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BIOCHEMICAL VALUE OF STRAWBERRY VARIETIES GROWN UNDER THE CONDITIONS OF THE NORTHERN STEPPE OF UKRAINE

SUMMARY

The study of new agents for indicating practical biodiversity in local varieties of strawberry is a promising area in terms of obtaining both new variant for health diet and culture in general for local consumption. The purpose of the study was to demonstrate the possibilities of variability of different varieties of strawberry (*Fragaria ananassa* Duch) in terms of the content of valuable food elements people consumption. Five varieties of strawberry Honey, Rusanivka, Asia, Alba, Clary were studied by biochemical analysis methods by contents of macro-, micro- and biologically-active elements. Comprehensively, the variety Clary prevailed in terms of the content of valuable food substances, which is recommended for more intensive production implementation due to its high value in satisfying nutritional needs. Local diversity of older varieties is a good source of hidden polymorphism for use in improving glucose and dietary fiber content. Local varieties also have a high level of content of relevant valuable minerals and vitamins for use in schemes for the genetic improvement of modern varieties of this crop. These characteristics are determined mainly genetically and are weakly dependent on environmental conditions in their formation. In the future, it is planned to study the variability in biochemical parameters of berries for more modern varieties.

Keywords: strawberry, variety, nutritional value, microelements, product quality, biologically active substances.

INTRODUCTION

Ecologically variety exam is a long process that takes at least about ten years from the initial stages to the introduction of a promising adapted genotype (Nazarenko, 2015). The main trends are the introduction of varieties that simplify

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the cultivation technology, have increased resistance to biotic and abiotic stresses, expand the adaptation zones of culture, create new types of fruits, primarily more attractive in shape and color, growing strawberry varieties with increased health benefits and ensuring consistent high quality (Goldberger et al, 2019).

According to the Food and Agriculture Organization of the United Nations (FAO), global strawberry production was over 9.56 million tons in 2022 (Hernández-Martínez et al, 2023). China is the world's largest producer of strawberries, accounting for one-third of the world's production and more than three times that of the United States, the world's second-largest strawberry producer (Simpson, 2018).

Breeders in the fruit industry must anticipate the need for varieties at least 10 years into the future, as this is the minimum time that the most strawberry varieties require for the establishment process from first pollination to introduction in farming (Kadir et al, 2006). This aspect looks at general trends in our lives, such as environmental issues, healthy whole foods, consumer lifestyle trends (Farvid et al, 2021), as well as the expectations and needs of farmers (Zhou et al, 2015; Nazarenko, 2016).

Global warming significantly effects on the development strategy of agriculture (Nazarenko et al, 2019; Nazarenko et al, 2022), as this sector negatively affects the intensity of forest plantations and significantly increases the carbon footprint created during the fruits cultivation and processing (Andrés et al, 2021). Long-term fruit production system is more sustainable than an annual cropping system, which may be true, but in both cases the natural vegetation is replaced by cultivated plants, greatly impoverishing biodiversity (Zacharaki et al, 2024).

As we learn more about the health benefits of eating fruit, the demand for more whole foods is increasing (Granatstein et al, 2013). These products can take the form of fresh fruit with a high content of health-promoting substances or other natural products, such as fruit concentrates of natural sources of antioxidants, antimicrobial agents or food colors for the health and food industry (Giampieri et al, 2015). The concern for biochemically complete nutrition is one of the main driving forces of the global food market for the global community, although it depends on the region, it is one of the first issues in importance for consumers (Hernández-Martínez et al, 2023). Consumers see the connection between nutrition and health and associate their diet with prevention of cardiovascular disease, vision problems, lack of energy, obesity, arthritis/joint pain and high cholesterol (Zhou et al, 2015).

Fruit production should be at the forefront of the movement for a healthy diet with the spread of so-called "superfruits", which have proven to be a source of extremely beneficial components for health (Ahmad et al, 2024). Although the most famous are blueberries, pomegranates and a few exotic foods such as acai, noni fruit and mangosteen, many fruits from temperate climates are also considered "superfruits", according to the recommendations of scientists. These include fruits such as apple, plum, prune, blackberry, raspberry, strawberry, grape, black currant (Simpson, 2018).

The purpose of the investigation is to identify the limits of variability of different varieties of strawberry (*Fragaria ananassa* Duch) in terms of the content of valuable food elements that determine the consumer quality of products, under the condition of wide utilization of these varieties in the Steppe region agriculture, preferably at the level of small farms, to identify genotypic and conditions of cultivation variance, their interaction. These varietal resources are a local source of biodiversity and enrichment of the human diet.

MATERIAL AND METHODS

The research was carried out under the conditions of LLC Agrosilprom, village Znamenivka, Novomoskovsk district, Dnipropetrovsk region, in 2021-2023 (48°62′05″ n. l. 35°48′20″ e. l.). Five varieties of strawberry Honey, Rusanivka, Asia, Alba, Clary were studied by biochemical analysis methods (average sample of 1 kg from each plot, in three replications for each variety). The cultivation technology was trivial for the region, with drip irrigation.

