

Contents

Preface	vii
Color Insert	facing page 46
1 Chemistry to Remember	1
1.1 Introduction	1
1.2 Metric System	1
1.3 Density and Specific Gravity	1
1.4 Liquids, Solids, and Gases	3
1.4.1 Pressure and Temperature	4
1.4.2 Liquids	4
1.4.3 Gases.	5
1.5 Chemistry Fundamentals	5
1.5.1 Matter	5
1.5.2 Structure	6
1.5.3 Periodic Table	6
1.5.4 Compounds.	6
1.5.5 Solutions	7
1.5.6 Electrolyte Solutions	11
1.5.7 pH.	12
1.5.8 Oxidation: Reduction and Electrolysis.	12
1.5.9 Halogens	13
1.5.10 Sulfur	13
1.6 Organic Chemistry	13
2 Safety First	18
2.1 Introduction	18
2.2 Regulatory Agencies and Acts	18
2.3 Laboratory and Winery Hazards	20
2.4 Chemical Hazards	21
2.4.1 Toxic Chemicals	21
2.4.1.1 Dose, Duration, Frequency, and Routes of Exposure	21
2.4.1.2 Classification of Toxins	23
2.4.2 Reactive Chemical Hazards.	24
2.4.3 Chemical Handling and Storage	25
2.4.3.1 Ordering and Receiving.	27
2.4.3.2 Proper Labeling.	28
2.4.3.3 Proper Storage.	29
2.4.4 Chemical Waste.	31
2.4.4.1 Classification.	31
2.4.4.2 Waste Disposal	32
2.4.5 Personal Protection Equipment.	35
2.4.6 Chemical Accidents and Emergencies.	37

2.4.6.1	Spills	37
2.4.6.2	Accidental Inhalation or Ingestion	39
2.4.6.3	Fire	40
2.4.6.4	Gas Cylinder Leaks	41
2.5	Physical Hazards	42
2.5.1	Physical Hazards Associated with Laboratory Work	42
2.5.1.1	Equipment Hazards	42
2.5.1.2	Compressed and Liquid Gas Hazards	44
2.5.1.3	Vacuum Hazards	45
2.5.1.4	Glassware Hazards	46
2.5.1.5	Slip, Trip, and Fall Hazards	46
2.5.1.6	Ergonomic Hazards	47
2.5.2	Physical Hazards in the Cellar	49
2.5.3	Damage Control	52
3	What's Your Number?	54
3.1	Introduction	54
3.2	Quality	56
3.2.1	Setting up a QA Program	56
3.2.2	Laboratory Staff	57
3.2.3	Analytical Methods	58
3.2.3.1	Method Validation	59
3.2.3.2	Reagents, Standards, and Controls	64
3.2.4	Analytical Techniques	66
3.2.4.1	Calculations	66
3.2.4.2	Proper Measurement	70
3.2.4.3	Sample Quality	77
3.2.4.4	Preventative Maintenance	78
3.2.5	Records	80
3.2.6	Inadvertent Error	82
4	Berry to Bottle	83
4.1	Introduction	83
4.2	Wine History	83
4.3	Grape Varieties	87
4.4	Appellations	88
4.4.1	France	89
4.4.1.1	Burgundy	89
4.4.1.2	Bordeaux	91
4.4.1.3	Rhône	92
4.4.1.4	Loire	93
4.4.1.5	Champagne	93
4.4.1.6	Languedoc-Roussillon	93
4.4.1.7	Provence	93
4.4.2	Italy	94
4.4.2.1	Piedmont	94
4.4.2.2	Tuscany	94
4.4.2.3	Emilia Romagna-Veneto	96
4.4.3	Spain	96
4.4.3.1	Rioja-Penedés-Cava	96
4.4.3.2	Jerez	97
4.4.4	Portugal	97
4.4.4.1	Douro	97
4.4.4.2	Vinhos Verdes	98

