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Dynamics of the average fruit weight and the ratio of kernels to pulp in cherry fruits grown in the Southern Steppe zone of Ukraine

Abstract. The popularity of sweet cherries among consumers is due to the high taste qualities of fruits with an attractive appearance and the early ripening period. Among external quality indicators, the mass of sweet cherries and the kernel-to-pulp ratio are of the greatest importance for consumers, which affects the market value. The purpose of the study was to examine the average fruit weight and kernel weight of 33 cherry varieties of three maturation periods, both promising and common in Ukraine, and identify varieties and variety samples that have scientific and practical value in terms of the considered parameters. Determining the average fruit weight, kernel weight, and kernel-to-pulp ratio in cherry fruits was conducted during the period of economic ripeness. Sampling and preparation of samples for analysis were conducted in accordance with DSTU ISO 874-2002. The average weight of the fruit in sweet cherries grown in the conditions of the Southern Steppe zone of Ukraine was at the level of 8.41 grams, the average weight of the kernel was 0.56 grams. The optimal fruit weight was provided by the fruits of the sweet cherry group of the late ripening period (7.27-12.18 g). The most stable, with minimal coefficients of variation in the indicators under study in the context of early-ripening varieties in terms of fruit and kernel mass, were the varieties Sweet earlies and Rubinova rannia. Among the group of varieties of medium ripening, the most stable mass of fruits and kernels were the fruits of the varieties Temp and Vynka. In late ripening varieties, the lowest variability in the content of fruit and kernel weight was recorded in the Regina variety. It was identified that the dominant influence for the formation of fruit mass in all groups of varieties was exerted by the weather conditions of years of research, and for the formation of kernel mass in all groups of varieties – varietal features. The results of the study will be useful when choosing cherry varieties of different maturation periods that are suitable for selling fruits and further processing them

Keywords: ripeness, regression analysis, bone mass, variation of indicators

INTRODUCTION

Sweet cherries belong to the most popular kernel crops among consumers of fruit products (Tolstolik, 2021; Ivanova *et al.*, 2022). Such popularity of this fruit crop is due to the high taste qualities of fruits with an attractive appearance, and an early ripening period (Bak *et al.*, 2010; Alrgei *et al.*, 2016; mézes *et al.*, 2017). Cherry fruits begin to ripen in the third decade of may and thus open

the period of consumption of fresh fruit (Turovtseva & Turovtsev, 2014). According to the Ukrainian Association of agricultural exports, Ukrainian producers annually grow 133 thousand tonnes of sweet cherry fruits (Ukraine ranks second..., 2022), and according to FAO (Food and Agriculture..., 2022) statistics over the past 10 years, the level of sweet cherry fruit production in the

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world is within 2 million tonnes, which led to an acute shortage and high sales prices for it (Ivanova *et al.*, 2019). Keserović *et al.* (2014), and others note that about 70% of the world's total sweet cherry is produced by European countries (Bouhadidaa *et al.*, 2009; Barac *et al.*, 2014; Gaudet *et al.*, 2019), followed by Asia – 20% and North America – 10% (Sanderson *et al.*, 2019; mezhenskyj *et al.*, 2020).

The increase in fruit production is due to a number of reasons: variety renewal and introduction of new high-quality fruit varieties (Mir *et al.*, 2021; Shevchuk *et al.*, 2021; Shevchuk *et al.*, 2021); progress in agriculture and fruit processing technology (Bell *et al.*, 2017). The popularity of fruit consumption is confirmed by numerous studies of the content of biologically active substances in fruits (Ivanova *et al.*, 2021) and their therapeutic and preventive health effects (Milošević & Milošević, 2012; Eslami *et al.*, 2022). Blando & Oomah (2019) notes that the consumption of sweet cherries has a positive effect on human health, namely, it counteracts oxidative stress, reduces inflammation, regulates blood glucose levels and improves cognitive function, promotes faster recovery from muscle damage caused by exercise. Many studies are devoted to the examination of the biochemical composition of sweet cherries by species and varietal characteristics. A study of the fruit content of four species of the *Prunus* genus conducted by Cao *et al.* (2015) in China determined the suitability of *Prunus cesarus* for processing due to the high content of ascorbic acid and anthocyanins.

According to biological characteristics, sweet cherries grow best in moderately warm climates, in Ukraine, the vast majority of the plantings are concentrated in the Southern region, in particular, in the Zaporizhzhia, Dnepropetrovsk, Odesa, Kherson, and Mykolaiv regions (Kishchak, 2014; Ivanova *et al.*, 2021; Ivanova *et al.*, 2021).

