# EVALUATION OF BERRY RESISTANCE TO DETACHMENT AND COMPRESSION OF SOME NEW *VITIS VINIFERA* L. CULTIVARS FOR TABLE GRAPES

## EVALUAREA REZISTENȚEI LA DESPRINDERE ŞI COMPRESIUNE A BACELOR UNOR SOIURI NOI *VITIS VINIFERA* L. PENTRU STRUGURI DE MASĂ

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***Abstract.*** *Since quality requirements for table grapes are closely related to their mechanical characteristics, the aim of this work was the assessment of berry resistance to detachment from the pedicel and its resistance to compression at five new Vitis vinifera L. cultivars for table grapes: Gelu, Milcov, Napoca, Splendid and Transilvania. The determinations made on the mature berries consisted in the analysis of the normal pressing force and the deformation under its influence, as well as the force required for the detachment of berries from the pedicels, using a CETR UMT-2 tribometer. Grape berries with higher weight and volume and larger diameter (Transilvania cv.) incurred a higher mechanical deformation, while long berries (Gelu cv.) showed higher resistance to detachment from the pedicel probably due to a more pronounced development of vascular bundles, indicating a higher resistance of grapes to handling, packing, transport and storage*.
**Key words:** berry elasticity, grape quality, mechanical features, table grapes, vascular bundles.

***Rezumat.*** *Întrucât caracteristicile de calitate ale strugurilor de masă sunt strâns legate de însuşirile lor fizico-mecanice, scopul acestui studiu a fost evaluarea rezistenței la compresiune şi detaşare de pe pedicel a bacelor provenind de la cinci soiuri noi Vitis vinifera L. pentru struguri de masă: Gelu, Milcov, Napoca, Splendid şi Transilvania. Determinările efectuate asupra boabelor mature au constat în analiza forței normale de presare şi a deformării suportate sub influența acesteia, precum şi a forței necesare detaşării bacelor de pe pedicel, folosind un tribometru automatizat CETR UMT-2. Bacele cu masă şi diametru mai mare (Transilvania cv.) au prezentat o elasticitate superioară, suportând o deformare mecanică mai mare, în timp ce bacele mai alungite (Gelu cv.) au prezentat o rezistență mai mare la detaşarea de pedicel, datorită unei dezvoltări mai pronunțate a fasciculelor vasculare, indicând o rezistenşă crescută a strugurilor la manipulare, ambalare, transport şi depozitare.*

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**Cuvinte cheie:** caracteristici de calitate, elasticitatea bacelor, fascicule vasculare, proprietăşi mecanice, struguri de masă.

## INTRODUCTION

The term *quality* implies the degree of excellence of a product or its suitability for a particular use (Abbot, 1999). Although grapes have many attributes that can be examined, the quality is not something that can be readily quantified (Creasy and Creasy, 2009). Besides visual quality and taste, when table grapes are destined for transport or storage occur a number of mechanical factors to be monitored (e.g. berry elasticity, pedicel resistance to detachment, berry skin thickness). Moreover, mechanical parameters are directly related to some sensory properties (e.g. crispness) and resistance of grapes to injury during harvest or packing (Kok and Celik, 2004; Rolle *et al*., 2012).

In viticulture, mechanical analysis of grapes is of special interest in order to recognize the potential of each cultivar to satisfy market requirements (Rolle *et al*., 2012). Mechanical particularities of grapes vary mainly under the influence of the genetic factor (cultivar), but other factors may intervene: climatic conditions, plant vigour, grapes position on the vine stock, the degree of ripening and grape health (Constantinescu *et al*., 1970).

Since quality requirements of table grapes are closely related to their physico-mechanical particularities, the aim of this work was to provide relevant information concerning grapes suitability for packing, transport and storage of five new *Vitis vinifera* L. cultivars created in Romania. Scientific data obtained also contribute to a better understanding of the economic potential of the studied cultivars and their value for further breeding programs.

## MATERIAL AND METHOD

Research has been carried out on five *V. vinifera* L. cultivars for table grapes created in Romania: Gelu (free fecundation of Coarnă neagră seeds, irradiated with X rays), Milcov (Coarnă neagră × Muscat Hamburg), Napoca (Alphonse Lavallée × (Regina viilor × Muscat Hamburg), Splendid (Black rose × Regina viilor) and Transilvania (Black rose × Cardinal), all growing in the Ampelographic Collection of the University of Agricultural Sciences and Veterinary Medicine Iaşi, Romania (27°53' E; 47°09' N). Grape harvest was conducted according to OIV/VITI 371/2010 Resolution protocol (OIV, 2010). For each cultivar 5 berry/grape were harvested from 20 grapes.

