Cellar Methods to Reduce Methoxypyrazine Levels in Cabernet franc & Cabernet Sauvignon Wine

Final Report

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Accomplishments:

The following experiments were done:

1. Yeast Experiment – Cabernet Sauvignon must was carefully separated and fermented with various yeasts. Pasteur Red was used as the Control, Christian Hanson as the M-L strain for all yeast strains and no enzymes were employed. Fermentations were done in triplicate. (Tables 5 & 8.)
2. M-L Experiment. Cabernet Franc must was fermented with Pasteur Red yeast and no enzymes were employed. The fermented wine was carefully separated and various ML strains were added directly after yeast fermentation was completed. All MLF's were done in triplicate. (Table 7.)
3. Enzyme Experiment. Cabernet Franc must was carefully separated, and various enzymes were added in triplicate. The yeast was added soon after. Pasteur Red is the yeast employed and Christian Hanson is the M-L strain employed. (Table 6.)
4. Oak Experiment. Cabernet Franc must was carefully separated into 4 groups of three batches. Various levels of French oak chips were added prior to yeast fermentation. The oak chips remained in the fermenting must until the yeast fermentation was complete (approx. 12 days). After pressing off, Christian Hansen ML bacteria was added. (Table 9.)
In all experiments pH reduction was performed by tartaric acid addition to a target endpoint of 3.60.

Objectives:

a) To reduce the levels of methoxypyrazine (IBMP) in Michigan Cabernet Sauvignon, Cabernet Franc, and Merlot wines to below the threshold for human perception.
b) To evaluate some cellar techniques, which repeatedly reduce the quantity of IBMP in wines, which are made from fruit with high levels of IBMP.
c) To provide a database for selecting specific protocols of cellar techniques and their ability to reduce IBMP.
d) Compare stir bar sorptive extraction (SBSE) with our already proven quantification method in order to assess its accuracy.

Methods:

a) Compare levels of IBMP in wines fermented from commercially available yeasts.
b) Compare wines that have had different enzymes added during maceration for differences in level of IBMP.
c) Compare wines which have been inoculated with different strains of malo-lactic bacteria for differences in levels of IBMP
d) Compare level of IBMP in wines that had varying levels of oak addition during fermentation.

Procedures:

Wine Production

Yeast strains[z]	M-L Strains [z]	Commercial Enzymes [y]
Pasteur Red	Christan Hanson Viniflora	Rapidase Ex-Color
ICV-GRE	Enoferm alpha	Rapidase ADEX G
D-21	Enoferm beta	
MI-24	Lalvin-31	
ICV-D80	Lalvin-41	
NT-50	Lalvin OSU	
ICV-254D	Lalvin EQ54	
BM-45	Lalvin Elios 1	
Cepage C.S.	Lalvin B1	
W15		
CSM		

z- www.lallemandwine.us
y- www.dsm-oenology.com

Table 1. Specific Yeast, M-L and Enzymes employed.

Analytical Methods

Stir Bar Sorptive Extraction (SBSE) was assessed for possible use in measuring and quantifying IBMP,using a HP 6890 GC/Leco Pegasus II MS coupled with a Gerstrel Thermal Desorption Unit (TDS). The Twisters (SBSE) utilize the same extraction phase as the Solid Phase Micro Extraction SPME fibers, although the twisters employ 1000 times the phase of the fibers. This suggests 1000 times the sensitivity, reducing the need for sample preparation and concentration. However, preliminary studies have shown that the efficiency of the TDS is low enough to reduce the sensitivity, and produce inconsistent results. We decided not to pursue the twisters any further for this use.

Using the Wampfler method we had trouble developing consistent standard curves. This has lead us to believe the equipment may not be working properly. Subsequently the MS has lost communication with the computer controls and the unit has been shipped out to

LECO for repairs. The unit is receiving full software and hardware updates at a discounted price of $17,000. These costs are being incurred by Dr. Randolph Beaudry's lab, and funds from MSU Dept. of Horticulture. We did not ask the MGWIC for additional funding to help cover these costs.