The productivity of varieties is investigated by many indicators, in particular: maturation periods, storage periods, logistics of transportation, commercial qualities of fruits, the content of biologically active substances in them, methods of influencing the marketability of fruits, yield, the possibility of manufacturing processed products from cherry fruits, etc. Thus, Grandi *et al.* (2017) note the dependence of the taste qualities of sweet cherries on the date of fruit harvesting. They highlight the need to determine the physiological date of ripening of fruits on the tree and not reduce it due to commercial or marketing necessity. The paper by Zhang *et al.* (2017) is devoted to the examination of the influence of product quality on the selling price, transportation conditions to maintain high quality, especially in express logistics. The authors proposed a dynamic monitoring and quality assessment system (DMQAS), based on multisensors to reduce the quality loss of fresh cherry fruits in express logistics. The paper by Chockchaisawasdee *et al.* (2016) presents the development of methods for post-harvest

processing of sweet cherry fruits to extend the terms of their storage and transportation and provides data on biologically active components of sweet cherry fruits.

The purpose of the study was to assess the average weight of fruits and the ratio of pulp and kernel in the fruits of cherry varieties of Ukrainian and foreign selection grown in the conditions of the Southern Steppe of Ukraine.

LITERATURE REVIEW

In the context of the problem under study, attention is drawn to the issues of quality management of cherry products in the thematic literature, in particular, which concerns the study by Bustamante *et al.* (2021). The paper presents the results of examining the impact of foliar top dressing with potassium before harvesting on the quality of harvested fruits, and the condition of cherry trees grown in plastic shelters in gardens in Southern Chile. It was identified that an intensive potassium regime can improve the quality of fruits of the cherry variety Regina; however, the results vary substantially depending on the season and terrain.

Researchers have developed methods for their post-harvest processing and investigated the content of biologically active components to extend the shelf life and transportation of sweet cherry fruits (Chockchaisawasdee *et al.*, 2016).

Changes in the amount of accumulated biologically active substances in the fruits of sweet cherries of the varieties Skeena and Sweetheart by spraying with gibberellic acid (GA₃), abscisic acid (ABA), salicylic acid (SA), and glycine-betaine (GB) were investigated by S. Correia *et al.* (2020). Researchers identified that spraying the trees with GA₃, ABA, SA, and GB increased the anthocyanin content of Skeena sweet cherries. GA₃ and GB caused a decrease in carotenoid content in Skeena and a decrease in ascorbic acid content in Lubka sweet cherries. GA₃ caused the greatest changes by increasing the anthocyanin content (42%), reducing the carotenoid content (19%) and ascorbic acid (53%). *Ascophyllum nodosum* one of the new processing methods, along with GB, causes the opposite effect of GB, increasing carotenoids and ascorbic acid, but reducing the content of phenols.

A large number of studies are devoted to the examination of variations in accumulated biological substances in cherry fruits depending on the variety (Budak, 2017; Antognoni *et al.*, 2020). Productivity, namely yields and fruit quality, depending on the density of planting in two varieties of sweet cherries Ziraat 0900 and Cordia on the Gisela 6 graft was investigated by Arsov *et al.* (2020). As a result, it was determined that the highest total yield for these varieties was for planting schemes of 5×3.5 m, and the weight and density of fruits did not vary depending on the planting scheme and met the established standards.

The dependence of the yield and quality of cherry fruits on graft-variety combinations in Ukraine was

investigated by O. Kischak (Kishchak, 2013; Kishchak, 2014), and it is noted that the most low-growing trees at the age of six were trees of the Donchanka variety on Gisela 5 (2.6 m), Studenykivs'ka (2.7 m) and VSL-2 (2.8 m), which is 14.7% lower than on Mahalebs'ka sweet cherry, wild sweet cherry; the same varieties (on Studenykivs'ka graft) were also the most precocious and productive, and in the fifth year after planting, the yield reached 13.2 t/ha.

The study of new seven varieties of sweet cherries Cetățuia, Cătălina, Bucium, Golia, Maria, Ștefan, Tereza in the conditions of the North-East of Romania was conducted by S. Sîrbu and indicates a minor relationship between the number of days from the time of full flowering to the ripening of fruits and their commercial quality and chemical composition (Sîrbu *et al.*, 2012).

In Ukraine, breeding work on the creation of new varieties of sweet cherries and, accordingly, the study of productivity indicators depending on varietal characteristics was conducted by M. Turovtsev and V. Turovtseva at Melitopol Research Station of Horticulture named after M.F. Sidorenko of the Institute of Horticulture of National Academy of Agrarian Sciences (Turovtseva & Turovtsev, 2014). Researchers identified new promising varieties of sweet cherries Efektna, Udacha, Avangard, Bigaro Turovtsevoi, Siianets` Turovtsevoi, Modna, Novynka Turovtsevoi, Trudova, Vizytka, Pamyatna, capable of producing an annual harvest of high-quality fruits.