Berry length (mm) and diameter (mm) and were measured using an electronic vernier caliper, while skin thickness (mm) was measured using an outside micrometer (error ± 0.01 mm). Berry elasticity (as deformation supported by berries) and the pedicel resistance to detachment (as the force required for pedicel detachment) were performed using a single-platform, fully-computerized CETR UMT-2 tribometer. Data regarding normal and friction forces (N), deformation (mm), coefficient of friction (COF) and time of action (sec) were automatically retrieved and processed by a computer. Data were reported as mean having specified the standard deviation (±). Regression analysis was performed to look for relationships between data.

## RESULTS AND DISCUSSIONS

Transilvania cv. presented the lowest number of berries per cluster, but with the largest weight of 100 berries (768 ± 32 g). Based on the standard deviation, Splendid cv. showed a high irregularity of berry weight, followed by Transilvania and Napoca. Number of seeds was generally low, varying from 1.67 (Gelu) to 2.67 (Milcov) (tab. 1).

*Table 1*

**Physico-structural features of grapes at technological maturity**

| Features | Gelu | Milcov | Napoca | Splendid | Transilvania |
|---|---|---|---|---|---|
| Berries / grape | 66 ± 12 | 46 ± 11 | 49 ± 6 | 46 ± 9 | 39 ± 7 |
| 100 berries weight (g) | 489 ± 21 | 305 ± 14 | 437 ± 26 | 494 ± 29 | 768 ± 26 |
| 100 berries vol. ($cm^3$) | 471 ± 18 | 296 ±16 | 430 ±19 | 485 ± 22 | 750 ± 25 |
| Rachis weight (g) | 6.29 ± 0.12 | 3.55 ± 0.41 | 5.85 ± 0.71 | 5.23 ± 0.71 | 6.80 ± 0.48 |
| Seeds number | 1.67 ± 0.58 | 2.67 ± 0.58 | 1.67 ± 0.58 | 2.00 ± 1.00 | 2.00 ± 0.00 |
| Skin weight (g) | 0.45 ± 0.04 | 0.44 ± 0.05 | 0.37 ± 0.03 | 0.42 ± 0.04 | 0.51 ± 0.09 |
| Pulp weight (g) | 4.32 ± 0.21 | 2.45 ± 0.13 | 3.83 ± 0.93 | 4.51 ± 0.09 | 7.01 ± 0.37 |
| Seeds weight (g) | 0.06 ± 0.02 | 0.13 ± 0.04 | 0.08 ± 0.02 | 0.10 ± 0.05 | 0.15 ± 0.01 |
| Structure index | 51.31 | 39.52 | 36.60 | 43.45 | 44.05 |
| Composition index | 8.47 | 4.30 | 8.70 | 8.67 | 10.62 |
| Berry index | 20.45 | 32.79 | 22.88 | 20.24 | 13.02 |

Note: Structure index - berry weight / rachis weight; Composition index - pulp weight / skin and seeds weight); Berry index - berries in 100 g. Mean values with standard deviation (±).

Composition index showed lower values due to a higher weight of skin (0.37 - 0.51 g) and seeds (0.06 - 0.15 g) in relation to pulp weight, while berry index presented low values, specific to table grape cultivars. According to Constantinescu G. *et al.* (1970), the structure index presents values ranging from 12 to 50, with high values for table grapes, while the berry index has smaller values for table grape cultivars (~30).

Grape quality and its technological characteristics can be assessed by analysing the physico-mechanical particularities, obtaining important information on grape suitability for transport and storage. Mechanical measurements were performed on the mature berries and consisted in the analysis of the normal force of the compression and deformation occurring under its influence, as well as the force required to separate the berry from the pedicel. Berry weight, volume, length and diameter, and skin thickness were determined for the berries considered for the study (tab. 2).

Berry deformation (Z), the force (F) required and the time of action until cracking (T), varied significantly depending on cultivar. The most important deformations, indicating a high elasticity, were supported by Transilvania cv. berries (1.41 mm), followed by Splendid cv. (1.18 mm).

The force (Fz) applied until berry cracking was the highest at Transilvania cv., and the lowest for Milcov cv. Berries of Transilvania cv. resisted the longest time under the action of the deformation force (4.56 seconds).

