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FRUIT CHARACTERISTICS OF RESISTANT LOCAL APPLE VARIETIES OF TRANSCARPATHIA

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In the Transcarpathian region there are favourable conditions for organic gardening. Local varieties resistant to major diseases and adapted to local soil and climatic conditions can be used in organic gardening and breeding. Indigenous varieties disappear and are replaced by new, popular varieties. The present study is aimed to preserve local native varieties Shtetin red, Batul, Durnaika, Solivarske, Krasa Zakarpattia, and Ferkovania by grafting onto M.9 rootstock and determine the main biochemical and morphometric parameters of the fruits. In the experiment ten commercial apple varieties suitable for organic cultivation and six old varieties were included in order to compare them. Fruit sampling in 2020-2024 was performed at technological maturity, which was determined using the starch iodine test. The soluble solids content (SSC, °Brix) was determined with a refractometer at 20°C. Titratable acidity (TA, % of malic acid) was determined in 30 ml of the filtrate by titration with 0,1 mol L^{-1} KOH and phenolphthalein solution was used as indicator. Among the studied varieties, the highest content of malic acid was found in the variety Batul (1.55 %) and the lowest – in Solivarske (0.28%). The highest amount of soluble sugars was in the Orion variety (13.7%) and the lowest in the Reanda and Reglindia varieties (9.6%). The content of soluble sugars in the fruit of old Transcarpathian apple varieties was in this range. The highest content of sugars was found in the variety of Ferkovania (12.2 %) and Krasa Zakarpattia (11.5 %), and the lowest one – in the variety Batul (9.8 %). The highest sugar-acid ratio was in the variety Solivarske (36.77), the lowest one in the variety Batul (6.34); it was also low in the varieties of Krasa Zakarpattia, Orion, Red Topaz, Sirius. The high sugar-acid ratio also have Reglindia, Durnaika and Ferkovania. Old variety Durnaika was distinguished by the largest average fruit weight (604.5 g). Based on biochemical and morphometric parameters, the apples of all six old Transcarpathian varieties are suitable for fresh consumption, as well as for processing.
Key words: *aboriginal varieties, gene pool conservation, biodiversity protection, Ukrainian Carpathians, dry soluble substances, sugars, titrated acids.*
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Характеристика плодів стійких місцевих сортів яблунь Закарпаття
Маргітай В.

У Закарпатській області існують сприятливі умови для ведення органічного садівництва. Місцеві сорти, стійкі до основних хвороб і адаптовані до місцевих ґрунтово-кліматичних умов, можуть використовуватися в органічному садівництві та селекційній роботі. Аборигенні сорти поступово зникають і замінюються новими, популярними. Метою цього дослідження є збереження місцевих аборигенних сортів – Штетінське червоне, Батул, Дурнайка, Соліварське, Краса Закарпаття та Феркованя – шляхом щеплення їх на підщепу М.9 і визначення основних біохімічних та морфометричних параметрів плодів. У досліді було включено десять комерційних сортів яблуні, придатних для органічного вирощування, та шість стародавніх сортів для порівняння. Відбір плодів у 2020–2024 роках проводили у фазі технологічної стиглості, яку визначали за допомогою крохмально-йодної проби. Вміст розчинних сухих речовин (SSC, °Brix) визначали за допомогою рефрактометра при 20 °С. Титровану кислотність (ТА, % яблучної кислоти) визначали у 30 мл фільтрату шляхом титрування розчином КОН концентрацією 0,1 моль $л^{-1}$ із використанням фенолфталеїну як індикатора. Серед досліджуваних сортів найвищий вміст яблучної кислоти виявлено у сорту Батул (1,55 %), а найнижчий – у сорту Соліварське (0,28 %). Найвищий вміст розчинних цукрів відзначено у сорту Оріон (13,7 %), а найнижчий – у сортів Реанда та Регліндія (9,6 %). Вміст розчинних цукрів у плодах старих закарпатських сортів перебував у цих межах. Найвищий показник вмісту цукрів мав сорт Феркованя (12,2 %) і Краса Закарпаття (11,5 %), а найнижчий – сорт Батул (9,8 %). Найвище співвідношення цукрів до кислот зафіксовано у сорту Соліварське (36,77), найнижче – у сорту Батул (6,34); низькі значення також відзначено для сортів Краса Закарпаття, Оріон, Ред Топаз і Сіріус. Високим співвідно-