According to an analytical review of literature sources, the study of the quality of fruits of varieties and forms of sweet cherries is conducted simultaneously with many studies related to the cultivation of this crop, the collection and sale of fruits, and subsequent processing. Since sweet cherries as a fruit crop are the hallmark of the region of the Southern Steppe of Ukraine and are of great national economic importance, a comprehensive study of the components of the production process of this crop is an urgent issue.

MATERIALS AND METHODS

The study was conducted during 2008-2019 in horticultural farms of the Melitopol District of the Zaporizhzhia region. To assess quality indicators, cherry fruits of common and promising varieties in Ukraine of three maturation periods were selected: 1st (early) – Sweet Earlies, Merchant, Bigaro Burlat, Rubinova rannia, Valerii Chkalov, Kazka, Zabuta; 2nd (medium) – Kordia, Octaviia, Vynka, Pervistok, Temp, Liubymytsia Turovtseva, Talisman, Dilema, Melitopol'ska chorna, Orion, Chervneva rannia, Dachnytsia, Prostir; 3rd (late) – Karina, Regina, Mirazh, Krupnoplidna, Udivitiel'na, Zodiac, Siurpryz,

Kolkhoznitsia, Kosmichna, Prazdnichna, Anons, Temporian, Meotyda.

Determination of the average fruit weight, kernel weight, and kernel-to-pulp ratio in cherry fruits was conducted during the period of economic ripeness. A sample was taken from 100 fruits (in each repetition) from 3-5 typical trees during the period of economic ripeness to determine the weight of one cherry fruit. The experiment is repeated three times. Fruits must be selected in such a way that the sample taken is characteristic in quality for the harvest of this season. All selected fruits were weighed, then the mass of one fruit was determined by dividing the total mass by their number (100 pieces). After weighing the fruit sample, their kernels were removed. The resulting kernels were washed from the pulp. Moisture from the surface of the kernels was removed with filter paper, after which they were weighed and the average mass of one kernel was determined by dividing the total mass by their number (100 pieces) (Serdiuk *et al.*, 2020). Sampling and preparation of samples for analysis were conducted in accordance with DSTU ISO 874-2002 (Fresh fruits and..., 2003).

The region of growing is characterised by insufficient moisture in terms of precipitation in general. The climate is Atlantic-continental, arid with high temperatures. The direction of dry winds is North-East. According to the complex of climatic indicators, the region of the study is suitable for growing sweet cherries.

Meteorological data from the Melitopol weather station (46° 49'N, 35° 22'e) for 2008-2019 were used to analyse the impact of weather conditions (Ivanova *et al.*, 2020). The average annual air temperature is 9.1-9.9°C. The sum of active temperatures of 10°C and above, from April to October, is over 3,300°C. The average amount of precipitation per year is 475 mm. The hydrothermal coefficient ranges between 0.22...0.77.

The analysis and processing of experimental data was conducted according to V. Mezhenskyi (Mezhenskyi, 2017), using the computer programmes MS Office Excel 2010, the Statistica package.

RESULTS AND DISCUSSION

The results of 12 years of research allow stating that the average weight of the fruit in cherry fruits was at the level of 8.41 grams, the average weight of the kernel was 0.56 grams. In the conducted studies, the average weight of the fruit of early maturing sweet cherries is 7.61 grams, kernels – 0.50 grams (Table 1), that is, it was 10.51% and 12% lower compared to the average varietal value of the investigated indicators.

Table 1. Weight of fruit (grams), kernel (grams), and their ratio (%) in early maturing cherry fruits (2008-2019), $\bar{x} \pm s\bar{x}$, n=5.

