MICROBIOLOGY OF FERMENTED FOODS

Volume 1

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Edited by

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To the memory of my parents,
who encouraged and supported me
through a long education

Preface to Volume 1

When I was first approached by Elsevier Applied Science Publishers with the suggestion that I consider editing a text on fermented foods, my immediate reaction was that the field had been covered by several other books which have appeared recently. However, a more detailed appraisal resulted in the conclusion that there was a place for a text which sought to cover the food fermentations of both the developed and the developing worlds. There is, inevitably and happily, a great deal of overlap between the fermentations practised in various parts of the world and division of this text into two volumes owes more to publishing convenience than to an exclusiveness between the two sets of topics.

A number of the overseas contributors, in their replies to the invitation to write sections for the book, mentioned varying degrees of concern over the adequacy of their written English. This created for me a difficult dilemma. Should I edit very heavily so as to achieve a uniform and cohesive style, or should I accept as far as possible compatible with clarity, the individual approaches to the presentation of written English? Most of my overseas authors asked me to do whatever was necessary with their English, and I elected for the minimum interference compatible with this request. The result, I hope, has preserved the diversity of approaches which is a continuing fascination of work on food fermentations, particularly those of the less developed parts of the world. I asked that as far as possible the lists of references cited in the chapters should include the title of each paper, since this is of value to people in less developed countries who frequently need to send abroad for reprints, having very limited access to journals. For various reasons this could not always be complied with but I hope that the book's users will be forgiving in this matter.

The topics covered in this first volume will in general be familiar throughout most of the world, although even here there are many exceptions. For example, most British people regard pickles as preserves with vinegar, i.e. acetic acid, as the principal acidulant; most Europeans are well aware that many vegetables can be preserved by spontaneous lactic fermentation, although not all people in (for example) the olive-growing areas appreciate that the inevitable result of immersing olives in brine under farm conditions will be a lactic fermentation essential to production of the preferred organoleptic qualities.

Again, the farther East one goes across Europe, the more diverse (it seems) is the range of fermented milks and cheeses. The United States has many of these available on at least a local basis, a reminder of the great diversity of traditions to which it is heir.

Progress in food fermentation will draw upon many other disciplines in addition to microbiology. Tony Godfrey's chapter shows the increasing importance of enzymes in both fermented and non-fermented foods. In this case the contribution of a class of microbial products to the production of non-fermented foods is, in economic terms, very substantial.

The ability of fermented food to supply vitamins to the diet is perhaps not very important in the more developed parts of the world where a reasonable diet is normally available to all. Even here, however, certain groups, such as vegans, may be at risk to particular deficiencies, such as that of vitamin B_{12} in a dietary regime free of all animal products. The demonstration of the presence of substantial amounts of vitamin B_{12} in tempeh will have importance to people whose diets exclude animal products. As Keith Steinkraus' chapter shows, fermented foods can also make other significant vitamin contributions to the diets of people in less developed countries.

Vinegar is a case where there is a need for appropriate, small-scale technology for local use in the developing countries. The Tropical Development and Research Institute (TDRI) has been active in the development of technologies on a scale and with the raw materials appropriate to these countries. Martin Adams' chapter bridges the gap between the large-scale operations often found in the more industrialised countries and the TDRI's work on production methods for tropical countries. Of course, countries such as France continue (happily) to produce what most gourmets still regard as the finest vinegar in the world by the slow and laborious Orleans method, a very primitive technology by most standards.

Bread, in its origins a food of the higher latitudes, has been taken into all

parts of the world by the early explorers and has become as commonplace in the moist tropics as it is in Northern Europe. The development of specialised strains of wheat and of the new, hybrid grain, triticale, will extend the range over which bread-making grain can be grown. Pressed and dried yeast preparations offer the baker simplicity and reliability in bread-making, but they are the products of a fairly sophisticated microbial technology. Dried yeast can be exported to developing countries but this represents a further drain on their inadequate supplies of 'hard' currency. Frank Sugihara shows that sourdough leavens can be easily maintained in a wide variety of climatic conditions, and can probably give satisfactory results with a bigger range of flours than can dried yeast. This technology is therefore of potential interest to developing countries. Its use has already undergone great expansion in the USA of recent years, with 'San Francisco Sourdough Bread' on sale right across the country, and in other industrialised countries sourdough breads are becoming more readily available, being valued both for their organoleptic qualities and as part of the movement to return to a supposedly simpler way of life.