шенням цукрів до кислот характеризуються сорти Регліндія, Дурнайка та Феркованя. Стародавній сорт Дурнайка вирізнявся найбільшою середньою масою плоду (604,5 г). На основі біохімічних і морфометричних показників яблука всіх шести старих закарпатських сортів придатні як для споживання у свіжому вигляді, так і для переробки. Встановлено, що дерева всіх досліджених аборигенних сортів, щеплені на клонові вегетативні підщепи М.9, які найчастіше використовуються в промислових садах України, забезпечують високоякісний урожай у третьому–сьомому вегетаційному сезоні, що дає змогу швидко окупити витрати на закладання та вирощування саду й отримати прибуток. Ці сорти мають перспективу використання як в інтенсивних, так і в екстенсивних органічних садах.
Ключові слова: *аборигенні сорти, збереження генофонду, охорона біорізноманіття, українські Карпати, сухі розчинні речовини, цукри, титровані кислоти.*
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Introduction

The consumption of fruit and vegetables is very important in human nutrition. They provide nutrients and non-nutritive components with significant biological activity, thus contributing to a healthy diet, with reduction of disease risk. Based on scientific data, nutritionists suggest that increasing fruit and vegetable consumption is one of the best strategies to decrease the burden of several chronic diseases (Devirgiliis et al. 2024). Scientific evidence showed that a higher consumption of fruit and vegetables is associated with a lower risk of all-cause mortality, particularly cardiovascular mortality.

Apples are one of the most consumed and healthy fruit due to their content of high value nutrients and secondary metabolites (Sut et al. 2019; Doğan et al. 2024). It is the most important and most popular fruit crop in temperate climate zones, grown under various ecological conditions across a wide range of areas (Bolat et al. 2019). The production of apple is increasing. The apple is a convenient fruit available in retail throughout the world all year and it is a result of its high storability. Their beautiful appearance, crisp flesh, pleasant flavor, and sweetness attract consumers and fetch a high price (Milošević et al. 2019). Appearance, fruit size, uniformity, color and freshness, as well as nonvisual attributes such as taste, aroma, flavour, firmness (texture), nutritional value and health benefits, are components that determine the attractiveness of the fruit to consumers (Milošević et al. 2019).

Today, apple production focuses on regular plantations established with a few highly productive cultivars of extraordinary quality (Mratinić, Akšić 2012), and four of them, namely Golden Delicious, Gala, Red Delicious, and Idared account for 48 % of global production. This massive use of limited and related cultivars, combined with vegetative practices based on cuttings and grafting, has dramatically reduced apple genetic diversity. Hence, many interesting and well adapted traditional and local varieties considered obsolete were no longer cultivated and have been partly lost (Contessa, Botta 2016; Farina et al. 2016; Bassi et al. 2018; Marconi et al. 2018; Iaccarino et al. 2019). In Ukraine production is based mainly on intensive orchards with few commercial varieties: Golden Delicious, Red Delicious, Gala, Fuji, Granny Smith, Pinova.

Food and Agriculture Organization of the United Nations highlights on almost 95% loss of varieties, that were grown in the early 20th century. Nowadays, genetic erosion is accelerated like never before in the past by a change in farming practice in the countryside and in the life of people in the country (Posolda et al. 2019).

In the past decades we have seen that old fruit trees from various plantations or alleys are vanishing as well as unique and extremely variable varieties. This leads to the disappearance of our cultural heritage and a valuable source for breeding. The variety of cultural plants is a unique and irreplaceable wealth created by nature and later preserved by means of the purposeful activities of man (Dokoupil 2016).

For these reasons, it is necessary to protect and conserve genetic resources worldwide (Posolda et al. 2019).

There are numerous apple genetic resources conservation and utilization programs that are trying to establish the collections of germplasm in situ. However, these efforts have not been enough to compare the complete variability found in the world (Mratinić, Akšić 2012).

Local varieties are used in breeding programmes because of their adaptability to climatic conditions. Their importance also lies in their adaptability to soil conditions (Dokoupil 2016).