| Pomological variety | Fruit weight (grams) | | | | Kernel weight (grams) | | | | Ratio of fruit mass to kernel mass, % |
|--------------------------|-----------------------|------------------|-------------------|--------------------------|-----------------------|------------------|-------------------|--------------------------|---------------------------------------|
| | Average weight, grams | min weight, gram | max weight, grams | Variation by year, Vy, % | Average weight, grams | min weight, gram | max weight, grams | Variation by year, Vy, % | |
| Rubinova rannia | 7.32±0.41 | 5.05 | 9.07 | 19.4 | 0.49±0.01 | 0.40 | 0.57 | 11.5 | 6.69 |
| Valerii Chkalov | 8.35±0.29 | 6.46 | 9.43 | 12.2 | 0.72±0.02 | 0.61 | 0.85 | 11.9 | 8.62 |
| Sweet Earlies | 7.73±0.23 | 6.51 | 9.03 | 10.6 | 0.74±0.02 | 0.58 | 0.91 | 12.4 | 9.57 |
| Merchant | 6.25±0.40 | 4.46 | 8.34 | 22.5 | 0.61±0.03 | 0.49 | 0.81 | 17.5 | 9.76 |
| Kazka | 9.10±0.36 | 7.17 | 11.56 | 14.0 | 0.60±0.03 | 0.46 | 0.89 | 19.5 | 6.59 |
| Bigaro Burlat | 6.79±0.29 | 5.38 | 8.25 | 14.9 | 0.63±0.02 | 0.49 | 0.80 | 13.1 | 9.27 |
| Zabuta | 7.73±0.33 | 6.38 | 9.60 | 15.1 | 0.70±0.03 | 0.52 | 0.87 | 16.7 | 9.05 |
| Average value | 7.61±0.33 | 5.91 | 9.32 | 15.5 | 0.64±0.02 | 0.50 | 0.81 | 14.6 | 8.40 |
| <i>HIP</i> ₀₅ | 0.649 | | | | 0.084 | | | | |

In the fruits of sweet cherries of medium-ripening and late-ripening varieties, the average fruit weight exceeded the average varietal value by 0.23% and 8.88%, respectively (Table 2, 3). Thus, among the varieties under

study, the optimal fruit weight was provided by the fruits of the sweet cherry group of the late ripening period. The average kernel weight in late-ripening fruits was 11.11% higher compared with the average varietal value.

Table 2. Weight of fruit (grams), kernel (grams), and their ratio (%) in cherry fruits of medium-ripening varieties (2008-2019), $\bar{x} \pm s\bar{x}$, n=5.

| Pomological variety | Fruit weight (grams) | | | | Kernel weight (grams) | | | | Ratio of fruit mass to kernel mass, % |
|------------------------|-----------------------|------------------|-------------------|--------------------------|-----------------------|------------------|-------------------|--------------------------|---------------------------------------|
| | Average weight, grams | min weight, gram | max weight, grams | Variation by year, Vy, % | Average weight, grams | min weight, gram | max weight, grams | Variation by year, Vy, % | |
| Vynka | 7.46±0.25 | 6.34 | 8.89 | 11.8 | 0.62±0.02 | 0.49 | 0.72 | 11.4 | 8.31 |
| Pervystok | 8.13±0.37 | 6.69 | 10.98 | 15.9 | 0.46±0.02 | 0.39 | 0.63 | 19.7 | 5.65 |
| Temp | 8.90±0.27 | 7.65 | 10.55 | 10.8 | 0.77±0.02 | 0.60 | 0.93 | 12.6 | 8.65 |
| Liubymytsia Turovtseva | 7.47±0.48 | 5.11 | 10.09 | 22.5 | 0.53±0.01 | 0.41 | 0.62 | 12.2 | 7.09 |
| Talisman | 8.93±0.51 | 6.80 | 11.81 | 19.8 | 0.69±0.03 | 0.52 | 0.89 | 16.2 | 7.72 |
| Dylema | 9.91±0.43 | 7.92 | 12.01 | 15.0 | 0.60±0.02 | 0.46 | 0.77 | 17.0 | 6.05 |
| Melitopol'ska chorna | 9.37±0.38 | 7.63 | 11.81 | 14.2 | 0.47±0.01 | 0.40 | 0.60 | 11.5 | 9.05 |
| Cordia | 8.54±0.65 | 5.51 | 11.75 | 26.6 | 0.64±0.02 | 0.50 | 0.74 | 12.6 | 5.01 |
| Octavia | 8.69±0.45 | 6.01 | 10.77 | 18.2 | 0.52±0.01 | 0.40 | 0.61 | 11.6 | 6.08 |
| Orion | 6.85±0.40 | 4.61 | 8.77 | 20.7 | 0.39±0.01 | 0.31 | 0.50 | 15.9 | 5.69 |
| Chervneva rannia | 7.48±0.27 | 5.90 | 8.68 | 12.8 | 0.49±0.02 | 0.36 | 0.67 | 18.7 | 6.55 |
| Dachnytsia | 8.09±0.40 | 5.71 | 9.98 | 17.2 | 0.50±0.01 | 0.37 | 0.61 | 12.3 | 6.18 |

