COMPARATIVE ANALYSIS OF TWO SUCCESSIVE VINTAGES OF CABERNET SAUVIGNON MUST AND PRE-BARREL WINE FROM TWO DISTINCT SOIL TYPES

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By

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COMMITTEE MEMBERSHIP

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ABSTRACT

Comparative Analysis of Two Successive Vintages of Cabernet Sauvignon Must and Pre-Barrel Wine from Two Distinct Soil Types

Jon Page

The objective of this study was to determine if there were significant statistical differences in the response variables of Cabernet Sauvignon must and pre-barreled wine analyzed from two vintages from two distinct soil types.

Research was conducted at California Polytechnic University, San Luis Obispo to examine the quantitative chemical analysis of 22 different response variables of Cabernet Sauvignon grapes. The same 22 variables were analyzed in must and pre-barreled wine samples harvested from both Calodo Clay Loam soil and Zaca Clay soil. The analyses were done at both California Polytechnic University, San Luis Obispo and Vinquiry Inc. Labs. The results were then statistically analyzed and results recorded.

The results for the vintage year for must showed that 15 of 22 response variables or 68.2 % tested significant at the $P<0.05$ level. From these 15 significant variables for must 4 of the variables tested significant for year * soil interaction at the $P<0.05$ level. The vintage year results for pre-barrel wine showed 9 of 22 response variables or 40.9 % tested significant at the $P<0.05$ level. The results for the variables for must and pre-barrel wine in the vintage year showed 24 of 44 variables or 54.5% were significant at the $P<0.05$ level. These results seem to indicate that there is a very strong probability that the vintage year has a significant effect on the Cabernet Sauvignon grapes.

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Introduction

1.1 Vineyard Terroir Study

Vineyard terroir is a concept that encompasses the influences of soil, geography, geology, macro and meso climates of a certain area on the grapes (Gladstones and Smart,1997). This idea has been in circulation for a long time. These characteristics with the right winemaker can create a unique wine that is consistent from year to year. If a producer knows the right cultivar to plant in the correct soil the job of making quality wine becomes easier. Wine is said to be grown in the field. One cannot make good wine with bad grapes. Many grape growers are constantly struggling to raise a consistently productive quality crop. Yearly consistency in the quality of wine grapes is beneficial to the winemaker in producing a quality product. A winery that has a consistent quality product may well attract a larger customer following and increase revenue.

In 2004 the Soil Science Department of California Polytechnic State University, San Luis Obispo conducted a three year research project funded by the John Deere company. John Deere was specifically interested in research data pertaining to their soil moisture sensors that were being produced.

Cal Poly researchers decided to conduct their research at the Carmody/McKnight Vineyards in Paso Robles, California. They had found a block of Cabernet Sauvignon grapes that were bisected by two distinct soil types. These two soils were determined to be Calodo Clay Loam and Zaca Clay.

The important aspects of the soil research portion were identified and an appropriate experimental design was designed and used for the experiment. The Cabernet Sauvignon grapes from the two soil types would be harvested and the must and pre-barreled wine would be chemically analyzed for 22 predetermined variables. The variables to be analyzed are Brix, pH, titratable acidity, color at A420 nm & A520 nm, intensity & hue, total SO_2, free SO_2, copper, iron, potassium, calcium, assimilable amino nitrogen, ammonia, sucrose, reducing sugar, acetic acid, lactic acid, malic acid, tartaric acid, and total organic acid profile. The daily temperature and rainfall data for the vineyard were collected from an onsite weather monitor. Regional temperature and rainfall data were collected from the county weather service.

The scope of this report investigates if there are any significant differences in vintage years. The 2004 study (Olsen, 2006) compared if two distinct soil types significantly affected Cabernet Sauvignon grapes. This particular study compares data from the 2005 vintage year Cabernet Sauvignon grapes to the 2004 vintage year Cabernet Sauvignon grapes to examine if Cabernet Sauvignon grapes are significantly affected by vintage year.

1.2 Problem Statement

Are there any significant differences in the response variables for Cabernet Sauvignon must and pre-barreled wine of two successive vintages from two different soil types?

1.3 Hypothesis

It is anticipated that there will be a significant difference between two successive vintages of Cabernet Sauvignon must and pre-barreled wine analyzed from two distinct soil types. These differences will be quantified by chemical analysis of 22 different predetermined variables. The twenty-two response variables will then tested by statistical measures to determine if there are significant differences. The response variables to be tested for must and pre-barrel wine are as follows: Degrees brix, pH, titratable acidity, A420 absorbance, A520 absorbance, intensity, hue, total SO2, free SO2, Copper, Iron, potassium, calcium, assimable amino nitrogen, ammonia, sucrose, reducing sugar, acetic acid, lactic acid, malic acid, tartaric acid, and total organic acid profile.

1.4 Objectives

1) To determine if there are significant statistical differences in the response variables of two successive vintages of Cabernet Sauvignon must analyzed from two distinct soil types.

2) To determine if there are significant statistical differences in the response variables of two successive vintages Cabernet Sauvignon pre-barreled wine analyzed from two distinct soil types.

1.5 Justification

The John Deere company has commissioned and funded a three year study of vineyard terroir at a winery in the Paso Robles appellation. The goal is to quantitatively evaluate if there is a significant difference in soil. Cabernet Sauvignon grapes from two separate adjoining soil types in the vineyard will be collected and analyzed. The project is intended to identify if there are significant differences in the twenty – two response variables analyzed from the must and wine samples. This analysis would show if there is a significant difference between the two successive vintage years of Cabernet Sauvignon grapes grown on the two soils. The project is important to winemakers who source grapes from single estates or single vineyard plots. The grapes from these areas are grown in the same soil and the same cultural practices occur regularly but the climatic conditions can often change. These climatic variations can vary from several days, weeks, months or sometimes a year. An example being one year is hot and dry and the next is cool and wet. If a significant difference in terroir is determined this would be beneficial to winemakers. A winemaker would then have confidence that his or her wines from single vineyard sites would stay consistent from year to year.

Chapter 2

Review of Literature

2.1 Terroir Concept

Terroir is a very old concept that goes back to the time of the ancients. Wines by type were mentioned in The Epic of Gilgamesh circa 18th century B.C. There were also records of wine found in Egyptian Pharaoh's tombs that were recorded to the plots of land from which they were harvested.(Pott, 2004).

Terroir is a term that is not easily defined. There are varied meanings of terroir depending on where you are in the world and what cultural philosophies are followed. One concept includes soil, geology, topography, and climate all in interaction with each other (Gladstone and Smart, 1997). Another has the same aspects but includes regional cultural practices in the grape production (Renouil and Traversay, 1962). One of these practices in France is chaptalisation (chaptalization in American English). This is the practice of adding sugars to the must. The term has been changed to enrichissement du mout, (enrichment of the must) to destigmatise the practice. Enrichment of the must is allowed in cooler appellations of France but not in the southern appellations where the temperatures are warmer (Gade, 2004). A third researcher has tried to narrow down the previous parameters to four terms. The four terms encompass the elements of nutriment, space, slogan and conscious in the definition of terroir (Vaudour, 2002). The "nutrient" terroir takes into account the agronomical influences on individual sections of land or whole regions. The "space" terroir deals with the economic factors that influence the defined geographic area. "Slogan" terroir include ecological and community values within a certain geographic area and how the community perceives themselves as a whole. This perception is then conveyed to the public by means of media and advertising. "Conscious" terroir deals with socio-economic factors .

Terroir is a concept in many European wine making countries. It influences the type of grapes grown in certain regions and the types of wines produced there (Wilson, 1998). The French consider it so important that a government agency, the AOC, determines distinct growing regions and strict wine production rules (Gade, 2004).

Terroir in wine production is important because it influences the quality and yield of the grapes. For this reason the geographic location of a vineyard site is an important factor to be considered. German

vineyard locations are chosen for their excellent sunlight exposure, wind and cold tolerance, and good soil types (Hoppmann and Schaller, 1981a, 1981b). It has been suggested that a greater south facing slope inclination will increase the heat that is gathered from the sun (Robinson, 2006) thus increasing production. Regional differences in vineyard locations, supported by geographic and geological data, have shown to be beneficial in California (Sayed, 1992). These different regional variances in climate, microclimate and different soils impart different characteristics to grapes grown in different parts of California. These characteristics give wines their individual character. This is important to California as many different varietals are produced of varying complexities and flavor. This gives the consumer more choices of wines from different regions of the state. This in turn provides sales of wines to consumers inside and outside of California.

2.2 Soil

Soil is a major factor in choosing a vineyard site. Soils are important for mineral uptake. The vine takes up many minerals from the soil. Nitrogen is a vital mineral to the vines for growth. The amount of nitrogen found in natural soil that the vine uptakes can be considered an aspect of terroir (van Leeuwen et al., 2000). The nitrogen supply can be widely variable depending on the type of soil. The reason it is considered an aspect of terroir is because it is influenced by organic matter turnover. The turnover of soil organic matter is dependent on soil temperature, soil pH, soil moisture content and soil aeration (van Leeuwen and Seguin, 2006) . A vine that has a low uptake of nitrogen will be less robust and have a decreased yield and berry weight. Limited nitrogen uptake will also increase tannins, grape sugar in the berries and anthocyanins (Kliewer, 1971). The increased phenolic content in the wine and berries raises the production quality of red wine (Chone et al, 2001a). A soil that is deficient in nitrogen can be adjusted using nitrogen fertilizer. Soil is also important in the amount of water it can supply to the vine. The grape quality is influenced by a moderate water supply to the vines given at regular intervals (Seguin, 1975).Dry farmed or unirrigated plots face water deficits due to the fact the only water is from rainfall. This produces lower yields and smaller berries but increases the phenolic content of the berries. This is good for producing higher quality red wines (Duteau et al.,1981; van Leeuwen and Seguin, 1994, Koundouras et al., 1999; Chone et al., 2001a; Tregoat et al., 2002; van Leeuwen et al., 2004) A soil with a distribution of

clay helps the vines by increasing water storage capacity (Maltman, 2008). Bedrock materials, such as granite, sandstone, and shale, can help in the uptake of potassium (Woodbridge, 1990). Soils composed from serpentinite bedrock were found to be deficient in nutrients (Kruckeberg, 1986). A German study showed that soil types without climate interaction were significant to grape yields (Wahl, 1988).

2.3 Climate

Climatic conditions are important to imparting character to the grapes. Sunlight and temperature play a major role in the grape maturation in the vineyard site as well as the larger region (Hoppmann and Schaller, 1996). This influences the quality and character of the wine (Becker,1988). Lower daytime temperatures under 70 degrees Fahrenheit have shown that grapes tend to be high in acid and low in pH (Lasko and Kliewer,1975). This is good and bad for the winemaker. The pH range in wines is between 3.30 and 3.65 depending on varietal and winemaking preference. The acid range for wines is between 0.50 g/L and 0.85 g/L depending on varietal and winemaker style preference. Another factor is rainfall and how well the soil holds water for the vine to use (Van Leeuwen and Seguin, 2006).

2.4 Sensory

Sensory and chemical analysis experiments have been performed by numerous research groups to try and narrow the concept of terroir to scientific terms. Sensory trials have been conducted on Cabernet Sauvignon grapes over various vintages in numerous vineyards (Noble and Elliot-Fisk, 1990). Differences in Pinot Noir have been distinguished from each other (Guinard and Cliff, 1987) as well as Gewürztraminer (Reynolds et al, 1995, 1996).

2.5 Chemical Analysis

Brix is a measurement of sucrose and soluble solids in grape must at 20 degrees C (68 degrees F). This measurement is important as it will give an idea of how much alcohol can be produced from the must. Usually 0.56 of the initial brix reading will convert to alcohol. A brix reading of 24 degrees would produce between 12-13 % alcohol. The measurement of one degree brix is one gram of sucrose per one hundred grams of solution. This equates to a percentage weight to weight ratio. A hydrometer, refractometer or densitometer can be used to measure brix.

The pH scale is an indicator of how acidic or alkaline an aqueous solution is. In this case it is wine. Wines, depending on varietal, range between a pH of 3.30 and 3.65 at 25 degrees C (77 F). A solution is measured with a pH meter. The probe is suspended in the solution and measures the amount of hydrogen ions present. The instrument then generates a number corresponding to the concentration of the hydrogen ions present in the solution. A low pH has a higher concentration of ions than a higher pH does. By using a pH meter to measure the hydrogen ions a winemaker can adjust their wine to fit within this pH range.

Titratable Acidity (T.A.) is important because it measures the concentration of organic acids in the wines. The acids help to chemically stabilize the wine and give it balance. The desired range depending on varietal is between 0.60 and 0.90. A wine is measured after fermentation to check the T.A. and after any acid additions to check the wine to see if it is still within the desired range.

Color analysis is done to check the colors of red, brown, and yellow in wines. All light wavelengths are measured in nanometers. The spectrometer is a machine that measures the absorbance of light at all visible wavelengths. A wine sample is placed in the spectrometer and measured at absorbance level 420 nanometers (A420) and again at absorbance level 520 nanometers (A520). The absorbance of A420 will produce a complimentary color of yellow. The Absorbance of A520 will produce a complimentary color of red. By adding A420 and A520 together (A420 + A520) you get a value for intensity. Intensity is how bright or dim the color is. By dividing A420 by A520 (A420/A520) you get a value for Hue. Hue is important because the number gets larger as the wines begin to age.

Chapter 3

Methods and Materials

3.1 Procedures for Data Collection

Each sample lot was picked and stored in a labeled macro bin at Carmody/Mcknight. Directly afterward three two gallon freezer bags of must sample were collected from each bin. These were transported to Cal Poly and stored for subsequent analysis in the flash freezer. The must in the macro bins at Carmody/McKnight were allowed to ferment to dryness. Directly after becoming dry three two gallon freezer bags of pre-barreled wine were collected from each bin. These were transported to Cal Poly and stored for analysis in the flash freezer.

3.1.1 Treatments

There are six treatment variables in this experiment. They are the two distinct soil types to be evaluated. The two soils are a Calodo Clay Loam soil and a Zaca Clay soil. The second two are the two vintage years, 2004 and 2005. The third two are the Cabernet Sauvignon must and Cabernet Sauvignon wine.

3.1.2 Experimental Unit

The Cabernet Sauvignon block bisected by the two soils were located at Carmody/McKnight Vineyards in the Paso Robles AVA. The block is located on a south facing slope. The Zaca Clay soil is on the north end of the block and runs about half way down the slope. The Calodo Clay Loam runs from the middle of the block in a southward direction to the end of the block. The grapes from the Zaca Clay soil were collected from the upper slope of the block and the Calodo Clay Loam was collected from the lower slope of the block. There were 5 sample blocks for each of the soil locations. Samples were taken from all blocks. Each sample block was 3 rows wide. The length of each row in each sample block was comprised of 35 individual plants. The next sample block was in a south running direction diagonally from the first block. Block three was north of block two and diagonal. This pattern was the same for each block in each soil. The sample plots for each soil were separated by 70 plants.

3.1.3 Experimental Design and Number of Replications

The design unit was a completely randomized design with a factorial arrangement of treatments. The design was chosen to compensate for the variability in the soil blocks in the field. The factorial arrangement was used because there were six treatments comprised of the two soils, two years, must, and wine

3.2 Procedures for Data Analysis

Each sample of pre-barrel wine were analyzed at Cal Poly for brix, pH, titratable acidity, color at A420 nm and A520 nm, intensity and hue. Each analysis was conducted ten times. These numbers were then averaged and the means recorded for each sample plot (see Appendix for data).

3.2.1 Brix

A sample of 2-3 ml of wine was placed by pipette onto a handheld digital refractometer and the measurement was recorded. The device was cleaned with deionized water (DI) and the instrument recalibrated to 0 degrees Brix between each measurement. A refractometer is usually used for juice. In this case it was used to gather the same data, used in the same way, and then compare that data to a previous study.

3.2.2 pH

A sample of 30-35 ml of wine was placed in a clean beaker. This was then measured with a recalibrated pH meter. The meter had been calibrated at pH buffers of 4, 7, and 10. The pH measurements were recorded.

3.2.3 Titratable acidity

200 ml of deionized water (DI) was boiled and placed in a 500 ml beaker. A pre - calibrated pH meter was used to measure the sample while being titrated. A 2 ml sample of wine was put in the water and titrated to a pH value of 8.2 using 0.1 N NaOH solution. A 5 ml sample of wine was then added to the water and

titrated to pH 8.2 using 0.1 N NaOH. The NaOH used was recorded and used to determine the measurement of titratable acid.

3.2.4 Color analysis

A digital color spectrometer was allowed to warm up for ten minutes before a cuvette with deionized (DI) water was inserted as a blank and the absorbance set at 420 nm. Two ml of sample was filtered through a 0.45 micron filter into a clean beaker. The sample was then diluted 1:10 with deionized (DI) water and placed in a cuvette for reading in the spectrometer. Absorbance and transmittance were recorded. This procedure was repeated on each sample for 520 nm.

3.2.5 Intensity

The intensity value for each sample was calculated by adding the absorbance value at 420 nm to the absorbance value at 520 nm. (A420 nm + A 520 nm) .

3.2.6 Hue

The Hue value for each sample was calculated by dividing the Absorbance value at 420 nm by the Absorbance value at 520 nm. (A420 nm / A520 nm.

3.3 Data Analysis Performed at Enardis Vinquiry Labs

Must and pre-barrel wine samples were sent to Enardis Vinquiry Labs in Napa, CA for analysis. The must samples were tested for Brix, pH, titratable acidity, color at A420 nm & A520 nm, intensity & hue, total SO_2, free SO_2, copper, iron, potassium, calcium, assimiable amino nitrogen, ammonia, sucrose, reducing sugar, acetic acid, lactic acid, malic acid, tartaric acid, and total organic acid profile.

The wine samples were tested for total SO_2, free SO_2, copper, iron, potassium, calcium, assimiable amino nitrogen, ammonia, sucrose, reducing sugar, acetic acid, lactic acid, malic acid, tartaric acid, and total organic acid.

Chapter 4

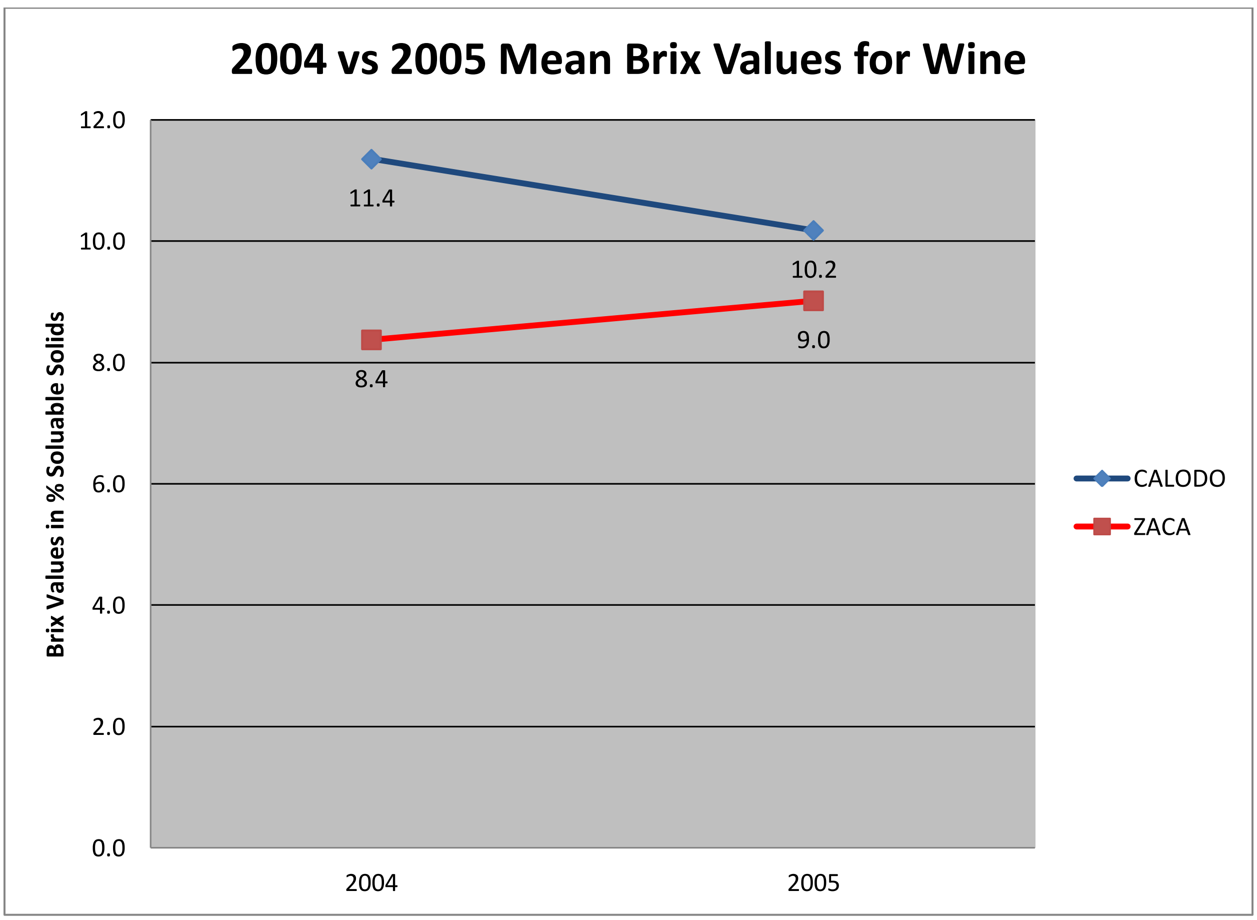
Results and Discussion

4.1 Pre -Barrel Wine Analysis Tested at Cal Poly

4.1.1 Brix

The Brix analysis for wine showed a highly significant difference between soils with a P value of 0.001. The Calodo Clay Loam soil had a higher means than the Zaca Clay soil. The difference in vintage years and year * soil interaction was not significant at the $P < 0.05$ level. Brix is not measured in dry wine. The reason it was done was to compare data to the previous year's study. The data was inadvertently collected and analyzed. The graph data does not reflect a Brix reading but more a refractive index of the wine.

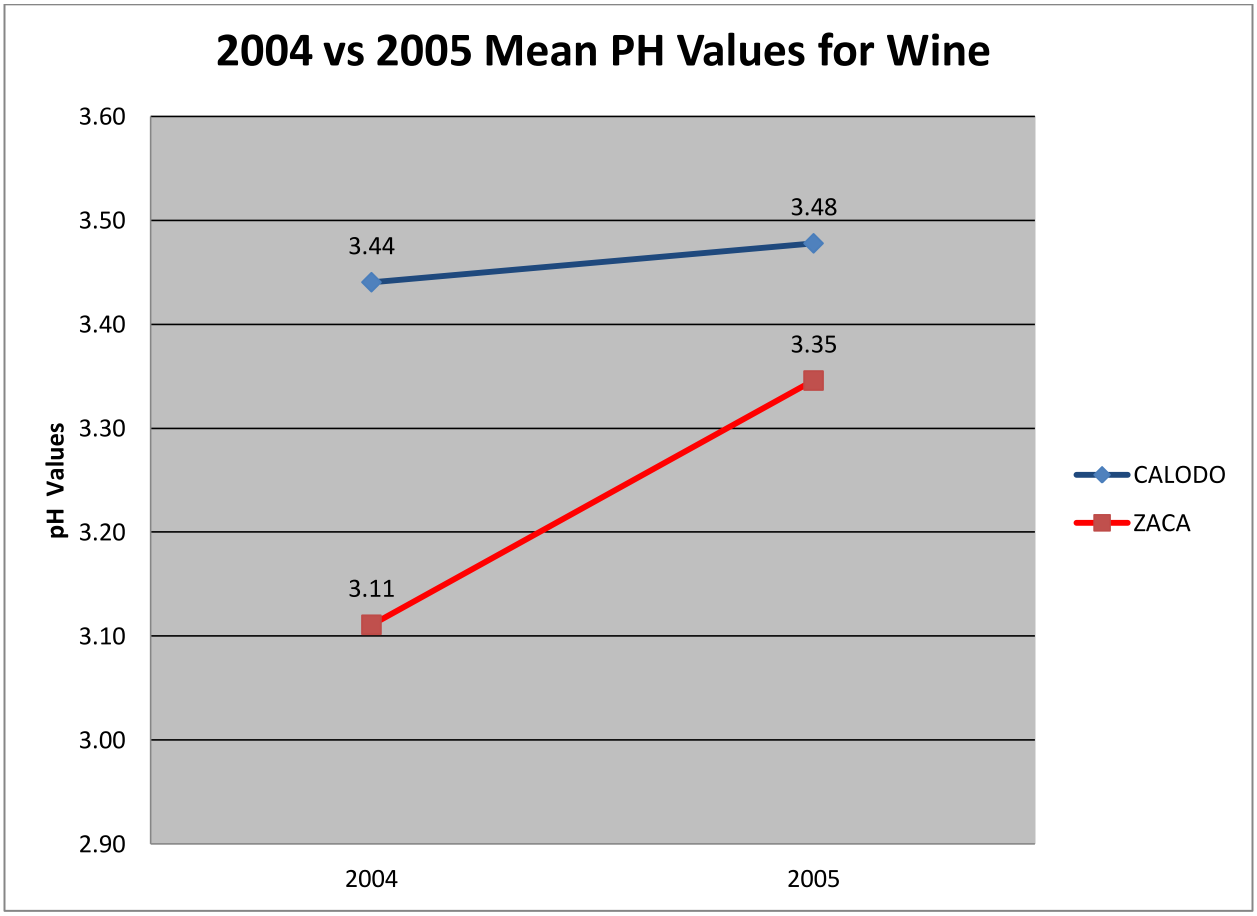
Figure 1: Mean Brix Values for Wine



4.1.2 pH

The pH analysis for wine showed a highly significant difference between soil with a P value of 0.00. The Calodo Clay Loam soil had a higher mean. There was a significant difference between vintage years with a P value of 0.015. The 2005 year had a higher mean. There was not a significant difference between year * soil interactions at the P < 0.05 level.

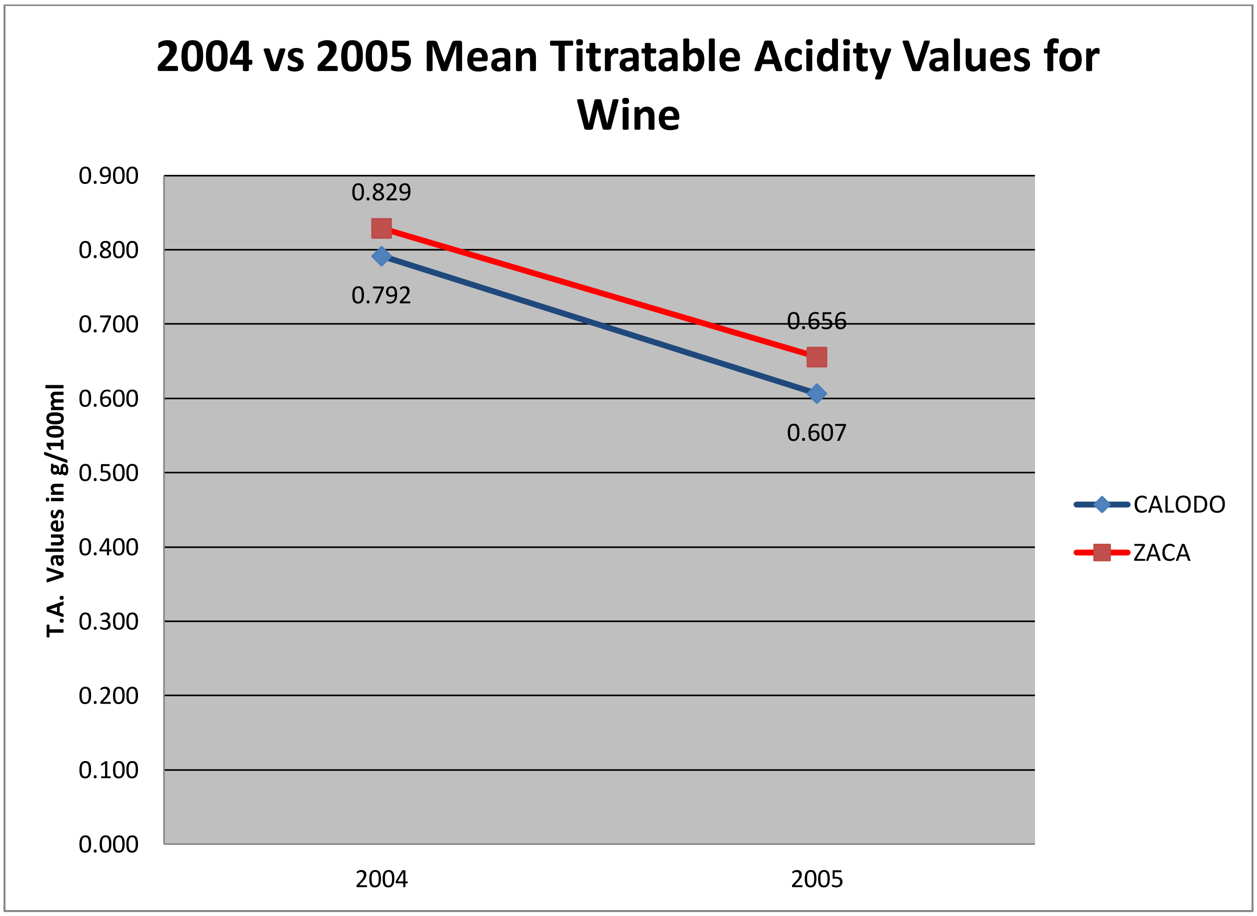
Figure 2: Mean pH Values for Wine



4.1.3 Titratable Acidity

The analysis for titratable acidity in wine showed a highly significant difference between vintage years with a P value of 00.000. The 2004 vintage had a higher mean than the 2005 vintage. The difference between the soils and the year * soil interaction was not significant at the $P < 0.05$ level.

