VOLUME 2
FOOD PRODUCTS SERIES

BEVERAGES

TECHNOLOGY, CHEMISTRY AND MICROBIOLOGY

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CHAPMAN & HALL

BEVERAGES

technology, chemistry and microbiology

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CHAPMAN & HALL
London · Glasgow · Weinheim · New York · Tokyo · Melbourne · Madras

Published by Chapman & Hall, 2-6 Boundary Row, London SE1

Chapman & Hall, 2-6 Boundary Row, London SE1 8HN, UK

Blackie Academic & Professional, Wester Cleddens Road, Bishopbriggs, Glasgow G64 2NZ, UK

Chapman & Hall GmbH, Pappelallee 3, 69469 Weinheim, Germany

Chapman & Hall Inc., One Penn Plaza, 41st Floor, New York NY 10119, USA

Chapman & Hall Japan, Thomson Publishing Japan, Hirakawacho Nemoto Building, 6F, 1-7-11 Hirakawa-cho, Chiyoda-ku, Tokyo 102, Japan

Chapman & Hall Australia, Thomas Nelson Australia, 102 Dodds Street, South Melbourne, Victoria 3205, Australia

Chapman & Hall India, R. Seshadri, 32 Second Main Road, CIT East, Madras 600 035, India

First edition 1994

Typeset in 10½/12½pt Garamond by Acorn Bookwork, Salisbury, Wilts
Printed in Great Britain by St. Edmundsbury Press, Bury St. Edmunds, Suffolk

ISBN 0 412 45720 2

A catalogue record for this book is available from the British Library

Library of Congress Catalog Card Number: 93-074892

(∞) Printed on permanent acid-free text paper, manufactured in accordance with ANSI/NISO Z39.48-1992 (Permanence of Paper).

BEVERAGES

Preface

Beverages are a diverse group of commodities, which range from that most innocuous and essential drink, water, to the most ardent of spirits, such as Navy rum. Beverages may be consumed hot, cold or very cold indeed, and may or may not be carbonated. Despite these wide differences, there are many common factors, not least, as the more chemically minded will note, the occurrence of the same flavour-active compounds in beverages of an apparently very different nature. It is also noteworthy that the consumption of beverages can be totally unrelated to the basic biological function of slaking thirst. Coffee and tea – the cup that cheers, but does not inebriate – are often drunk for their mild stimulatory properties in quantities which far exceed those required to maintain bodily hydration. Sports drinks are drunk to assist athletic performance, while the motive behind consumption of alcoholic beverages is, of course, well known. Sadly a minority, albeit a significant minority, drink alcohol purely for the temporary escape from reality or, more alarmingly, to find the courage for violence and aggression.

The beverage industry, in its widest context, faces changing times, with the contraction of old markets offset by new developments and opportunities. The total value of the beverage market, especially that of soft drinks and some 'international' beers is very large indeed but, for a number of reasons, this tends not to be reflected in the content of food science and technology courses. The intention of this book is to provide, for persons with a basic knowledge of chemistry and microbiology, a technical view of beverages, which is both comprehensive in approach and yet of sufficient detail to be truly useful both for undergraduate and equivalent students and for persons entering the unfamiliar, and often alarming, world of industry. In common with the companion books in this Series, *Beverages*, is structured to meet the requirements of both undergraduates and the graduate in industry, and, to

attain this end, provides a full discussion of manufacturing processes in the context of technology and its related chemistry and microbiology, as well as a more fundamental appraisal of the underlying science.

Information boxes and * points are used to place the text in a wider scientific and commercial context, and exercises are included in all chapters to encourage the reader to apply the knowledge gained from the book to unfamiliar situations. Where appropriate, an outline of quality assurance and control procedures is included.

A.H.V.
J.P.S.

A note on using the book

EXERCISES

Exercises are not intended to be treated like an examination question. Indeed in many cases there is no single correct, or incorrect, answer. The main intention is to encourage the reader in making the transition from an acquirer of knowledge to a user. In many cases the exercises are based on 'real' situations and many alternative solutions are possible. In some cases provision of a full solution will require reference to more specialist texts and 'starting points' are recommended.