The content of such valuable elements as calcium, sulfur, magnesium, potassium, zinc, boron, copper, molybdenum, manganese were studied in the laboratory of the research center for biosafety and ecological control of agricultural resources of the Dnipro State Agrarian and Economic University.

The samples preparation protocol involved mineralization using the Multiwave GO Plus microwave decomposition system (Anton Paar (Austria), adding 0.5 g of 10 ml of 65% nitric acid and 1 ml of concentrated hydrochloric acid (Sigma-Aldrich). The mineralization time (together with the cooling time) was 45 min at a temperature of 185 °C.

The study of the mineral substances content was carried out using an atomic emission spectrometer with an Agilent 5110 inductively coupled plasma at the emission intensity of the light flux at the wavelengths corresponding to each element. Multi-element solutions produced by Agilent (Ca, S, Mg, K, B, Zn, Mo, Mn, Cu) were used as standards during the study.

The content (per 100 g) of such substances as glucose, dietary fiber in berries, vitamins A, E, C, PP was analyzed in the laboratory of biochemistry and plant physiology of the Department of Plant Physiology and Introduction of Dnipro national university named by O. Honchar.

To determine the glucose content, extraction was performed and a VPCH-17 sugar meter (Elcantr (Spain) was used. Extraction of the solution to determine the percentage of glucose content was carried out by a standard method. Dietary fibers content was analyzed by enzymatic and gravimetric methods.

The contents of A, E (tocopherol), PP (nicotinamide) in the samples was investigated by a standardized fluorometric method at the appropriate wavelengths of light using a ULAB 102UV spectrophotometer, vitamin C was detected by a titrometric method due to oxidation in dehydroascorbic acid in grape samples (5 g sample).

Statistic analyze of data was performed by ANOVA-analysis, grouping and estimation of data was provided by discriminant and cluster analysis (Euclidian distance, single linkage) (Statistic 10.0, multivariant module, TIBCO, Palo Alto, USA). The normality of the data distribution was examined using the Shapiro–Wilk W-test. Differences between samples were assessed by Tukey HSD test.

RESULTS AND DISCUSSION

The investigation of the obtained material was performed in several stages. During the first, the content of key valuable macroelements calcium, sulfur, magnesium, potassium was determined. Usually, low availability of sulfur and magnesium can cause problems, sources of other elements are usually sufficient. The fact that the content of these elements may depend on the variety and/or growing conditions (year) was also significant.

The results are presented in Table 1. A total of three samples per variant (varieties) were examined during three years of cultivation. According to the results of the factor analysis, both the variety factor ($F = 147.17$; $F_{0.05} = 2.66$; $P = 3.27*10^{-18}$) and the year factor ($F = 3.62$; $F_{0.05} = 2.44$; $P = 0.03$), although with a highly significant difference. The interaction of factors was not significant ($F = 3.34$; $F_{0.05} = 3.50$; $P = 0.06$). According to a pairwise comparison (Tukey's test), Clary was ahead with a high calcium content, followed by Asia, followed by Honey and Alba, Rusanivka (were on the same level). The trait varies significantly between varieties, but in limits of each variety it is low-variable (less than 5%).

Table 1. The content of macronutrients in strawberry berries depending on the genotype (2021 – 2023), (x=27, ±SD).

Parameters	Honey	Rusanivka	Asia	Alba	Clary
Calcium, mg/kg	41.30±1.56[a]	39.00±1.79[a]	45.20±1.61[b]	40.40±1.41[a]	53.20±1,98[c]
Sulfur, mg/kg	12.00±1.04[a]	17.20±1.12[b]	16.00±1.14[b]	15.10±1.15[bc]	19.90±1,27[d]
Magnesium, g/kg	18.10±0.86[a]	17.25±0.77[a]	26.87±1.25[b]	30.11±1.34[c]	34.76±1,37[d]
Potassium, mg/kg	162.00±1.09[a]	169.00±1.05[b]	151.00±1.01[c]	149.00±1.00[c]	215.00±1,17[d]

Note: indicate significant differences at P < 0.05 by ANOVA-analyze with Bonferroni amendment.

Sulfur content is especially interesting, since the sources of this element in the diet are more limited. According to the results of the factor analysis, the variety factor had a significant effect ($F = 24.92$; $F_{0.05} = 2.66$; $P = 4.18*10^{-5}$), the year factor was unreliable ($F = 2.04$; $F_{0.05} = 2.44$; $P = 0.08$). The genotype-environment interaction was also unreliable ($F = 2.01$; $F_{0.05} = 3.50$; $P = 0.09$). According to a pairwise comparison (Tukey's test), variety Clary was ahead with a high sulfur content, then Rusanivka, on the same level as variety Asia, variety Alba was on the same level as the Asia, but statistically significantly inferior to variety Rusanivka in terms of sulfur content. The worst was variety Honey. The trait varies less significantly between varieties, but in limits of each variety trait is slightly variable (at the level of 3-5%). The investigated varieties demonstrate the absence of significant polymorphism for this trait, but it is quite difficult to manifest.

