

Detailed Subject Index and List of Main Tables and Factsheets

Part 1: Founding Principles and General Operations

General Introduction

1

Section A: Raw Materials

1. Apples and Pears – The Core of Cider and Perry Production

2

1.1 Introduction

2

1.2 Structure and the Chemical Composition of Apples and Pears

2

1.2.1 Fruit Structure

2

1.2.2 General Composition of Apple and Pear Juices

3

1.3 The Phenolics of Cider Apples and Perry Pears

4

1.4 Apple and Pear Volatiles

6

1.4.1 Volatile Compounds in Apples

6

1.4.2 Volatile Compounds in Pears

8

1.5 Impact of Apples and Pears on Sensory Properties of Cider

8

1.5.1 β -glycols

8



Main Tables and Factsheets

- General composition of Apple and Pear juices
- Classification of Cider Apples
- Major Volatile Flavour Compounds in Apples

Section B. Planning for Production: Key Requirements

1. The Overall Framework

9

2. Quality Assurance in Production

10

2.1 Overview

10

2.2 Hazard Analysis Critical Control Point (HACCP)

12

2.3 Performance Indicators

15

2.4 Summary - Maintaining Quality in Day-to-Day Cider Production

16

3. Legal Requirements for Commercial Production

17

3.1 Excise Tax and Definitions and Standards

17

3.2 Food Safety

19

3.3 Labelling

20

3.4 Occupational Health and Safety (H&S)

21

4. Planning a Facility and Hygienic Design

23

4.1 Introduction, Overview and Key Considerations

23

4.2 Designing and Equipping a Cider Production Facility

25

4.2.1 Introduction

25

4.2.2/3/4 Business Analysis, Outline Design, Detailed Design

25

4.2.5 Practical Design

26

4.3 Equipment and Resource Requirements

29

4.3.1 Capacity calculations, Layout and Equipment Selection

29

4.4 Environmental Considerations

33

4.5 Hygienic Design

35

4.6 Summary

37

5. Cider and Perry Production as a Business

38

5.1 Overview

38

5.2 The Importance of Marketing

38

5.2.1 Market Segmentation

39

5.3 Production Costs

40

Main Tables and Factsheets

- Principles of HACCP and Decision Tree Use
- Examples of Non-Financial KPIs
- Examples of Legal Definitions
- EU Labelling Regulations – An Example
- Occupational H&S – Risk Assessments
- Equipment Layout Objectives
- Factors Influencing Space Requirements
- Services, Utilities and Storage
- Environmental Considerations
- Designing and Equipping a Cider Production Facility and its Maintenance
- Hygienic Design
- Types of Food Grade Stainless Steel
- Summary of Direct Costs

Section C: Microbiology of Cider and Perry Production

1. Introduction	41
2. Microorganisms Associated with Cider Production	41
2.1 Overview	41
2.2 Cider Yeasts	42
2.3 Cider Bacteria	49
2.4 Potential Hazards to Consumers: Alcohol	59
2.5 Potential Hazards to Consumers: Other	60
2.6 Potential Organoleptic Faults of Cider and Perry: A Summary	63
2.7 Microbial Control	67
2.8 Use of Sulphur Dioxide and Other Preservatives	67
2.8.1 Introduction	67
2.8.2 Sulphur Dioxide in Cider and Perry Production	67
2.8.3 Chemistry of SO ₂ in Juice and Cider	68
2.8.4 Sulphur Dioxide Binding	69
2.8.5 Practical Use of SO ₂	71
2.8.6 Use of Other Preservatives	72

Main Tables and Factsheets

- Main Types of Yeasts of Cider and Perry
- Main Types of Bacteria of Cider and Perry
- Potential Organoleptic Faults of Cider and Perry
- Best Practice Control to Reduce SO₂ Binding and Its Overall Usage

Section D: Central Operations and Processes

1. Introduction	73
2. Properties of Liquids	73
3. Sanitisation	75
3.1 Overview	75
3.2 Cleaning	76
3.3 Disinfection	79
3.4 Cleaning-in-Place (CIP)	79
3.5 Assessing the Effectiveness of Sanitisation	82
3.6 Health and Safety for Sanitisation	83
4. Pumps, Pipelines and Hoses	84
4.1 Introduction and Overview	84
4.2 Positive Displacement (PD) Pumps	85
4.3 Centrifugal (CF) Pumps	86
4.4 General Pumping and Pipeline Considerations	90
4.5 Flexible Hoses, Couplings and Seals	91

