EVALUATION OF APPLE VARIETIES FOR INDUSTRIALIZATION IN AN INTENSIVE SYSTEM

EVALUAREA SOIURILOR DE MĂR PENTRU INDUSTRIALIZARE ÎN SISTEM INTENSIV

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Abstract.

Purpose: Evaluation of the agrobiological and technological performance of ten apple cultivars grafted on M9 rootstock in southeastern Republic of Moldova to identify optimal varieties for industrial processing.

Material and Methods: In 2025, at a density of 2,083 trees/ha (4 × 1.2 m), cultivars 'Champion', 'Florina', 'Gloster', 'Golden Delicious', 'Idared', 'Mutsu', 'Pinova', 'Renet Simirenco', 'Golden Rezistent', and 'Granny Smith' were evaluated. Yield parameters (kg/tree, t/ha), average fruit mass (g), firmness (kgf/cm²), titratable acidity (%), soluble solids content (°Brix), and pH were determined.

Results: Yield ranged from 9.91 t/ha ('Mutsu') to 39.33 t/ha ('Golden Rezistent' – 18.88 kg/tree), followed by 'Idared' (32.76 t/ha). Average fruit weight varied between 126.1 g ('Pinova') and 164.2 g ('Mutsu'). Highest firmness was recorded in 'Gloster' (12.3 kgf/cm²). Soluble solids content ranged from 14.2 °Brix ('Mutsu') to 16.2 °Brix ('Champion'). Maximum titratable acidity was found in 'Renet Simirenco' (1.01%), 'Granny Smith' (1.01%), and 'Idared' (0.91%).

Conclusions: Cultivars 'Renet Simirenco', 'Granny Smith', and 'Idared' are optimal for juice production due to high firmness and acidity, while 'Golden Rezistent' and 'Champion' offer superior yields for concentrate production.

Keywords: *Malus domestica*, fruit yield, firmness, titratable acidity, industrial processing.

Rezumat.

Scop: Evaluarea performanțelor agrobiologice și tehnologice ale zece soiuri de măr altoite pe M9 în zona de sud-est a Republicii Moldova (S.A. „Ghermes Agroservice”, Saiți), pentru identificarea celor optime procesării industriale.

Material și Metodă: În 2025, la o densitate de 2083 pomi/ha (4 × 1,2 m), s-au evaluat soiurile: 'Champion', 'Florina', 'Gloster', 'Golden Delicious', 'Idared', 'Mutsu', 'Pinova', 'Renet Simirenco', 'Golden Rezistent' și 'Granny Smith'. S-au analizat producția (kg/pom, t/ha), masa fructului (g), fermitatea (kgf/cm²), aciditatea titrabilă (%), substanța uscată solubilă (°Brix) și pH-ul.

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Rezultate: Producția a variat între 9,91 t/ha ('Mutsu') și 39,33 t/ha ('Golden Rezistent' – 18,88 kg/pom), urmat de 'Idared' (32,76 t/ha). Masa fructelor a oscilat între 126,1 g ('Pinova') și 164,2 g ('Mutsu'). Cea mai ridicată fermitate a înregistrat-o 'Gloster' (12,3 kgf/cm²). Substanța uscată solubilă a atins valori între 14,2 °Brix ('Mutsu') și 16,2 °Brix ('Champion'). Aciditatea maximă s-a stabilit la 'Renet Simirenco' (1,01%), 'Granny Smith' (1,01%) și 'Idared' (0,91%).

Concluzii: Soiurile 'Renet Simirenco', 'Granny Smith' și 'Idared' se recomandă pentru sucuri datorită fermității și acidității ridicate, iar 'Golden Rezistent' și 'Champion' pentru randamente înalte destinate concentratelor.

Cuvinte cheie: *Malus domestica*, producție de fructe, fermitate, aciditate titrabilă, industrializare.

INTRODUCTION

The cultivated apple (*Malus domestica* Borkh.) is the predominant fruit species in temperate zones, accounting—alongside bananas and citrus—for the largest share of global fruit production. Worldwide, apple ranks third in total fruit production volume [Balan, 1996; Babuc, 2012]. In the Republic of Moldova, apple crops occupy the leading position among cultivated fruit species and are well represented across all pomological zones of the country due to favorable agroclimatic conditions [Cimpoieș, 2000; Dadu, 2004].

Apple orchards occupy over 60% of the total fruit-growing area in the Republic of Moldova and account for more than 70% of total fruit production, representing a highly profitable sector. Apple trees possess high yield potential (50–70 t/ha) and high nutritional value. Fruits contain sugars (7.6–16.4%), organic acids (0.16–1.27%), pectic substances (0.2–1.1%), and essential vitamins (A, B1, B2, B9, C, and PP). Owing to their high storage capacity, apples provide fresh fruit availability throughout the entire year [Balan, 2009; Balan, 2015; Bilici, 2020].

