CENTENARY OF THE OIV
45th WORLD CONGRESS OF VINE AND WINE
14-18 OCTOBER 2024 FRANCE-DIJON
OIV
Available on IVES Conference Series vine & wine
DOI : https://doi.org/10.58233/gRle0G5n

Novel table grape varieties as "ready-to-eat" products

Lucia Rosaria Forleo[1], Teodora Basile[1], Bruna Suriano[1], Maria Francesca Cardone[1], Antonio Domenico Marsico[1]and Rocco Perniola[1]

[1] Council for Agricultural Research and Economics -Research Center Viticulture and Enology (CREA-VE), Via Casamassima 148-70010 Turi (Ba), Italy

Abstract. Consumers are increasingly requesting ready-to-eat products, which save time. Offering ready-to-eat fruits provides a quick and easy way for consumers to incorporate healthy products into their diets. In this study, we evaluated the suitability of several table grape varieties for inclusion in the processing and packaging lines of ready-to-eat products. This work was based on the characterization of genetic materials and varietal innovation. Historical and commercial grape varieties, along with novel genotypes from the breeding project at the CREA-VE research center (Turi, Southern Italy) were tested. We examined the disarticulation of berries from the pedicel by measuring the force required to detach the berries, the length of the brush adhering to the pedicel, and the diameter of the brush. Low values of these parameters indicate the berries' ability to be stored as fresh-cut products without the pedicel. Since maintaining organoleptic properties is important, we measured various quantitative and qualitative parameters. We found several historical and commercial varieties and new ones that did not show lacerations after detachment from the pedicel. Moreover, for some varieties, it was possible to maintain the grape bunches on the vine for extended periods without protective treatments.

1. Introduction

Scientific studies have shown that a diet rich in fruits and vegetables reduces disease risk [1-4]. The World Health Organization recommends consuming over 400 grams of fruits and vegetables daily to lower the risk of noncommunicable diseases (NCDs) [5].

In industrialized countries, eating outside the home often leads to higher energy intake and poorer diet quality [6]. People tend to consume fewer fruits and vegetables while increasing processed foods and sugary drinks. In contrast, a higher intake of fruits and vegetables can replace energy-dense, nutrient-poor foods associated with obesity [7, 8].

Improving the quality of out-of-home meals requires collaboration between the food industry and catering sectors, with a focus on providing healthier options. Recently, the availability and consumption of minimally processed fruits and vegetables have increased. Modern consumers, concerned with both health and convenience, prefer ready-to-eat, high-quality fruits with minimal pesticide residue.

Table grapes are well-suited for ready-to-eat processing. Globally, around 72 million tons are produced, with 31 million tons for fresh consumption [9]. Italy produces 1.1 million tons, mainly in Apulia and Sicily, making it a major European producer. Export demand is growing, especially for seedless varieties that offer convenience as ready-to-eat products and health benefits.

Grapes are rich in polyphenols, which have antioxidant, anti-inflammatory, and protective effects against NCDs such as cardiovascular diseases and cancer [10].

This study aimed to explore table grape biodiversity and identify seedless grape varieties that resist skin tearing after detachment from the pedicel, thereby reducing spoilage and enhancing their suitability as ready-to-eat products.

2. Materials and methods

2.1. Grape samples

The study was conducted in 2023 on 195 table grape varieties, including 77 historical, 7 commercial, and 111 new genotypes from the breeding program at the CREA-Research Center for Viticulture and Enology in Turi (BA), Italy. All vines were cultivated in the same area in Southeast Bari, Apulia, and grape samples were collected at commercial maturity. The analysis focused on both

qualitative and quantitative traits such as bunch weight, berry weight, bunch length, seed type, berry color, length and width of the brush, skin tearing upon pedicel detachment, pH, total acidity, sugar content, and texture. Bunch and berry weights were measured using an OHAUS NVL2101/2 digital scale (OHAUS, Parsippany, New Jersey, USA). Skin tearing was visually assessed, with 0 indicating absence and 1 indicating presence. All analyzed berries were divided into 4 classes regarding seed development: 1 for aborted and not evaluable seeds, 2 for aborted and rudimentary seeds, 3 for complete not lignified seeds, and 4 for lignified seeds.

2.2. Chemical analyses

Approximately 50 berries were used to assess pH, total soluble solids (TSS) expressed in °Brix, and titratable acidity (TA) expressed in g/L of tartaric acid. TSS levels were measured with an Atago PR 1 digital refractometer (Atago Co., Tokyo, Japan), while TA was determined through titration. The pH was recorded using a CRISON BASIC 20 pH meter (CRISON STRUMENTI S.p.A., Carpi, Italy).

