

Acknowledgements	xi		
Preface	xii		
1. Introduction to the Table Wine-Making Process			
1. Introduction	1		
2. Great Wines Begin with Great Grapes	3		
2.1. Measuring Quality	7		
2.2. Measuring Maturity	7		
2.3. Tasting Grapes	8		
2.4. Postharvest Quality	8		
3. An Overview of Key Elements in Wine Making	9		
3.1. Fermentation	9		
3.2. Composition Parameters	9		
3.3. Ammonium and Amino Acids	10		
3.4. Sulfur	10		
2. Flavors and Aromas in Foods and Beverages			
1. Introduction	11		
2. Basic Sensory Assessment	13		
2.1. Taste	13		
2.2. Aroma	14		
3. Descriptive Analysis	14		
4. Tasting and Making Judgments	18		
5. Other Taste and Aroma Tests	20		
5.1. Discrimination Tests	20		
5.2. Mapping the Tongue	21		
5.3. Taste Sensitivity Testing	21		
3. Wine Chemistry			
1. Organic Acids, pH and Their Role in Wine Making	23		
1.1. Introduction	23		
1.2. Physical Chemistry	24		
1.3. Preservative Role	26		
1.4. Impact on Sulfur Dioxide	26		
1.5. pH and Color	26		
1.6. Role in Fermentation	26		
1.7. Adjusting pH	27		
1.8. Aroma and Flavor	27		
2. Phenolics, Diversity and Their Role in Wine Making	28		
2.1. Introduction	28		
2.2. Non-flavonoid Phenolics	28		
2.3. Flavonoids	28		
2.4. Tannins	31		
2.5. Copigmentation and Matrix Effects	34		
3. Oxygen and Its Role in Wine Making	36		
3.1. Introduction	36		
3.2. Oxidation	36		
3.3. Aldehyde Formation	38		
3.4. Condensation of Tannins and Anthocyanins	38		
4. Aroma: Diversity and Diverse Origins	39		
4.1. Introduction	39		
4.2. Classes and Origins	40		
4.3. Fruit-Derived	40		
4.4. Yeast-Derived	43		
4.5. Bacterial	49		
4. Safety			
1. Introduction	51		
1.1. Generic Safety Issues	51		
1.2. Laboratory-Specific Issues	52		
2. Selected Material Safety Data Sheet Documents	53		
2.1. Potassium/Sodium Metabisulfite	53		
2.2. Carbon Dioxide	54		
3. Equipment	55		
3.1. Crusher–Destemmer	55		
3.2. Press	55		
3.3. Cold Rooms	55		
5. Table Wine Production			
1. Planning	57		
2. Quantity	58		
3. Choice of Major Equipment Items	58		
3.1. Construction Materials	58		
3.2. Destemmer–Crusher	59		
3.3. Presses	59		
3.4. Fermenters	60		
3.5. Cooperage	60		

