations about the compliance with the requirements and the quality of peaches, nectarines and apricots.

From the studied specialized literature, we found that there are separate studies on the morphological characteristics of some varieties of peaches, nectarines and apricots, specific to the countries to which the individual researchers belong, but so far, no such approach has been presented and applied to assess the conformity and quality of fresh fruits. We believe that the applied approaches and methods for assessing some of the indicators of fresh fruits need some modern additions.

Therefore, an opportunity has been proposed to improve quality studies directly related to the results of morphological characterization. The presence in the scientific literature of some studies in the field of morphological characteristics, composition and some of the properties of peaches, nectarines and apricots is evidence of the relevance of the chosen problem, as well as the fact that researchers are actively working in this direction in different countries.

Despite the existing publications and data on these issues, many of them have not been fully researched:

There are no scientific publications proposing the relationship of the results obtained after applying the methodology for assessment of morphological characteristics with the requirements for the size and weight of fruits for the individual quality class, reflected in Ordinance 16, 2010 and Regulation 543, 2011. The results obtained from the conducted research are not bound to the requirements of modern normative documents and no generalizations are made by the authors about the quality of the studied fresh fruits. Therefore, we believe that the possibility of the following has not been sufficiently explored:

• On the applicability of a quality assessment and the relationship between the results obtained after the application of the morphological characteristic,

• After analysis and summary of the results, and comparison with the regulated requirements in the regulatory documents, to determine the compliance with the requirements and the quality of the tested fresh fruits.

A significant part of the studies carried out present results for one or several varieties of peaches, nectarines and apricots, and the studies are targeted and related to the study of some specific characteristics and properties of the fruits. To date, no approach has been developed, proposed and applied to assess the conformity and quality of fresh fruit based on morphological characteristics. Therefore, we consider it of interest to propose a systematic approach to the study of specific varieties of peaches, nectarines and apricots by morphological characteristics in order to determine the quality of the fruits. This, in turn, is the main argument for the development and conduct of experimental research on the problem, which is in line with the EU requirements, the problems of the circular economy, sustainable consumption and ensuring the quality of fresh fruits offered to consumers.

2.3. Method for determining the morphological characteristics of the fruits and the stone separated from them

The morphological characteristics of stone fruits include the sequential determination of the average size, mass of the fruits and the stones and stalks separated from them (Nedev, Grigorov, Baev, Serafimov, Strandzhev, Kavardzhikov, Lazarov, Nikolov, Dzhuvinov, Popov, Slavov, Iliev, Stoyanov, Kanev, Krinkov, Vishanska, Topchiyski, Petrova, 1980). The size and mass of the fruits are mainly influenced by the climate and the specifics of the region in which the particular variety is grown, as well as by the age, condition and load (amount of fruit) of the tree (Vassilev, Georgiev, Belyakov, 1982).

The morphological characteristics - shape, mass and dimensions (length, height and width) of the fruits and the stone separated from them are determined according to an established methodology (Nedev, Grigorov, Baev, Serafimov, Strandzhev, Kavardzhikov, Lazarov, Nikolov, Dzhuvinov, Popov, Slavov, Iliev, Stoyanov, Kanev, Krinkov, Vishanska, Topchiyski, Petrova, 1980). According to her, the measurements were made on three samples of 50 fruits, of each variety using a caliper and an analytical scale.

In stone fruits, four sides are distinguished: petiole (main), top, abdomen and dorsal. On the abdominal side there is an abdominal suture, which is the place of adhesion of the ends of the carpel. The measurements (also called diameters) of the fruits and the stones separated from them are three: length or height, in mm (the distance between the petiole and the top side), width, in mm (the largest distance between the two sides) and thickness, in mm (the largest distance between the abdomen and the dorsal side) (Iliev, Vitanov, Yoncheva, Belyakov, 1977; Nedev, Grigorov, Baev, Serafimov, Strandzhev, Kavardzhikov, Lazarov, Nikolov, Dzhuvinov, Popov, Slavov, Iliev, Stoyanov, Kanev, Krinkov, Vishanska, Topchiyski, Petrova, 1980). The results obtained from the measurements of the fruits were averaged and the diameter of the largest cross-section was calculated.

The result for the diameter of the largest cross-section is compared with the requirements reflected in Ordinance 16, 2010 and Regulation 543/2011, and the quality class of the fruit is determined.