For the magnesium content, according to the results of the factor analysis, the variety factor had a significant effect ($F = 779.19$; $F_{0.05} = 2.66$; $P = 3.22*10^{-45}$), but not the year factor ($F = 2.33$; $F_{0.05} = 2.44$; $P = 0.06$). The interaction of factors by influence was also unreliable ($F = 2.85$; $F_{0.05} = 3.50$; $P = 0.07$). According to a pairwise comparison (Tukey's test), variety Clary was ahead with a high magnesium content, followed by Alba, Asia (with significant differences between the varieties), significantly lower content in varieties Honey and Rusanivka. The trait varies significantly between varieties, but in limits of each variety trait is slightly variable (at the level of 3-4%). Thus, the set of varieties does not have significant polymorphism for this trait.

According to the factor analysis, potassium content depended significantly on the variety factor ($F = 133.10$; $F_{0.05} = 2.66$; $P = 5.34*10^{-14}$), but not on the year factor ($F = 2.30$; $F_{0.05} = 2.44$; $P = 0.06$). The interaction of factors by influence was also unreliable ($F = 2.10$; $F_{0.05} = 3.50$; $P = 0.09$). According to a pairwise comparison (Tukey's test), variety Clary was ahead with a high potassium content, followed by variety Rusanivka, variety Honey was significantly different from the previous one, and the Alba and Asia varieties had a significantly lower content (they were on the same level according to the trait). The trait varies significantly between varieties, but in limits of each variety trait is low-variable (at the level of 2-3%). Thus, the set of varieties does not show significant polymorphism for this trait.

The results of the conducted discriminant analysis showed (Table 2) that the content of sulfur is less variable in terms of the component determined by the variety, and the variability in the content of potassium, calcium, and magnesium is much more determined.

Table 2. The results of the discriminant analysis of the investigation parameters reliability according to the content of macroelements.

Trait	Wilks' Lambda	Partial	F	p-level
By variety ($F_{critical}$ =4.37)				
Calcium	0.01	0.06	136.60	< 0.01
Sulfur	0.01	0.27	24.36	< 0.01
Magnesium	0.01	0.01	769.71	< 0.01
Potassium	0.01	0.08	105.59	< 0.01
By years ($F_{critical}$ =2.39)				
Calcium	0.09	0.75	3.18	0.04
Sulfur	0.97	0.98	0.04	0.96
Magnesium	0.98	0.99	0.19	0.82
Potassium	0.98	0.99	0.8	0.82

The factor of year, i.e. environment, was significant only for calcium content. It is possible to conclude that the content of the relevant substances is actually mediated only by genotypic features, given that according to the results of the calculated centroid distances (Fig. 1), the years were quite contrasting in terms of their conditions. At the same time, the obtained characteristics of the clusters in the factor space according to the canonical functions show a clear differentiation and separation of each of the varieties, much lower variability in the group than between genotypes. Each variety had its own significant features in the complex, only Rusanivka and Alba form a group with an unreliable difference between the varieties.

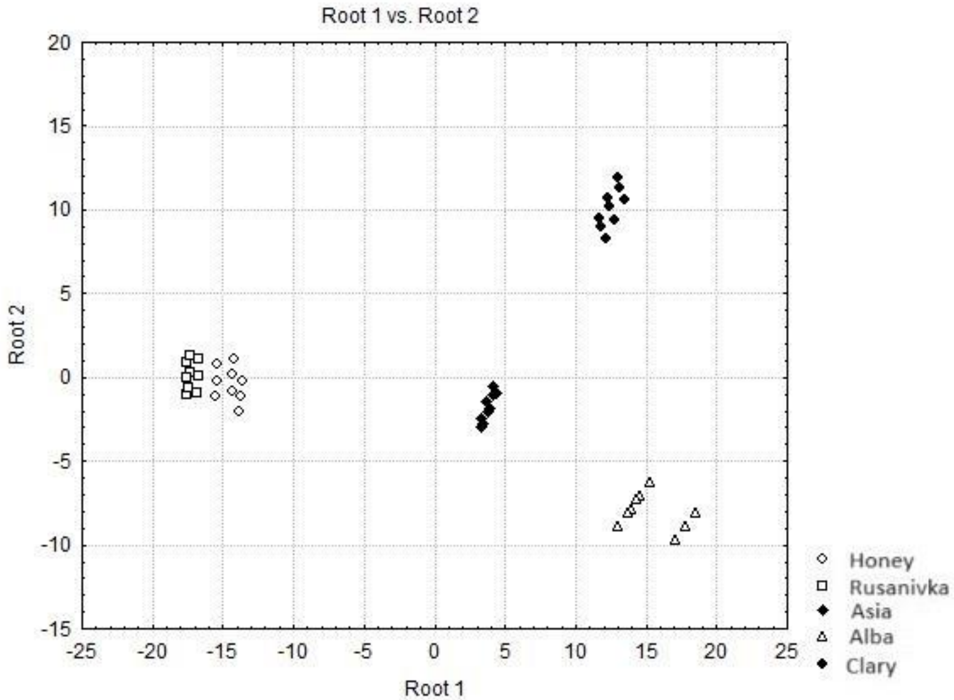

Figure 1. Results of discriminant analysis by macroelements content.

