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Factorial analysis of taste quality and technological properties of cherry fruits depending on weather factors

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ABSTRACT

The results of researching the fund formation of dry soluble substances, sugars, and titrated acids in cherry fruits of 10 studied varieties under the Southern Steppe Subzone of Ukraine are given. According to the content of biochemical quality indicators, the following varieties were selected: Modnytsya (the content of dry soluble substances is 17.1%), Ozhidaniye (the content of sugars is 11.7%), and Solidarnost (the content of titrated acids is 1.79%). The cherry fruits units. By conducting a two-factor dispersion analysis, the feasibility of forecasting the content of the principal components of the chemical composition (dry soluble substances, sugars, titrated acids) in the cherry fruits was determined by average values and a factor that maximally impacts the accumulation of the studied indicators was identified during the studies. The dominant influence of weather conditions during research years was determined. Therefore, the taste qualities of the cherry fruits were proposed to forecast by average varietal value. The average and strong correlation dependences of influencing 19 weather factors on the content of the studied biochemical indicators in the cherry fruits were determined. The accumulation dependence models of dry soluble substances, sugars, and titrated acids were built based on the principal component and least-squares methods. The first-rank weather indicators with the maximum influence particles were identified for the studied biochemical quality indicators. The average monthly air temperature in June maximally impacted the fund accumulation of dry soluble substances in the cherry fruits (delta = 9.9%), the content of sugars - the average monthly precipitation in June (delta = 8.5%), on the content of titrated acids - the total number of precipitation days in June (delta = 18.62%). At the end of the flowering phase before fruit ripening and in the last month of fruit formation, humidity indicators had the greatest influence on the accumulation of the studied biochemical indicators in the cherry fruits (June).of Melitopol purpura and Modnytsya have maximum indicators of the sugar-acid index in the range of 8.9-9.3 relative

Keywords: cherry, biochemical quality indicators, factor analysis, components method, weather factor

INTRODUCTION

Cherry is a widespread crop, the fruits of which are valued for their pleasant taste and dietary properties in fresh and processed forms. Tartan cherry is native to Europe and popular in the USA **[1]**. The annual world production of stone fruit crops, particularly cherries, is 950 thousand tons on average. Ukraine is one of the countries producing stone fruits, namely cherry and wild cherry **[2]**, **[3]**. As of 2017, Ukraine ranks third place in terms of production volume, which is 172 thousand tons **[4]**. Compared to the wild cherry, the cherry has a characteristic astringent taste due to the higher acid/sugar ratio **[5]**, is rich in polyphenolic compounds such as flavonoids **[6]**, and has much more hydroxycinnamic acids, procyanidins, flavonol glycosides and flavonols **[7]**, **[8]**. The crop's popularity and high taste qualities are due to the high content of dry substances. Dry substances of the fruits are divided into insoluble and soluble in water. Insoluble substances are mainly those that build cell walls and mechanical tissue elements. The content of dry insoluble substances in some fruit products is small, on average 2-5%. The content of dry soluble substances in the cherry fruits is 14.4-21.6% on average. These include carbohydrates, nitrogenous substances, acids, tannins, other phenolic substances, soluble forms of pectins and vitamins, enzymes, mineral salts, etc. This compound group is represented by carbohydrates, mainly sugars **[9]**, **[10]**.

Scientists have determined that sugars in cherry fruits are 6.5-21.5%. They are represented by glucose, fructose, and sucrose. The quantitative ratio is dominated by glucose and fructose. Fructose is considered to be a particularly valuable and easily digestible sugar. It is 2 times sweeter than sucrose and 3 times sweeter than glucose. The richer its fruits, the sweeter they are **[11]**.

Organic acids are other important components of the chemical composition, which significantly impact the cherry fruits' quality, taste, and technological properties. Organic acids in the cherry are about 0.7-3%. The main acids are apple and lemon and a small amount of amber, salicylic, and ant. But it should be noted that the sour taste of the fruits is not due to the total supply of the acids but the titrated acidity, that is, the content of free acids **[12]**. The fruit quality is an important economic characteristic of the crop. The main purpose of its fruits is technological processing, but fresh cherry fruits are also used as an anti-inflammatory agent. Their use prevents colon cancer, stomach ulcers, and bronchitis. The decisive criteria for choosing the pomological variety of the cherry when consumers purchase are the appearance and taste of the fruits **[13]**.

Such principal components of the chemical composition, like sugars and organic acids, are involved in forming the taste qualities of the crop. The importance of crop varieties with high taste qualities has recently increased for fresh consumption and processing **[14]**, **[15]**. It was established that the content of dry soluble substances is in the inverse average correlation dependence on the amount of precipitation for the cherry fruit of the Lotovka (-0.76) and Shpanka (-0.83) varieties **[16]**. Climatic growing conditions have a decisive impact on forming the taste qualities of the fruit crops. Therefore, when global climate changes are observed in today's conditions, the research of the formation mechanisms of the taste qualities and technological properties of the cherry fruits of the updated variety range, influenced by various weather indicators with the selection of the best varieties for further storage and processing, is relevant **[17]**. Between the hydrothermal coefficient and the content of dry soluble substances in both varieties, a significant inverse correlation was established with the correlation coefficients -0.96 and -0.91. The regression equation is derived, whereby using the hydrothermal coefficients can forecast the content of dry soluble substances in the fruits **[16]**. Other researchers note that the temperature increase and the humidity decrease lead to increased content of dry soluble substances, including sugars. The content of chemical components varies depending on the variety and ripeness stage **[18]**. The ripeness stage of the cherry fruits is determined by the optimal content of sugars, acids, and anthocyanins **[19]**, **[20]**. The dependence of the content of chemical composition components in the fruits on the pomological variety of the cherry and climatic growing conditions is known **[21]**. Indicators of the chemical composition of the fruits vary by research years, but the average value characterizes the biological characteristics of the varieties and the possibility of their use.

As the crop advances from north to south, the sugar content in the cherry fruits of the same varieties usually increases **[22]**. The fruit crops accumulate less dry substances, including sugars, with the maximum precipitation amount. Dry years are characterized by a low total supply of nutrients **[23]**. The cherry fruits contain dry substance not less than 14-15%, sugars not less than 9-10%, and total acidity, not more than 1-1.2%, and are used to prepare canned fruits.

Therefore, the content level of dry soluble substances, sugars, and titrated acids in the stonecrop fruits, in particular cherries and wild cherries, as well as their accumulation and further storage, depend on many factors **[24]**. The degree of stressful weather factors influences the formation of the taste and technological parameters in the cherry.

To further improve the cherry fruits' transportation, storage, and processing technology, it may be possible to forecast the content of dry soluble substances, sugars, and titrated acids in the fruits, depending on the various influences of certain weather factors. Therefore, the research aim was to develop a mathematical model for improving the forecast of dry soluble substances, sugars, and titrated acids in the cherry fruits depending on the weather factors of regions with hydrothermal parameters similar to the Southern Steppe Zone of Ukraine.