Acknowledgements

The authors wish to thank all who gave assistance in the writing of this book. Special appreciation is due to:

Debbie and Phil Andrews for providing hand drawn and computer-generated illustrations respectively.

Those manufacturers of food processing equipment, food ingredients and laboratory equipment, who willingly provided information concerning the 'state of the art': Carlsberg-Tetley Brewing Ltd, Burton on Trent, UK; Courage Brewing Ltd, Reading, UK; Dal Cin SpA, Milan, Italy; Unipektin AG, Zurich, Switzerland; G.E.A. Wiegand, GmbH, Ettlingen, Republic of Germany, Schmidt-Bretten UK Ltd, London, UK.

The libraries of the AFRC Institute of Food Research, Reading Laboratory and the University of Reading for their assistance in obtaining information.

Our colleagues in Reading and elsewhere for their help and interest during the preparation of the book.

Contents

1

MINERAL WATER AND OTHER BOTTLED WATERS

OBJECTIVES

After reading this chapter you should understand

- The nature of the different types of bottled water
- The key importance of the source
- The means of water abstraction
- Post-abstraction processes
- Quality assurance and control
- The chemical constitution of bottled waters
- Potential public health risks associated with bottled waters
- The general microbiological status of bottled waters
- The chemical and microbiological testing of bottled waters

1.1 INTRODUCTION

Bottled mineral waters have been consumed for many years either as a 'safe' form of water in areas where mains supplies are of dubious quality or because of the perceived therapeutic effects of minerals present. In recent years, however, there has been a very large increase in sales of natural mineral waters in countries such as the UK where consumption was previously limited. This may be attributed to two main causes: firstly, adverse publicity, in many cases misplaced, concerning the safety of mains water and, secondly, the perception of spring, or other natural waters, not only as a 'healthful' drink but as representing a 'healthful' and sophisticated life-style. Despite this many non-carbonated bottled waters have been found to contain large numbers of viable micro-organisms (see page 12).

The perceived therapeutic properties of some natural mineral waters have been noted above. This perception stems historically

BOX 1.1 **Drink no longer water**

In a real sense, organoleptic differences between different brands of water are usually slight. Despite this various newspapers and magazines have published articles in which the relative hedonistic merits of different waters were discussed in a manner normally reserved for fine wines. At a time when a considerable proportion of the world population is desperately short of water of any kind, such articles must be seen as some of the absurdities of life.

from the great spas of Europe and the association of certain water sources with the cure, or alleviation, of specific diseases such as liver complaints. Therapeutic properties were usually associated with the mineral content of the waters although more esoteric properties such as naturally occurring radioactivity were also considered beneficial. It should be appreciated, however, that while the value of mineral waters in treatment of specific disease must be considered dubious, the presence of a high level of inorganic salts in some waters make these unsuitable for persons with kidney disease or for infant feeding.

Various descriptions are attached to bottled waters and these frequently vary on a national or regional basis. Natural mineral water is extracted from underground water-bearing strata via springs, wells or boreholes. It is characterized by its content of mineral salts and trace elements, and is subjected only to minimal treatment in order that its essential properties should be preserved. A full legislative definition of natural mineral water has been established within the EEC (Table 1.1). In many non-EEC countries no definition has been established and additional treatments, particularly disinfection, may be permitted. EEC regulations also permit certain indications of mineral content to be stated on labels providing that specified conditions are met (Table 1.2) but no indication relating to the prevention, treatment or cure of human diseases may be used.

Various types of bottled drinking water other than natural mineral waters are available. Spring water, in the context of EEC regulations, is potable water from a source which either does not meet the requirements for mineral water or for which no application for recognition has been made. Spring water is not currently legally

Table 1.1 EEC requirements for natural mineral waters

Natural mineral water is a water clearly distinguishable from ordinary drinking because:

(a) It is characterized by its content of certain mineral salts and their relative proportions and of the trace elements or of other constituents.
(b) It is obtained directly from natural or drilled sources from underground water-bearing strata.
(c) It is constant in composition and stable in discharge and temperature (due account being taken of the cycles of natural fluctuations).
(d) It is collected under conditions which guarantee the original bacteriological purity.
(e) It is bottled close to the emergence of the source with particular hygienic precautions.
(f) It is not subjected to any treatment other than those permitted by this standard.
(g) It is in conformity with all the provisions laid down in this standard.