Due to the nutritional, therapeutic, and prophylactic properties of the fruit, as well as the technological suitability and agrobiological traits of the trees, apple cultivation remains widespread in temperate regions.

Managing apple orchards designated for industrial processing requires specific cultural practices that ensure tree health, high yield efficiency, and optimal fruit processing attributes. Key management factors include selecting suitable cultivars with optimal sugar-to-acid ratios, balanced soil management (fertilization, irrigation), canopy training and pruning, flower thinning, and effective phytosanitary protection against pests and diseases such as apple scab (*Venturia inaequalis*) and powdery mildew (*Podosphaera leucotricha*).

MATERIAL AND METHOD

The trial was conducted in 2025 within an experimental apple orchard belonging to S.A. „Ghermes Agroservice”, located in the southeastern fruit-growing zone of the Republic of Moldova (Saiți village, Căușeni district). The experimental

material comprised ten apple cultivars: 'Champion', 'Florina', 'Gloster', 'Golden Delicious', 'Idared', 'Mutsu', 'Pinova', 'Renet Simirenco', 'Golden Rezistent', and 'Granny Smith' (Cimpoieş et al., 2001). All cultivars were grafted on M9 rootstock and planted in 2005 at a spacing of 4.0 × 1.2 m, establishing a tree density of 2,083 trees/ha. Trees were trained as modified palmettes (Balan et al., 2018).

Soil management, irrigation, fertilization, and plant protection against diseases and pests were carried out according to standard pomological recommendations [Babuc 2012]. Chemical flower thinning with urea was performed according to the methodology developed by Balan & Vamașescu (2018). Canopy management included chemical thinning of flowers using foliar urea and winter/spring structural pruning. Crop protection included treatments with low-environmental-impact products, and overall orchard management was tailored toward processing fruit production.

The experimental design was a randomized complete block with 4 replications, each experimental unit consisting of 8 trees (n = 32 trees per treatment). Biometric and biochemical fruit parameters were evaluated at commercial harvest maturity: **Yield parameters:** Fruit number per tree, yield per tree (kg/tree), and total yield (t/ha). **Average fruit mass (g):** Determined by weighing a sample of 20 representative apples per replication (n = 80 apples per treatment) using a digital precision balance (±0.01 g, RADWAG AS 82/220.X2). **Fruit firmness (kgf/cm²):** Measured on 20 apples per replication ($n = 80$) on unpeeled fruit cheeks using a manual/digital penetrometer. **Soluble Solids Content (SSC, °Brix):** Determined from juice samples using a digital refractometer (DR201-95, Germany). **Titratable Acidity (% malic acid) and pH:** Titratable acidity was determined by neutralization with 0.1 N NaOH to pH 8.1 and expressed as percentage of malic acid. Juice pH was recorded with a calibrated benchtop pH meter.

Fruit quality parameters were evaluated by mass (g), soluble solids content (°Brix), titratable acidity expressed as % malic acid, fruit firmness (kg/cm²), and pH. Fruit mass was determined by weighing a sample of 20 apples per replicate using a digital balance (±0.01 g) (AS 82/220.X2). Soluble solids content in fruits was measured using a digital refractometer (DR201-95, Germany). Fruit firmness was determined on 20 apples in four identical replicates (n = 80) for each treatment.

RESULTS AND DISCUSSIONS

Managing apple orchards for industrial processing requires achieving high yields while maintaining critical technological fruit properties. Table 1 presents yield performance evaluated during the 20th leaf (2025 season). Despite tree age, high productivity levels were maintained across most cultivars. The medium-vigorous cultivar 'Golden Rezistent' achieved the highest fruit load, averaging 148 fruits/tree, followed by 'Idared' (115 fruits/tree), 'Champion' (102 fruits/tree), and 'Renet Simirenco' (101 fruits/tree). Fruit number per tree for 'Florina', 'Gloster', and 'Granny Smith' ranged from 88 to 97 pieces/tree. Medium-vigor cultivars 'Golden Delicious' and 'Pinova' produced fewer fruits (69–72 fruits/tree). The lowest fruit load was recorded in the vigorous cultivar 'Mutsu' (29 fruits/tree).