With some fermented foods the movement has been from East to West. Soy sauce, although a static market in Japan, is rapidly expanding in Europe and North America. Its success in the USA is shown by the growth of the Kikkoman Co.'s offshoot in Wisconsin. The dietary value of soy sauce is such that it is developing this market penetration at a time when there is a vigorous campaign against the use of high levels of sodium chloride in the diet. Tamotsu Yokotsuka's article shows how the Japanese have succeeded in developing a very ancient and highly traditional technology into a very modern, highly mechanised process, without losing the qualities, both organoleptic and almost mystical, which make soy sauce unique.

With mushroom cultivation there is movement in both directions. The techniques developed in Western Europe and the USA for cultivation of *Agaricus*, are being more widely adopted elsewhere and there is a developing interest in the West in some of the techniques for growing Eastern fungi such as the padi-straw mushroom and certain tree fungi, as Fred Hayes demonstrates.

If you, the reader, have comments, criticisms, or a complaint that some important area has been omitted, I shall be most pleased to receive your comments, etc., for action should the opportunity present itself.

Brian J. B. Wood

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Contents

VOLUME 1

VOLUME 2

Chapter 1

Vinegar

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1. INTRODUCTION

Vinegar is a dilute solution of acetic acid produced by a two-stage fermentation process. In the first stage fermentable sugars are converted into ethanol by the action of yeasts, normally strains of *Saccharomyces cerevisiae*, while in the second bacteria of the genus *Acetobacter* oxidise the ethanol to acetic acid. An outline of the overall process is presented in Fig. 1.

The subject of vinegar production has been periodically reviewed from various points of view, but normally stressing the most modern, most sophisticated procedures used (Conner & Allgeier, 1976; Greenshields, 1978; Ebner, 1982). While it is hoped that the present chapter does not neglect this important area, some attempt is made to give greater emphasis to traditional methods still widely practised and which, in certain cases, may be more appropriate to local conditions and requirements.

2. THE ORIGINS OF VINEGAR PRODUCTION

The production of vinegar can occur as a spontaneous fermentation. Both types of micro-organism necessary for its production are commonly associated with plant products as part of their natural microflora, and at

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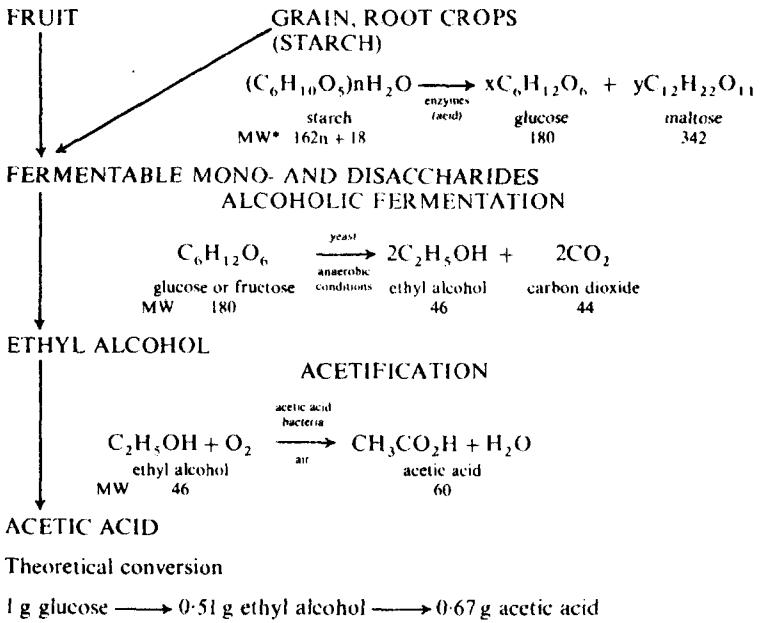

Theoretical conversion

1 g glucose ⟶ 0·51 g ethyl alcohol ⟶ 0·67 g acetic acid

Note: *MW = Molecular weight.

Fig. 1. Schematic outline of vinegar production.

each stage in the process conditions are in some way restrictive to microbial competition. An initially high sugar concentration, typically 10% w/v or more, and an acid pH favour the production of ethanol by yeasts. During alcoholic fermentation, anaerobic conditions are created, the pH drops further and the ethanol concentration rises. At the end of yeast fermentation when the sugars have been consumed, aerobic conditions are re-established at the surface of the liquid permitting the growth of ethanol utilising acetic acid bacteria. These produce high levels of acetic acid (between 0·7 and 1·7 M in most commercial vinegars) decreasing the pH still further to a value of 3 or below. Thus, a suitable substrate left open to the environment will, in many cases, undergo a natural fermentation to produce first ethanol and, in time, a product resembling vinegar. This, in all probability, is why vinegar was an early discovery of Man, preceding recorded history but succeeding the discovery of alcoholic beverages perhaps by only a matter of days!