JOURNAL of Horticulture, Forestry and Biotechnology
Volume 28(2), 2024, 64-71
https://jhfb.ro/index.php/jhfb
Print ISSN: 2066-1797
Online ISSN: 3045-1876

Fruit characteristics of some scab-resistant and non-scab-resistant apple varieties

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Manuscript received: 9 October 2024; revised: 9 November 2024; accepted: 10 November 2024

Abstract
Scab-resistant apple varieties are essential for organic farming, which has seen significant growth in Europe recently. Although breeding for scab resistance has produced several commercially competitive varieties, a truly exceptional candidate in terms of quality attributes is still lacking. Therefore, this research aimed to assess the fruit quality traits of ten apple varieties, including both scab-resistant and non-scab-resistant types, cultivated in different locations with similar climatic conditions. The traits evaluated encompassed both physical and chemical characteristics, such as fruit size, weight, shape, firmness, pH, water content, titratable acidity (TA), total soluble solid content (TSS), and Vitamin C levels. The results indicated that 'Jonagold' and 'Pinova' cultivars excelled in terms of physical properties, while 'Pinova' and 'Champion' cultivars' chemical characteristics registered higher values as compared to other cultivars under study.

Keywords: *Malus domestica* Borkh., fruit quality, TA, TSS, firmness, Vitamin C

Introduction

The cultivation of organic fruits and the use of non-chemical management techniques are increasingly vital for sustainable fruit production. Regulatory bodies are progressively banning or limiting chemical usage to ensure safer food products for consumers, free from harmful pesticides and with reduced environmental impact. However, this shift may compromise certain quality characteristics of the fruit, both physical and chemical [38]. The transition from chemicals-based pest and disease management to organic farming represents a great challenge for farmers to deal with [35]. A crucial sensory attribute of fruits is the general aspect of the fruit which has a great influence on their attractiveness and market value. The most important quality parameters of horticultural products are size, color, shape, texture/firmness, and taste. However, all these quality traits can be compromised by apple scab (*Venturia inaequalis*) which can diminish considerably the market value of apple fruits.

Apples are highly popular and widely consumed, valued for their delightful taste, juiciness, vibrant color, appealing texture, and nutritional benefits. They have excellent storage capabilities, are available year-round in the market, and are regarded as healthy food choices due to their long shelf-life capacities [23]. In addition to their fresh consumption, apples can be used as raw material for various processing technol-ogies [18, 31]. Among these apple products juices [34], dried fruits [16], preserves [19, 10], or puree are the most common [17]. Additionally, fermentation processes can produce various apple products, includ-ing probiotic-fermented apple juices [27, 29, 9] and cider [37, 20, 11], as well as fermented items made from apple pomace, which are considered industrial by-products [6, 21, 15, 42]. The high nutritional value of fruits, the sugars-acidity ratio, and the sensory characteristics are health-promoting resources that can-not be found in any agricultural crops [28]. Apples are seasonal fruits, however, under proper storage conditions, their shelf life can be extended through months and consumed all year round [3, 5].

In the last years, climate change with its consequences and various social, economic, and political issues and limitations brought significant pressure on farmers. Organic farming expectancies, lack of labor, and financial difficulties generate a desperate need for new crop varieties to ensure food safety and security. Even though several new apple varieties have been obtained worldwide, the conservation of genetic re-sources and launching new cultivars witnessed a discontinuity in the recent years [35]. New apple culti-vars

need to be bred with high resistance to important diseases such as apple scab or mildew to avoid food insecurity and to provide a satisfactory balance between food demand and food supply at reasonable prices.

Previous reports suggest that orchards where both susceptible and resistant cultivars are grown are less affected by apple scab [13, 7, 26]. Although the use of different cultivars in an orchard has been shown to reduce apple scab occurrence. The use of highly effective products is not always the key to cure the trees. The time of application of fungicides, weather conditions, prediction models, and orchard hygiene are critical for effective scab management [4, 30].

Therefore, the primary objective of this study was to evaluate and compare the fruit quality traits of six scab-resistant and four scab-susceptible apple varieties to highlight their potential for marketability and breeding.