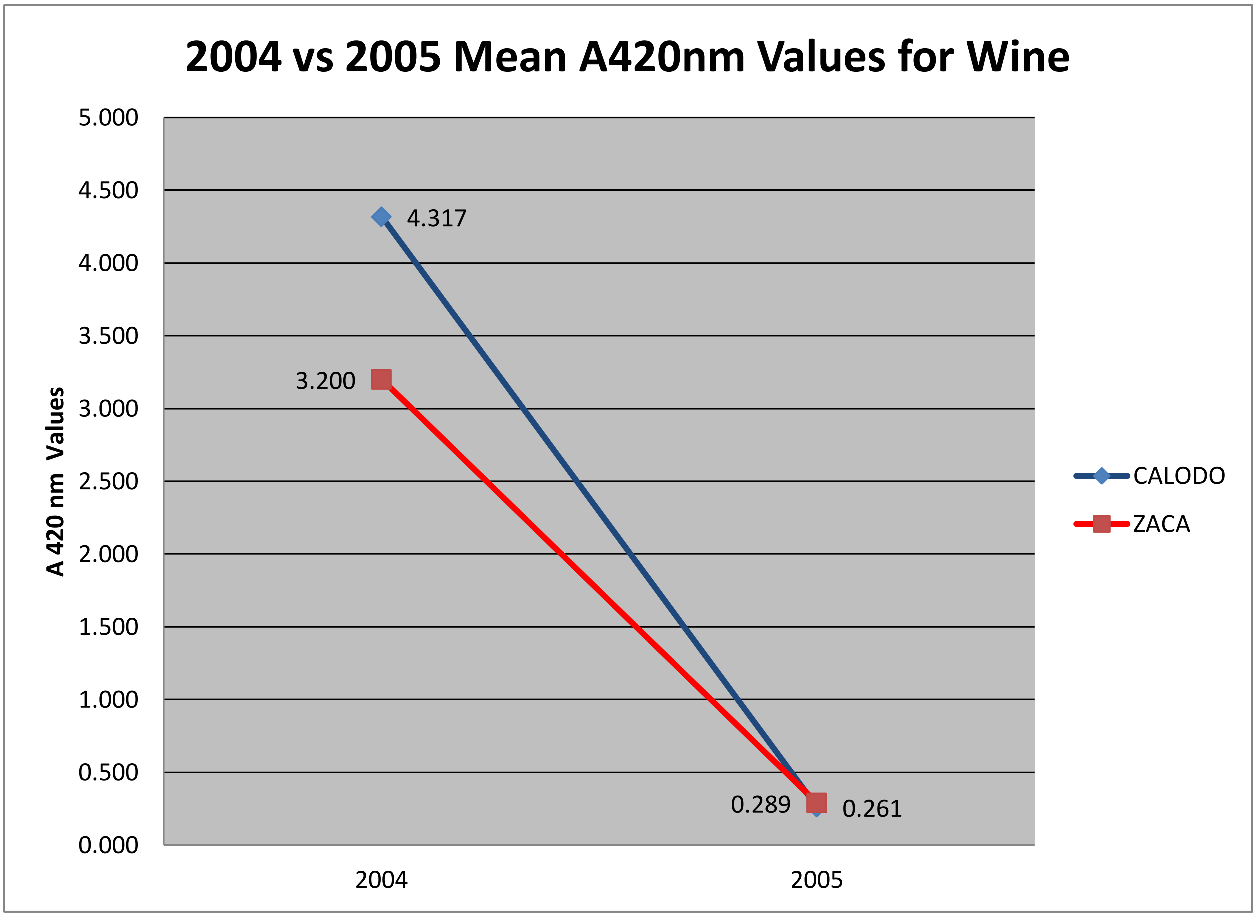
Figure 3: Mean Values for Titratable Acidity for Wine



4.1.4 Absorbance at 420 nm

The analysis for A420 nm color absorbance in wine showed a highly significant difference between vintage years. There was a significant difference between soils and between year * soil interaction. The vintage year was highly significant with a P value of 00.000. The 2004 year had a higher mean than 2005. The difference in soils was significant with a P value of 0.015 with Calodo Clay Loam soil having a higher mean. The year * soil interaction had a P value of 0.011 with the 2004 vintage year Calodo Clay Loam and Zaca Clay soils having a higher mean than the 2005 vintage year.

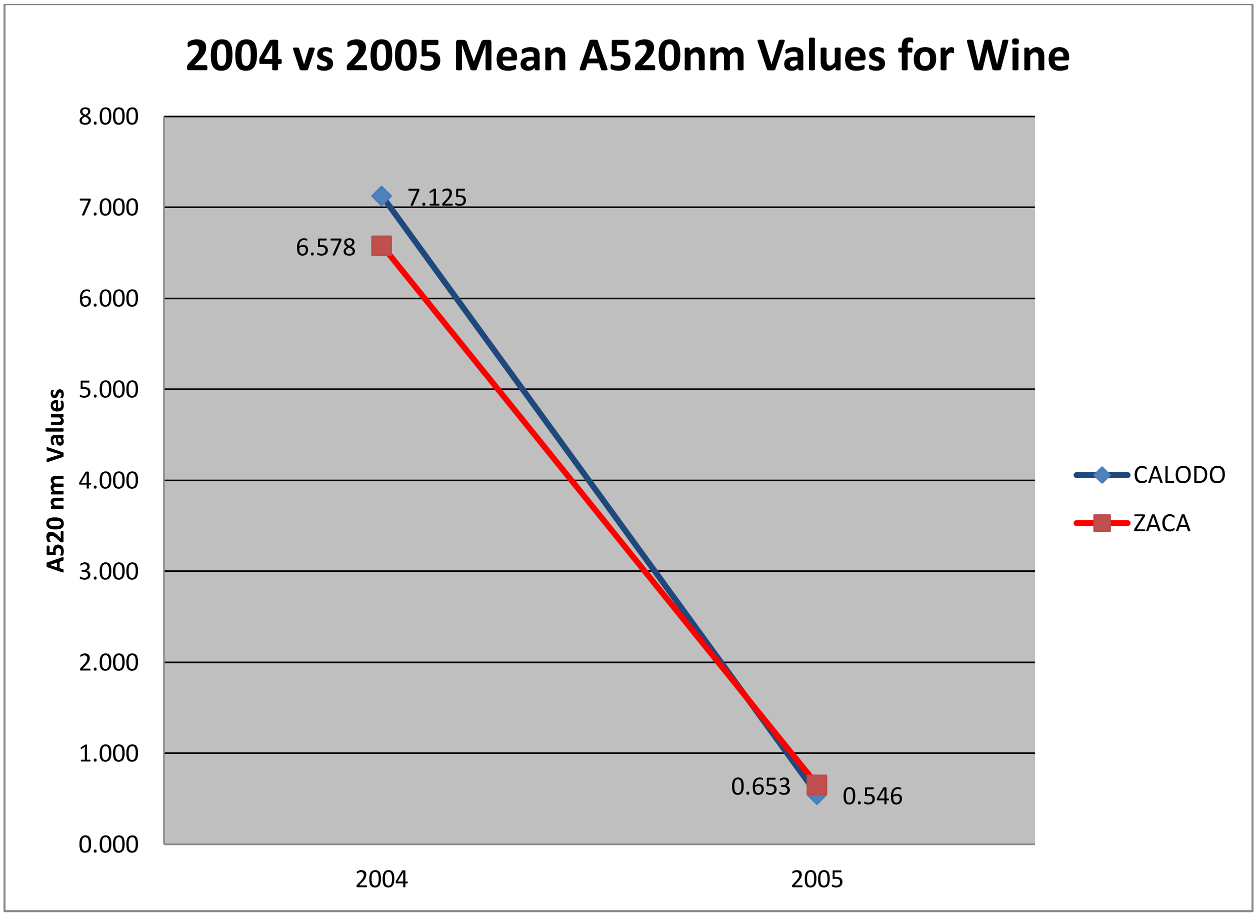
Figure 4: Mean Color Absorbance at 420 nm for Wine



4.1.5 Absorbance at 520 nm

The analysis for A520 color absorbance in wine showed a highly significant difference between vintage years with a P value of 00.000. The 2004 vintage year had a higher mean. The soil and year * soil interaction were not significant at the $P < 0.05$ level.

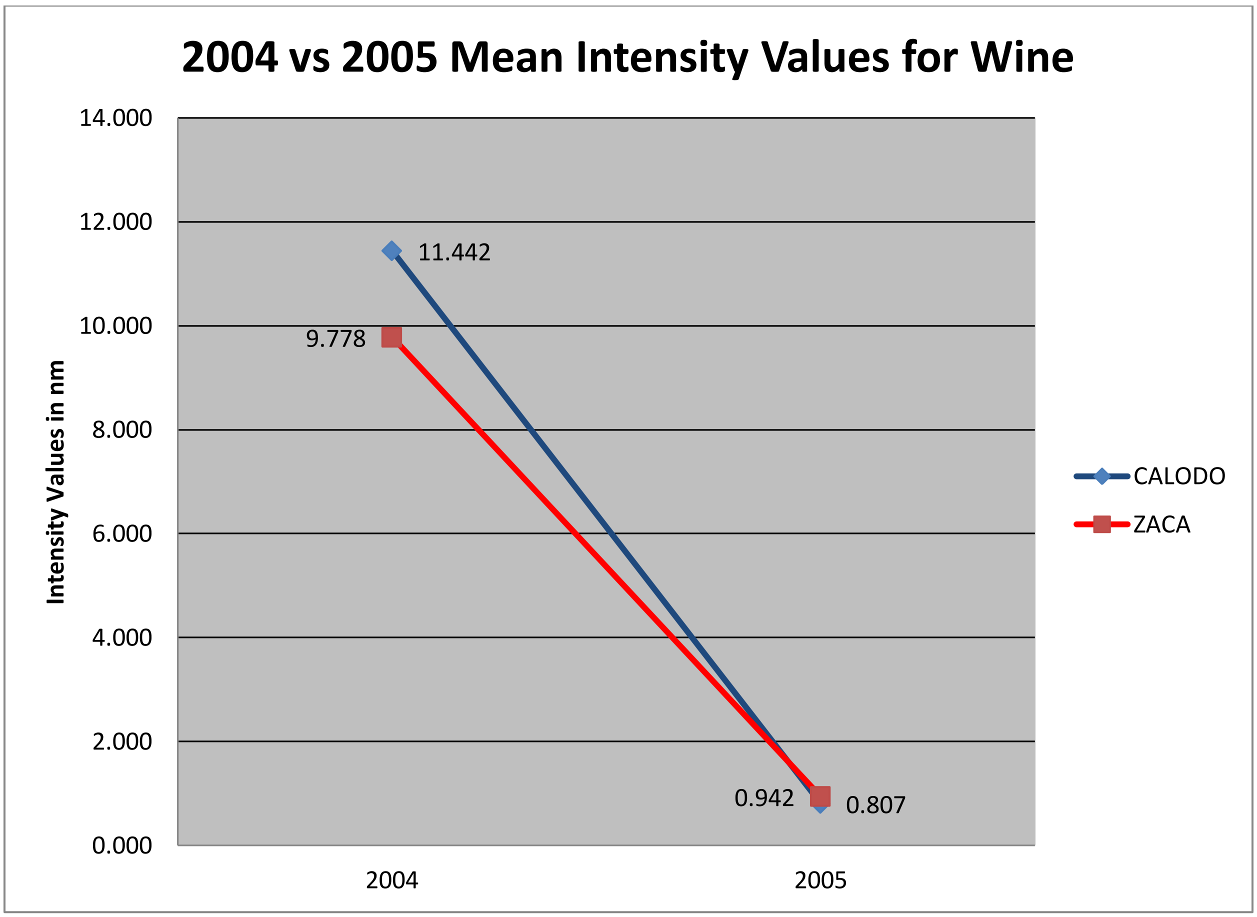
Figure 5: Mean Color Absorbance at 520 nm for Wine



4.1.6 Intensity

The analysis for intensity in wine showed a highly significant difference between vintage years with a P value of 0.000. The 2004 year had a higher mean than 2005. The soil and year * soil interaction were not significant at the $P < 0.05$ level.

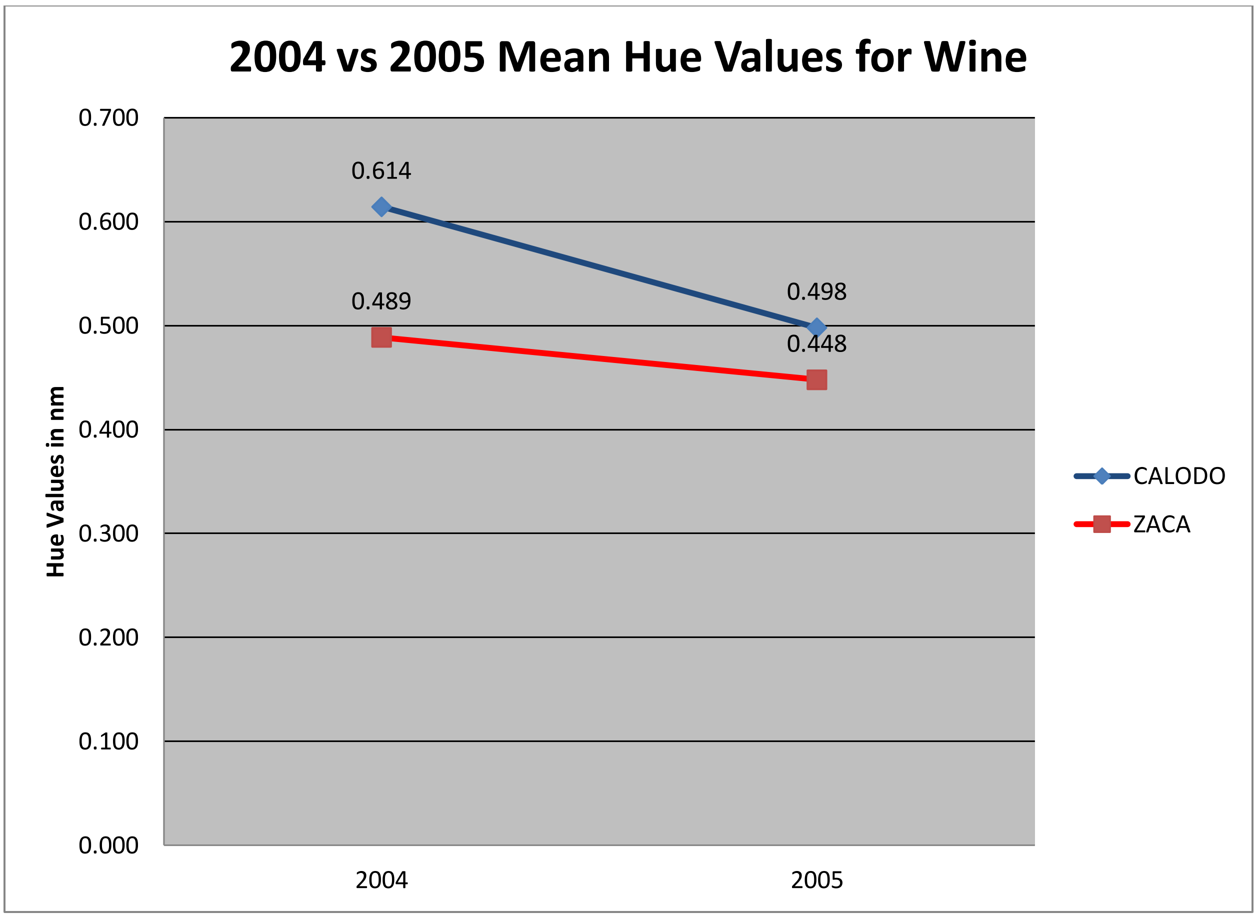
Figure 6: Mean Intensity Values for Wine



4.1.7 Hue

The analysis for hue in wine showed a highly significant difference between vintage years and between soils. The year * soil interaction was not significant at the $P < 0.05$ level. The vintage years had a P value of 0.003 with the 2004 year having a higher mean. The soil had a P value of 0.001 with the Calodo Clay Loam soil having a higher yield.

Figure 7: Mean Values for Hue Color for Wine

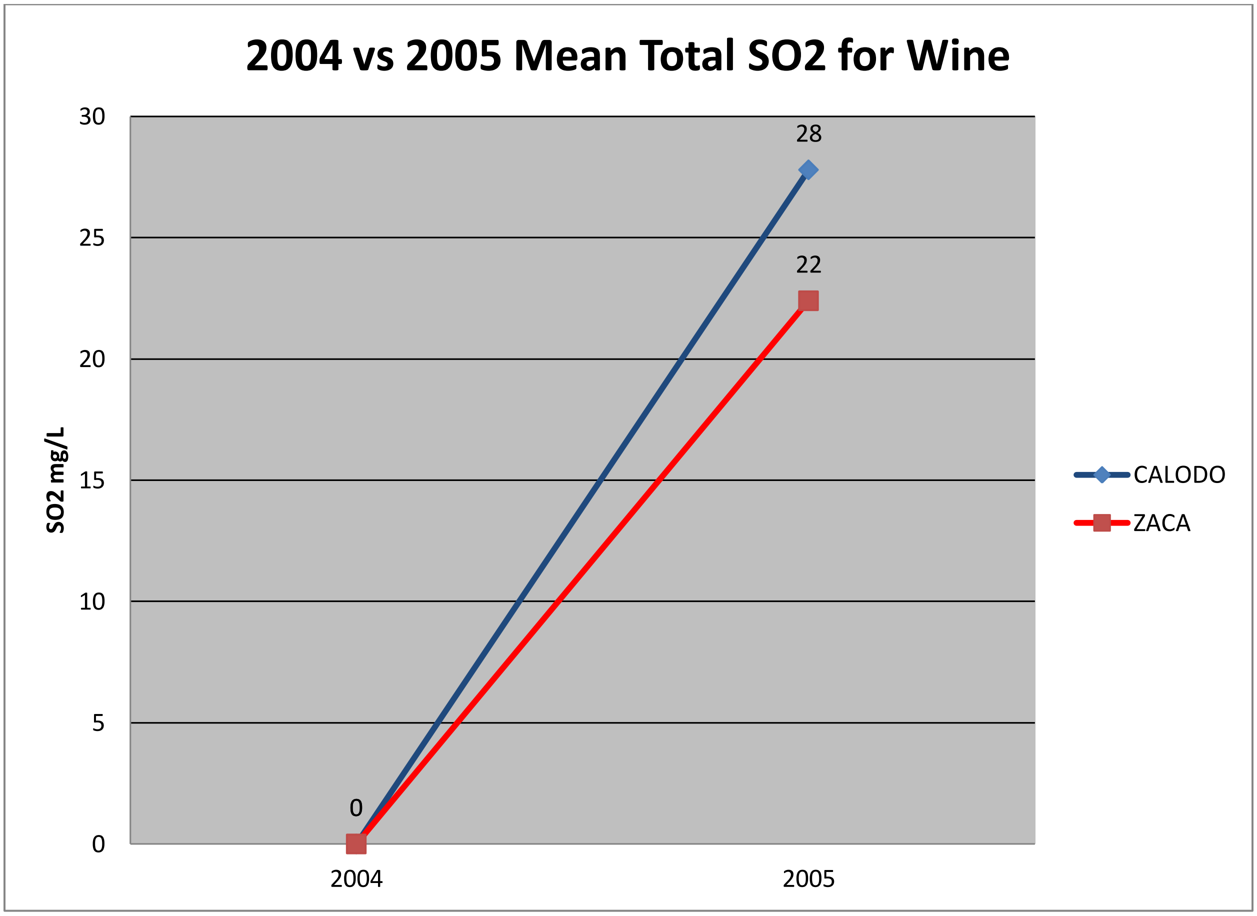


4.2 Pre-Barrel Wine Analysis tested at Enardis Vinquiry Labs

4.2.1 Total SO 2

The analysis for SO2 in wine showed a highly significant difference with a P value of 00.000. The 2005 vintage year had a higher mean. The soil and the year * soil interaction were not significant at the P < 0.05 level.

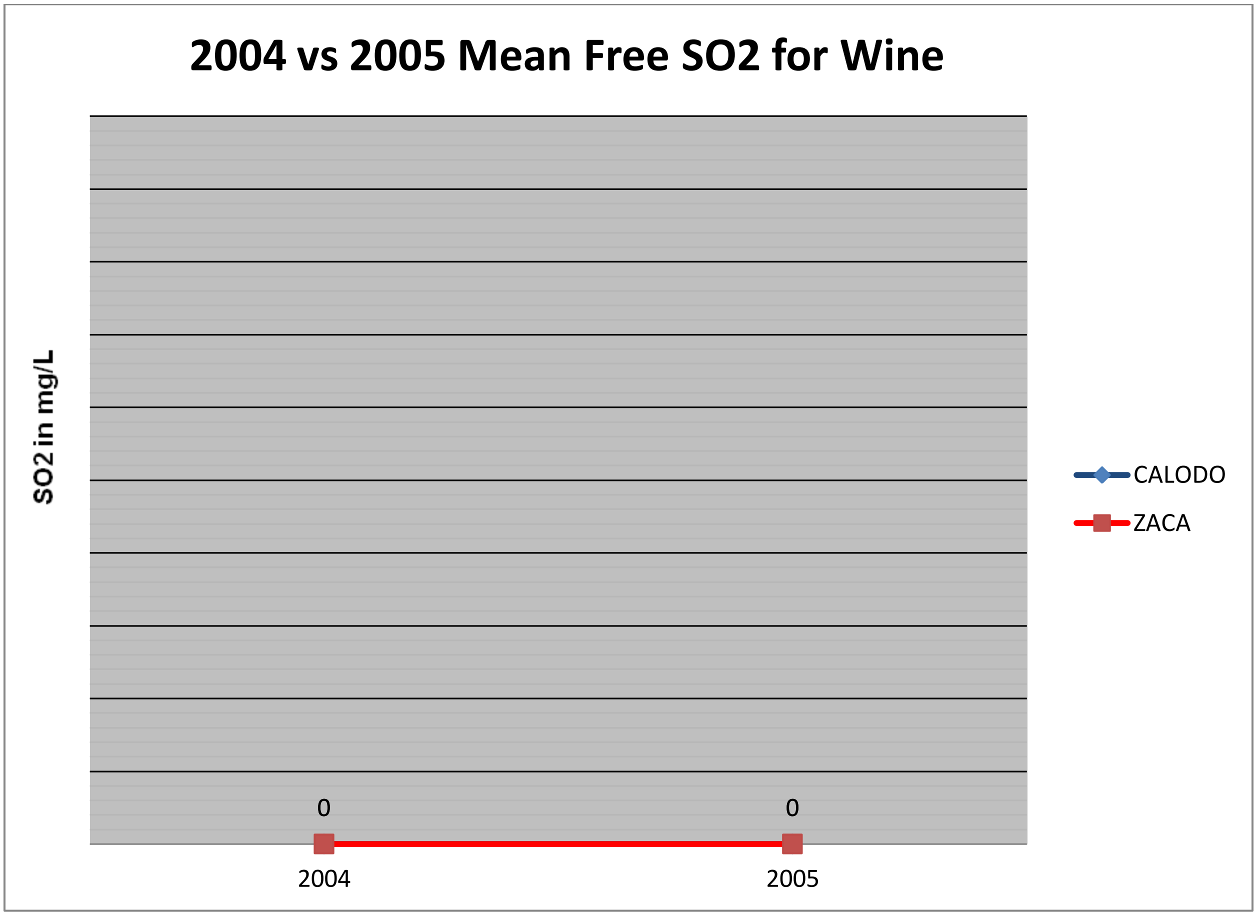
Figure 8: Mean Values for Total SO 2 for Wine



4.2.2 Free SO 2

There was 0.00 Free SO2 detected in any of the wine samples for the 2004 and 2005 vintage years collected from the Calodo or Zaca soils. The lines for Zaca and Calodo soils overlap each other on the chart with the Calodo line being obscured. This gives the impression that only the Zaca soil was measured for the two years.

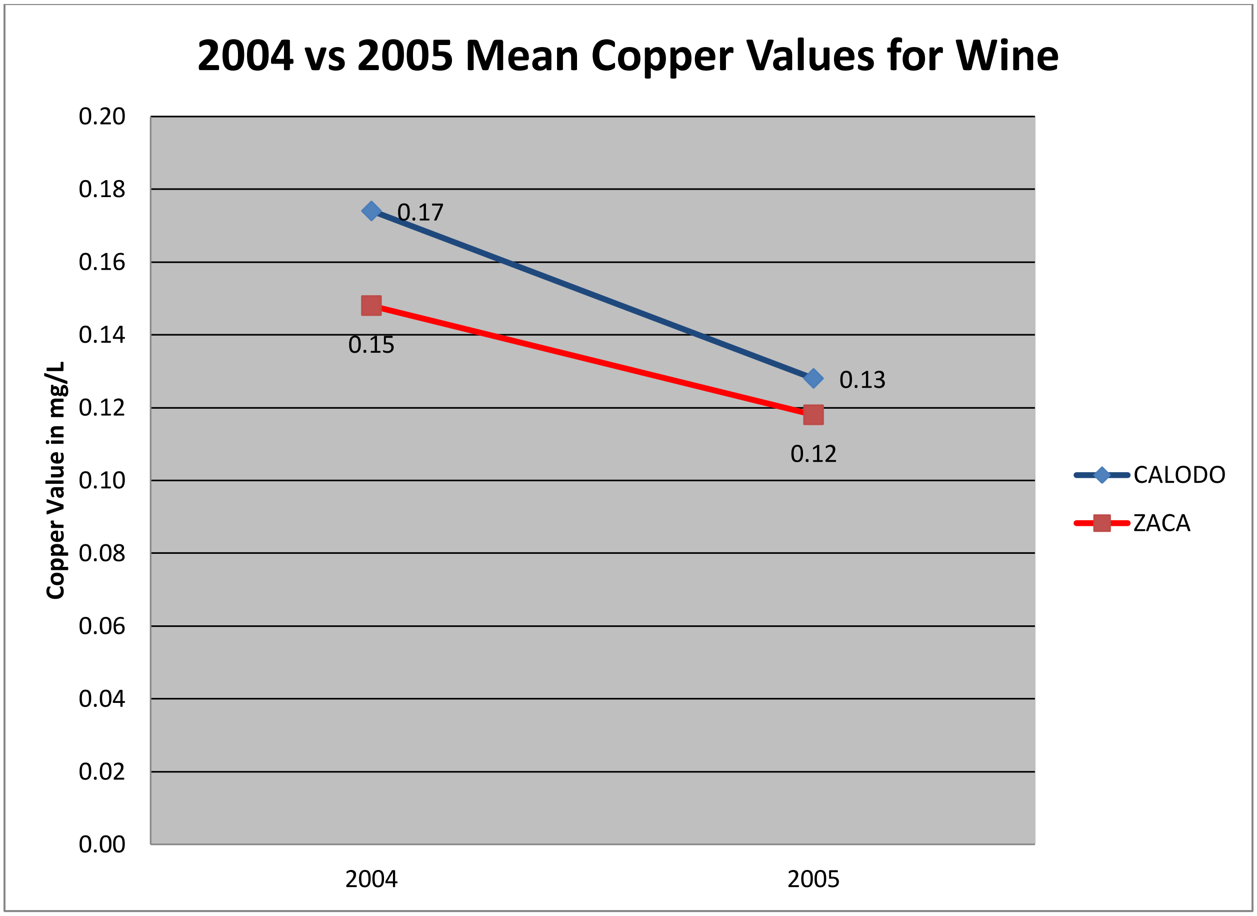
Figure 9: Mean Values for Free SO 2 for Wine



4.2.3 Copper

The analysis for copper in wine showed no significant differences for vintage year, soil, and year * soil at the $P < 0.05$ level.