Table 2, Continued

| Pomological variety | Fruit weight (grams) | | | | Kernel weight (grams) | | | | Ratio of fruit mass to kernel mass, % |
|---------------------|-----------------------|------------------|-------------------|--------------------------|-----------------------|------------------|-------------------|--------------------------|---------------------------------------|
| | Average weight, grams | min weight, gram | max weight, grams | Variation by year, Vy, % | Average weight, grams | min weight, gram | max weight, grams | Variation by year, Vy, % | |
| Prostir | 9.34±0.35 | 778 | 11.67 | 13.2 | 0.67±0.03 | 0.54 | 0.91 | 16.1 | 7.17 |
| Average value | 8.39±0.40 | 6.43 | 10.59 | 16.8 | 0.56±0.02 | 0.44 | 0.70 | 17.3 | 6.67 |
| HIP ₀₅ | 0.520 | | | | 0.046 | | | | |

Table 3. Weight of fruits (grams), kernels (grams), and their ratio (%) in late-maturing cherry fruits (2008-2019), $\bar{x} \pm s\bar{x}$, $n=5$.

| Pomological variety | Fruit weight (grams) | | | | Kernel weight (grams) | | | | Ratio of fruit mass to kernel mass, % |
|---------------------|-----------------------|------------------|-------------------|--------------------------|-----------------------|------------------|-------------------|--------------------------|---------------------------------------|
| | Average weight, grams | min weight, gram | max weight, grams | Variation by year, Vy, % | Average weight, grams | min weight, gram | max weight, grams | Variation by year, Vy, % | |
| Krupnoplidna | 11.67±0.47 | 8.73 | 13.72 | 14.0 | 0.51±0.02 | 0.40 | 0.61 | 14.2 | 4.37 |
| Karina | 9.57±0.37 | 7.55 | 11.94 | 13.5 | 0.66±0.02 | 0.56 | 0.79 | 11.1 | 6.89 |
| Regina | 7.99±0.23 | 6.71 | 9.00 | 10.1 | 0.74±0.02 | 0.62 | 0.88 | 10.4 | 9.26 |
| Mirazh | 7.73±0.24 | 6.30 | 8.81 | 11.1 | 0.58±0.01 | 0.46 | 0.67 | 11.5 | 7.50 |
| Udivitiel'na | 12.18±0.51 | 10.01 | 14.60 | 14.7 | 0.43±0.02 | 0.30 | 0.56 | 20.9 | 3.53 |
| Zodiak | 8.95±0.29 | 7.23 | 10.05 | 11.2 | 0.56±0.01 | 0.47 | 0.64 | 11.3 | 6.25 |
| Siurpryz | 7.37±0.28 | 6.00 | 9.40 | 13.2 | 0.57±0.03 | 0.40 | 0.79 | 21.2 | 7.73 |
| Kolkhoznitsa | 8.14±0.37 | 5.67 | 9.93 | 16.0 | 0.70±0.04 | 0.40 | 0.88 | 21.3 | 8.59 |
| Kosmichna | 9.91±0.41 | 8.05 | 12.21 | 14.6 | 0.76±0.02 | 0.56 | 0.91 | 13.4 | 9.44 |
| Prazdnichna | 7.27±0.27 | 5.71 | 8.76 | 13.2 | 0.71±0.02 | 0.52 | 0.82 | 13.5 | 5.16 |
| Anons | 9.84±0.37 | 7.96 | 11.77 | 13.2 | 0.60±0.02 | 0.50 | 0.69 | 12.4 | 6.09 |
| Temporion | 9.68±0.43 | 7.44 | 12.01 | 15.4 | 0.75±0.02 | 0.68 | 0.89 | 11.1 | 7.74 |
| Meotyda | 9.78±0.39 | 7.21 | 11.72 | 14.1 | 0.66±0.02 | 0.46 | 0.79 | 14.9 | 6.74 |
| Average value | 9.23±0.35 | 7.27 | 11.07 | 13.4 | 0.63±0.03 | 0.48 | 0.76 | 14.4 | 6.82 |
| HIP ₀₅ | 0.538 | | | | 0.039 | | | | |

Among the group of early ripening varieties, the minimum fruit weight was recognised in Merchant fruits (4.46 g) of the 2018 harvest, which is 41.39% lower than the average varietal value. The maximum value of fruit weight at the level of 11.56% was identified in the fruits of the Kazka harvest of 2016 (excess over the average varietal value – 52.03%). The variety of early maturation, which according to the results of the study was characterised by the largest mass of the fruit was Kazka, and the smallest – Merchant at HIP₀₅ – 0.649 (Table 1). The minimum average kernel weight was considered for fruits of the Rubinova rannia variety – 0.40 g, harvested in 2008 (37.50% lower than the average varietal value). The maximum kernel mass index was recorded in Sweet Earlies fruits of 0.91 g in 2016 (excess over the average varietal

value – 42.18%). The variety of this maturation period, which, according to the results of all years of the study, was characterised by the largest mass of kernels, was Sweet Earlies; the smallest – Rubinova rannia, at HIP₀₅ – 0.084. The optimal value of the complex indicator of the kernel-to-pulp ratio, which tends to the minimum values, was determined in the Kazka fruits – 6.59%.

