Developments in Food Science

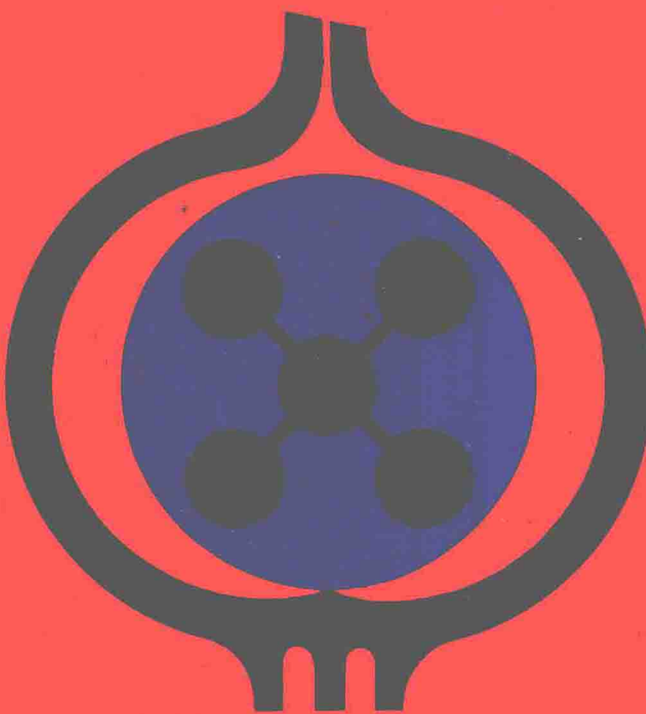
3B

FOOD FLAVOURS

Part B.
The Flavour of Beverages

I.D. MORTON

A.J. MACLEOD



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DEVELOPMENTS IN FOOD SCIENCE 3B

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Part B. The Flavour of Beverages

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ELSEVIER

Amsterdam — Oxford — New York — Tokyo 1986

ELSEVIER SCIENCE PUBLISHERS B.V.
Sara Burgerhartstraat 25
P.O. Box 211, 1000 AE Amsterdam, The Netherlands

Distributors for the United States and Canada:

ELSEVIER SCIENCE PUBLISHING COMPANY INC.
52, Vanderbilt Avenue
New York, NY 10017, U.S.A.

Library of Congress Cataloging-in-Publication Data
(Revised for vol. 3B)

Food flavours.

(Developments in food science ; 3A-)
Includes bibliographies and indexes.
Contents: pt. A. Introduction -- pt. B. The flavour of beverages.
1. Flavor. 2. Food--Analysis. I. Morton, I. D. (Ian Douglas) II. MacLeod, A. J. (Alexander Joseph) III. Series.
TX541.F66 1982 664 80-17054
ISBN 0-444-41857-1 (v. 1)
ISBN 0-444-42599-3 (v. 2)

ISBN 0-444-42599-3 (Vol. 3B)
ISBN 0-444-41688-9 (Series)

Printed in The Netherlands

Developments in Food Science 3B

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PREFACE

The first volume of the series *Food Flavours* provided a general introduction to the whole subject. This volume is the first to be devoted to consideration of aspects of the flavour of a specific group of food commodities. Subsequent volumes, currently in preparation, will be similarly commodity-orientated. In this volume there is a comprehensive survey of the flavour of most beverages. Certainly a few minor omissions must occur but the important beverage groups, coffee, tea, cider, beer, wines, vermouth and fortified wines, distilled beverages and non-alcoholic fruit beverages are all discussed by internationally recognised authorities from the U.S.S.R., U.S.A., Italy, Switzerland, the Netherlands and the U.K.

Each chapter reflects the general approach and the differing emphasis on the various aspects of the flavour of the beverage under discussion. We are grateful for the cooperation of the reviewers and also for the speed in production which has permitted appropriate citations to the early 1986 literature as well as to the older literature. Particularly with coffee and tea, the more traditional aspects of flavour study and development are still highly relevant.

As before, the editors must, of course, accept full responsibility for the selection of topics covered and for any omissions. We would be very pleased to hear from any readers offering comment or constructive criticism.

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CONTENTS

Chapter I

THE FLAVOUR OF COFFEE

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1. INTRODUCTION

The flavour of the brew made by hot water extraction of roasted coffee, together with the headspace aroma from the dry product, are generally considered to be unique, and have wide appeal throughout the world. Furthermore, coffee aroma is also released during the roasting process itself, and during the grinding of the roasted beans, which add to its organoleptic attractions. Both the flavour and headspace aroma are, however, somewhat unstable, deteriorating with time, depending on conditions, leading to the less attractive 'stale' coffee.