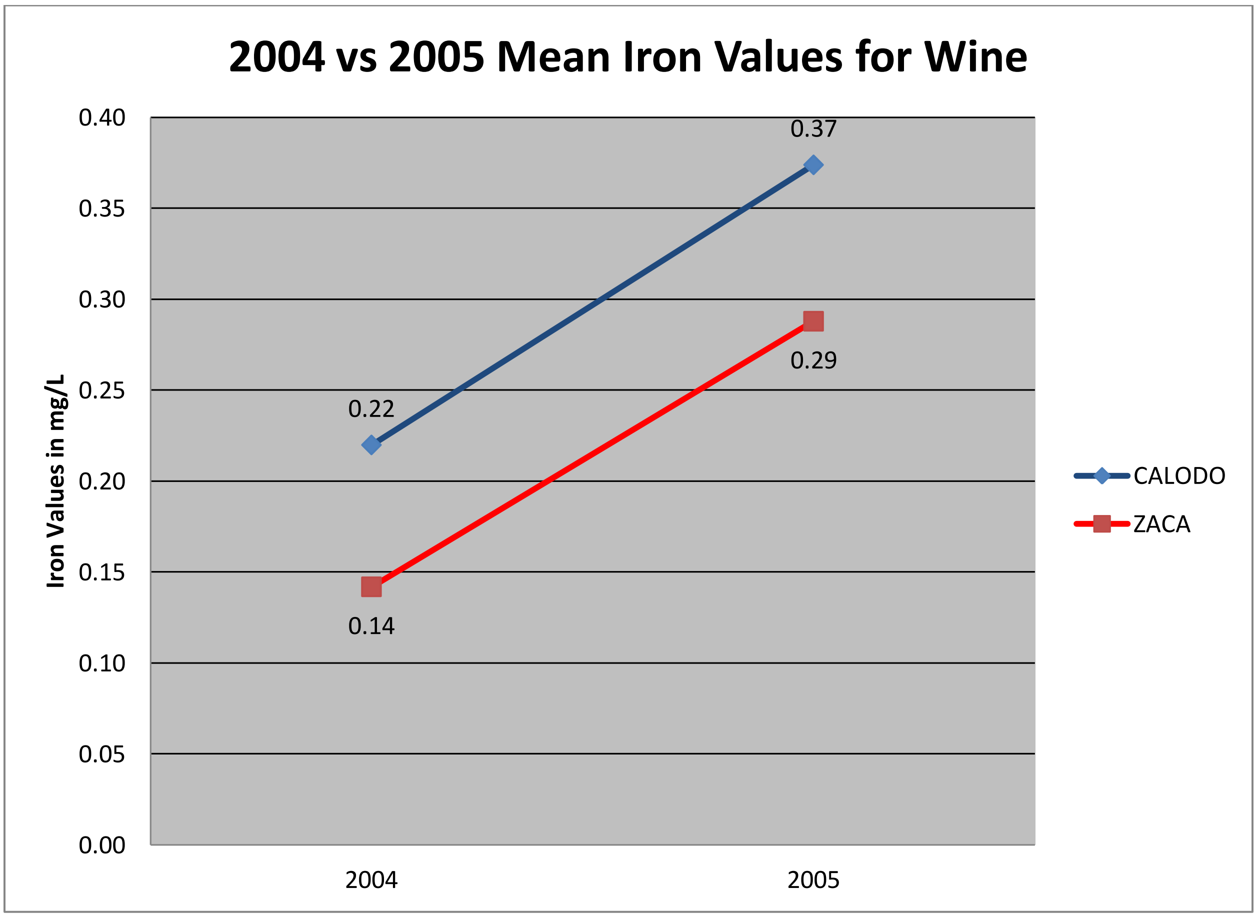
Figure 10: Mean Values for Copper for Wine



4.2.4 Iron

The analysis for iron in wine showed a highly significant difference in the vintage years and the soil. The P value for the vintage year was 0.000 with the 2005 year having a higher mean. The soil had a P value of 0.002 with the Calodo Clay Loam soil having a higher mean. The year * soil interaction was not significant at the $P < 0.05$ level.

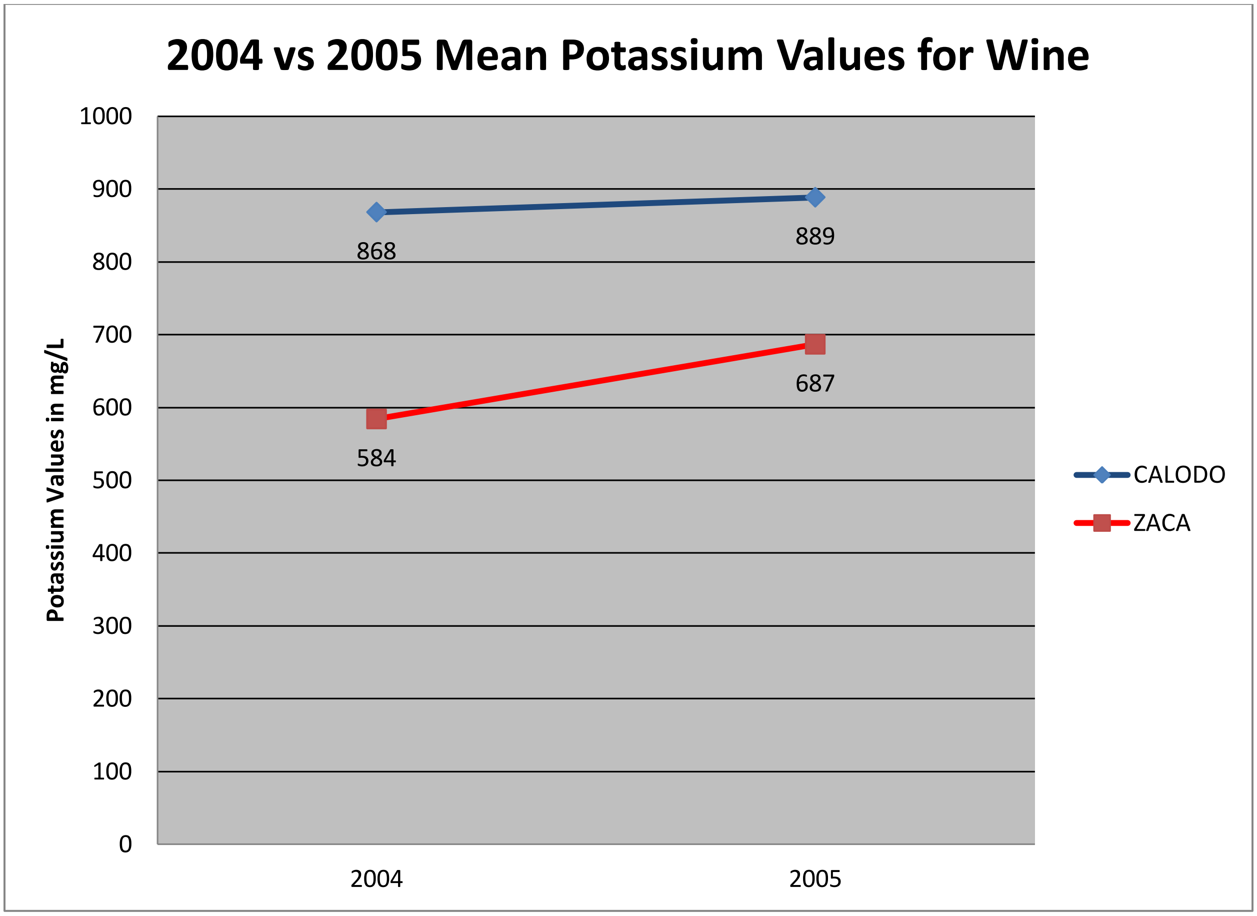
Figure 11: Mean Values for Iron for Wine



4.2.5 Potassium

The analysis for potassium in wine shows a highly significant difference between soils at a P value of 0.018.The Calodo Clay Loam soil has a larger mean. The vintage year and the year * soil interaction were not significant at the P < 0.05 level.

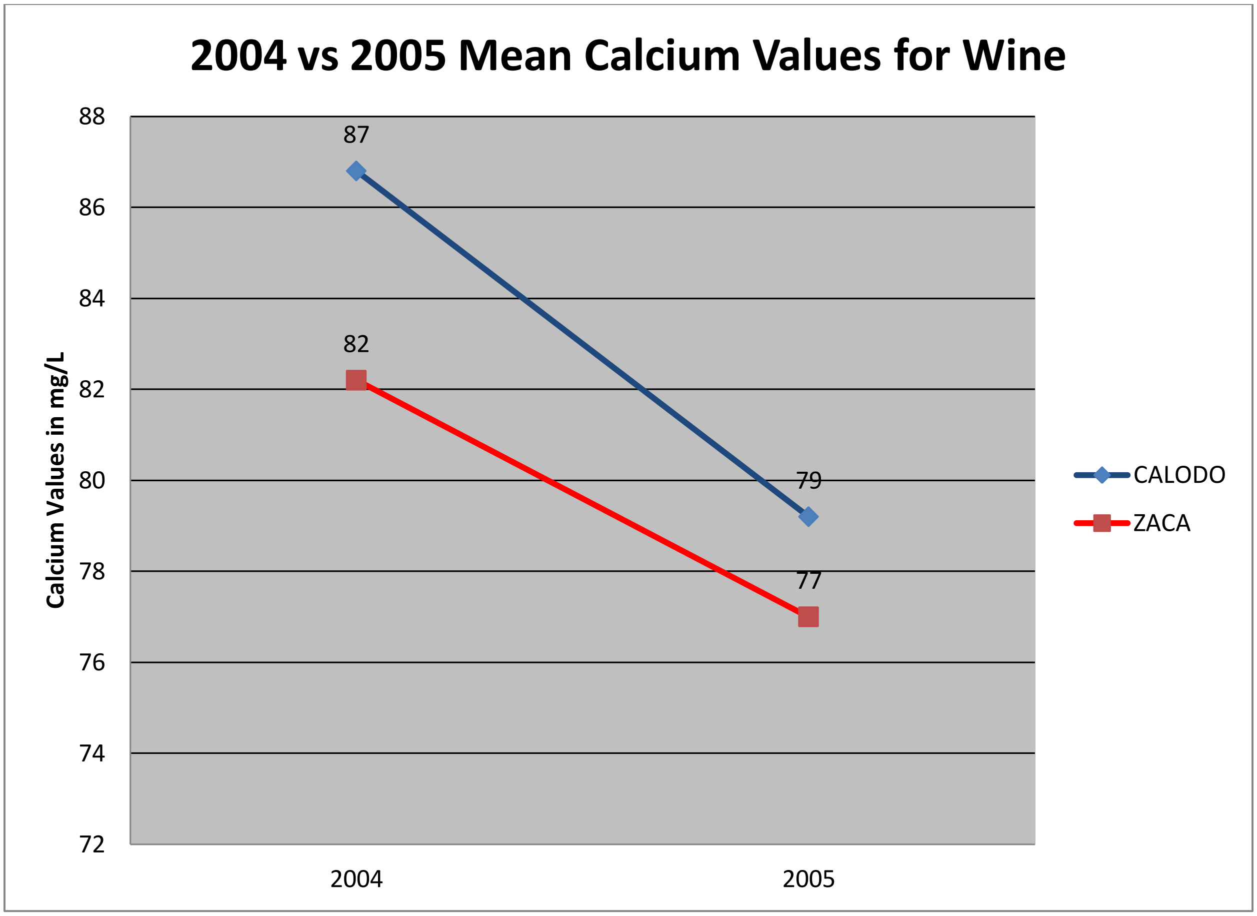
Figure 12: Mean Values for Potassium for Wine



4.2.6 Calcium

The analysis for calcium in wine showed no significant differences for vintage year, soil, or year * soil interaction at the $P < 0.05$ level.

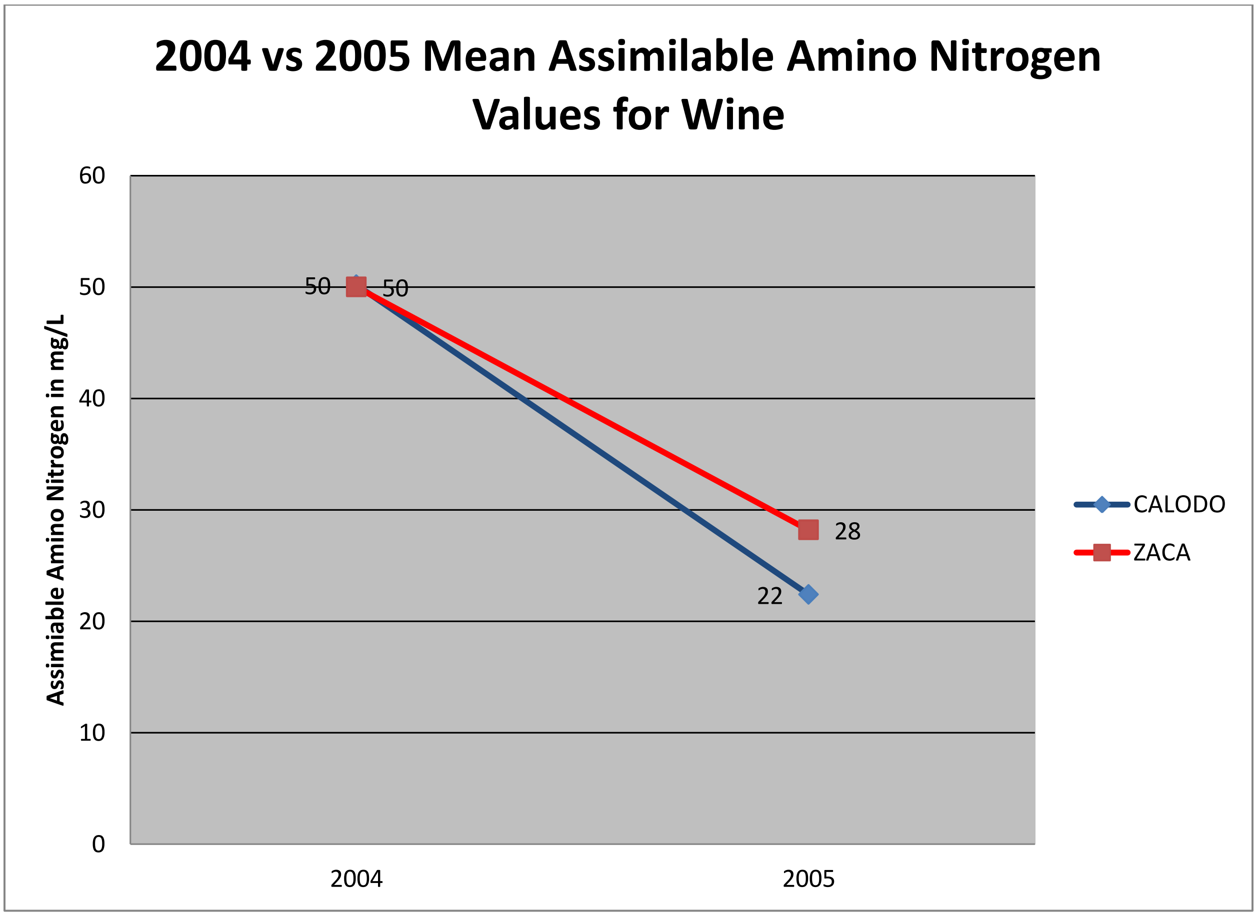
Figure 13: Mean Values for Calcium for Wine



4.2.7 Assimilable Amino Nitrogen

The analysis for assimilable amino nitrogen in wine showed that the difference between the vintage years was highly significant at the $P < 0.01$ level. The P value for the vintage years was 0.000 with the 2004 year having a higher mean than the 2005 year. The soil and the year * soil interaction were not significant at the $P < 0.05$ level.

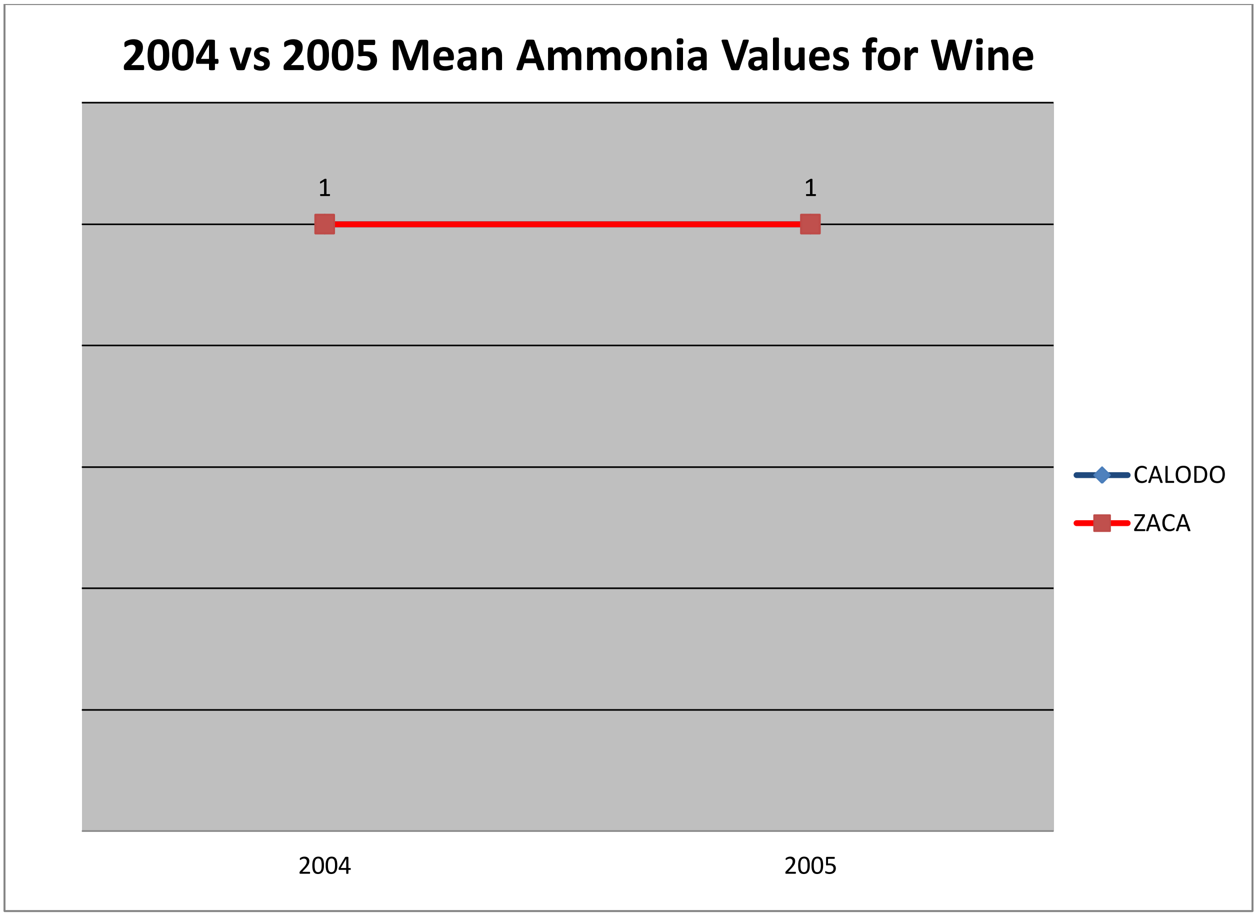
Figure 14: Mean Values for Assimilable Amino Nitrogen for Wine



4.2.8 Ammonia

The analysis for ammonia in wine showed that the differences in the vintage year, soil, and the year * soil interaction were not significant at the $P < 0.05$ level.

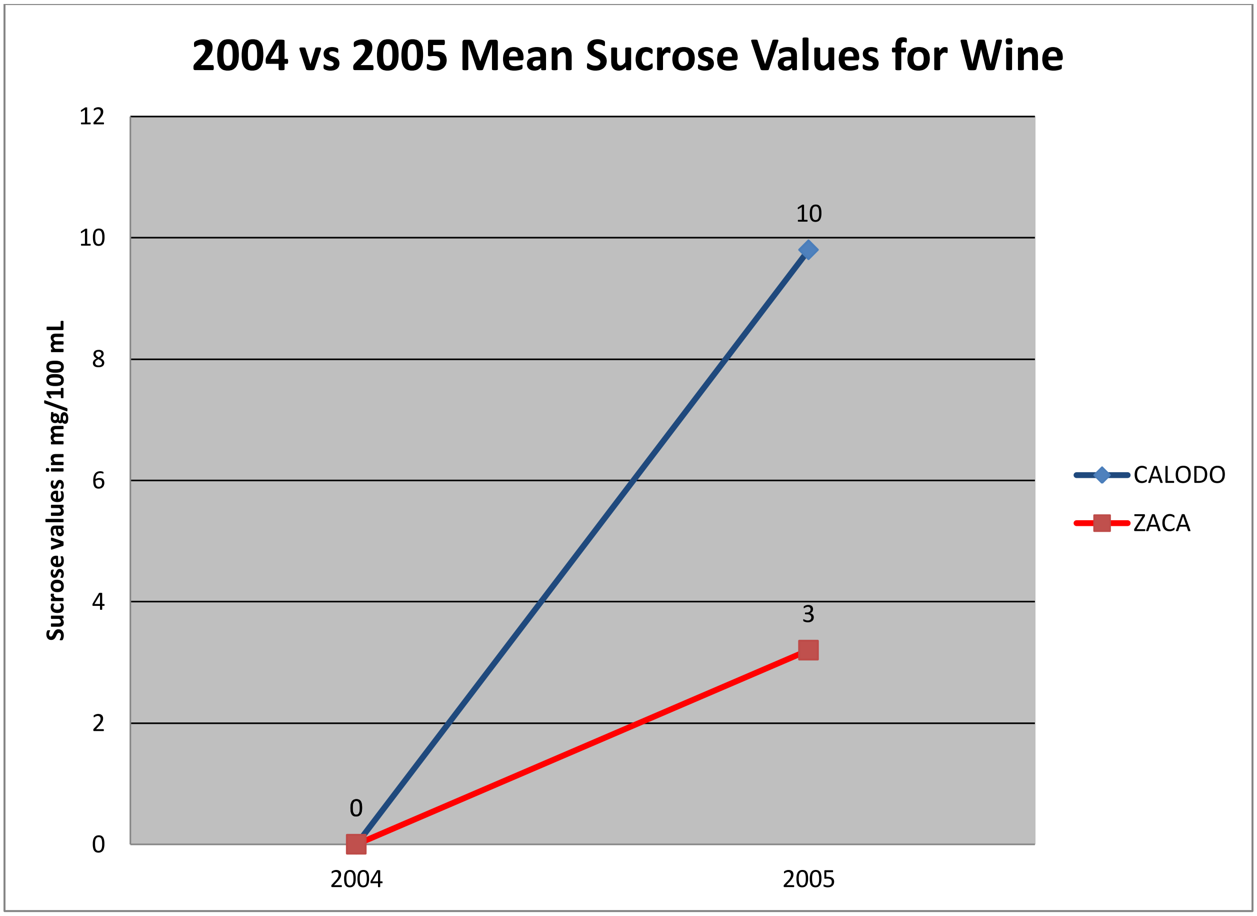
Figure 15: Mean Values for Ammonia for Wine



4.2.9 Sucrose

The analysis for sucrose in wine showed the differences in the vintage year, soil, and the year * soil interaction were not significant at the $P < 0.05$ level.

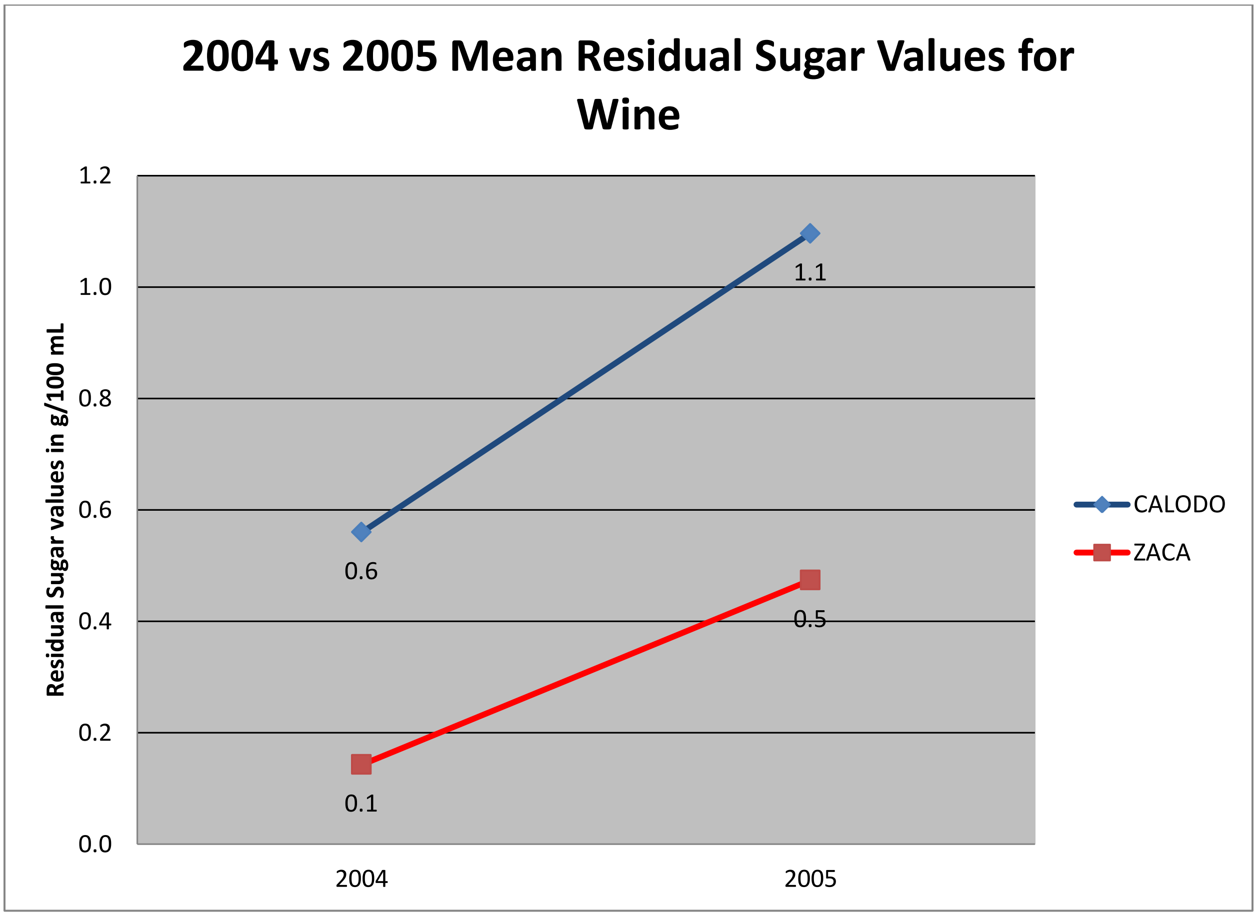
Figure 16: Mean Values for Sucrose for Wine



4.2.10 Residual Sugar

The analysis for residual sugar in wine showed that the difference between the soils was significant at the $P < 0.05$ level. The P value was 0.047 with the Calodo Clay Loam soil having a higher mean than the Zaca Clay. The vintage year and the year * soil interaction were not significant at the $P < 0.05$ level.