Given the hurdles faced with IBMP analyses using MSU equipment and the desire to meet project deadlines, Jon Treloar traveled to UC Davis to perform all IBMP analyses utilizing the equipment in Dr. Sue Ebeler's lab at no cost, for which we are extremely grateful for.
Due to the sensitivity of their GC/MS, sample concentration was no longer required, and very little sample prep was done. The following describes the method used:

Sample Preparation: 60 mL amber colored glass bottles filled to the teflon lined cap with each wine were shipped overnight to University of California Davis, California. The samples were stored in a refrigerator at 7 °C awaiting IBMP analyses. GC 99% pure -2-methoxypyrazine was purchased from Pyrazine Specialties (Atlanta, GA) for standards. The internal standard, 98.2% pure 3-isobutyl-$^2H_3$-2-methoxypyrazine (dIBMP), was purchased from CDN Isotopes (Quebec, Canada).
Three grams of sodium chloride (NaCl) was placed into 20 mL round bottom headspace sampling vials (Gerstel, Baltimore, MD) followed by10 mL of wine sample with 50 ng/L (10 µL of 50 µg/L) d_3MIBP in pure EtOH. The vials were immediately sealed with metal screw caps containing teflon septa (Gerstel, Baltimore, MD). The vials were inverted multiple times to dissolve the NaCL. The vials were stored upright in the dark for a minimum of 24 hrs to allow equilibrium achievement prior to sampling.

Instrumental Analysis: Samples were analyzed with an Agilent 6890 gas chromatograph (GC) /5973 mass selective detector (MSD) equipped with a Gerstel MPS2 autosampler and a HP-5MS capillary column (30m, 0.25mm I.D., 0.25 µm film thickness) (J&W Scientific, Folsom, CA) utilizing the method described by Chapman et al (2004) with a modified flow rate as noted below.

The MPS2 warmed the samples to 40ºC for 5 minutes prior to adsorption. A 2 cm divinylbenzene/Carboxen™/polydimethylsiloxane (Supelco, Bellefonte, PA) 23 gauge solid phase microextraction (SPME) fiber was inserted into the vial, and agitated at 40ºC for 30 minutes. The fiber was desorbed with the injector held at 260 ºC for 5 minutes, with no purge. To assure no carry-over, the fiber was held in the inlet for an additional 5 minutes purging at a rate of 50 mL/min. The oven program held at 40 ºC for 5 minutes, ramping 2.5 ºC/min to 80 ºC, 5 ºC/min to 110 ºC, and 25 ºC/min to 230 ºC and held for 5 min to completion.

Helium (99.999%) was used as the carrier gas and held at a constant pressure [4.8 psi(0.33 ATM)], with a nominal initial flow of 0.8 mL/min and an average linear velocity of 32 cm/sec. The MSD interface was held at 280 ºC

Detection was accomplished using selected ion monitoring mode (SIM). Quantification was carried out using ions *m/z* 124 (IBMP) and *m/z* 127 (dIBMP). Qualifier ions *m/z* 94 (IBMP) and *m/z* 154 (dIBMP) were used to validate the quantifier ions. Each sample was analyzed in triplicate, and each experiment (i.e. 2003 yeast trial) was completed utilizing a single fiber.

Results and Discussion:

Linearity: A standard curve was developed using model wine (2g/L KHT and 12% v/v ethanol) prior to beginning analysis (Figure.1), and every time a SPME fiber was replaced (all producing $R^2 \geq 0.95$). The MPS2 fiber agitation coupled with the 260 ºC inlet temperature reduced the longevity of the SPME fibers (~100 samples), and care was taken to assess chromatography quality during extended fiber life. The initial regression equation for wine samples is as follows:

IBMP concentration (ng/L) = $(A/A_{is} - 0.034)/0.0162$ (A= IBMP peak area, A_{is} =internal standard peak area).