In accordance with generally accepted views on the nature of sensory or organoleptic effects, the flavour of an aqueous solution of substances is made up of: (a) the basic taste sensations of sour, bitter, sweet and salt detected by the tongue, provided by non-volatile substances present in relatively large amounts, and (b) the odour (aroma) perceived by the olfactory organs, provided by vapours of substances, volatile to a greater or lesser degree, some often present in an exceedingly small amount (parts per million, or per billion). In addition, there may be other tactile sensations in the mouth, notably an astringent action on the tongue. Headspace aroma from the dry product, directly detected from the front nasal passage, may not be exactly the same, in composition, as that of the volatile substances released into the mouth cavity from the made-up aqueous solution. For a coffee brew also, therefore, flavour equals taste plus aroma, so that in considering coffee flavour overall, it is necessary to deal with each group of components, both separately and in their interaction. In the non- and semi-scientific literature, the terms 'taste' and 'flavour' tend to be used interchangeably, whereas 'taste' should only refer to the non-volatile components. This is also evident in the French language, i.e. the words 'le goût', 'la saveur', 'le parfum' and 'l'arôme', though the terms 'charactère aromatique' and 'charactère savoureux' appear to express the distinction correctly. Similarly, in the German language we have 'der Geschmack' (taste or flavour) and 'der Geruch' (odour).

As might be expected, the flavour of coffee is highly complex in character, and not yet fully understood, primarily due to the very large number of different substances present, and the need to distinguish those that do or might contribute to sensory effect. Furthermore, coffee is not a single product, but comprises a range of products differing, somewhat to markedly, in flavour. This situation arises because of the different originating types of green coffee that can be roasted, and, importantly, the different levels of roasting that are practised (i.e. in a continuum of light, medium or darkly roasted, see Table I.I). The different types of green coffee available are well described in the literature (Kroplien, 1963; Clarke, 1974; Sivetz and Desrosier, 1979; Jobin, 1982). For our purpose, here it is only necessary to distinguish between the two main botanical and economic species, *Arabica* and *Canephora (Robusta)* of the Genus *Coffea*, though not forgetting the recently developed hybrid, *Arabusta*, with flavour characteristics approximately intermediate. Furthermore, each of these species is processed from coffee cherry to dry coffee beans in the producing countries in either of two main ways, the 'wet-process' and the 'dry process', which again confer different final flavour characteristics to the coffee, with the more sophisticated wet process providing 'better' flavour, and certainly being more expensive. In addition, geographical origin is used to characterize a particular coffee. Commercial roasted coffee will, however, generally be blends, though individually sourced coffees will also be sold. Within a given country, green coffee from different locations may also be blended.

Flavour, even from the same coffee, will also differ according to the method of brewing, with its differential effect on taste, volatile components, and the bland components that are extracted into the brew, and on the concentration in solution of each of these components. The bland components are essentially high molecular weight substances, such as polysaccharides and complex interacted substances from roasting. Whilst not an appropriate sub-

TABLE I.I

Levels of coffee roasts

Level of roast[a]		Approximate dry matter loss[b] (%)	Other features
'Light'		1—5	
'Medium'		5—8	
'Dark'	French Italian Spanish	8—14	Oil coming to surface

[a] Reflectance colour.
[b] Percentage weight figures based on dry green and dry roasted coffee. About 10—12% should be added to obtain figures on an As Is basis. (i.e. composition based on total weight of sample).

ject in a chapter on coffee flavour, the presence of stimulant substances, in particular caffeine, should be noted, and many people regard this aspect to be very important to the enjoyment of coffee. However, coffee that has been decaffeinated, usually by selective extraction processes on the green coffee, is widely consumed, especially in the U.S.A. The subsequently roasted coffee may or may not be slightly different in flavour from the same non-decaffeinated coffee.

Coffee also comprises instant coffee. The flavour relationship of the many different kinds, with brewed coffee is primarily a matter of the success, or otherwise, of the extraction and retention procedures of the volatile components in manufacture.

It is necessary, therefore, first to examine the nature of coffee flavours, and then to discuss the studies that have been made, especially in recent years, to determine the composition of both roasted coffee and its brews, and to relate findings with perceived coffee flavour, both taste and aroma.

2. ORGANOLEPTIC TESTING

Coffee, as drunk for pleasure by the consuming public in different parts of the world, is brewed in a number of different ways, which have been described in various magazine articles and occasionally in scientific papers. It is necessary to try to divest coffee brewing from the aura and mystique that can surround it, and the physiological and environmental factors that can influence judgment as to the true resultant flavour. Even so, the taste of coffee is subjective.

The former Coffee Brewing Institute of New York City, which closed in 1976, devoted considerable resources to a scientific understanding of brewing, and their various bulletins and reports remain valuable publications.