According to the requirements for quality and compliance control of fresh fruits, only fruits of local production, which are for processing in the country, are not subject to control. According to the provisions reflected in Regulation 543/2011, the peaches, nectarines and apricots examined are classified according to the diameter of the largest cross-section in three quality classes: *Class Extra, Class I and Class II.*

In the case of *peaches and nectarines*, the size is determined by the diameter according to the largest cross-section of the fruit or by the mass of the fruit. The minimum size is: 56 mm or 85 g for Extra class; 51 mm or 65 g for Class I and Class II. In the case of *apricots*, the determination of the size is mandatory for class Extra, class I and class II (table 2).

Table 2.

Classification of peaches, nectarines and apricots by quality, according to the maximum cross-sectional diameter

Quality class	**Minimum diameter, in mm**	
	Peaches and nectarines	**Apricots**
Class Extra	56	35
Class I	51	30
Class II	51	under 30

Source: Ordinance 16, 2010, Regulation 543/2011

The mass of the fruit, stone and stalk separated from them is determined by an analytical balance with an accuracy of the third decimal place. The average result of the measurements obtained for each of the studied indicators (fruit mass, stone mass, peduncle mass) was calculated. The percentage ratio between the individual parts of the fruit (fruit flesh, stone and stalk), which is known in the scientific literature as the mechanical composition of the fruit, is determined.

The results of the morphological characteristics of the fruits present a complete description of the individual species and varieties (mass and size of the fruit, stones and petioles). The drupes and peduncles of the fruit represent a different part of the total mass of the fruit, with some varieties being relatively large and in other varieties it is smaller. Therefore, the percentage of fruit flesh: pits: stalks is controlled for different types and varieties of stone fruits and is extremely important in determining the purpose of the specific type and variety: for fresh consumption, as a raw material for the canning industry or for export.

The results obtained from the morphological characteristics of fruits are important in:

- *description and characteristics of the fruits of individual species and varieties;*
- *determination of the quality and purpose of the specific variety of fresh fruits for fresh consumption, import or export, and as a raw material for the processing industry;*
- *reduction of financial losses and realization of a positive effect from the use of the specific variety of fruits in the processing industry, for the production of fruit, fruit and sugar preserves, fruit juices, nectars, etc.;*
- *calculation of the expected amount of waste from the specific fruit variety (fruit flesh, skin, stone and stalk) that will be generated after their processing or culinary processing.*

3. Research the quality of peaches, nectarines and apricots based on morphological characteristics

3.1. Examination of the quality of peaches and nectarines

The morphological characteristics of the studied varieties of peaches and nectarines are presented in 2 tables and 6 figures.

Peaches of the Red haven variety are an American variety, widespread both in Bulgaria and around the world. The skin of the fruit is yellow-colored, and the stalk is firmly attached to the fruit.

The examined fruits are very large, and the established dimensions are: length 72,8 mm, width 77,9 mm, thickness 78,1 mm and weight 267,56 g. The stone is large, well separated from the fruit flesh and has dimensions of 39,0 mm long, 22,7 mm wide, 29,2 mm thick and weighing 12,95 g. It makes up 4,84% of the mass of the studied fruits (fig. 2 and fig. 3). The results obtained were confirmed by a group of researchers, according to them, the peach pit of this variety makes up 5-10% of the total mass of the fruit, and the composition of the nut was found to contain from 1,2 to 2,4% amygdalin (Bolarinwa, Orfila, Morgan, 2014; Lee, Oh, Shin, 2017).

The peaches of the studied variety have a cross-sectional diameter of 78,0 mm. Therefore, the peaches of the Redhaven variety meet the requirements for quality class Extra (Regulation 543/2011).

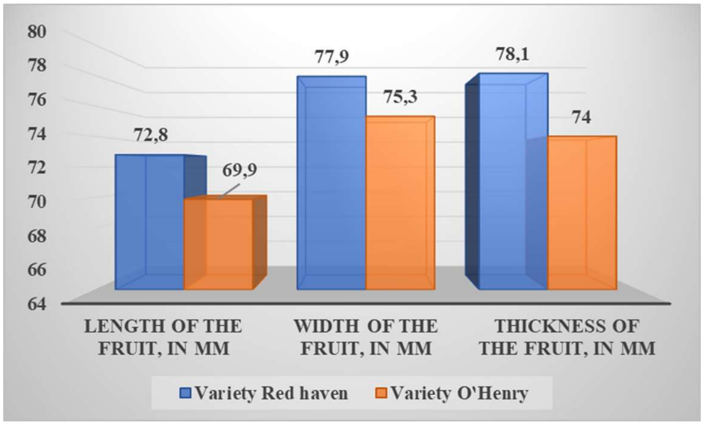

Figure 2. Dimensions of the fruits of Redhaven peaches
and variety "O'Henry"
Source: Own research

