

PRELIMINARY RESULTS ON FRUIT QUALITY
OF THE APPLE CULTIVATED IN ECOLOGICAL SYSTEM

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ABSTRACT

Known being the increasing demand for ecological fruits, both at national level and on international markets, the apple cultivated in the ecological system in Romania can bring economic and social benefits. The orientation towards apple cultivars with genetic resistance to diseases will be gradually imposed, especially in the case of apple, being the main factor in obtaining ecological productions. The value of the ecological apples, as dessert fruits, depends directly on the following physico-chemical characteristics: size (weight and caliber), content of fruit in soluble solids and acids (specially malic acid), firmness and the color of the epidermis. This work aims to quantify the quality elements of the fruits at the maturity of harvesting for 12 apple cultivars, of different origin (6 with Romanian origin and 6 foreign cultivars), located in a field trial of RIFG Pitești, Romania, managed in ecological system. The preliminary results registered at the level of 2022 show that the fruits size varied from 144.26 g ('Rubinola' cv.) to 306.8 g ('Orion' cv.), and the fruit caliber 71.62 mm ('Crimson Crisp' cv.) to 92.13 mm ('Orion' cv.). The cultivars 'Rumina', 'Topaz' and 'Orion' were noted for the high content of soluble solids (over 14%). 'Rubinola' cv. was noted by the high pH of fruits (4.02) and high acid content (0.88% malic acid).

INTRODUCTION

Ecologic management practices exclude the use of synthetic pesticides and fertilizers, being allowed only organic ones such as animal and green manure, compost, sulfur and copper products, pheromone traps and other biological control methods (Holb et al. 2003; Peck et al. 2006; Jonsson 2007; Amarante et al. 2008; Butac et al. 2021).

Ecological apple culture is still quite limited in most European countries, due to the attack of diseases and pests and small control possibilities of them (Jönsson, 2007, Amarante et al. 2008), as well as due to the lack of pesticides and fertilizers admitted in ecological agriculture (McArtney & Walker, 2004), which limits profitability of ecological apple plantations.

In Romania, according to Eurostat data, published in 2021, ecological agriculture included, at the level of 2019, an area of approximately 395,228 ha, respectively 2.9% of the agricultural area. The fruit trees occupied only 15,905 ha, that is, a share of only 4% of the total ecological agriculture at national level (Butac et al. 2021). According to the same data, the area cultivated with apple in the

ecological system is 3,296 ha in the conversion period and only 1,868 ha ecological, which ensured a ecological production of about 12,000 tones. It is expected that by 2021, the area cultivated with apple in the ecological system will increase to about 3,000 ha, with a total ecological production of 18,000 tones.

In the last years, in the Romanian ecological fruit-growing sector was introduce new scab-resistant cultivars with higher fruit quality, such as 'Topaz', 'Red Topaz', 'Orion', 'Luna', 'Crimson Crisp', 'Dalinred', 'Santana', 'Ariwa' and 'Natyra' due to collaboration between breeder, growers and marketing organizations (Kienzle et al., 2016; Kienzle and Kelderer, 2017).

This work aims to quantify the quality elements of the fruits at the maturity of harvesting for 12 apple cultivars, of different origin (6 with Romanian origin and 6 foreign cultivars), located in a field trial of RIFG Pitești, Romania, managed in ecological system.

MATERIALS AND METHODS

The research has been carried out at Research Institute for Fruit Growing Pitesti, Romania (central part of Romania 44°53'56" Northern latitude, and 24°51'35" Eastern longitude), in apple field trial, established in 2009. The trees were planted at a distance of 3.5 x 2.5 m, 3 trees per cultivars in 3 replications. The trees were trained as spindle, with drip irrigation. Soil is medium-textured, heavy-clay, with low humus content. The average multi-annual temperature was 10.0°C, the maximum temperature 38.8°C, whereas the minimum temperature -24.4°C; total annual rainfalls recorded was 678.1 mm. Compared to the baseline for 53 years period, there is a tendency to increase average temperatures in the winter months (January and February), which causes an early start of trees in vegetation with negative influences on resistance to late spring frosts. There is also a tendency to increase temperature in the summer months (June, July and August), which determines a low resistance to drought. Regarding precipitation, there is a rainfall exceeding in winter (121 mm) and a rainfall deficit in summer (153 mm). In 2022 (when the determinations were performed), the average annual temperature was with 1.6°C higher than the multiannual average, and the precipitation was with 151.8 mm lower than the multiannual average.

Twelve apple cultivars with different origin, grafted on M9 rootstock, were evaluated: (Table 1).