Material and Method

Plant material

To carry out this experiment apple fruits were harvested from high-density apple orchards located in Cluj-Napoca (46°46′0″N 23°35′0″E) from Romania and Orhei (47°23′N 28°49′E) from the Republic of Moldova. The 12-years-old apple trees were grafted on M9 rootstocks. Ten trees of six scab-resistant (R) cultivars (‘Topaz’, ‘Pinova’, ‘Rozela’, ‘Generos’, ‘Florina’, ‘Champion’) and four scab-susceptible (S) cultivars (‘Jonagold’, ‘Reneitte Simirenko’, ‘Golden Delicious’ and ‘Idared’) were selected to be analyzed in this experiment (Fig. 1). Thirty fruits were harvested from each tree at optimum stage of maturity, when a significant proportion of fruits had its surface colored in red or blushed colour (Fig. 1) and subjected further to quality analyses.

Determination of pomological properties

Thirty apple fruits from each cultivar were randomly chosen and subjected to analyses.

Physical characteristics

To measure the weight of the apple fruits a WLC 6/A2 high precision balance (Partner, CE) was used. The size of the fruits was then measured with a digital caliper including the length (L), width (W) and thickness (T) of the fruits. The fruit shape index was then calculated as a ratio between fruit length and fruit width. The fruit firmness was measured using a digital Force Gauge PCE-PTR 200N with a penetration tip of 8 mm diameter and expressed in kgf/cm2.

Chemical characteristics

The total amount of soluble solids (TSS) was determined using a Kern Optics ORA 4FA refractometer at room temperature. Total sugars were quantified according to Luff Schoorl method by extracting the sugars in ethanol [12]. Titratable acidity was determined by titration with a NaOH (0.1 N) solution [8]. The results were expressed in % of malic acid. The TSS:TA ratio was also calculated indicating the maturity index of the fruits. The pH of the samples was determined using a portable WTW 3310 pH meter. To determine the water content of the apples, the cores were removed and the fruits were sliced and placed in a Memmert Um UF260 m oven until constant weight at 60°C and then the water content was calculated according to the following formula:

$$Water\ content\ (\%) = \frac{fresh\ weight - dry\ weight}{fresh\ weight}\ x\ 100$$

The Vitamin C (acid ascorbic) content was determined by iodine titration [33].

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https://jhfb.ro/index.php/jhfb
Print ISSN: 2066-1797
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Figure 1. Fruit appearance of the apple cultivars used in this study

Statistical analysis

SPSS 20.0 and Past 4.03 Softwares were used to perform statistical analyses. The analysis of variance (ANOVA) was assessed first to evaluate the level of significance ($P < 0.05$) regarding the quality parameters between the apple cultivars. Afterward, Tukey's HSD test was conducted to compare the means of the resulting data. Pearson's correlation has been assessed to measure the degree of relationship between the quality traits analyzed in this study.

Results and Discussion

The physical characteristics of the apple fruits analyzed are presented in Table 1. The results show that fruit length ranged between 5.19 and 7.66 cm among the cultivars analyzed. Fruit width varied from 6.54 and 8.71 cm, while fruit thickness ranged between 6.45 and 7.96 cm. Therefore, in terms of fruit size, based on the three measured dimensions of the apple fruits, 'Generos' cultivar had the biggest fruit size, followed by 'Rozela' and 'Jonagold'. After fruit dimensions, fruit weight is another important quality trait that defines the size of a fruit. The data show that fruit dimensions were positively correlated with fruit weight. The highest values in terms of fruit weight have been registered for 'Generos', 'Jonagold', and 'Champion' cultivars. The lowest fruit weight was recorded in 'Reneitte Simirenko' cultivar (121.89±1.98 g). In some cultivars, fruit firmness can be positively correlated with fruit size (ex. 'Royal Gala') which denotes that larger fruits were slightly firmer at harvest [18].