Peaches of the O'Henry variety are large fruits, and the stalk is short, medium thick, firmly attached to the fruit. The skin is thick, the stone is large, easily separated from the fruit flesh. The fruits are used both for fresh consumption and for processing (canned fruits, fruit and sugar preserves, nectars, etc.). The examined fruits are even in shape and size. From the study carried out, it was found that the mass of the fruits was 201,32 g. The examined fruits were 69,9 mm long, 75,3 mm wide and 74,0 mm thick (fig. 2). The stalk is 8,1 mm long and is shorter than that of Redhaven peaches. The stone is large and well separated from the fruit with a mass of 9,79 g and is 4,86% of the mass of the fruit (fig. 3). The results obtained were confirmed by a group of researchers, according to them, the peach pit of this variety makes up 5-10% of the total mass of the fruit (Bolarinwa, Orfila, Morgan, 2014; Lee, Oh, Shin, 2017). The diameter of the fruit is 74.7 mm. The established morphological characteristics of peaches of the O'Henry variety classify the fruit as class E quality (Regulation 543, 2011).

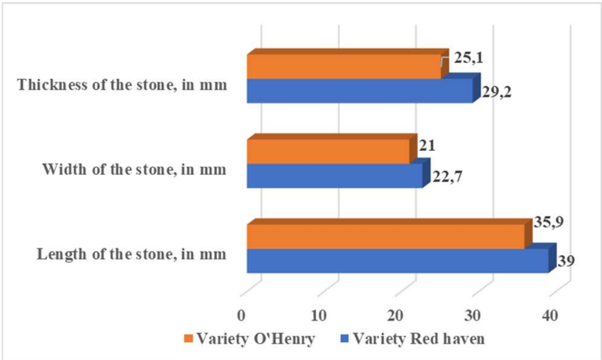

Figure 3. Stone dimensions of peaches varieties Redhaven and O'Henry
Source: Own research

The O'Henry peaches examined were smaller in width and thickness than the Redhaven peaches (fig. 2). This is probably due to the greater amount of fruit on the plants or is a specific species and varietal characteristic, and also influences the climatic conditions during fruit ripening (temperature, precipitation, etc.).

The summarized results for the mechanical composition of the two peach varieties studied are presented in fig. 4. From the fruit study, we found that the percentage of fruit flesh in the fruits of the two large-fruited varieties is the same, 95,1%. The average stone mass is higher for Redhaven peaches and lighter for the stone separated from the O'Henry variety by 3,16 g, respectively. Consequently, the proportion of stone and stem in the fruit of the O'Henry variety is higher than that of the Redhaven variety.

The summarized results are evidence that the fruits of the studied peach varieties, the pits and stalks separated from them have a typical shape and size characteristic of the respective variety. The fruits of the Redhaven peaches are the largest with a larger mass, the separated stone is larger, and the stalk mass is higher compared to the other peach variety studied (fig. 4.).

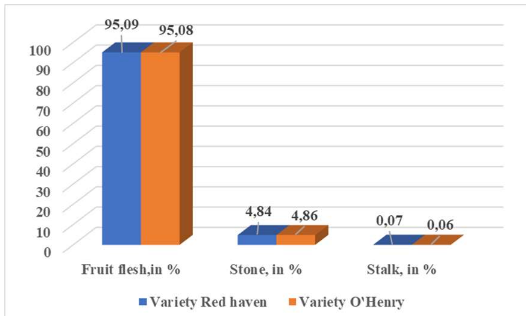

Figure 4. Mechanical composition of some varieties of peaches
Source: Own research

The results obtained (fig. 4) prove that in the case of Redhaven fruits: the percentage of fruit flesh is higher; the proportion of stone and stem is highest in the fruits of the O'Henry variety – 4,92%.

Based on the analysis and summaries of the results obtained, the following generalizations were made: the highest yield was for peaches of the Redhaven variety and the lowest was for peaches of the O'Henry variety. This is explained by the established high percentage of fruit meat (95,09%) and low percentage of stones and stalks – 4,91%. The mass and percentage of stones and petioles does not depend on the size of the fruit, but is a specific varietal feature of the studied fruits. We found that there were small differences in the studied peach varieties. This ratio of the individual parts of the mechanical composition of the fruit is controlled and taken into account when evaluating the fruits, determining the production yield and is an important element of the cost of the finished product (dried fruits, fruit, fruit and sugar preserves, etc.). Such studies are necessary in determining the effect of cultivation and in evaluating different varieties of peaches as raw materials for the processing industry.

