

ECONOMIC MICROBIOLOGY

Volume 3

1 P500
R66
1977

ECONOMIC MICROBIOLOGY
Volume 1

ALCOHOLIC BEVERAGES

edited by

A. H. ROSE

*School of Biological Sciences
University of Bath,
Bath, England*

1977



ACADEMIC PRESS

LONDON NEW YORK SAN FRANCISCO

A Subsidiary of Harcourt Brace Jovanovich, Publishers

PREFACE TO THE SERIES

Controlling and exploiting the World's flora and fauna have been fundamental to Man's colonization of this planet. His ability to regulate the activities, both pathogenic and saprophytic, of micro-organisms, and to go on to harness microbial activity in the manufacture of foods and chemicals represents a truly outstanding achievement especially when one remembers that microbes represented an invisible activity or agent until microbiology became established as a science during the latter half of the last Century. Only then did it become apparent that Man's very existence depends on microbial activity.

This multi-volume series aims to provide authoritative accounts of the many facets of exploitation and control of microbial activity. The first volume describes production of alcoholic beverages, and in the second and third volumes there are accounts of the microbiological production of commercially important chemicals. Production of microbial biomass is the subject of the fourth volume, and in the fifth there are accounts of production of enzymes from micro-organisms and of industrially-important chemical conversions or reactions mediated by microbes. Later volumes will deal with biodeterioration caused by microbes, sewage purification and the microbiology of foods. Throughout the volumes, emphasis is placed on the chemical activities of micro-organisms for it is these activities which affect with such impact the activities of man. It is hoped that the series will provide an adequate testimony to the unique relationship which Man has forged with his smallest servants.

January, 1977

ANTHONY H. ROSE

CONTENTS

Contributors	v
Preface to the Series	vii
Preface to Volume 1	ix
Notes	xiv

1. History and Scientific Basis of Alcoholic Beverage Production

A. H. ROSE

I. Introduction	1
II. History of alcoholic beverages	3
III. Microbiology and biochemistry of alcoholic beverage production	7
IV. World-wide production of alcoholic beverages	33
V. Acknowledgements	37
References	37

2. Beer

ANNA M. MacLEOD

I. Introduction	44
II. Historical aspects of brewing	44
III. Outline of the brewing process	48
IV. Malting	50
V. Mashing	59
VI. Direct conversion of barley to wort	71
VII. Wort boiling and cooling	73
VIII. Fermentation	81
IX. Beer treatments	103
X. Beer properties	111
XI. Beer defects	118
XII. The state of the industry	123
XIII. Acknowledgements	126
References	126

5. Fruit and Honey Wines

ANDRZEJ JARCZYK AND WIESLAW WZOREK

*Department of Food Technology,
Agricultural University of Warsaw, Warsaw, Poland*

I. Introduction	387
II. General information	388
III. Raw materials	392
IV. Technological processing	394
A. Pressing	394
B. Conservation and storage of fruit must	397
C. Preparation of fruit must for fermentation	398
D. Fermentation	402
E. Mellowing	405
F. Filling-up	412
G. Sparkling and carbonated wines	412
V. Honey wine (mead)	413
A. Definition and classification	413
B. Honey as a raw material	414
C. Technological processing	415
References	419

I. INTRODUCTION

Fruit wines have for many years now been an important product obtained from fruit processing. Like the term 'grape wine' or 'wine', the oenological product obtained from fruits is designated 'fruit wine'. Production of fruit wines has gained a foothold in many countries, particularly those characterized by a rougher climate in which cultivation of the grape vine cannot be developed.

The term 'fruit wines' is hard to define, particularly as regards distinguishing it from fermented grape musts with a content of several per cent alcohol, and from cider and perry, all products with a long standing tradition (Warcollier, 1928; Charley, 1954). Considering that legal rules covering fruit wines, as enforced in many countries at the present time, recognize as a fruit wine any fermented fruit must with at least 8-9% alcohol content by volume, the authors have decided not to deal in this chapter with the production of cider, perry or other fruit beverages with an alcohol content below 8-9%. Moreover no further consideration has been given herein to the relatively limited production of wines of pineapples, oranges, grapefruits (Amerine and Cruess, 1960), or to those derived from other tropical fruits like dates or figs.

The authors have discussed wines made from fruits typically originating from regions with climatic conditions most close to those of Central Europe. Such fruits include mainly apples, currants (and other berry fruits) as well as certain stone-fruits, such as plums or cherries.

Production of fruit wines differs essentially from that of grape wines, particularly with regard to the highly differentiated raw material, the need for sweetening and dilution of fruit musts, and the resulting differences as regards the process of fermentation and mellowing.

