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EVALUATING JUICE EXTRACTION EFFICIENCY IN THREE DIFFERENT WHITE WINE CULTIVARS

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Abstract: The study evaluated juice extraction efficiency and pomace-to-liquid ratios in three white wine grape cultivars ('Sauvignon Blanc', 'Muscat Ottonel', and 'Fetească Albă') grown in three private vineyards from Arad County, Romania, throughout the 2022-2024 growing season. The aim was to evaluate cultivar-related changes in processing performance under controlled pressing conditions and estimate the implications for winemaking efficiency and by-product output. Grapes were harvested at optimum maturity and then processed by similar winemaking processes. Juice yield, extraction efficiency, pomace yield, pomace moisture content, juice turbidity, must density, and pressing pressure were determined using standardized oenological methods. Statistical analysis was performed to identify cultivar-specific technological responses. The results revealed substantial diversity in extraction efficiency between cultivars. 'Fetească Albă' had the best juice output (74.6-76.2 L/100 kg) and extraction efficiency (74.6-76.2%), but the lowest pomace yield (23.8-25.4 kg/100 kg) and lower pomace moisture content (64.8-66.0%). However, 'Muscat Ottonel' had the lowest extraction efficiency (69.5-70.8%), higher pomace retention (29.2-30.5 kg/100 kg), and increased juice turbidity (200-215 NTU), indicating lower pressing efficiency and more residual sediment. 'Sauvignon Blanc' had moderate performance across all parameters. The findings show that cultivar has a considerable impact on juice extraction dynamics and pomace production, even under uniform technological circumstances. The observed variability is most likely due to differences in berry morphology and tissue composition. These findings emphasize the significance of cultivar selection in increasing winemaking process efficiency and controlling pomace byproducts in white winemaking systems. 'Fetească Albă' demonstrated superior technological performance in terms of juice recovery and clarity, whereas 'Muscat Ottonel' displayed lower extraction efficiency and higher solid waste formation.

Introduction

Juice extraction efficiency is a key factor influencing wine quality, production costs, and winery sustainability [12,20]. The liquid-to-pomace ratio affects both juice yield and the extraction of aromatic and phenolic compounds [32]. Berry traits such as skin thickness, pulp consistency, and cell wall composition strongly influence extraction efficiency [5]. White cultivars including 'Sauvignon Blanc', 'Muscat Ottonel', and 'Fetească Albă' respond differently to mechanical pressing due to their specific berry morphology [16,27].Environmental conditions and berry ripeness also affect juice recovery, as heat stress and skin thickening may reduce extraction efficiency [21,26].

However, comparative data on white wine cultivars under regional terroir conditions remain limited [31].This study compares juice extraction efficiency and pomace-to-liquid ratios in 'Sauvignon Blanc', 'Muscat Ottonel', and 'Fetească Albă', aiming to identify cultivar-specific extraction patterns and their relationship with grape chemical composition.

Material and method

Experimental Site and Plant Material

The study was conducted during 2022–2024 in three commercial vineyards from Mâsca, Arad County (western Romania), under temperate-continental climatic conditions favorable for white grape production. Three cultivars were evaluated: 'Sauvignon Blanc', 'Muscat Ottonel', and 'Fetească Albă'. Grapes were harvested at technological maturity (20–23 °Brix; 5.5–7.5 g/L acidity; pH 3.1–3.5). The experiment followed a randomized design with three cultivars, three vineyards, three vintages, and three biological replicates (81 samples total).

Grape Processing and Juice Extraction

Grapes were destemmed, crushed, and pressed under standardized pneumatic press conditions (0.2–0.6 MPa, 60 min). Juice yield included free-run and press fractions. Must was settled for 12 h at 10 °C before analysis. Extraction efficiency was determined gravimetrically from 5 kg grape samples.

Pomace, Turbidity, and Density Analysis

Pomace moisture was measured by oven drying at 105 °C to constant weight. Juice turbidity (NTU) was determined nephelometrically, while must density was measured using a digital densimeter at 20 °C. All analyses were performed in triplicate under standardized conditions.

Statistical Analysis

Data were analyzed using XLSTAT 2022.3. ANOVA and Tukey's HSD test ($p < 0.05$) evaluated cultivar, vineyard, and vintage effects. PCA were used to assess relationships among extraction efficiency, pomace yield, turbidity, and cultivar performance.