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Table 1. The main physical characteristics of the apple cultivars under study at harvest

	Cultivars	Fruit length (cm)	Fruit width (cm)	Fruit thickness (cm)	Fruit shape index	Fruit weight (g)	Firmness (kgf/cm^2)
1	**Topaz** ^{R}	6.24±0.09 ^{bcde}	7.74±0.08 ^{bc}	7.96±0.09 ^{d}	1.25±0.01 ^{de}	169.14±13.26 ^{abc}	6.98±0.03 ^{b}
2	**Jonagold** ^{S}	6.81±0.14 ^{ef}	7.71±0.09 ^{bc}	7.50±0.13 ^{cd}	1.11±0.02 ^{ab}	202.10±16.32 ^{c}	6.64±0.17 ^{b}
3	**Pinova** ^{R}	6.87±0.23 ^{ef}	7.62±0.16 ^{bc}	7.40±0.21 ^{bcd}	1.09±0.01 ^{a}	188.83±22.67 ^{bc}	7.44±0.63 ^{b}
4	**Rozela** ^{R}	6.78±0.18 ^{ce}	8.17±0.28 ^{cd}	7.97±0.26 ^{d}	1.19±0.03 ^{cd}	181.56±10.41 ^{abc}	5.74±0.22 ^{b}
5	**Generos** ^{R}	7.66±0.08 ^{f}	8.71±0.09 ^{d}	7.85±0.54 ^{d}	1.18±0.02 ^{c}	292.660±5.00 ^{d}	4.75±0.33 ^{a}
6	**Reneitte Simirenko** ^{S}	5.19±0.12^{a}	6.54±0.11 ^{a}	6.45±0.10 ^{a}	1.26±0.02 ^{e}	121.89±1.98 ^{a}	3.87±0.27 ^{a}
7	**Florina** ^{R}	5.86±0.11 ^{ab}	6.77±0.12 ^{a}	6.79±0.10 ^{ab}	1.16±0.01 ^{bc}	135.43±10.61 ^{ab}	6.12±0.25 ^{b}
8	**Golden Delicious** ^{S}	6.46±0.19 ^{bcde}	6.98±0.13 ^{ab}	6.92±0.12 ^{bc}	1.21±0.01 ^{cde}	141.88±3.80 ^{abc}	4.67±0.15 ^{a}
9	**Champion** ^{R}	5.98±0.26 ^{bc}	7.29±0.28 ^{ab}	7.22±0.30 ^{bc}	1.22± 0.02 ^{cde}	197.19±6.03 ^{c}	3.92±0.15 ^{a}
10	**Idared** ^{S}	5.99±0.16 ^{bcd}	7.06±0.29 ^{ab}	6.97±0.29 ^{bc}	1.18±0.01 ^{c}	125.91±4.88 ^{a}	4.45±0.50 ^{a}

*Note: ^{R}-scab resistant; ^{S}-susceptible to scab. The data presented are means±S.E. Lowercase letter in common indicate no significant differences between the apple cultivars within the same fruit quality parameter according to Tukey's HSD test at p<0.05, n=30.

Fruit firmness is an important maturity index in association with other fruit quality parameters. Delayed harvest can lead to softer fruits with low storability capacity and increased storage disease susceptibility. Thus, apple fruits are recommended to be harvested with a firm texture to extend their shelf life, but it has to be mentioned that fruit firmness depends on the cultivar as well [1, 23]. Fruit firmness of the chosen apple cultivars at harvest varied from 3.87 kgf/cm2 in 'Reneitte Simirenko' to 7.44 kgf/cm2 in 'Pinova'. These results are in accordance with those reported by Oltenacu and Lascăr (2015) who claim that storage decreases firmness in most of the apple cultivars in different percentages [25]. Fruit shape is an important external quality trait of the fruit which influences the usage of fruits and also consumers' preferences. In this regard, the shape index of the apple fruits varied slightly among the cultivars indicating a profile shape of flat to roundish. The data show that 'Reneitte Simirenko', 'Topaz' and 'Champion' cultivars had the flattest shape of the apples. On the opposite, 'Pinova', 'Jonagold', 'Florina' and 'Golden Delicious' cultivars had a more pleasant aspect and a round shape of the apples. A previous study demonstrates that the round shape of hedonic foods increases the desirability, choice probability and consumption [43]. These results could be considered in future breeding programs to improve fruit quality through desirability and positive effect which influence the judgment of the consumers.