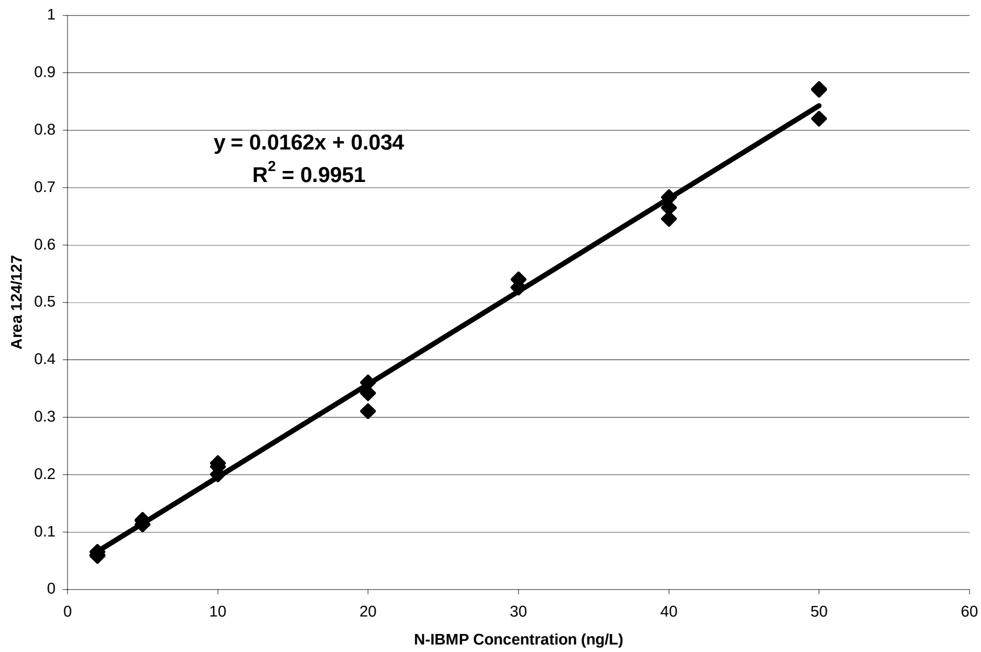

Figure 1. Initial standard curve developed using model wine.

Effect of yeast choice: The concentration of IBMP in all treatments was lower than expected. Given numerous reports suggesting climate has a significant effect on IBMP concentration in wine, with cool climate grown grapes typically having higher levels, this study's results raise questions about current understanding of climate's direct role in IBMP concentration. All yeast treatments resulted in IBMP concentrations lower than 10 ng/L, the lowest reported organolepticly detectable level in red wine (Kotseridas *et al*. 1998).

Yeast choice had a significant affect on IBMP concentration in Cabernet Sauvignon wines in both 2003 and 2004. Wines produced using D-21 yeast contained the highest IBMP concentration, statistically higher than Pasteur Red, Fermicru VR5, MI-24, ICV-D80, ICV-D80 and BM-45 (Table 2).

Table 2. Effect of yeast choice on IBMP concentration in Cabernet Sauvignon wines produced in 2003.

Yeast Selection	Mean IBMP (ng/L)	Std. Dev
Lalvin ICV-D21	4.45a	1.33
Lalvin ICV-GRE	4.19ab	0.69
Cepage Cabernet	3.91abc	1.59
Lalvin W15	3.74abc	0.42
NT-50	3.43abc	0.50
Lalvin ICV-D254	3.35abc	0.43
Pasteur Red	2.99bc	0.30
Fermicru VR5	2.98bc	0.41
MI-24, Mitech	2.98bc	0.52
Lalvin ICV-D80	2.93c	0.31
Lalvin BM-45	2.92c	0.36
	*	

* $p < 0.05$

More importantly, BM-45 and ICV-D80 were both significantly lower than ICV-D21 and ICV-GRE. There were subtle differences in IBMP concentration among the majority of yeast strains compared in this study, however the differences between the highest concentration (ICV-D21) and the lowest (BM-45) is 35%.

The 2004 yeast study provided additional significant differences in IBMP concentration based on yeast choice (Table 3). Cabernet Sauvignon wines fermented with Enoferm CSM proved to have a significantly lower IBMP concentration then those that were fermented solely by the native flora. In this experiment there was a 37% difference in IBMP concentration in the wines with the highest and lowest IBMP levels.

Table 3. Effect of yeast choice on IBMP concentration in Cabernet Sauvignon wines produced in 2004.

Yeast Selection	Mean IBMP (ng/L)	Std. Dev
Natural/Native Flora	5.48a	0.83
Pasteur Red	4.47ab	0.86
Enoferm CSM	3.99b	0.23
	*	

* $p < 0.05$

It is problematic to compare different vintages as well as yeasts responses to two different wines. However, Pasteur Red yeast was utilized in both experiments and provides a base data point to which possible relationships might be calculated. Using the 2004 results, the percentage of difference between the Pasteur Red and CSM (-10.5%), and Pasteur Red and Native (18.5%) can be compared to the 2003 data, assuming the relative response be equal in another wine. Given that the wines fermented with Pasteur Red in 2003 had an average of 2.99 ng/L IBMP the calculated IBMP concentration for

CSM and Native flora would be 2.68 ng/L and 3.54 ng/L respectively. Figure 2 illustrates the likely relationship of the response in IBMP concentration based on yeast choice from 2003 & 2004 experiments.