Thus, the studied traits are mainly weakly variable, which indicates the significant homogeneity of the studied material. In terms of the content of calcium, magnesium, sulfur, potassium, variety Clary clearly prevailed, the variety Honey was the worst overall, which showed the lowest indicators in most parameters (except for the potassium content), Rusanivka and Alba groups are in second place and variety Asia is the third. According to the factor analysis, the variety factor was always significant, the year factor only for calcium content, the genotype-environment interaction was always unreliable.

At the next stage (Table 3), the content of valuable trace elements boron, zinc, copper, molybdenum, and manganese was analyzed for all five strawberry varieties. According to the results of the factor analysis, the boron content was significantly influenced by the variety factor ($F = 95{,}45$; $F_{0.05} = 2{,}66$; $P = 2{,}62{*}10^{-11}$), year factor was not significant ($F = 1{,}64$; $F_{0.05} = 2{,}44$; $P = 0{,}09$). The interaction of factors by influence was not significant ($F = 1{,}10$; $F_{0.05} = 3{,}50$; $P =$

0,11). According to a pairwise comparison (Tukey's test), variety Clary was ahead with a high boron content, then Honey and Alba (on the same level), then Rusanivka (on the same level as variety Alba), variety Asia was worse. The trait varies significantly between varieties, in terms of one variety trait is low-variable (at the level of 2-5%).

Table 3. The content of micronutrients in strawberry berries depending on the genotype (2021 – 2023), (x=27, ±SD).

Parameter	Honey	Rusanivka	Asia	Alba	Clary
Boron, mg/kg	190.00±1.74[a]	185.00±1.69[b]	179.00±1.43[c]	188.00±1.71[ab]	213.00±2.12[d]
Zinc, mg/kg	0.09±0.01[a]	0.11±0.01[a]	0.17±0.02[b]	0.07±0.01[ac]	0.19±0.02[b]
Copper, mkg/kg	120.00±1.24[a]	112.00±1.12[b]	112.00±1.11[b]	102.00±1.05[c]	121.00±1.25[a]
Molybdenum, mkg/kg	10.20±0.22[a]	11.00±0.33[b]	10.00±0.23[a]	9.20±0.17[c]	12.80±0.35[d]
Manganese, mg/kg	0.21±0.02[a]	0.22±0.03[a]	0.28±0.03[b]	0.22±0.03[a]	0.31±0.03[b]

Note: indicate significant differences at P < 0.05 by ANOVA-analyze with Bonferroni amendment.

According to the results of the factor analysis, zinc content was significantly influenced by the variety factor (F = 84.56; $F_{0.05}$ = 2.66; P = $2.64*10^{-10}$), year factor was not significant (F = 1.15; $F_{0.05}$ = 2.44; P = 0.10). The interaction of factors by influence was unreliable (F = 1.00; $F_{0.05}$ = 3.50; P = 0.12). According to a pairwise comparison (Tukey's test), varieties Clary and Honey were ahead with a high zinc content, then Rusanivka and Asia (were on the same level), then Alba. The trait varies significantly between varieties, in terms of one variety trait is low-variable (at the level of 2-4%).

As for the copper content, according to the results of the factor analysis, this trait was significantly influenced by the variety factor (F = 59.34; $F_{0.05}$ = 2.66; P = $5.95*10^{-9}$), year factor was not significant (F = 1.85; $F_{0.05}$ = 2.44; P = 0.08). The interaction of factors by influence was unreliable (F = 1.41; $F_{0.05}$ = 3.50; P = 0.09). According to a pairwise comparison (Tukey's test), variety Clary was first with a high copper content, followed by Honey, then Rusanivka and Asia (were on the same level), variety Alba was significantly worse. The trait varies lower significantly between varieties, in terms of one variety trait is low-variable (at the level 2-3 %).

According to the results of the factor analysis, the molybdenum content was significantly influenced by the variety factor (F = 6.77; $F_{0.05}$ = 2.66; P = 0.01), year factor was not significant (F = 1.90; $F_{0.05}$ = 2.44; P = 0.08). The interaction of factors by influence was unreliable (F = 1.41; $F_{0.05}$ = 3.50; P = 0.09). According to a pairwise comparison (Tukey's test), variety Clary was first with a high molybdenum content, variety Rusanivka was second, then varieties Honey and Asia (were on the same level), variety Alba was significantly inferior to all other. The trait varies slightly between varieties, in terms of one variety trait is low-variable (at the level of 2-3%). It can be concluded that there is little polymorphism in the varieties.