The morphological characteristics of the studied peach varieties make it possible to determine the diameter of the cross-section of the fruit, which is set out in the regulatory documents. The results obtained were compared with the requirements and it was found that the *peaches of the Redhaven variety and of the O'Henry variety are of class Extra quality* (Regulation 543/2011).

Nectarines of the Sungrand variety are oval fruits, evenly covered with a dark red color. The fruit flesh is yellow, separating from the stone. The skin is medium thick, and the stone of the fruit is medium-sized. The fruits are large, measuring 73,6 mm long, 73,3 mm wide, 68,8 mm thick and weighing 216,728 g. The stone is medium-sized, well separated from the fruit flesh and has dimensions: length 41,1 mm, width 24,8 mm, thickness 29,6 mm and weight 11,376 g. It is 5,25% of the mass of the fruit variety under study (fig. 5 and fig. 6). It was found that the *diameter of the fruits was 71,1 mm*, therefore *the nectarines of the Sungrand variety are of class Extra quality* (Regulation 543/2011).

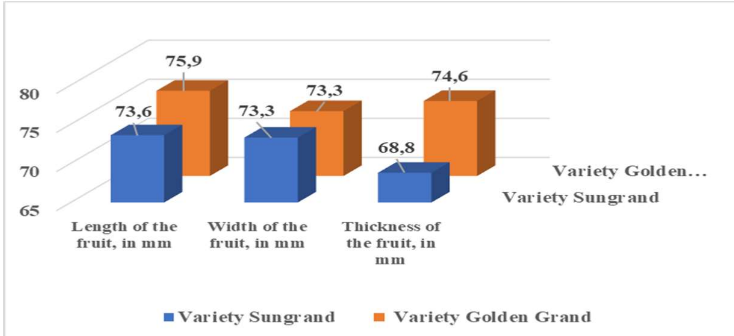

Figure 5. Fruit sizes of nectarines of variety Sungrand and variety Golden Grand
Source: Own research

The studied ***nectarines of the Golden Grand*** variety are large, oval fruits. The skin of the fruit is colored lemon yellow; the fruit flesh is well separated from the stone. The stone is medium-sized. The stalk of the fruit is short, firmly attached to the fruit.

Nectarines of the Golden Grand variety have an average mass of 230,230 g. The average mass of the stone is 13,064 g and it is 5,67% of the mass of the fruit. The studied fruits are 75,9 mm long, 73,30 mm wide and 74,6 mm thick. The length of the stem is 9,7 mm. The stone separated from the fruit is 46,2 mm long, 25,1 mm wide and 31,7 mm thick (fig. 6). The diameter of the fruits is 74,0 mm. The established morphological characteristics of the *nectarines of the Golden Grand variety* correspond to the requirements reflected in Regulation 543/2011 for *quality class Extra*.

The studied nectarines of the Golden Grand variety have a larger diameter (by 2,90 mm) compared to the fruits of the Sungrand variety. A probable reason for the identified differences in size is the specifics of varietal characteristics, growing conditions and the ripening period of fruits.

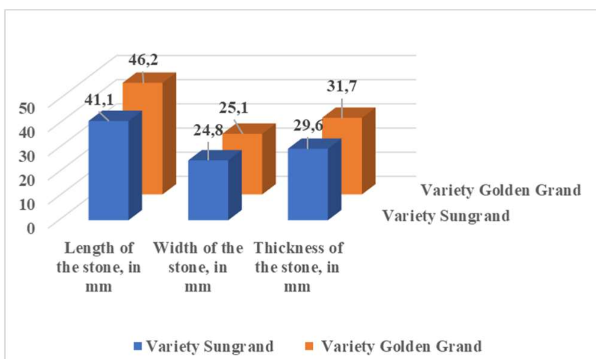

Figure 6. Stone dimensions of nectarines variety Sungrand and variety Golden Grand
Source: Own research

From the study of the two varieties of nectarines (fig. 5) we find that the fruits of the Golden Grand variety are larger. The average stone mass is higher in nectarines of the Golden Grand variety. The stone separated from the Sungrand variety is lighter by 1,688 g, respectively. From the data reflected in fig. 7, we find that the percentage of fruit meat in the fruits of the Sungrand variety is higher. In the fruits of the Golden Grand variety, the proportion of the stone and stalk is higher, compared to the nectarines of the Sungrand variety. After summarizing the results obtained, we found that the nectarines and the stone separated from them have a characteristic shape and size for the variety. The fruits of the nectarines of the Sungrand variety, the separated stone and the stalk have a lower mass compared to the other studied variety of nectarines.

