



Image taken by finalist, 2024

Transforming Waste into Value:

The Impact of Grape Pomace Variety and Extraction Parameters on Grape Seed Oil Yield and Physicochemical Properties



Image taken by finalist, 2024

Introduction

- California's Central Valley produces 75% of the state's wine grapes but also generates significant pomace waste. If not properly managed, this pomace poses an environmental issue.
- Cold-pressed oils (<49°C) are gaining popularity among health-conscious consumers due to their higher nutrient and lower levels of harmful compounds. Grape seed oil, extracted through cold-pressing, is rich in antioxidants, vitamin E, and polyunsaturated fatty acids, making it a potential ingredient in health, beauty, and food industries.
- The Central Valley grape farmers struggle with low profitability, particularly due to harsh climate. Transforming pomace into valuable products like grape seed oil helps reduce waste and diversify revenue streams.
- The objective of this project is to 1) investigate the impact of factors, such as temperature and water content, on grape seed oil extraction rates and quality using the mechanical pressing method; and 2) determine the profitability of grape seed oil production in California's Central Valley and beyond.



Grape pomace. Note. From Wikipedia, 2010 (https://en.m.wikipedia.org/wiki/File:Pomace_in_the_vineyard_after_pressing.jpg)



Cold-pressed oil. Note. From Mécène, 2025, by James Pendleton (<https://mecenemarket.com/blogs/journal/what-is-cold-pressed-olive-oil>)

Hypothesis

- It is hypothesized that grape variety influences seed oil yield and quality, and that optimizing extraction methods will enhance oil quality, profitability, and sustainability.

Methodology



Fig. 1 Grape Seed Oil Extraction Flow Chart (Image taken and graph created by finalist, 2024)



Fig. 2 Grape Seed Oil Analysis (Image taken by finalist and her parent, Qun Sun, 2024; Graph created by finalist, 2024)

- Data was analyzed using JMP 18. One-way ANOVA and Tukey's HSD test ($p < 0.05$) were used to compare treatments.

Calculations

- Seed Separation Rate (%) = $\frac{\text{Grape Seeds (g)}}{\text{Grape Pomace (100g)}} \times 100\%$
- Oil Extraction Rate (%) = $\frac{\text{Grape Oil (g)}}{\text{Grape Seed (100g)}} \times 100\%$
- Oil Density (g/mL) = $\frac{\text{Weight of 5mL Oil (g)}}{\text{Volume of 5mL of Oil (mL)}}$

Data

Table 1 Grape Seed Characteristics

Varieties	Length (mm)	Width (mm)	Weight (g)	Shape	Color
Pinot Noir	6.48±0.39 a ^a	4.16±0.15 a	0.0278±0.001 ab	oval, long, wide	medium brown
Zinfandel	6.27±0.21 abc	3.65±0.29 cd	0.0240±0.001 b	oval	medium brown
Cabernet Sauvignon	5.93±0.20 cd	3.82±0.13 bc	0.0252±0.0008 ab	oval	dark brown
Tempranillo	6.09±0.22 bcd	3.97±0.17 ab	0.0240±0.001 b	oval	medium brown
Ruby Cabernet	5.07±0.20 f	3.32±0.16 e	0.0186±0.001 c	oval, short, narrow	dark brown
Syrah	5.78±0.26 de	3.40±0.21 de	0.0238±0.002 b	oval	light brown
Chardonnay	5.50±0.25 e	3.77±0.17 bc	0.0236±0.002 b	oval, short, wide	light brown
Vermentino	6.41±0.18 ab	3.63±0.13 cd	0.0290±0.002 a	oval, long	green brown
Albarino	6.17±0.25 abc	3.75±0.20 bc	0.0250±0.003 ab	oval	green brown
Fiano	6.45±0.21a	3.35±0.17 e	0.0252±0.002 ab	oval	green brown

Values represent the mean of 10 replicates followed by the standard deviation ($n = 10$); ^a Means within a column with no same letters indicate significant differences for Tukey's HSD test at $p < 0.05$ (Data Table created by finalist using Excel, 2024)