Some of the resistant local cultivars could be used in the breeding programs in order to transfer the polygenic resistance although many of them have undergone genetic erosion (Mratinić, Akšić 2012).

Apple and processed apple products contain different amounts of dietary fibres, sugars, acids, and various bioactive secondary metabolites, like phenolic compounds, which are responsible for most of the antioxidant activities of the fruit (Akagić et al. 2019).

Ancient apple cultivars usually have higher nutraceutical value than commercial ones (Bartolini, Ducci 2017; Lo Piccolo et al. 2019).

The trees of old apple varieties, which mainly grow without special agricultural technology and adapt well to changing environmental conditions, are expected to have substantially higher content of phenols and flavonoids in the peel and pulp whose production is a result of plant response to their greater exposure to environmental stress (Iacopini et al. 2010; Belviso et al. 2013; Bartolini et al. 2015; Felice et al. 2015; Stanivuković et al. 2017; Akagić et al. 2019; Nkuimi Wandjou et al. 2019; Oszmiański et al. 2019). They also differ in the content of organic acids and sugars compared with commercial cultivars (Belviso et al. 2013; Bartolini et al. 2015; Akagić et al. 2019; Lo Piccolo et al. 2019).

It has been well established that foods rich in polyphenols have powerful cardioprotective properties and show anti-cancer activities (Lo Piccolo et al. 2019).

Soluble sugars and organic acids are crucial determinants of fruit tastes which combine with aromas to influence considerably the overall organoleptic quality of fruit (Ma et al. 2019).

The aim of the present study was to scan the sugar and organic acid content of traditional and commercial apple cultivars to select the most appropriate for table consumption or for fruit processing industries apple cultivars.

The objective of the study was to save indigenous endangered apple varieties in the Transcarpathian region, to study the basic nutritional characteristics of fruits in order to determine the direction of use in health and diet nutrition, and processing.

The main tasks of the research are:

− to determine the main biochemical parameters of the fruit, such as the content of soluble solids, sugars, titratable acids, sugar-acid ratio and compare with the ten market available varieties for organic gardening;

− to determine the weight, size and shape of the fruits.

Materials and methods

Due to the screening of the assortment of apple varieties in Transcarpathia, ancient local native varieties were selected: Shtetin red, Batul, Durnaika, Solivarske, Krasa Zakarpattia and Ferkovania.

The experiment was conducted in an apple orchard located in the village of Storozhnytsya (48°35'28.3"N 22°10'35.3"E, 106 m a.s.l.) near the town of Uzhhorod (Western Ukraine, Transcarpathian region). Apple cultivars grafted onto M.9 rootstock were used. During the year 2016, Summer budding was carried out on M.9 rootstocks in the nursery of "Konik" farm. The grafting was carried out at the height of 25 cm from the soil level in August. The orchard was established in the spring of 2018. Planting distance was 3.3 × 0.7 m or 4329 trees ha^{-1}. Trees were trained to a vertical axis system. Tree vigor was controlled by root pruning. Root pruning was carried out in early spring on one side of a row of trees at a distance of 30 cm and an angle of 30 degrees. Standard cultural practices were used (winter prunning, soil management, pest and disease management, weed control, drip irrigation). Orchard floor management involved grass alleyways and 1-m-wide grass-free strips in the tree rows.

The soil was sod-podzolic, heavy, acidic on alluvial deposits of the river Uzh, in a foothill zone of Transcarpathian region. Humus content was 2.1 %.

Fruit quality studies were conducted in 2020-2024. Ten trees per cultivar were selected according to similar crop load. In the experiment ten commercial apple cultivars and six old cultivars were included. Fruit sampling was performed at technological maturity, which was determined using the starch iodine test. Fruits from all apple cultivars were picked from the outer layer of the trees, avoiding the tops and bottoms. Samples of 30 fruits per variety were collected.

The soluble solids content (SSC, °Brix) and total soluble sugars (TS) were determined with a refractometer at 20°C. Titratable acidity (TA, % of malic acid) was determined in 30 ml of the filtrate by titration with 0,1 mol L^{-1} KOH and phenolphthalein solution was used as indicator. The sweetness index was calculated as the TS/TA ratio.