II. GENERAL INFORMATION

Fruit wines are beverages obtained by alcoholic fermentation of fruits (with the exception of vine grapes) or of juices thereof, with an alcohol content amounting to between approximately 8-9 and 18% (v/v), and sometimes even more. Fruit wines are made mainly out of pome fruits, berry fruits and stone fruits, and less frequently out of citrus and other fruits.

The above definition does not include alcoholic fruit-beverages like cider or perry, since these have a lower alcohol content than fruit wines, of the order of 5-7% (v/v) because sucrose is not added to the juice. The desired strength of fruit wines is obtained by sweetening prepared fruit juices with sugar.

Many criteria have been adopted as valid in connection with the classification of fruit wines. Firstly they are divided, depending on the colouring, into white and red wines, usually with no distinction being made to pink (or rosé) wines (Wzorek, 1973). The basic components which affect the properties of wine are the sugar and the alcohol contents. Detailed wine classification is based upon a differentiation in the contents of the above components. In Poland, for example, a distinction is drawn between dry wines, containing between 0 and 10 g sugar/l and 9-11% alcohol by volume; semi-dry wines, containing from 20 to 30 g sugar/l and 10-12% alcohol by volume; slightly sweet wines, containing 45 to 65 g sugar/l and 11-13% alcohol by volume; sweet wines, containing 80 to 110 g sugar/l and 12-14% alcohol by volume; and very sweet wines with a sugar content in excess of 120 g sugar/l and an alcohol content of the order of 13-18% by volume. Dry and semi-dry wines are designated also as table wines, while those slightly sweet, sweet or very sweet are known as dessert wines. A similar classification is adopted, furthermore, in other countries which is specified by the pertaining standards (GOST 17292-71—Vina plodovo-jagodnye, 1971; GOST 5400-70—Vina plodovo-jagodnye naturalnye, 1970; ČSN 567810—Ovocne vina, PN-71/A-79121 Wino owocowe, 1971); Tables 1 and 2. A distinction is also made for carbonated fruit wines, following a mechanical saturation with carbon dioxide, and sparkling wines containing carbon dioxide obtained by alcoholic fermentation. A separate group is represented by herb wines (including vermouths) with certain added herb and spice ingredients. As far as the commercial turnover is concerned, a distinction is made between ordinary and fine wines, the latter being marked by constant properties and by a higher quality. Dry and semi-dry fruit wines are made in only limited quantities. Also wines produced out of a single brand of fruits are rather scarce.

The chemical composition of typical fruit wines produced at present in Poland is shown in Table 3. Table 4 lists the chemical composition of certain fruit wines made in the U.S.S.R. The chemical composition of wines produced in the German Federal Republic is listed by Wucherpennig (1969, 1971).

Certain of the chemical components listed in Tables 3 and 4 have an influence upon the quality of fruit wines. Such components include the non-sugar soluble extract, ash and volatile acids.

Table 1
Standards for analytical data for some fruit wines produced in U.S.S.R.
(Norma GOST 17292-71—Vina plodovo-jagodnye)

Wine	Alcohol (% by volume)	Total sugars (g/100 ml)
Sparkling wines	11.5	5
Carbonated white wines	11	7
Carbonated rosé wines	10-11	10
Table dry wines	10-13.5	0.3
Table white wines with sugar content up to 1% (w/v)	12	1.0
Table slightly sweet wines	10-13	5-8
Sweet unfortified wines	13-14.5	10-16
Liqueur-type unfortified wines	14	25
Fortified strong wines	16-18	7-10
Fortified sweet wines	14-16	10-18
Liqueur-type fortified wines	13-16	20-30
Sweet honey wines	12-16	16-20
Liqueur-type honey wines	14	30
Aromatized strong wines	16-18	8-10
Aromatized sweet wines	16	13-16
Liqueur type aromatized wines	16	20

Table 2
Analytical data for some fruit wines produced in Czechoslovakia
(CSN Standard 567810—Ovocná vina)

Wine	Alcohol (% by volume)	Total sugars (g/100 ml)
Table wines	10	2.0 (max)
Slightly sweet wines	12	3.0-8.0
Sweet wines	14	10.0

Standardization of non-sugar soluble extracts and ash content is aimed at preventing excessive wine dilution. The chemical component that is related to the quality of the raw material used and of the hygiene in the technological process involved is the volatile acidity. With general technological and sanitary requirements being adhered to, and with the correct fermentation course, the volatile acid (expressed as acetic acid) does not usually exceed 1.2 g/l for white and 1.6 g/l for red wines.