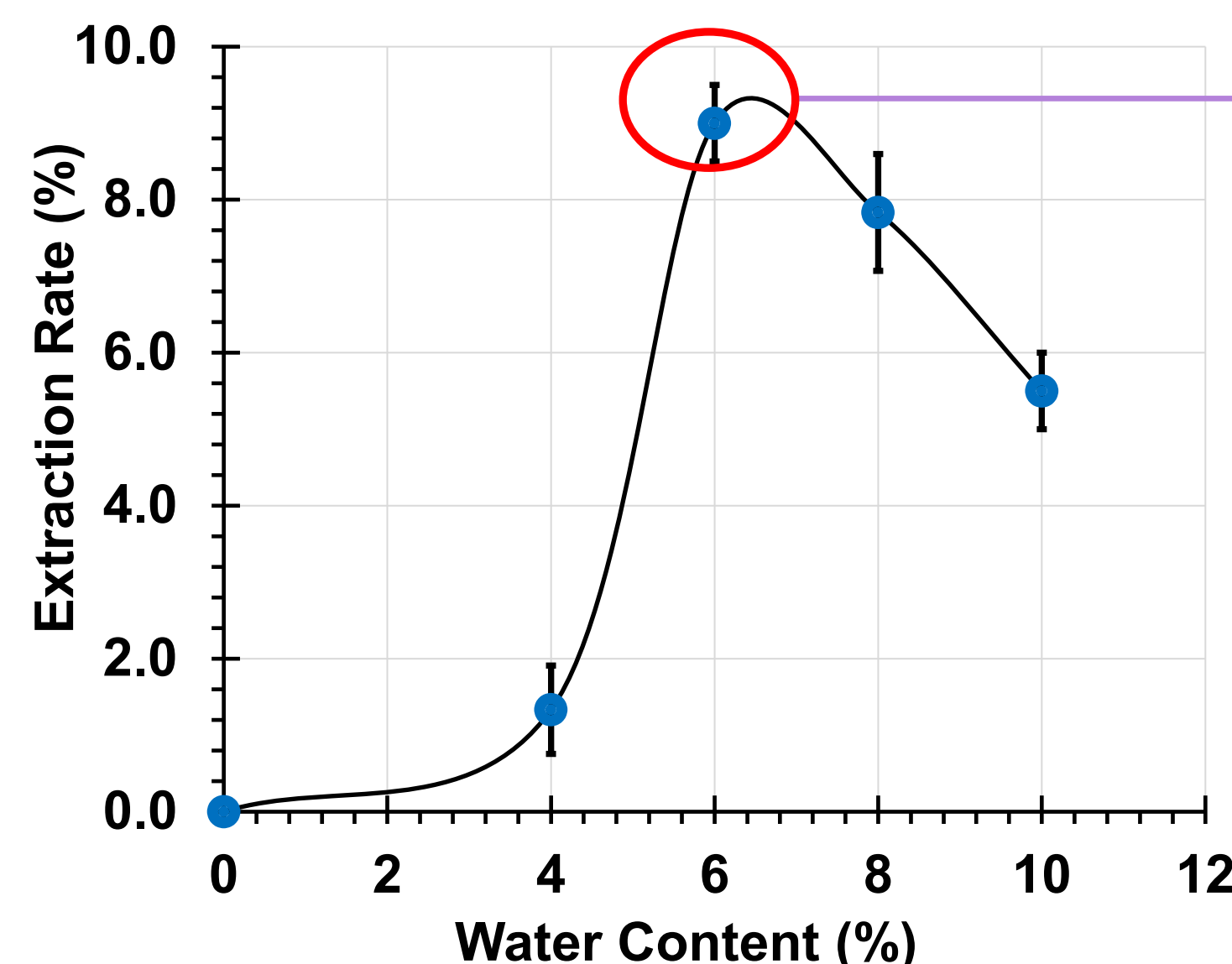


Fig. 3 Effect of Water Content on Grape Seed Oil Extraction Rate (Graph created by finalist using Excel, 2024)

At 6% water content, the highest extraction rate is achieved for cold-pressed seed oil.