Conclusions

The current study identified that grape cultivar has a substantial impact on juice extraction efficiency, pomace output, and must quality in white winemaking under similar processing circumstances for three consecutive vintages (2022-2024). Cultivar-related variances were more significant than vineyard-related variability, showing the significance of varietal traits in pressing performance. Fetească Albă outperformed the other cultivars in terms of technological efficiency, with the maximum juice output and extraction yields, as well as the lowest pomace yield, moisture, and turbidity. These findings suggest increased pressing performance and more efficient liquid-solid separation. In contrast, Muscat Ottonel exhibited lower extraction efficiency, higher pomace retention, and increased turbidity, indicating reduced extractability and greater clarification requirements. Sauvignon Blanc exhibited moderate and consistent technical characteristics across all vintages.

The gradual increase in juice yield from 2022 to 2024 indicates that vintage circumstances and grape maturity also influence extraction performance. The measured values for juice extraction efficiency (65-75%) and pomace: liquid ratio (0.33-0.47 kg/L) was similar to those reported in the literature for white *Vitis vinifera L.* cultivars. Overall, the data demonstrate that cultivar selection is an essential role in improving pressing efficiency and lowering pomace formation in white winemaking, with Fetească Albă demonstrating the best technological efficiency.

Results and discussions

Significant cultivar-dependent differences in juice extraction efficiency and pomace characteristics were observed during the 2022–2024 vintages. 'Fetească Albă' showed the best technical performance, with the highest juice yield and extraction efficiency, combined with the lowest pomace retention and turbidity. In contrast, 'Muscat Ottonel' exhibited lower extraction efficiency, higher pomace moisture, and greater juice turbidity, indicating reduced juice release and higher solid retention. 'Sauvignon Blanc' displayed intermediate and stable extraction behavior.

Table 1. Juice extraction efficiency and pomace-to-liquid ratios in three white wine grape cultivars from private vineyards in Mâsca, Arad County, 2022-2024 (mean ± SD)

Cultivar	Vineyard	Juice volume (L)	Juice extraction efficiency (%)	Pomace mass (kg)	Pomace:Liquid ratio (kg/L)	TSS (°Brix)	pH	Titratable acidity (g/L)
Sauvignon Blanc	V1	3.60 ± 0.11	72.0 ± 1.9	1.40 ± 0.04	0.39 ± 0.02	21.8 ± 0.32	3.25 ± 0.03	6.80 ± 0.18
Sauvignon Blanc	V2	3.54 ± 0.09	70.8 ± 2.1	1.46 ± 0.05	0.41 ± 0.02	22.1 ± 0.28	3.28 ± 0.02	6.50 ± 0.22
Sauvignon Blanc	V3	3.66 ± 0.10	73.2 ± 1.8	1.34 ± 0.03	0.37 ± 0.01	21.5 ± 0.35	3.22 ± 0.04	6.90 ± 0.19
Muscat Ottonel	V1	3.48 ± 0.08	69.6 ± 2.0	1.52 ± 0.06	0.44 ± 0.03	22.5 ± 0.27	3.30 ± 0.03	6.30 ± 0.16
Muscat Ottonel	V2	3.41 ± 0.10	68.2 ± 2.2	1.59 ± 0.05	0.47 ± 0.04	22.8 ± 0.26	3.35 ± 0.03	6.10 ± 0.14
Muscat Ottonel	V3	3.51 ± 0.09	70.2 ± 1.9	1.49 ± 0.04	0.42 ± 0.01	22.3 ± 0.24	3.29 ± 0.02	6.40 ± 0.15
Fetească Albă	V1	3.70 ± 0.07	74.0 ± 1.6	1.30 ± 0.03	0.35 ± 0.02	21.2 ± 0.21	3.20 ± 0.02	7.10 ± 0.14
Fetească Albă	V2	3.77 ± 0.08	75.4 ± 1.7	1.23 ± 0.02	0.33 ± 0.03	21.0 ± 0.20	3.18 ± 0.03	7.30 ± 0.16
Fetească Albă	V3	3.68 ± 0.09	73.6 ± 1.5	1.32 ± 0.03	0.36 ± 0.02	21.4 ± 0.23	3.22 ± 0.02	7.00 ± 0.15

Different superscript letters within the same column indicate statistically significant differences at **$p < 0.05$** according to Tukey's HSD test following one-way ANOVA. Values are expressed as mean ± standard deviation (n = 3).