2.3. Fruit detachment force (FDF)

The fruit detachment force (FDF) between pedicel and berry was measured using an XforceP texture analyzer (Zwick/Roell). An individual grape pedicel was inserted through the hole of a metal base and firmly clamped with a spring clamp, which was then fastened to the load cell fixture. A gradually increasing force was applied to the fruit in the direction of the pedicel until the fruit detached. The maximum FDF value at the moment of separation was recorded from the scale indicator. Fifteen berries with pedicels from each variety were measured.

2.4. Statistical analysis

Data analysis was conducted using Statgraphics Centurion XVI software. A one-way ANOVA was performed with a significance level of $p < 0.05$, followed by Tukey's post-hoc test for further comparisons. Spearman rank correlation analysis ($p < 0.05$) was also applied to assess the relationships between various variables, including length, brush width, hardness, and the occurrence of tearing and detachment.

3. Results and discussion

3.1. Historical varieties

Across all 77 historical varieties, the Spearman rank correlations revealed a positive correlation between skin tearing and both length and brush width (for length: Correlation = 0.2127, p=0.0000; for width: Correlation = 0.3138, p=0.0000). Of the 77 varieties analyzed, only 37 did not exhibit skin tearing after the pedicel was detached, and only 5 did not contain woody seeds inside. As shown in Table 1, both Incrocio Gargiulo and Carina have the lowest values for berry weight, and pedicel detachment. In contrast, Sernia has higher values for detachment, as well as the highest berry weight. The table also highlights the Incrocio Bellini variety, which exhibited tearing; notably, it is the only variety with the largest brush width. This confirms the positive correlation between tearing and brush size, as indicated by the Spearman Rank Correlation.

The total soluble solids content values, expressed in Brix, among the varieties that did not show tearing, ranged from a maximum of 23.9 for Carina to a minimum of 16.4 for Blush seedless (Table 2). According to OIV resolution VITI 1/2008 [11], table grapes are considered ripe with TSS ≥ 16 °Brix. Since the grapes in question presented values higher than 16 °Brix, they can be considered ripe.

Table 1. Brush length, brush width, berry weight, and detachment force of the pedicel, parameters of historical varieties of table grapes studied (mean values).

Variety	Brush length (mm)	Brush width (mm)	Berry weight (g)	Detachment (N)
Blush Seedless Rs.	1.36 b*	1.35 b	3.35 c	2.70 ab
Carina B.	3.50 a	1.48 b	2.00 d	1.10 b
Incrocio Gargiulo 102011 B.	3.58 a	1.21 b	2.02 d	1.32 b
Ruby Seedless Rs.	2.54 ab	1.24 b	4.34 b	3.62 a
Sernia Rs.	2.41 ab	1.62 b	5.73 a	4.54 a
Incrocio Bellini Rs.†	3.91 a	2.25 a	3.55 c	3.77 a

*Different letters within the same column mean significant differences according to Tukey's test ($p \leq 0.05$). † Variety showing tearing.

Table 2. Seed class, total soluble solids, pH, and titratable acidity, parameters of historical varieties of table grapes studied (mean values).

Variety	Seed classes	TSS (°Brix)	TA (g/L)	TSS/TA (g/L)	pH
Blush Seedless Rs.	2	16.4	2.6	63.1	3.80
Carina B.	1	23.9	3.0	79.7	4.14
Incrocio Gargiulo 102011 B.	1	22.8	3.3	69.1	4.03
Ruby Seedless Rs.	2	22.2	3.8	58.4	3.68
Sernia Rs.	3	23.7	2.9	81.7	3.85
Incrocio Bellini Rs. †	1	16.0	4.05	38.8	3.70

† Variety showing tearing.

3.2. Commercial varieties

Among the 7 varieties analyzed, only one exhibited skin tearing after the pedicel was removed. For all 7 varieties, the Spearman rank correlations revealed no significant correlation between tearing and brush length or width. This is likely due to the small sample size and the fact that these varieties have already been selected for their favorable traits.

Autumn Pearl, Black Magic, Millennium, and Superior Seedless showed the lowest values for pedicel detachment (see Table 3).

In Table 4, we can see the recorded values of total soluble solids content, with a maximum of 20.0 for Summer Royal and a minimum of 15.2 for Superior Seedless.

However white table grapes with TSS < 16 °Brix, are considered ripe when the TSS (expressed as g L^{-1}) to TA (expressed as g L^{-1}) ratio is >20 [11]; Superior Seedless had TSSC/TA ratio greater than 20.