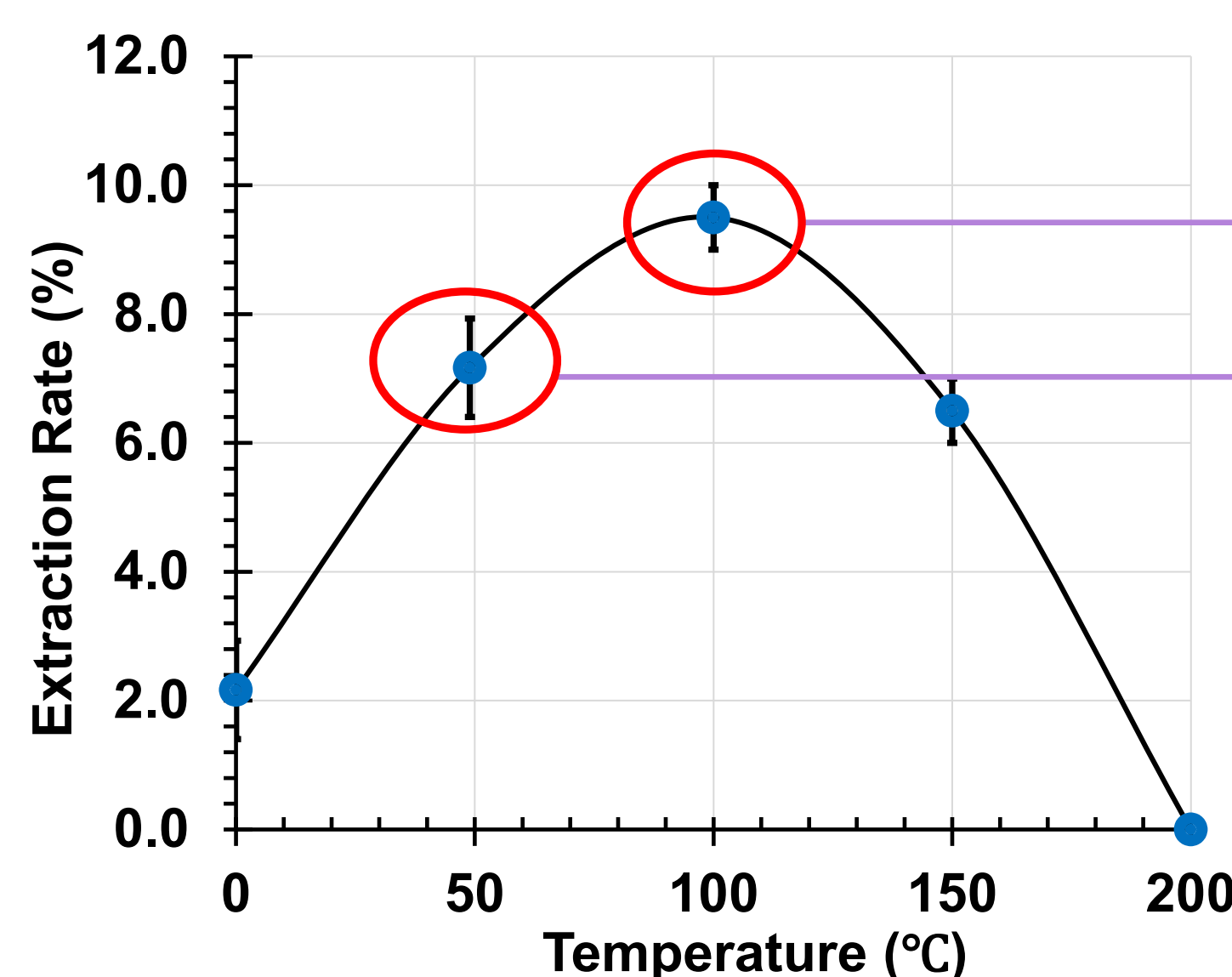


Fig. 4 Effect of Temperature on Grape Seed Oil Extraction Rate (Graph created by finalist using Excel, 2024)

Although the highest extraction rate occurs at 100 °C, this is not considered cold-pressed oil.

At 49 °C, the highest extraction rate is achieved for cold-pressed seed oil.

