

# The Effect of Sulfates and Residual Sugars on Wine pH Level

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# Introduction

**Background:** The main goal of this study is to determine the relationship between our explanatory variables the level of sulfates and residual sugars on the response variable pH level of wine. We expect that as there is an increase in sulfates in the wine, there will be a more acidic pH level ( $\text{pH} < 7$ ). Additionally, we expect that as residual sugars increase the wine's pH level will increase to become more neutral ( $\text{pH} = 7$ ).

**Research Question 1:** Is there an effect of added sulphates on the pH of the wine?

**Research Question 2:** Is there an effect of the residual sugars on the pH of the wine?

# Method

## Sample Data:

- Our dataset was found on the website Kaggle and was non-random as it was measuring a population of wines
- Observations were taken from red variants of the Portuguese "Vinho Verde" wine
- Our final sample size was 976 observations
  - we had to remove 167 outliers that created significant effects
- Our study focused on the variables pH residual sugars and sulfates
  - pH was measured in standard pH values
  - We converted and measured sulfates as a categorical variable based on the IQR
    - levels included: "Low", "Medium", and "High".
  - Residual sugars were measured in grams

## Analysis Method:

- To analyze the dataset we utilized the program R to check normality and to generate a linear model
- we used the functions:
  - `mylm <- lm()`
  - `summary(mylm)`
  - `cor.test()`

# Descriptive Statistics

## Response Variable:

- pH

- pH is the concentration of hydronium and hydrogen ions in a solution, there is an appropriate range in which the pH of a wine can be
- lower pH means the wine is more stable which is why winemakers add sulphates to their wines

	Median	Range	Min	Max	Sulphate Frequency		
pH	3.32	(2.92, 3.69)	2.92	3.69	Low	Medium	High
Res. Sugar Centered	-0.01	(-1,1.45)	-1	1.45	119	687	170

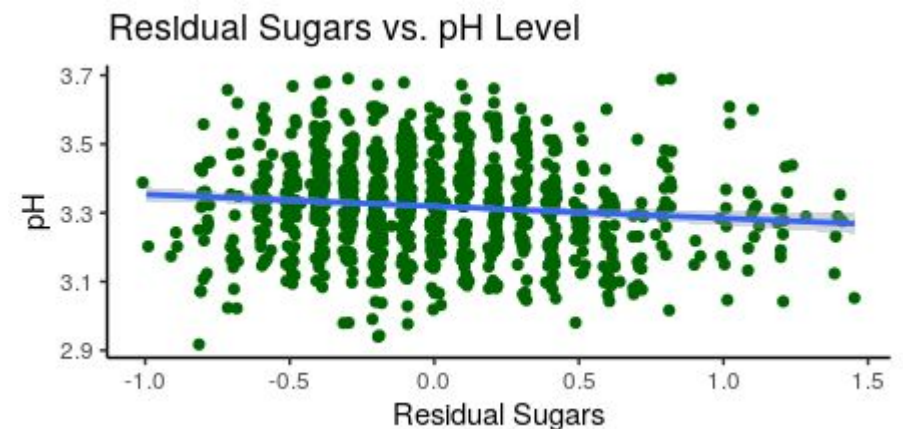
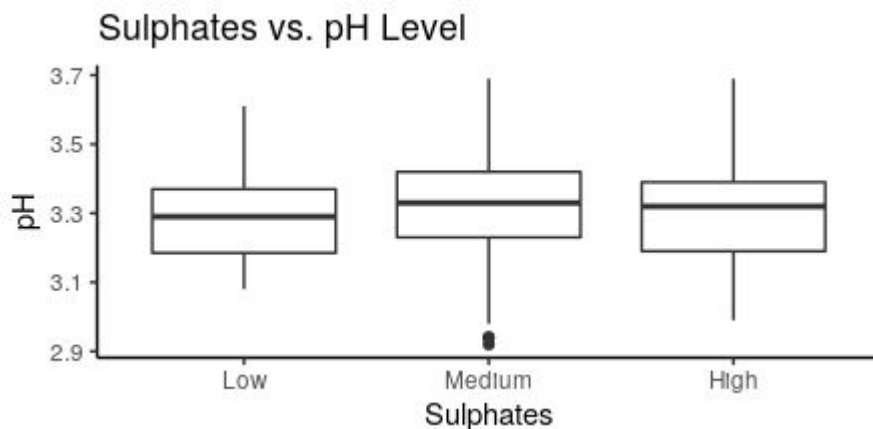
## •Explanatory Variables:

### •Sulphates

- sulphates are added to wine to increase their stability by preventing oxidation
- oxidation can cause the color and flavor of the wine to change and is undesirable in the winemaking process

### •Residual Sugars

- residual sugars are the sugars left over in a wine after fermentation. Too many residual sugars can cause the wine to ferment a second time in the bottle. This compromises the stability of the wine

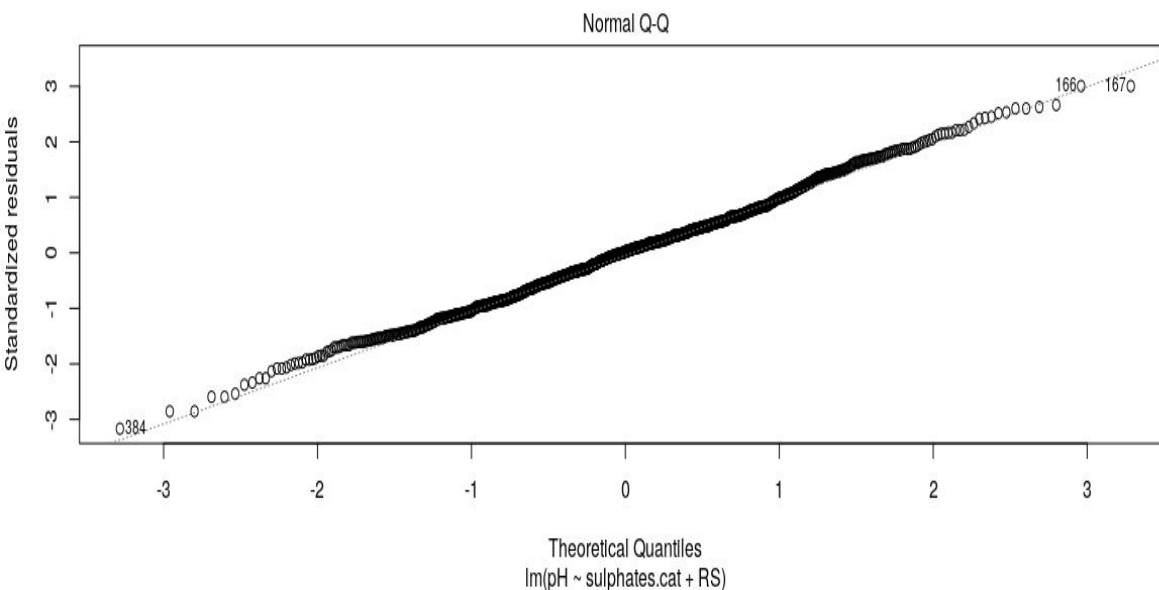
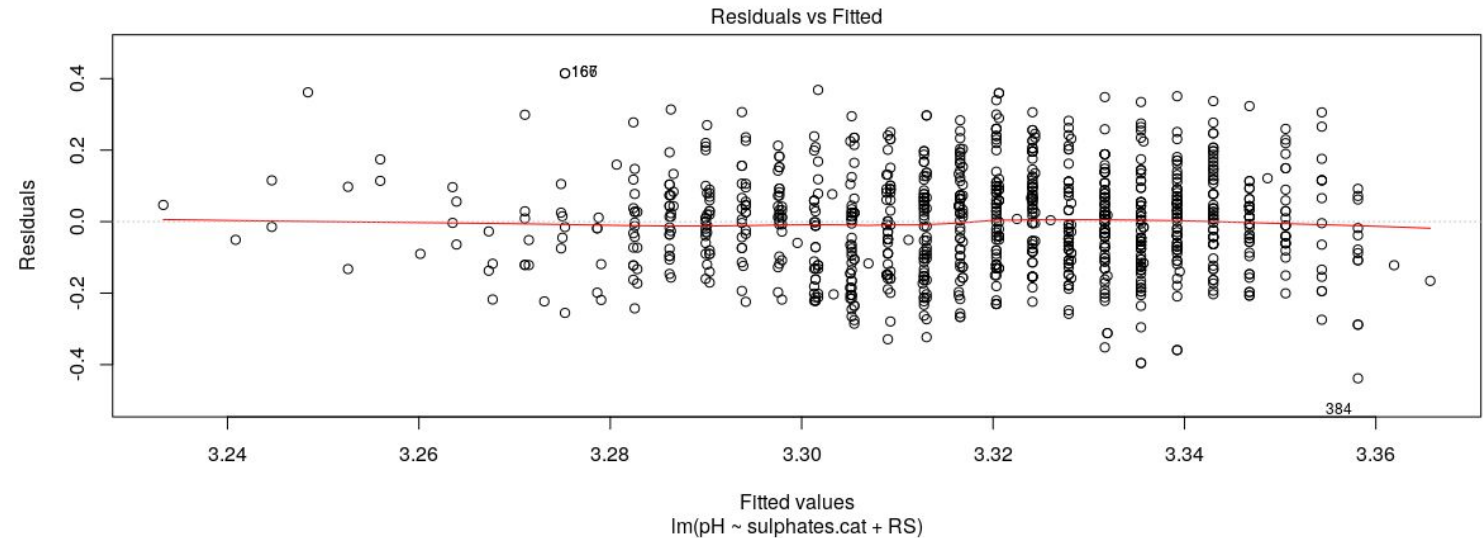