Scientific Hypothesis

By conducting a two-factor dispersion analysis, the feasibility of forecasting the content of the principal components of the chemical composition in the cherry fruits will be determined by average values, and a factor that maximally impacts the accumulation of the studied indicators will be identified during the studies. It is foreseen to select the cherry varieties with the best quality indicators for transportation, storage, and processing of the fruits while preserving their biological value.

MATERIAL AND METHODOLOGY

Samples

The research was conducted during 13 consecutive vegetation periods from 2008 to 2019. During the experiment, we used the meteorological data provided by the meteorological station at Melitopol, Ukraine. Cherry plantations, where the research was conducted, are located in the Southern Steppe Subzone of Ukraine, 46°50′25″ north latitude, 35°21′32″ east longitude.

The following indicators characterize Chernozem's southern loamy soil of the experimental areas: humus content is 3.1%, and soil reaction is 8.1 ±0.2.

The region's climate is Atlantic-continental, with high temperatures and insufficient moisture. Climatic conditions of the zone where the research was conducted are given in Table 1.

Table 1 Climatic conditions of the Southern Steppe Subzone of Ukraine.

No.	Climate	Parameters
1	Annual average air temperature	9.1-9.9 °C
2	Average monthly air temperatures in the warmest months	20.5-23.1 °C
3	Sum of active temperatures above 10 °C from April to October	3316 °C
4	Annual average precipitation	475 mm
5	Annual average relative humidity	73%
6	Annual average wind speed	3.7 m/s
7	Hydrothermal coefficient	0.22-0.77

In general, the research region is favorable for cherry growing according to meteorological indicators. However, it should be noted that the genetic properties of cherry fruits can vary in a wide range due to the influence of stressful weather factors. Therefore, the influence of weather factors on the biochemical indicators of the cherry fruits makes it possible to choose the cherry varieties with the optimum content of dry soluble substances, sugars, and titrated acids. This will make it possible to establish the production of high-quality fruit products.

The cherries were grown according to the generally accepted technology for the zone. The trees were planted from 1999-2001 according to the 6×4 m scheme. Spaces between rows were under black steam. The gardens were not irrigated.

Chemicals

Iron-blue (ferricyanide) potassium – K_3 [Fe $(CN)_6$] (red blood salt), 0.1 n solution of alkali (NaOH), methylene blue, phenolphthalein (producer by "Merck" (Germany).

Animals and Biological Material

Ten cherry varieties of three terms of ripening were chosen: early – Ozhidaniye (Figure 1a); medium – Vstrecha (Figure 1b), Shalunya (Figure 1c), Seyanets Turovtseva (Figure 1d), Griot Melitopol (Figure 1e), Modnytsya (Figure 1f), Ekspromt (Figure 1g); late – Melitopol purpura (Figure 1h), Solidarnost (Figure 1i), Igrushka (Figure 1j).

a)

b)

Figure 1 Photos of individual samples of sour cherries: a – Ozhidaniye; b – Vstrecha; c – Shalunya, d – Seyanets Turovtseva; e – Griot Melitopol; f - Modnytsya; g – Ekspromt; h – Melitopol purpurna; i – Solidarnost; j – Igrushka.

Instruments

Refractometer (IRF-454 B2M, manufacturer, open joint-stock company "KOMZ", Kazan).

Laboratory thermometer (TLS-200, manufacturer LLC "Inter-Synthesis", Ukraine).

Photo colorimeter (KFK-3, manufacturer LLC "Inter-Synthesis", Ukraine).

Flame spectrophotometer (Saturn-4, manufacturer "Inter-Synthesis" Limited Liability Company, Ukraine

Laboratory Methods

The content of dry soluble substances (SSC) was determined by the refractometer method **[25]**, the mass concentration of sugars was determined by the ferricyanide method **[25]**, and the mass concentration of titrated acids (TA) was determined by the titrimetric method.

Description of the Experiment

Sample preparation: Trees typical of a certain pomological variety, of the same age, with a medium intensity of fruiting were selected for conducting the research. The cherries of each pomological variety were harvested when the flesh was still dense enough, but the taste and colour were characteristic of this pomological variety. The calendar date of harvesting was determined by the following quality indicators of the fresh fruits: appearance, fruit size by the largest transverse diameter. The selected fruits corresponded to the indicators of the first commodity grade, in particular: shape and colour – typical of the pomological variety, fruits with a stalk, without mechanical damage to skin and flesh, without damage by pests and fungal diseases. The fruits were harvested from trees in 4 different places of the crown.

Number of samples analysed: To determine the content of dry soluble substances, sugars and titrated acids, a sample was taken for each pomological variety of 100 fruits from 6 trees that entered the full fruiting.

Number of repeated analyses: All measurements of an instrument and readings were performed 3 times.

Number of experiment replication: The number of repetitions of each experiment to determine one value was also 3 times.

Design of the experiment: The number of repetitions of each experiment to determine one value was also 3 times. The content of dry soluble substances (SSC) was determined by the AOAC official method 920.151 **[26]**. The mass concentration of sugars was determined by the ferricyanide method **[25]**, the essence of which is the property of reducing monosaccharides to restore iron-blue (ferricyanide) potassium – K_3 $[Fe(CN)_6]$ (red blood salt) in iron-blue (ferrocyanide) potassium – K_4 $[Fe(CN)_6]$ (yellow blood salt) in an alkaline environment. Methylene blue was used as an indicator. When potassium ferricyanide was restored, the colour changed from blue to colourless or light yellow. The sucrose amount was determined by previously turning it into inverted sugar. The titrimetric method determined the mass concentration of titrated acids (TA). The essence is to neutralize organic acids in the experimental product with 0.1 n alkali solution. Titration is carried out before the transition of the solution from an acidic medium to an alkaline one. The moment of transition of the medium to an alkaline one is visually fixed by appearing the pink colour of the solution in the presence of a phenolphthalein indicator. Measurement instruments, auxiliary equipment, utensil, reagents and materials: a homogenizer; a blender or a mortar with a pestle; a 25-, 50- or 100-cm^3 pipette; an Erlenmeyer flask which can be connected to a reflux condenser; a 250-cm^3 graduated cylinder; a 250-cm^3 beaker with a magnetic or mechanical stirrer; a 50-cm^3 burette; a reflux condenser; analytical scales with weighing accuracy up to 0,01 g; a water bath. Reagents: only reagents of the established analytical purity and distilled or demineralized water or water of equivalent purity were used for the analysis; Sodium hydroxide NaOH with 0.1 mol/dm^3 (0.1N) concentration; phenolphthalein, a solution with 10 g/dm^3 (1%) mass concentration in ethyl alcohol with 95% volume concentration.

Statistical analysis

The dependence models of the studied indicators were built according to the following scheme:

1st group of the indicators – the content of dry soluble substances, sugars, and titrated acids in different cherry varieties.

2nd group of the indicators – the hydrothermal coefficient, temperature difference for certain periods, the sum of active temperatures, and the sum of effective temperatures.