Table 2 Grape Seed Oil Characteristics

Varieties	Density (g/mL)	Viscosity (mPa·S)	Odor	Color (AU)		
				420nm	520nm	620nm
Pinot Noir	0.930±0.003 a	43.5	nutty, fruity	8.510±0.19 b	1.045±0.09 ab	0.530±0.03 b
Zinfandel	0.917±0.003 b	42.6	slight grassy	5.230±0.15 e	0.705±0.08 c	0.360±0.03 c
Cabernet Sauvignon	0.919±0.004 b	41.5	slight nutty	7.790±0.14 c	0.825±0.07 bc	0.465±0.05 bc
Tempranillo	0.920±0.003 b	42.8	medium nutty	5.745±0.07 d	0.760±0.07 c	0.430±0.05 bc
Ruby Cabernet	0.918±0.002 b	42.1	slight nutty	10.780±0.10 a	0.780±0.11 c	0.325±0.04 c
Syrah	0.915±0.002 bc	41.8	delicate, nutty	2.975±0.07 g	0.750±0.07 c	0.435±0.07 bc
Chardonnay	0.905±0.001 d	41.6	grassy	3.840±0.11 f	1.240±0.08 a	0.815±0.05 a
Vermentino	N.d.	N.d.	N.d.	N.d.	N.d.	N.d.
Albarino	0.909±0.003 cd	42.5	slight nutty	4.180±0.11 f	1.175±0.08 a	0.780±0.04 a
Fiano	N.d.	N.d.	N.d.	N.d.	N.d.	N.d.

Values represent the mean of three replicates followed by the standard deviation ($n = 3$). ^a Means within a column with no same letters indicate significant differences for Tukey's HSD test at $p < 0.05$. ^b N.d. = Not detected. (Data Table created by finalist using Excel, 2024)

Table 3 Revenue and Profit Analysis of Grape Seed Oil Production

Varieties	Pomace (g)	Seed Rate (%)	Extraction Rate (%)	Seed (g)	Oil (L)	Oil Revenue (\$)	Total Revenue (\$)	Total Cost (\$)	Profit (\$)
Pinot Noir	1000000	45	10.0	450000	45	1800	1850	374	1476
Zinfandel	1000000	20	5.7	200000	11	452	502	306	196
Cabernet Sauvignon	1000000	20	6.0	200000	12	480	530	308	222
Tempranillo	1000000	40	6.0	400000	24	960	1010	332	678
Ruby Cabernet	1000000	25	4.5	250000	11	450	500	306	194
Syrah	1000000	18	10.1	180000	18	727	777	320	457
Chardonnay	1000000	15	8.5	150000	13	508	558	310	248
Vermentino	1000000	12	N.d.	120000	N.d. ^b	N.d.	N.d.	N.d.	N.d.
Albarino	1000000	20	9.0	200000	18	718	768	320	448
Fiano	1000000	7	N.d.	70000	N.d.	N.d.	N.d.	N.d.	N.d.

^b N.d. = Not detected. (Data Table created by finalist using Excel, 2024)