Table 3. Brush length, brush width, berry weight, and detachment force of the pedicel, parameters of commercial varieties of table grapes studied (mean values).

Variety	Brush length (mm)	Brush width (mm)	Berry weight (g)	Detachment (N)
Autumn Crisp B.	2.13 n.s.	1.90 bc*	11.61 a	8.71 a
Autumn Pearl Rs.	2.09 n.s.	1.36 c	5.94 b	4.09 b
Black Magic N.	3.18 n.s.	1.93 b	7.14 b	4.50 b
Millenium B.	2.16 n.s.	2.57 a	5.64 b	3.65 b
Summer Royal N.	1.65 n.s.	1.78 bc	5.92 b	9.71 a
Superior Seedless B.	2.07 n.s.	2.52 a	6.68 b	5.32 b

*Different letters within the same column mean significant differences according to Tukey's test ($p \leq 0.05$), n.s. not significantly different.

Table 4. Seed class, total soluble solids, pH, and titratable acidity, parameters of commercial varieties of table grapes studied (mean values).

Variety	Seed classes	TSS (°Brix)	TA (g/L)	TSS/TA (g/L)	pH
Autumn Crisp B.	1	18.3	4.4	41.6	3.65
Autumn Pearl Rs.	1	16.4	4.0	41.0	3.68
Black Magic N.	1	19.4	3.9	49.7	3.79
Millenium B.	1	16.5	5.9	28.0	3.21
Summer Royal N.	1	20.0	4.9	40.8	3.54
Superior Seedless B.	1	15.2	4.0	38.0	3.68

3.3. New varieties

The 111 new genotypes developed from the CREA VE breeding program have been categorized into two groups: 42 that have already been selected (3 of which are registered in the *Registro nazionale delle varietà di vite*, with others in the registration process) (Table 5) and 69 that are still in the observation and future selection phase (Table 7). In total, 57 seedless genotypes did not show skin tearing after pedicel detachment. The tables include only genotypes with an average berry weight of 5 g or more. Notably, these genotypes exhibited no signs of pathogen infection in the vineyard despite not receiving phytosanitary treatments for about 2 months, with N 23/011 untreated for over 4 months. This result is particularly important given the increasing consumer demand for products with little to no residue.

As shown in Table 5, the white variety Gallianum has the lowest pedicel detachment force while the red variety Ursi, shows the highest value. For these genotypes, the Spearman rank correlations indicated no relationship between tearing and brush length or width.

The varieties in Table 6 showed TSS values, expressed in Brix, ranging from 20.0 for white Medunio to 23.3 for black Egnatia, a variety already registered.

Table 5. Brush length, brush width, berry weight, and detachment force of the pedicel, parameters of new varieties of table grapes selected (mean values).

Variety	Brush length (mm)	Brush width (mm)	Berry weight (g)	Detachment (N)
Anxa N.	1.19 bc*	1.09 c	7.40 a	6.75 ab
Dertum B.	0.85 c	1.24 bc	5.54 ab	5.54 bc
Egnatia N.	0.91 c	1.16 c	5.93 b	7.54 ab
Gallianum B.	2.49 b	1.40 abc	5.90 b	2.50 d
Medunio B.	5.01 a	2.30 a	6.36 ab	4.00 cd
Ursi Rs	1.90bc	1.90 ab	6.00 b	8.12 a
Vigilarum B.	2.44 b	1.70 ab	6.31 ab	4.16 cd

*Different letters within the same column mean significant differences according to Tukey's test ($p \leq 0.05$).

Table 6. Seed class, total soluble solids, pH, and titratable acidity, parameters of new varieties of table grapes selected (mean values).

Variety	Seed classes	TSS (°Brix)	TA (g/L)	TSS/ TA (g/L)	pH
Anxa N.	1	22.2	2.3	96.5	4.37
Dertum B.	1	23.1	3.4	67.9	4.14
Egnatia N.	1	23.3	3.7	63.0	3.89
Gallianum B.	1	21.4	2.9	73.8	3.75
Medunio B.	1	20.0	2.85	70.2	3.73
Ursi Rs	1	22.8	4.6	49.6	3.58
Vigilarum B.	1	22.2	3.4	65.3	3.53

For the genotypes still in the selection process (Table 7), the Spearman rank correlations revealed a positive relationship between tearing and both brush length and width (for length: Correlation = 0.4249, p=0.0000; for width: Correlation = 0.5483, p=0.0000). The genotype N 20/117 Rs. recorded the highest values for detachment and hardness, while N 22/031 B. had the lowest values.