3. Correlation analysis of 1 and 2 groups of the indicators.
4. Selection of the most significant weather factors that impact the biochemical quality indicators.
5. Check the statistical hypothesis according to the Student criterion.
6. Construction of regression models based on the principal component method for each biochemical quality indicator of the cherry fruits.
7. Ranking and evaluating the weather indicators impacting the formation of the biochemical quality indicators of the cherry fruits.

In the works of many scientists **[27]**, **[28]**, **[29]**, **[30]** a general scheme of correlation-regression analysis was proposed for cases when the number of influence factors significantly exceeds the number of research options.

The instruments of a modern Data Mining computer technology with RStudio software environment were used to perform the statistical analysis.

RESULTS AND DISCUSSION

The chemical composition of the cherry fruits is formed mainly by carbohydrates, vitamins, and polyphenols. The group of carbohydrates includes sugars, pectin substances, and other compounds, which by 80 – 90 % are the quantitative composition of dry substances. Therefore, one of the important indicators that characterize the fruits is dry soluble substances. Their content is considered during the manufacture of processed products since raw materials and sugar consumption depends on this. The cherry fruits are characterized by a high content of dietary and medicinal substances that contribute to the body's functioning. They also contain simple sugars - glucose and fructose, improving heart function, ascorbic acid (5-10 mg/100 g of raw mass), vitamins A, B_1, B_2, and PP, as well as minerals - phosphorus, calcium, magnesium, iron. According to these indicators, the cherry ranks second after the apple **[16]**, **[31]**. Sugar and organic acids are the main nutritional and taste components of fruit juices that contribute to the formation of the main content of soluble solids and sensory properties **[32]**, **[33]**. When processing and storing the fruit juices, sugars and organic acids are less susceptible to change than other components such as pigments, antioxidants, and taste compounds. Dry soluble substances (DSS) are an important quality indicator of fruits. In the scientists' researches, DSS values ranged from 13.4 to 21.8%, significantly differing (p <0.05) among the varieties **[34]**, **[35]**. Except for Xiuyu and M-15 varieties, the DSS value for other varieties was above 14.0%, considered the "preferred line" for the cherries **[36]**.

Therefore, one of the important indicators that characterize the fruits is dry soluble substances. According to the research, this indicator in the cherry variety samples was 16.27% on average in the south of Ukraine (Table 2). The DSS highest average mass fraction varieties include Seyanets Turovtseva (17.02%) and Modnytsya (17.05%). Ekstrom variety (14.48%) had the lowest content of dry soluble substances.

Table 2 Content of dry soluble substances (DSS) in cherry fruits, % (2007-2019), $\bar{x} \pm s\bar{x}$, n = 5.

Pomological variety	Average content, %	Min content, %	Max content, %	Variation by years, Vp, %
Vstrecha	15.87 ±2.81	11.03	18.91	17.5
Ozhidaniye	16.31 ±2.02	10.31	18.27	12.5
Shalunya	15.94 ±2.70	11.28	19.19	17.2
Seyanets Turovtseva	17.02 ±3.53	10.23	21.49	20.6
Griot Melitopol	18.63 ±3.31	14.06	22.36	17.7
Melitopol purpura	15.79 ±2.81	11.43	19.98	17.8
Modnytsya	17.05 ±2.92	12.26	20.30	16.8
Ekspromt	14.48 ±2.53	10.03	17.26	16.9
Solidarnost	15.03 ±3.63	10.23	19.36	24.1
Igrushka	16.58 ±2.80	10.50	18.90	17.1
Average value	16.27 ±3.00	11.14	19.60	18.6
HIP_{05}	0.587	–	–	–

According to the research years, the average and significant variability of DSS content was found in the cherry varieties. The strong influence of abiotic factors on the DSS content in the cherry fruits was established for Seyanets Turovtseva and Solidarnost varieties with the variation coefficients of 20.6 and 24.1%, respectively. According to the research years, the most stable in terms of DSS content was the Ozhidaniye variety, with a variation coefficient of 12.5%. The fruits of the Modnytsya cherry variety were characterized by the optimum average DSS content (17.05%) and the average variability of this indicator (16.8%).

In fruits, the most common sugars are glucose, fructose, and sucrose, which are responsible for sweetness perception, while the main organic acids responsible for sourness perception are usually malic acid, critic acid, and tartaric acid, and so on. Glucose was the dominant sugar in the tested cultivars, followed by fructose and sucrose, which confirmed the previous research in Turkey **[37]**, Poland **[38]**, Hungarian **[39]**, and Italy **[40]**. Sorts *Ujfehertoi turbos*, *Erdi jubileum,* and *Erdi fubileum* had the highest glucose content, and Meili the lowest (12.239, 12.070, 10.475, and 6.399 g/100 g FW, respectively) **[33]**. By correlation analysis, the content of glucose was highly correlated with TSS and fructose (r = 0.892 and 0.836, respectively; p <0.001), similar to the tendency described for cherries, including sour **[39]** and sweet cherries **[40]**.

According to the research years, the average content of sugars in the cherry fruits of ten varieties was 11.28% (Table 3). The largest average mass fraction of sugars had the fruits of Griot Melitopol variety (12.19%), and the smallest – Ekspromt (10.35%). According to the research, the content variability of sugars in the cherry fruits of different pomological varieties was at the medium and high levels with an oscillation range of Vp = 14.7-25.5%. The most stable content of sugars in the fruits had the Vstrecha variety (Vp = 14.7%). The fruits of the Ozhidaniye variety were characterized by the optimum average content of sugars (11.69%) and the indicator variability (16.8%). Our data are correlated with the results obtained by other researchers **[41]**, **[42]**.

Table 3 Content of sugars in cherry fruits, % (2007–2019), $\bar{x} \pm s\bar{x}$, n=5.

Pomological variety	Average content, %	Min content, %	Max content, %	Variation by years, Vp, %
Vstrecha	10.80 ±1.51	7.18	13.34	14.7
Ozhidaniye	11.69 ±1.90	6.65	14.03	16.8
Shalunya	10.84 ±1.92	7.45	14.04	17.6
Seyanets Turovtseva	11.55 ±2.43	8.03	15.07	20.8
Griot Melitopol	12.19 ±2.51	8.36	16.22	21.1
Melitopol purpura	11.33 ±2.20	7.15	14.65	19.5
Modnytsya	11.73 ±2.84	7.45	15.23	24.1
Ekspromt	10.35 ±1.73	6.14	12.65	16.4
Solidarnost	10.70 ±2.72	6.54	14.54	25.5
Igrushka	11.59 ±2.21	6.45	13.76	19.4
Average value	11.28 ±2.20	7.14	14.50	19.9
HIP_{05}	0.503	–	–	–

The important quality indicator of the cherry fruit is the content of titrated acids. Their formation is impacted on the weather growing conditions **[3]**, **[13]**, **[16]**, **[43]**, **[30]**. In particular, according to the literature data with significant moisture in 2018, compared to 2016 and 2017, the content of titrated acids is higher for the cherry fruits of the following varieties: Alpha by 14.5 and 15%, Pamyat Artemenka – 14 and 10%. Precipitations during the growing season and the ripening phase are strongly correlated with the content of titrated acids of the cherry fruits of Pamyat Artemenka and Alpha varieties with the correlation coefficients of r = 0.81 ±0.4 and r = 0.94 ±0.23 and r = 0.64 ±0.56 and r = 0.39 ±0.74 **[16]**.