Statistical evaluation. All data were analyzed using the Microsoft Office Excel software package. The mean value (M) and standard error (m) were calculated.

Results

A collection of endangered apple varieties of the Transcarpathian region was created. The important characteristics of fruits of selected varieties were investigated.

The amount of soluble sugars among the studied varieties is highest in the Orion variety (13.7 %), which is marketed as a sweet apple. The lowest in the Reanda and Reglindia varieties (9.6 %). The content of soluble sugars in the fruits of old Transcarpathian apple varieties is in this range. The highest content

of sugars was found in the variety of Ferkovania (12.2 %) and Krasa Zakarpattia (11.5 %), and the lowest one – in the variety Batul (9.8 %).

Among the studied varieties, the highest content of malic acid was found in the variety Batul (1.55 % by weight), and the lowest one in the variety Solivarske (0.28 %). This is 5.54 times lower than in the Batul variety. The remaining varieties, including 10 commercial resistant ones, are in this range (Table 1). The high content of malic acid was also found in the variety Orion (1.32 %) and Krasa Zakarpattia (1.11 %).

The fruits of the varieties of Shtetin Red and Ferkovania have a malic acid content almost the same as those of Rosela, Luna, Remo.

The sugar-acid ratio is the highest in the variety Solivarske (36.77), and the lowest one in the variety Batul (6.34). The high sugar-acid ratio is also found in Reglindia, Durnaika and Ferkovania varieties. These are apple varieties that have a sweet and sour taste. It is low in the varieties of Krasa Zakarpattia, Orion, Red Topaz, Sirius.

The highest average fruit weight has the Durnaika variety (604.5 g). This is the distinctive feature of this variety. According to the method of pomological description of varieties by size, this fruit is very large, by weight it is exceptionally large (Table 2).

Shtetin Red and Ferkovania produce large fruits, with above-average weight.

Krasa Zakarpattia has the smallest fruit among the studied varieties, nevertheless, the fruit of this variety belong in size to the middle, as well as fruit of the variety Batul. The Solivarske variety has big fruit.

The shape index (the ratio of the height of the fruit to its diameter (L / D ratio)) is a relatively stable pomological characteristic of the variety and allows to estimate the shape of the fruit. According to this index, the fruits of most varieties (Krasa Zakarpattia, Durnaika, Ferkovania, Batul, Solivarske) can be classified as flattened-rounded. And the fruits of Shtetin red variety belong to flat-rounded.

All varieties are high-yielding, produce good-quality fruit, and are resistant to scab. All these

Table 1. Biochemical parameters of fruits at harvest time (average of 2020-2024 years), M±m

Variety name	Soluble solid content (SSC) [%]	Total soluble sugars (TS) [%]	Titratable acidity (TA) [%]	Sugars/acids ratio (TS/TA)
*Batul	14.00 ± 0.19	9.83 ± 0.36	1.55 ± 0.47	6.35 ± 0.31
*Krasa Zakarpattia	16.38 ± 0.72	11.49 ± 0.51	1.11 ± 0.37	10.37 ± 0.93
*Solivarske	14.67 ± 0.66	10.29 ± 0.46	0.28 ± 0.05	36.77 ± 0.27
*Durnaika	15.31 ± 1.12	10.75 ± 0.79	0.37 ± 0.07	29.13 ± 2.86
*Shtetin red	15.20 ± 1.03	10.67 ± 0.72	0.54 ± 0.03	19.93 ±1.13
*Ferkovania	17.33 ± 0.49	12.16 ± 0.23	0.57 ± 0.04	21.43 ± 1.63
Orion	19.46 ± 0.34	13.65 ± 0.14	1.32 ± 0.06	10.33 ± 0.48
Red Topaz	14.86 ± 0.78	10.43 ± 0.18	1.04 ± 0.28	10.04 ± 0.45
Sirius	14.97 ± 0.46	10.51 ± 0.44	0.95 ± 0.09	11.08 ± 0.44
Rosela	14.97 ± 0.08	10.51 ± 0.09	0.56 ± 0.06	18.88 ± 1.30
Luna	17.14 ± 0.07	12.03 ± 0.05	0.60 ± 0.03	19.94 ± 0.08
Revena	15.69 ± 0.24	11.01 ± 0.17	0.70 ± 0.07	15.93 ± 1.59
Remo	16.49 ± 0.13	11.57 ± 0.09	0.65 ± 0.01	17.93 ± 0.50
Reanda	13.68 ± 0.05	9.60 ± 0.04	0.77 ± 0.06	12.53 ± 0.95
Relinda	17.14 ± 0.51	12.03 ± 0.36	0.91 ± 0.04	13.31 ± 0.87
Reglindia	13.64 ± 2.05	9.50 ± 1.44	0.32 ± 0.02	30.02 ± 3.33