The results of the chemical analyses revealed that 'Pinova' cultivar had the highest Vitamin C content (5.84±0.12 mg/100 g), 2-fold higher than most of the other cultivars under study (Table 2). Similar Vitamin C (5.5 mg/100 g) and TSS contents (16.5 g/100 g) were reported by Solomakhin and Blanke (2010) when investigating the influence of coloured hailnet on sensorial and nutritional attributes of 'Pinova' and 'Fuji Kiku 8' apple trees [36]. After 'Pinova', the Vitamin C content of 'Topaz' and 'Jonagold' cultivars ranged between 3.14±0.12 and 3.80±0.08 mg/100 g). The lowest ascorbic acid content was found in the fruits of 'Florina' apples (2.24±0.11 mg/100 g).

The total soluble solid content in the investigated apple cultivars was ranging between 12.66±1.61% and 16.93±0.92%. The highest TSS content was found in 'Champion' (16.93±0.67%), followed by 'Idared' (16.66±0.60%), 'Reneitte Simirenko' (16.66±0.92%) and 'Rozela' (16.62±0.51%) with similar contents (Table 2).

The lowest content of TSS was detected in 'Florina' cultivar (12.66±1.61%). These variations in TSS content between the cultivars could be attributed to several factors that influence the sugar accumulation in fruits. Many research have shown already that TSS levels increase in fruits as they ripen and pH decreases simultaneously [14, 41]. Other factors, such as temperature has a crucial role in these changes: as temperature increases the TSS content in fruits decreases [22]. According to previous research, the skin colour of the fruits is positively correlated with TSS content and it can be reduced by high rates of nitrogen and potassium which increases the organic acid content in fruits and reduces the TSS/TA ratio [40, 41].

The TSS/Acid ratio is a key characteristic in determining the taste and the feel of the fruits which relies in their characteristic falvor. It is also an important indicator of commercial ripeness [39]. At the beginning of the fruit ripening process the TSS/TA ratio in low due to the low sugar content and high acid content of the unripen fruits. During ripening acids become degraded in fruits which determines the increase of the sugar

JOURNAL of Horticulture, Forestry and Biotechnology
Volume 28(2), 2024, 64-71
https://jhfb.ro/index.php/jhfb
Print ISSN: 2066-1797
Online ISSN: 3045-1876

content and the TSS/TA ratio[2]. The TSS/TA ratio varieed from 0.60 to 1.32 among the apple cultivars analysed. The highest values were recorded in three scab-resistant cultivars such as 'Generos' (1.32), 'Rozela' (1.25) and 'Pinova' (1.04).