3.6. Transfer Pumps, Lines and Fittings	61	8. Detection and Differentiation of Wine Microorganisms	87
3.7. Filters and Bottling Equipment	61	8.1. Microscopic Examination	87
3.8. Controlled-Temperature Rooms	62	9. Culture of Wine Microorganisms	88
4. Background to Wine-Making Practice	62	9.1. Yeasts	88
4.1. Record-Keeping	62	9.2. Lactic Acid Bacteria	89
4.2. General Issues	62	9.3. Acetic Acid Bacteria	90
4.3. Protocol Development	63	10. Microbiological Culture Media	90
4.4. Preparation for Ferment and Choosing When to Harvest	63	11. Techniques	90
4.5. Harvest, Transport and Storage	64	11.1. Methods	90
4.6. Destemming and Crushing/Pressing	65	11.2. Melting Culture Media	90
4.7. Clarifying and Making Preliminary Adjustments (White Wines)	66	11.3. Preparation of Dilutions	91
4.8. Analyses, Adjustments and Additions	67	11.4. Pour Plate Technique	92
4.9. Nutrition and Hydrogen Sulfide	67	11.5. Spread Plate Technique	92
4.10. Yeast Choice and Preparation	68	11.6. Membrane Filtration Technique	93
4.11. Temperature Management	69	11.7. Most Probable Number Technique	94
4.12. Cap Management in Red Wines	69	12. Incubation of Plates	94
4.13. Aroma Management	70	12.1. Yeasts	94
4.14. Optional Additions: Red Wines	70	12.2. Lactic Acid Bacteria	94
4.15. Press-off and Complete Red Wine Fermentation	70	12.3. Acetic Acid Bacteria	94
4.16. Malolactic Fermentation	70	12.4. Counting and Calculation	94
4.17. Clarifying, Aging, Fining and Stabilizing	71	7. Harvest Protocols	
4.18. Blending	75	1. Sampling	97
4.19. Prebottling Adjustments and Bottling	75	1.1. Terminology	97
4.20. Waste Disposal	76	1.2. Preamble	97
5. Problematic Ferments	76	1.3. Occupational Health and Safety	100
5.1. Sluggish and Stuck Primary Ferments	76	1.4. Quality Assurance Records	100
5.2. Sluggish and Stuck Malolactic Ferments	77	1.5. Procedure	100
		1.6. Equations and Calculations	100
		1.7. Equipment and Materials	101
		1.8. Benchmark Values	101
		2. Measuring Berry Maturity	101
		2.1. Introduction	101
		2.2. Preparation for Analysis	102
		2.3. Comprehensive Analysis Example	103
		3. Berry Maturity by Sensory Analysis	104
		3.1. Introduction	104
		3.2. Training and Research Procedure	104
		3.3. Practical or Field Protocol	110
		8. Winery Protocols	
		1. Cleaning, Hygiene and Maintenance	112
		1.1. Purpose	112
		1.2. Occupational Health and Safety	112
		1.3. Quality Assurance Records	112
		1.4. General	112
		1.5. Care of Stainless Steel	113
		1.6. Care of Barrels	113
		1.7. Recipes and Methods	114
		2. pH Adjustment	115
		2.1. Purpose	115
		2.2. Occupational Health and Safety	115
6. Microbiology and Methods			
1. Introduction	79		
2. Stuck Fermentations	81		
2.1. Killer Yeasts	81		
3. Microbial Spoilage of Wine	81		
3.1. Yeasts	81		
3.2. Bacteria	82		
3.3. Molds	83		
3.4. Cork Taint	84		
4. Critical Control Points in Spoilage Prevention	84		
4.1. Grape Production	84		
4.2. Grape Harvest	84		
4.3. Grape Processing	84		
4.4. Alcoholic Fermentation	84		
4.5. Malolactic Fermentation	84		
4.6. Bottling	84		
5. Monitoring the Process	85		
5.1. Monitoring Points	85		
6. Sampling	85		
6.1. Sampling Technique	86		
7. In-House Testing	86		

2.3. Quality Assurance Records	115	2.2. Hazard Analysis and Critical Control Point	128
2.4. Procedure	115		
2.5. Notes	115	3. Concepts	129
2.6. Cautions	119	3.1. Terminology for Solutes in Solution	129
2.7. Equipment and Materials	119	3.2. Volumetric Apparatus	131
2.8. Benchmark Values	119	3.3. Balances	132
3. Culture Preparation and Inoculation	119	3.4. pH	132
3.1. Purpose	119	3.5. Spectrophotometry	133
3.2. Yeast	119	3.6. Chromatography	134
3.3. Oenococcus	119	3.7. Filtration—Centrifugation	134
4. A Red Wine Production Protocol	120	4. Preparation of Grape Extracts	135
4.1. Harvesting and Transportation	120	5. Sampling, Dilutions and Calculations	135
4.2. Initiating Fermentation	120	5.1. Dilution Factor	136
4.3. Monitoring Fermentation	120	5.2. Calculation Example: Titratable Acids	136
4.4. Racking off Gross Lees	120		
4.5. Initiating Malolactic Fermentation	120		
4.6. Racking and Aging	121		
4.7. Fining and Stabilizing	121		
4.8. Filtering and Bottling	121		
5. A White Wine Production Protocol	121	10. Essential Analyses	
5.1. Harvesting and Pressing	121	1. °Brix	138
5.2. Initiating Fermentation	122	1.1. Purpose	138
5.3. Monitoring Fermentation	122	1.2. Occupational Health and Safety	138
5.4. Racking, Fining and Cold-Stabilizing	122	1.3. Quality Assurance Records	138
5.5. Filtering and Bottling	122	1.4. Physics/Chemistry	138
6. Bentonite Protein Stability Test	123	1.5. Procedure	139
6.1. Purpose	123	1.6. Sources of Error	139
6.2. Occupational Health and Safety	123	1.7. Notes	139
6.3. Quality Assurance Records	123	1.8. Equipment and Materials	141
6.4. Sources of Error	123	1.9. Benchmark Values	142
6.5. Procedure	123	2. Baumé	142
6.6. Chemistry	123	2.1. Purpose	142
6.7. Notes	124	2.2. Occupational Health and Safety	142
6.8. Equipment and Materials	124	2.3. Quality Assurance Records	142
7. Copper Fining Trial	124	2.4. Physics/Chemistry	142
7.1. Purpose	124	2.5. Procedure	142
7.2. Occupational Health and Safety	124	2.6. Sources of Error	143
7.3. Quality Assurance Records	125	2.7. Notes	143
7.4. Procedure	125	2.8. Equipment and Materials	143
7.5. Chemistry	125	2.9. Benchmark Values	143
7.6. Notes	125	3. pH	143
7.7. Equipment and Materials	125	3.1. Purpose	143
7.8. Storage	125	3.2. Occupational Health and Safety	143
8. Other Fining Trials	125	3.3. Quality Assurance Records	143
8.1. Purpose	126	3.4. Chemistry	144
8.2. Occupational Health and Safety	126	3.5. Procedure	144
8.3. Quality Assurance Records	126	3.6. Sources of Error	144
8.4. Procedure	126	3.7. Notes	144
8.5. Stock Solutions	126	3.8. Equipment and Materials	145
		3.9. Benchmark Values	145
		4. Titratable Acidity	145
		4.1. Purpose	145
9. Principles of Analysis		4.2. Occupational Health and Safety	145
1. Priorities	127	4.3. Quality Assurance Records	145
2. Quality Assurance	127	4.4. Chemistry	145
2.1. Legal Requirements	128	4.5. Procedure	145
		4.6. Sources of Error	145