During our research, the average value of titrated acids (TA) was 1.51% in the cherry fruits (Table 4). The maximum amount of TA was found in the cherry fruits of Griot Melitopol and Solidarnost varieties. Griot Melitopol variety of the 2014 harvest had the highest number of TA (2.06%). The cherry fruits of the Solidarnost variety (2019 harvest) also showed the maximum content of TA – 2.08%.

According to the research, the variability of TA content in the cherry fruits was at the medium and high levels (Vp = 14.9-26.7%). The most stable content of TA was in the cherry fruits of Solidarnost (Vp = 14.9%) and Ekspromt (15.7%), and the most variable - was in the cherry fruits of Melitopol purple (Vp = 24.5%) and Vstrecha (Vp = 26.7%). Solidarnost variety had the optimal indicator variability (Vp = 14.9%) and average content of TA (1.79%). The maximum sugar-acid index (SAI) was determined for the cherry fruits of Melitopol purple (8.9 relative units) and Modnytsya (9.3 relative units) varieties.

Table 4 Content of titrated acids (TA) in cherry fruits, %, (2008-2019), $\bar{x} \pm s\bar{x}$, n = 5.

Pomological variety	The average content of TA, %	Content of TA, %		Variation by years, Vp, %	SAI, relative units
		min	max		
Vstrecha	1.45 ±0.38	0.85	1.93	26.7	7.4
Ozhidaniye	1.51 ±0.31	1.01	1.92	21.1	7.7
Shalunya	1.49 ±0.34	1.04	1.91	22.6	7.2
Seyanets Turovtseva	1.62 ±0.30	1.03	2.03	18.7	7.1
Griot Melitopol	1.65 ±0.31	1.08	2.06	18.7	7.8
Melitopol purpura	1.26 ±0.31	0.92	1.82	24.5	8.9
Modnytsya	1.26 ±0.26	0.97	1.75	21.3	9.3
Ekspromt	1.40 ±0.22	1.05	1.72	15.7	7.3
Solidarnost	1.79 ±0.26	1.51	2.08	14.9	5.9
Igrushka	1.65 ±0.30	1.22	2.01	18.1	7.0
Average value	1.51 ±0.33	1.07	1.92	22.3	7.4
HIP_{05}	0.265	–	–	–	

The dominant influence of the weather conditions on all chemical composition components of the cherry fruits was found according to the results of the two-factor dispersion analysis (Table 5). The weather conditions of the

research years (factor A) had the following influence particles: DSS – 61.9%, sugars – 53.5%, and TA – 40.8%. The influence of varietal characteristics (factor B) on the quality indicators of the cherry was less significant.
The influence particle of factor B was 13.0% for DSS, 5.6% for sugars, and 17.3% for TA.

Table 5 Results of two-factor dispersion analysis.

Variation source	Square sum	Freedom degree	Dispersion	Fact	Ftable.095	Influence, %
			Dry soluble substances			
Factor A (year)	2238.1	2	186.5	1435.7	1.8	61.9
Factor B (variety)	471.1	9	52.3	402.9	1.9	13.0
Interaction of AB	855.6	108	7.9	60.9	1.3	23.7
			Sugars			
Factor A (year)	1051.2	11	87.6	915.0	1.8	53.5
Factor B (variety)	111.6	9	12.4	129.5	1.9	5.6
Interaction of AB	757.7	108	7.0	73.2	1.3	38.6
			Titrated acids			
Factor A (year)	24.6	12	2.0	77.5	1.8	40.8
Factor B (variety)	10.5	9	1.1	44.0	1.8	17.3
Interaction of AB	9.1	108	0.0	3.2	1.3	15.1

The average varietal value of the studied indicators should be used when developing a mathematical model **[9]**, **[44]**, **[45]**.

The correlations between the fund of dry soluble substances, sugars, and titrated acids in the cherry fruits of the studied varieties (Y_1) and the complex weather conditions for 13 years (factors Xi) were determined.

The most influential weather factors were selected according to the calculated paired correlation coefficients$r_{Y_1 X_i}$.

The significance of these correlation coefficients was tested using a statistical hypothesis $H_0: \rho = 0$ (where ρ – is the correlation coefficient of the general population) under the alternative hypothesis $H_1: \rho \neq 0$ at the significance level$\alpha = 0{,}05$.

The Student criterion was used for checking the statistical hypothesis.

The significant correlation coefficients were determined at the significance level of 0.05 and the number of freedom degrees $k = 11$, which had the intervals in the range of [-1; -0.55] and [0.55; 1].

According to the above algorithm, the regression models were built based on the calculated principal components and transformed into formula 3, as per formulas 1 and 2. The following regression models were obtained after normalizing the factors (reduction to uniform units of measurement of the studied indicators):

$$\hat{Y}_1 = 0{,}055\tilde{x}_1 + 0{,}2137\tilde{x}_2 - 0{,}0854\tilde{x}_3 + 0{,}3382\tilde{x}_4 + 0{,}2457\tilde{x}_5 - 0{,}1151\tilde{x}_6 + 0{,}2292\tilde{x}_7 - 0{,}075\tilde{x}_8 + 0{,}036\tilde{x}_9 - 0{,}1462\tilde{x}_{10} + 0{,}1094\tilde{x}_{11} - 0{,}1094\tilde{x}_{12} + 0{,}2362\tilde{x}_{13} + 0{,}2922\tilde{x}_{14} + 0{,}0088\tilde{x}_{15} + 0{,}2380\tilde{x}_{16} + 0{,}2706\tilde{x}_{17} + 0{,}3514\tilde{x}_{18} + 0{,}3279\tilde{x}_{19}$$

$$\hat{Y}_2 = 0{,}1928\tilde{x}_1 - 0{,}2231\tilde{x}_2 + 0{,}2887\tilde{x}_3 - 0{,}1492\tilde{x}_4 - 0{,}1771\tilde{x}_5 + 0{,}2721\tilde{x}_6 - 0{,}2420\tilde{x}_7 + 0{,}2759\tilde{x}_8 + 0{,}214436\tilde{x}_9 + 0{,}1774\tilde{x}_{10} + 0{,}2488\tilde{x}_{11} + 0{,}2712\tilde{x}_{12} - 0{,}1953\tilde{x}_{13} + 0{,}1482\tilde{x}_{14} + 0{,}20988\tilde{x}_{15} - 0{,}2305\tilde{x}_{16} - 0{,}2499\tilde{x}_{17} - 0{,}1745\tilde{x}_{18} - 0{,}2099\tilde{x}_{19}$$

$$\hat{Y}_3 = 0{,}3523\tilde{x}_1 + 0{,}2542\tilde{x}_2 + 0{,}3357\tilde{x}_3 - 0{,}2697\tilde{x}_4 + 0{,}3623\tilde{x}_5 + 0{,}3498\tilde{x}_6 + 0{,}3767\tilde{x}_7$$

The above models characterize the dependence of the accumulation indicators of dry soluble substances ($\widehat{Y}_1$), sugars ($\widehat{Y}_2$), and the content of titrated acids ($\widehat{Y}_3$) on the weather factors (X_i).