2.1 Methods of Brewing

The object of coffee brewing is to prepare a hot dilute aqueous solution of the soluble solids of roasted coffee (at, say, between 0.9 and 4.0% w/w concentration), though not exhaustively, together with the aromatic volatile constituents, in such a way that substantially all of the spent coffee grounds can be discarded. Two steps are involved: (a) contacting of the roasted coffee, usually in the pre-ground condition, with water, and (b) separation of the grounds, which may take place consecutively or simultaneously. By mechanistic principle, the two main methods can be summarized as: (1) 'Steeping' ('slurrying'), with or without agitation, followed by sedimentation or simple filtration or both, and (2) 'Percolation' in fixed beds of roast coffee held in a container with an internal filtration facility, in either multiple passes, recirculation or single-pass by gravity or under pressure of the extracting water or liquor. The latter may include passage of a mixture of liquid and vaporized water (steam).

The second method is perhaps now in greatest use, but it comprises a considerable number of variants and, furthermore, often includes electric heating and automatic operation. In consumer practice, the different methods of domestic brewing are described in other and different ways, most usually by reference to the name or brand name of the brewing device, or brewer. Brewer terminology will also differ in U.S. and British usage. In the second group is the well-known coffee percolator, with an internal perforated basket to hold the charge of roasted coffee, in to which there is multiple passage of coffee liquor by pumping up through the coffee and back into the container, in which the water/liquor is often at 100° C.

This method was once the most popular, with its 'stove-top' (U.S.), electric and automatic variants, but has largely given way to so-called 'filter' methods, generally using disposable filter papers, though also screens. The traditional French brewer providing cafe filtré, and the U.S. 'Drip-pot', are examples, together with simple filter cones for manual use. Filter cones and other shapes are, however, increasingly part of an automatic system, of which there are a large number of different proprietary makes in Europe and in the U.S.A. The flow of water is single-pass, and the time of filtration, whilst dependent on the nature of the coffee bed itself and the rate of addition of water, is also determined by the porosity of the filter medium and its support.

The Italian 'Espresso' brewing machine is also popular, with its name self-evidently deriving from its use of pressure, steam or mechanical (piston). The flow of water is also single-pass, but the time of contact is very short, of the order of seconds, compared with gravity filtration (many minutes) or the percolator. So-called 'vacuum coffee-makers', of which the 'Cona' is a proprietary make, are also very popular, in which there is some recirculation of coffee liquor. On removing from the source of heat, the vacuum created in the lower bowl allows the contents in the upper extracting spherical bowl to pass finally to this lower bowl, which can be used for subsequent pouring.

The simple saucepan of the first method is still used; it will be noted also that the steeping method is the one used by experts to assess the quality of a given coffee. It is generally recognized that the coffee liquor should not be boiled, but there is a wide range of hot water temperatures that can be used in brewing, especially in single-pass methods. The difference in temperature between that of the water on entering and that actually in contact with the coffee should be noted.

There has been, and is, a number of different brewing devices for larger scale catering use, where a large number of cups of coffee have to be provided in a short time period. The 'urn' of elaborate construction is often used, which relies on percolation—filtration using a muslin bag, as described by Sivetz and Desrosier (1979). The expensive Espresso machine with piston operation, providing single cups of coffee at a time (although the speed of operation is fast), is also popular in catering establishments.

2.2 Soluble Solids Concentration—Extraction Yield Relationships

In the first analysis of coffee brewing, it is necessary to know both the concentration of coffee soluble solids (% w/w) and the extraction yield taken of those solids (calculated as a percentage, dry solubles weight to starting roasted coffee weight), present in the prepared brew. Nearly all prepared brews will be drained (filtered) substantially free of the spent grounds. A percentage of the water originally used for brewing will be retained by the grounds, and not available in the brew. There may also be some evaporative loss of water during brewing, though the amount is generally small. The exact percentage quantity of water/liquor retained by filtered grounds will vary somewhat with the brewing conditions, primarily whether gravity or pressure draining of the grounds, and grind size of the coffee. Fine grinds will retain more water than coarse grinds; pressure draining will release more water than gravity, especially if there is 'hold-up' of liquor in the filtering device.

2.2.1 Brewing charts

A typical figure for the residual moisture content of wet spent grounds, with gravity draining from a filter cone, using finely ground coffee, is 76% w/w or As Is (i.e. composition based on total weight of sample). Calculations based on other published data suggest values of 73% (medium grind), and as low as 60% for a coarse grind; and 63% in an Espresso machine, with pressure draining from a medium grind coffee.

A more useful figure, however, is the water content based on the original weight of coffee used. It will also differ, strictly speaking, on the extraction yield taken, other conditions being the same. The figure of 76% moisture content in the spent grounds corresponds to 71% in the original roasted coffee weight (at a 27% extraction yield), or in other words, 2.45 (equals 71/29) parts of water are retained in the grounds for each one part of finely ground coffee used. The Coffee Brewing Institute (CBI) took the values 2.1—2.2 for coarse and medium grind coffee, extracted over the yield range 15—25%. A value as low as 1.42 may be calculated from the data of Voilley *et al.* (1980) from experimental work with an Espresso machine (medium to fine grind). An important consequence of this retention (at whatever level) is that the weight or volume of brew available for drinking, as a percentage of the water originally used, will also vary directly with the initial ratio of water to coffee (or so-called 'brewing ratio') used.