*Table 2*

**The mechanical characteristics of analysed berries**

| Cultivar | Gelu | Milcov | Napoca | Splendid | Transilvania |
|---|---|---|---|---|---|
| Weight (g) | 4.87 ± 0.15 | 3.01 ± 0.14 | 4.39 ± 0.21 | 4.65 ± 0.23 | 7.61 ± 0.37 |
| Volume ($cm^3$) | 4.02 ± 0.22 | 2.87 ± 0.19 | 3.79 ± 0.25 | 3.52 ± 0.20 | 6.54 ± 0.14 |
| Dimeter (mm) | 17.80 ± 0.90 | 15.73 ± 0.31 | 17.93 ± 1.17 | 17.72 ± 0.78 | 18.47 ± 0.67 |
| Length (mm) | 23.90 ± 1.28 | 20.77 ± 0.70 | 20.33 ± 2.39 | 22.20 ± 1.39 | 22.17 ± 1.35 |
| Skin thick. (mm) | 0.41 ± 0.03 | 0.44 ± 0.05 | 0.27 ± 0.02 | 0.29 ± 0.02 | 0.46 ± 0.05 |
| Fz (N) | 1.41 ± 0.11 | 1.03 ± 0.09 | 2.65 ± 0.07 | 1.70 ± 0.11 | 3.46 ± 0.04 |
| Z (mm) | 0.72 ± 0.02 | 0.56 ± 0.01 | 0.53 ± 0.07 | 1.18 ± 0.08 | 1.41 ± 0.04 |
| T (s) | 2.05 ± 0.22 | 1.66 ± 0.19 | 2.34 ± 0.17 | 2.89 ± 0.09 | 4.56 ± 0.14 |
| Ft (mN) | 20.14 ± 7.11 | 10.08 ± 1.30 | 13.32 ± 3.17 | 15.74 ± 1.02 | 11.12 ± 1.42 |
| Ff (mN) | 11.51 ± 4.06 | 9.44 ± 1.21 | 4.31 ± 2.09 | 8.19 ± 1.34 | 10.44 ± 3.03 |
| COF | 0.56 ± 0.12 | 0.92 ± 0.10 | 0.31±0.17 | 0.59±0.07 | 0.93±0.27 |

Note: Skin thick. (mm) - berry skin thickness; Fz (N) - normal force (Newton); Z (mm) - deformation; T (s) - time of action (seconds); Ft (mN) - tensile force (millinewtons); Ff (mN) - friction force (millinewtons); COF - coefficient of friction.

In figure 1, is plotted the dynamics of the parameters Z (decreasing due to deformation) and Fz (positive values), in relation to the time of action.

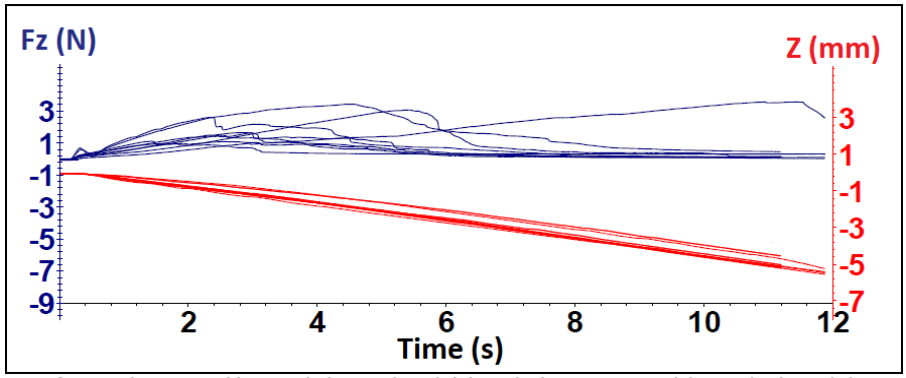


**Fig. 1** Diagram of berry deformation (Z) in relation to normal force (Fz) and time of action (sec)

Note: Z (mm) - deformation (negative values due to decreasing); Fz (N) - normal pressing force (positive variations); Time (s) - time of action (seconds).

Detachment of the berries from the pedicel is triggered by the intensification of pectic and cellulase enzymes activity, this process occurring during grape maturation (Burzo *et al.*, 2005). During grape storage, at some susceptible cultivars, can be observed the undesirable phenomenon of multiple berries detachment, this negative feature being increasingly to the attention of researchers and breeders.

For the analysis of resistance to detachment, berries were cut from the rachis with a scissor, with the pedicel attached. The forces necessary to detach the berries from the pedicel were very low (10.08 - 20.14 mN). To confirm the results was necessary to analyse the force of friction (Ff) and the coefficient of friction

(COF) between pedicel brush with vascular bundles, pulp and skin, thus obtaining new clues on the moment of berry detachment (see tab. 3).