4.4.4.3	Madeira	98
4.4.5	Germany	98
4.4.6	South Africa	99
4.4.7	Chile	101
4.4.8	Argentina	101
4.4.9	Australia	101
4.4.10	New Zealand	102
4.4.11	United States	102
4.4.11.1	New York	103
4.4.11.2	Washington	103
4.4.11.3	Oregon	105
4.4.11.4	California	105
4.5	Wine Production Overview	105
4.5.1	Vineyard	106
4.5.2	Harvest	106
4.5.3	Fermentation	108
4.5.4	Maturation	112
4.5.5	Blending, Fining, and Stabilization	113
4.5.6	Filtration and Bottling	113
4.5.7	Sparkling Wine	114
4.5.8	Money Matters	117

5 Vineyard to Harvest 118

5.1	Introduction	118
5.2	The Grape	118
5.2.1	Mature Grape Physiology	119
5.2.1.1	Organic Acids	119
5.2.1.2	Alkaline Metals	120
5.2.1.3	Nitrogen Compounds	120
5.2.1.4	Phenolic Compounds	120
5.2.1.5	Aromatic Substances	121
5.2.1.6	Sugar	122
5.2.2	Grape Structure	123
5.2.2.1	Seeds	123
5.2.2.2	Skin	123
5.2.2.3	Pulp	124
5.3	Preharvest	124
5.3.1	Vineyard Sampling	125
5.3.2	Sugar Determinations	126
5.3.2.1	°Oechsle	129
5.3.2.2	Baumé	129
5.3.2.3	°Balling and °Brix	130
5.3.3	Glucose and Fructose Determinations	131
5.3.3.1	Enzymatic Method	132
5.3.3.2	Other Residual Reducing Sugar Methods	133
5.3.4	Potential Alcohol (Ethanol) Determinations	134
5.3.5	Alcohol (Ethanol) Determinations	137
5.3.5.1	Ebulliometry Method	138
5.3.5.2	Other Alcohol Determination Methods	140
5.3.6	pH and Acidity Determinations	141
5.3.6.1	pH	142
5.3.6.2	Titrateable Acidity	143
5.3.7	Potassium, Calcium, and Other Alkaline Metals Determinations	145
5.3.8	Total Phenols and Anthocyanin Determinations	146

5.4	Harvest	148
5.4.1	Nitrogen and Amino Acid Determinations	150
5.4.2	Insoluble Solids Determinations	151
5.4.3	Total, Free, and Bound Sulfur Dioxide Determinations	152
5.4.3.1	Forms of Sulfur Dioxide	153
5.4.3.2	Maintaining SO ₂ Levels	155
5.4.3.3	Aeration–Oxidation Method	157
5.4.3.4	Ripper Method	158
5.4.3.5	Other Methods	160
5.5	Summary	161
6	Fermentation × 2	162
6.1	Introduction	162
6.2	Preparation for Fermentation	163
6.2.1	Sugar Adjustments	164
6.2.2	Acid Adjustments	165
6.2.2.1	Acid Additions	165
6.2.2.2	Deacidification	166
6.3	Baseline Analyses	166
6.3.1	Volatile Acidity and Acetic Acid Determinations	167
6.3.1.1	Acetic Acid Enzymatic Method	168
6.3.1.2	Volatile Acidity Distillation Method	169
6.4	Primary Alcohol Fermentation	173
6.4.1	Yeast Metabolism	174
6.4.2	Cultured Yeast and Inoculation	177
6.4.3	Monitoring Fermentation	180
6.4.3.1	Soluble Solids (Apparent °Brix) via Hydrometer	181
6.4.3.2	Soluble Solids (Apparent °Brix) via Density Meter	186
6.4.3.3	Verification of Dryness	187
6.5	Secondary Malolactic Fermentation	188
6.5.1	Taxonomy and Morphology of Wine Microorganisms	190
6.5.1.1	Lactic Acid Bacteria	190
6.5.1.2	Yeasts	191
6.5.1.3	Spoilage Bacterium	192
6.5.1.4	Other Methods of Identification	192
6.5.2	Prefermentation Analyses	193
6.5.3	<i>Oenococcus oeni</i> Culture Preparation	193
6.5.3.1	Culture Buildup	194
6.5.4	Monitoring MLF	196
6.5.5	L-Malic Acid Determinations	196
6.5.5.1	Paper Chromatography	197
6.5.5.2	Thin-Layer Chromatography	197
6.5.5.3	Capillary Electrophoresis	197
6.5.5.4	Enzymatic Method	198
6.5.6	Cessation of Fermentation	198
7	Maturation Matters	200
7.1	Introduction	200
7.2	Maturation and Aging	201
7.2.1	Advantages of Maturation	201
7.3	Removal of Substances	202
7.4	Storage Containers	203
7.4.1	Cooperage	203