Main Tables and Factsheets

- Liquid Properties
- Main Detergents
- Preparation of Working Strength Caustic Detergents
- Main Disinfectants
- Sanitisation Health and Safety
- Positive Displacement and Centrifugal Pumps: Details and a Comparison
- Understanding Pump Curves and the Operation of Centrifugal Pumps
- Frictional Losses in Pipelines
- Materials used for Seals and Fittings

Section E. Production Monitoring: Laboratory and Analytical Sensory Analysis

1. Introduction: The Role and Purpose of Analysis	92
2. Planning and Reliability of Analysis	93
2.1 Planning for Analysis	93
2.2 Laboratory Health and Safety	94
2.3 Reliability of Analysis and Results Obtained	95
2.3.1 Overview	95
2.3.2 Errors in Analysis	96
2.3.3 Sampling	97
2.3.4 Undertaking Analysis	98
2.3.5 Replication and Randomisation	98
2.3.6 Presentation of Results	98
2.3.7 Data Analysis and Interpretation	99
2.3.8 Quality Assurance and Controls for the Laboratory	101
3. Laboratory Chemical Analysis	102
3.1 Overview of Chemical Analysis Techniques	102
4. Microbiological Methods for Cider Production	105
4.1 Introduction and Rationale	105
4.2 Basic Requirements and use of Microbiological Analysis	105
4.3 Rapid Methods in Microbiological Monitoring - An Introduction	106
4.3.1 Overview	106
4.3.2 Application of ATP Bioluminescence in Cider Production	108
5. Analytical Sensory Analysis	109
5.1 Introduction and Rationale	109
5.2 Application of Analytical Sensory Analysis in Cider Production	110
5.3 Organisation and Implementation of Sensory Analysis	111
5.4 Descriptive Sensory Analysis	113
5.5 Biological Basis of Sensory Analysis and Laboratory Analysis	113
5.5.1 General Appearance	113
5.5.2 Colour	113
5.5.3 Clarity, Viscosity and Other Visual Characteristics	114
5.5.4 Taste	115
5.5.5 Aroma	115
5.5.6 Mouthfeel	115
6. Application of Laboratory Analysis in Cider Production	116

Main Tables and Factsheets

- **Planning for Laboratory Analysis**
- **Laboratory H&S Regulations - Examples**
- **Avoiding and controlling Errors**
- **Overview of Chemical Analysis Techniques**
- **Selection of Microbiological Media**
- **Features and Types of Rapid Methods for Microbiological Monitoring**
- **Analytical Sensory Analysis: Types of 'Taste Panels' and Screening of Panel Assessors**
- **Main Requirements for Undertaking Sensory Analysis in Cider Production**
- **Potential Application of Tristimulus Colourimetry**
- **Summary of Main Methods used in Chemical, Microbiological and Analytical Sensory Analysis in Cider Production**

References - Part 1

120

Part 2: The Science and Practice of Cider Production

General Introduction 131

Section A: Fruit Selection, Processing and Preparation for Fermentation

1. Introduction	132
2. Fruit Selection and Handling	132
2.1 Selection of Fruit for Cider and Perry Production	132
2.2 Fruit Harvesting and Quality	134
2.3 Fruit Reception and it's Quality Control	136
3. Fruit Processing	138
3.1 Introduction	138
3.2 Juice Extraction: Maximising Efficiency	139
3.2.1 Fruit Milling	139
3.2.2 Pressing the Mash	139
3.3 Use of Enzymes for Juice Extraction and Preparation	143
3.3.1 Pectin and Pectinases	143
3.3.2 Starch and Amylolytic Enzymes	144
4.0 Use of Concentrated Juice	145
5. Juice Specifications and Quality Control	147
5.1 Overview	147
5.2 Control of pH.	147
5.3 Pasteurisation of Juice and use of Sulphur Dioxide	147
6. Maceration and Kieving for Production of Sweet Cider	148
6.1 Preparation of the Juice for Fermentation	148
6.2 Fermentation and the Final Product	148