Juice yields ranged within the typical values reported for white *Vitis vinifera* cultivars processed under standard pressing conditions. Differences among cultivars were mainly associated with berry morphology, including skin thickness, pulp consistency, and cell wall composition. Must parameters (21–23 °Brix, pH 3.18–3.35, and acidity 6.1–7.3 g/L) confirmed appropriate harvest maturity.

Table 2. Juice extraction and pomace-related parameters of three white wine grape cultivars across vineyards and growing season (2022)

Year	Cultivar	Vineyard Mâsca	Juice Yield (L/100 kg)	Extraction Efficiency (%)	Pomace Yield (kg/100 kg)	Pomace Moisture (%)	Juice Turbidity (NTU)	Must Density (g/cm³)
2022	Sauvignon Blanc	V1	71.2 ± 1.02^{c}	68.9 ± 0.91^{c}	28.8 ± 0.87^{c}	69.5 ± 0.44^{c}	190 ± 9^{c}	1.086 ± 0.0008^{c}
		V2	70.0 ± 0.89^{d}	67.8 ± 0.83^{d}	30.0 ± 1.04^{b}	70.1 ± 0.51^{b}	200 ± 11^{b}	1.087 ± 0.0009^{b}
		V3	72.0 ± 1.15^{c}	69.7 ± 0.98^{c}	28.0 ± 0.92^{c}	68.9 ± 0.39^{c}	180 ± 8^{c}	1.085 ± 0.0010^{c}
	Muscat Ottonel	V1	68.0 ± 0.81^{e}	65.8 ± 0.74^{e}	32.0 ± 0.95^{a}	72.0 ± 0.48^{a}	220 ± 10^{a}	1.089 ± 0.0010^{a}
		V2	67.5 ± 0.94^{e}	65.2 ± 0.88^{e}	32.5 ± 1.08^{a}	72.5 ± 0.55^{a}	230 ± 12^{a}	1.090 ± 0.0011^{a}
		V3	69.0 ± 0.86^{e}	66.7 ± 0.79^{e}	31.0 ± 0.89^{a}	71.5 ± 0.46^{a}	215 ± 9^{a}	1.088 ± 0.0009^{a}
	Fetească Albă	V1	73.0 ± 0.74^{b}	70.8 ± 0.69^{b}	27.0 ± 0.71^{d}	67.5 ± 0.36^{d}	165 ± 6^{d}	1.083 ± 0.0005^{d}
		V2	74.0 ± 0.88^{a}	71.9 ± 0.82^{a}	26.0 ± 0.79^{e}	66.8 ± 0.32^{e}	155 ± 5^{e}	1.082 ± 0.0004^{e}
		V3	73.5 ± 0.79^{b}	71.2 ± 0.73^{b}	26.5 ± 0.75^{d}	67.0 ± 0.34^{d}	160 ± 5.5^{e}	1.083 ± 0.0006^{d}

Different superscript letters within the same column indicate statistically significant differences at **$p < 0.05$** according to Tukey's HSD test following one-way ANOVA. Values are expressed as mean ± standard deviation (n = 3).

Across all vintages, 'Fetească Albă' consistently produced higher juice recovery, lower pomace yield, and reduced turbidity, supporting its suitability for efficient white winemaking. 'Muscat Ottonel' required greater clarification and showed lower pressing efficiency, likely due to higher pectin and polysaccharide content. Vintage effects slightly influenced extraction parameters, but cultivar-specific behavior remained the dominant factor.

Table 3. Juice extraction and pomace-related parameters of three white wine grape cultivars across vineyards and growing season (2023)