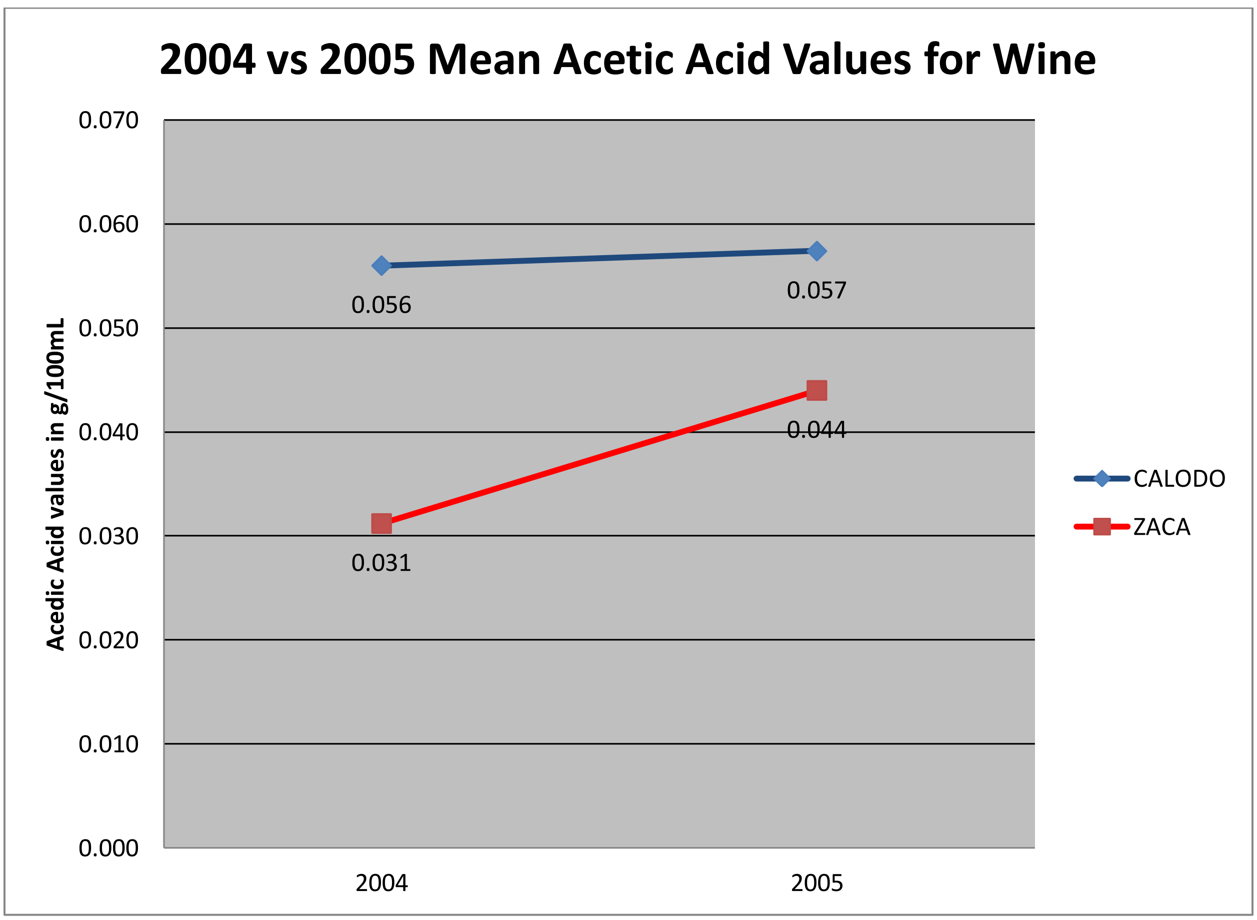
Figure 17: Mean Values for Residual Sugars for Wine



4.2.11 Acetic Acid

The analysis for acetic acid in wine showed that the difference between the soils was highly significant at the P < 0.01 level. The P value was 0.000 with the Calodo Clay Loam soil having a higher mean than the Zaca Clay. There was no significance at P < 0.05 for the vintage year and the year * soil interaction. According to Waterhouse Labs at U.C. Davis Acetobacter aceti is a bacterium that can cause ethanol and glucose to become acetic acid.Three yeasts commonly found in the vineyard that cause large amounts of acetic acid to be formed are Kloeckera, Hansenula, and Metschnikowia The acetic acid is formed early in fermentation and damaged grapes are usually the cause. Acetobacter aceti outgrowth can be prevented by preventing oxygen to contact the wine and by using quality grapes. Sulfur dioxide will also help to minimize the outgrowth of the bacteria. The must and pre-barreled wine were fermented in covered macro bins that were not 100% airtight.

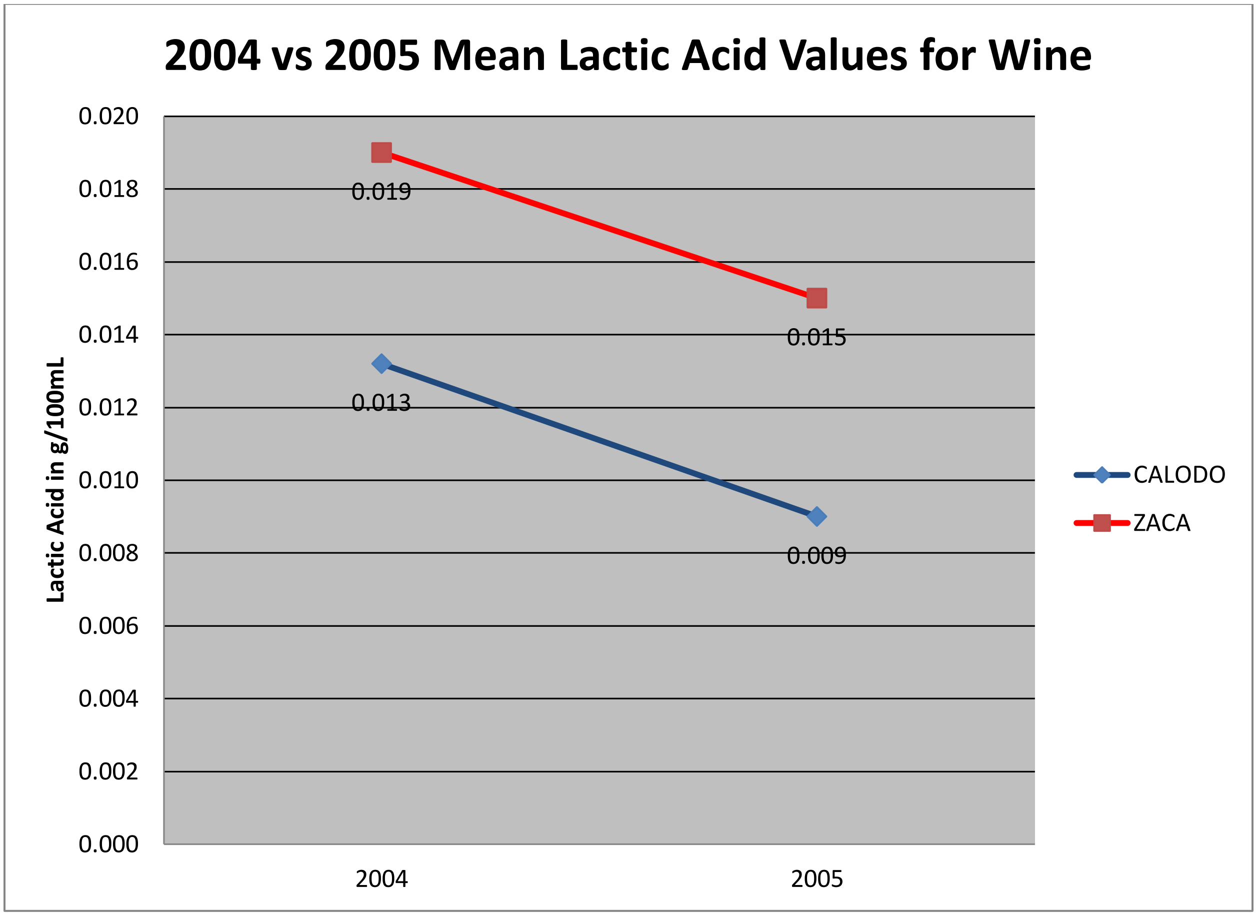
Figure 18: Mean Values for Acetic Acid for Wine



4.2.12 Lactic Acid

The analysis for lactic acid in wine showed the differences in the vintage year, soil, and the year * soil interaction were not significant at the $P < 0.05$ level. This may be due to the fact that Lactic acid is formed from Malic acid during Malo – Lactic Fermentation.

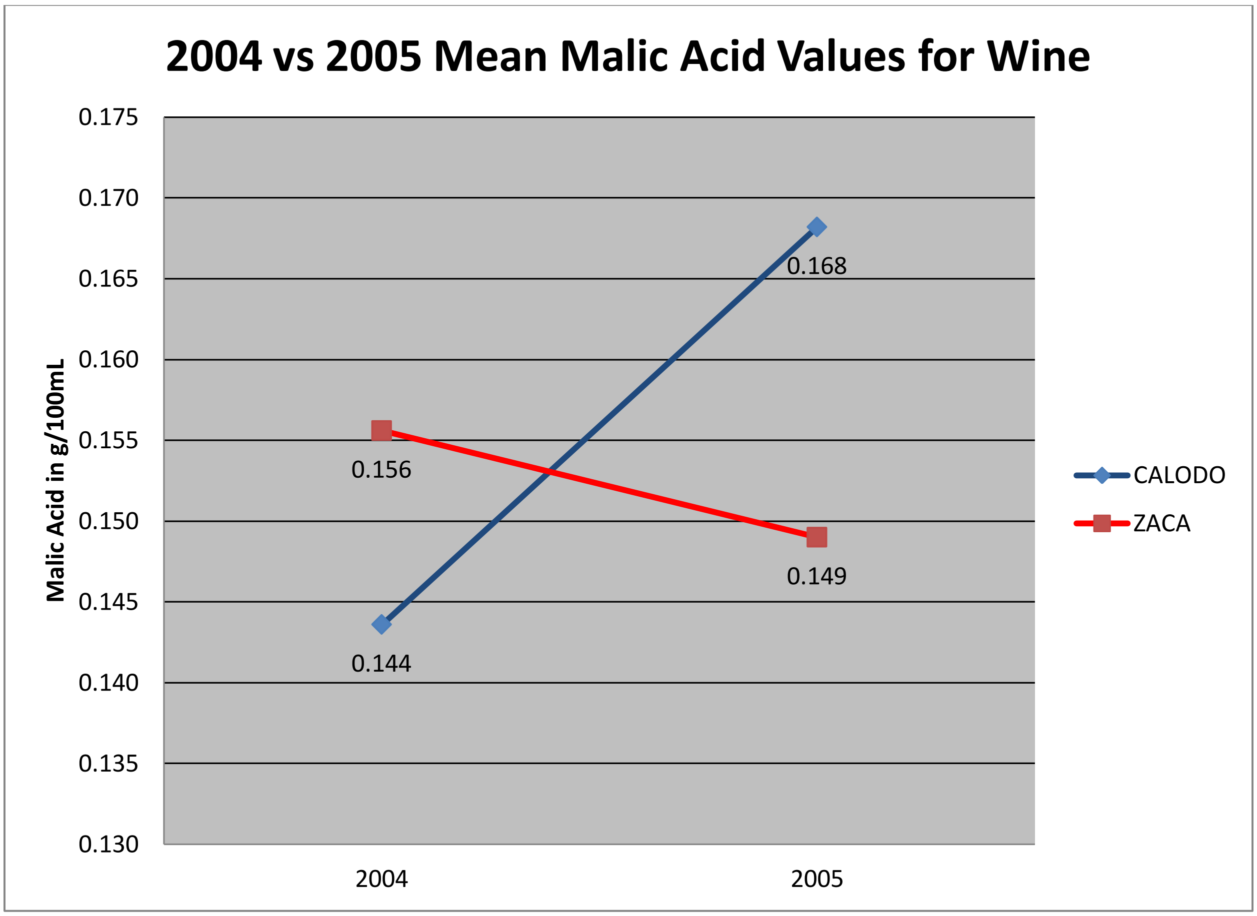
Figure 19: Mean Values for Lactic Acid for Wine



4.2.13 Malic Acid

The analysis for malic acid in wine showed the differences in the vintage year, soil, and the year * soil interaction were not significant at the $P < 0.05$ level. Although the mean chart indicates a possible interaction the P value for year * soil interaction was 0.104.

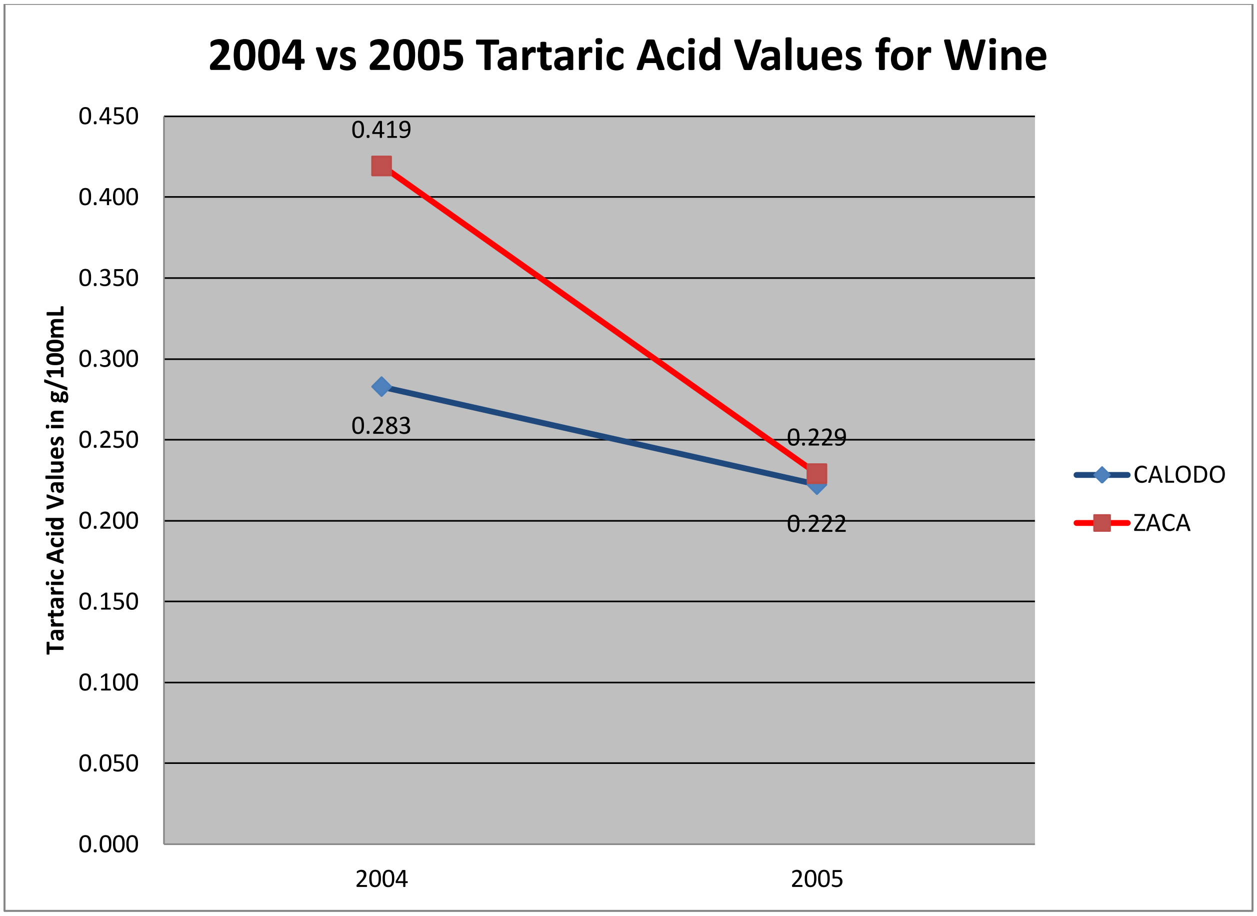
Figure 20: Mean Values for Malic Acid for Wine



4.2.14 Tartaric Acid

The analysis for tartaric acid in wine showed difference in vintage year to be significant at the $P < 0.05$ level. The P value was 0.014 with the 2004 year having a higher mean value. The soil and the year * soil interaction were not significant at the $P < 0.05$ level.

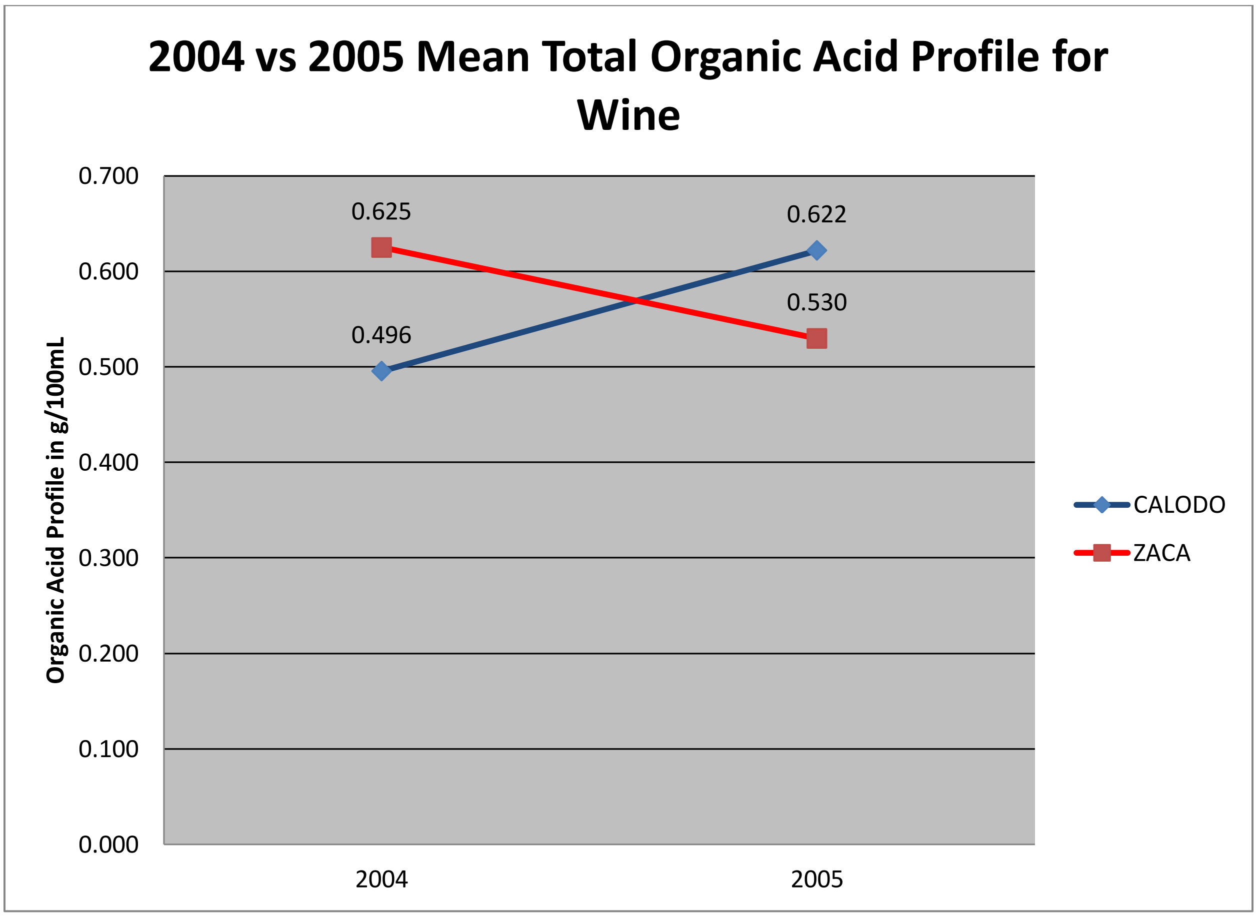
Figure 21: Mean Values for Tartaric Acid for Wine



4.2.15 Total Organic Acid Profile

The acids collectively measured in the total organic acid profile for wine were acetic acid, citric acid, lactic acid, malic acid, succinic acid, and tartaric acid. The analysis for the total organic profile in wine showed that there was a significant difference at the $P < 0.05$ level for the year * soil interaction. The P value was 0.031 with the 2004 Zaca Clay interaction having the highest mean value. Individually the vintage year and the soil type were not significant at the $P < 0.05$ level even though there was an interaction between the year and soil.

Figure 22: Mean Values for Total Organic Acid Profile for Wine

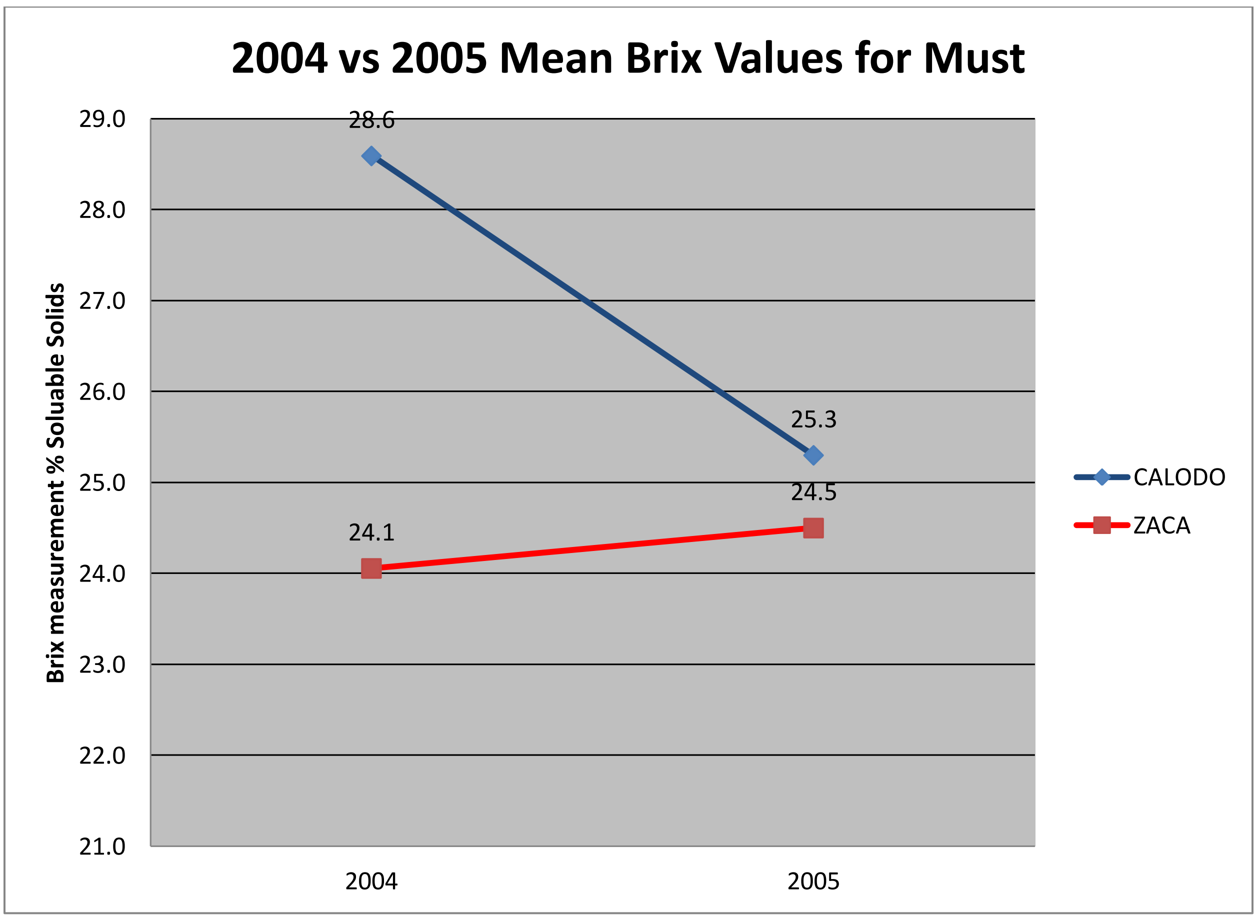


4.3 Must Analysis Tested by Enardis Vinquiry Labs

4.3.1 Brix

The analysis for Brix in must showed a significant difference between vintage years at the $P < 0.05$ level with a P value of 0.015. The 2004 year had a higher means than the 2005 year. The difference in soil and year * soil interaction were highly significant at the $P < 0.01$ level. The P value for the soil was 0.000 with the Calodo Clay Loam soil having a higher mean value than the Zaca Clay soil. The year * soil interaction P value was 0.003 with the 2004 Calodo Clay Loam having the highest mean value.

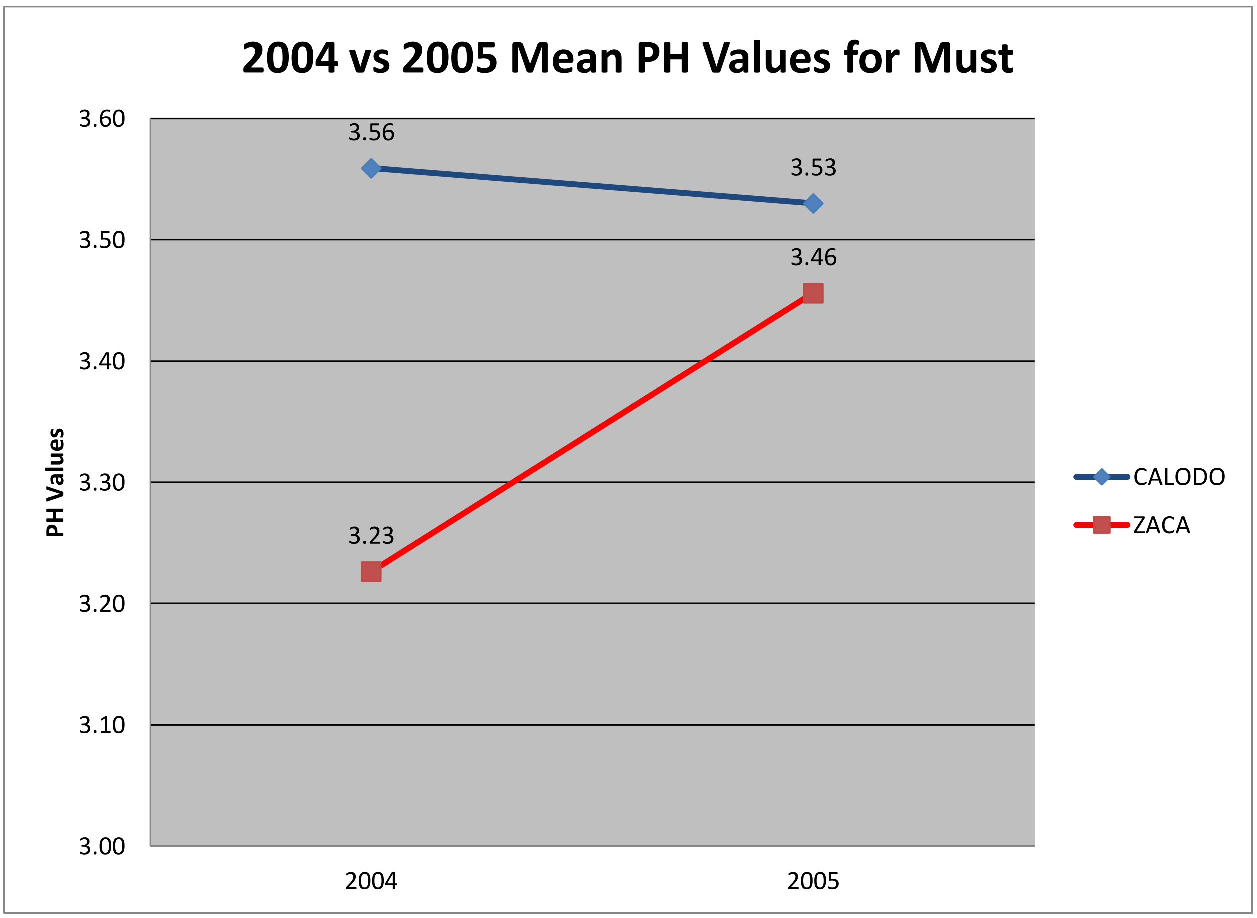
Figure 23: Mean Values for Brix for Must



4.3.2 PH

The analysis for pH in must showed a highly significant difference for vintage years, soil, and year * soil interaction at the $P < 0.01$ level. The P value for vintage year was 0.007 with the 2005 year having a higher means than the 2004 year. The P value for the soil was 0.000 with the Calodo Clay Loam soil having a higher mean value than the Zaca Clay soil. The year * soil interaction P value was 0.001 with the 2004 Calodo Clay Loam having the highest mean value.