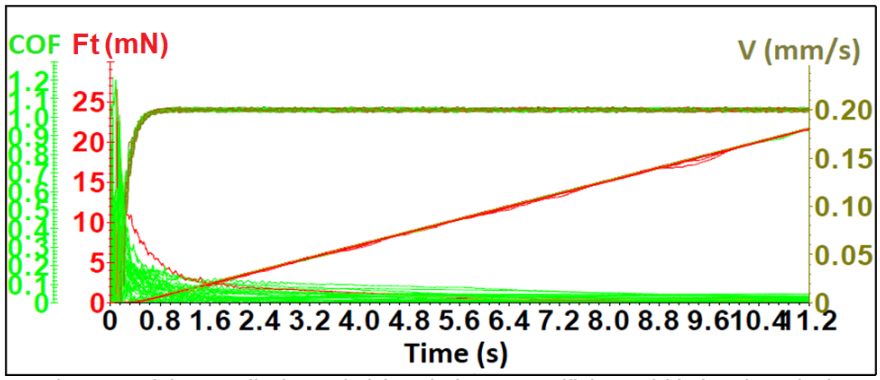


**Fig. 2** Diagram of the tensile force (Ft) in relation to coefficient of friction (COF), time and speed of action (V)

Obtained data revealed that the lowest berry resistance to detachment was showed by Milcov and Transilvania cv., requiring a tensile force of 10.08 mN and 11.12 mN respectively. Analysing the force-friction-time relationship (fig. 2), was concluded that the highest resistance to detachment from the pedicel was showed by Gelu cv. berries, followed by Splendid, Napoca and Transilvania cv.

Correlation between the biometric characteristics of the berries, their elasticity (represented by the deformation incurred) and their resistance to the detachment, indicated a positive relationship between these parameters (tab. 3).

*Table 3*

**Correlation of the biometrical and mechanical features of the berries**

| Features | Weight (g) | Volume (mL) | Diameter (mm) | Length (mm) | Skin thickness (mm) |
|---|---|---|---|---|---|
| Fz (N) | *0.8360* | *0.8562* | *0.7620* | -0.1426 | -0.0060 |
| Z (mm) | *0.8133* | *0.7378* | 0.5738 | 0.3720 | 0.2157 |
| T (s) | *0.9432* | *0.9226* | *0.7030* | 0.1570 | 0.2245 |
| Ft (mN) | -0.0249 | -0.1554 | 0.3594 | *0.7747* | -0.2549 |
| Ff (mN) | 0.3000 | 0.3037 | -0.0678 | *0.7673* | *0.8165* |
| COF | 0.2485 | 0.3346 | -0.3571 | 0.0728 | *0.8529* |

Note: Fz (N) - normal force (Newton); Z (mm) - deformation; T (s) - time of action (seconds); Ft (mN) - tensile force; Ff (mN) - friction force; COF - coefficient of friction.

According to data correlation, berries with higher weight (r = 0.8133) and volume (r = 0.7378) supported higher mechanical deformations. Also, the forces required were significantly higher for berries with larger diameter (r = 0.7620).

Moreover, higher tensile and friction forces were positively correlated with berry length (r = 0.7747, and 0.7673 respectively), possibly due to a more pronounced development of central and peripheral vascular bundles (fig. 3).

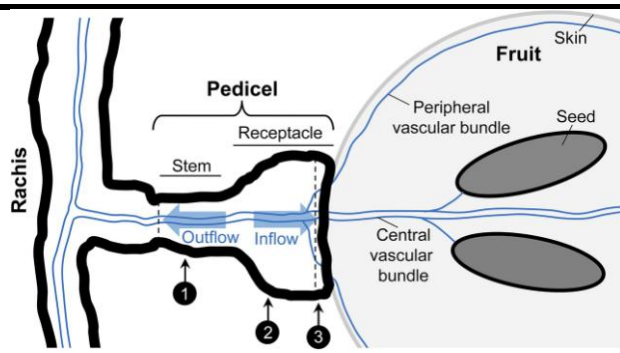


**Fig. 3** Schematic drawing of berry pedicel and vascular system (Knipfer T. *et al*., 2015)

## CONCLUSIONS

1. Grapes of new *Vitis vinifera* L. cultivars, created in Romania, showed superior physico-mechanical characteristics indicating their high quality and their high resistance to handling, packing and storage.

2. The most important deformation, indicating a high elasticity, was supported by Transilvania cv. berries, while the highest berry resistance to detachment was showed by Gelu cv., followed by Splendid and Napoca cv.

3. Data analysis showed that berries with thicker skin, higher weight and volume and larger diameter incurred a higher mechanical deformation, while elongate berries showed higher resistance to detachment from the pedicel, probably due to a more pronounced development of vascular bundles.

4. Evaluation of mechanical characteristics provides relevant data on the potential of cultivars to satisfy market requirements, particularly on the suitability of grapes to transport and storage, and their value for further breeding programs.

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