Year	Cultivar	Vineyard Mâsca	Juice yield (L/100 kg)	Extraction efficiency (%)	Pomace yield (kg/100 kg)	Pomace moisture (%)	Juice turbidity (NTU)	Must density (g/cm³)
2023	Sauvignon Blanc	V1	72.5 ± 1.10^{c}	71.1 ± 0.95^{c}	27.5 ± 0.90^{c}	68.5 ± 0.42^{c}	185 ± 8^{c}	1.085 ± 0.0008^{c}
		V2	70.8 ± 0.85^{d}	69.4 ± 0.80^{d}	29.2 ± 1.05^{b}	69.2 ± 0.50^{b}	195 ± 10^{b}	1.086 ± 0.0009^{b}
		V3	73.2 ± 1.25^{c}	71.7 ± 1.05^{c}	26.8 ± 0.88^{c}	67.8 ± 0.38^{c}	175 ± 7^{c}	1.084 ± 0.0010^{c}
	Muscat Ottonel	V1	69.5 ± 0.90^{e}	68.1 ± 0.82^{e}	30.5 ± 0.95^{a}	71.0 ± 0.48^{a}	210 ± 9^{a}	1.088 ± 0.0009^{a}
		V2	68.2 ± 1.05^{f}	66.8 ± 0.94^{f}	31.8 ± 1.12^{a}	71.8 ± 0.55^{a}	225 ± 11^{a}	1.089 ± 0.0010^{a}
		V3	70.1 ± 0.88^{e}	68.7 ± 0.79^{e}	29.9 ± 0.91^{a}	70.8 ± 0.46^{a}	205 ± 8^{a}	1.087 ± 0.0008^{b}
	Fetească Albă	V1	74.0 ± 0.78^{b}	72.5 ± 0.70^{b}	26.0 ± 0.75^{d}	66.5 ± 0.35^{d}	160 ± 5^{d}	1.082 ± 0.0005^{d}
		V2	75.3 ± 0.92^{a}	73.8 ± 0.84^{a}	24.7 ± 0.82^{e}	65.8 ± 0.31^{e}	150 ± 4^{e}	1.081 ± 0.0004^{e}
		V3	73.6 ± 0.81^{b}	72.1 ± 0.73^{b}	26.4 ± 0.79^{d}	66.9 ± 0.37^{d}	155 ± 6^{d}	1.082 ± 0.0006^{d}

Different superscript letters within the same column indicate significant differences (**$p < 0.05$**) according to Tukey's HSD multiple comparison test following one-way ANOVA. Values are expressed as mean ± SD (n = 3).

The results confirm that grape cultivar strongly influences juice extraction, pomace formation, and must quality. Optimizing pressing strategies according to cultivar characteristics may improve extraction efficiency and processing performance in commercial white wine production.

Table 4. Juice extraction and pomace-related parameters of three white wine grape cultivars across vineyards and growing season (2024)

Year	Cultivar	Vineyard Mâsca	Juice Yield (L/100 kg)	Extraction Efficiency (%)	Pomace Yield (kg/100 kg)	Pomace Moisture (%)	Juice Turbidity (NTU)	Must Density (g/cm³)
2024	Sauvignon Blanc	V1	73.0 ± 1.08^{c}	71.6 ± 0.94^{c}	27.0 ± 0.82^{c}	67.8 ± 0.41^{c}	175 ± 8^{c}	1.086 ± 0.0008^{c}
		V2	71.8 ± 0.92^{d}	70.3 ± 0.86^{d}	28.2 ± 0.97^{b}	68.4 ± 0.47^{b}	185 ± 9^{b}	1.087 ± 0.0009^{b}
		V3	73.5 ± 1.17^{c}	72.0 ± 1.02^{c}	26.5 ± 0.79^{c}	67.2 ± 0.38^{c}	170 ± 7^{c}	1.085 ± 0.0010^{c}
	Muscat Ottonel	V1	70.2 ± 0.88^{e}	68.7 ± 0.81^{e}	29.8 ± 0.91^{a}	70.0 ± 0.46^{a}	200 ± 9^{a}	1.088 ± 0.0009^{a}
		V2	69.5 ± 1.01^{e}	68.0 ± 0.93^{e}	30.5 ± 1.05^{a}	70.8 ± 0.52^{a}	215 ± 11^{a}	1.090 ± 0.0011^{a}
		V3	70.8 ± 0.84^{e}	69.3 ± 0.77^{e}	29.2 ± 0.86^{a}	69.5 ± 0.43^{a}	205 ± 8^{a}	1.089 ± 0.0010^{a}
	Fetească Albă	V1	75.0 ± 0.79^{b}	73.4 ± 0.72^{b}	25.0 ± 0.68^{d}	65.5 ± 0.33^{d}	150 ± 5^{d}	1.081 ± 0.0005^{d}
		V2	76.2 ± 0.93^{a}	74.6 ± 0.85^{a}	23.8 ± 0.81^{e}	64.8 ± 0.29^{e}	140 ± 4^{e}	1.080 ± 0.0004^{e}
		V3	74.6 ± 0.86^{b}	73.1 ± 0.78^{b}	25.4 ± 0.74^{d}	66.0 ± 0.35^{d}	145 ± 6^{e}	1.081 ± 0.0006^{d}

Different superscript letters within the same column indicate statistically significant differences at **$p < 0.05$** according to Tukey's multiple comparison test following one-way ANOVA. Values are expressed as mean ± standard deviation (n = 3).