According to the results of the factor analysis, the manganese content was significantly influenced by the variety factor (F = 60.16; $F_{0.05}$ = 2.66; P = $1.43*10^{-9}$), year factor was not significant (F = 1.72; $F_{0.05}$ = 2.44; P = 0.09). The interaction of factors by influence was unreliable (F = 1.11; $F_{0.05}$ = 3.50; P = 0.11). According to a pairwise comparison (Tukey's test), varieties Clary and Asia (at the same level) with a high manganese content were ahead, followed by a group of varieties Rusanivka, Honey and Alba. The trait varies slightly between varieties, in terms of one variety trait is low-variable (at the level of 2-3%).

The results of the conducted discriminant analysis showed (Table 4) that the content of molybdenum is less variable in terms of the component determined by the variety, and the variability in the content of zinc and boron is much more determined.

The factor of year, i.e. environment, was not significant for any of the traits. It is possible to conclude that the content of the relevant substances is actually depended on only genotypic features, given that according to the results of the calculated centroid distances (Fig. 2), the years were quite contrasting in terms of their conditions.

Table 4. The results of the discriminant analysis of the investigation parameters reliability according to the content of microelements.

Trait	Wilks' Lambda	Partial	F	p-level
By variety ($F_{critical}$ =4.37)				
Boron	0.01	0.09	91.51	< 0.01
Zinc	0.01	0.10	81.68	< 0.01
Copper	0.01	0.13	58.20	< 0.01
Molybdenum	0.07	0.57	6.77	0.01
Manganese	0.01	0.12	59.17	< 0.01
By years ($F_{critical}$ =2.39)				
Boron	0.98	0.99	0.02	0.98
Zinc	0.99	0.98	0.23	0.79
Copper	0.98	0.99	0.01	0.99
Molybdenum	0.98	0.99	0.01	0.98
Manganese	0.98	0.99	0.02	0.98

At the same time, the received characteristics of the clusters in the factor space according to the canonical functions show clear differentiation and separation of Clary, Alba and Asia, quite significant variability in the group, varieties Rusanivka and Honey form one group. Clusters of varieties, unlike the previous group of traits, are quite sparse.

In this way, the investigated traits are mainly weakly variable, which indicates the significant homogeneity of the studied material. Comprehensively, variety Clary prevailed in terms of the best content of microelements. According to the factor analysis, the variety factor was always significant, the year factor was never and the genotype-environment interaction was always unreliable. The group of traits is characterized by a significantly lower differentiating ability.

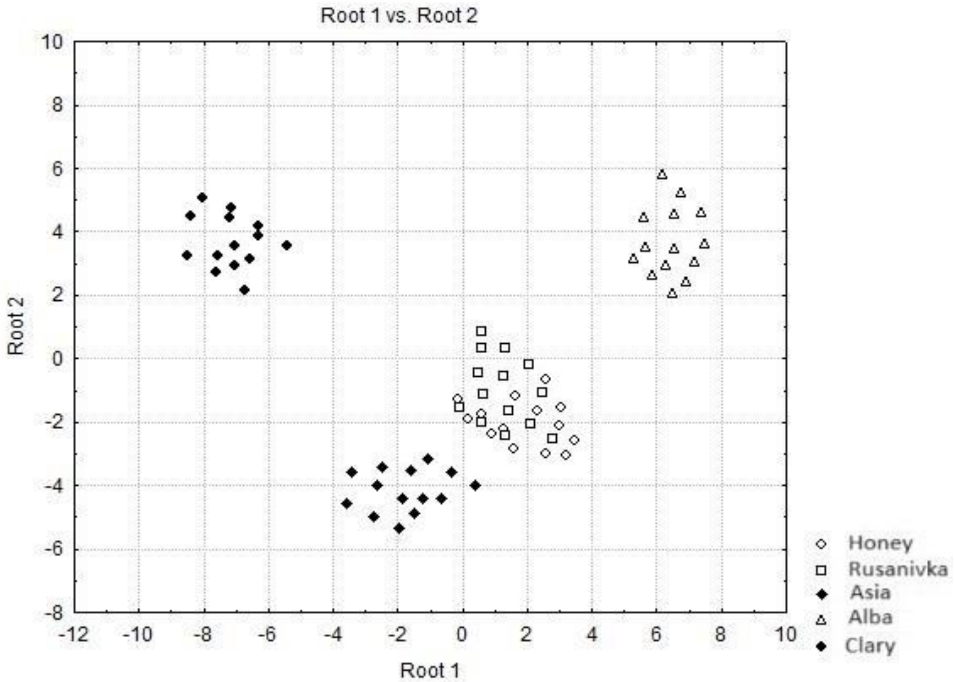

Figure 2. Results of discriminant analysis by microelements content.

