Wine by Design
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Agenda

- Background and Problem
- Winemaking Process
- Mixture Design
- Rating the Wine
- Mixture Experiment Analysis
- Optimization
Background and Problem

- We make wine as part of a garagista co-op that is over 15 years old, Bellante Family Winery.

- The co-op buys premium Syrah grapes from multiple vineyards in Santa Barbara County, California.

- Our goal is to have fun, learn, experiment with the winemaking process, and make the best wine we can.

- There is a constraint –
  - we buy grapes more than a year before we taste and blend the wine...and...
  - we must use all of the wine we have made for blending and bottling
Winemaking Calendar

- February – Buy Grapes
- Sept/Oct – Crush
- November – Pressing and 1st Racking
- February – 2nd Racking
- May – 3rd Racking
- July – Blending Experiment & Blending Panel
- August – Bottling
- Clean up for next year
Winemaking Process

- Grapes are hauled from the vineyard to the winery in 1000lb bins. At the winery, the grapes are de-stemmed and crushed before going into stainless steel tanks for fermentation.

- The grapes are left to macerate for 5 days in cooled stainless steel tanks at 55° F. This allows the juice and skins to be in contact and for any natural yeasts to begin the fermentation process.
Winemaking Process

- Yeast is added to begin the fermentation process. During this time the “cap” must be punched down several times a day to increase contact with the skins.

- The wine is then pressed to separate the juice from the skins and seeds. The juice goes back into the stainless steel tanks.
Winemaking Process

- After a week or so in stainless steel, the wine is racked into oak barrels. Racking removes the solids that have settled out of the liquid. Racking is done about every 8 weeks for 3-4 months to continually remove the solids.

- Finally, about 11 months later, the winemakers determine the best blend(s) via DOE and the wine is blended and bottled.
Rhone Style Wines

- There are many grape varietals used in Rhone style wines.
- Syrah, Grenache, Viognier, Mourvedre, Cinsaut are just a few common varietals.
- Most Rhone wines are blends, with at least one of these varietals as the predominant grape.
- Cote Rotie (roasted slope) is a style that is primarily Syrah with a small portion of Viognier blended in.
- A small amount of Viognier (3 to 5%) can have a big impact on the nose without affecting the taste.
- This is the style that we produced in the 2011 vintage.
- We acquired approximately 100 lbs of Viognier grapes.
- Because it was not enough to fill a barrel, we co-fermented it with each of the Syrah vineyard grapes.
The Mixture Design

- Why a Mixture Design instead of a traditional DOE?
  - We are interested in making the best blend of the wine from the different vineyards
  - Each year we get grapes from different vineyards, as available
  - Year to year variability in weather and harvesting
  - The process variables – barrel type, barrel age, yeast, etc... have been determined by the chief winemaker
The Mixture Design

- Experimental Factors are Syrah grapes from 3 different vineyards in the Santa Barbara viticultural appellation of California.
  - Jack McGinley
  - Thompson
  - Martian – a new vineyard, easier to obtain grapes
  - Mixed – 1 barrel of left over juice that did not fit into single vineyard barrels; all grapes are precious (and paid for)
The Mixture Design

- 4 factor mixture experiment, each factor is a different barrel of wine.
- 15 runs
  - 4 corner points (100% single barrel)
  - 6, 2 barrel mixes at 50% each, edge mid-points
  - 4, 3 barrel mixes at 33% each for each barrel, center of each face
  - 1, 4 barrel mix at 25% each, volumetric center
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<tr>
<th>Glass</th>
<th>Jack McGinley Vineyard</th>
<th>Thompson Vineyard</th>
<th>Martian Vineyard</th>
<th>Mixed</th>
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Rating the Wine

- The winemaker and assistant winemakers taste all of the 15 glasses of wine.
- The glasses of wine (runs) are force ranked from best to worst on two criteria and an overall
  - Nose
  - Taste
  - Overall
- These scores are recorded as the Y-values of the DOE.
More on Forced Rank

- Most wine drinkers do not know how to score wines.
- Those who do know how to score wines will require much more time than we have available.
- The wines in the glass change over time.
- So, a forced rank process for our nose, taste, and overall response variables.
- In class many years/decades ago, Doug Montgomery used the forced rank scoring method from his winemaking experiments.
- So, why not use it for blending?
Mixture Experiment Analysis

- Data collection for the Overall Ranks
  - 4 glasses (runs) that scored really well across the panel
  - Some assistant winemakers have different preferences (and their scores were discarded)