The indicators Δ_j, that estimate the influence particle of certain weather factors on the content of dry soluble substances, sugars, and titrated acids, were determined according to the coefficients of the calculated regression models. The calculation results are shown in tables 6 and 7.

The values of the influence particle coefficients of the weather factors (Δ_i, %) for indicators of dry soluble substances and sugars) are in the range of 0.2-9.9%. We divided the weather factors into ranks depending on the coefficient values Δ_i(I = 1-19). The average monthly air temperature in June (X1) had the maximum influence on the fund accumulation of dry soluble substances and received 1 rank by the indicator value Δ_{X1}, which was 9.9%. For the accumulation of sugars, the average monthly precipitation in June was crucial at Δ_{X2} – 8.5%.

Table 6 Table of paired correlation coefficients and indicators $\Delta_i, \%$ – factor influences particles on the accumulation of dry soluble substances and sugar in cherry fruits.

(Xi)	Factors	Dry soluble substances			Sugars		
		Paired correlation coefficients ($r_{Y_jX_i}$)	Values of factor influence particle ($\Delta_i, \%$)	Rank	Paired correlation coefficients($r_{Y_jX_i}$)	Values of factor influence particle ($\Delta_i, \%$)	Rank
1	**Average monthly air temperature in June**	0.7689	9.9%	1	0.7462	7.4%	3
2	**Average monthly precipitation in June**	-0.6955	9.6%	2	0.8961	8.5%	1
3	**Average minimum relative humidity in March**	0.6932	2.3%	16	0.5899	3.6%	17
4	**Average minimum relative humidity in June**	-0.8298	7.8%	5	0.9111	8.5%	2
5	**Amount of precipitation during the period from the end of flowering to fruit ripening**	-0.6301	7.3%	6	-0.8305	7.1%	4
6	**Total number of precipitation days of more than 1 mm in March**	0.8983	2.7%	15	-0.6463	3.3%	18
7	**Total number of precipitation days with more than 1 mm in June**	-0.8311	8.9%	3	-0.7501	6.2%	5
8	**Average air temperature during the fruit harvest period**	0.6211	8.3%	4	-0.7089	4.2%	15
9	**Absolute maximum air temperature during the fruit harvest period**	0.7401	1.1%	18	-0.6496	3.9%	16
10	**Difference between absolute maximum and minimum air temperatures during the fruit harvest period**	0.5704	3.3%	12	-0.6720	4.5%	12
11	**Average minimum air temperature during the fruit harvest period**	0.7279	3.1%	13	0.6450	6.0%	8
12	**Average maximum air temperature during the fruit harvest period**	0.9047	5.0%	11	0.7104	6.1%	7
13	**Amount of precipitation during the fruit harvest period**	-0.7347	6.8%	8	0.7563	5.6%	10
14	**Number of precipitation days with more than 1 mm during the fruit harvest period**	-0.5913	2.7%	14	-0.5859	3.0%	19
15	**Amount of effective temperatures during the fruit harvest period**	0.5605	0.2%	19	-0.6644	5.1%	11
16	**Hydrothermal coefficient during the fruit harvest period**	-0.7884	7.1%	7	-0.7801	6.2%	6
17	**Absolute minimum relative humidity during the fruit harvest period**	-0.6504	1.4%	17	0.6252	4.5%	13
18	**Average minimum relative humidity during the fruit harvest period**	-0.6417	6.2%	10	0.6481	4.3%	14
19	**Average relative humidity during the fruit harvest period**	-0.7416	6.3%	9	-0.7775	5.6%	9

The indicators Δ_j, that estimate the influence particle of certain weather factors on the content of dry soluble substances, sugars, and titrated acids, were determined according to the coefficients of the calculated regression models. The calculation results are shown in Tables 6 and 7.

The values of the influence particle coefficients of the weather factors ($\Delta_i, \%$) for indicators of dry soluble substances and sugars) are in the range of 0.2-9.9%. We divided the weather factors into ranks depending on the coefficient values Δ_i (I = 1 – 19). The average monthly air temperature in June (X1) had the maximum influence on the fund accumulation of dry soluble substances and received 1 rank by the indicator value Δ_{X1}, which was 9.9 %. For the accumulation of sugars, the average monthly precipitation in June was crucial at Δ_{X2} – 8.5%.

2nd rank by influence degree on DSS accumulation (Δ_{X2} – 9.6%) and sugars (Δ_{X4} – 8.54%) received such weather indicators as the average monthly precipitation in June (X) and the minimum relative humidity in June (X). The total number of precipitation days with more than 1 mm in June (X7) for DSS and the average monthly air temperature in June (X1), while forming the fund of sugars, had the coefficient values Δ of 8.9% and 7.44% and took 3rd rank. The weather indicators, which received 4-19 ranks, had less influence on forming the fund of dry soluble substances and sugars in the cherry fruits. This is confirmed by the values of the influence particles Δ , which had a range of 0.2 to 7.1%. Of the 19 common weather factors that have an important role, while forming the fund of dry soluble substances and sugars, 12 factors are crucial during the fruit harvest period, 4 factors – are in June and 2 factors are important in March, and 1 factor - in the period from flowering to fruit ripening.

The fruit ripening stage, which takes place in June, is crucial for forming the fund of dry soluble substances and sugars in the cherry fruits of the studied varieties. Summarizing the obtained data, we may conclude that the most significant indicators (1-3 ranks), while forming the fund of dry soluble substances and sugars in the cherry fruits, were revealed the following:

Average monthly air temperature, average monthly precipitation, minimum relative humidity, and a total number of precipitation days in June. To analyze the influence of the weather factors on the accumulation of the fund of titrated acids, 7 indicators of the weather factors (X_i), a certain growing season that can significantly impact the accumulation of the fund of titrated acids in the cherry fruits, were found and selected (Table 7). The analysis of the values of the influence particle coefficients of the weather factors ($\Delta_i, \%$) on the accumulation of titrated acids in the cherry fruits) allowed to determine their oscillation range – 8.9-18.6%. Of the 7 weather factors that significantly impact the accumulation of titrated acids in the cherry fruits, 4 factors are crucial during the fruit harvest period, 2 factors are in June, and 1factor is important in the period from flowering to fruit ripening.

Table 7 Paired correlation coefficients and indicators $\Delta_i, \%$ - factor influences particles on the content of titrated acids in cherry fruits.