In the groups of medium-ripening and late-ripening varieties, the fruits of the Orion and Kolkhoznitsa varieties harvested in 2012 and 2008 were characterised by the minimum fruit weight of 4.61 g and 5.67 g. The fruit weight was less than the average varietal value by 45.05 and 38.57%, respectively. The largest mass of fruits in varieties of medium and late maturation periods was recorded in Dylema (2010 harvest) and Udivitiel'na

(2011 harvest) with values of 12.01 g and 14.54 g, respectively (excess over the average varietal value – 43.14 and 57.53%, respectively). Among medium-ripening and late-ripening varieties, the maximum average fruit weight was identified in the fruits of the varieties Dylema and Kosmichna (9.91 g). The minimum average kernel weight was determined in the fruits Orion – 0.31 g and Udivitiel'na – 0.30 g, which were harvested in 2008 and 2017, respectively. The indicators were lower than the average value for varieties by 44.64% and 52.38%, respectively. The maximum kernel mass was recorded in fruits of the Temp 0.94 g (in 2011) and Kosmichna varieties 0.91 g (in 2015) (excess over the average varietal value – 67.85% and 44.44%, respectively). Varieties of medium and late maturation periods, which, according to the results of average values of twelve-year studies, were characterised by the largest mass of kernels, were Temp and Kosmichna, and the smallest – Pervistok, Melitopol'ska chorna, Krupnoplidna at $HIP_{05} = 0.046$ and $HIP_{05} = 0.039$. The optimal value of the complex indicator of the kernels-to-pulp ratio was determined in the fruits of the Cordia (5.01%), Pervistok (5.65%), Orion (5.69%), Udivitiel'na (3.53%), and Krupnoplidna (4.37%) varieties. Studies by Georgian researchers established that the relative mass of kernels to the mass of fresh fruits ranged from 3.7% to 8.4% (Maglakelidze *et al.*, 2017). According to K.M. Bhat, the highest percentage of kernels in the total weight of sweet cherries was recorded at 7.58% in the Makhmali variety (Bhat *et al.*, 2018).

From a technological standpoint, varieties, the fruits of which differ not only in the maximum fruit

weight, minimum values of kernel mass, and the ratio of kernel mass to fruit but also in the stability of these indicators are of particular value. The presented results indicate the average variability of fruit and kernel weight over the years of research in the group of early-ripening varieties. The greatest influence of abiotic factors on fruit weight and kernel weight was identified in the fruits of this group for Merchant (it has a substantial variability of 22.5%) and Skazka with coefficients of variation – 19.5, respectively. The most stable in terms of indicators under study in the context of early ripening varieties in terms of fruit mass and kernel mass parameters are Sweet Earlies ($V_y=10.6\%$) and Rubinova rannia ($V_y=11.5\%$). The variability of these indicators over the years of research in the fruits of sweet cherries of medium-ripening and late-ripening varieties was average and substantial. Among the medium-ripening varieties, the fruits of the Temp ($V_y=11.8\%$) and Vynka ($V_y=11.4\%$) varieties were the most stable in terms of fruit and kernel weight, respectively, and the most variable were the Kordia ($V_y=26.6\%$) and Pervistok ($V_y=19.7\%$) varieties. In late-maturing varieties, the greatest variability in the content of fruit and kernel weight was recorded in the Kolkhoznitsa ($V_y=16.0\%$) and Udivitiel'na ($V_y=20.9\%$) varieties; the lowest – in Regina ($V_y=10.1\%$ and 10.4%).

It was identified that for the formation of fruit mass in all groups of varieties, the dominant influence was exerted by the weather conditions of years of research (factor A) with the part of influence for early-maturing varieties – 39.7%, medium-maturing – 51.5% and late-maturing – 26.1% (Table 4).

Table 4. Results of two-factor analysis of variance in the formation of fruit mass and kernel mass in cherry fruits