| Glass | Jack | Thompn | Martian | Mixed | Chuck | Dan | Michael | Robert | Pam | Martin | Steve | FSteve | S | Mark | Total | Range | Subtotal |
|-------|------|--------|---------|-------|-------|-----|---------|--------|-----|--------|-------|--------| | | | |
| 1     | 0    | 1      | 0       | 0     | 5     | 2   | 4       | 5      | 3   | 3      | 1     | 4      | 4 | 4     | 31    | 4     | 22    |
| 2     | 0.333| 0      | 0.333   | 0.333 | 13    | 7   | 13      | 13     | 12  | 12     | 7     | 11     | 15| 15    | 103   | 6     | 70    |
| 3     | 0.25 | 0.25   | 0.25    | 0.25  | 14    | 8   | 15      | 15     | 10  | 8      | 5     | 9      | 14| 14    | 98    | 10    | 70    |
| 4     | 0.333| 0.333  | 0       | 0.333 | 4     | 3   | 2       | 2      | 5   | 6      | 3     | 2      | 12| 12    | 39    | 4     | 22    |
| 5     | 0.5  | 0      | 0.5     | 0     | 9     | 11  | 9       | 9      | 6   | 4      | 12    | 10     | 1 | 1     | 71    | 8     | 48    |
| 6     | 1    | 0      | 0       | 0     | 1     | 1   | 1       | 1      | 1   | 1      | 2     | 1      | 2 | 2     | 11    | 1     | 6     |
| 7     | 0.5  | 0      | 0.5     | 0.5   | 8     | 10  | 8       | 8      | 13  | 10     | 10    | 3      | 6 | 6     | 76    | 10    | 57    |
| 8     | 0    | 0.5    | 0.5     | 0     | 10    | 13  | 10      | 10     | 9   | 15     | 15    | 15     | 15 | 15    | 102   | 6     | 67    |
| 9     | 0.333| 0.333  | 0.333   | 0     | 15    | 6   | 14      | 14     | 8   | 11     | 6     | 7      | 7 | 7     | 88    | 9     | 68    |
| 10    | 0    | 0      | 1       | 0     | 11    | 14  | 11      | 11     | 14  | 14     | 14    | 14     | 14 | 14    | 111   | 3     | 75    |
| 11    | 0    | 0.333  | 0.333   | 0.333 | 12    | 9   | 12      | 12     | 7   | 9      | 8     | 6      | 9 | 9     | 84    | 6     | 61    |
| 12    | 0    | 0.5    | 0       | 0.5   | 3     | 5   | 5       | 4      | 4   | 4      | 5     | 4      | 8 | 3     | 41    | 5     | 26    |
| 13    | 0    | 0      | 0       | 1     | 7     | 12  | 7       | 6      | 11  | 7      | 13    | 13     | 10| 10    | 86    | 7     | 50    |
| 14    | 0.5  | 0.5    | 0       | 0     | 2     | 4   | 3       | 3      | 2   | 2      | 9     | 5      | 11| 11    | 41    | 7     | 16    |
| 15    | 0    | 0      | 0.5     | 0.5   | 6     | 15  | 6       | 7      | 15  | 13     | 11    | 12     | 13| 13    | 98    | 9     | 62    |
What Is The Best Mixture?

Matrix of Mixture Contour Plots for Response (component amounts)

**Very Good Wine Region**

**Not So Good Wine Region**
Using the Models

- It is pretty easy to find the optimal solution using the desirability function.
- One unfortunate possible outcome is a very small yield of optimal quality wine.
- It is also possible that the remaining (residual) is poor quality!
- We used the models of the response variables and desirability function to adjust the optimal solution to increase its yield while minimizing the degradation of the quality.
- We also use the models to identify the quality of the residual wine, or to even establish an intermediate wine.
What Happens If You Just Mix All Of The Barrels Together?

- If you mix the quantities of each of the four vineyards together, the overall score is 67 with a desirability of .12
- There is definitely a better combination.
From the winemakers rankings, there are a couple of good combinations; but all of the wine needs to be used to fulfil the shares in the co-op.

We need to create a minimum of 70 cases of wine for distribution to the members, and additional cases for members to acquire if available.

The analysis identifies the best wine as a single vineyard wine from the Jack McGinley vineyard. This would only provide 4 bottles per share of the optimal, and 20 bottles of a not-so-good wine.
Optimization

- By blending Jack and Thompson in a 71/29 ratio the desirability only drops to .94
- A sub-optimal blend of Thompson, the mixed barrel and Martian in a 57/36/7 ratio is created with a desirability of .68
- This gives the members 18 bottles of very good and good wine for their share.
- The remaining Martian wine is bottled as the residuals.

<table>
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<tr>
<th>Varietal</th>
<th>%</th>
<th>Gallons</th>
<th>%</th>
<th>Sub</th>
<th>Residual</th>
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<tr>
<td>Jack</td>
<td>71.00%</td>
<td>30.00</td>
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<tr>
<td>Thompson</td>
<td>29.00%</td>
<td>12.25</td>
<td>57.29%</td>
<td>47.75</td>
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<td>Martian</td>
<td>0.00%</td>
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<td>6.72%</td>
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<td>Mixed</td>
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<td>Total</td>
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And The Winner Is?

- Three wines were made and the allotment was 6 bottles of the Optimal, 12 bottle of the Sub-optimal and 6 bottles of the Residuals.

**Optimal Solution**

**Sub-Optimal Solution**

**Residuals**

**TALBOT’S SYRAH 2011**
Jack McGinley Vineyard
Thompson Vineyard

**LILY’S BLEND 2011**
Thompson Vineyard
Martian and Jack McGinley Vineyards

**SYRAH 2011**
Martian Vineyard
Going Forward

- The co-op is transitioning this year to a professional winery.

- As professionals, the experiments will only get bigger as grapes are sourced from more vineyards, combined with the need to offer a good/better/best solution.

- Additional constraints will need to be considered:
  - \( \geq 75\% \) must be included to label the wine a varietal.
  - \( \geq 85\% \) must be included to label the wine a specific appellation.
  - \( \geq 85\% \) must be included to label the wine a specific vineyard.

- Next year there will also be a Pinot Noir and a Viognier.
Accolades from the Experts!

They probably know more about statistics than wine.
Cheers!

The 2011 Wine Making Team