Table 2. The main chemical properties of apple cultivars under study at harvest

	Cultivars	Total Soluble solids - TSS (%)	Total sugars (g/l)	Titratable acidity (%)	TSS/TA	Vitamina C (mg/100g)	pH	Water content (%)
1	**Topaz** [R]	15.20±0.70 [bc]	136.42±7.45 [cd]	25.13±0.35 [c]	0.60 [a]	3.80±0.08 [b]	3.42 [a]	85.92±0.17 [c]
2	**Jonagold** [S]	14.10±0.87 [b]	124.71±9.24 [bc]	21.79±0.26 [c]	0.65 [a]	3.14±0.12 [ab]	3.52 [ab]	83.32±0.71 [bc]
3	**Pinova** [R]	14.42±0.29 [b]	128.15±3.08 [ac]	13.82±0.52 [a]	1.04 [c]	5.84±0.12 [c]	3.87 [c]	84.53±0.15 [c]
4	**Rozela** [R]	16.62±0.51 [c]	109.00±5.42 [ab]	13.33±0.66 [a]	1.25 [d]	2.86±0.06 [ab]	3.43 [a]	85.51±0.60 [c]
5	**Generos** [R]	15.5±0.74b [c]	105.25±0.74 [d]	11.76±0.33 [a]	1.32 [d]	2.58±0.03 [ab]	3.72 [bc]	80.85± 0.23 [ab]
6	**Reneitte Simirenko** [S]	16.66±0.92 [c]	151.23±0.92 [d]	24.79±0.11 [c]	0.67 [a]	2.26±0.09 [a]	3.34 [a]	80.83±0.55 [ab]
7	**Florina** [R]	12.66±1.61 [a]	108.82±1.61 [a]	20.25±0.23 [bc]	0.63 [a]	2.24±0.11 [a]	3.89 [c]	79.40±0.83 [a]
8	**Golden Delicious** [S]	14.66±0.60 [b]	130.00±0.60 [c]	15.66±0.53 [ab]	0.94 [b]	2.48±0.11 [ab]	3.90 [c]	81.74±0.66 [ab]
9	**Champion** [R]	16.93±0.67 [c]	154.43±0.67 [d]	20.20±0.33 [bc]	0.84 [b]	2.54±0.07 [ab]	3.90 [c]	80.36±0.51 [a]
10	**Idared** [S]	16.66±0.60 [c]	151.23±0.60 [d]	19.66±0.11 [bc]	0.85 [b]	2.57±0.09 [ab]	3.90 [c]	79.97±0.81 [a]

*Note: [R]-scab resistant; [S]-susceptible to scab. The data presented are means±S.E. Lowercase letter in common indicate no significant differences between the apple cultivars within the same fruit quality parameter according to Tukey's HSD test at $p<0.05$, n=30.

Beside flavour and crispyness, the water content or the juiciness of the apple fruits has a great influence on consumer's judgement. It is well known that vegetables have a water content of 90-96%, while fruits have a slightly lower content which ranges between 80-90% [32].

Apple fruits contain approx. 80-84% of water [24]. The results show that all the apple cultivars had a water content around 80%, however the highest water contents were recorded in 'Topaz' (85.92±0.17) and 'Rozela' (85.51±0.60%) cultivars, followed by 'Pinova' (84.53±0.15%) and 'Jonagold' (83.32±0.71%) with similar content. The least juicy cultivars were 'Idared' and 'Florina' with a water content slight below 80% (79.97±0.81%; 79.40±0.83%).

Fruit quality is given by a series of fruit attributes perceived and evaluated by the consumer. The first and decisive attributes are the general aspect (the attractiveness) and flavour. Therefore, in order to evaluate the fruit quality traits of the 10 apple cultivars under study, Pearson's correlation has been assessed to examine the relationship between external and internal fruit characteristics (Fig. 2).

The results of the Pearson's correlation indicate a positive linear correlation between fruit firmness and fruit weight ($r=0.75$, $P<0.05$); fruit dimensions and TSS content: $r=0.59$ (fruit length/TSS); $r=0.79$ (fruit width/TSS) and $r=0.84$ (fruit thickness/TSS) $P<0.05$. It has been shown, that TSS content and water content (WC) of the fruits are positively correletaed with fruit weight as well: $r=0.96$ (TSS/fruit weight); $r=0.66$ (WC/fruit weight) at $P<0.05$. Furthermore, it can be observed that fruit firmness, TSS content and water content are all positively correlated to titratable acidity content (Fig. 2).

The pH of the fruits seemed to be influenced by fruit size, fruit weight and fruit firmness. The Vitamin C (ascorbic acid) content was strongly correlated with pH ($r=0.91$), fruit weight ($r=0.63$), TA ($r=0.56$) and TSS content ($r=0.54$) at $P<0.05$. Total sugars, followed the same pattern of correlation to all the fruit traits as TSS content.