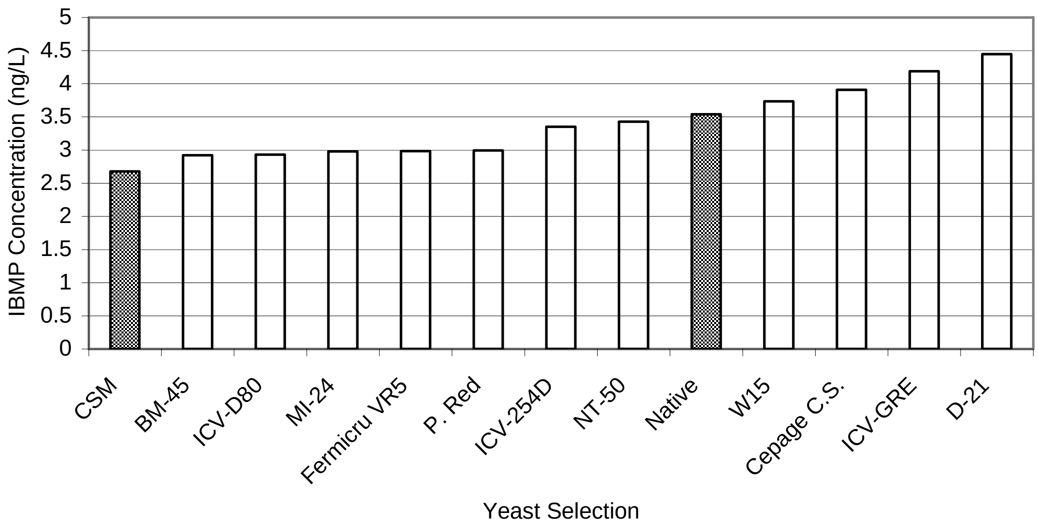

Figure 2. Influence of yeast on IBMP concentration. A comparison of 2003 and 2004 Cabernet Sauvignon wines. Shaded data points represent theoretical IBMP concentration based on 2003 and 2004 yeast/IBMP relationships using Pasteur Red as a benchmark.

Influence of malolactic bacteria strain choice: The IBMP concentration in Cabernet Franc wines resulting from different malolactic bacteria fermentations is summarized in Table 4. Lalvin VP41 produced wines with the lowest IBMP concentration, and Lalvin 31 produced wines with the highest. However, the malolactic bacteria did not have a statistically significant effect on the resulting wine's IBMP concentration.

Table 4. Effect of Malolactic choice on IBMP concentration in Cabernet Franc wines produced in 2004.

MLF Selection	Mean IBMP (ng/L)	Std. Dev
Lalvin 31	3.08	0.82
Lalvin Elios 1	2.77	0.46
Lalvin Pro Vino	2.75	0.44
Enoferm Beta	2.71	0.34
Enoferm Alpha	2.51	0.27
Viniflora Oenos	2.48	0.39
Lalvin VP41	2.31	0.05
	ns	

Impact of color extraction enzymes: The IBMP concentrations of Cabernet Franc wines that had Rapidase Ex-color enzyme added produced wines that had the lowest IBMP concentration (Figure 3), while the wines made without enzymes resulted in the highest IBMP concentration. However, the results were not statistically significant, and the extreme variabilityof the replications of each treatment suggest that unknown factors influenced the results rendering the data inconclusive.

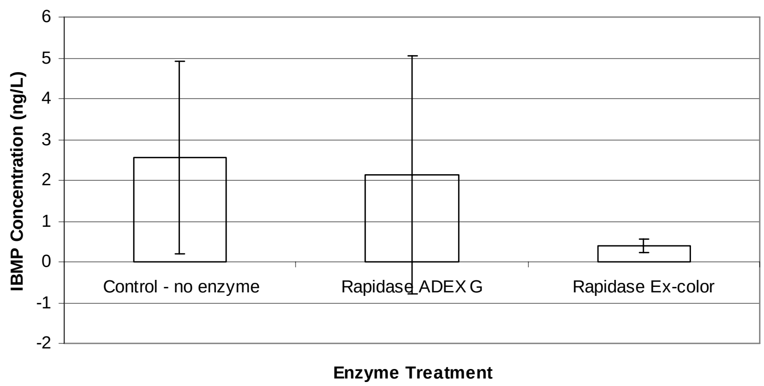

Figure 3. Influence of the use of color extraction enzyme on IBMP concentration in Cabernet Franc wines.

Impact of French oak chip additions:
Wines made with the highest rate of French oak chip additions produced wines with the highest IBMP concentration (Figure 4.). However, as with the Enzyme trial, unknown variability was introduced within the replications for the 1.0g/L and 4.0 g/L, giving the results very little significance.