Factor symbol (Xi)	Factors	Paired correlation coefficients ($r_{Y_jX_i}$)	Values of factor influence particle ($\Delta_i, \%$)	Rank
1	**Average monthly precipitation in June**	0.8507	17.7%	2
2	**Amount of precipitation during the period from the end of flowering to fruit ripening**	0.7838	15.7%	3
3	**Total number of precipitation days with more than 1 mm in June**	0.8621	18.6%	1
4	**Difference between absolute maximum and minimum air temperatures during the fruit harvest period**	-0.7415	11.5%	6
5	**Amount of precipitation during the fruit harvest period**	0.6119	8.9%	7
6	**Number of precipitation days with more than 1 mm during the fruit harvest period**	0.7754	15.7%	4
7	**Hydrothermal coefficient during the fruit harvest period**	0.6208	11.9%	5

For further research result analysis, the factors, depending on the coefficient values Δ_i (i = 1-7), were divided into ranks. The total number of precipitation days in June (X3) maximally impacted the accumulation of titrated acids in the cherry fruits and received 1st rank by the value of the index Δ_{X3}, which was 18.6%. 2nd rank by influence degree on the accumulation of titrated acids in the cherry fruits (Δ_{X1} – 17.7%) was received by such weather indicators as the average monthly precipitation in June (X1). During the growing season, from the end of flowering to fruit ripening (X2), while forming the fund of titrated acids, the precipitation had the coefficient value Δ of 15.7% and took 3rd rank. The remaining 4 weather factors (X1, X2, X3, X4) had a much smaller impact on the formation of the fund of titrated acids in the cherry fruits (Δ_X = 8.9-15.7%).

The above analysis confirms that the accumulation of DSS, sugars, and titrated acids in the cherry fruits were most influenced by the humidity indicators of the last fruit formation month (June) and the period from the end of flowering to fruit ripening.

CONCLUSION

1. Some varieties, namely Modnytsya (the content of DSS is 17.05 %, Vp is 16.8%), Ozhidaniye (the content of sugars is 11.69%; Vp is 16.8%), and Solidarnost (the content of TA is 1.79%, Vp is 14.9%), are the most suitable for growing in the Southern Steppe Subzone of Ukraine according to technological properties.
2. It was determined that the fruits of Melitopol purple and Modnytsya varieties have the maximum indicators of the sugar-acid index (8.9-9.3 relative units).
3. It is advisable to forecast the taste qualities of the cherry fruits according to the average varietal value based on the dominant influence of the weather conditions of the research years (factor A). Factor A had the influence particles - 61.9, 53.5, and 40.8%, respectively, on forming the foundation of DSS, sugars, and TA in the cherry fruits.
4. The correlation analysis of the influence of the weather factors on the content of DSS, sugars, and titrated acids in the cherry fruits was carried out. The average and strong correlation dependences were determined ($\left|r_{Y_jX_i}\right| \geq 0{,}55,\ i = 1-19, j = 1$ between 19 weather factors (Xi, i = 1-19) and the accumulation of the biochemical indicators in the cherry fruits.
5. The accumulation dependence models of the biochemical indicators (DSS, sugars, TA) in the cherry fruits were built based on the principal component and the least-squares methods.
6. The 1st rank weather parameters were determined due to the calculation of the influence particles of each weather factor on the biochemical indicators in the cherry fruits. It was found that the average monthly air temperature in June (Δ = 9.9%) had the maximum influence on the accumulation of dry soluble substances, the average monthly precipitation in June (Δ = 8.5%) on the content of sugars, the total number of precipitation days in June (Δ = 18.62%) on the content of titrated acids in the cherry fruits.
7. The air humidity indicators at the end of the flowering phase before fruit ripening and the last month of fruit formation had the greatest influence on the accumulated biochemical indicators in the cherry fruits (June).

REFERENCES

1. McCune, L. M., Kubota, C., Stendell-Hollis, N. R., & Thomson, C. A. (2010). Cherries and Health: A Review. In Critical Reviews in Food Science and Nutrition (Vol. 51, Issue 1, pp. 1–12). Informa UK Limited. https://doi.org/10.1080/10408390903001719
2. Serdyuk, M., Ivanova, I., Malkina, V., Kryvonos, I., Tymoshchuk, T., & Ievstafiieva, K. (2020). The formation of dry soluble substances in sweet cherry fruits under the influence of abiotic factors. In Scientific Horizons (Vol. 88, Issue 3, pp. 127–135). Zhytomyr National Agroecological University. https://doi.org/10.33249/2663-2144-2020-88-3-127-135
3. Ivanova, I., Serdiuk, M., Malkina, V., Bandura, I., Kovalenko, I., Tymoshchuk, T., Tonkha, O., Tsyz, O., Mushtruk, M., & Omelian, A. (2021). The study of soluble solids content accumulation dynamics under the influence of weather factors in the fruits of cherries. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 15, pp. 350–359). HACCP Consulting. https://doi.org/10.5219/1554
4. Zheplinska, M., Mushtruk, M., Kos, T., Vasyliv, V., Kryzhova, Y., Mukoid, R., Bilko, M., Kuts, A., Kambulova, Y., & Gunko, S. (2020). The influence of cavitation effects on the purification processes of beet sugar production juices. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 14, pp. 451–457). HACCP Consulting. https://doi.org/10.5219/1284
5. Yılmaz, F. M., Görgüç, A., Karaaslan, M., Vardin, H., Ersus Bilek, S., Uygun, Ö., & Bircan, C. (2018). Sour Cherry By-products: Compositions, Functional Properties and Recovery Potentials – A Review. In Critical Reviews in Food Science and Nutrition (Vol. 59, Issue 22, pp. 3549–3563). Informa UK Limited. https://doi.org/10.1080/10408398.2018.1496901
6. Alba C., M.-A., Daya, M., & Franck, C. (2017). Tart Cherries and health: Current knowledge and need for a better understanding of the fate of phytochemicals in the human gastrointestinal tract. In Critical Reviews in Food Science and Nutrition (Vol. 59, Issue 4, pp. 626–638). Informa UK Limited. https://doi.org/10.1080/10408398.2017.1384918
7. Zheplinska, M., Mushtruk, M., Shablii, L., Shynkaruk, V., Slobodyanyuk, N., Rudyk, Y., Chumachenko, I., Marchyshyna, Y., Omelian, A., & Kharsika, I. (2022). Development and shelf-life assessment of soft-drink with honey. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 16, pp. 114–126). HACCP Consulting. https://doi.org/10.5219/1738