# Assumptions

## Assumptions: Linearity, Equal Variance, and Normal Distribution

Linearity and Equal Variance:

- The Residual Plot shows a random pattern supporting linearity
- The plot shows no pattern or funneling indicating the data shows equal variance



### Normal Distribution

- The QQ plot distribution is normally distributed
- Median value of the points falling at -0.02 and a Range of only (-0.48,0.67)
- We removed the outliers

# Results

## Results:

Call:

```
lm(formula = pH ~ sulphates.cat * RS_c, data = dfE)
```

Residuals:

	Min	1Q	Median	3Q	Max
	-0.44351	-0.10082	0.00311	0.08674	0.42493

Coefficients:

	Estimate	Std. Error	t value	Pr(> t )	
(Intercept)	3.305555	0.010624	311.132	<0.00000000000000002	***
sulphates.catLow	-0.012823	0.016874	-0.760	0.4475	
sulphates.catMedium	0.022642	0.011869	1.908	0.0567	.
RS c	-0.050354	0.023265	-2.164	0.0307	*
sulphates.catLow:RS c	0.068362	0.036825	1.856	0.0637	.
sulphates.catMedium:RS_c	0.005988	0.026204	0.229	0.8193	

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Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1385 on 970 degrees of freedom

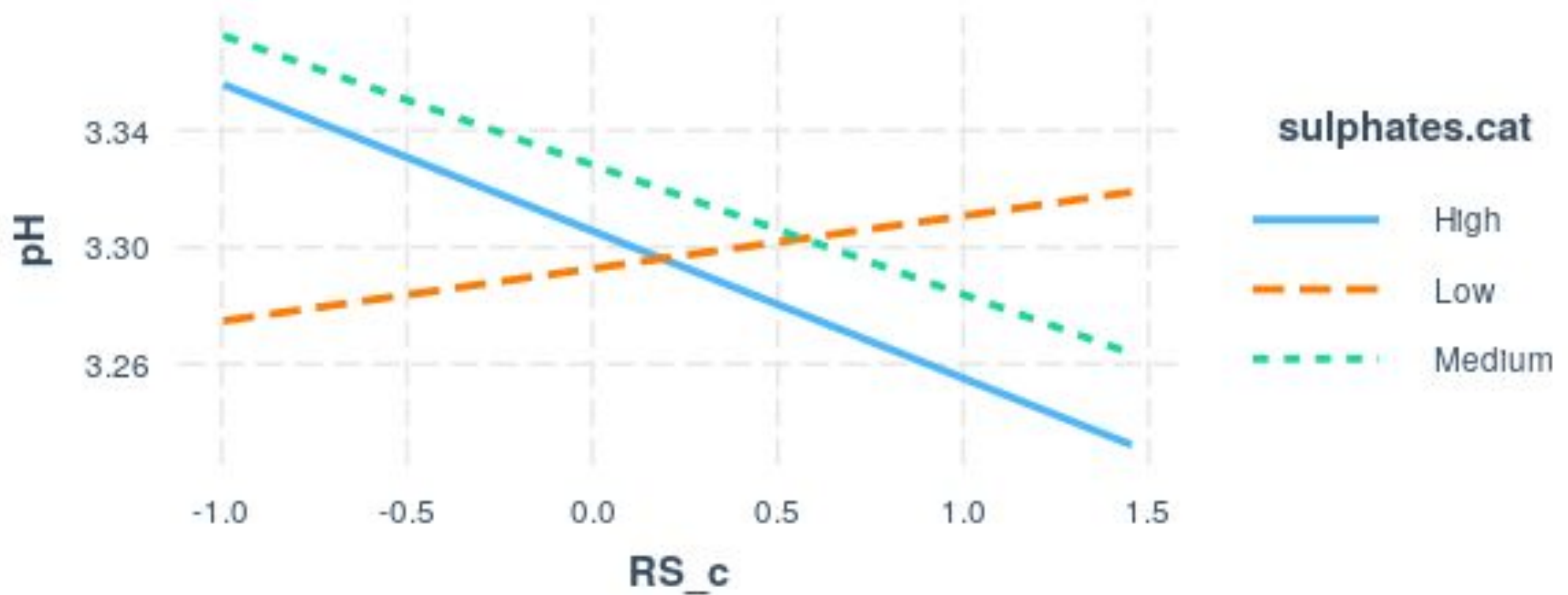
Multiple R-squared: 0.02761, Adjusted R-squared: 0.0226

F-statistic: 5.508 on 5 and 970 DF, p-value: 0.00005218

## Equation

$$Y = 3.31 - 0.02(\text{sulphates.catLow}) + 0.02(\text{sulphates.catMedium}) - 0.04(\text{RS\_c})$$

# Results



## Interaction Plot:

- The variable 'residual sugars' is mean-centered
- Does the effect of residual sugars depend on sulphates?
  - It appears there may be an interaction between residual sugars and low sulphates, but the summary shows that the p-value is greater than (0.05)
  - sulphates.catLow:RS\_c ( p = 0.0637)

# Discussion

## Interpretation:

- **Research Question 1:**
- no significant effect of added sulphates on the pH of the wines
- p-values greater than 0.05