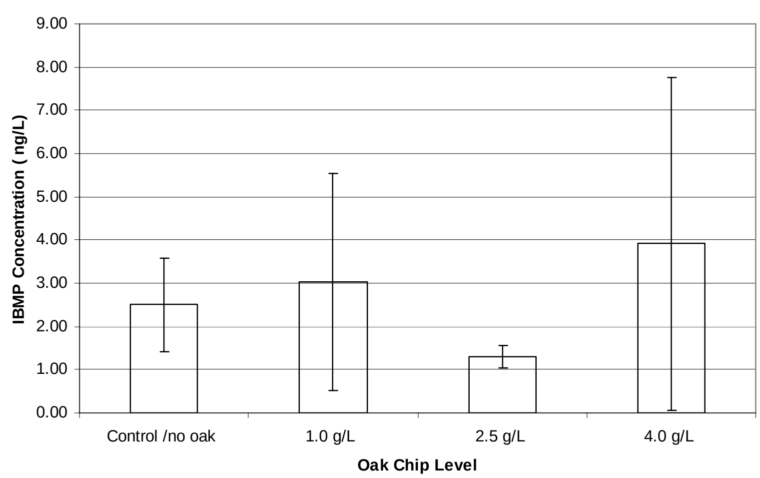

Figure 4. Impact of French oak chip additions on IBMP concentration in Cabernet Franc wines.

Conclusions:

The concentrations of IBMP in these wines are 2.31-5.48 ng/L and are consistent with what has been reported in the literature for red wine. Kotseridas *et al* (1999) reported as low as 2.0 ng/L and Allen *et al* (1994) reported as high as 56.3 ng/L. However, it is unclear why the IBMP levels in our study were so low. The grapes were grown in a cool-climate, accumulating less than 1500 GDD (base 10°C) at the time of harvest both years of the experiment. They were harvested at a fairly low sugar content (20.2-22.0 Brix) and might be considered "under-ripe" by criteria of warmer growing regions. Lacey *et al* (1991) reported an average of 6.8 ng/L IBMP in Australian wines and an average of 25.9 ng/L in New Zealand wines. Much more work needs to be done to further understand the factors involved in the development and reduction of IBMP in grapes irrespective of climate.

Yeast choice clearly has an impact on the IBMP concentration of wines (Tables 2 & 3). Of the yeast strains included in this study, CSM, BM-45 and ICV-D80 produced wines with the lowest IBMP concentration. ICV-GRE and D-21 produced wines with the highest IBMP concentrations. Significant differences in IBMP concentration of as much as 37% (1.53 ng/L) were shown, however the fermentation of wines having differing initial IBMP concentrations would be necessary to determine whether a 37% difference would result in a wine with a considerably higher initial IBMP concentration. The yeast strain experiments might have resulted in higher IBMP concentrations across all treatments if a different ML strain had been used, given that Viniflora Oenos produced wines with lower IBMP concentration than other strains (Table 4) although not significantly significant.

It is not clear whether the significant difference in IBMP concentration is a result of the yeast having an ability to produce additional IBMP from must precursors or whether there is a reaction/binding of the initial IBMP with yeast secondary metabolites. Reports of IBMP concentrations being as high 24 hrs after vatting (prior to alcoholic fermentation starting) being similar or below that after alcoholic fermentation has completed suggests that it is more likely that the IBMP is bound in some way by the yeast rather than being produced (Roujou de Boubee *et al*, 2002). Further, ligand binding proteins found in the nasal epithelium of many mammals have been shown to bind semi-specifically to IBMP (Pelosi et al. 1982, Pevsner et al. 1985,). This leads us to speculate that individual yeast starains may produce differing levels of similar binding proteins that bind to IBMP and subsequently settle out during vinification. Although no such reports have been published, this needs to be addressed experimentally. Now that it has been shown that yeasts have a varying effect on resulting wine, further research is warranted to understand the mechanism of this result.

Malolactic bacteria choice did not appear to have a clear effect on IBMP concentration in the resulting wine, this is consistent with previous studies (Sala *et al*. 2002, 2004, Roujou de Boubee *et al*. 2002). Lalvin VP41 produced wines with the lowest IBMP concentration (2.31 ng/L), and Lalvin 31 produced the wines with the highest IBMP concentration (3.08ng/L) although these differences were not statistically significant (Table 5). The ML strain experiment results may as well been higher if a yeast such as D-21 was used, which produced wines with the highest IBMP concentration (Figure 4).