At the last stage (Table 5), the content of biologically active components of glucose, dietary fiber, vitamins A, E, C and PP was analyzed for all five strawberry varieties. According to the results of the factor analysis, the glucose content was significantly influenced by the variety factor ($F = 16.15$; $F_{0.05} = 2.66$; $P = 1.62*10^{-5}$), year factor was not significant ($F = 1.15$; $F_{0.05} = 2.44$; $P = 0.11$). The interaction of factors by influence was not significant too ($F = 0.34$; $F_{0.05} = 3.50$; $P = 0.14$). According to a pairwise comparison (Tukey's test), varieties Clary, Alba and Asia were on the first place with a high glucose content, followed by Rusanivka and Honey. The trait varies quite significantly between varieties; in terms of one variety this trait is moderately variable (at the level of 7-8%)

Table 5. The content of biologically-active components in strawberry berries depending on the genotype (2021 – 2023), conversion per 100 g (x=27, ±SD).

Parameter	Honey	Rusanivka	Asia	Alba	Clary
Glucose, g	7.34 ± 0.25^{a}	7.45 ± 0.29^{a}	8.32 ± 0.23^{b}	8.43 ± 0.21^{b}	8.61 ± 0.22^{b}
Dietary fibers, g	$2.17 \pm 0{,}14^{a}$	$2.17 \pm 0{,}32^{a}$	$1.98 \pm 0{,}10^{a}$	$1.94 \pm 0{,}15^{a}$	$2.45 \pm 0{,}15^{b}$
Vitamin A, mkg	5.17 ± 0.11^{a}	5.34 ± 0.12^{a}	5.39 ± 0.12^{a}	5.45 ± 0.13^{ab}	6.12 ± 0.14^{c}
Vitamin E, mg	$0.57 \pm 0{,}02^{a}$	$0.61 \pm 0{,}02^{a}$	$0.55 \pm 0{,}03^{a}$	$0.53 \pm 0{,}01^{ab}$	$0.66 \pm 0{,}02^{ac}$
Vitamin C, mg	$60.10 \pm 0{,}29^{a}$	$63.20 \pm 0{,}31^{b}$	$68.10 \pm 0{,}35^{c}$	$69.70 \pm 0{,}32^{d}$	$69.20 \pm 0{,}37^{d}$
Vitamin PP, mg	0.310 ± 0.14^{a}	0.340 ± 0.13^{a}	0.320 ± 0.13^{a}	0.300 ± 0.14^{ab}	0.380 ± 0.15^{c}

Note: indicate significant differences at P < 0.05 by ANOVA-analyze with Bonferroni amendment.

According to the results of the factor analysis, the dietary fiber content was also significantly influenced by the variety factor (F = 51.95; $F_{0.05}$ = 2.66; P = $1.62*10^{-11}$), year factor was not significant (F = 2.26; $F_{0.05}$ = 2.44; P = 0.06). The interaction of factors by influence was not significant (F = 1.35; $F_{0.05}$ = 3.50; P = 0.11). According to a pairwise comparison (Tukey's test), variety Clary was ahead with a higher content of dietary fibers, the difference between the others was not statistically significant. The trait varies quite significantly between varieties; in terms of one variety this trait is moderately variable (at the level of 7-10%, which indicates significant hidden polymorphism in this parameter).

According to the results of the factor analysis, the vitamin A content was also significantly influenced by the variety factor (F = 28.17; $F_{0.05}$ = 2.66; P = $3.45*10^{-8}$), year factor was not significant (F = 0.15; $F_{0.05}$ = 2.44; P = 0.16). The interaction of factors by influence was not reliable (F = 0.10; $F_{0.05}$ = 3.50; P = 0.22). According to a pairwise comparison (Tukey's test), variety Clary was ahead with a higher content of vitamin A, the difference between the others was not statistically significant. The trait varies slightly between varieties, in terms of one variety this trait is slightly variable (at the level of 2-4%, which indicates the absence of hidden polymorphism in this parameter).

Table 6. The results of the discriminant analysis of the investigation parameters reliability according to the content of biologically-active components.