The new genotypes all showed values higher than 16 °Brix, so we can consider them ripe (Table 8).

Table 7. Brush length, brush width, berry weight, and detachment force of the pedicel, parameters of new varieties of table grapes in observation (mean values).

Variety	Brush length (mm)	Brush width (mm)	Berry weight (g)	Detachment (N)
N 20/115 Rs.	1.74 b*	1.52 ab	5.53 b	4.61 ab
N 20/117 Rs.	0.87 b	1.07 bc	5.00 b	5.90 a
N 20/156 B.	1.36 b	1.14 bc	5.35 b	2.93 b
N 22/031 B.	1.30 b	0.90 c	5.36 b	2.70 b
N 23/011 N.	5.65 a	1.90 a	7.436 a	4.80 ab

*Different letters within the same column mean significant differences according to Tukey's test ($p \leq 0.05$).

Table 8. Seed class, total soluble solids, pH, and titratable acidity, parameters of new varieties of table grapes in observation (mean values).

Variety	Seed classes	TSS (°Brix)	TA (g/L)	TSS/ TA (g/L)	pH
N 20/115 Rs.	1	18.3	4.7	38.9	3.40
N 20/117 Rs.	1	19.3	2.4	80.4	3.75
N 20/156 B.	1	19.5	4.1	47.6	3.53
N 22/031 B.	2	24.0	4.3	55.8	3.43
N 23/011 N.	1	20.7	5.3	39.1	3.55

Overall, we can say that these new genotypes showed no signs of infection by pathogens, without phytosanitary treatments in the field for about 2 months (N 23/011 for over 4 months).

Further characterization is in progress on new genotypes revealing the nutraceutical value of the selected new seedless varieties. The Egnatia variety in other studies has shown anti-tumor activity [3].

This is a very important result given the growing demand from consumers for products with low or no residual content that provide health benefits.

For the new genotypes still in the selection phase, there is a positive correlation between skin tearing and brush length and width. This suggests that larger brushes may increase the probability of tearing the skin.

4. Conclusion

Among the 195 genotypes analyzed, 68 seedless genotypes had no tearing in the skin after detachment of

the pedicel, and 57 were new genotypes with no signs of infection by pathogens even in the absence of phytosanitary treatments.

The study highlights that selected seedless varieties maintain integrity after harvest and during processing, show resistance to pathogens, and provide health benefits. These are suitable for ready-to-eat production.

Overall, the new seedless table grape varieties have favorable structural properties and meet consumer demand for healthy, ready-to-eat fruit with minimal residues. The combination of seedlessness, structural properties related to detachment, and resistance to pathogens may represent minimal good criteria for the selection of fresh-cut table grape varieties in a breeding program.

5. Acknowledgment

This research was funded by Italian Ministry of University and Research (MUR), Project "POFACS—Conservabilità, qualità sicurezza dei prodotti ortofrutticoli ad alto contenuto di servizio", PON R&I 2014-2020.

6. References

1. M.A.S. Van Duyn, E. Pivonka, J Amer Diet Ass, 100, 12 (2000).
2. F.J. He, C.A. Nowson, G.A. MacGregor, The Lancet 367, 9507 (2006).
3. R.A. Milella et al, Front. Plant Sci., 13, 1064023 (2023).
4. F.J. He, C.A. Nowson, M. Lucas, G.A. MacGregor, J. Hum. Hypertens., 21, 9 (2007).
5. W. H. Organization, Fruit and vegetables for health: report of the Joint FAO (2005).
6. NUTRIZIONE C. D. R. A. E., Linee Guida Per Una Sana Alimentazione (Centro di Ricerca Alimenti e Nutrizione: Roma, Italy, 2018).
7. B.H. Lin, R.M. Morrison, Food Review/National Food Review, 25, 3 (2002).
8. B.C. Tohill, F.A.O. Joint, Dietary intake of fruit and vegetables and management of body weight [electronic resource]. (World Health Organization, 2005).
9. Report OIV, 2022. Available at: https://www.oiv.int/it/what-we-do/global-report?oiv
10. J.S. Câmara et al., Foods, 10, 1 (2020).
11. OIV. 2008. Resolution VITI 1/2008. OIV Standard on Minimum Maturity Requirements for Table Grapes. Organisation Internationale de la Vigne et du Vin, Paris Available at: https://www.oiv.int/public/medias/369/viti-2008-1-en.pdf