Table 1

The apple cultivars studied

No.	Cultivars	Genitors	The main traits
1	Aura	Prima x BN 33/39	Scab resistance; large fruit
2	Rumina	Selection from Golden delicious	Scab resistance; good storage capacity
3	Jonaprim	Prima x Jonathan	Scab resistance; fruit quality
4	Rebra	Florina x Idared	Scab resistance; fruit quality
5	Rustic	Florina x Pionier	Scab resistance; fruit quality
6	Redix	Goldsupr x Prima PN	Scab resistance; fruits like Starkrimson
7	Orion	Golden delicious x Otava	Scab resistance; fruit quality
8	Luna	Topaz x Golden delicious	Scab resistance; fruit quality
9	Rubinola	Prima x Rubin	Scab resistance; fruit quality
10	Topaz	Rubin x Vanda	Scab resistance; fruit quality

11	Goldrush	Golden delicious x Coop 17	Scab resistance; good storage capacity
12	Crimson Crisp	PCFW2-134 x PR1 669-205	Scab resistance; fruit quality

In 2022, the following parameters were appreciated:

- fruits weight was recorded with a balance in g/fruit;
- fruits soluble solids content with a digital refractometer in % Brix;
- pH and the malic acid content of fruits was measured using the device

Minititrator Hanna Instrument 84532. Titratable acidity was expressed as % or g/100 g fresh matter;

- fruit firmness was measured with non-destructive penetrometer Qualitest HPE-II-FFF equipped with a test anvil ball of \varnothing 5mm;

- fruit skin color parameters (CIE L*, a*, b*) were measured using a Konica Minolta CR 400 chromameter, where L* corresponds to Luminance or darkness, and a* and b* to the chromaticity coordinates. The CIELAB color scale is organized in a cube form. The L* axis runs from top to bottom. The maximum for L* is 100, which represents a perfect reflecting diffuser. The minimum for L* is zero, which represents black. The a* and b* axes have no specific numerical limits. Positive a* is red. Negative a* is green. Positive b* is yellow. Negative b* is blue.

The data were included in an Excel database and interpreted using the following statistical index: average, standard deviation and coefficient of variability.

RESULTS AND DISCUSSIONS

The average fruits weight was 184.71 g, varying between 149.13 g at 'Crimson Crisp' cv. and 306.80 g at 'Orion' cv. Compared with average per experience (control), 'Orion', 'Aura' and 'Rebra' cvs., had much larger fruits (Table 2). Of the Romanian cultivars, were noted by large fruits 'Aura', 'Jonaprim' and 'Rebra', (over 180 g). Of the cultivars from Czech Republic, 'Orion' cv. was noted (306.80 g), and among the American ones the both cultivars had small fruit (around 150 g) (Table 2).

The caliber of fruits was 77.41 mm on average, varying between 71.62 mm at 'Crimson Crisp' cv. and 92.13 mm at 'Orion' cv. (Table 2).

For apples, the fruit firmness is considered as a major quality parameter that indicates the storage capacity. The firmness is correlated with the skin thickness, an important characteristic for harvesting, transport and consumers. The average values of fruit firmness are range between 61.26 HPE units for 'Rubinola' cv. and 76.20 HPE units for 'Rumina' cv. Compared with average per experience (control), 'Rumina', 'Rebra', 'Rustic', 'Luna', 'Goldrush' and 'Crimson Crisp' cvs., were much firmer (Table 2).

The coefficient of variability (%) for the external fruits parameters reached in average 24.51 for weight (large variability), 7.32% for caliber (small variability) and 6.35 for firmness (small variability) (Table 2).

Table 2

The mean value of external fruit quality (RIFG Pitești - Maracineni, 2022)

No.	Cultivars	Fruit weight (g)	Caliber (mm)	Firmness (HPE units)
1	Aura	236.30	73.86	67.10
2	Rumina	172.73	75.13	76.20
3	Jonaprim	182.53	82.47	63.93
4	Rebra	185.26	76.10	71.06
5	Rustic	179.46	75.23	73.36
6	Redix	175.63	81.36	69.56
7	Orion	306.80	92.13	67.46
8	Luna	170.23	77.85	71.43
9	Rubinola	144.26	76.12	61.26
10	Topaz	163.60	75.29	69.73
11	Goldrush	150.60	71.82	72.83
12	Crimson Crisp	149.13	71.62	75.23
Average		184,71	77,41	69,93
Standard deviation		45,27	5,67	4,44
Coefficient of variability (%)		24,51	7,32	6,35

Color is also an important quality parameter that directly affects appearance and consumer acceptability (Pathare et al. 2013). Color intensity depends on the cultivar due to pigments content, like anthocyanins.