Note: * – Old apple varieties of Ukrainian Carpathians

Table 2. Morphometric parameters of fruits at harvest time of old apple varieties of Ukrainian Carpathians (average of 2020-2024 years), M±m

Variety	Fruit weight [g]	Fruit length [mm]	Fruit diameter [mm]	L/D ratio
Batul	135.17 ± 20.88	56.50 ± 3.39	66.67 ± 5.28	0.85 ± 0.08
Krasa Zakarpattia	126.00 ± 5.96	53.00 ± 6.16	63.60 ± 5.13	0.83 ± 0.04
Solivarske	155.20 ± 27.44	60.70 ± 2.98	71.90 ± 4.65	0.85 ± 0.06
Durnaika	604.50 ± 155.18	98.75 ± 4.79	126.25 ± 10.31	0.78 ± 0.04
Shtetin red	217.75 ± 37.19	74.63 ± 5.18	84.88 ± 6.64	0.88 ± 0.10
Ferkovania	183.00 ± 30.75	67.64 ± 4.39	81.36 ± 5.16	0.83 ± 0.05

varieties are resistant to major diseases, including scab, and partially to powdery mildew and cancer. The results of study by Papp et al. (2016) showed, that Batul has good disease tolerance against fungal diseases and can be grown in organic orchards where synthetic pesticides are prohibited. Batul might possess polygenic resistance or maybe new major scab resistance genes. According to investigation of Kása et al. (2004) the Batul is moderately resistant to the fire blight, and Sikulai (Krasa Zakarpattia) is highly resistant. They can be used as sources of resistance to fireblight (Hevesi et al. 2004).

It was found that trees of all studied aboriginal varieties grafted on clone vegetative M9 rootstocks, which are most commonly used in industrial orchards in Ukraine, are producing a high-quality harvest in the third-seventh growing season, which makes it possible to quickly recover the costs that was spent on planting and growing a garden and make a profit. These varieties have the perspective of using in intensive and extensive organic orchards.

Soluble solids, which include mainly sugars (approximately 20%–70%) and smaller amounts of organic acids, vitamins, proteins, free amino acids, essential oils, salts, and glucosides (Wills et al. 1983), are good indicators of the sugar content of apples and presumably of sweetness (Milošević et al. 2019). Sweetness is an important edible quality of fruit, which directly affects consumer preferences and purchasing behavior. The sweetness of apple fruit is mainly determined by soluble sugar contents, including mainly fructose, glucose and sucrose (Wei et al. 2020).

For people with diabetes the content of readily soluble sugars in food is important. Among the old Transcarpathian varieties the lowest sugar content is in the varieties Batul (9.83) and Solivarske (10.29), whereas among the commercial varieties for organic production the lowest sugar content is found in the varieties Reanda (9.60) and Reglindia (9.50). Therefore, they can be recommended for patients with diabetes.

Varieties with a high content of malic acid Batul, Krasa Zakarpattia may be suitable for the production of dried fruit, fruit chips, pastila, cider, as well as for fresh consumption for patients with diabetes and low acidity of gastric juice. It should be noted that according to Korobka et al. (2018) when apples are dried, the content of dry substances and sugars in the product increases, and the content of organic acids decreases. Therefore, the low sugar-acid ratio of these two old varieties makes them ideal for drying.

Sugar-acid ratio is used by some authors for the classification of apple cultivars (Milošević et al. 2019). Specifically, apple cultivars with TS/TA ratios below 20 are acidic and suitable for processing and cider production, while cultivars with TS/TA ratios above this value are sweet and suitable for direct consumption. Therefore, it confirms that Batul with TS/TA 6.35 and Krasa Zakarpattia with TS/TA 10.37 are the best for processing and cider production.