Suppose a brewing ratio of 16 : 1 is used, and there is a retention of 2.5 parts of water per part of roasted coffee; then the prepared brew will have 13.5 parts of the original 16 parts of water, or a recovery of 84%. In practice, it is the volume of brew that is most easily measured. By plotting the brewing ratio against the ratio or percentage, volume of brew/weight of coffee, a straight-line relationship will be observed for a given grind of coffee and brewing device. The greater the amount of water used, the greater will also be the percentage amount of brew available for drinking. If, under the conditions of brewing, 20% of the solubles in the roasted coffee are extracted and pass into the brew, then, in the above example, it also follows that the coffee soluble solids concentration in the brew will be $0.2/13.5 \times 100 = 1.48\%$ w/w. At other brewing ratios, coffee grinds, type of filtration and extraction yields, the corresponding figures may be similarly calculated.

As the soluble solids concentration of a coffee brew is an important parameter for flavour, it is useful to construct a so-called Brewing Chart, as first devised by the CBI (but using ounce/U.S. gallon units). The percentage soluble solids concentration (on the y-axis) is plotted against the brewing ratio (x-axis), though the latter is preferably expressed as its inverse, the more familiar weight of roast and ground coffee, in grams per litre of water used, for an expected range of extraction yields (say 15—30%). The percentage extraction yield is given by:

$$\frac{\%\ \text{soluble solids concentration} \times \text{weight of brew obtained}}{\text{weight of roasted coffee}}$$

These relationships may be determined experimentally, or calculated on the basis of the assumptions already outlined. Soluble solids concentrations, which will be of the order of 0.5—4.0% w/w, are somewhat difficult to measure accurately, though special hydrometers are available. A refractometer

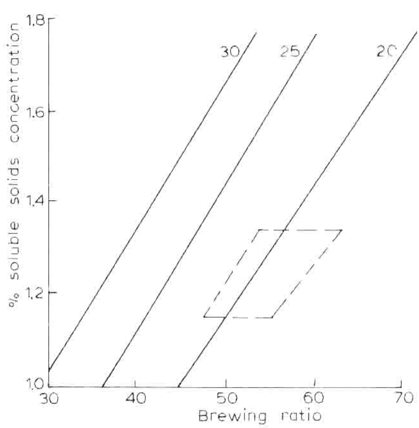

Fig. I.1. Coffee brewing chart. Relationship between percent soluble solids concentration and brewing ratio (g roast coffee per litre of water used) for three different extraction yields; 20, 25 and 30% in-cup.

reading to the fourth decimal place may be used; otherwise brews have to be evaporated to dryness and weighed. Such a chart will not cover all brewing conditions (different grinds/brewing device), though in so doing the errors are not large. A brewing chart, for gravity draining from a fine grind, is illustrated in Fig. I.1. The main area of interest for English tastes is for soluble solids concentration between 1.0 and 1.5% w/w. The brewing ratio is readily decided by the brewer, but the extraction yield obtainable is determined by a number of factors.

2.2.2 Extraction yield

The actual yield obtained in any brewing process will depend, apart from the coffee—water ratio (upon which the brewing chart is primarily based), also upon the availability of soluble solids (that is the blend, and roast level of the coffee used), their ease of extraction (degree of grind and water temperature) and, of course, the time of extraction.

Grinds (i.e. average particle size and distribution) may be simply defined as 'coarse', 'medium', 'fine' or 'very fine'; though there is no common agreement as to how each of these should be defined in terms of a screen analysis. The standards originally recommended by the National Coffee Association (of the U.S.A.) and published by the CBI with its own terminology are of interest (see Table I.II). Extraction yield will be expected to depend upon the temperature of extraction (which, however, will generally be between 90 and 100°C), and upon the time of extraction (often predetermined by the brewing device).

The choice of grind used will also be determined by the nature of the

TABLE I.II

U.S. recommended coffee grind specifications

Grind description		Screen analysis[a]			Average particle size (μm)[e]
		% Retention		% Passing	
		(1)[b]	(2)[c]	(3)[d]	
Regular	= coarse	33	55	12 ± 3	1130
Drip	= medium	7	73	20 ± 4	800
Fine	= fine	0	70	30 (+10, −5)	680

Source: NCA.
[a] Rotap machine for 5 min.
[b] Combined amount on 1680 and 1190 μm screens.
[c] Combined amount on 840 and 590 μm screens.
[d] Through 590 μm screen.
[e] Derived from graphical plot at 50% cumulative.