Note: Modified from *European Regional Standard for Natural Mineral Waters*.

Table 1.2 Requirements for label indications of mineral content

Label indication	*Mineral constituent*	*Requirement*
Low mineral content	inorganic constituents	dry residue not above 500 mg/l
Very low mineral content	inorganic constituents	dry residue not above 50 mg/l
Rich in mineral salts	inorganic constituents	dry residue above 1500 mg/l
Contains:		
bicarbonate	bicarbonate above	600 mg/l
calcium	calcium	above 200 mg/l
chloride	chloride	above 200 mg/l
fluoride	fluoride	above 1 mg/l
iron	bivalent iron	above 1 mg/l
magnesium	magnesium	above 50 mg/l
sodium	sodium	above 200 mg/l
sulphate	sulphate	above 50 mg/l
Suitable for a low sodium diet	sodium	not above 20 mg/l
Acidic	free carbon dioxide	above 250 mg/l

Note: Based on *The Natural Minerals Waters Regulations* (1985)

defined but labelling must be such as to avoid any possibility of confusion with natural mineral water. Such water is subject to legislation relating to potable water. In the US, no distinction is currently made between bottled mineral water and other bottled waters. It is likely, however, that legal definitions of mineral and spring water will be introduced.

The recognition that water, particularly that of low mineral content, is an uninteresting drink, together with the desire of bottlers to add value to basic material has led to the development of a range of what may best be described as 'flavoured waters'. These range from simple products containing water and a small quantity of fruit juice to more complex beverages containing infusions of herbs and other ingredients. In some cases, especially where the ingredients include ginseng, therapeutic properties may be implied. Such products are intermediate between natural waters and soft drinks.

BOX 1.2 **Children's teeth are set on edge**

Fluoridation of drinking water is a recognized means of reducing dental decay amongst children and, in June 1993, the UK Health Secretary, Virginia Bottomley, announced plans to extend fluoridation of piped water supplies. There is, however, considerable opposition to fluoridation. This is based both on the moral contention that fluoridation amounts to forced medication and on the public health contention that fluoridation can lead to bone cancer and an impaired immune system. Fluoridation of piped water is thus a factor favouring selection of bottled drinking water, sales of which benefited when the process was introduced in some parts of the UK. In contrast, fluoridated bottled water is available in the United States and commands a high price in areas where the natural fluoride content of piped water is low.

1.2 TECHNOLOGY

The technology of bottled waters is straightforward, few treatments are permitted and the underlying philosophy, supported by legislation in the case of mineral waters, is to preserve the properties ascribed to the water at source up to the point of consumption.

1.2.1 The source

Natural mineral waters must be abstracted only from officially recognized sources which, in the case of EEC member countries, are published in the *Official Journal of the European Communities*. Details of the source required for recognition include a hydrological description, physical and chemical characteristics of the water, microbiological analyses, levels of toxic substances, freedom from pollution and stability of the source. Such legislation does not apply to other waters, but judgement of the suitability of a source should be based on similar criteria.

In general terms, the most suitable aquifer is deep, with a long transit time and few cracks or fissures. In the case of shallow aquifers the main concern is the possibility of surface water passing more, or less, directly into the source. No aquifer, however, is totally immune from risk of pollution. In many cases this results from activities which affect the geology and hydrology of the catchment area. Examples include the drilling of deep shafts or the extension of existing mining activities, diversion of watercourses, and the dumping of waste material into disused mineshafts and deep quarries. There are no known recent examples of pollution necessitating the closure of a source used for bottled water, but bores providing potable water for food processing have been affected. Instances include separate cases of microbiological and chemical pollution due to the dumping of cattle slurry and cheese whey into disused mineshafts, and lead pollution from ancient spoil heaps following diversion of a stream.