Trait	Wilks' Lambda	Partial	F	p-level
By variety ($F_{critical}$ =4.37)				
Glucose	0.01	0.35	15.85	< 0.01
Dietary fibers	0.01	0.14	51.24	< 0.01
Vitamin A	0.01	0.23	28.79	< 0.01
Vitamin E	0.32	0.84	1.56	0.20
Vitamin C	0.01	0.15	46.79	< 0.01
Vitamin PP	0.01	0.45	10.45	< 0.01
By years ($F_{critical}$ =2.39)				
Glucose	0.85	0.99	0.08	0.92
Dietary fibers	0.90	0.94	1.12	0.33
Vitamin A	0.86	0.99	0.18	0.83
Vitamin E	0.90	0.94	1.12	0.33
Vitamin C	0.86	0.99	0.12	0.88
Vitamin PP	0.85	0.99	0.08	0.92

The variety factor did not affect vitamin E content (F = 2.47; $F_{0.05}$ = 2.66; P = 0.06), year factor was not significant (F = 1.01; $F_{0.05}$ = 2.44; P = 0.12). The interaction of factors by influence was also not significant (F = 0.70; $F_{0.05}$ = 3.50; P = 0.14). According to a pairwise comparison (Tukey's test), variety Clary was ahead with a higher content of vitamin E, but on the same level as variety Rusanivka. The trait varies slightly between varieties, in terms of one variety this trait is slightly variable (at the level of 2-3%, which indicates the absence of hidden polymorphism in this parameter).

The vitamin C content was significantly influenced by the variety factor

($F = 45.07$; $F_{0.05} = 2.66$; $P = 1.12*10^{-10}$), year factor was not significant ($F = 1.10$; $F_{0.05} = 2.44$; $P = 0.11$). The interaction of factors by influence was also reliable ($F = 0.12$; $F_{0.05} = 3.50$; $P = 0.24$). According to a pairwise comparison (Tukey's test), varieties Clary and Alba were on the first place with a higher content of vitamin C, followed by variety Asia, followed by variety Rusanivka, variety Honey was the worst. The trait varies slightly between varieties, in terms of one variety this trait is slightly variable (at the level of 4-5%, which indicates the absence of hidden polymorphism in this parameter).

The content of vitamin PP was significantly affected by the variety factor ($F = 9.07$; $F_{0.05} = 2.66$; $P = 0.002$), year factor was not significant ($F = 0.80$; $F_{0.05} = 2.44$; $P = 0.12$). The interaction of factors by influence was not significant ($F = 0.92$; $F_{0.05} = 3.50$; $P = 0.11$). According to a pairwise comparison (Tukey's test), variety Clary was ahead with a higher content of vitamin PP. The trait varies slightly between varieties, in terms of one variety this trait is slightly variable (at the level of 1-3%, which indicates the absence of hidden polymorphism in this parameter).

The results of the conducted discriminant analysis showed (Table 6) that the content of vitamins (except vitamin E) is less variable in terms of the component determined by the variety, and the variability in the content of vitamin C and dietary fibers is much more determined.

The factor of year, i.e. environment, was not significant for the indicators. It is possible to conclude that the content of the relevant substances is influenced only by varietal diversity, not and by the environmental effect for all cases, especially for the content of vitamin C and dietary fibers, taking into account that according to the results of the calculated centroid distances (Fig. 3), the years were quite contrasting in terms of their conditions.

At the same time, the received characteristics of the clusters in the factor space according to the canonical functions show a clear differentiation and separation of the variety Clary; varieties Rusanivka and Honey, Alba and Asia form a group. Clusters of varieties of this traits group are quite rare, which indicates a significant polymorphism of traits.

In this way, the investigated vitamin content traits are mainly low-variable, which indicates the significant homogeneity of the studied material, the traits of glucose and dietary fiber content are moderately variable (significant varietal polymorphism, which is characteristic of older varieties). The variety Clary prevailed comprehensively in terms of the best content of glucose, dietary fiber and vitamins. According to the factor analysis, the variety factor was mostly significant (except for the vitamin E content); the year factor was not significant in any case. The group of traits is characterized by a significantly intermediate differentiating ability between the first and second. The best practice option would be to plant variety Clary.

The problem of preserving the appropriate biodiversity of the main cultivated plants is largely based on the possibility of using local varietal resources (Nazarenko et al, 2022), in this case, traditional strawberry varieties for growing in farms of the region, which mainly, considering the conservative trends in viticulture, can be created tens of years ago (Galli et al, 2016; Andrés et al, 2021). According to research, these varieties can nevertheless be the basis for improving the nutritional quality of the diet and contain a high level of relevant valuable substances for consumption (Skrovankova et al, 2015; Nazarenko and Simchenko, 2023). Moreover, as already partially noted earlier, such an advantage can be both complex and tied to the use of several varieties in production (Liu et al, 2023a), which is all the more relevant considering the need for strawberries, as for a culture, to form according to ripening periods and external features (color and shape of the berry) of its kind on the conveyor during the relevant marketing period (Durán-Soria et al, 2020; Zacharaki et al, 2024).