Table 3
Composition of some Polish fruit wines. From data supplied by the Warsaw Institute of Fermentation Industry (1974)

Type of wine	Alcohol (%) by volume)	Total sugars				Ash
		Total sugars	Non-sugar soluble	Acid (as malic acid)	Volatile acidity	
White slightly sweet	12.3	64.7	19.1	5.1	0.87	1.9
Red slightly sweet	12.6	66.9	22.2	6.6	0.9	2.2
White sweet	12.9	103.1	23.2	5.6	0.82	2.0
Red sweet	13.0	104.0	30.3	7.3	0.95	2.9
White very sweet	14.1	135.3	22.9	6.7	0.65	2.2
Red very sweet	13.5	131.8	25.9	7.0	0.75	2.7
<i>Single fruit wines</i>						
Apple, slightly sweet	12.4	62.0	18.0	6.2	1.10	1.8
Apple, sweet	13.0	101.8	23.7	5.4	0.85	2.0
Red current, slightly sweet	12.4	72.2	22.1	6.9	0.90	2.0

Table 4

Composition of some fruit wines produced in U.S.S.R. (Mitjukov *et al.*, 1965)

Wine	Alcohol (%) by volume	Acidity (g/l)	Total sugars (g/l)	Non-sugar solubles (g/l)
White dry	12.3	7.4	15.6	22.0
Red semi-dry	12.7	8.5	33.7	30.1
White slightly sweet	12.8	7.3	65.7	25.0
Red slightly sweet	13.1	8.4	59.3	31.5
White sweet	13.3	7.6	104.9	30.6
Red sweet	13.6	8.7	97.9	35.1

The concentration (in g/100 l) of non-sugar solubles is calculated using the formula:

$$E_t - [S_r + (S_t - S_r) \cdot 0.95]$$

in which E_t is the value for the concentration (g/100 ml) of soluble solids, S_r of reducing sugars (g/100 ml), and S_t of total sugars (g/100 ml).

The U.S.S.R. and Poland are ranked among the two World leading fruit-wine makers. Annual output of fruit wines amounted in the U.S.S.R. in 1968 to 323 million litres, with plans for 1975 providing for 480 million litres (Trofimenko, 1969) and, in Poland, to 160 million litres in 1972 (Rocznik Statystyczny, 1973). Other European countries are producing smaller quantities of fruit wines (cider not included). For example, the German Federal Republic produces approximately 15 million litres (Korth, 1973; Skibe, 1969). Large-scale wineries in operation at the present time are offering a production capacity of up to 10 million litres of fruit wine annually.

III. RAW MATERIALS

Basic raw materials for production of fruit wines are fruits of different varieties. Used most frequently are fruits typical of countries with a moderate climate (Golomštok and Šapiro, 1962). Apart from the fruit classifications as adopted in the wine-making industry, namely into stone, berry and pome fruits, fruits can also be divided, for practical reasons, into cultivated fruits (for example apples, currants, strawberries) and those growing in the wild (for example bilberries, blackberries, bog bilberries, elderberries, rose hips, bird

Table 5
Chemical composition of edible parts of several fruits used in wine making. From Pijanowski *et al.* (1973)

Fruit	Content (per cent weight of)											
	Water	Dry matter	Insoluble substances	Total sugars	Sucrose	Inverted sugar	Nitrogenous compounds (N x 6.25)	Acid (as malic acid)	Cellulose	Pectin (as calcium pectate)	Tannins	Ash
Apples (<i>Pirus malus</i>)	85.0	15.0	2.0	10.0	2.5	7.6	0.3	0.6	1.3	0.6	0.07	0.3
Apricots (<i>Armeniaca vulgaris</i> Lam.)	86.0	14.0	2.5	6.7	3.6	2.9	0.8	1.3	0.8	0.9	0.07	0.7
Bilberries (<i>Vaccinium myrtillus</i>)	86.5	13.5	3.7	6.6	0.2	6.4	0.8	0.8	2.3	0.6	0.22	0.3
Blackberries (<i>Rubus fruticosus</i>)	85.0	15.0	6.2	5.5	0.5	4.9	1.3	0.9	4.0	0.7	0.29	0.6
Black currant (<i>Ribes nigrum</i>)	80.3	19.7	6.0	7.0	1.8	5.0	1.7	3.0	4.0	1.1	0.39	0.8
Cherries (<i>Prunus cerasus</i>)	83.1	16.9	2.2	9.7	0.5	9.2	1.0	1.3	0.3	0.25	0.14	0.5
Cowberries (<i>Vaccinium vitis idaea</i> L.)	83.6	16.4	4.1	8.7	0.5	8.2	0.7	2.0	1.8		0.25	0.3
Currant (<i>Ribes rubrum</i>)	83.8	16.2	7.2	5.3	0.2	5.1	0.5	2.4	4.5	0.6	0.21	0.7
Gooseberry (<i>Ribes grossularia</i>)	85.5	14.5	4.7	6.1	0.5	5.6	0.5	1.9	2.7	0.8	0.09	0.5
Peaches (<i>Persica vulgaris</i> Mill)	84.5	15.5	3.0	7.8	4.3	3.3	0.7	0.8	1.0	0.7	0.10	0.6
Pears (<i>Pirus communis</i>)	83.5	16.5	3.0	9.5	1.3	8.2	0.4	0.3	2.6	0.5	0.03	0.4
Plums (<i>Prunus domestica</i>)—and others	82.0	18.0	2.4	9.3	1.8	7.3	0.7	1.2	0.6	0.8	0.07	0.5
Raspberries (<i>Rubus idaeus</i>)	84.0	16.0	9.1	4.7	0.2	4.5	1.4	1.6	5.7	0.55	0.26	0.6
Rose hips (<i>Rosa canina</i> L.)	70.0	30.0	8.0	7.0	-	-	1.5	2.0	-	-	-	1.6
Strawberries (<i>Fragaria vesca</i> , <i>F. virginiana</i>)	88.5	11.5	2.2	6.5	0.6	5.9	0.7	1.0	1.8	0.55	0.20	0.7