The results of the study (fig. 7) prove that the percentage of fruit meat in Sungrand nectarines is higher. Therefore, the proportion of stone and stalk is higher in nectarines of the Golden Grand variety, being 5,73% of the fruit mass.

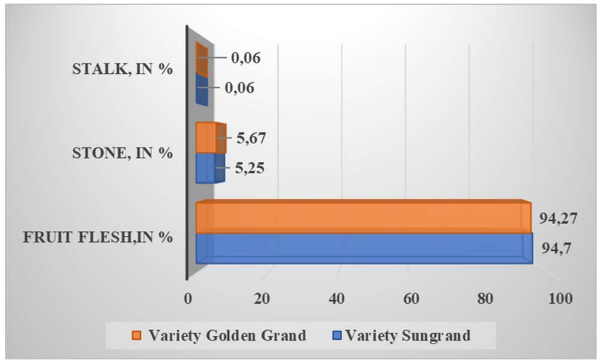

Figure 7. Mechanical composition of certain varieties of nectarines
Source: Own research

The nectarines of the Sungrand variety are lighter, and in the Golden Grand variety, the separated stone is larger and with a higher mass. After summarizing the results obtained, we came to the conclusion that the yield of Sungrand nectarines is higher. This is due to the higher percentage of fruit meat (fig. 7) and the low percentage of stone and stalk – 5,31%. In the case of nectarines of the Golden Grand variety, the yield is lower, due to the low percentage of fruit flesh and the higher percentage of stones and petioles separated from the fruit. The higher yield of nectarines of the Sungrand variety will determine the preferences of consumers and processors for this variety both for fresh consumption and for processing.

The morphological characteristics of the studied varieties of nectarines make it possible to determine the average diameter of the cross-section of the fruit. Based on the results obtained and the comparisons made with the requirements reflected in the regulatory documents, it was determined that the nectarines *variety Sungrand and variety Golden Grand* are *quality class Extra* (Regulation 543/2011).

In the studied literature, no similar studies have been found in which the relationship of the results of the morphological characteristics of the fruits with the requirements reflected in the regulatory framework for the varieties of peaches and nectarines studied by us has been presented, with which to compare the results obtained. We believe that such research is useful and necessary in the modern conditions of a market economy, because the quality of fresh fruits is a major requisite of the labeling and is the basis for the motivated choice of consumers. The morphological characteristics of the fruits provide a complete and complex assessment of the specific varieties of peaches and nectarines studied, and based on the mechanical composition of the fruits, an assessment is made of the purpose of the fruits and the effect of their use as a raw material for the processing industry.

3.2. Examination of the quality of apricots

The Hungarian Apricot variety is well distributed in Europe, it was imported to our country after the Liberation, the fruits are well known and preferred. Specific to them is that they are flat-spherical in shape, the skin of the fruits is medium thick, yellow-orange colored. The stalk of the fruit is fresh, firmly attached to the fruit. The stone is large and is 7,3% of the mass of the fruit, oval, with a rough surface. The nut separated from the stone is sweet with an average mass of 1 g.

The summarized results are presented sequentially for the fruit, stalk, drupe, and cross-sectional diameter of the examined fruits (fig. 8, fig. 9). The fruits of the studied apricot variety have an average weight of 54,56 g, medium-sized, with an average length, width and thickness of 47,7 mm, 44,7 mm, 48,6 mm, respectively. respectively 28,1 mm, 14,1 mm, 2,9 mm. The mass of the stone is 3,98 g and is 7,29% of the mass of the studied fruits. *The cross-sectional diameter of the fruit is 46,6 mm*, therefore, according to this indicator, the apricots of the Hungarian variety comply with the regulated *quality requirements of the Extra class* (Ordinance 16, 2010).