| Indicator | Fruit weight | | | | | | Kernel weight | | | | | |
|---|----------------|-------------------|----------|------------|---------------|-----------|----------------|-------------------|----------|------------|---------------|-----------|
| | Sum of squares | Degree of freedom | Variance | F_{fact} | $F_{tab.095}$ | Impact, % | Sum of squares | Degree of freedom | Variance | F_{fact} | $F_{tab.095}$ | Impact, % |
| Group of early ripening cherry varieties | | | | | | | | | | | | |
| Factor A (year) | 215.7 | 11 | 19.61 | 123.2 | 1.8 | 39.7 | 1.0 | 11 | 0.09 | 34.8 | 1.8 | 24.4 |
| Factor B (variety) | 194.1 | 6 | 32.35 | 203.3 | 2.2 | 35.7 | 1.5 | 6 | 0.26 | 98.1 | 2.2 | 37.5 |
| AB interaction | 106.7 | 66 | 1.61 | 10.1 | 1.4 | 19.6 | 1.1 | 66 | 0.01 | 6.4 | 1.4 | 27.0 |
| Group of medium-ripening cherry varieties | | | | | | | | | | | | |
| Factor A (year) | 671.9 | 11 | 61.08 | 598.7 | 1.8 | 51.5 | 1.4 | 11 | 0.12 | 153.2 | 1.8 | 16.5 |
| Factor B (variety) | 356.5 | 12 | 29.71 | 291.2 | 1.8 | 27.3 | 5.1 | 12 | 0.42 | 513.2 | 1.8 | 60.5 |
| AB interaction | 236.9 | 132 | 1.795 | 17.5 | 1.3 | 18.1 | 1.6 | 132 | 0.01 | 15.0 | 1.3 | 19.5 |

Table 4, Continued

| Indicator | Fruit weight | | | | | | Kernel weight | | | | | |
|---|----------------|-------------------|----------|-------------------|----------------------|-----------|----------------|-------------------|----------|-------------------|----------------------|-----------|
| | Sum of squares | Degree of freedom | Variance | F _{fact} | F _{tab.095} | Impact, % | Sum of squares | Degree of freedom | Variance | F _{fact} | F _{tab.095} | Impact, % |
| Group of late-ripening cherry varieties | | | | | | | | | | | | |
| Factor A (year) | 463.7 | 11 | 42.16 | 384.7 | 1.8 | 26.1 | 1.8 | 11 | 0.16 | 275.1 | 1.8 | 21.5 |
| Factor B (variety) | 1024.4 | 12 | 85.37 | 778.9 | 1.8 | 57.8 | 4.5 | 12 | 0.37 | 626.3 | 1.8 | 53.4 |
| AB interaction | 248.9 | 132 | 1.88 | 17.2 | 1.3 | 14.0 | 1.9 | 132 | 0.01 | 24.1 | 1.3 | 22.6 |

The part of influence of varietal characteristics (Factor B) on the formation of fruit mass was 35.7%, 27.3%, and 1.8%, respectively. For the formation of kernel mass in all groups of varieties, varietal characteristics (Factor B) had a dominant influence with a part of influence for early-maturing varieties – 37.5%, medium-maturing – 60.5%, and late-maturing – 53.4%. The part of influence of varietal characteristics on the formation of kernel mass was 24.4%, 16.5% and 21.5%, respectively, for the analysed groups.

An important indicator that determines the competitiveness of cherry fruits is the average fruit weight and the kernel-to-pulp ratio (Pérez-Sánchez *et al.*, 2010; Maglakelidze *et al.*, 2017; Herasko *et al.*, 2020). According to many researchers, the average weight of cherry fruits and the kernel-to-pulp ratio are influenced by genetic soil-climatic conditions and characteristics of the variety. Thermal resources of the growing season of crops and varieties and moisture indicators are also important indicators (Diachuk, 2017; Herasko & Todorova, 2020).

The results obtained are consistent with the data of other studies on the formation of the average weight of the fruit and kernel in various pomological varieties of sweet cherries. Thus, the weight of sweet cherries ranged from 5.9 g (Scorpelka) to 9.2 g (Andreiaş) in the conditions of North-Eastern Romania (Corneanu *et al.*, 2020). As a result of investigating nine foreign varieties in Georgia, it was identified that all the varieties under study had large fruits except for Moro (Maglakelidze *et al.*, 2017). The average weight of sweet cherries ranged from 6.9 g (Moro) to 10.2 g (Celeste), and the kernel weight ranged from 0.2 g (Burlat) to 0.56 g (Celeste).

The study by Bieniek *et al.* (2011) identified that in Lithuania, on average, over three years, the weight of sweet cherries ranged from 3.78 to 6.45 g. Evaluation of nine varieties of sweet cherries based on external signs of fruit quality was conducted in the conditions of the Mediterranean part of Croatia (Radunić *et al.*, 2014). It was identified that the fruits of the cherry varieties Isabella and Tugarka had an average weight of more than 7.5 g, and the variety Burlat – less than 5 g. The study by (Iurea *et al.*, 2019) in Romania determined that the largest

fruit mass was identified in the Elaiasi (8.9 g) and Croma (9.4 g) varieties. The highest mass index of the cherry fruit (10.0 g) was recorded in the Andreiaş variety by the Romanian researcher M. Corneanu *et al.* (2021). In the conditions of India according to K.M. Bhat *et al.* (2018), the highest kernel mass was identified in cherry fruits of the Regina and Misri varieties at the level of 0.48 g, and the lowest – 0.34 g in the Stella variety. Considering the above, the study of cherry fruits of different varieties according to the selected quality indicators grown in the steppe of Ukraine is relevant.