1.2.2 Abstraction

The means of abstraction depends on the nature of the source, spring water typically rises from the spring through a bed of gravel, while water from artesian wells and bores normally requires no pumping. Pumping is required from non-artesian wells and bores and submersible pumps are commonly used. Precautions must be taken against contamination of the source at the point of abstraction. Pumps, for example, can become colonized by micro-organisms or, if not properly maintained, become a source of chemical pollution. Precautions should also be taken to ensure that the source is protected from pollution arising from ancillary operations. Hard standing for lorries and other vehicles, for example, should be designed and constructed to prevent oil or fuel leaks being washed into the water-bearing strata.

1.2.3 Post-abstraction treatment

(a) Filtration and disinfection

Filtration or decanting of natural spring water, preceded where necessary by oxygenation, is permitted in EEC countries. The technological objective is removal of unstable elements and filtration must not be intended to improve the microbiological status of the water. Other types of bottled water may, depending on national regulations, be microfiltered with membranes of 0.1–10 μm pore size, to remove micro-organisms. Microfiltration is usually coupled with ultraviolet disinfection or is complemented by ozone treatment directly before bottling. Alternatively ozone treatment may be applied without prior microfiltration.

(b) Addition, or removal, of CO_2

The situation with respect to CO_2 content, and thus to effervescence or non-effervescence, is complicated in that CO_2 may be removed from naturally carbonated waters, or added to naturally uncarbonated. Further a distinction must be made between CO_2 derived from the source and that from another origin. This is reflected in the labelling requirements (Table 1.3). Equipment for carbonation is the same as that used for soft drinks (Chapter 3, pages 92–4). Carbonation is usually effective in reducing the population of micro-organisms and preventing subsequent growth, but *must not* be relied upon as a means of disinfecting water from an unsafe source.

(c) Bottling

According to EEC regulations natural mineral water must be bottled at source (with the exception in the UK of water which, prior to 17 July 1980, was being transported in tanks to a remote bottling plant) and sold in bottles which were those used at the time of bottling. There are no restrictions on other types of water.

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* Additional treatment can be applied in the US and some other countries. ***Specially prepared drinking water*** is water in which the mineral content has been adjusted and controlled to improve the taste. The designation may be applied either to bottled water, or water supplied by a public utility. In addition ***purified water*** is widely available at retail level. This conforms to the US Pharmacopoeia standard, with a mineral content of less then 10 mg/l. Processing may be by distillation, ion exchange or reverse osmosis.

Table 1.3 Requirements for label indications of carbonation

Label indication	*Carbonation*
Natural mineral water	none (non-effervescent)
Naturally carbonated natural mineral water	CO_2 content after bottling the same as at source and any replaced CO_2 derived from the source
Natural mineral water fortified by gas from the spring	CO_2 content greater than at source but the CO_2 derived from source
Carbonated natural mineral water	CO_2 partially or totally derived from an origin other than the source
Fully decarbonated or partially decarbonated	CO_2 removed by physical treatment

Note: Based on *The Natural Minerals Waters Regulations* (1985)

BOX 1.3 **Sparkles near the brim**

In some cases the CO_2 is removed from the water at abstraction and then used to carbonate the water at bottling. In the UK, some supermarket retailers have considered the description of such water as 'naturally carbonated', although legal, to be misleading and have refused to stock water labelled in this way. In New York State the bottlers of Perrier(R) water were fined $40 000 for claiming, amongst other contentious items, that the water is 'naturally sparkling' and 'bubbles to the surface'. (Anon 1991. *Food Chemical News*, **August 26**, 34).

Conventional bottling plant is used and there are no technological difficulties although careful sanitization is required to prevent the colonization of the bottling plant by micro-organisms.

Bottles may be glass, polyethyleneterephthalate (PET) or high-density polythene. Problems of chemical taint from PET bottles have been attributed to the leaching of plasticizers, or their thermal degradation products, into the water. Problems have also been reported in the US with the development of 'plastic' flavours in high-density polythene bottles containing water disinfected by ozone treatment. This has been attributed to low molecular weight oxygenated species formed by oxidation of the high-density polythene by residual ozone.