4.7. Notes	146	1.2. Occupational Health and Safety	157
4.8. Equipment and Materials	146	1.3. Quality Assurance Records	157
5. Sulfur Dioxide by Aspiration	146	1.4. Chemistry	157
5.1. Purpose	146	1.5. Calculations (Single-Beam Spectrophotometer)	157
5.2. Occupational Health and Safety	146	1.6. Procedure	158
5.3. Quality Assurance Records	146	1.7. Notes	158
5.4. Chemistry	147	1.8. Equipment and Materials	158
5.5. Procedure	147	1.9. Benchmark Values	159
5.6. Calculations	147	2. Ammonium by Enzymatic Assay	159
5.7. Notes and Sources of Error	147	2.1. Purpose	159
5.8. Equipment and Materials	147	2.2. Occupational Health and Safety	159
5.9. Benchmark Values	148	2.3. Quality Assurance Records	160
6. Sulfur Dioxide by Titration	149	2.4. Chemistry	160
6.1. Purpose	149	2.5. Calculations	160
6.2. Occupational Health and Safety	149	2.6. Procedure	160
6.3. Quality Assurance Records	149	2.7. Notes	161
6.4. Chemistry	149	2.8. Equipment and Materials	161
6.5. Procedure	149	2.9. Benchmark Values	161
6.6. Notes	149	3. Reducing Sugars by Enzymatic Assay	161
6.7. Equipment and Materials	150	3.1. Purpose	161
6.8. Benchmark Values	150	3.2. Occupational Health and Safety	161
7. Reducing Sugars by Clinitest[®]	150	3.3. Quality Assurance Records	161
7.1. Purpose	150	3.4. Chemistry	161
7.2. Occupational Health and Safety	150	3.5. Procedure	161
7.3. Quality Assurance Records	150	3.6. Notes	162
7.4. Chemistry	150	3.7. Equipment and Materials	162
7.5. Procedure	151	3.8. Benchmark Values	163
7.6. Notes and Sources of Error	151	4. Reducing Sugars (Somogyi–Nelson)	163
7.7. Equipment and Materials	151	4.1. Purpose	163
7.8. Benchmark Values	151	4.2. Occupational Health and Safety	163
8. Tartrate Stability	151	4.3. Quality Assurance Records	163
8.1. Purpose	151	4.4. Chemistry	163
8.2. Occupational Health and Safety	151	4.5. Procedure	163
8.3. Quality Assurance Records	151	4.6. Notes	164
8.4. Chemistry	151	4.7. Equipment and Materials	164
8.5. Procedure	152	4.8. Benchmark Values	164
8.6. Notes and Interpretation	153	5. Proteins	164
8.7. Equipment and Materials	153	5.1. Purpose	164
8.8. Benchmark Values	154	5.2. Occupational Health and Safety	165
9. Turbidity	154	5.3. Quality Assurance Records	165
9.1. Purpose	154	5.4. Chemistry	165
9.2. Occupational Health and Safety	154	5.5. Calculations	165
9.3. Quality Assurance Records	154	5.6. Procedure	165
9.4. Chemistry	154	5.7. Notes	165
9.5. Procedure	154	5.8. Equipment and Materials	165
9.6. Sources of Error	154	6. Malic Acid by Enzymatic Assay	165
9.7. Notes	154	6.1. Purpose	165
9.8. Equipment and Materials	154	6.2. Occupational Health and Safety	166
		6.3. Quality Assurance Records	166
		6.4. Chemistry	166
		6.5. Calculations	166
		6.6. Procedure	166
		6.7. Notes	167
		6.8. Equipment and Materials	167
11. Quality Assurance, Teaching and Research			
1. Free Amino Nitrogen	156		
1.1. Purpose	156		