Varieties with a low content of malic acid and high sugar-acid ratio, such as Solivarske, Durnaika, Reglindia are suitable for fresh consumption in the diet of patients with high acidity of gastric juice. In addition, because of its green skin and white flesh in the Durnaika variety, the fruits of this variety are hypoallergenic and can be used for baby nutrition and for the diet of people with allergic reactions.

The content of sugars and organic acids, which depend on the plant genotype (Akagić et al. 2019) is also influenced by environmental factors and by horticultural practice undertaken in an orchard. For example, Milošević et al. (2019) reported effect of fertilization on the accumulation of sugars and titratable acids in apple fruit.

Our results are in agreement with Akagić et al. (2019), which reported higher level of total organic acid in local apples than in commercial cultivars. Probably this is due to the fact that modern cultivars are selected for less acid taste.

Similar to other authors who studied old varieties in their localities we found that the old varieties of apples in Transcarpathia are well adapted to soil and climatic conditions in which they produce high-quality fruits with good organoleptic properties and high concentrations of nutrients, so they can be a source of genes for selection.

Conclusions

As a result of screening of the assortment of apple varieties in Transcarpathia, old local native varieties were selected: Shtetin red, Batul, Durnaika, Polovanya, Solivarske, Krasa Zakarpattia and Ferkovania. A collection of seedlings of these varieties has been created, and they have good compatibility with the M.9 rootstock.

The main biochemical parameters of the fruit, such as the content of soluble solids, sugars, titratable acids, sugar-acid ratio was determined and compared with ten market available varieties for organic gardening. Also the weight, size and shape of the fruits were established.

The highest average fruit weight has the Durnaika variety (604.5 g). This is the peculiarity of this variety. According to the method of pomological description of varieties by size, this fruit is very large, by weight – exceptionally large.

Based on biochemical and morphometric parameters, the apples of all six old Transcarpathian varieties are suitable for fresh consumption as dessert apples, as well as for processing into juices, purees, dried fruits, chips, and pastila. Some of them, Batul, Krasa Zakarpattia, are suitable for processing into cider due to the high content of organic acids.

The good fruit quality characteristics of these varieties represent an important reference in selection of materials for breeding programs aimed at improving the characteristics of the domestic apple germplasm.

Moreover, farmers focusing on local and niche markets may be interested in these local varieties to promote their valorization.

AKAGIĆ, A., VRANAC, A., GAŠI, F., DRKENDA, P., SPAHO, N., ORUČEVIĆ ŽULJEVIĆ, S., HUDINA, M. (2019) Sugars, acids and polyphenols profile of commercial and traditional apple cultivars for processing. *Acta Agriculturae Slovenica*, 113(2), 239–250. DOI: https://doi.org/10.14720/aas.2019.113.2.5

BARTOLINI, S., DUCCI, E. (2017) Quality evaluation of local apple varieties: Physicochemical and antioxidant properties at harvest and after cold storage. *Agronomy Research*, 15(5), 1866–1877. DOI: https://doi.org/10.15159/AR.17.054

BARTOLINI, S., VITI, R., DUCCI, E. (2015) Local fruit varieties for sustainable cultivations: Pomological, nutraceutical and sensory characterization. *Agrochimica*, 59(4), 281–294. DOI: https://doi.org/10.12871/0021857201541

BASSI, M., LUBES, G., BIANCHI, F., AGNOLET, S., CIESA, F., BRUNNER, K., OBERHUBER, M. (2018) Ascorbic acid content in apple pulp, peel, and monovarietal cloudy juices of 64 different cultivars. *International Journal of Food Properties*, 20, 2626–2634. DOI: https://doi.org/10.1080/10942912.2017.1381705

BELVISO, S., SCURSATONE, B., RE, G., ZEPPA, G. (2013) Novel data on the polyphenol composition of Italian ancient apple cultivars. *International Journal of Food Properties*, 16(7), 1507–1515. DOI: https://doi.org/10.1080/10942912.2011.599089