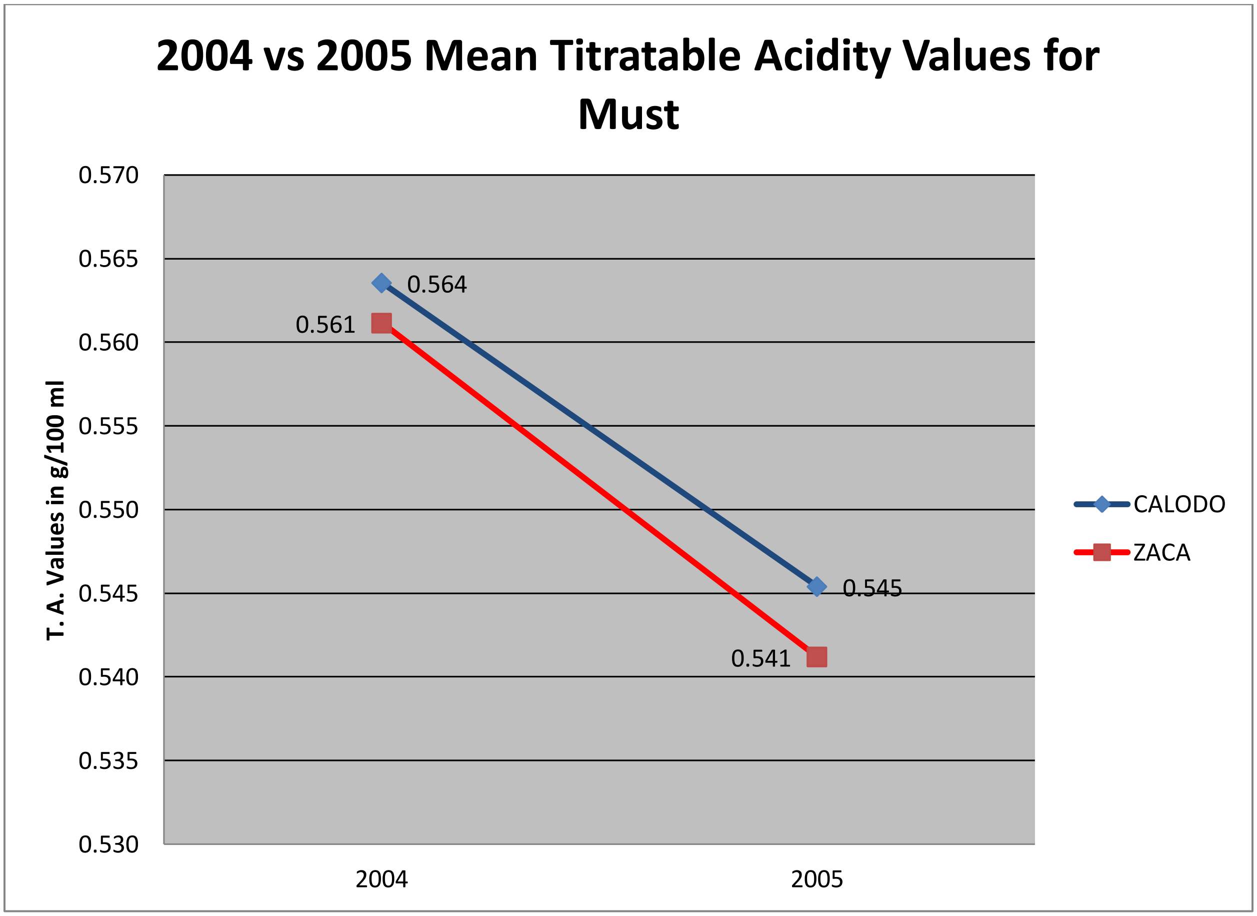
Figure 24: Mean Values for pH for Must



4.3.3 Titratable Acidity

The analysis for titratable acidity in must did not show significant differences for vintage years, soil, and year * soil interaction at the $P < 0.05$ level.

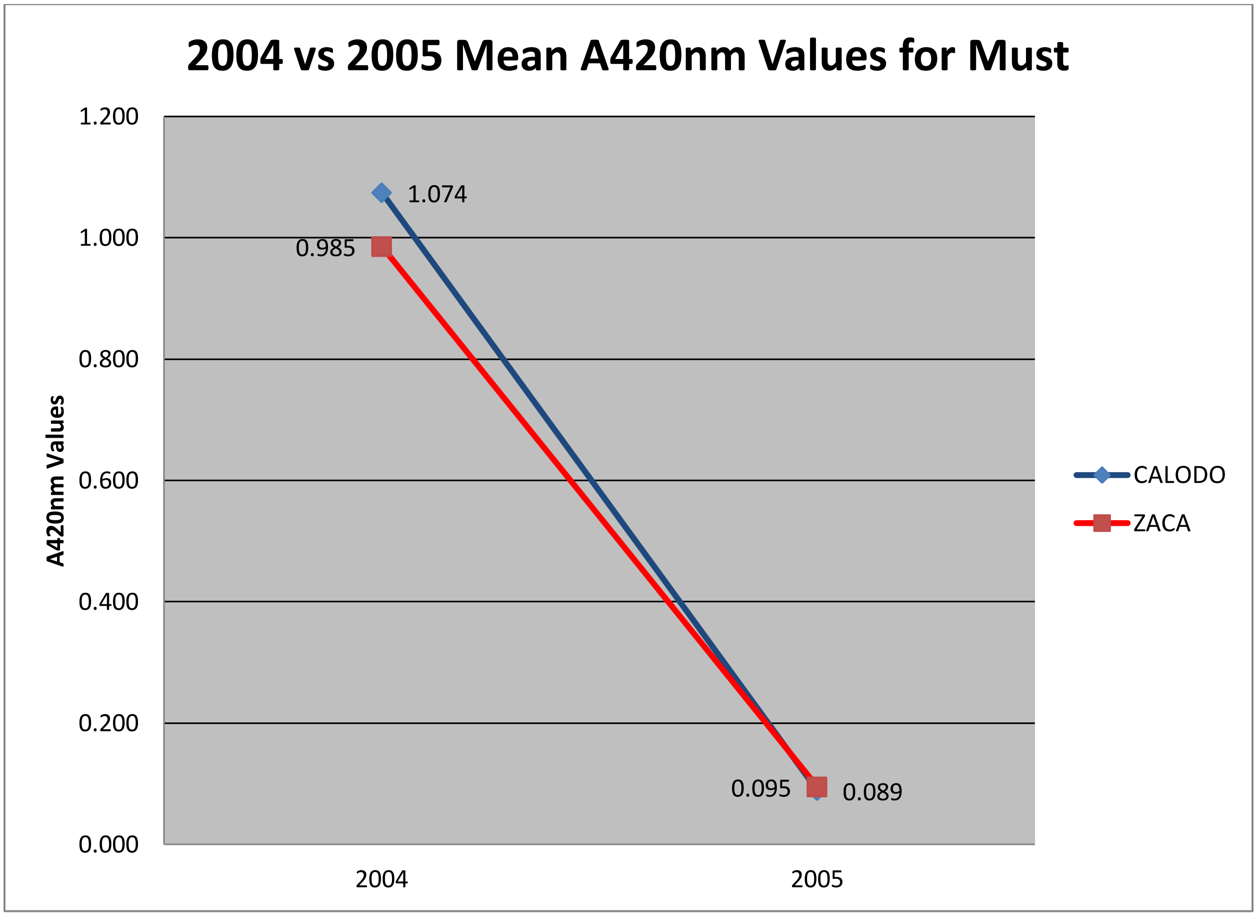
Figure 25: Mean Values for Titratable Acidity for Must



4.3.4 A420 Color Absorbance

The analysis for A 420 color absorbance in must showed a highly significant difference for vintage years at the $P < 0.01$ level. The P value was 0.000 with the 2004 year having a higher mean value than 2005. The soil and year * soil interaction were not significant at the $P < 0.05$ level.

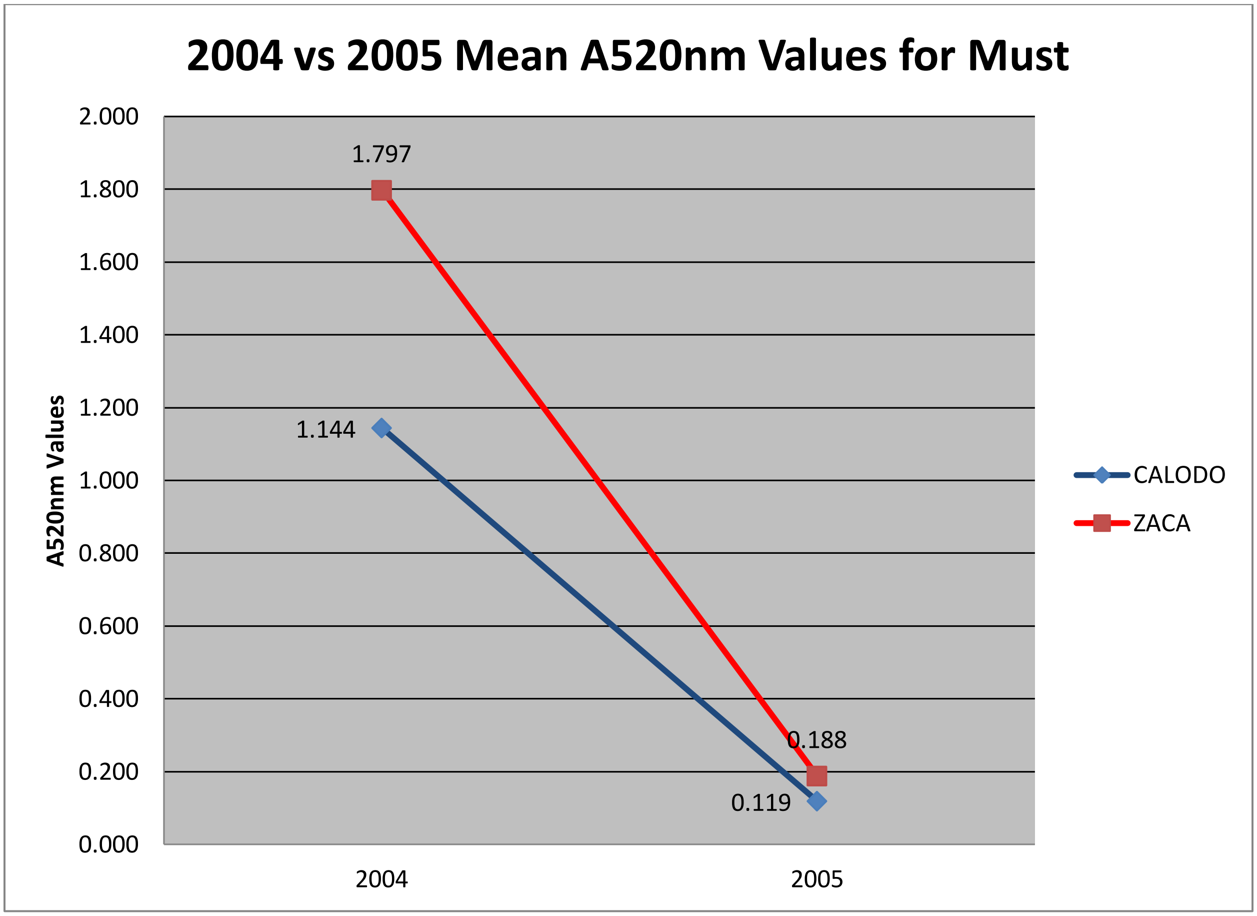
Figure 26: Mean Values for Color Absorbance 420 nm for Must



4.3.5 A520 Color Absorbance

The analysis for A 520 color absorbance in must showed a highly significant difference for vintage years at the $P < 0.01$ level. The P value was 0.000 with the 2004 year having a higher mean value than 2005. The soil and year * soil interaction were not significant at the $P < 0.05$ level.

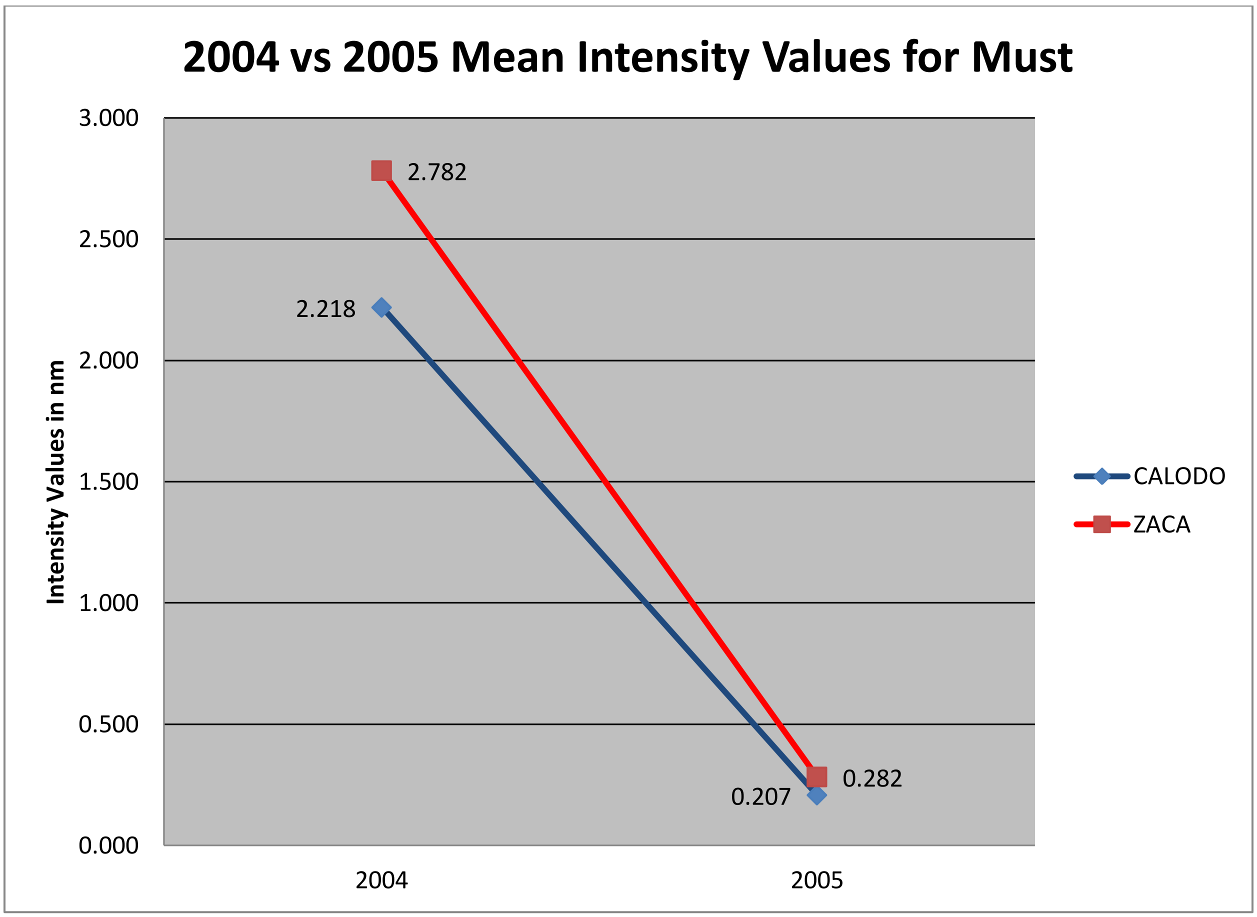
Figure 27: Mean Values for Color Absorbance 520 nm for Must



4.3.6 Intensity

The analysis for Intensity in must showed a highly significant difference for vintage years at the $P < 0.01$ level. The P value was 0.000 with the 2004 year having a higher mean value than 2005. The soil and year * soil interaction were not significant at the $P < 0.05$ level.

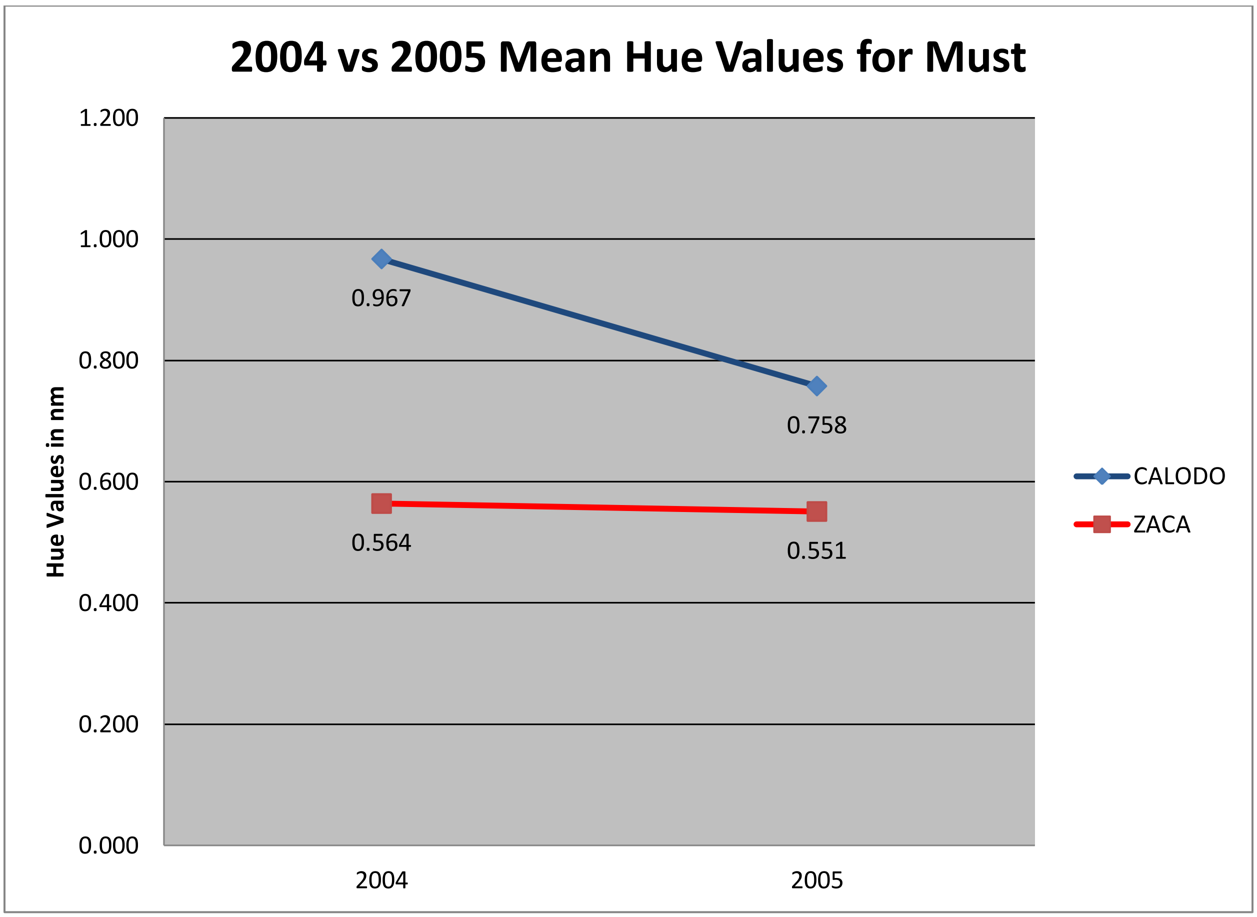
Figure 28: Mean Values for Intensity for Must



4.3.7 Hue

The analysis for hue in must showed a highly significant difference for soil at the $P < 0.01$ level. The P value was 0.000 with the Calodo Clay Loam soil having a higher mean value than Zaca Clay. The vintage year, and year * soil interaction were not significant at the $P < 0.05$ level.

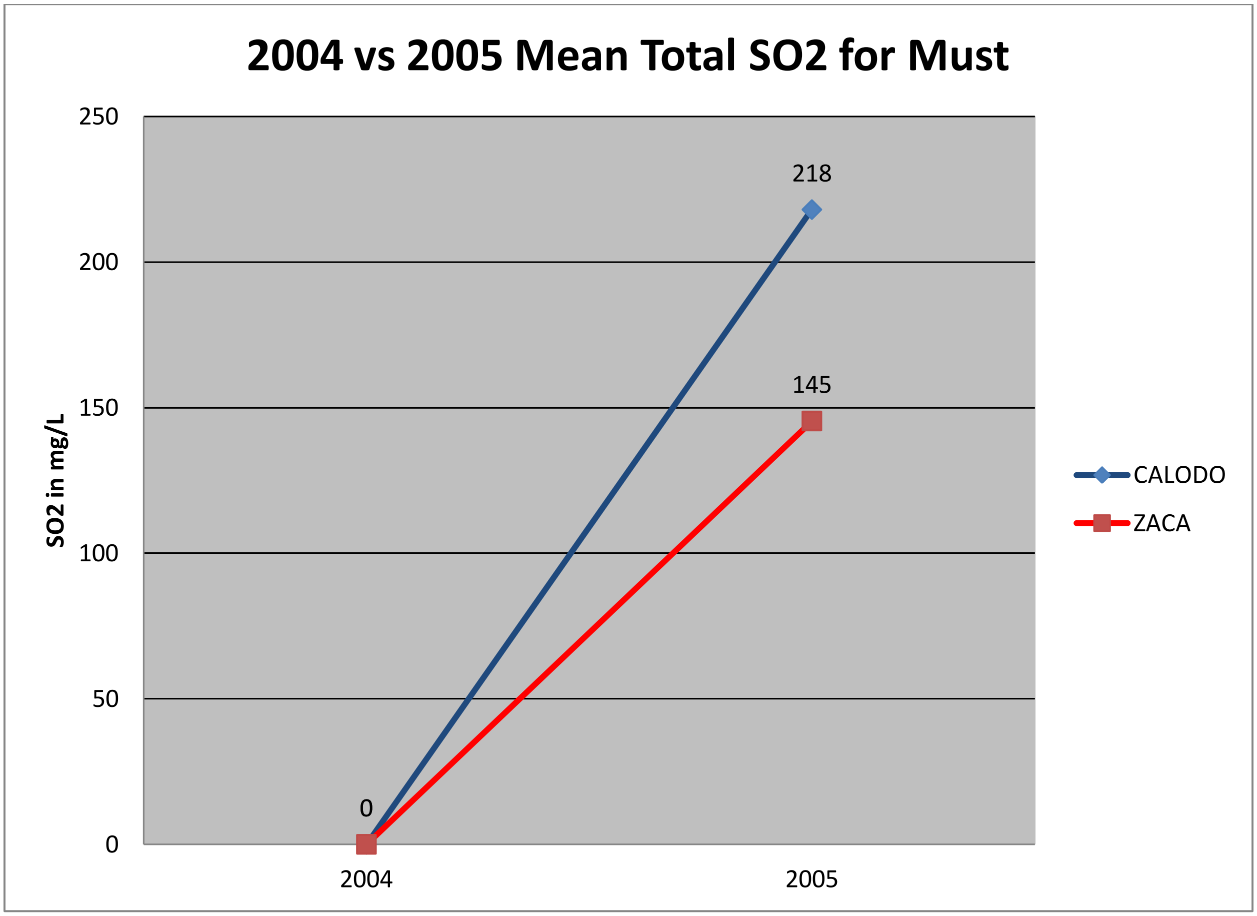
Figure 29: Mean Values for Hue Color for Must



4.3.8 Total SO 2

The analysis for total SO2 in must showed a highly significant difference for vintage year at the $P < 0.01$ level. The P value was 0.000 with the 2005 year having a higher mean value than the 2004. The soil, and year * soil interaction were not significant at the $P < 0.05$ level.

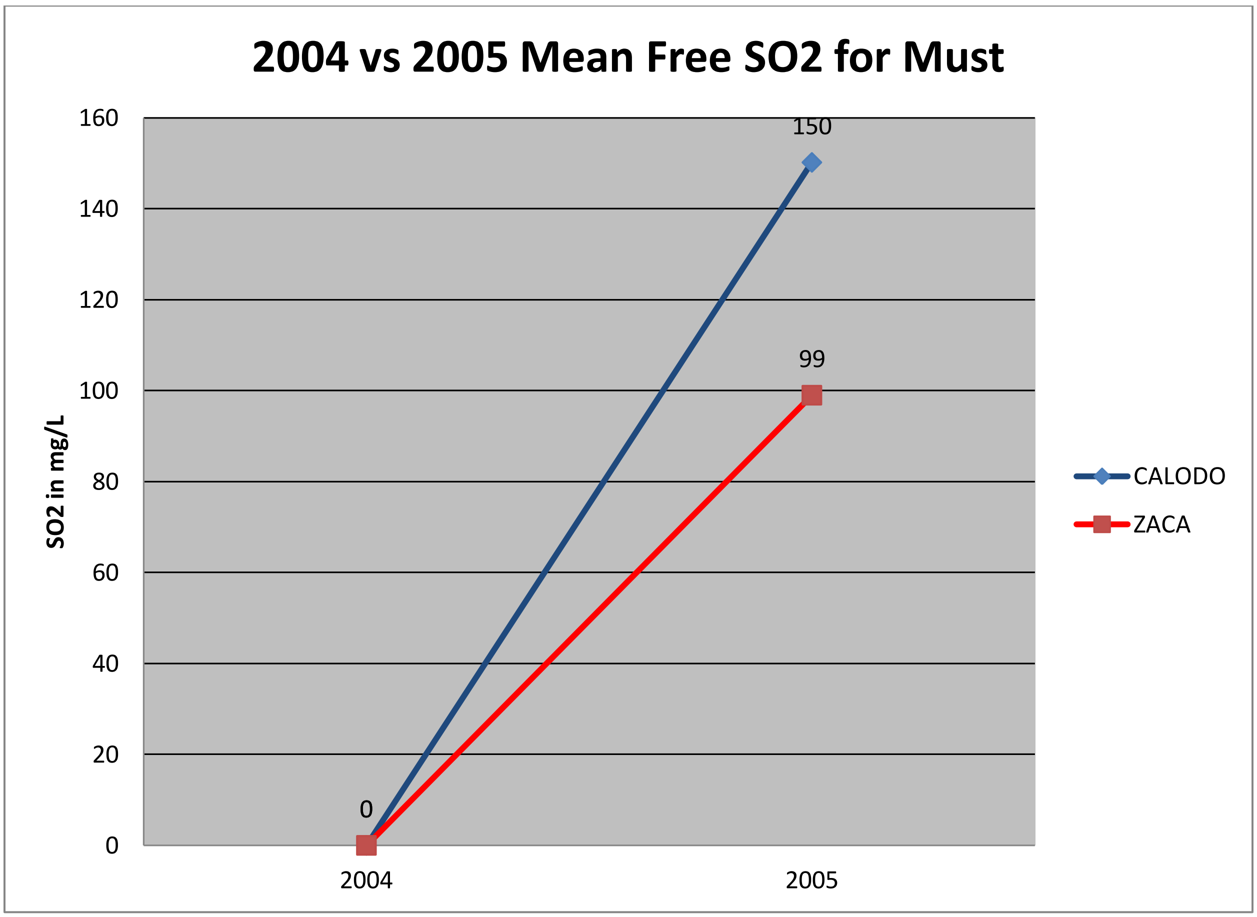
Figure 30: Mean Values for Total SO2 for Must



4.3.9 Free SO 2

The analysis for free SO2 in must showed a highly significant difference for vintage year at the $P < 0.01$ level. The P value was 0.000 with the 2005 year having a higher mean value than the 2004. The soil, and year * soil interaction were not significant at the $P < 0.05$ level.

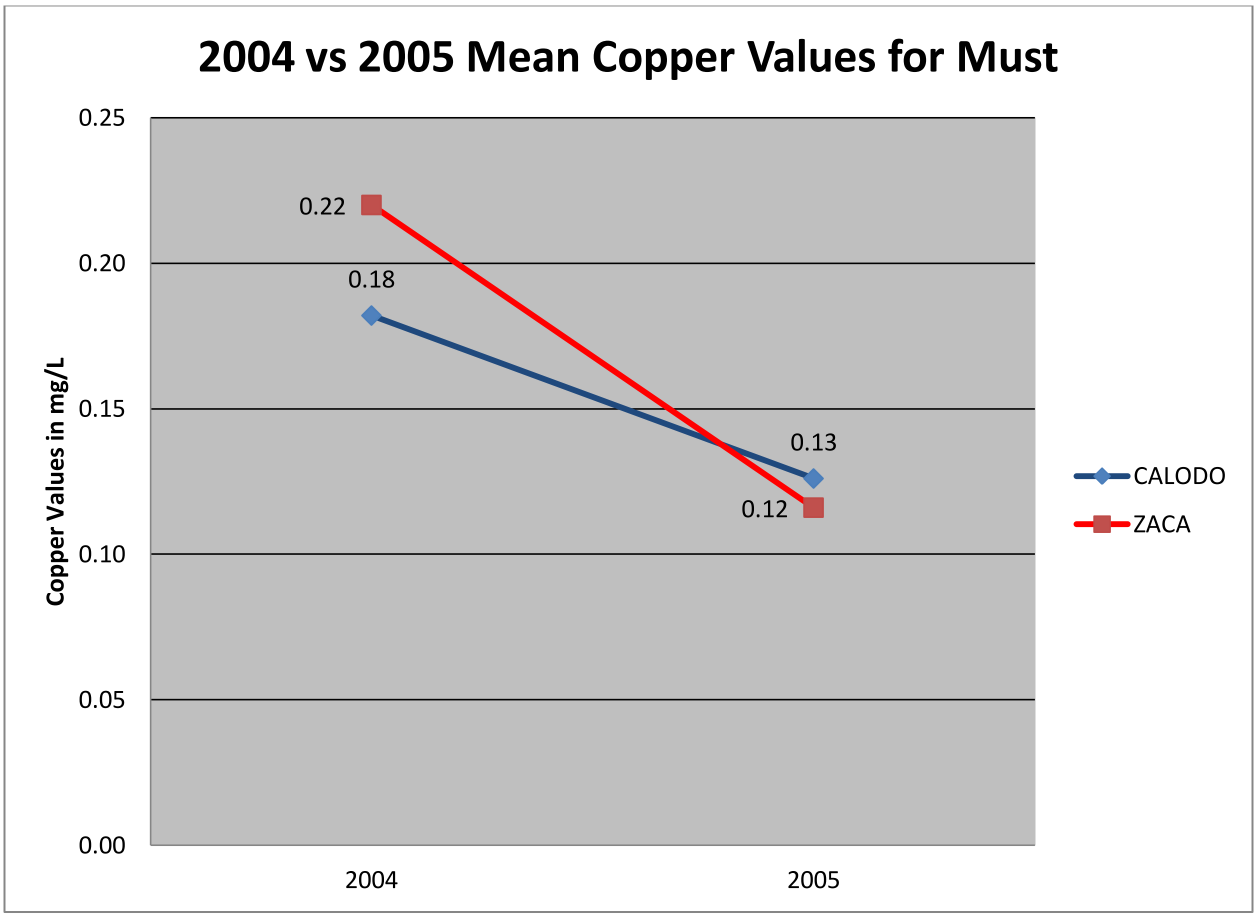
Figure 31: Mean values for Free SO2 for Must



4.3.10 Copper

The analysis for copper in must showed a highly significant difference for vintage year at the $P < 0.01$ level. The P value was 0.000 with the 2004 year having a higher mean value than the 2005. The soil, and year * soil interaction were not significant at the $P < 0.05$ level. Although the year * soil interaction was not significant at the stated P value it should be noted that it was very close at 0.061.