The studied variety Roxana is a Bulgarian variety, specific for the fruits is that they are large, with a rounded shape, and the stone is well separated from the fruit flesh and is 5,1% of the mass of the fruit. The fruit has an average weight of 67,26 g, with an average length, width and thickness of 58,7 mm, 50,5 mm, 51,2 mm, respectively. The stem is fresh, green in color and an average length of 6,0 mm. The stone is large, well separated from the fruit flesh, with an average length, width, thickness, respectively 32,8 mm, 13,5 mm, 25,8 mm. The average mass of the separated stones is 3,42 g and is 5,07% of the mass of the fruit. *The cross-sectional diameter* of the fruit is 50,9 mm (fig. 8, fig. 9), according to this size, *the apricots of the Roxana variety correspond to the quality requirements of the Extra class* (Ordinance 16, 2010).

Figure 8. Apricot fruit sizes from variety Hungarian, variety Roxana, variety Delmast and variety Silistra compotna
Source: Own research

Apricot Delmast is a French variety, the fruits are large, and the stalk is short, firmly attached to the fruit. The skin of the fruit is dark orange colored, the stone is oval, with a rough surface, medium-large, easily separated from the fruit flesh and is 6,4% of the mass of the fruit. The average mass of the fruit is 39,51 g, and the dimensions of length, width and thickness are 43,7 mm, 41,3 mm, 41,4 mm respectively (fig. 8). The stalk is fresh, 3,7 mm long, and is 2,30 mm and 1,19 mm shorter than that of the Roxana and Hungarian apricots. The stone is medium-sized, well separated from the fruit flesh with an average mass of 2,38 g and is 6,02% of the mass of the fruit (fig. 9). The cross-sectional diameter of the fruits of the studied variety is 41,3 mm. Based on the established results, the apricots of the Delmast variety are of *Extra quality* (Ordinance 16, 2010).

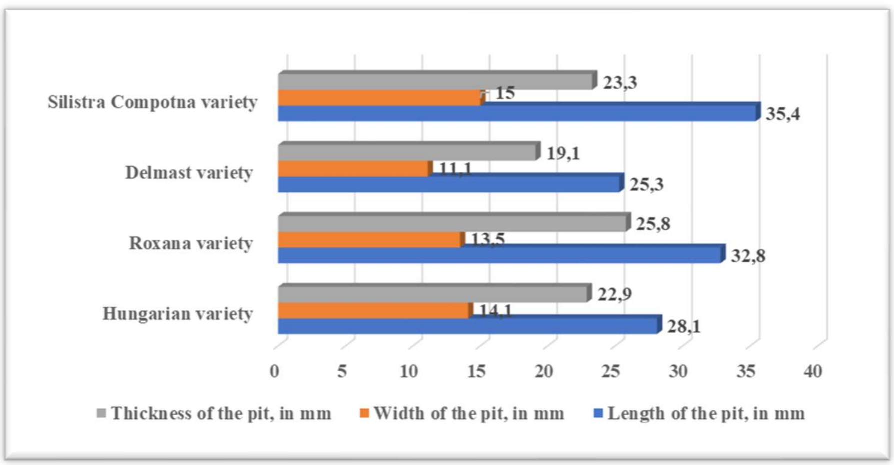

Figure 9. Apricot pit dimensions from the variety Hungarian, variety Roxana, variety Delmast and variety Silistra compotna
Source: Own research

The Apricot variety Silistra compotna is a Bulgarian variety. The fruits are large, globose, flattened on the sides, with symmetrical halves. The fruit flesh is orange, easily separated from the stone, and the nut is sweet. The fruits are medium-sized with an average weight of 65,12 g, flattened, of medium length, width and thickness, respectively 58,84 mm, 42,4 mm, 48,0 mm (fig. 8). The stalk is fresh, 5,9 mm long, shorter by 0,1 mm than in the Roxana variety and 1,0 mm and 2,2 mm longer than the fruit stalks in the Hungarian and Delmast varieties, respectively. The stone is large, well separated from the fruit flesh with an average weight of 4,08 g and makes up 5,68% of the mass of the fruit. The diameter of the fruits of the studied variety is 45,2 mm, therefore the apricots of the Silistra Compotna variety are of *Extra quality* (Ordinance 16, 2010).

The studied apricots of the Delmast variety have the smallest width and thickness compared to the apricots of the other varieties studied (fig. 8). This is probably due to the greater load of trees with fruits, and also influence the varietal characteristics and climatic conditions during fruit ripening (temperature, precipitation, etc.).