BOLAT, İ., YILMAZ, M., İKINCI, A. (2019) Determination of the performance of some apple cultivars matured in different periods in the Mediterranean transitional zone. *Yuzuncu Yil University Journal of Agricultural Sciences*, 29(2), 258–267. DOI: https://doi.org/10.29133/yyutbd.471552

CONTESSA, C., BOTTA, R. (2016) Comparison of physicochemical traits of red-fleshed, commercial and ancient apple cultivars. *Horticultural Science*, 43(4), 159–166. DOI: https://doi.org/10.17221/132/2015-HORTSCI

DEVIRGILIIS, C., GUBERTI, E., MISTURA, L., RAFFO, A. (2024) Effect of Fruit and Vegetable Consumption on Human Health: An Update of the Literature. *Foods*, 13(19), 3149. DOI: https://doi.org/10.3390/foods13193149

DOĞAN, D. E., RASHID, H. H. R., LIZALO, A., SOYSAL, D., DEMIRSOY, H. (2024) Growth, fruit bearing behaviour, yield and quality of some apple cultivars. *Scientia Horticulturae*, 327, 112762. DOI: https://doi.org/10.1016/j.scienta.2023.112762

DOKOUPIL, L. (2016) Occurrence and records of old varieties of pome fruit in the Tišnov region. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 64(1), 53–61. DOI: https://doi.org/10.11118/actaun201664010053

FARINA, V., GIANGUZZI, G., MAZZAGLIA, A. (2016) Fruit quality traits of six ancient apple (Malus domestica Borkh.) cultivars grown in the Mediterranean area. International *Journal of Fruit Science*, 16(3), 275–283. DOI: https://doi.org/10.1080/15538362.2015.1102675

FELICE, F., MARAGÒ, E., SEBASTIANI, L., DI STEFANO, R. (2015) Apple juices from ancient Italian cultivars: A study on mature endothelial cells model. *Fruits*, 70(6), 361–369. DOI: https://doi.org/10.1051/fruits/2015033

HEVESI, M., GÖNDÖR, M., KÁSA, K., HONTY, K., TÓTH, M.G. (2004) Traditional and commercial apple and pear cultivars as sources of resistance to fireblight. *EPPO Bulletin*, 34(3), 377–380. DOI: https://doi.org/10.1111/j.1365-2338.2004.00761.x

IACCARINO, N., VARMING, C., PETERSEN, M.A., VIERECK, N., SCHÜTZ, B., TOLDAM-ANDERSEN, T.B., ENGELSEN, S.B. (2019) Ancient Danish apple cultivars – A comprehensive metabolite and sensory profiling of apple juices. *Metabolites*, 9(1). DOI: https://doi.org/10.3390/metabo9070139

IACOPINI, P., CAMANGI, F., STEFANI, A., SEBASTIANI, L. (2010) Antiradical potential of ancient Italian apple varieties of Malus × domestica Borkh. in a peroxynitrite-induced oxidative process. *Journal of Food Composition and Analysis*, 23(6), 518–524. DOI: https://doi.org/10.1016/j.jfca.2009.05.004

KÁSA, K., HEVESI, M., TÓTH, M. (2004) Evaluation of traditional Hungarian apple cultivars as sources of resistance to fire blight. *Acta Horticulturae*, 663, 225–228. DOI: https://doi.org/10.17660/ActaHortic.2004.663.35

KOROBKA, S., BABYCH, M., KRYGUL, R., ZDOBYTSKYJ, A. (2018) Results of research into technological process of fruit drying in the solar dryer. *Eastern-European Journal of Enterprise Technologies*, 1(8-91), 64–73. DOI: https://doi.org/10.15587/1729-4061.2018.122816

LO PICCOLO, E., LANDI, M., MASSAI, R., REMORINI, D., CONTE, G., GUIDI, L. (2019) Ancient apple cultivars from Garfagnana (Tuscany, Italy): A potential source for 'nutrafruit' production. *Food Chemistry*, 294, 518–525. DOI: https://doi.org/10.1016/j.foodchem.2019.05.027

LO PICCOLO, E., VIVIANI, A., GUIDI, L., REMORINI, D., MASSAI, R., BERNARDI, R., LANDI, M. (2019) Discerning between two Tuscany (Italy) ancient apple cultivars, 'Rotella' and 'Casciana', through polyphenolic fingerprint and molecular markers. *Molecules*, 24(9). DOI: https://doi.org/10.3390/molecules24091758