Table 3

The mean value of fruit color (RIFG Pitești - Maracineni, 2022)

No.	Cultivar	CIELAB color values*		
		L*	a*	b*
1	Aura	49.93	24.65	19.96
2	Rumina	50.60	-0.64	24.50
3	Jonaprim	56.65	9.29	24.50
4	Rebra	50.07	9.81	20.16
5	Rustic	43.16	30.52	16.06
6	Redix	28.24	19.93	6.77
7	Orion	71.89	-14.08	32.26
8	Luna	72.59	-5.47	33.14
9	Rubinola	43.66	26.11	17.37
10	Topaz	42.37	26.72	17.39
11	Goldrush	71.14	-9.16	32.17
12	Crimson Crisp	30.00	24.48	9.72
Average		50.86	11.85	21.17
Standard deviation		15.05	15.79	8.55
Coefficient of variability (%)		29.59	133.27	40.42

According to the CIELAB color scale it is noted that, there are significant differences between cultivars. It is known that, when approaching of optimum maturity, cultivars become more lightness (L*), redder (a*) and bluer (b*). The lightness ('L' value) is ranging from 28.24 at 'Redix' cv. (dark red color) to 72.59 at 'Luna' cv. (yellow color) The 'a' value, indicating green color of the skin, registered negative values for 'Rumina', 'Orion', 'Goldrush' and 'Luna' cvs. The smallest value was registered for 'Orion' cv. (-14.08) with yellow skin. The yellowness index ('b' value) varied from 6.77 for 'Redix' cv. to 32.26 for 'Orion' cv. (Table 3).

The average values of the coefficient of variability regarding the fruit color are very high, indicating a great variability, from cultivars with yellow fruits to cultivars with dark red fruits (Table 3).

Soluble solids content (SSC) is considered as a good indicator of the sugar content of apples and presumably of sweetness (Hoehn et al. 2003). For apple studied cultivars, the SSC is between 10.73% Brix ('Aura' cv.) and 15.23% Brix ('Orion' cv.). Among the apple cultivars studied were remarked by higher content in the soluble solids content (over 14%) 'Orion', 'Rumina' and 'Topaz' (Table 4).

Our results regarding 'Goldrush' cv. are similar with results obtained by Leccese et al. (2009) and Petkova et al. (2019).

Regarding pH, some authors report that the pH of apples has values between 3 and 4. In our study, the values of fruits pH ranged between 3.22 ('Topaz' cv.) and 4.02 ('Rubinola' cv.) (Table 4).

The main organic acid in apple fruits is malic acid, as its content is up to 90% of the total organic acids (Wu et al., 2007). In apple cultivars with high amounts of malic acid, the sour taste becomes predominant (Wojdylo et al., 2008). The highest content of malic acid had 'Rubinola' cv. (0.88 g/100 g fresh weight) and the lowest values were registered for 'Rebra' (0.23 g/100 g fresh weight) (Table 4).

Table 4

The mean value of internal fruit quality (RIFG Pitești - Maracineni, 2022)

No.	Cultivars	Soluble solids content (% Brix)	pH	Malic acid (%)
1	Aura	10.73	3.61	0.41
2	Rumina	14.22	3.86	0.47
3	Jonaprim	11.96	3.75	0.47
4	Rebra	12.56	3.98	0.23
5	Rustic	11.10	3.43	0.30
6	Redix	11.40	3.86	0.27
7	Orion	15.23	3.69	0.42
8	Luna	13.80	3.77	0.37
9	Rubinola	11.96	4.02	0.88
10	Topaz	14.56	3.22	0.45
11	Goldrush	12.46	3.73	0.42
12	Crimson Crisp	12.96	3.68	0.28
Average		12,74	3,72	0,41
Standard deviation		1,44	0,22	0,17
Coefficient of variability (%)		11,28	6,01	40,68



Figure 1. 'Aura', 'Rebra' and 'Topaz' cvs. – good fruits quality

CONCLUSIONS

The orientation towards apple cultivars with genetic resistance to diseases will be gradually imposed, especially in the case of apple, being the main factor in obtaining ecological productions.

The data about the external and internal fruit characteristics of some apple cultivars grown in ecological conditions are useful for growers in order to introduce in the new orchards only cultivars with high quality fruits and also for breeder in order to select the possible genitors in cross combinations.

Thus, in this study the following apple cultivars were noted:

- 'Aura', 'Orion' and 'Rebra' for large fruits;
- 'Rumina', 'Rebra', 'Rustic', 'Luna', 'Goldrush' and 'Crimson Crisp' for firmness;
- 'Orion', 'Rumina' and 'Topaz' for high sugar content.

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