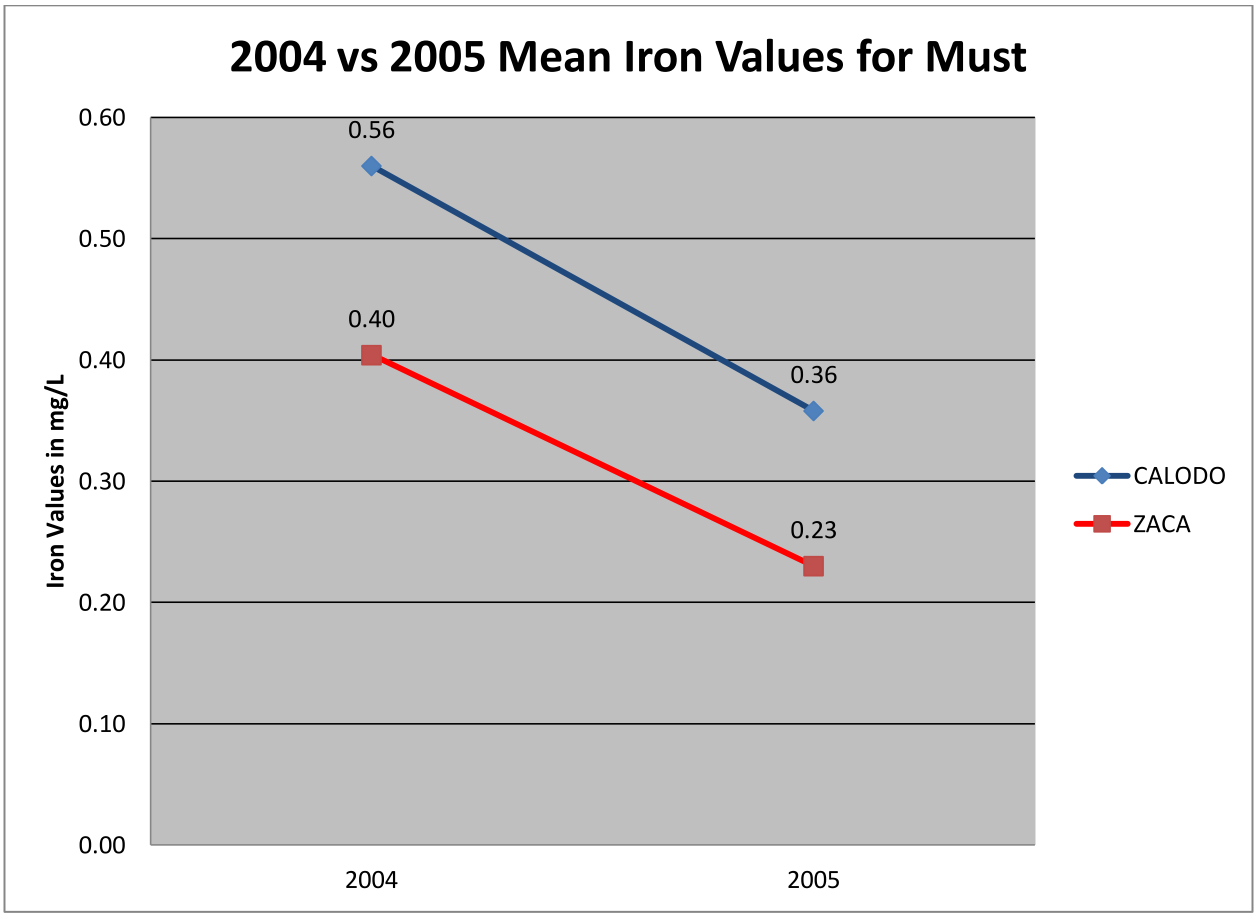
Figure 32: Mean Values for Copper for Must



4.3.11 Iron

The analysis for iron in must showed a highly significant difference for vintage year, and soil at the P < 0.01 level. The vintage year P value was 0.000 with the 2004 year having a higher mean value than the 2005. The soil P value was 0.004 with Calodo Clay Loam soil having a higher mean than Zaca Clay. The year * soil interaction was not significant at the P < 0.05 level.

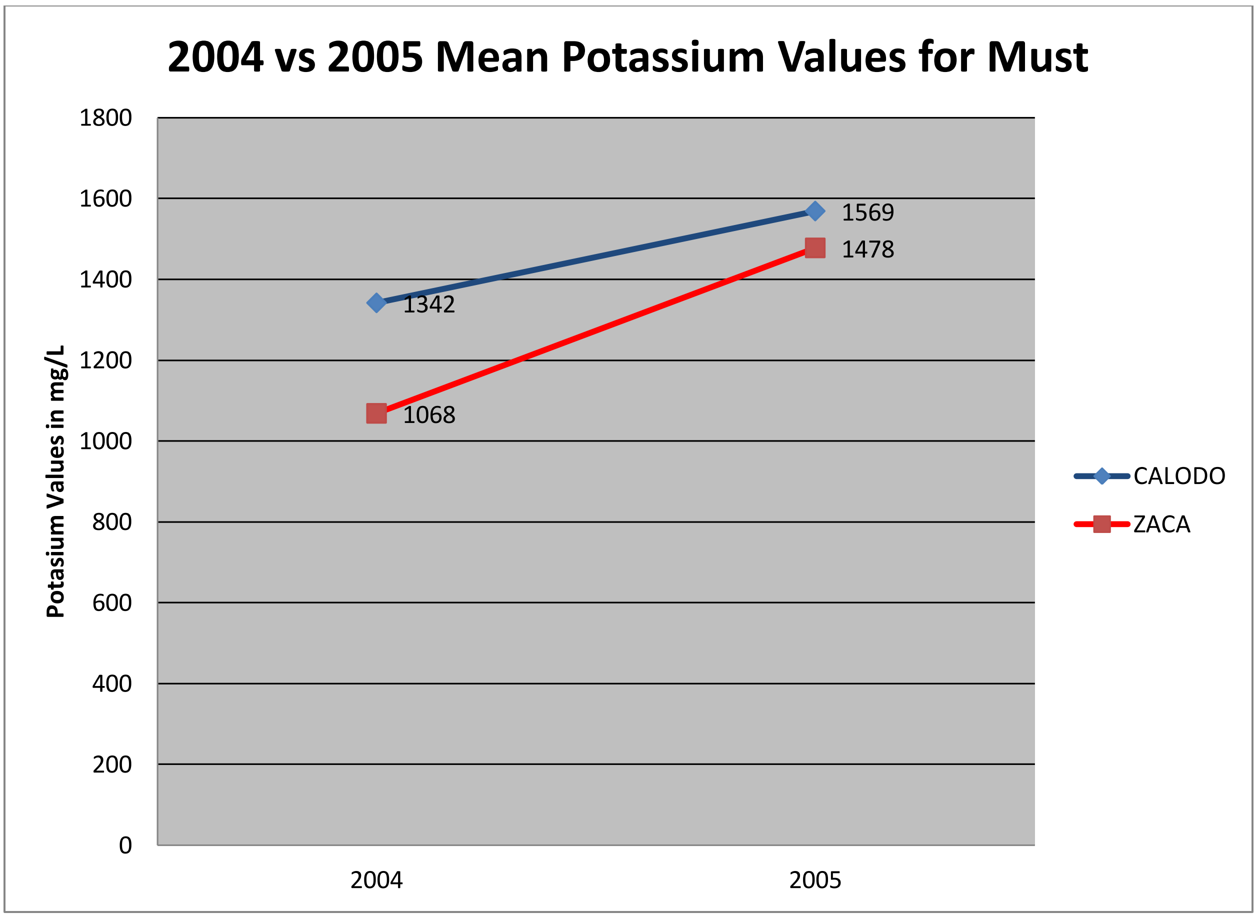
Figure 33: Mean Values for Iron for Must



4.3.12 Potassium

The analysis for potassium in must showed a highly significant difference for vintage year at the $P < 0.01$ level. The P value was 0.002 with the 2005 year having a higher mean value than the 2004. The soil, and year * soil interaction were not significant at the $P < 0.05$ level. The soil was very close to being significant at $P < 0.05$ with a P value of 0.056.

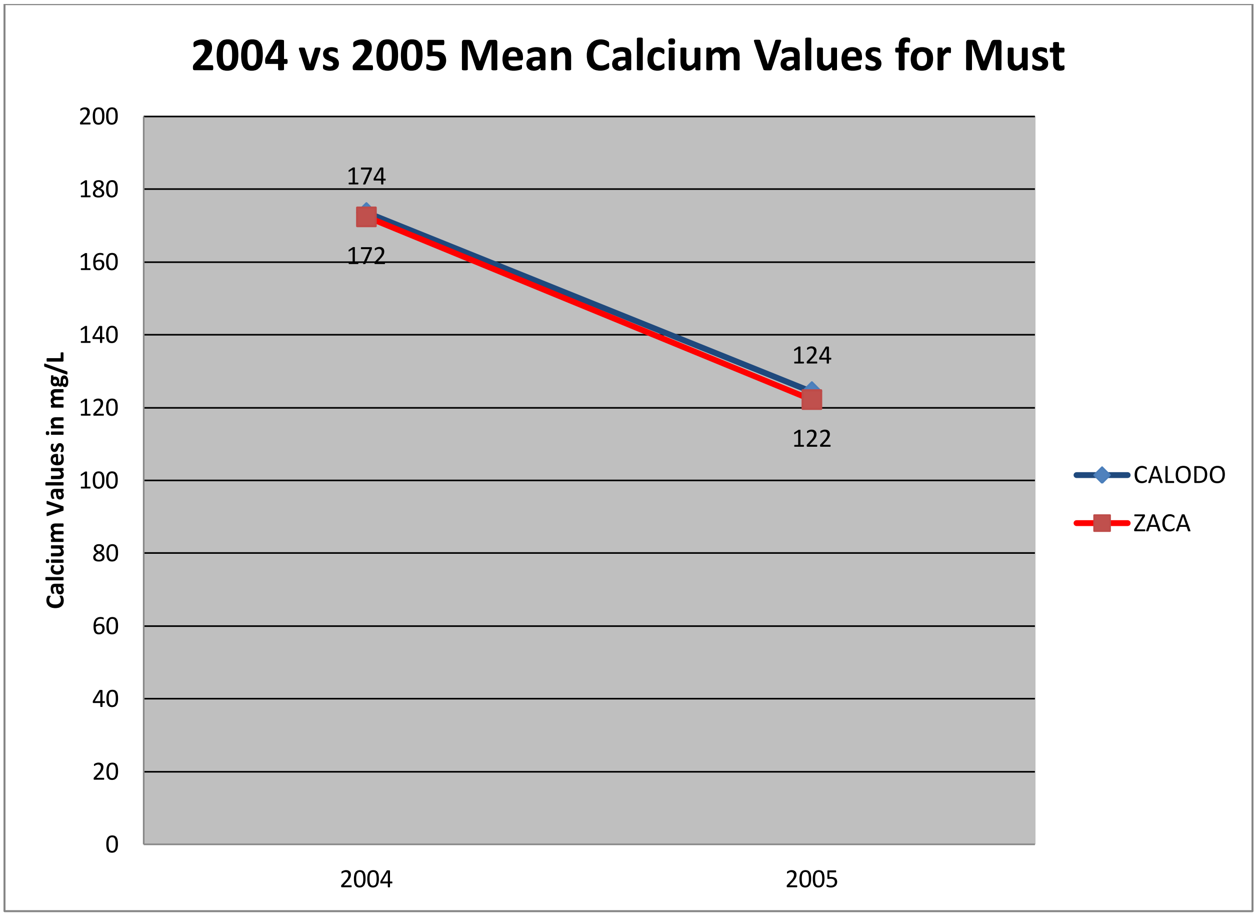
Figure 34: Mean Values for Potassium for Must



4.3.13 Calcium

The analysis for calcium in must showed a highly significant difference for vintage year at the $P < 0.01$ level. The P value was 0.000 with the 2004 year having a higher mean value than the 2005. The soil, and year * soil interaction were not significant at the $P < 0.05$ level.

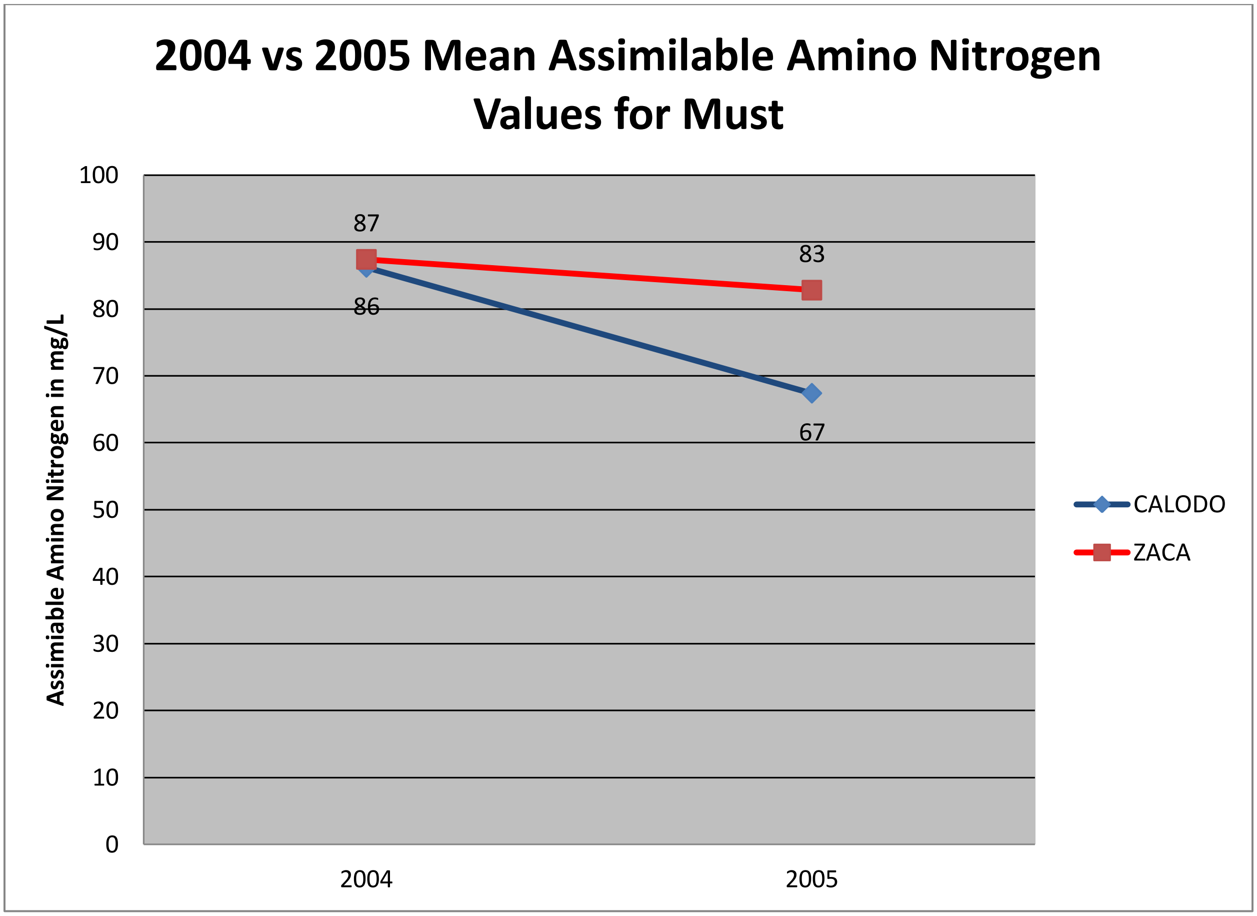
Figure 35: Mean Values for Calcium for Must



4.3.14 Assimilable Amino Acid

The analysis for assimilable amino acid in must showed no significant difference for vintage year,soil , or year * soil interaction at the $P < 0.05$ level. The P value for the vintage year was 0.067 which is close to the stated P value of $P < 0.05$.

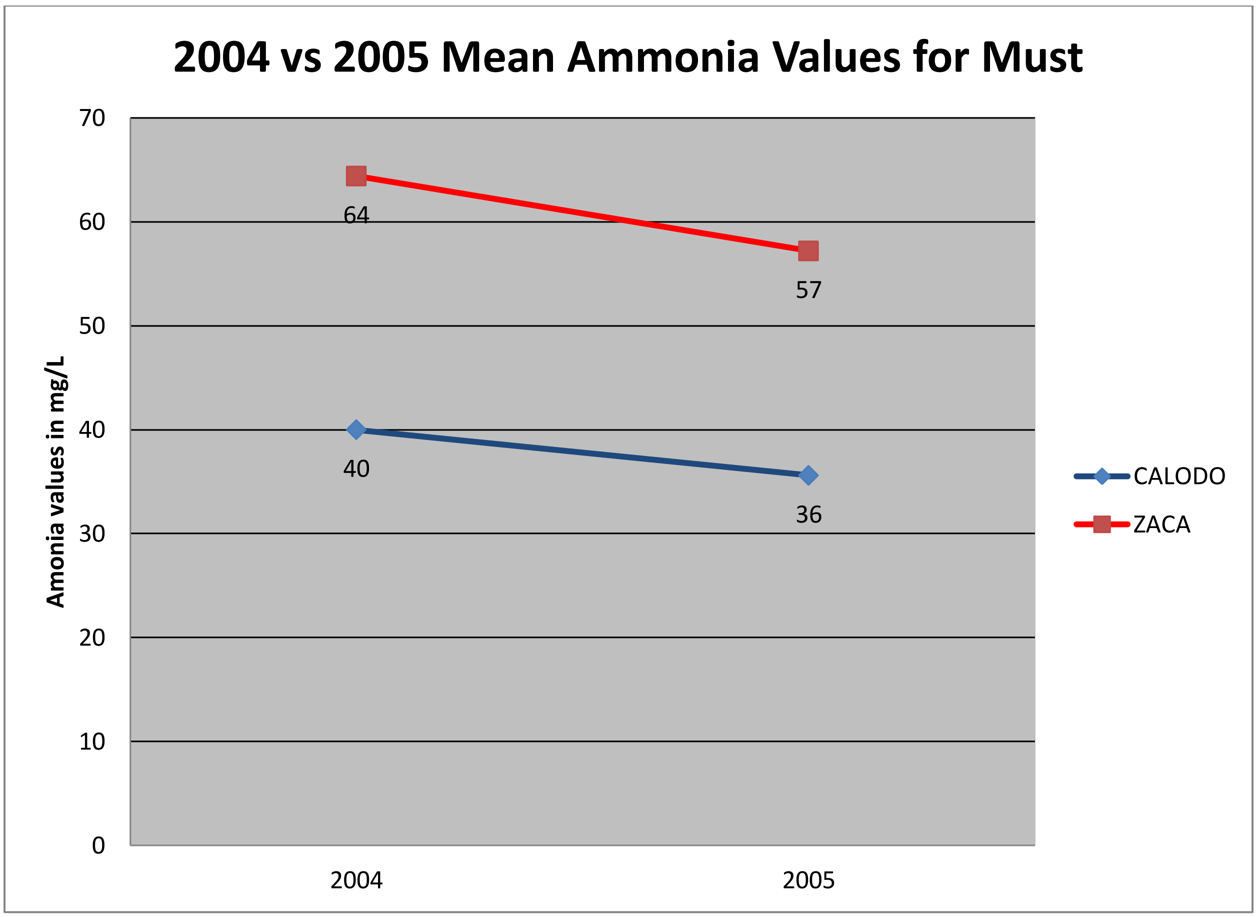
Figure 36: Mean Values for Assimilable Amino Nitrogen for Must



4.3.15 Ammonia

The analysis for ammonia in must showed a highly significant difference for soil at the $P < 0.01$ level. The P value was 0.000 with the Zaca Clay soil having a higher mean value than the Calodo Clay Loam soil. The vintage year, and year * soil interaction were not significant at the $P < 0.05$ level.

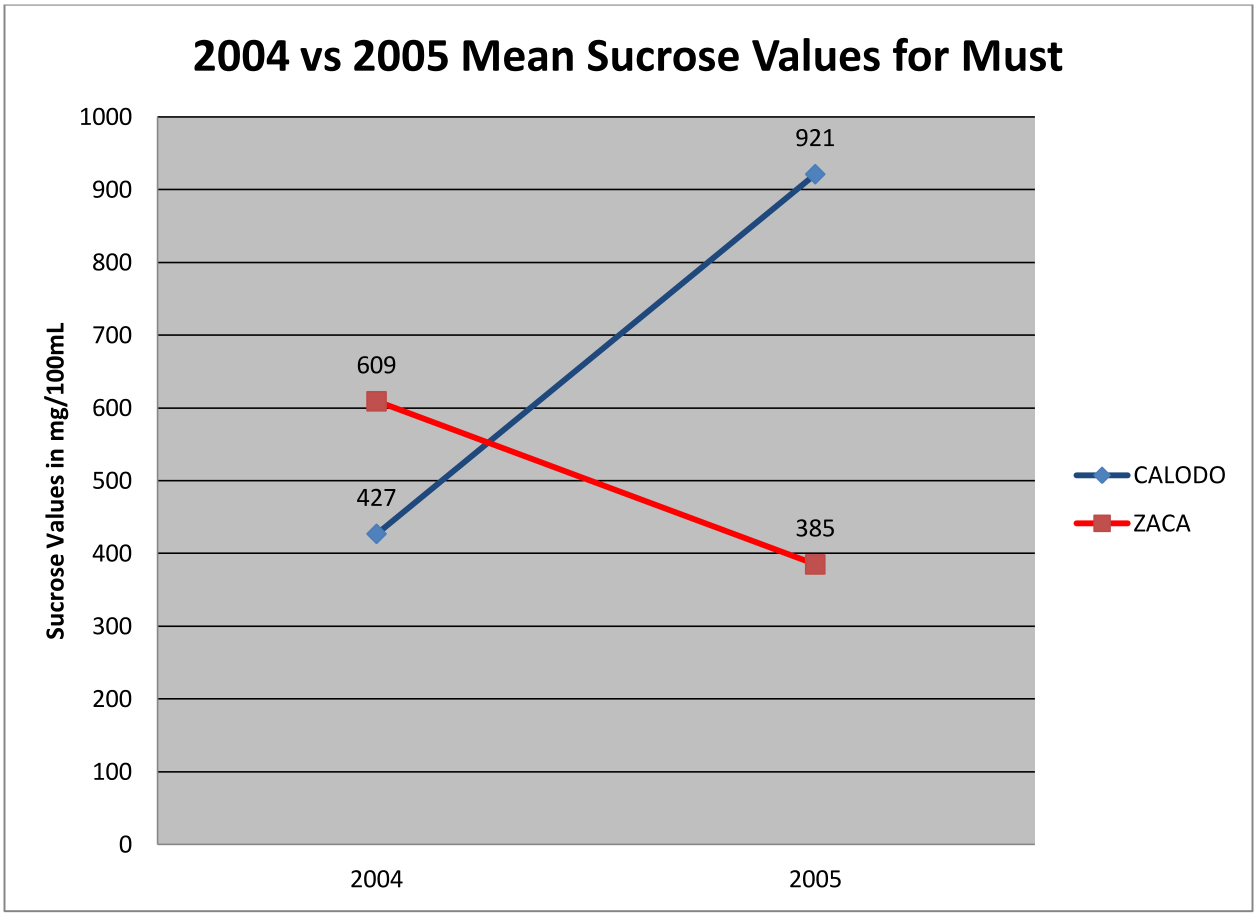
Figure 37: Mean Values for Ammonia for Must



4.3.16 Sucrose

The analysis for sucrose in must did not show significant differences for vintage years ,soil, and year * soil interaction at the $P < 0.05$ level. The graph shows an interaction but the P value for year * soil interaction was above $P < 0.05$ percent at 0.090.

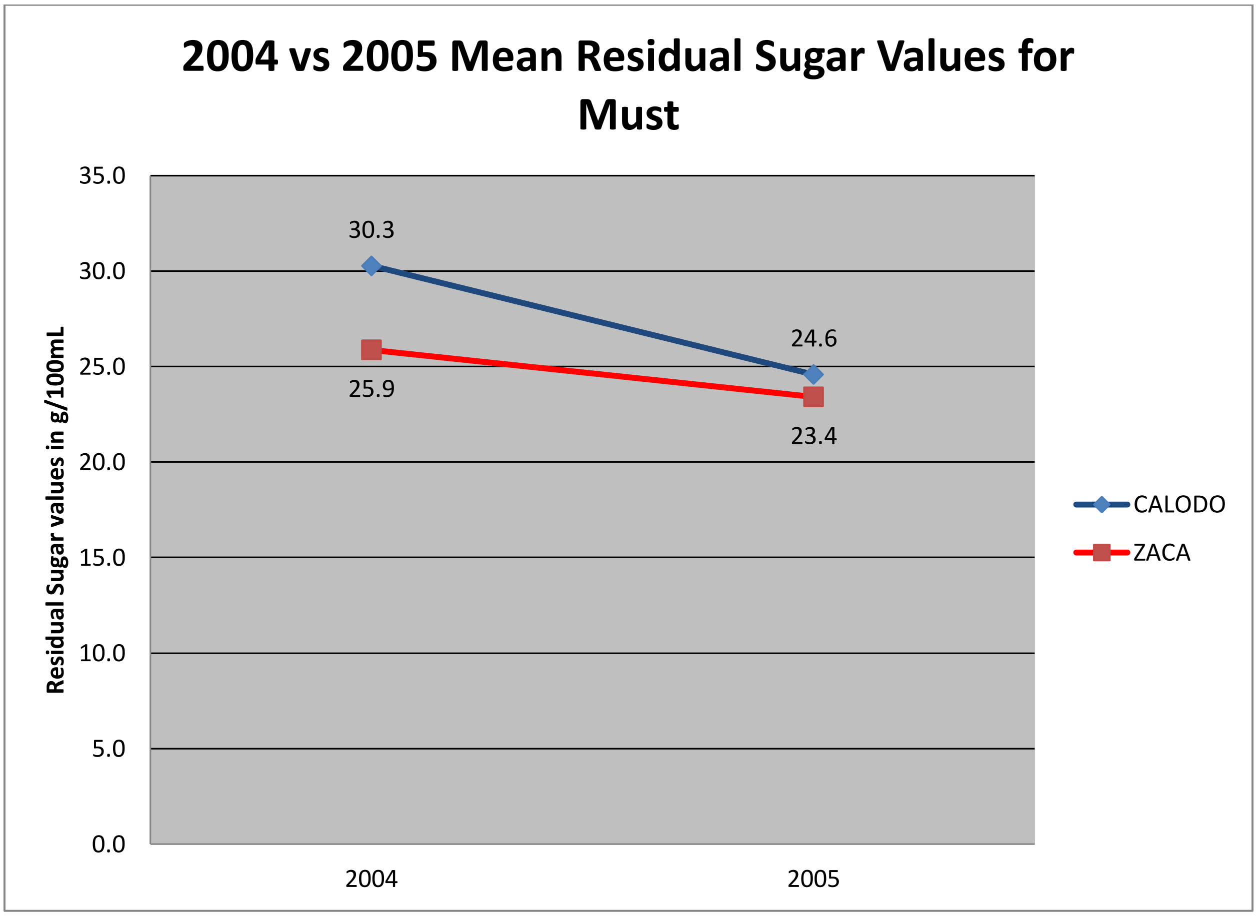
Figure 38: Mean Values for Sucrose for Must



4.3.17 Residual Sugars

The analysis for residual sugars in must showed a highly significant difference between vintage years, and soil at $P < 0.01$. There was a significant difference for the year * soil interaction at the $P < 0.05$ level. The P value for the vintage year was 0.000 with the 2004 year having a higher mean value. The soil P value was 0.002 with Calodo Clay Loam soil having a higher mean value than Zaca Clay. The year * soil interaction P value was 0.042 with the 2004 Calodo Clay Loam having the highest mean value.