7.4.1.1	Wood	204
7.4.1.2	Barrel Construction	204
7.5	Protecting the Wine	205
7.5.1	Oxidation	206
7.5.1.1	Oxygen and Wine Color	207
7.5.1.2	Formation of Acetaldehyde	208
7.5.2	Microbial Spoilage	208
7.5.2.1	Acetic Acid Bacterial Spoilage	208
7.5.2.2	Lactic Acid Bacterial Spoilage	209
7.5.2.3	Yeast Spoilage	210
7.5.2.4	Conclusion	212
7.6	Maintenance of Maturing Wines	212
7.6.1	Barrel Storage	213
7.6.1.1	Topping	213
7.6.1.2	Racking	213
7.6.1.3	Cellar Temperature	214
7.7	Organoleptic Evaluation	214
7.7.1	Organoleptic Terminology	215
7.7.2	Wine Sensory	216
7.7.2.1	Flavor Identification	216
7.8	Fining	216
7.8.1	Bentonite Fining	220
7.8.2	Albumen Fining	222
7.8.3	Gelatin and Isinglass Fining	222
7.8.4	Copper Sulfate Fining	223
7.9	Wine Stability	224
7.9.1	Freeze Test	225
7.9.2	Cold Conductivity	226
7.10	Filtration	227
7.11	Blending	229
7.11.1	Fractional Blending	230

8 Bottling Basics 231

8.1	Introduction	231
8.2	Packaging	231
8.2.1	Labels	232
8.2.2	Bottles	233
8.2.3	Cork	233
8.2.3.1	Cork Quality Control	235
8.2.3.2	TCA	237
8.3	Bottling Lines	238
8.4	Preparing Wines for Bottling	239
8.4.1	Required Analyses	240
8.4.1.1	Sulfur Dioxide	240
8.4.1.2	EtOH	241
8.4.1.3	Acidity	241
8.4.1.4	Microbial Growth	242
8.4.1.5	Carbon Dioxide	242
8.4.1.6	Oxygen and Wine Temperature	243
8.4.1.7	Wine Density	243
8.5	Prebottling Activities	244
8.5.1	Bottling Line Sanitation	244
8.5.2	Membrane Filter Integrity Test	245
8.6	Bottling	246