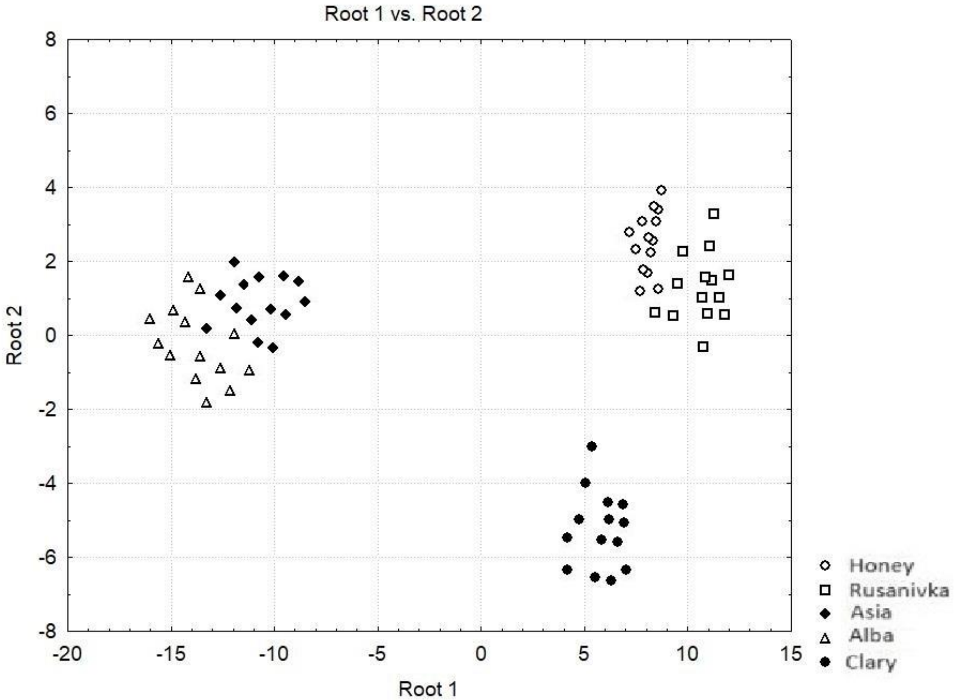

Figure 3. Results of discriminant analysis by biologically-active components content.

We find that local material may also have a sufficient level of hidden polymorphism to be used as a source of primary selection for the improvement of certain traits (Badenes and Byrne, 2012), which was also partly noted earlier (mainly the first and second groups, glucose and dietary fiber traits) (Nazarenko and Simchenko, 2023). High varietal differentiation (the first group of traits) indicates the possibility of biodiversity impoverishment with careful selection of forms more positive for complete nutrition, while lower (the second-third group of traits) to a significant complication in the selection of more useful varieties

(Liu et al, 2023b), although in these studies it can be considered quite optimal for the second group of traits.

In turn, a higher variability in the variety itself by trait can lead to a more significant variation of the parameter depending on environmental conditions, which is not always positive for the regular practice. But, taking into account the recent trends of cultural advancement to the south due to global climate changes (Hernández-Martínez et al, 2023), this problem can be neglected for some of the studied traits (Badenes and Byrne, 2012; Fan et al, 2024). At the same time, this study shows that traditional strawberry varieties, which have been tested by a long period of production use, are in principle enough to ensure proper level in diet (Petranet al, 2017). The possibility of finding a variety with a high level of key characteristics (Sakamoto et al, 2016; Raj et al, 2022).

At the same time, less valuable varieties are also available in production, which may be appropriate to use due to marketing preferences, but they are able to decrease the level of consumption of valuable food elements (Cockerton et al, 2021). But any final recommendation needs clarification from the point of view of such important characteristics for strawberry as taste qualities, preferences for the shape and color of the berry (Petranet al, 2017), possibilities for processing and technological qualities of products (Űnal and Okatan, 2023; Jiang et al, 2024).

In the future, it is planned to conduct a comparative study with more modern and intensive strawberry varieties according to this set of characteristics, in order to establish the variability of these forms in comparison and the level of necessary provision of the completeness of the diet by varieties that are more traditional for growing by small agrofirms and farms in the region, which mainly provide strawberry production for the region.

CONCLUSIONS

Except for the content of glucose and dietary fiber, the studied characteristics are mainly low-variable, which indicates the significant homogeneity of the varietal set. That is, primary selection is possible for improving the source material based on only two moderately variable traits; other traits are stable in term of variety variability and do not show significant polymorphism. Taking into account the generally high level of variability for local germplasm, this trend is significant. The variety Clary prevailed comprehensively in terms of the content of valuable food substances, it can be considered the unequivocal leader in terms of nutritional value. The conducted classification shows the uniqueness of variety Clary according to the studied parameters, which indicates the complex problems of the majority of local varieties with regard to the content of necessary substances. The variety factor has always been significant with one exception for vitamin E content, which indicates, firstly, about the need in find new sources to improve this characteristic and secondly, the importance of introducing a new source of complete nutrition of the variety itself, which is a prerequisite for the success of this strategy. The year factor is important for the calcium content, i.e. environmental characteristics were significant for this characteristic. Considering that the conditions of environment were contrasting by results of discriminant analysis, it should be noted that for these traits are not depend on this factor as morphometric or yield traits (except E content).Genotype-environment interaction was actually derived for traits where the effect of environment was significant.

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