Results

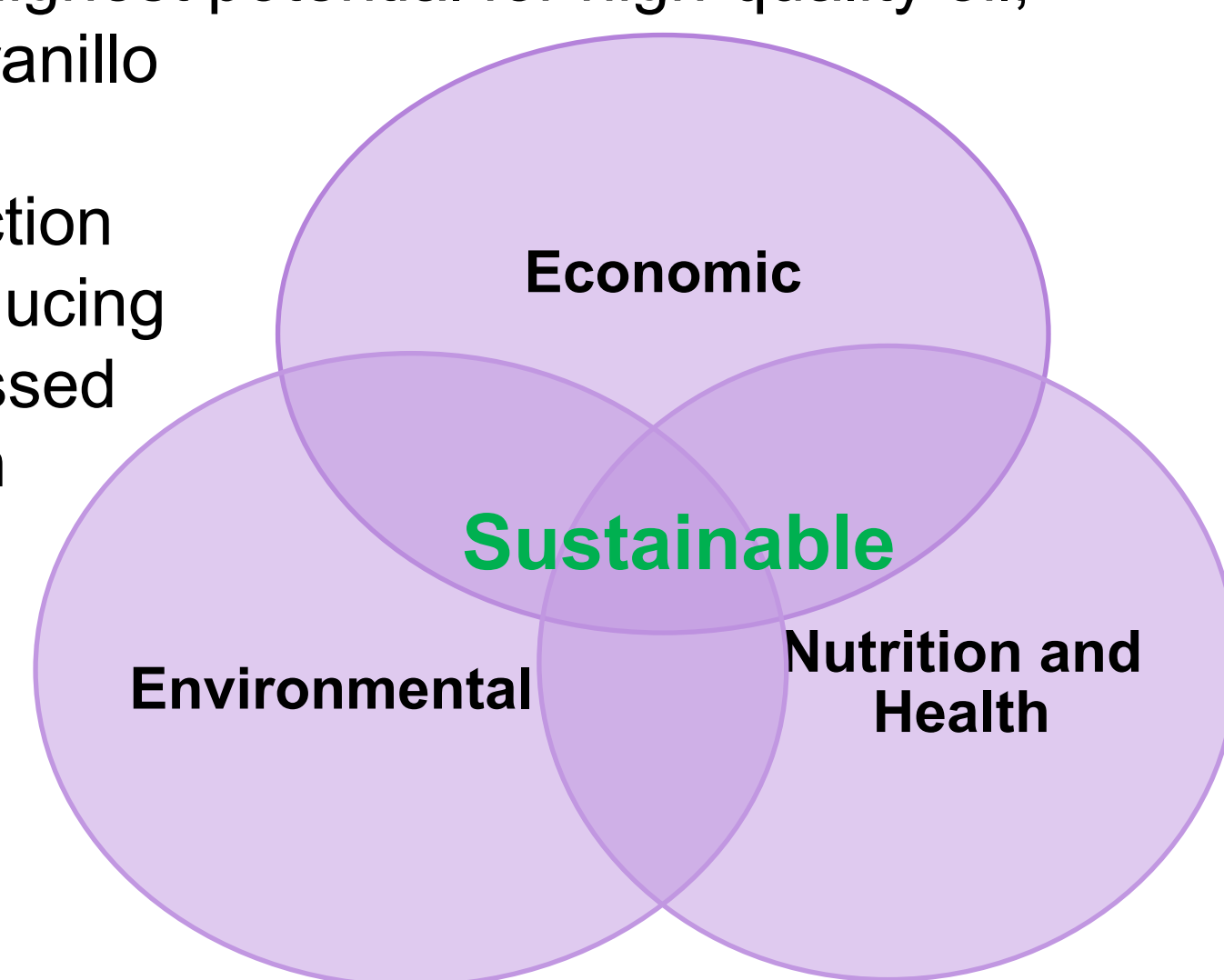
- Red grape seeds had a more pronounced brown color, and Pinot Noir seeds were the largest (Table 1).
- Temperature and moisture content significantly affected seed oil extraction. Optimal extraction for cold-pressed oil was at 49°C and 6% moisture content (Figs.3 and 4).
- Pinot Noir and Tempranillo had the highest seed separation rates. Pinot Noir and Syrah achieved the highest oil extraction rates (Table 3).
- Seed oil from the red varieties showed higher absorbance at 420 nm (yellow), while white varieties showed higher absorbance at 620 nm (green) (Table 2).
- Pinot Noir showed the highest potential profit, followed by Tempranillo, Syrah, and Albariño (Table 3).

Discussion

- Heat weakens seed cell structures, enhancing oil release and diffusion, but overheating can reduce efficiency by compacting the seed meal.
- Moisture softens seed walls, improving pressing efficiency, but excessive water prevents sufficient pressure for effective extraction.
- Red varieties, Pinot Noir and Tempranillo, showed good oil production potential due to high seed separation after wine fermentation, and low pressing pressure during production. Syrah's high extraction rate makes it a strong candidate if the pomace could generate after fermentation.
- White varieties yielded less oil due to lower seed separation, as pomace was generated before fermentation.
- Red variety seeds likely contain more phenolics, explaining higher absorbance at 420 nm (yellow), while white varieties probably have more chlorophyll, leading to higher absorbance at 620 nm (green).

Conclusions and Significance of Project

- Red grape pomace generally yielded more oil, with Pinot Noir showing the highest potential for high-quality oil, followed by Tempranillo and Syrah.
- The optimal extraction conditions for producing premium cold-pressed oil were 49°C with 6% water content.
- Cold-pressed oil extraction yields are lower than those from solvent methods, but the oil quality is higher.



Future Research

- Investigate the shelf life, fatty acid, vitamin E content, and stability of Pinot Noir, Tempranillo, and Syrah seed oils.
- Explore the commercialization potential in the food, cosmetics, and pharmaceutical industries.
- Explore additional uses of grape pomace to further enhance its value and increase farmers' profitability.