Figure 10 presents summarized results of the mechanical composition of the studied apricot varieties. From the conducted study, we found that the highest percentage of fruit flesh there is in apricots of the Delmast variety, and the percentage of stalks is lowest in apricots of the Silistra Compotna variety. The stone of the studied fruits has the highest percentage in the apricot's variety Hungarian, and the lowest in the variety Roxana. Therefore, the proportion of stone and stalk in the studied apricot varieties is highest in the fruits of the Hungarian variety (7,37%) and lowest in the Roxana variety (5,15%).

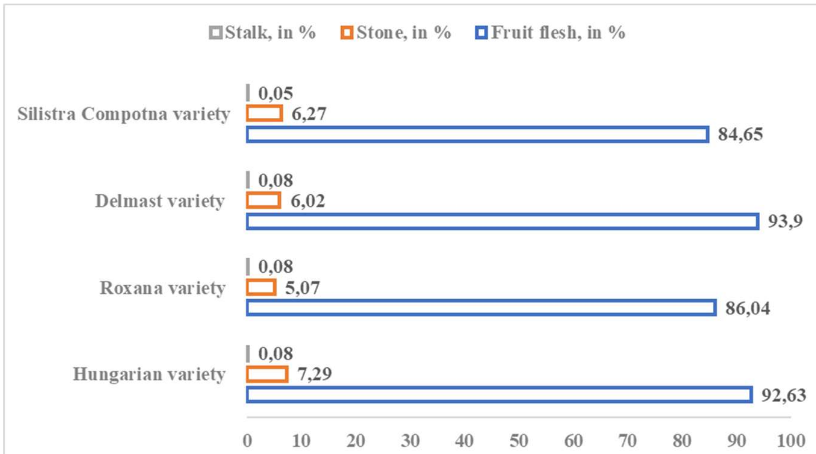

Figure 10. Mechanical composition of some varieties of apricots
Source: Own research

The results obtained from the study (fig. 10) prove that the percentage of fruit flesh is almost equal, with the fruit of the Delmast variety being 1,27% higher than that found in the Hungarian variety, and the lowest in the fruits of the Roxana variety. We found that the proportion of stone and stem is highest in the fruits of the Hungarian variety – 7,37%, and the lowest in the Roxana variety. After analyzing the results, we came to the conclusion that the highest yield of apricots of the Delmast variety and the lowest yield of the Silistra Compotna variety. The high yield of the Delmast variety is determined by the established high percentage of fruit meat (93,90%) and the low percentage of stones and stalks – 6,10%. The proportion of the individual parts of the mechanical composition of the fruit is controlled and taken into account when determining the market value of the fruit for fresh consumption and as a raw material for processing. The sweet nuts separated from the stone of the studied varieties of apricots are used in the production of confectionery, as substitutes for almond kernels.

The mass and percentage content of the stones and petioles does not depend on the size of the fruit, but is a specific species and varietal characteristic of the studied fruits. We found that there are differences in the studied varieties of apricots. This indicator determines the production yield and is an essential element of the cost of the products, such as dried fruits, fruit and fruit and sugar preserves. Such studies are necessary when determining the need and effect of growing a particular variety of apricots and when evaluating the fruits of different varieties of apricots as a raw material for the processing industry.

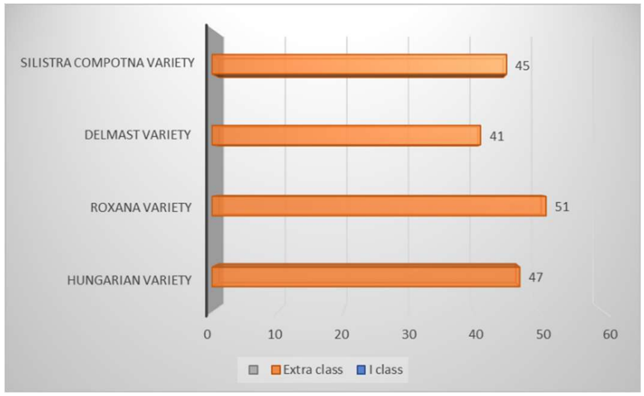

Figure 11. Cross-sectional diameter and quality of some variety's apricots
Source: Own research

From the morphological characteristics of the studied varieties of apricots, the diameter of the cross-section of the fruits is determined (fig. 11), laid down in the requirements laid down in the normative documents, and according to its values, the quality of the fruits is determined. After comparing the results obtained with the requirements reflected in the regulatory documents, we found that the apricots of the Hungarian variety, the Roxana variety, *the Delmast variety and the Silistra compotna variety are of Extra quality* (Ordinance 16, 2010).