The enzyme addition (Figure 3.) and oak chip addition (Figure 4.) trials suffered from an unknown source of IBMP contamination that resulted in an extreme source of error wine production replications. The source remains unclear and further investigation is needed.

There have not been any reports suggesting that spoilage microbes may produce IBMP as a byproduct, although bacteria and fungi not typically associated with winemaking, have been reported to produce IBMP and have been troublesome to the water treatment industry (Gallois et al, 1985). It remains unclear whether or not minor differences in IBMP concentration might be explained by unknown biological contamination, although the relatively common occurrence of IBMP in many types of organisms allows for speculation. Thus, additional information and experimentation is warranted to fully understand the native microbiological environmental influence on IBMP concentration during the winemaking process.

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Table 5. Wine data of Cabernet Sauvignon (UCD2,4,5,8,10,21) yeast trials. IBMP Reduction

Yeast	Harvest Date	SS	HARVEST pH	TA	Residual Sugar (g/L)	Total Acidity (g/L)	PH	BOTTLING %alcohol	Volatile Acidity (g/L)	%MLF
ICV-GRE a	11/4/03	20.2	3.34	10.53	2.0	7.05	3.72	12.2	0.60	100
ICV-GRE b	11/4/03	20.2	3.34	10.53	4.0	7.35	3.70	12.1	0.48	100
ICV-GRE c	11/4/03	20.2	3.34	10.53	4.0	7.12	3.68	12.0	0.48	100
D-21 a	11/4/03	20.2	3.34	10.53	4.0	8.40	3.44	11.5	0.78	100
D-21 b	11/4/03	20.2	3.34	10.53	2.0	8.17	3.48	11.3	0.78	100
D-21 c	11/4/03	20.2	3.34	10.53	2.0	8.40	3.45	11.5	0.60	100
MI-24 a	11/4/03	20.2	3.34	10.53	2.0	7.12	3.56	12.0	0.54	100
MI-24 b	11/4/03	20.2	3.34	10.53	5.0	7.20	3.64	12.1	0.81	100
MI-24 c	11/4/03	20.2	3.34	10.53	2.0	7.42	3.53	11.6	0.54	100
ICV-D80 a	11/4/03	20.2	3.34	10.53	4.0	7.27	3.60	12.3	0.48	100
ICV-D80 b	11/4/03	20.2	3.34	10.53	5.0	7.42	3.77	11.9	0.60	100
ICV-D80 c	11/4/03	20.2	3.34	10.53	3.0	7.27	3.67	12.1	0.48	100
P. Red a	11/4/03	20.2	3.34	10.53	3.0	7.12	3.60	12.1	0.60	100
P. Red b	11/4/03	20.2	3.34	10.53	4.0	7.50	3.44	12.0	0.75	100
P. Red c	11/4/03	20.2	3.34	10.53	4.0	7.30	3.49	11.8	0.60	100
NT-50 a	11/4/03	20.2	3.34	10.53	4.0	7.35	3.57	12.0	0.72	100
NT-50 b	11/4/03	20.2	3.34	10.53	2.0	7.80	3.63	11.7	0.55	100
NT-50 c	11/4/03	20.2	3.34	10.53	2.0	7.50	3.64	11.6	0.59	100
ICV-254D a	11/4/03	20.2	3.34	10.53	4.0	7.40	3.64	12.1	0.54	100
ICV-254D b	11/4/03	20.2	3.34	10.53	5.0	7.65	3.58	12.1	0.60	100
ICV-254D c	11/4/03	20.2	3.34	10.53	4.0	7.20	3.63	12.1	0.60	100
BM-45 a	11/4/03	20.2	3.34	10.53	4.0	8.20	3.47	11.9	0.63	100
BM-45 b	11/4/03	20.2	3.34	10.53	4.0	8.02	3.50	12.0	0.60	100
BM-45 c	11/4/03	20.2	3.34	10.53	4.0	7.95	3.53	12.1	0.72	100

Table 5 cont. Wine data of Cabernet Sauvignon (UCD2,4,5,8,10,21) yeast trials. IBMP Reduction