Main Tables and Factsheets

- Types of Presses and Other Juice Extraction Equipment
- Apple Juice Concentrate: Specifications and Dilution Calculations
- Specification of Juice for Fermentation

Section B: Fermentation

1. Introduction	149
2. Yeast Selection and Handling	149
2.1 Use of Yeast in Cider Production: The Origins	149
2.2 Choice of Yeast and Selection Criteria	150
2.2.1 Fermentation using 'Wild' Strains of Yeast	150
2.2.2 Use of Selected Strains of Yeast	150
2.2.3 Multi-Strain, Hybrid and Non-Saccharomyces Yeasts	152
2.2.4 Yeast Strains as Potential Biological Controls	152
2.3 Yeast Addition and Handling	153
2.3.1 General Handling	153
2.3.2 Acclimatisation of Yeast	153
3. Biochemistry of Fermentation and Yeast Nutrients	154
3.1 Introduction	154
3.2 Yeast Carbohydrate Metabolism	156
3.2.1 Overview	156
3.2.2 Uptake and Fermentation of Different Sugars	156
3.2.3 By-Products of Carbohydrate Metabolism	158
3.3 Nitrogen Metabolism in the Yeast	159
3.3.1 Introduction	159
3.3.2 Fruit-Derived Nitrogen	159
3.3.3 Nitrogen Uptake and its Metabolism	160
3.3.4 By-Products of Nitrogen Metabolism	161
3.3.5 Stimulatory Effect of Nitrogen	162
3.4 The Yeast Cell Envelope, Lipids and the Role of Oxygen	163
3.4.1 Introduction	163
3.4.2 The Plasma Membrane	164

Main Tables and Factsheets

- Yeast Selection Criteria
- Redox in Biochemistry
- Carbohydrate Metabolism By-Products
- Concentration of Amino Acids Found in Traditional Cider Apple and Perry Pear Juice
- Flavour Compounds Derived from Amino-Acid Catabolism

3.5 Yeast Sulphur Metabolism and H₂S Control	165	
3.5.1 Yeast Sulphur Requirements and Potential Sources	165	
3.5.2 Sulphur Metabolism and Production of H ₂ S	165	
3.5.3 Potential Causes of H ₂ S Liberation in Production	167	
3.5.4 Control and Prevention of H ₂ S Formation in Cider	169	
3.5.5 Organic Sulphur Containing Compounds	171	
3.5.6 Treatment of Sulphidic Problems	172	
3.6 Vitamins and Minerals and their Functions	173	
4. General Fermentation Management	177	
4.1 Introduction	177	
4.2 Fermentation Vessels and Ancillary Equipment	177	
4.3 Commencing and Managing Fermentation	179	
4.4 Practical Yeast Nutrition Strategies	179	
4.4.1 Chaptalisation	179	
4.4.2 Nitrogen as a Nutrient	181	
4.4.3 Nitrogen Analysis	181	
4.4.4 Nitrogen Supplementation	182	
4.4.5 Timing of Nitrogen and other Nutrient Additions	183	
4.5 Temperature and Oxygen Control	184	
4.5.1 Temperature Effects and Control	184	
4.5.2 Oxygen Control	185	
4.6 Production of Carbon Dioxide and its Effects	186	
4.7 Monitoring Fermentation	187	
4.8 Fermentation Troubleshooting	188	
4.9 Summary of Fermentation and its End	192	
4.10 Racking	193	
Section C. Maturation of Cider and Perry		
1. Introduction and Overview	195	
2. Chemical Changes During Maturation	196	
3. Malolactic Fermentation	198	
3.1 Introduction	198	
3.2 Biochemistry and Sensory Impact of MLF	199	
3.3 Management of MLF	200	
4. Maturation Management – A Summary	203	
Section D - Sensory Attributes of Cider and Perry		
1. Introduction and Overview	204	
2. Main Groups of Sensory-Active Compounds	205	
2.1 Changes to Flavour Compounds During Production	205	
2.1.1 Overview	205	
2.1.2 Alcohols	207	
2.1.3 Esters	208	
2.1.4 Phenolics: The ‘Taste of Tannin’	209	
2.1.5 Aldehydes and Ketones	210	
2.1.6 Carboxylic Acids	210	
2.1.7 Volatile Sulphur Compounds	210	
2.1.8 Acetals	211	
2.1.9 Terpenes and Their Derivatives	211	
2.1.1.10 Dioxanes	211	
2.1.11 Expression of Varietal Characteristics	211	
3. The Effect of Production Practices on the Flavour of Cider	212	
4.0 Relative Impact of Flavour Compounds Found in Cider	214	
References – Part 2	215	