MA, B., DING, Y., LI, C., LI, M., MA, F., YUAN, Y. (2019) Comparative proteomic analysis reveals key proteins linked to the accumulation of soluble sugars and organic acids in the mature fruits of the wild Malus species. *Plants*, 8(11). DOI: https://doi.org/10.3390/plants8110488

MARCONI, G., FERRADINI, N., RUSSI, L., CONCEZZI, L., VERONESI, F., ALBERTINI, E. (2018) Genetic characterization of the apple germplasm collection in central Italy: The value of local varieties. *Frontiers in Plant Science*, 9. DOI: https://doi.org/10.3389/fpls.2018.01460

MILOŠEVIĆ, T., MILOŠEVIĆ, N., MLADENOVIĆ, J. (2019) Tree vigor, yield, fruit quality, and antioxidant capacity of apple (Malus × domestica Borkh.) influenced by different fertilization regimes: Preliminary results. *Turkish Journal of Agriculture and Forestry*, 43(1), 48–57. DOI: https://doi.org/10.3906/tar-1803-109

MRATINIĆ, E., AKŠIĆ, M.F. (2012) Phenotypic diversity of apple (Malus sp.) germplasm in south Serbia. *Brazilian Archives of Biology and Technology*, 55(3), 349–358. DOI: https://doi.org/10.1590/S1516-89132012000300004

NKUIMI WANDJOU, J.G., SUT, S., GIULIANI, C., FICO, G., PAPA, F., FERRARO, S., DALL'ACQUA, S. (2019) Characterization of nutrients, polyphenols and volatile components of the ancient apple cultivar 'Mela rosa dei monti sibillini' from Marche region, central Italy. *International Journal of Food Sciences and Nutrition*, 70(7), 796–812. DOI: https://doi.org/10.1080/09637486.2019.1580684

OSZMIAŃSKI, J., LACHOWICZ, S., GAMSJÄGER, H. (2019) Phytochemical analysis by liquid chromatography of ten old apple varieties grown in Austria and their antioxidative activity. *European Food Research and Technology*, 246(3), 437–448. DOI: https://doi.org/10.1007/s00217-019-03411-z

PAPP, D., KIRÁLY, I., TÓTH, M. (2016) Suitability of old apple varieties in organic farming, based on their resistance against apple scab and powdery mildew. *Organic Agriculture*, 6(3), 183–189. DOI: https://doi.org/10.1007/s13165-015-0126-2

POSOLDA, M., MLČEK, J., URBANOVÁ, M., ŘEZNÍČEK, V. (2019) Mapping of traditional and regional varieties of apple trees and pear trees in Kroměříž area. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 67(2), 425–434. DOI: https://doi.org/10.11118/actaun201967020425

STANIVUKOVIĆ, S., ŽUJIĆ, M., ŽABIĆ, M., MIĆIĆ, N., BOSANČIĆ, B., DURIĆ, G. (2017) Characterization of old apple cultivars from Bosnia and Herzegovina by means of pomological and biochemical analysis. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 45(1), 97–104. DOI: https://doi.org/10.15835/nbha45110537

SUT, S., ZENGIN, G., MAGGI, F., MALAGOLI, M., DALL'ACQUA, S. (2019) Triterpene acid and phenolics from ancient apples of Friuli Venezia Giulia as nutraceutical ingredients: LC-MS study and in vitro activities. *Molecules*, 24(6). DOI: https://doi.org/10.3390/molecules24061109

WEI, K., MA, C., SUN, K., LIU, Q., ZHAO, N., SUN, Y., PAN, L. (2020) Relationship between optical properties and soluble sugar contents of apple flesh during storage. *Postharvest Biology and Technology*, 159. DOI: https://doi.org/10.1016/j.postharvbio.2019.111021

WILLS, R. B. H., SCRIVEN, F. M., GREENFIELD, H. (1983) Nutrient composition of stone fruit (Prunus spp.) cultivars: Apricot, cherry, nectarine, peach and plum. *Journal of the Science of Food and Agriculture*, 34(12), 1383–1389. DOI: https://doi.org/10.1002/jsfa.2740341211

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