Table 1

Fruit yield depending on the biological characteristics of the variety, year 2025

Cultivar	Fruits per tree (pcs)	Yield per tree (kg)	Total yield (t/ha)
Champion	102	14.06	29.30
Florina	97	13.05	27.19
Gloster	88	12.59	26.22
Golden Delicious	69	9.02	18.78
Idared	115	15.73	32.76
Mutsu	29	4.76	9.91
Pinova	72	9.08	18.91
Renet Simirenco	101	13.79	28.72
Golden Rezistent	148	18.88	39.33
Granny Smith	93	11.92	24.83

Yield per tree ranged from 4.76 to 18.88 kg/tree (corresponding to 9.91–39.33 t/ha). The highest individual tree yields were obtained from 'Golden Rezistent' (18.88 kg/tree; 39.33 t/ha) and 'Idared' (15.73 kg/tree; 32.76 t/ha). High yields were also demonstrated by 'Champion' (14.06 kg/tree), 'Renet Simirenco' (13.79 kg/tree), 'Florina' (13.05 kg/tree), 'Gloster' (12.59 kg/tree), and 'Granny Smith' (11.92 kg/tree).

In contrast, 'Pinova', 'Golden Delicious', and 'Mutsu' exhibited substantially lower yields (4.76–9.08 kg/tree), primarily due to strong biennial bearing behavior during the 2025 season.

Average fruit weight is a cultivar-specific genotypic trait that varies according to crop load, environmental factors, and agrotechnical management. Average fruit weight across the evaluated cultivars ranged between 126.1 g and 164.2 g (Table 2). 'Mutsu', which carried a low crop load, produced the largest fruits (164.2 g), followed by 'Gloster' (143.1 g), 'Champion' (137.9 g), 'Idared' (136.8 g), and 'Renet Simirenco' (136.6 g). The smallest fruit mass was recorded in 'Golden Rezistent' (127.6 g) and 'Pinova' (126.1 g).

Fruit firmness is a crucial parameter determining post-harvest handling resistance and processing efficiency. Firmness depends on genetic characteristics and cell wall pectin integrity, which is heavily stabilized by calcium content (Cimpoieș et al., 2001).

As shown in Table 2, fruit firmness at harvest was highest in 'Gloster' (12.3 kgf/cm²). High firmness values were also recorded for 'Renet Simirenco' (10.8 kgf/cm²), 'Granny Smith' (10.6 kgf/cm²), 'Pinova' (10.5 kgf/cm²), 'Florina' (10.3 kgf/cm²), and 'Mutsu' (10.0 kgf/cm²).

Table 2

Fruit physical and biochemical quality parameters of apple cultivars for industrial processing (2025)

Cultivar	Average fruit weight, gr	Fruit firmness, kgf/cm²	Titratable acidity (% malic acid)	Soluble Solids Content (°Brix)	pH values
Champion	137.9	9.1	0.67	16.2	3.80
Florina	134.6	10.3	0.51	15.1	3.65
Gloster	143.1	12.3	0.69	15.6	3.77
Golden Delicious	130.7	9.5	0.48	15.7	3.78
Idared	136.8	9.8	0.91	14.4	3.85
Mutsu	164.2	10.0	0.62	14.2	3.77
Pinova	126.1	10.5	0.39	15.3	3.70
Renet Simirenco	136.6	10.8	1.01	14.6	3.71
Golden Rezistent	127.6	9.6	0.71	14.7	3.75
Granny Smith	128.2	10.6	1.01	15.0	3.74

Titratable acidity is a primary contributor to flavor profile and industrial juice yield. Acidity varied significantly among cultivars (Table 2). High titratable acidity levels were recorded in 'Renet Simirenco' (1.01%), 'Granny Smith' (1.01%), and 'Idared' (0.91%), making them ideal for juice processing where acid retention is required. The lowest acidity was observed in 'Pinova' (0.39%).

Soluble Solids Content (SSC/TSS) reflects sugar accumulation resulting from starch conversion during fruit maturation. SSC values were consistently high across all evaluated varieties, ranging from 14.2 °Brix in 'Mutsu' to 16.2 °Brix in 'Champion'.

CONCLUSIONS

All ten evaluated apple cultivars grafted on M9 rootstock demonstrated suitable agrobiological and technological characteristics for industrial processing under the conditions of southeastern Republic of Moldova.

The highest total fruit yields were recorded in 'Golden Rezistent' (39.33 t/ha; 18.88 kg/tree) and 'Idared' (32.76 t/ha; 15.73 kg/tree), demonstrating their high economic productivity in 20-year-old intensive plantings.

Cultivars 'Renet Simirenco', 'Granny Smith', and 'Idared' are highly recommended for acid-balanced juice production due to their elevated titratable acidity (0.91–1.01%) and firm pulp texture (9.8–10.8 kgf/cm²).

Cultivars 'Champion', 'Gloster', and 'Golden Delicious' displayed elevated Soluble Solids Content (15.6–16.2 °Brix), making them excellent candidates for purees, concentrates, and aromatic cider production.

ACKNOWLEDGEMENTS. This study was supported by the Technical University of Moldova through the institutional subprogram "Research and Extension Center for Agriculture, Biodiversity and Rural Development" No. 020499

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