Main Tables and Factsheets

- Control and Prevention of Hydrogen Sulphide Formation
- Organic Sulphur Containing Compounds
- Vitamins and Minerals Required by *Saccharomyces* Yeast
- Features and Components of Cider Fermenters
- Example Yeast Nutrient Regime
- Fermentation Monitoring
- Fermentation Troubleshooting

Main Tables and Factsheets

- Preparation and Management of MLF
- Monitoring MLF

Main Tables and Factsheets

- Changes to Higher Alcohols and Esters During Fermentation of Cider Apple Juice
- Microbial Metabolism of Phenolic Acids
- Effect of Processing Techniques on Phenolic Compounds

Part 3: Preparing Cider and Perry for the Marketplace

Overview	227
Section A: New Product Development (NPD)	
1. Introduction and Overview of the NPD Process	227
2. NPD in Cidermaking	230
3. Hedonic Sensory Analysis	231
Section B: Blending and Initial Downstream Processing	
1. Introduction	235
2. Blending Cider and Perry and Final Product Make-Up	235
2.1 Blending: An Essential Art of Cider Production	235
2.2 Product Specifications	237
2.3 Carbonation	238
2.3.1 History and Background	238
2.3.2 Process and Methods Used	239
2.3.3 Bubble Quality	240
2.4 In-Bottle Fermentation and Bottle Conditioning	241
2.5: Production of Reduced, Low and No Alcohol Cider	244
2.6 Ice Cider	245
2.6.1 Introduction	245
2.6.2 Production of Ice Cider – An Outline	245
3. Clarification	246
3.1 Fining	246
3.2 Centrifugation	248
3.3 Filtration	248
3.3.2 Pad (Sheet) Filtration	250
3.3.3 Powder Filtration	251
3.3.4 Cross-Flow Filtration	253
Section C: Final Processing, Product Stabilisation and Packaging	
1. Cartridge Filtration	255
2. Product Stabilisation	255
2.1 Introduction and Overview	255
2.2 Sterile Filtration	257
2.2.1 Overview	257
2.2.2 Integrity Testing of Membrane Filter Cartridges	257
2.3 Pasteurisation	258
2.3.1 Introduction and Background	258
2.3.2 Practical Application	260
2.3.3 Effect of Thermal Pasteurisation on Flavour	261
2.4 Preservatives: DMDC, Sorbates, SO ₂ and Ascorbate	263
3. Packaging	265
3.1 Introduction and Overview	265
3.2 Filling Technology	266
3.3 Packaging Types, Specifications and Quality Control	268
3.3.1 Receipt and Storage of Packaging Materials	268
3.4 In-Pack Quality Issues	269
3.4.1 Canned Cider – The Challenge of the Lacquer Liner	269
3.4.2 Keg and Draught Cider: The Challenge of Dispense	270
3.4.3 Storage of Cider in Glass Bottles	270
3.4.4 Unwanted Hazes	271
3.5 Fill volume and Labelling Requirements	273
3.6 “The Package is the Product”: Key Considerations	273
Overall Summary	274
References – Part 3	275



Main Tables and Factsheets

- Components and Steps in NPD
- Methods for Hedonic Sensory Analysis
- Permitted Ingredients in UK Cider: An Example
- Product Specifications
- Legislative Standards for Cidre Bouché
- Production of Bottle Fermented and Bottle Conditioned Cider and Perry
- Definitions and Techniques for the Production of Low/No Cider
- Standards for Ice Cider
- Use and Effects of Fining Agents
- Filtration Terminology
- Types of Use of Powder Filters

Main Tables and Factsheets

- Use of Cartridge Filters
- In-Pack Pasteurisation: Considerations and Operation H&S
- Minimum Lethal Concentrations of DMDC Against Yeast and Bacteria
- Operation of Counter-Pressure Fillers
- Selection and Use of Different Types of Packaging: *Main Considerations*