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Volume 28(2), 2024, 64-71
https://jhfb.ro/index.php/jhfb
Print ISSN: 2066-1797
Online ISSN: 3045-1876

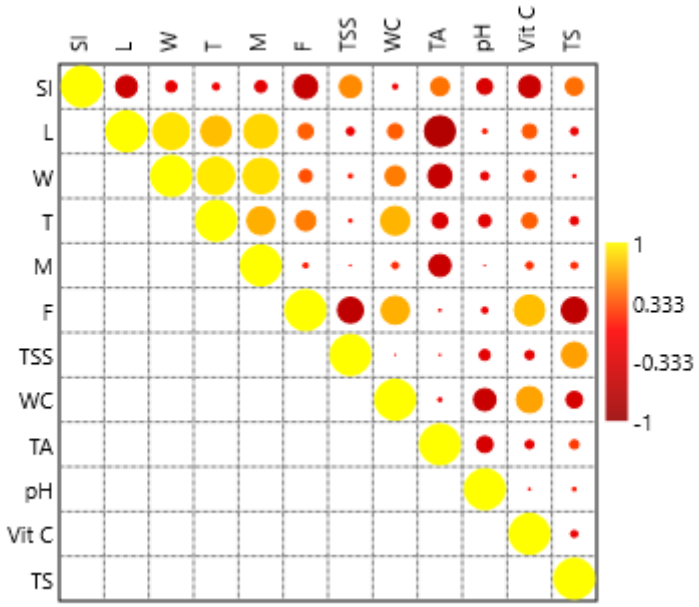

Figure 2. Pearson's correlations between the internal and external characteristics of apple fruits. SI-shape index; L-fruit length; W-fruit width; T-fruit thickness; M-fruit weight; F-fruit firmness; TSS-total soluble solids; WC-water content; TA-titratable acidity; pH-pH; Vit C-ascorbic acid content; TS-total sugars.

Conclusions

The findings of our research serve as a real proof that scab-resistant apple varieties have a great potential and possess valuable fruit qualities even if some non-scab resistant cultivars overtake them in terms of fruit firmness, TSS and Vitamin C content. The existence and broadening knowledge about scab-resistant cultivars may offer valuable information and resources for future breeding programs to improve the performance of future varieties.

References

[1] Abdualrahman, M.A. (2015), *Comparative study of local and imported apple fruits (Malus domestica) and their uses in juice production*. Science International (Dubai), 3 (2), 69-72.
[2] Ackermann, J., Fischer, M., Amado, R. (1992), *Changes in sugars, acids, and amino acids during ripening and storage of apples (cv. Glockenapfel)*. Journal of agricultural and food chemistry, 40(7), 1131-1134.
[3] Bars-Cortina, D., Macià, A., Iglesias, I., Garanto, X., Badiella, L., Motilva, M.J. (2018), *Seasonal Variability of the Phytochemical Composition of New Red-Fleshed Apple Varieties Compared with Traditional and New White-Fleshed Varieties*. J. Agric. Food Chem. 66, 10011–10025.
[4] Berrie, A. (2019), Chapter 9. *Disease monitoring and decision making in integrated fruit disease management*. In: Integrated management of diseases and insect pests of tree fruit. Burleigh Dodds; p. 201–32.
[5] Bílková, A., Baďurová, K., Svobodová, P., Vávra, R., Jakubec, P., Chocholouš, P., Švec, F., Sklenářová, H. (2020), *Content of major phenolic compounds in apples: Benefits of ultra-low oxy-gen conditions in long-term storage*. J. Food Compos. Anal. 92, 103587.
[6] Bortolini, D.G., Benvenutti, L., Demiate, I.M., Nogueira, A., Alberti, A., Zielinski, A.A.F. (2020), *A new approach to the use of apple pomace in cider making for the recovery of phenolic compounds*. LWT 126, 109316.
[7] Bousset, L, Blaise, P., Kellerhalls, M., Gessler, C. (1997), *Mixtures of apple cultivars in orchards: effect on the scab epidemics*. IOBC WPRS Bull; 42–48.
[8] Cairns, A. M., Watson, M., Creanor, S. L., Foye, R. H. (2002), *The pH and titratable acidity of a range of diluting drinks and their potential effect on dental erosion*. Journal of Dentistry, 30(7-8), 313-317.
[9] Chen, C., Lu, Y., Yu, H., Chen, Z., Tian, H. (2019), *Influence of 4 lactic acid bacteria on the flavor profile of fermented apple juice*. Food Biosci. 27, 30–36.
[10] Cruz, A.C., Guiné, R.P., Gonçalves, J.C. (2015), *Drying Kinetics and Product Quality for Convective Drying of Apples (cvs. Golden Delicious and Granny Smith)*. Int. J. Fruit Sci. 15, 54–78.