8. Tyshchenko, L., Pylypchuk, O., Israelyan, V., Adamchuk, L., & Akulyonok, O. (2021). Honey is a marinade component for meat semi-finished products. In Animal Science and Food Technology (Vol. 12, Issue 2). The National University of Life and Environmental Sciences of Ukraine. https://doi.org/10.31548/animal2021.02.008
9. Serdiuk, M. E., Priss, O. P., Haprindashvili, N. A & Ivanova, I. Ye. (2020). *Doslidnytskyi praktykum. Ch. 1.Metody doslidzhennia plodoovochevoi ta yahidnoi produktsii*. Melitopol: Liuks, 364 p. (In Ukraine)
10. Cittadini, E. D., Lubbers, M. T. M. H., de Ridder, N., van Keulen, H., & Claassen, G. D. H. (2008). Exploring options for farm-level strategic and tactical decision-making in fruit production systems of South Patagonia, Argentina. In Agricultural Systems (Vol. 98, Issue 3, pp. 189–198). Elsevier BV. https://doi.org/10.1016/j.agsy.2008.07.001
11. González-Gómez, D., Bernalte, M. J., Ayuso, M. C., Fernández-León, M. F., Lozano, M., Rato, A. E., Palma, V., & Santos, A. C. (2017). Evaluation of different postharvest conditions to preserve the number of bioactive compounds, physicochemical quality parameters, and sensory attributes of 'Sweetheart' cherries. In Acta Horticulturae (Issue 1161, pp. 581–586). International Society for Horticultural Science (ISHS). https://doi.org/10.17660/actahortic.2017.1161.92
12. Palamarchuk, I., Mushtruk, M., Sukhenko, V., Dudchenko, V., Korets, L., Litvinenko, A., Deviatko, O., Ulianko, S., & Slobodyanyuk, N. (2020). Modelling of the process of vybromechanical activation of plant raw material hydrolysis for pectin extraction. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 14, pp. 239–246). HACCP Consulting. https://doi.org/10.5219/1305
13. Vasylyshyna, O., & Postolenko, Je. (2020). The influence of weather conditions on the formation of the components of the chemical composition of cherry fruits. In Visnyk agrarnoi nauky (Vol. 98, Issue 2, pp. 29–36). Publishing House of National Academy Agrarian Sciences of Ukraine. https://doi.org/10.31073/agrovisnyk202002-05
14. Blando, F., & Oomah, B. D. (2019). Sweet and sour cherries: Origin, distribution, nutritional composition, and health benefits. In Trends in Food Science & Technology (Vol. 86, pp. 517–529). Elsevier BV. https://doi.org/10.1016/j.tifs.2019.02.052
15. Malkina, V., Ivanova, I., Serdiuk, M., Kryvonos, I., & Bilous, E. (2019). Regression analysis of the dependence of the cherry yield from hydro-thermal factors in the conditions of multicollinearity. In Scientific Horizons (Vol. 84, Issue 11, pp. 51–60). Zhytomyr National Agroecological University. https://doi.org/10.33249/2663-2144-2019-84-11-51-60
16. Vasylyshyna, O. V. (2019). Influence of climatic factors on the formation of the content of dry soluble substances and sugars in cherry fruit. In Agrology (Vol. 2, Issue 1, pp. 27–30). Dnipro State Agrarian and Economic University. https://doi.org/10.32819/2617-6106.2018.14014
17. Marija Viljevac, V., Krunoslav, D., Ines, M., Vesna, T., Dominik, V., Zvonimir, Z., Boris, P., & Zorica, J. (2017). Season, location, and cultivar influence on bioactive compounds of sour cherry fruits. In-Plant, Soil, and Environment (Vol. 63, Issue No. 9, pp. 389–395). Czech Academy of Agricultural Sciences. https://doi.org/10.17221/472/2017-pse
18. Sukhenko, Y., Sukhenko, V., Mushtruk, M., & Litvinenko, A. (2018). Mathematical Model of Corrosive-Mechanic Wear Materials in Technological Medium of Food Industry. In Lecture Notes in Mechanical Engineering (pp. 507–514). Springer International Publishing. https://doi.org/10.1007/978-3-319-93587-4_53
19. Poll, L., Petersen, M., & Nielsen, G. S. (2003). Influence of harvest year and harvest time on soluble solids, titratable acid, anthocyanin content, and aroma components in sour cherry (Prunus cerasus L. cv. "Stevnsbær"). In European Food Research and Technology (Vol. 216, Issue 3, pp. 212–216). Springer Science and Business Media LLC. https://doi.org/10.1007/s00217-002-0641-8
20. Shanina, O., Galyasnyj, I., Gavrysh, T., Dugina, K., Sukhenko, Y., Sukhenko, V., Miedviedieva, N., Mushtruk, M., Rozbytska, T., & Slobodyanyuk, N. (2019). Development of gluten-free non-yeasted dough structure as the factor of bread quality formation. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 13, Issue 1, pp. 971–983). HACCP Consulting. https://doi.org/10.5219/1201
21. Lakatos, L., Szabó, Z., Soltész, M., Nyéki, J., Dussi, M. C., Szabó, T., & Sun, Z. (2014). The influence of meteorological variables on sour cherry quality parameters. In Acta Horticulturae (Issue 1020, pp. 287–292). International Society for Horticultural Science (ISHS). https://doi.org/10.17660/actahortic.2014.1020.41
22. Schuster, M. (2016). New cultivars of first quality cherries at Dresden-Pillnitz. In Acta Horticulturae (Issue 1139, pp. 1–6). International Society for Horticultural Science (ISHS). https://doi.org/10.17660/actahortic.2016.1139.1