Yeast	Harvest Date	HARVEST SS	pH	TA	Residual Sugar (g/L)	Total Acidity (g/L)	BOTTLING PH	%alcohol	Volatile Acidity (g/L)	%MLF
Cepage C.S. a	11/4/03	20.2	3.34	10.53	2.0	8.47	3.18	12.0	0.72	100
Cepage C.S. b	11/4/03	20.2	3.34	10.53	3.0	7.50	3.57	11.9	0.60	100
Cepage C.S. c	11/4/03	20.2	3.34	10.53	3.0	7.27	3.54	11.9	0.60	100
Fermicru VR5 a	11/4/03	20.2	3.34	10.53	4.0	8.02	3.45	11.8	0.36	100
Fermicru VR5 b	11/4/03	20.2	3.34	10.53	5.0	7.80	3.48	11.9	0.60	100
Fermicru VR5 c	11/4/03	20.2	3.34	10.53	2.0	7.95	3.46	11.9	0.60	100
W15 a	11/4/03	20.2	3.34	10.53	4.0	7.80	3.50	11.7	0.48	100
W15 b	11/4/03	20.2	3.34	10.53	2.0	7.80	3.48	11.7	0.48	100
W15 c	11/4/03	20.2	3.34	10.53	4.0	8.25	3.49	11.9	0.51	100
Natural/Wild	11/4/03	20.2	3.34	10.53	2.0	7.35	3.71	11.7	0.51	100

Table 6. Wine data of Cabernet Franc EnzymeTrials. IBMP Reduction

Trial	Harvest Date	SS	HARVEST pH	TA	Residual Sugar (g/L)	Total Acidity (g/L)	PH	BOTTLING %alcohol	Volatile Acidity (g/L)	%MLF
Control a	11/4/03	19.8	3.39	8.29	3.0	8.17	3.40	12.0	0.54	100
Control b	11/4/03	19.8	3.39	8.29	6.0	8.55	3.57	12.0	0.60	100
Control c	11/4/03	19.8	3.39	8.29	4.0	8.10	3.47	12.2	0.60	100
Control Blend	11/4/03	19.8	3.39	8.29	1.0	6.45	3.73	12.1	0.54	100
Rapidase Ex-Color a	11/4/03	19.8	3.39	8.29	5.0	8.10	3.48	12.2	0.60	100
Rapidase Ex-Color b	11/4/03	19.8	3.39	8.29	4.0	8.4	3.58	12.0	0.51	100
Rapidase Ex-Color c	11/4/03	19.8	3.39	8.29	4.0	8.18	3.59	12.2	0.54	100
Rapidase Ex-Col Blend	11/4/03	19.8	3.39	8.29	4.0	7.12	3.55	12.0	0.60	100
Rapidase ADEX G a	11/4/03	19.8	3.39	8.29	3.0	7.87	3.44	12.2	0.45	100
Rapidase ADEX G b	11/4/03	19.8	3.39	8.29	2.0	8.4	3.57	12.0	0.40	100
Rapidase ADEX G c	11/4/03	19.8	3.39	8.29	2.0	8.25	3.44	12.1	0.54	100
Rapidase ADEXG Blend	11/4/03	19.8	3.39	8.29	1.0	6.45	3.73	12.1	0.54	100

Table 7. Wine data of Cabernet Franc IBMP Malolactic Bacteria Trials.

Treatment	Harvest Date	S.S (brix)	HARVEST pH	T.A (g/L)	Residual Sugar (g/L)	pH	T.A (g/L)	BOTTLING %alcohol	Volatile Acidity (g/L)	%MLF
Beta -1	10/20/04	22.2	3.56	6.41	1.5	3.21	6.86	12.6	0.45	100
Beta - 2	10/20/04	22.2	3.56	6.41	1.0	3.23	6.94	12.4	0.45	100
Beta -3	10/20/04	22.2	3.56	6.41	2.0	3.21	7.24	12.6	0.44	100
Pro Vino –1	10/20/04	22.2	3.56	6.41	3.0	3.24	7.50	12.4	0.51	100
Pro Vino - 2	10/20/04	22.2	3.56	6.41	1.0	3.24	7.16	12.4	0.47	100
Pro Vino - 3	10/20/04	22.2	3.56	6.41	2.0	3.24	8.44	12.6	0.46	100
Elios – 1	10/20/04	22.2	3.56	6.41	2.0	3.21	7.13	12.7	0.48	100
Elios – 2	10/20/04	22.2	3.56	6.41	3.0	3.23	6.98	12.6	0.47	100
Elios - 3	10/20/04	22.2	3.56	6.41	2.0	3.27	7.80	12.7	0.47	100
31 – 1	10/20/04	22.2	3.56	6.41	4.0	3.28	9.23	12.7	0.42	100
31 – 2	10/20/04	22.2	3.56	6.41	3.0	3.28	7.65	12.6	0.42	100
31 – 3	10/20/04	22.2	3.56	6.41	3.0	3.25	8.18	12.6	0.50	100
Alpha – 1	10/20/04	22.2	3.56	6.41	3.0	3.14	8.03	12.3	0.51	100
Alpha – 2	10/20/04	22.2	3.56	6.41	2.0	3.16	8.33	12.6	0.48	100
Alpha – 3	10/20/04	22.2	3.56	6.41	3.0	3.20	7.43	12.4	0.58	100
Oenos – 1	10/20/04	22.2	3.56	6.41	3.0	3.16	8.40	12.4	0.50	100
Oenos – 2	10/20/04	22.2	3.56	6.41	3.0	3.20	7.80	12.7	0.48	100
Oenos – 3	10/20/04	22.2	3.56	6.41	0.5	3.20	8.10	12.5	0.45	100
VP-41 – 1	10/20/04	22.2	3.56	6.41	2.0	3.20	7.73	12.3	0.52	100
VP-41 – 2	10/20/04	22.2	3.56	6.41	2.0	3.18	8.13	12.5	0.48	100
VP-41 - 3	10/20/04	22.2	3.56	6.41	2.0	3.21	7.35	12.3	0.52	100