cherries; Kulešova 1959). The chemical composition of certain fruits used for the making of wine is presented in Table 5.

Certain of the cultivated fruits may grow wild (for example apples), added to which certain wild fruits (such as rose hips) may be grown on plantations. Fruits grown in the wild are noted for a higher content of acid, of vegetable tannins, and by a stronger aroma, and present for the above reasons a valuable raw material for production of wine. Dried fruits can be used for the production of wine (Amerine and Cruess, 1960).

The next basic raw material, indispensable for the production of practically all types of wine, is sugar. Used usually for this purpose is sucrose obtained from sugar beet or from sugar cane.

Water used for diluting must in the making of certain fruit-wine brands must meet the requirements demanded generally of drinking water. Furthermore, wine production from only slightly sour fruits involves an after-acidification with edible organic acids, like citric acid, tartaric acid and lactic acid. Auxiliary agents used in the production of fruit wines include: pure yeast cultures, carbon dioxide, sulphur dioxide, sulphites, filter aids (asbestos, cellulose, diatomaceous earth), clarifying agents (bentonites, egg white, tannin, gelatin, silica gel, activated carbon), ascorbic acid, nitrogen, pectolytic preparations, and other substances (Jakob, 1971).

IV. TECHNOLOGICAL PROCESSING

A. Pressing

Fruits are delivered to the winery in cases, chip baskets, or sometimes in bulk by lorries or railway cars. The raw material is sorted out on conveyor belts, and washed in washers of various types. Primary washing of a raw material, such as apples, is sometimes commenced while in the flumes when water handling is used in the process.

With an increased must yield in mind, fruits are disintegrated prior to pressing, using disintegrating equipment of various types. In some cases, parts of the fruit that can cause a deterioration in the flavour and aroma of ready must (shanks) are removed prior to disintegra-

tion. For many years soft, mainly berry, fruits have been crushed with the use of crusher equipment, while hard fruits (such as apples and pears) have required the use of hammer mills. The present practice provides for an even more frequent application of disintegrators, mostly of the Rietz type.

Most commonly in use for pressing the majority of fruits are the hydraulic rack-and-cloth presses in which pulp is filled into cloths which are then ploughed in by press racks made of wood, aluminium or plastics. The pressure obtained inside rack-and-cloth presses, within the layers of the pulp subjected to pressing, is of the order of up to 30 kg/cm². Despite the labour involved in loading the pulp and offloading the pomace, the rack-and-cloth press finds a ready application, with a high pressing output that amounts in the case of apples to approximately 75% of the total available. Basket presses find a limited application with fruit pressing, because of the low output of must. Useful, on the other hand, for pressing of fruit of various varieties, have been the Bücher-Guyer modified basket presses incorporating a draining system for rendering the pulp fluffy in the course of the pressing action, and a mechanized attachment for feeding pulp and offloading pomace (Fig. 1). The processing capacity of a Bücher-Guyer type HP-5000 press amounts to 5,000-6,000 kg for apples, and up to 34,000 kg for black currants per hour, with the volume capacity of the basket of 6 m³ (Mroźewski and Chwiej, 1969).

Presses offering a continuous action, namely screw, band, band-and-roller presses, as well as those operated on the principle of continuous vacuum filters, find a limited application with fruit pressing, because of their low working output, and particularly in the case of worm presses, of a considerable content of slurry in the juice obtained.

Pomace pressing in order to increase the yield of must is seldom applied because of a low profitability. The pressing yield can, on the other hand, be boosted effectively by adding pectolytic preparations in doses of 0.1-0.5% (Rzędowski, 1956; Pijanowski *et al.*, 1964; Daškevič and Vol, 1966), as well as by pressing a primarily fermented pulp.

An ever more frequently applied practice involves pressing the pulp following a previous warming up to a temperature of approximately 80-85°C, with simultaneous addition of pectolytic prepa-