In the studied literature, no studies have been found in which the relationship of the results of the morphological characteristics and mechanical composition of the fruits with the requirements reflected in the current regulatory framework for the varieties of apricots studied by us has been presented and analyzed, with which to compare the results obtained. Such studies are useful and necessary in the modern conditions of a market economy, because the quality of fresh fruits is extremely important, it is one of the mandatory requisites of the fruit labeling and last but not least it is the basis for the motivated choice of consumers when choosing and buying a specific variety of fresh fruits.

4. Conclusion

The study of the morphological characteristics of some varieties of peaches, nectarines and apricots gives us grounds to summarize that the high yield and high quality determine the advantages of the studied varieties of fruits. From the study we have found:

- The studied varieties of peaches, nectarines and apricots, the pit and stalks separated from them, have a typical shape and size. The diameter of the cross-section of fruits, set out in the normative documents, is determined and according to the values of this indicator, the quality of the examined varieties, peaches, nectarines and apricots, is *class Extra quality*.
- Based on the results of the morphological characteristics of the studied fruits, a complete, complex assessment (of fruits, stones and stalks) of the studied varieties of peaches, nectarines and apricots was made, and *on the basis of the mechanical composition of the fruits, an assessment was made of the purpose of the fruits and the effect of their use as a raw material for the processing industry*.

Based on the results obtained after the application of the proposed integrated approach for assessing the quality of certain varieties of stone fruits (peaches, nectarines and apricots), the following main conclusions can be drawn on the basis of morphological characteristics:

1. By means of the morphological characteristics of stone fruits, the mass, sizes of fruits, stones and petioles of individual varieties are determined. The results are extremely useful and serve to: classify the fruit (according to the size and mass of the fruit); determine quality of fruit; evaluation of the purpose of fruits for fresh consumption and as a raw material for the canning industry; determination of the yield of the respective stone fruit variety and based on the result, the economic effect of the use of the particular fruit variety as a raw material in the processing industry, for the production of fruit preserves, fruit and sugar preserves, nectars, dried fruits, etc., is calculated.

2. The quality of the examined stone fruits was determined by the diameter of the cross-section of the fruits, and after comparing the results with the requirements set out in the regulatory documents, it was established:
   - peaches variety Redhaven and variety O'Henry are *quality class Extra*;
   - nectarines variety Sungrand and variety Goldengrand are *quality class Extra*;
   - the apricots variety Hungarian, variety Roxana, variety Delmast and variety Silistra Compotna are *quality class Extra*.

In today's dynamically developing environment, the quality of fresh fruits (FFs) is extremely important for consumers, traders and processors of FFs. In recent years, the requirements for FFs and in particular for their freshness, composition, properties and quality have significantly increased. There are many and different factors (support for the production of FFs, length of supply chains, market organization, etc.) influencing the supply of quality raw materials to the market, retail chains and canneries and in particular quality fresh fruits.

With the conducted study, we prove the possibility of assessing the quality and the purpose of fresh fruits, by applying the complex approach to the morphological characteristics of fruits. The results of the morphological characteristics of the fruits should be compared with the requirements reflected in Ordinance 16, 2010 and Regulation 543/2011, and depending on the average diameter of the fruits, the quality of the fruits is determined. According to the requirements reflected in the regulatory documents, one of the requisites in the designations on the packaging of fresh fruits is quality class.

By carrying out a morphological characterization of fresh fruits, the aim is to determine the mass, size of the fruits, stones and petioles of individual varieties of fresh fruit. The results obtained are applicable in:

- writing the full description and characteristics of the studied variety of fresh fruits;
- the classification of fruits (according to the size and mass of fruits);
- determining the quality of the fruit;
- assessment of the purpose of the fruits, depending on their quality, for: the commercial network (fresh consumption), export, raw material for canning industry;
- calculation of the expected number of wastes from the specific fruit variety (skin, stone and stalk) that will be generated after their processing or culinary processing.
- determination of the yield of the respective stone fruit variety, and on the basis of the result, the effect of using the specific fruit variety as a raw material for the processing industry, for the production of fruit preserves, nectars, dried fruits, etc., is calculated. Through these calculations, financial losses can be reduced and a positive effect is realized from the use of a certain fruit variety in the processing industry.

The focus of future work may be directed at: calculation of the expected number of wastes from the certain fruit variety (by carrying out a morphological characterization of fresh fruits - skin, stone and stalk) that will be generated after their processing or culinary processing.; introduce the possibility to manage and use the separated wastes obtained after possessing of fresh fruits.

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