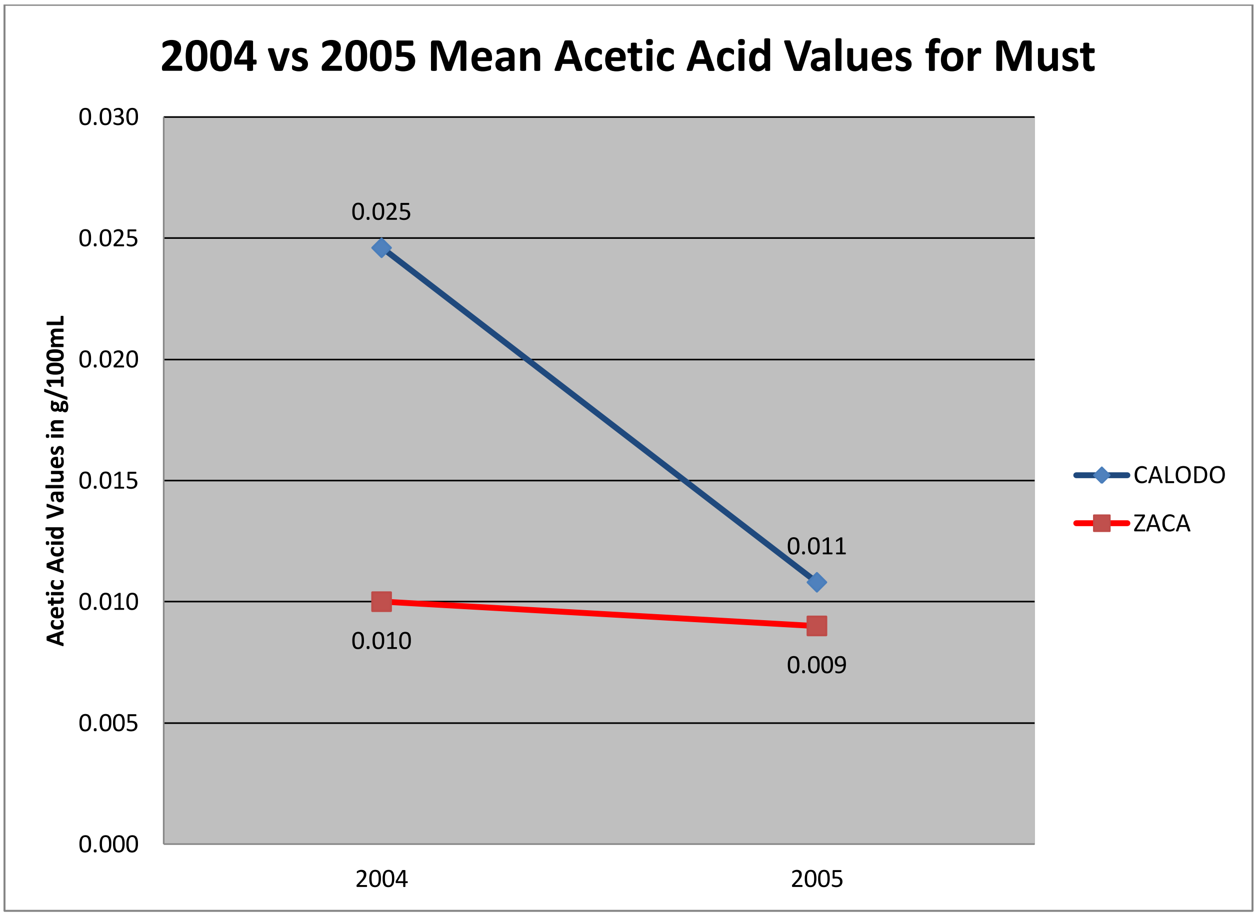
Figure 39: Mean Values for Residual Sugars for Must



4.3.18 Acetic Acid

The analysis for acetic acid in must showed a highly significant difference for vintage years, soil, and year * soil interaction at $P < 0.01$. The P value for the vintage year was 0.001 with the 2004 year having a higher mean value than 2005. The soil P value was 0.001 with Calodo Clay Loam soil having a higher mean value than Zaca Clay. The year * soil interaction P value was 0.004 with the 2004 Calodo Clay Loam having the highest mean value.

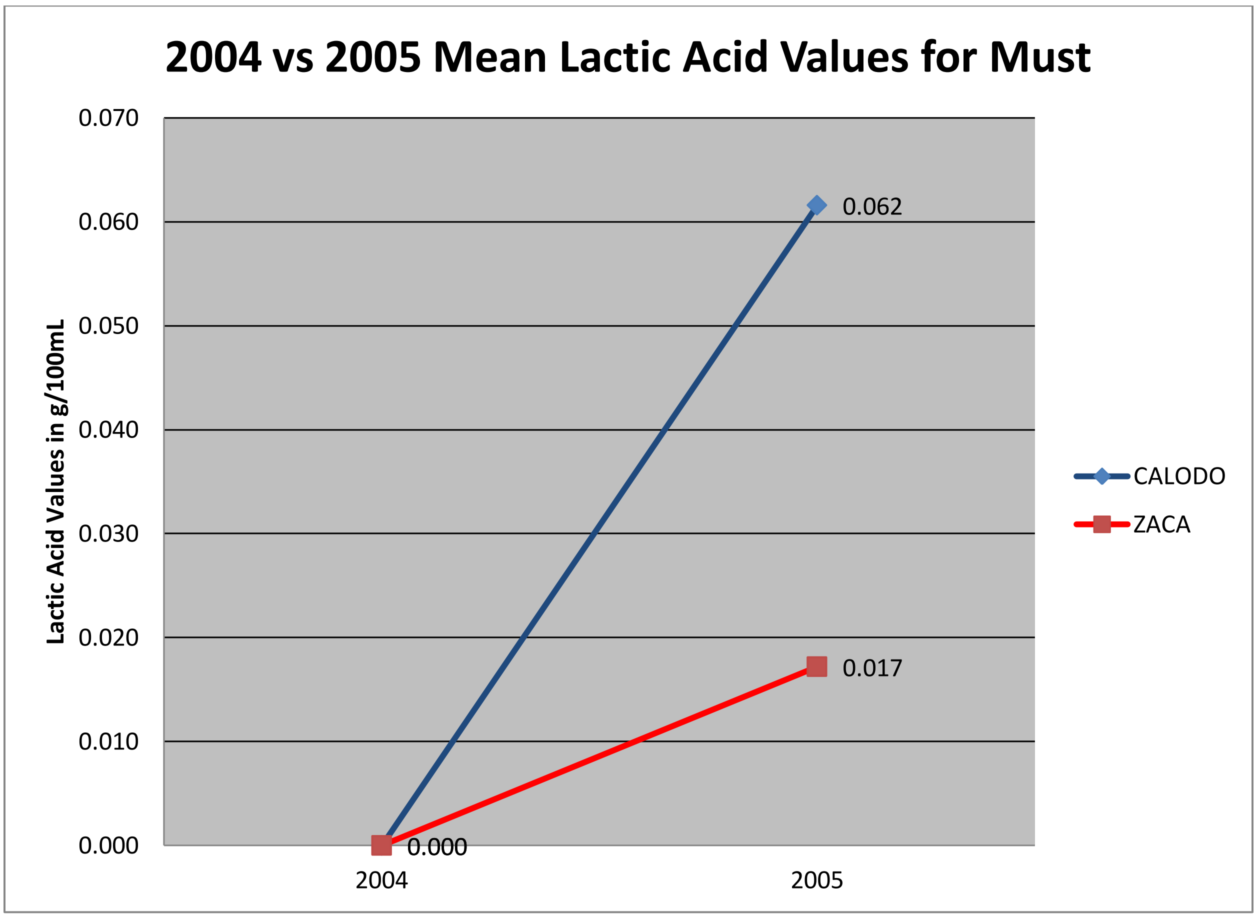
Figure 40: Mean Values for Acetic Acid for Must



4.3.19 Lactic Acid

The analysis for lactic acid in must showed a significant difference for vintage year at $P < 0.05$ level. The P value for the vintage year was 0.015 with the 2005 year having a higher mean value than 2004. The soil and the year * soil interaction were not significant at the P .05 level.

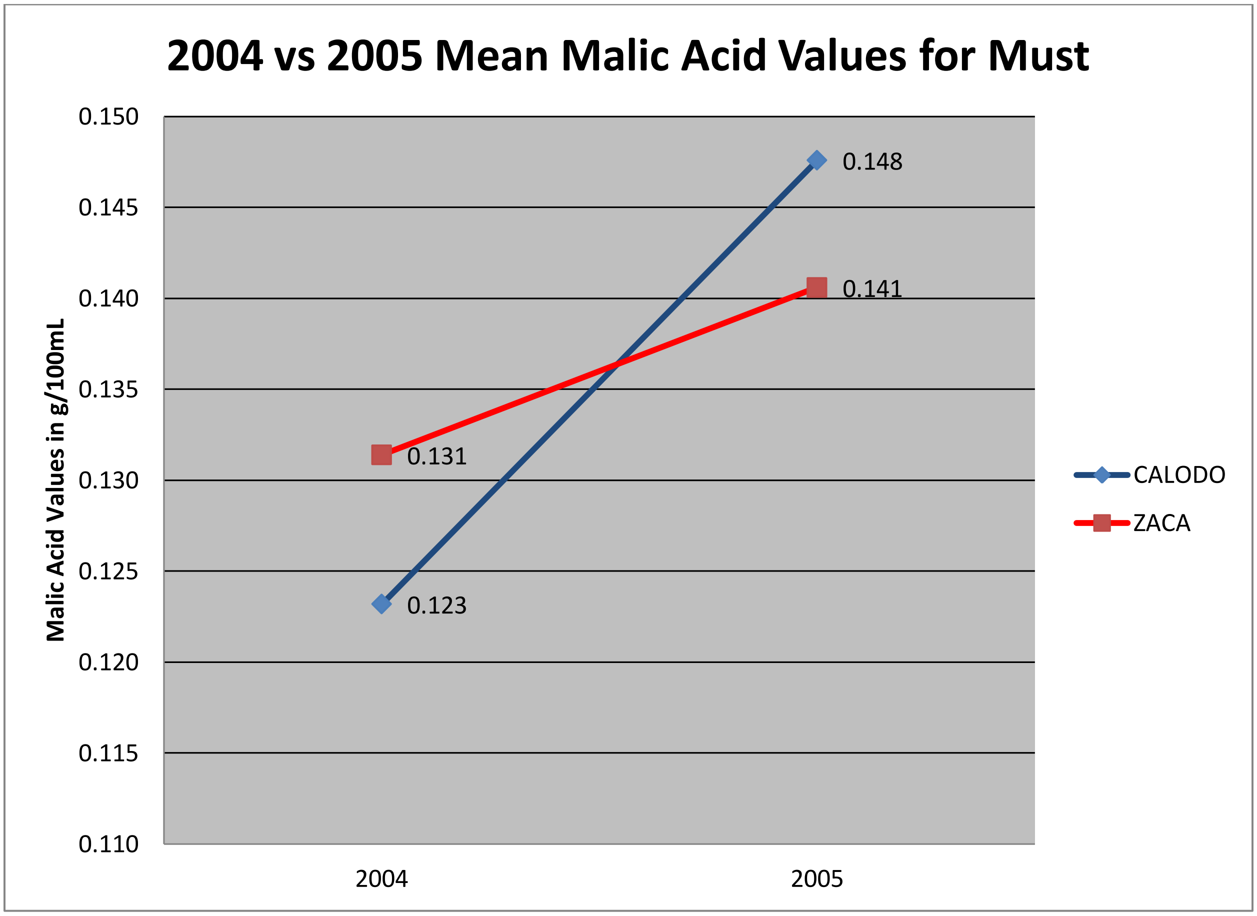
Figure 41: Mean Values for Lactic Acid for Must



4.3.20 Malic Acid

The analysis for malic acid in must showed no significant difference for vintage year, soil, or year * soil interaction at the P < 0.05 level.

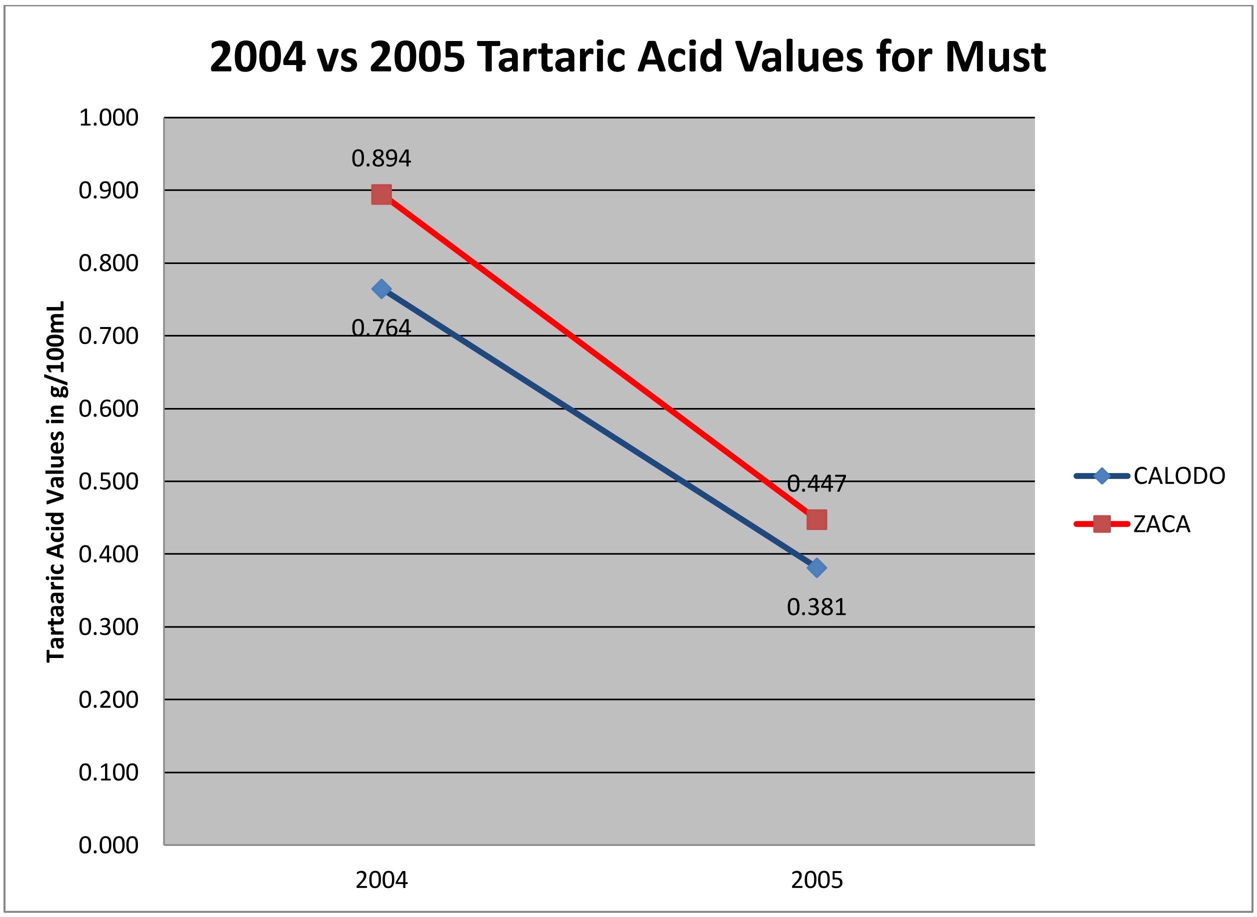
Figure 42: Mean Values for Malic Acid for Must



4.3.21 Tartaric Acid

The analysis for tartaric acid in must showed a highly significant difference for vintage year at the $P < 0.01$ level and a significant difference for soil at the $P < 0.05$ level. The P value for the year was 0.000 with the 2004 year having a higher mean than 2005. The P value for the soil was 0.035 with Zaca Clay having a higher mean value than Calodo Clay Loam. The year * soil interaction was not significant at the $P < 0.05$ level.

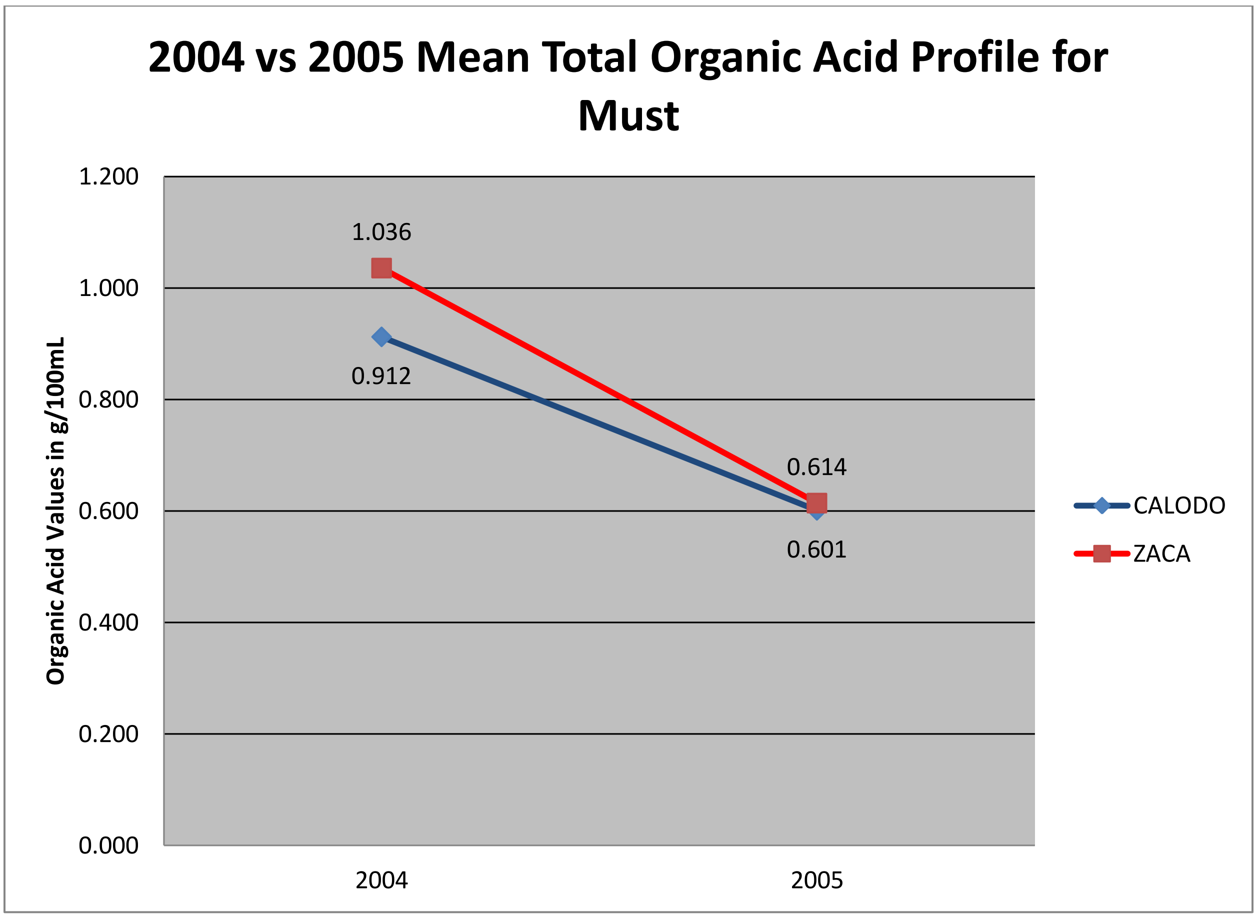
Figure 43: Mean Values for Tartaric Acid for Must



4.3.22 Total Organic Acid Profile

The analysis for the total organic acid profile in must showed a highly significant difference for vintage year at the $P < 0.01$ level. The P value was 0.000 with the 2004 year having a higher mean value than 2005. The soil and the year * soil interaction were not significant at the $P < 0.05$ level.

Figure 44: Mean Values for Total Organic Acid Profile for Must



Chapter 5

Conclusions and Recommendations for Future Study

5.1 Conclusions

In this study 22 response variables were analyzed for both the must and the pre-barrel wine data. The statistical analysis generated listed P values for the year, the soil, and the year * soil interaction (listed in Appendix). Some of the response variables had P values listed for more than one category. Although there were three categories of P values listed per response variable this study was mainly focused on the significance of the P values for the vintage year of the response variable.

5.1.1 Response Variable Analysis for Vintage Year

The analysis for the vintage year showed significant results under the $P < 0.05$ for 10 wine and 16 must response variables. The pH and tartaric acid response variables measured in wine were significant with P values of less than .05. Titratable acidity, A420 color absorbance, A520 color absorbance, intensity, hue, total SO_2, iron , and assimilable amino nitrogen all were highly significant with values of $P < 0.01$. In the must analysis Brix and lactic acid response variables were significant with values of $P < 0.05$. The other 14 were highly significant with a $P < 0.01$ value. They were pH,A420 color absorbance, A520 color absorbance, intensity, totalSO_2, free SO_2, copper, iron, calcium, potassium, residual sugar, acetic acid, tartaric acid, and total organic profile.

5.1.2 Response Variable Analysis for Soil

The soil analysis showed significant results under the $P < 0.05$ level for 8 wine and 8 must response variables. The A420 color absorbance, potassium, and residual sugar variables for wine were significant at the $P < 0.05$ level. The Brix, pH, hue, iron, and acetic acid wine variables were highly significant at $P < 0.01$. The must variable for tartaric acid was significant at the $P < 0.05$ level. Brix, pH, hue, iron, ammonia, reducing sugar, and acetic acid were all highly significant at $P < 0.01$.

5.1.3 Response Variable Analysis for Year * Soil Analysis

The year * soil interaction analysis showed significant results under the $P < 0.05$ level for 2 wine and 4 must response variables. The titratable acidity and total organic acid profile variables for wine were significant at the $P < 0.05$ level. The residual sugar variable for must was significant at the $P < 0.05$ level. The Brix, pH, and acetic acid must variables were highly significant at $P < 0.01$.

5.1.4 Wine and Must Response Variables not significant at $P < 0.05$

The analysis results showed that there were 7 wine and 4 must response variables that were not significant. The analysis of these variables returned P value results for the vintage year, soil, and year * soil interaction that were all greater than 0.05. The wine variables were free SO_2, copper, calcium, ammonia, sucrose, lactic acid, and malic acid. The must variables were titratable acidity, assimiable amino nitrogen, sucrose, and malic acid.

5.1.5 Wine and Must Response Variables with Significant P Values in Multiple Categories

The analysis report showed that 4 wine response variables and 6 must variables tested significant at $P < 0.05$ in multiple categories. The pH variable result for wine was significant at $P < 0.05$ for year and highly significant at $P < 0.01$ for soil. The results for hue and iron both were highly significant at $P < 0.01$ for year and soil. There was no year * soil interaction for pH, hue, or iron. The A420 color absorbance variable for wine showed results in all three categories. The A420 variable was highly significant at $P < 0.01$ for year and significant at $P < 0.05$ for soil and year * soil interaction. The tartaric acid variable for must tested highly significant at $P < 0.01$ for the year and significant at $P < 0.05$ for soil. The iron must variable tested highly significant at $P < 0.01$ for year and soil. There were no year * soil interactions for the tartaric acid or iron variables in must. The must residual sugar variable tested highly significant at $P < 0.01$ for year and soil. The year * soil interaction was only significant at the $P < 0.05$ level. The Brix must variable for year was significant at $P < 0.05$.The soil and year * soil interaction results were both highly significant at $P < 0.01$. The results for the pH and acetic acid variables in must were the same. They both tested highly significant at $P < 0.01$ for year, soil, and year * soil interaction.

5.1.6 Response Variables with same P Category Range Occurring in both Must and Wine

There were instances where results from certain response variables were in the same P category range for analysis of both must and wine. An example of this might be a response variable result of $P < 0.05$ that occurs in both the wine and the must analysis results. There were 11 response variables that fell into this category. Sucrose and malic acid were both not significant at the $P < 0.05$ level for year, soil, or year * soil interaction. The response variables A420, A520, intensity, and total SO_2 tested highly significant at $P < 0.01$ for the vintage year. The response variables Brix, pH, hue, and acetic acid tested highly significant at $P < 0.01$ for soil. The response variable iron tested highly significant at $P < 0.01$ for both year and soil. None of the response variables listed tested significant in the year * soil interaction for both must and wine.

5.1.7 Evaluation of Vintage Year

The purpose of this study was to evaluate if the vintage year had a significant effect on the terroir of the Cabernet Sauvignon grapes. There were 22 response variables tested for the pre-barrel wine and the must for a total of 44 observations.

The results for the vintage year for must showed that 15 of 22 response variables or 68.2% tested significant at the $P<0.05$ level. From these 15 variables 14 tested highly significant at the $P < 0.01$ level. There were also 4 of the 15 variables that tested significant for year * soil interaction at the $P<0.05$ level. From these 4 variables 3 tested highly significant at the $P < 0.01$ level. The vintage year results for pre-barrel wine showed 9 of 22 response variables or 40.9% tested significant at the $P<0.05$ level. From these 9 variables, 8 tested highly significant at the $P < 0.01$ level. The results for the combined variables for must and pre-barrel wine in the vintage year showed 24 of 44 variables or 54.5% were significant at the $P < 0.05$ level. From these 24 variables, 22 were highly significant at the $P < 0.01$ level.

The results for must show that more than two thirds of the tested response variables are significant. Most of these variables were highly significant. One tested significant and 3 highly significant for year * soil interactions. Nearly one half of the response variables for pre-barrel wine tested significant with most

being highly significant. The overall combined results show that over one half of the response variables tested significant with the vast majority being highly significant.

These results seem to indicate that there is a very strong probability that the vintage year has a significant effect on the terroir of the Cabernet Sauvignon grapes.

5.2 Recommendations for Further Research

1. Rainfall and temperature data for the vineyard studied and the surrounding region should be included and analyzed.

2. Cluster sampling for the block samples should be conducted. The clusters should be crushed and the grape juice should be measured for Brix, titratable acidity, and pH values. These values can later be compared with the must and pre-barrel wine samples.

3. The sample plots for each soil should be located as close together as possible for better statistical data results.

4. From the data accumulated a further study on must and pre-barrel wine interaction could be performed in addition to this study.

Assumptions

This study assumes that the variation in weather in 2004 and 2005 did not adversely influence or affect the results of the response variables. This assumption is based on the experiment design and the statistical model used to analyze the data. The protocol for harvest and fermentation of the 2004 and 2005 Cabernet Sauvignon grapes is assumed to be within the same parameters for both years.

Limitations

The study procured the Cabernet Sauvignon grapes from a working vineyard and winery. Due to this the soil could not be dug up to see where an exact border of the two soils occurred. This makes the spacing of the sample blocks farther apart for accuracy purposes.