8.6.1	Bottle Queue	246
8.6.2	Membrane Filter	247
8.6.3	Filler	247
8.6.4	Corking Machine	248
8.6.5	Quality Control	249
8.6.6	Capsules, Wax, Labeling, and Storage	249
8.7	Microbiological Monitoring	251
8.7.1	Plating Media	251
8.7.2	Plate Inoculation, Incubation, and Identification	252
8.8	Required Analysis for International Trade	255
8.9	Bottle Aging	257
9	Analytical Procedures	258
9.1	Introduction	258
9.2	Procedures	259
9.2.1	Spectrometric Color and Phenolic Measurement	259
9.2.2	Density Measurement, Direct Method	262
9.2.3	Specific Gravity Measurement	263
9.2.4	Soluble Solids Measurement via Hydrometer	265
9.2.5	Density, Specific Gravity, and °Brix Measurements via Density Meter	267
9.2.6	Soluble Solids Measurement via Refractometer	269
9.2.7	pH Measurement	271
9.2.8	Titrateable Acids Assay, Manual	273
9.2.9	Titrateable Acids and pH Assay via Automated Titration	275
9.2.10	Fluoride (F) Assay via ISE	277
9.2.11	Ammonia (NH ₃) Assay via ISE	279
9.2.12	Free and Total Sulfur Dioxide (SO ₂) Assay via Ripper	280
9.2.13	Free and Total Sulfur Dioxide (SO ₂) Assay via Aeration–Oxidation	282
9.2.14	Reducing Sugar and Residual Reducing Sugar (RS) Enzymatic Assay	285
9.2.15	L-Malic Acid (LMA) Enzymatic Assay	287
9.2.16	Acetic Acid (AC) Enzymatic Assay	289
9.2.17	Volatile Acidity Assay via Distillation	292
9.2.18	Insoluble Solids (% Solids) Measurement	295
9.2.19	% v/v Alcohol Measurement via Ebulliometer	296
9.2.20	Yeast and Bacteria Viability and Cell Counts	299
9.2.21	Cold Stability Assay for the Verification of Bitartrate Stability via Freeze Test	300
9.2.22	Cold Stability Assay for the Verification of Bitartrate Stability via Conductivity	302
9.2.23	Heat Stability Assay for Verification of Protein Stability	304
9.2.24	Carbon Dioxide (CO ₂) Measurement via Carbodoseur	305
9.2.25	Acidulation Trial	306
9.2.26	Deacidulation Trial: Potassium Bicarbonate KHCO ₃ (or K ₂ CO ₃)	308
9.2.27	Gelatin Fining Trial	309
9.2.28	Isinglass Fining Trial	311
9.2.29	Egg White Fining Trial	312
9.2.30	Bentonite Fining Trial	314
9.2.31	Copper Sulfate (CuSO ₄) Trial	315

10 Reagents	318
10.1 Introduction	318
10.2 Reagents	319
10.2.1 Acetaldehyde (C ₂ H ₄ O) 10% w/v Solution	320
10.2.2 Acetic Acid (C ₂ H ₄ O ₂) 1% w/v Standard	320
10.2.3 Ammonia (NH ₃) 0.1% w/v Standard	321
10.2.4 Bentonite 5% w/v Slurry	322
10.2.5 20 °Brix Sucrose (C ₁₂ H ₂₂ O ₁₁) Standard	323
10.2.6 Copigmentation Buffer	323
10.2.7 Copper Sulfate (CuSO ₄) 100 mg/liter Solution	323
10.2.8 Isinglass 0.5% w/v Solution	324
10.2.9 Egg White 10% w/v Solution	325
10.2.10 Ethanol (EtOH) Solutions and Standards	325
10.2.11 Gelatin 1% w/v Solution	326
10.2.12 Hydrochloric Acid (HCl) Solutions	327
10.2.13 Hydrogen Peroxide (H ₂ O ₂) 0.3% v/v Solution	327
10.2.14 Indicator Solution	328
10.2.15 Iodine (I ₂) 0.02 <i>N</i> Solution	328
10.2.16 L-Malic Acid (C ₄ H ₆ O ₅) 0.2 g/L Standard	328
10.2.17 Malic Acid (C ₄ H ₆ O ₅) 10% w/v Solution	329
10.2.18 Phosphoric Acid (H ₃ PO ₄) Solutions	329
10.2.19 Potassium Bicarbonate (KHCO ₃) 4.5 % w/v Solution	330
10.2.20 Sodium Hydroxide (NaOH) Solutions	331
10.2.21 Starch 1% w/v Solution	331
10.2.22 Sulfur Dioxide (SO ₂) 200 mg/L Solution	332
10.2.23 Sulfuric Acid (H ₂ SO ₄) Solutions	333
10.2.24 Tartaric Acid (C ₄ H ₆ O ₆) 100 g/L Solution	333
10.2.25 Thiosulfate (S ₂ O ₃) Solution	334
10.3 Standardization	335
10.3.1 Standardization of Acid Solutions	335
10.3.2 Standardization of Base Solutions	336
10.3.3 Standardization of 0.02 <i>N</i> Iodine Solution	336
Appendix Laboratory Chemical Safety Summaries	337
Bibliography	359
Index	365