23. Mushtruk, M., Bal-Prylypko, L., Slobodyanyuk, N., Boyko, Y., & Nikolaienko, M. (2022). Design of Reactors with Mechanical Mixers in Biodiesel Production. In Lecture Notes in Mechanical Engineering (pp. 197–207). Springer International Publishing. https://doi.org/10.1007/978-3-031-06044-1_19
24. Kolyanovska, L., Palamarchuk, I., Sukhenko, Y., Mussabekova, A., Bissarinov, B., Popiel, P., Mushtruk, M., Sukhenko, V., Vasuliev, V., Semko, T., & Tyshchenko, L. (2019). Mathematical modeling of the extraction process of oil-containing raw materials with a pulsed intensification of the heat of mass transfer. In R. S. Romaniuk, A. Smolarz, & W. Wójcik (Eds.), Optical Fibers and Their Applications 2018. SPIE. https://doi.org/10.1117/12.2522354
25. Ivanova, I., Kryvonos, I., Shleina, L., Taranenko, G., & Gerasko, T. (2019). Multicriteria Optimization of Quality Indicators of Sweet Cherry Fruits of Ukrainian Selection During Freezing and Storage. In Modern Development Paths of Agricultural Production (pp. 707–717). Springer International Publishing. https://doi.org/10.1007/978-3-030-14918-5_69
26. Ivanova, I., Serdyuk, M., Malkina, V., Priss, O., Herasko, T., & Tymoshchuk, T. (2021). Investigation into sugar accumulation in sweet cherry fruits under abiotic factors effects. https://doi.org/10.15159/AR.21.004
27. Bal'-Prylypko, L. V., Derevyanko, L. P., Slobodyanyuk, N. M., Starkova, E. R., & Androshchiuk, O. S. (2018). Using of the Ampullaria glauca snails' caviar for correction of the effects of the ionizing radiation exposure in small dose. In Nuclear Physics and Atomic Energy (Vol. 19, Issue 2, pp. 159–165). National Academy of Sciences of Ukraine (Co. LTD Ukrinformnauka). https://doi.org/10.15407/jnpae2018.02.159
28. Bober, A., Liashenko, M., Protsenko, L., Slobodyanyuk, N., Matseiko, L., Yashchuk, N., Gunko, S., & Mushtruk, M. (2020). Biochemical composition of the hops and quality of the finished beer. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 14, pp. 307–317). HACCP Consulting. https://doi.org/10.5219/1311
29. Chen, M., & Ma, J. (2015). Application of Principal Component Regression Analysis in Economic Analysis. In Proceedings of the 2015 3rd International Conference on Management Science, Education Technology, Arts, Social Science, and Economics. 3rd International Conference on Management Science, Education Technology, Arts, Social Science, and Economics. Atlantis Press. https://doi.org/10.2991/msetasse-15.2015.255
30. Zheplinska, M., Mushtruk, M., Vasyliv, V., Sarana, V., Gudzenko, M., Slobodyanyuk, N., Kuts, A., Tkachenko, S., & Mukoid, R. (2021). The influence of cavitation effects on the purification processes of beet sugar production juices. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 15, pp. 18–25). HACCP Consulting. https://doi.org/10.5219/1494
31. de Souza, V. R., Pereira, P. A. P., da Silva, T. L. T., de Oliveira Lima, L. C., Pio, R., & Queiroz, F. (2014). Determination of the bioactive compounds, antioxidant activity, and chemical composition of Brazilian blackberry, red raspberry, strawberry, blueberry, and sweet cherry fruits. In Food Chemistry (Vol. 156, pp. 362–368). Elsevier BV. https://doi.org/10.1016/j.foodchem.2014.01.125
32. Sukhenko, Y., Mushtruk, M., Vasyliv, V., Sukhenko, V., & Dudchenko, V. (2019). Production of Pumpkin Pectin Paste. In Lecture Notes in Mechanical Engineering (pp. 805–812). Springer International Publishing. https://doi.org/10.1007/978-3-030-22365-6_80
33. Bett-Garber, K. L., Lea, J. M., Watson, M. A., Grimm, C. C., Lloyd, S. W., Beaulieu, J. C., Stein-Chisholm, R. E., Andrzejewski, B. P., & Marshall, D. A. (2015). The flavor of Fresh Blueberry Juice and the Comparison to Amount of Sugars, Acids, Anthocyanidins, and Physicochemical Measurements. In Journal of Food Science (Vol. 80, Issue 4, pp. S818–S827). Wiley. https://doi.org/10.1111/1750-3841.12821
34. Wang, R., Zhang, F., Zan, S., Gao, C., Tian, C., & Meng, X. (2021). Quality Characteristics and Inhibitory Xanthine Oxidase Potential of 21 Sour Cherry (Prunus Cerasus L.) Varieties Cultivated in China. In Frontiers in Nutrition (Vol. 8). Frontiers Media SA. https://doi.org/10.3389/fnut.2021.796294
35. Martin, K. R., & Coles, K. M. (2019). Consumption of 100% Tart Cherry Juice Reduces Serum Urate in Overweight and Obese Adults. In Current Developments in Nutrition (Vol. 3, Issue 5). Oxford University Press (OUP). https://doi.org/10.1093/cdn/nzz011
36. Palamarchuk, I. P., Mushtruk, M. M., Palamarchuk, V. I., Deviatko, O. S., Wójcik, W., Kalizhanova, A., & Kozbakova, A. (2021). Physical-mathematical modelling of the process of infrared drying of rape with vibration transport of products. In Mechatronic Systems 1 (pp. 243–253). Routledge. https://doi.org/10.1201/9781003224136-21
37. Schulz, M., Seraglio, S. K. T., Della Betta, F., Nehring, P., Valese, A. C., Daguer, H., Gonzaga, L. V., Costa, A. C. O., & Fett, R. (2019). Blackberry (Rubus ulmifolius Schott): Chemical composition, phenolic compounds, and antioxidant capacity in two edible stages. In Food Research International (Vol. 122, pp. 627–634). Elsevier BV. https://doi.org/10.1016/j.foodres.2019.01.034
38. Karaat, F. E., Gündüz, K., Saraçoğlu, O., & Yıldırım, H. (2019). Pomological and phytochemical evaluation of different cherry species: mahaleb (Prunus mahaleb L.), wild sweet cherry (Prunus avium L.), and wild

sour cherry (Prunus cerasus L.), sweet and sour cherry cultivars. In Acta Scientiarum Polonorum Hortorum Cultus (Vol. 18, Issue 4, pp. 181–191). Uniwersytet Przyrodniczy w Lublinie. https://doi.org/10.24326/asphc.2019.4.17

39. Sokół-Łętowska, A., Kucharska, A. Z., Hodun, G., & Gołba, M. (2020). Chemical Composition of 21 Cultivars of Sour Cherry (Prunus cerasus) Fruit Cultivated in Poland. In Molecules (Vol. 25, Issue 19, p. 4587). MDPI AG. https://doi.org/10.3390/molecules25194587

40. Zheplinska, M., Mushtruk, M., Vasyliv, V., Slobodyanyuk, N., & Boyko, Y. (2021). The Main Parameters of the Physalis Convection Drying Process. In Lecture Notes in Mechanical Engineering (pp. 306–315). Springer International Publishing. https://doi.org/10.1007/978-3-030-77823-1_31

41. Ballistreri, G., Continella, A., Gentile, A., Amenta, M., Fabroni, S., & Rapisarda, P. (2013). Fruit quality and bioactive compounds relevant to human health of sweet cherry (Prunus avium L.) cultivars grown in Italy. In Food Chemistry (Vol. 140, Issue 4, pp. 630–638). Elsevier BV. https://doi.org/10.1016/j.foodchem.2012.11.024

42. de Souza, V. R., Pereira, P. A. P., da Silva, T. L. T., de Oliveira Lima, L. C., Pio, R., & Queiroz, F. (2014). Determination of the bioactive compounds, antioxidant activity, and chemical composition of Brazilian blackberry, red raspberry, strawberry, blueberry, and sweet cherry fruits. In Food Chemistry (Vol. 156, pp. 362–368). Elsevier BV. https://doi.org/10.1016/j.foodchem.2014.01.125

43. Repajić, M., Puškar, B., Dugalić, K., Vahčić, N., Srečec, S., Dragović-Uzelac, V., Jurković, Z., & Levaj, B. (2019). Quality and Sensory Study of Fresh Sour Cherry Juices Upon Cultivar, Growing Area and Weather Conditions. In Journal of Food Science (Vol. 84, Issue 11, pp. 3264–3274). Wiley. https://doi.org/10.1111/1750-3841.14822

44. Smetanska, I., Tonkha, O., Patyka, T., Hunaefi, D., Mamdouh, D., Patyka, M., Bukin, A., Mushtruk, M., Slobodyanyuk, N., & Omelian, A. (2021). The influence of yeast extract and jasmonic acid on phenolic acids content of in vitro hairy root cultures of Orthosiphon aristatus. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 15, pp. 1–8). HACCP Consulting. https://doi.org/10.5219/1508

45. Serdyuk, M., Stepanenko, D., Baiberova, S., Gaprindashvili, N., & Kulik, A. (2016). Substantiation of selecting the method of pre-cooling of fruits. In Eastern-European Journal of Enterprise Technologies (Vol. 4, Issue 11(82), p. 62). Private Company Technology Center. https://doi.org/10.15587/1729-4061.2016.76235

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