Table 8. Wine data of Cabernet Sauvignon IBMP Yeast Trials.

			HARVEST					BOTTLING		
Treatment	Harvest Date	S.S (brix)	pH	T.A (g/L)	Residual Sugar (g/L)	pH	T.A (g/L)	%alcohol	Volatile Acidity (g/L)	%MLF
Pasteur Red –1	10/20/04	21.3	3.44	8.33	3.0	3.39	8.03	11.6	0.53	100
Pasteur Red - 2	10/20/04	21.3	3.44	8.33	4.0	3.39	8.03	11.6	0.56	100
Pasteur Red - 3	10/20/04	21.3	3.44	8.33	3.0	3.40	7.80	11	0.51	100
CSM – 1	10/20/04	21.3	3.44	8.33	4.0	3.40	7.13	11.7	0.49	100
CSM – 2	10/20/04	21.3	3.44	8.33	2.0	3.39	6.98	11.8	0.51	100
CSM - 3	10/20/04	21.3	3.44	8.33	2.0	3.35	7.05	11.4	0.55	100
Natural/Wild -1	10/20/04	21.3	3.44	8.33	2.0	3.33	6.83	11.8	0.71	100
Natural/Wild -2	10/20/04	21.3	3.44	8.33	2.0	3.26	7.13	11.9	0.74	100
Natural/Wild -3	10/20/04	21.3	3.44	8.33	4.0	3.28	6.75	11.7	0.56	100

Table 9. Wine data of Cabernet Franc IBMP Oak TrIals.

Treatment	Harvest Date	S.S (brix)	HARVEST pH	T.A (g/L)	Residual Sugar (g/L)	pH	T.A (g/L)	BOTTLING %alcohol	Volatile Acidity (g/L)	%MLF
Control /no oak -1	10/20/04	20.4	3.54	9.00	1.0	3.30	8.85	12.6	0.41	100
Control /no oak –2	10/20/04	20.4	3.54	9.00	1.5	3.24	8.36	12.0	0.43	100
Control /no oak –3	10/20/04	20.4	3.54	9.00	0.5	3.57	7.13	12.1	0.38	100
1g/L – 1	10/20/04	20.4	3.54	9.00	0.5	3.28	8.40	12.2	0.32	100
1g/L - 2	10/20/04	20.4	3.54	9.00	0.8	3.29	8.25	12.1	0.38	100
1g/L - 3	10/20/04	20.4	3.54	9.00	0.8	3.28	8.40	12.0	0.45	100
2.5g/L – 1	10/20/04	20.4	3.54	9.00	1.0	3.29	8.40	12.2	0.40	100
2.5g/L – 2	10/20/04	20.4	3.54	9.00	1.0	2.83	11.7	12.3	0.38	100
2.5g/L - 3	10/20/04	20.4	3.54	9.00	0.8	3.27	8.29	12.4	0.40	100
4.0g/L - 1	10/20/04	20.4	3.54	9.00	1.0	3.27	8.25	12.1	0.42	100
4.0g/L – 2	10/20/04	20.4	3.54	9.00	1.0	3.27	8.59	12.4	0.49	100
4.0g/L -3	10/20/04	20.4	3.54	9.00	1.0	3.55	7.88	12.2	0.40	100