- sulphates.cat.Low ( $p = 0.45$ )
  - Intercept = -0.01
- sulphates.cat.Medium ( $p = 0.06$ )
  - Intercept = 0.02
- **Research Question 2:**
- There is a significant effect of residual sugars on the pH of the wines
- The p-value was significant
- Residual Sugars ( $p = 0.03$ )
- intercept = -0.05
  - Each residual sugars equals 0.05 less pH



# Implications/Future Directions

- 1) Limitations:
  - An issue in our study was that we had many hidden outliers in our dataset that showed up after removing the first outliers. These values may have shifted our results to be more or less significant.
  - A possible confounding variable in our study may come from the variable citric acid, which could have easily shifted our pH values.
- 2) Implications and Future Research:
  - An implication of our study is that wine makers can influence the pH of wines utilizing residual sugars. We did not analyze all the possible variables that influence the pH of wine such as citric acid.
  - In a future study the effect of citric acid on pH could be tested
- 3) In a follow-up study:
  - more variables could be used in the model testing for the effect on pH.
  - A new more representative sampling of red wines in general could be used such as wine from a different vineyard

## References:

- Contributors, WebMD Editorial. "Why There Are Sulfites in Wine and How They Could Affect You." WebMD, WebMD, <https://www.webmd.com/diet/what-to-know-sulfites-in-wine#:~:text=Winemakers%20have%20been%20adding%20sulfur,the%20growth%20of%20unwanted%20microorganisms>.
- FS-52-W Commercial Winemaking ... - Purdue Extension. <https://www.extension.purdue.edu/extmedia/FS/FS-52-W.pdf>
- Sylvia Wu. "What Is Residual Sugar in Wine? – Ask Decanter." Decanter, 16 July 2020, <https://www.decanter.com/learn/residual-sugar-46007/#:~:text=At%20a%20certain%20level%2C%20residual,to%20make%20them%20more%20palatable>.