7. Acetic Acid by Enzymatic Assay	167	12.3. Quality Assurance Records	178
7.1. Purpose	167	12.4. Chemistry	178
7.2. Occupational Health and Safety	167	12.5. Calculations	178
7.3. Quality Assurance Records	167	12.6. Procedure	178
7.4. Chemistry	167	12.7. Notes	178
7.5. Calculations	168	12.8. Equipment and Materials	178
7.6. Procedure	168	13. Phenolics in White Grapes and Wine	178
7.7. Notes	168	13.1. Purpose	178
7.8. Equipment and Materials	169	13.2. Occupational Health and Safety	179
7.9. Benchmark Values	169	13.3. Quality Assurance Records	179
8. Volatile Acidity by Distillation	169	13.4. Chemistry	179
8.1. Purpose	169	13.5. Calculations	179
8.2. Occupational Health and Safety	169	13.6. Procedure	179
8.3. Quality Assurance Records	169	13.7. Notes	179
8.4. Chemistry/Physics	169	13.8. Equipment and Materials	180
8.5. Calculations	169	13.9. Benchmark Values	180
8.6. Procedure	170	14. Total Phenolics by Colorimetry	180
8.7. Notes	170	14.1. Purpose	180
8.8. Equipment and Materials	171	14.2. Occupational Health and Safety	181
8.9. Benchmark Values	171	14.3. Quality Assurance Records	181
9. Potassium (Sodium) by Flame Photometry	171	14.4. Chemistry	181
9.1. Purpose	171	14.5. Procedure	181
9.2. Occupational Health and Safety	171	14.6. Notes	181
9.3. Quality Assurance Records	171	14.7. Equipment and Materials	181
9.4. Calculations	171	15. Tannins	181
9.5. Procedure	171	15.1. Purpose	181
9.6. Measurement	171	15.2. Occupational Health and Safety	181
9.7. Notes	172	15.3. Quality Assurance Records	181
9.8. Equipment and Materials	172	15.4. Chemistry	181
9.9. Benchmark Values	172	15.5. Procedure	182
10. Anthocyanins and Total Phenolics in Red Grapes	172	15.6. Notes	183
10.1. Purpose	172	15.7. Equipment and Materials	183
10.2. Occupational Health and Safety	173	15.8. Reagent Preparation	183
10.3. Quality Assurance Records	173	15.9. Benchmark Values	183
10.4. Chemistry	173	16. Alcohol by Distillation	183
10.5. Calculations	173	16.1. Purpose	183
10.6. Procedure	173	16.2. Occupational Health and Safety	184
10.7. Notes	173	16.3. Quality Assurance Records	184
10.8. Equipment and Materials	175	16.4. Chemistry/Physics	184
10.9. Benchmark Values	175	16.5. Procedure	184
11. Color and Phenolics in Red Wine	175	16.6. Notes	185
11.1. Purpose	175	16.7. Alternative Methods	185
11.2. Occupational Health and Safety	175	16.8. Equipment and Materials	186
11.3. Quality Assurance Records	175	16.9. Benchmark Values	186
11.4. Chemistry	175	17. Alcohol by Ebulliometry	186
11.5. Calculations	176	17.1. Purpose	186
11.6. Procedure	176	17.2. Occupational Health and Safety	186
11.7. Notes	177	17.3. Quality Assurance Records	186
11.8. Equipment and Materials	177	17.4. Chemistry/Physics	186
12. Anthocyanins by Cellulose Chromatography	177	17.5. Procedure	186
12.1. Purpose	177	17.6. Notes	186
12.2. Occupational Health and Safety	178	17.7. Equipment and Materials	187

12. Sample Statistics

1. Introduction	189
2. Simple Descriptive Statistics	189
2.1. Range	189
2.2. Mean	189
2.3. Average	190
2.4. Mode	190
2.5. <i>Standard Deviation</i>	191
2.6. <i>Frequency Distribution</i>	191

2.7. Coefficient of Variation	191
2.8. Correlation Coefficient	191
2.9. Regression Coefficient	192
3. Experimentation	192

Bibliography	195
Appendix: List of Abbreviations and Symbols	203
Index	209