[11] Cusano, E., Cagliani, L.R., Consonni, R., Simonato, B., Zapparoli, G. (2020), *NMR-based metabolic profiling of different yeast fermented apple juices*. LWT, 118, 108771.
[12] De Bruyn, J. W., Van Keulen, H. A., Ferguson, J. H. A. (1968), *Rapid method for the simultaneous determination of glucose and fructose using anthrone reagent*. Journal of the Science of Food and Agriculture, 19(10), 597-601.
[13] Didelot, F., Brun, L., Parisi L. (2007), *Effects of cultivar mixtures on scab control in apple orchards*. Plant Pathol. 56(6):1014–22.
[14] GutiéRrez, M., Lahoz, J. M., Sola, M., Pascual, L., Vargas, A. M. (1994), *Postharvest changes in total soluble solids and tissue pH of cherimoya fruit stored at chilling and non-chilling temperatures*. Journal of Horticultural Science, 69(3), 459-463.
[15] Jin, Q., Qureshi, N., Wang, H., Huang, H. (2019), *Acetone-butanol-ethanol (ABE) fermentation of soluble and hydrolyzed sugars in apple pomace by Clostridium beijerinckii P.* Fuel, 244, 536–544.
[16] Kidoń, M., Grabowska, J. (2021), *Bioactive compounds, antioxidant activity, and sensory qualities of red-fleshed apples dried by different methods*. LWT 136, 110302.
[17] Lan, W., Bureau, S., Chen, S., Leca, A., Renard, C.M., Jaillais, B. (2021), *Visible, near- and mid-infrared spectroscopy coupled with an innovative chemometric strategy to control apple puree quality*. Food Control. 120, 107546.
[18] Lee, J., Mattheis, J. P., Rudell, D. R. (2013), *Fruit size affects physiological attributes and storage disorders in cold-stored 'Royal Gala'apples*. HortScience, 48(12), 1518-1524.
[19] Li, Y., Zhang, X., Nie, J., Bacha, S.A.S., Yan, Z., Gao, G. (2020), *Occurrence and co-occurrence of mycotoxins in apple and apple products from China*. Food Control. 118, 107354.
[20] Lobo, A.P., Bedriñana, R.P., Madrera, R.R.; Valles, B.S. (2021), *Aromatic, olfactometric and con-sumer description of sweet ciders obtained by cryo-extraction*. Food Chem. 338, 127829.
[21] Madrera, R.R., Bedriñana, R.P., Valles, B.S. (2017), *Enhancement of the nutritional properties of apple pomace by fermentation with autochthonous yeasts*. LWT-Food Sci. Technol., 79, 27–33.
[22] Menzel, C. M. (2022), *Effect of temperature on soluble solids content in strawberry in Queensland, Australia*. Horticulturae, 8(5), 367.
[23] Mohebbi, S., Babalar, M., Zamani, Z., Askari, M.A. (2020), *Influence of early season boron spraying and postharvest calcium dip treatment on cell-wall degrading enzymes and fruit firmness in 'Starking Delicious' apple during storage*. Sci. Hortic., 259, 108822.
[24] Musacchi, S., Serra, S. (2018), *Apple fruit quality: Overview on pre-harvest factors*. Scientia Horti-culturae, 234, 409-430.
[25] Oltenacu, N., Lascăr, E. (2015), *Capacity of maintaining the apples quality, in fresh condition-case study*.
[26] Parisi, L., Lespinasse, Y., Guillaumes, J., Kruger, J. (1993), *A new race of Venturia inaequalis viru-lent to apples with resistance due to the Vf gene*. Phytopathology. 1993;83(5):533–7.
[27] Peng, W., Meng, D., Yue, T., Wang, Z., Gao, Z. (2020), *Effect of the apple cultivar on cloudy apple juice fermented by a mixture of Lactobacillus acidophilus, Lactobacillus plantarum, and Lactoba-cillus fermentum*. Food Chem, 340, 127922.
[28] Preda, L. F., Butcaru, A. C., Mihai, C. A., Stănică, F. (2020), *Apple Scab Resistant Cultivars Culti-vated in Bucharest area-Fruits Characterization*. Journal of Horticulture, Forestry and Biotechnolo-gy, 24(3), 15-22.
[29] Roberts, D., Reyes, V., Bonilla, F., Dzandu, B., Liu, C., Chouljenko, A., Sathivel, S. (2018), *Viability of Lactobacillus plantarum NCIMB 8826 in fermented apple juice under simulated gastric and in-testinal conditions*. LWT 97, 144–150.
[30] Roșca, C., (2009), *Studii privind optimizarea producției la principalele specii pomicole din compartimentul de sud al Podişului Sucevei*- teză de doctorat, Iași.
[31] Rozsa, S., Lazăr V., Gocan T. M., (2020), *Tehnologia produselor Hoticole* 2 (Îndrumător lucrări practice) Ed. AcademicPress, ISBN 978-973-744-783-8.
[32] Saranwong, S., Kawano, S. (2007), *Fruits and vegetables*. Near-infrared spectroscopy in food sci-ence and technology, 219-245.
[33] Satpathy, L., Pradhan, N., Dash, D., Baral, P. P., Parida, S. P. (2021), *Quantitative determination of vitamin C concentration of common edible food sources by redox titration using iodine solution*. Letters in Applied NanoBioScience, 10(3), 2361-2369.
[34] Sauceda-Gálvez, J., Codina-Torrella, I., Martinez-Garcia, M., Hernández-Herrero, M., Gervilla, R., Roig-Sagués, A. (2021), *Combined effects of ultra-high-pressure homogenization and short-wave ultraviolet radiation on the properties of cloudy apple juice*. LWT136, 110286.
[35] Sestras, R. E., Sestras, A. F. (2023), *Quantitative traits of interest in apple breeding and their impli-cations for selection*. Plants, 12(4), 903.