CONCLUSIONS

The results of twelve-year studies suggest that the average weight of kernels in cherry fruits grown in the conditions of the Southern Steppe zone of Ukraine was at the level of 8.41 grams, the average mass of kernels is about 0.56 grams.

Among the varieties under study, three groups of ripeness, the optimal fruit weight was the fruits of sweet cherries of the late-ripening group (7.27-12.18 g), the average fruit weight exceeded the average varietal value by 8.88%.

The largest fruit mass among early ripening varieties, according to the results of twelve-year studies, was in the Kazka variety (9.10 grams). The lowest mass was identified in the Rubinova rannia variety (7.32 grams). The optimal value of the complex indicator of the kernel-to-pulp ratio was determined in fruits of the Skazka variety – 6.59%.

Among the varieties of the group of medium and late maturation periods, the maximum average fruit weight was recorded in the fruits of the Dylema and Kosmichna varieties (9.91 g). Varieties of two ripening groups, which, according to the results of average values, were characterised by the lowest kernel mass, were Pervistok, Melitopol'ska chorna, and Krupnoplidna. The optimal value of the complex indicator – the kernel-to-pulp ratio is determined in the range of 3.53-5.69% for fruits of the Kordia, Pervistok, Orion, Udovitiel'na, and Krupnoplidna varieties.

The most stable varieties with minimal coefficients of variation in the indicators under study in the context of early ripening varieties in terms of fruit mass

and kernel mass were Sweet Earlies ($V_y=10.6\%$) and Rubinovanna ($V_y=11.5\%$).

Among the group of varieties of medium ripening, the most stable weight of fruits and kernels were identified in the fruits of the Temp ($V_y=11.8\%$) and Vynka ($V_y=11.4\%$) varieties.

In the group of late-ripening varieties, the lowest variability in the content of fruit and kernel weight was recorded in the Regina variety ($V_y=10.1\%$ and 10.4%).

It was identified that for the formation of fruit mass in all groups of varieties, the dominant influence was exerted by the weather conditions of years of research with a part of the influence for varieties of the three maturation periods of 26.1-51.5%. For the formation of kernel mass in all groups of varieties, varietal characteristics had a dominant influence with a part of influence within the three groups of varieties of 37.5-60.5%.

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Динаміка середньої маси плоду та співвідношення кісточки до м'якоті в плодах черешні, що вирощені в умовах півдня степової зони України

Анотація. Популярність черешні серед споживачів обумовлена високими смаковими якостями плодів з привабливим зовнішнім виглядом, а також раннім строком досягання. Серед зовнішніх показників якості найбільше значення для споживачів має маса плодів черешні і співвідношення кісточки до м'якоті, що впливає на ринкову вартість. Метою досліджень було вивчення середньої маси плодів та маси кісточки 33 сортів черешні трьох строків досягання як перспективних, так і тих, що поширені в Україні і виділення сортів та сортозразків, що мають наукову та практичну цінність за досліджуваними параметрами. Визначення середньої маси плоду, маси кісточки, співвідношення кісточки до м'якоті у плодах черешні проводили у період споживчої стиглості. Відбір та підготовку проб до аналізів виконували згідно з ДСТУ ISO 874-2002. Середня маса плоду у плодах черешні, вирощених в умовах Півдня Степової зони України, знаходився на рівні 8,41 грам, середня маса кісточки – 0,56 грам. Оптимальну масу плодів мали плоди черешні групи пізнього терміну досягання (7,27-12,18 г.). Найбільш стійкими з мінімальними коефіцієнтами варіації за досліджуваними показниками в розрізі сортів раннього строку досягання за параметрами маси плоду та маси кісточки виявились сорти 'Світ Ерліз' та 'Рубінова Рання'. Серед групи сортів середнього терміну досягання найбільш стабільною масою плодів та кісточки було виділено плоди сортів 'Темп' та 'Винка'. У сортів пізнього терміну досягання найменша варіативність вмісту маси плоду та кісточки зафіксована у сорту 'Регіна'. Встановлено, що домінуючий вплив для формування маси плоду у всіх груп сортів мали погодні умови років досліджень, а для формування маси кісточки у всіх груп сортів – сортові особливості. Результати досліджень будуть корисними при виборі сортів черешні різних строків досягання, що придатні для реалізації плодів і подальшої їх переробки

Ключові слова: стиглість, регресійний аналіз, маса кісточки, варіювання показників