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Appendix A

Analysis of Variance for Wine

General Linear Model: Brix versus YEAR, SOIL

Analysis of Variance for Brix, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	0.371	0.371	0.371	0.28	0.602
SOIL	1	21.597	21.597	21.597	16.46	0.001
YEAR * SOIL	1	4.053	4.053	4.053	3.09	0.098
Error	16	20.990	20.990	1.312		
Total	19	47.011				

General Linear Model: PH versus YEAR, SOIL

Analysis of Variance for PH, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	0.09275	0.09275	0.09275	7.34	0.015
SOIL	1	0.26634	0.26634	0.26634	21.07	00.000
YEAR * SOIL	1	0.04881	0.04881	0.04881	3.86	0.067
Error	16	0.20229	0.20229	0.01264		
Total	19	0.61020				

General Linear Model: TA versus YEAR, SOIL

Analysis of Variance for TA, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	0.160444	0.160444	0.160444	55.55	00.000
SOIL	1	0.009382	0.009382	0.009382	3.25	0.090
YEAR * SOIL	1	00.000173	00.000173	00.000173	0.06	0.810
Error	16	0.046212	0.046212	0.002888		
Total	19	0.216211				

General Linear Model: A420 versus YEAR, SOIL

Analysis of Variance for A420, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	60.683	60.683	60.683	306.40	00.000
SOIL	1	1.483	1.483	1.483	7.49	0.015
YEAR * SOIL	1	1.640	1.640	1.640	8.28	0.011
Error	16	3.169	3.169	0.198		
Total	19	66.975				

General Linear Model: A520 versus YEAR, SOIL

Analysis of Variance for A520, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	195.425	195.425	195.425	190.98	00.000
SOIL	1	0.242	0.242	0.242	0.24	0.633
YEAR * SOIL	1	0.534	0.534	0.534	0.52	0.480
Error	16	16.372	16.372	1.023		
Total	19	212.574				

General Linear Model: Intensity versus YEAR, SOIL

Analysis of Variance for Intensity, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	473.91	473.91	473.91	225.58	00.000
SOIL	1	2.92	2.92	2.92	1.39	0.255
YEAR * SOIL	1	4.05	4.05	4.05	1.93	0.184
Error	16	33.61	33.61	2.10		
Total	19	514.49				

General Linear Model: Hue versus YEAR, SOIL

Analysis of Variance for Hue, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	0.030876	0.030876	0.030876	12.60	0.003
SOIL	1	0.038567	0.038567	0.038567	15.74	0.001
YEAR * SOIL	1	0.007126	0.007126	0.007126	2.91	0.107
Error	16	0.039208	0.039208	0.002450		
Total	19	0.115777				

General Linear Model: Total SO2 versus YEAR, SOIL

Analysis of Variance for Total SO2, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	3150.1	3150.1	3150.1	147.37	00.000
SOIL	1	36.5	36.5	36.5	1.71	0.210
YEAR * SOIL	1	36.5	36.5	36.5	1.71	0.210
Error	16	342.0	342.0	21.4		
Total	19	3565.0				

General Linear Model: Copper versus YEAR, SOIL

Analysis of Variance for Copper, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	0.007220	0.007220	0.007220	2.88	0.109
SOIL	1	0.001620	0.001620	0.001620	0.65	0.434
YEAR * SOIL	1	00.000320	00.000320	00.000320	0.13	0.726
Error	16	0.040160	0.040160	0.002510		
Total	19	0.049320				

General Linear Model: Iron versus YEAR, SOIL

Analysis of Variance for Iron, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	0.112500	0.112500	0.112500	46.06	00.000
SOIL	1	0.033620	0.033620	0.033620	13.76	0.002
YEAR * SOIL	1	00.000080	00.000080	00.000080	0.03	0.859
Error	16	0.039080	0.039080	0.002443		
Total	19	0.185280				

General Linear Model: Potassium versus YEAR, SOIL

Analysis of Variance for Potassium, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	18911	18911	18911	0.44	0.515
SOIL	1	295488	295488	295488	6.91	0.018
YEAR * SOIL	1	8446	8446	8446	0.20	0.663
Error	16	683781	683781	42736		
Total	19	1006627				

General Linear Model: Calcium versus YEAR, SOIL

Analysis of Variance for Calcium, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	204.80	204.80	204.80	3.06	0.099
SOIL	1	57.80	57.80	57.80	0.86	0.366
YEAR * SOIL	1	7.20	7.20	7.20	0.11	0.747
Error	16	1070.40	1070.40	66.90		
Total	19	1340.20				

General Linear Model: Assimiable Amino Nitrogen versus YEAR, SOIL

Analysis of Variance for Assimiable Amino Nitrogen, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	3075.2	3075.2	3075.2	73.35	00.000
SOIL	1	39.2	39.2	39.2	0.94	0.348
YEAR * SOIL	1	45.0	45.0	45.0	1.07	0.316
Error	16	670.8	670.8	41.9		
Total	19	3830.2				

General Linear Model: Ammonia versus YEAR, SOIL

Analysis of Variance for Ammonia, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	0.2000	0.2000	0.2000	1.00	0.332
SOIL	1	0.2000	0.2000	0.2000	1.00	0.332
YEAR * SOIL	1	0.2000	0.2000	0.2000	1.00	0.332
Error	16	3.2000	3.2000	0.2000		
Total	19	3.8000				

General Linear Model: Sucrose versus YEAR, SOIL

Analysis of Variance for Sucrose, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	211.25	211.25	211.25	2.11	0.165
SOIL	1	54.45	54.45	54.45	0.54	0.471
YEAR * SOIL	1	54.45	54.45	54.45	0.54	0.471
Error	16	1599.60	1599.60	99.97		
Total	19	1919.75				

General Linear Model: Reducing Sugar versus YEAR, SOIL

Analysis of Variance for Reducing Sugar, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	0.9396	0.9396	0.9396	3.24	0.091
SOIL	1	1.3494	1.3494	1.3494	4.65	0.047
YEAR * SOIL	1	0.0525	0.0525	0.0525	0.18	0.676
Error	16	4.6458	4.6458	0.2904		
Total	19	6.9874				

General Linear Model: Acetic Acid versus YEAR, SOIL

Analysis of Variance for Acetic Acid, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	00.0002520	00.0002520	00.0002520	3.45	0.082
SOIL	1	0.0018240	0.0018240	0.0018240	24.94	00.000
YEAR * SOIL	1	00.0001624	00.0001624	00.0001624	2.22	0.156
Error	16	0.0011700	0.0011700	00.0000731		
Total	19	0.0034085				

General Linear Model: Lactic Acid versus YEAR, SOIL

Analysis of Variance for Lactic Acid, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	00.0000840	00.0000840	00.0000840	0.31	0.583
SOIL	1	00.0001741	00.0001741	00.0001741	0.65	0.432
YEAR * SOIL	1	00.0000001	00.0000001	00.0000001	0.00	0.989
Error	16	0.0042788	0.0042788	00.0002674		
Total	19	0.0045370				

General Linear Model: Malic Acid versus YEAR, SOIL

Analysis of Variance for Malic Acid, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	00.0004050	00.0004050	00.0004050	0.99	0.334
SOIL	1	00.0000648	00.0000648	00.0000648	0.16	0.696
YEAR * SOIL	1	0.0012168	0.0012168	0.0012168	2.98	0.104
Error	16	0.0065432	0.0065432	00.0004089		
Total	19	0.0082298				

General Linear Model: Tartaric Acid versus YEAR, SOIL

Analysis of Variance for Tartaric Acid, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	0.07863	0.07863	0.07863	7.62	0.014
SOIL	1	0.02563	0.02563	0.02563	2.48	0.135
YEAR * SOIL	1	0.02100	0.02100	0.02100	2.03	0.173
Error	16	0.16516	0.16516	0.01032		
Total	19	0.29041				

General Linear Model: Total Organic Acid Profile versus YEAR, SOIL

Analysis of Variance for Total Organic Acid Profile, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
YEAR	1	0.00122	0.00122	0.00122	0.11	0.743
SOIL	1	0.00173	0.00173	0.00173	0.16	0.696
YEAR * SOIL	1	0.06138	0.06138	0.06138	5.61	0.031
Error	16	0.17520	0.17520	0.01095		
Total	19	0.23953				

Appendix B

Analysis of Variance for Must

General Linear Model: Brix versus Year, Soil

Analysis of Variance for Brix, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	10.139	10.139	10.139	7.41	0.015
Soil	1	35.591	35.591	35.591	26.00	00.000
Year * soil	1	17.447	17.447	17.447	12.74	0.003
Error	16	21.904	21.904	1.369		
Total	19	85.081				

General Linear Model: PH versus Year, Soil

Analysis of Variance for PH, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	0.05030	0.05030	0.05030	9.66	0.007
Soil	1	0.20665	0.20665	0.20665	39.67	00.000
Year * soil	1	0.08359	0.08359	0.08359	16.05	0.001
Error	16	0.08335	0.08335	0.00521		
Total	19	0.42389				

General Linear Model: TA versus Year, Soil

Analysis of Variance for TA, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	0.001815	0.001815	0.001815	1.26	0.278
Soil	1	00.000054	00.000054	00.000054	0.04	0.848
Year * soil	1	00.000004	00.000004	00.000004	0.00	0.958
Error	16	0.023037	0.023037	0.001440		
Total	19	0.024910				

General Linear Model: A420 versus Year, Soil

Analysis of Variance for A420, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	4.4011	4.4011	4.4011	75.25	00.000
Soil	1	0.0086	0.0086	0.0086	0.15	0.707
Year * soil	1	0.0112	0.0112	0.0112	0.19	0.667
Error	16	0.9357	0.9357	0.0585		
Total	19	5.3566				

General Linear Model: A520 versus Year, Soil

Analysis of Variance for A520, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	8.6764	8.6764	8.6764	46.88	00.000
Soil	1	0.6520	0.6520	0.6520	3.52	0.079
Year * soil	1	0.4266	0.4266	0.4266	2.31	0.148
Error	16	2.9612	2.9612	0.1851		
Total	19	12.7162				

General Linear Model: Intensity versus Year, Soil

Analysis of Variance for Intensity, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	25.4364	25.4364	25.4364	58.44	00.000
Soil	1	0.5110	0.5110	0.5110	1.17	0.295
Year * soil	1	0.2994	0.2994	0.2994	0.69	0.419
Error	16	6.9646	6.9646	0.4353		
Total	19	33.2115				

General Linear Model: Hue versus Year, Soil

Analysis of Variance for Hue, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	0.06199	0.06199	0.06199	3.52	0.079
Soil	1	0.46562	0.46562	0.46562	26.42	00.000
Year * soil	1	0.04827	0.04827	0.04827	2.74	0.117
Error	16	0.28203	0.28203	0.01763		
Total	19	0.85791				

General Linear Model: Total SO2 versus Year, Soil

Analysis of Variance for Total SO2, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	165074	165074	165074	34.77	00.000
Soil	1	6588	6588	6588	1.39	0.256
Year * soil	1	6588	6588	6588	1.39	0.256
Error	16	75971	75971	4748		
Total	19	254223				

General Linear Model: Free SO2 versus Year, Soil

Analysis of Variance for Free SO2, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	77626	77626	77626	36.04	00.000
Soil	1	3277	3277	3277	1.52	0.235
Year * soil	1	3277	3277	3277	1.52	0.235
Error	16	34459	34459	2154		
Total	19	118638				

General Linear Model: Copper versus Year, Soil

Analysis of Variance for Copper, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	0.032000	0.032000	0.032000	45.23	00.000
Soil	1	00.000980	00.000980	00.000980	1.39	0.256
Year * soil	1	0.002880	0.002880	0.002880	4.07	0.061
Error	16	0.011320	0.011320	00.000707		
Total	19	0.047180				

General Linear Model: Iron versus Year, Soil

Analysis of Variance for Iron, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	0.176720	0.176720	0.176720	19.45	00.000
Soil	1	0.100820	0.100820	0.100820	11.09	0.004
Year * soil	1	00.000980	00.000980	00.000980	0.11	0.747
Error	16	0.145400	0.145400	0.009088		
Total	19	0.423920				

General Linear Model: Potassium versus Year, Soil

Analysis of Variance for Potassium, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	506574	506574	506574	12.99	0.002
Soil	1	166166	166166	166166	4.26	0.056
Year * soil	1	41496	41496	41496	1.06	0.318
Error	16	624089	624089	39006		
Total	19	1338326				

General Linear Model: Calcium versus Year, Soil

Analysis of Variance for Calcium, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	12350.5	12350.5	12350.5	109.88	00.000
Soil	1	14.4	14.4	14.4	0.13	0.725
Year * soil	1	1.2	1.2	1.2	0.01	0.917
Error	16	1798.4	1798.4	112.4		
Total	19	14164.6				

General Linear Model: Assimiable Amino Nitrogen versus Year, Soil

Analysis of Variance for Assimiable Amino Nitrogen, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	684.5	684.5	684.5	3.87	0.067
Soil	1	344.4	344.4	344.4	1.95	0.182
Year * soil	1	252.1	252.1	252.1	1.42	0.250
Error	16	2832.0	2832.0	177.0		
Total	19	4113.0				

General Linear Model: Ammonia versus Year, Soil

Analysis of Variance for Ammonia, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	168.20	168.20	168.20	1.81	0.197
Soil	1	2645.00	2645.00	2645.00	28.49	00.000
Year * soil	1	9.80	9.80	9.80	0.11	0.749
Error	16	1485.20	1485.20	92.83		
Total	19	4308.20				

General Linear Model: Sucrose versus Year, Soil

Analysis of Variance for Sucrose, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	91260	91260	91260	0.46	0.507
Soil	1	156822	156822	156822	0.79	0.387
Year * soil	1	645482	645482	645482	3.26	0.090
Error	16	3168362	3168362	198023		
Total	19	4061927				

General Linear Model: Reducing Sugar versus Year, Soil

Analysis of Variance for Reducing Sugar, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	82.947	82.947	82.947	31.25	00.000
Soil	1	38.670	38.670	38.670	14.57	0.002
Year * soil	1	12.977	12.977	12.977	4.89	0.042
Error	16	42.474	42.474	2.655		
Total	19	177.067				

General Linear Model: Acetic Acid versus Year, Soil

Analysis of Variance for Acetic Acid, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	00.0002738	00.0002738	00.0002738	15.11	0.001
Soil	1	00.0003362	00.0003362	00.0003362	18.55	0.001
Year * soil	1	00.0002048	00.0002048	00.0002048	11.30	0.004
Error	16	00.0002900	00.0002900	00.0000181		
Total	19	0.0011048				

General Linear Model: Lactic Acid versus Year, Soil

Analysis of Variance for Lactic Acid, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	0.007762	0.007762	0.007762	7.47	0.015
Soil	1	0.002464	0.002464	0.002464	2.37	0.143
Year * soil	1	0.002464	0.002464	0.002464	2.37	0.143
Error	16	0.016624	0.016624	0.001039		
Total	19	0.029314				

General Linear Model: Malic Acid versus Year, Soil

Analysis of Variance for Malic Acid, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	0.0014112	0.0014112	0.0014112	1.96	0.181
Soil	1	00.0000018	00.0000018	00.0000018	0.00	0.961
Year * soil	1	00.0002888	00.0002888	00.0002888	0.40	0.536
Error	16	0.0115304	0.0115304	00.0007206		
Total	19	0.0132322				

General Linear Model: Tartaric Acid versus Year, Soil

Analysis of Variance for Tartaric Acid, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	0.86196	0.86196	0.86196	95.25	00.000
Soil	1	0.04802	0.04802	0.04802	5.31	0.035
Year * soil	1	0.00506	0.00506	0.00506	0.56	0.466
Error	16	0.14480	0.14480	0.00905		
Total	19	1.05983				

General Linear Model: Total Organic Acid Profile versus Year, Soil

Analysis of Variance for Total Organic Acid Profile, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Year	1	0.67124	0.67124	0.67124	76.18	00.000
Soil	1	0.02326	0.02326	0.02326	2.64	0.124
Year * soil	1	0.01524	0.01524	0.01524	1.73	0.207
Error	16	0.14099	0.14099	0.00881		
Total	19	0.85072				

Appendix C

Response Variables by Category for Pre-Barrel Wine

Pre-Barrel Wine	All P>.05	P Year<.05	P Year<.01	P Soil<.05	P Soil<.01	P year * soil<.05	P year * soil<.01
Brix					x		
PH		x			x		
TA			x				
A420			x	x		x	
A520			x				
Intensity			x				
Hue			x		x		
Total SO2			x				
Free SO2	x						
Copper	x						
Iron			x		x		
Potassium				x			
Calcium	x						
Assimiable Amino Nitrogen			x				
Ammonia	x						
Sucrose	x						
Reducing Sugar				x			
Acetic Acid					x		
Lactic Acid	x						
Malic Acid	x						
Tartaric Acid		x					
Total Organic Acid Profile						x	

Appendix D

Response Variables by Category for Must

Must	All P>.05	P Year<.05	P Year<.01	P Soil<.05	P Soil<.01	P year * soil<.05	P year * soil<.01
Brix		x			x		x
PH			x		x		x
TA	x						
A420			x				
A520			x				
Intensity			x				
Hue					x		
Total SO2			x				
Free SO2			x				
Copper			x				
Iron			x		x		
Potassium			x				
Calcium			x				
Assimiable Amino Nitrogen	x						
Ammonia					x		
Sucrose	x						
Reducing Sugar			x		x	x	
Acetic Acid			x		x		x
Lactic Acid		x					
Malic Acid	x						
Tartaric Acid			x	x			
Total Organic Acid Profile			x				

Appendix E

Wine and Must Response Variables with Significant P Values in Multiple Categories

Wine	All P>.05	P Year<.05	P Year<.01	P Soil<.05	P Soil<.01	P year * soil<.05	P year * soil<.01
Brix							
PH		**x**			**x**		
TA							
A420			**x**	**x**		**x**	
A520							
Intensity							
Hue			**x**		**x**		
Total SO2							
Free SO2							
Copper							
Iron			**x**		**x**		
Potassium							
Calcium							
Assimiable Amino Nitrogen							
Ammonia							
Sucrose							
Reducing Sugar							
Acetic Acid							
Lactic Acid							
Malic Acid							
Tartaric Acid							
Total Organic Acid Profile							

Must	All P>.05	P Year<.05	P Year<.01	P Soil<.05	P Soil<.01	P year * soil<.05	P year * soil<.01
Brix		**x**			**x**		**x**
PH			**x**		**x**		**x**
TA							
A420							
A520							
Intensity							
Hue							
Total SO2							
Free SO2							
Copper							
Iron			**x**		**x**		
Potassium							
Calcium							
Assimiable Amino Nitrogen							
Ammonia							
Sucrose							
Reducing Sugar			**x**		**x**	**x**	
Acetic Acid			**x**		**x**		**x**
Lactic Acid							
Malic Acid							
Tartaric Acid			**x**	**x**			
Total Organic Acid Profile							

Appendix F

<u>Response Variables with same P Category Range Occurring in both Must and Wine</u>

Wine&Must	All P>.05	P Year<.05	P Year<.01	P Soil<.05	P Soil<.01	P year * soil<.05	P year * soil<.01
Brix					**x**		
PH					**x**		
TA							
A420			**x**				
A520			**x**				
Intensity			**x**				
Hue					**x**		
Total SO2			**x**				
Free SO2							
Copper							
Iron			**x**		**x**		
Potassium							
Calcium							
Assimiable Amino Nitrogen							
Ammonia							
Sucrose	**x**						
Reducing Sugar							
Acetic Acid					**x**		
Lactic Acid							
Malic Acid	**x**						
Tartaric Acid							
Total Organic Acid Profile							

Appendix G

Means, Standard Deviation, Correlation of Variance for samples tested at Cal Poly

05 Calodo Clay Loam Wine	**Brix**	**PH**	**TA**	**A 420**	**A 520**	**Intensity**	**Hue**
Section #1							
1	9.8	3.49	0.735	0.306	0.514	0.820	0.595
2	9.9	3.48	0.720	0.252	0.412	0.664	0.612
3	9.8	3.48	0.720	0.311	0.504	0.815	0.617
4	9.7	3.47	0.735	0.317	0.532	0.849	0.596
5	9.8	3.47	0.735	0.348	0.594	0.942	0.586
6	9.9	3.53	0.735	0.324	0.550	0.874	0.589
7	9.6	3.45	0.735	0.296	0.500	0.796	0.592
8	9.8	3.52	0.750	0.321	0.544	0.865	0.590
9	9.8	3.52	0.735	0.321	0.542	0.863	0.592
10	9.9	3.52	0.735	0.299	0.508	0.807	0.589
Mean	9.8	3.49	0.734	0.310	0.520	0.830	0.596
St. Dev	0.0943	0.0275	0.0085	0.0250	0.0472	0.0720	0.0103
C.V.	0.0096	0.0079	0.0116	0.0808	0.0908	0.0869	0.0173

05 Calodo Clay Loam Wine	**Brix**	**PH**	**TA**	**A 420**	**A 520**	**Intensity**	**Hue**
Section #2							
1	9.4	3.68	0.570	0.185	0.277	0.462	0.668
2	9.6	3.65	0.600	0.185	0.274	0.459	0.675
3	9.3	3.66	0.585	0.202	0.293	0.495	0.689
4	9.6	3.65	0.585	0.185	0.267	0.452	0.693
5	9.6	3.68	0.555	0.186	0.270	0.456	0.689
6	9.5	3.70	0.600	0.183	0.290	0.473	0.631
7	9.5	3.70	0.600	0.182	0.259	0.441	0.703
8	9.4	3.66	0.570	0.190	0.282	0.472	0.674
9	9.5	3.70	0.585	0.180	0.278	0.458	0.647
10	9.4	3.70	0.555	0.176	0.273	0.449	0.645
Mean	9.5	3.68	0.581	0.185	0.276	0.462	0.671
St. Dev	0.1033	0.0215	0.0174	0.0069	0.0102	0.0152	0.0236
C.V.	0.0109	0.0058	0.0300	0.0374	0.0371	0.0329	0.0352

05 Calodo Clay Loam Wine	Brix	PH	TA	A 420	A 520	Intensity	Hue
Section #3							
1	10.5	3.21	0.765	0.316	0.560	0.876	0.564
2	10.9	3.21	0.630	0.319	0.574	0.893	0.556
3	10.9	3.24	0.705	0.323	0.558	0.881	0.579
4	10.5	3.22	0.705	0.320	0.558	0.878	0.573
5	10.8	3.20	0.705	0.316	0.574	0.890	0.551
6	10.7	3.21	0.735	0.304	0.558	0.862	0.545
7	10.7	3.20	0.750	0.286	0.516	0.802	0.554
8	10.8	3.21	0.765	0.319	0.564	0.883	0.566
9	10.7	3.20	0.750	0.296	0.530	0.826	0.558
10	10.9	3.20	0.705	0.321	0.572	0.893	0.561
Mean	10.7	3.21	0.722	0.312	0.556	0.868	0.561
St. Dev	0.1506	0.0125	0.0409	0.0124	0.0191	0.0306	0.0103
C.V.	0.0140	0.0039	0.0567	0.0399	0.0343	0.0353	0.0184

05 Calodo Clay Loam Wine	Brix	PH	TA	A 420	A 520	Intensity	Hue
Section #4							
1	11.6	3.36	0.525	0.346	0.638	0.984	0.542
2	11.7	3.35	0.600	0.364	0.668	1.032	0.545
3	11.5	3.35	0.615	0.346	0.646	0.992	0.536
4	11.8	3.36	0.600	0.335	0.624	0.959	0.537
5	11.9	3.36	0.615	0.341	0.636	0.977	0.536
6	11.5	3.36	0.615	0.341	0.634	0.975	0.538
7	11.7	3.34	0.615	0.335	0.626	0.961	0.535
8	11.6	3.33	0.615	0.332	0.620	0.952	0.535
9	11.6	3.30	0.630	0.349	0.640	0.989	0.545
10	11.5	3.31	0.615	0.344	0.640	0.984	0.538
Mean	11.6	3.34	0.605	0.343	0.637	0.981	0.539
St. Dev	0.1350	0.0220	0.0292	0.0091	0.0135	0.0226	0.0039
C.V.	0.0116	0.0066	0.0483	0.0266	0.0212	0.0230	0.0073

05 Calodo Clay Loam Wine	Brix	PH	TA	A 420	A 520	Intensity	Hue
Section #5							
1	9.5	3.59	0.750	0.238	0.373	0.611	0.638
2	8.9	3.59	0.765	0.238	0.373	0.611	0.638
3	9.0	3.57	0.780	0.243	0.374	0.617	0.650
4	9.4	3.56	0.780	0.251	0.388	0.639	0.647
5	9.4	3.56	0.795	0.238	0.374	0.612	0.636
6	9.4	3.56	0.795	0.243	0.378	0.621	0.643
7	9.2	3.56	0.795	0.245	0.386	0.631	0.635
8	9.1	3.56	0.795	0.250	0.390	0.640	0.641
9	9.1	3.56	0.795	0.351	0.484	0.835	0.725
10	9.5	3.55	0.810	0.236	0.355	0.591	0.665
Mean	9.3	3.57	0.786	0.253	0.388	0.641	0.652
St. Dev	0.2173	0.0135	0.0176	0.0347	0.0354	0.0698	0.0273
C.V.	0.0235	0.0038	0.0224	0.1370	0.0912	0.1089	0.0418

05 Zaca Clay Wine	Brix	PH	TA	A 420	A 520	Intensity	Hue
Section #1							
1	9.1	3.30	0.720	0.274	0.502	0.776	0.546
2	9.3	3.31	0.735	0.278	0.510	0.788	0.545
3	9.2	3.30	0.720	0.282	0.500	0.782	0.564
4	9.3	3.30	0.720	0.283	0.512	0.795	0.553
5	9.2	3.25	0.705	0.281	0.514	0.795	0.547
6	9.4	3.33	0.720	0.279	0.510	0.789	0.547
7	9.4	3.26	0.705	0.283	0.512	0.795	0.553
8	9.2	3.26	0.720	0.268	0.478	0.746	0.561
9	9.4	3.32	0.720	0.279	0.506	0.785	0.551
10	9.1	3.29	0.720	0.268	0.482	0.750	0.556
Mean	9.3	3.29	0.719	0.278	0.503	0.780	0.552
St. Dev	0.1174	0.0270	0.0085	0.0057	0.0128	0.0180	0.0065
C.V.	0.0127	0.0082	0.0119	0.0205	0.0254	0.0231	0.0117

05 Zaca Clay Wine	**Brix**	**PH**	**TA**	**A 420**	**A 520**	**Intensity**	**Hue**
Section #2							
1	8.5	3.30	0.765	0.263	0.548	0.811	0.480
2	8.4	3.27	0.750	0.287	0.580	0.867	0.495
3	8.7	3.29	0.765	0.251	0.524	0.775	0.479
4	8.7	3.28	0.735	0.264	0.544	0.808	0.485
5	8.7	3.29	0.735	0.247	0.496	0.743	0.498
6	8.5	3.29	0.735	0.258	0.500	0.758	0.516
7	8.5	3.28	0.840	0.244	0.472	0.716	0.517
8	8.7	3.29	0.720	0.262	0.526	0.788	0.498
9	8.4	3.29	0.720	0.251	0.492	0.743	0.510
10	8.6	3.29	0.720	0.256	0.508	0.764	0.504
Mean	8.6	3.29	0.749	0.258	0.519	0.777	0.498
St. Dev	0.1252	0.0082	0.0364	0.0122	0.0320	0.0433	0.0138
C.V.	0.0146	0.0025	0.0486	0.0472	0.0616	0.0558	0.0278

05 Zaca Clay Wine	**Brix**	**PH**	**TA**	**A 420**	**A 520**	**Intensity**	**Hue**
Section #3							
1	8.6	3.20	0.750	0.299	0.544	0.843	0.550
2	8.8	3.21	0.675	0.291	0.540	0.831	0.539
3	8.6	3.20	0.690	0.293	0.550	0.843	0.533
4	8.6	3.19	0.675	0.292	0.540	0.832	0.541
5	8.6	3.19	0.705	0.289	0.530	0.819	0.545
6	8.7	3.23	0.690	0.297	0.548	0.845	0.542
7	8.5	3.19	0.690	0.297	0.552	0.849	0.538
8	8.7	3.21	0.705	0.307	0.556	0.863	0.552
9	9.1	3.19	0.705	0.294	0.548	0.842	0.536
10	8.8	3.21	0.720	0.291	0.540	0.831	0.539
Mean	8.7	3.20	0.701	0.295	0.545	0.840	0.541
St. Dev	0.1700	0.0132	0.0224	0.0053	0.0076	0.0121	0.0060
C.V.	0.0195	0.0041	0.0320	0.0179	0.0139	0.0144	0.0111

05 Zaca Clay Wine	Brix	PH	TA	A 420	A 520	Intensity	Hue
Section #4							
1	9.1	3.43	0.675	0.218	0.372	0.590	0.586
2	9.1	3.42	0.675	0.230	0.392	0.622	0.587
3	8.9	3.43	0.690	0.226	0.380	0.606	0.595
4	9.2	3.37	0.675	0.238	0.402	0.640	0.592
5	9.0	3.38	0.675	0.234	0.398	0.632	0.588
6	9.0	3.36	0.690	0.240	0.406	0.646	0.591
7	8.9	3.41	0.690	0.238	0.396	0.634	0.601
8	9.0	3.37	0.690	0.227	0.386	0.613	0.588
9	8.9	3.41	0.690	0.223	0.372	0.595	0.599
10	9.0	3.37	0.690	0.227	0.376	0.603	0.604
Mean	9.0	3.40	0.684	0.230	0.388	0.618	0.593
St. Dev	0.0994	0.0276	0.0077	0.0072	0.0126	0.0196	0.0064
C.V.	0.0110	0.0081	0.0113	0.0314	0.0324	0.0316	0.0108

05 Zaca Clay Wine	Brix	PH	TA	A 420	A 520	Intensity	Hue
Section #5							
1	9.3	3.21	0.720	0.305	0.526	0.831	0.580
2	9.4	3.26	0.705	0.302	0.530	0.832	0.570
3	9.5	3.25	0.720	0.299	0.512	0.811	0.584
4	9.4	3.23	0.705	0.290	0.522	0.812	0.556
5	9.6	3.25	0.735	0.296	0.514	0.810	0.576
6	9.5	3.25	0.720	0.298	0.522	0.820	0.571
7	9.5	3.24	0.720	0.305	0.522	0.827	0.584
8	9.5	3.27	0.735	0.302	0.536	0.838	0.563
9	9.5	3.24	0.720	0.294	0.510	0.804	0.576
10	9.6	3.23	0.735	0.300	0.526	0.826	0.570
Mean	9.5	3.24	0.722	0.299	0.522	0.821	0.573
St. Dev	0.0919	0.0170	0.0111	0.0048	0.0082	0.0114	0.0090
C.V.	0.0097	0.0053	0.0153	0.0160	0.0156	0.0138	0.0157