[36] Solomakhin, A., Blanke, M. M. (2010), *Can coloured hailnets improve taste (sugar, sugar: acid ra-tio), consumer appeal (colouration) and nutritional value (anthocyanin, vitamin C) of apple fruit?* LWT-Food Science and Technology, 43(8), 1277-1284.
[37] Sousa, A., Vareda, J., Pereira, R., Silva, C., Câmara, J.S., Câmara, J.S., Perestrelo, R. (2020), *Geo-graphical differentiation of apple ciders based on volatile fingerprint*. Food Res. Int.137, 109550.
[38] Ssemugabo, C, Bradman A, Ssempebwa JC, Guwatudde D. Consumer Awareness and Health Risk (2023), *Perceptions of Pesticide Residues in Fruits and Vegetables in Kampala Metropolitan Area in Uganda*. Environ Health Insights. doi: 10.1177/11786302231184751.
[39] Su, M., Zhang, B., Ye, Z., Chen, K., Guo, J., Gu, X., Shen, J. (2013), *Pulp volatiles measured by an electronic nose are related to harvest season, TSS concentration and TSS/TA ratio among 39 peach-es and nectarines*. Scientia Horticulturae, 150, 146-153.
[40] Yamazaki, T., Niizuma, T., & Taguchi, T. (1971), *The relationship between organic acid and potassium content in apple juice*. Journal of the Japanese Society for Horticultural Science, 40(3), 268-271.
[41] Young, T. E., Juvik, J. A., Sullivan, J. G. (1993), *Accumulation of the components of total solids in ripening fruits of tomato*.
[42] Zheng, Z.; Shetty, K. (2000), *Enhancement of pea (Pisum sativum) seedling vigour and associated phenolic content by extracts of apple pomace fermented with Trichoderma spp. Process*. Biochem. 36, 79–84.
[43] Zhou, S., Chen, S., Li, S. (2021), *The shape effect: Round shapes increase consumers' preference for hedonic foods*. Psychology, Marketing, 38(11), 2051-2072.