

# **Biotechnological Innovations in Food Processing**



# Biotechnological Innovations in Food Processing

Food Processing

Functional Properties

Butterworth-Heinemann Ltd  
Linacre House, Jordan Hill, Oxford OX2 8DP

OXFORD LONDON BOSTON  
MUNICH NEW DELHI SINGAPORE SYDNEY  
TOKYO TORONTO WELLINGTON

First published 1991

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**British Library Cataloguing in Publication Data**

Biotechnological innovations in food processing.

— (BIOTOL series)

I. BIOTOL II. Series

664.0076

ISBN 0 7506 1513 3

**Library of Congress Cataloguing in Publication Data**

A catalogue record for this book is available  
from the Library of Congress

Composition by Thames Polytechnic  
Printed and bound in Great Britain by  
Butler & Tanner Ltd, Frome and London



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**BIOTECHNOLOGY BY OPEN LEARNING**

# **Biotechnological Innovations in Food Processing**

PUBLISHED ON BEHALF OF:

**Open universiteit**

and

**Thames Polytechnic**

Valkenburgerweg 167  
6401 DL Heerlen  
Nederland

Avery Hill Road  
Eltham, London SE9 2HB  
United Kingdom

**B**UTTERWORTH  
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# The Biotol Project

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This series of books has been developed through a collaboration between the Open universiteit of the Netherlands and Thames Polytechnic to provide a whole library of advanced level flexible learning materials including books, computer and video programmes. The series will be of particular value to those working in the chemical, pharmaceutical, health care, food and drinks, agriculture, and environmental, manufacturing and service industries. These industries will be increasingly faced with training problems as the use of biologically based techniques replaces or enhances chemical ones or indeed allows the development of products previously impossible.

The BIOTOL books may be studied privately, but specifically they provide a cost-effective major resource for in-house company training and are the basis for a wider range of courses (open, distance or traditional) from universities which, with practical and tutorial support, lead to recognised qualifications. There is a developing network of institutions throughout Europe to offer tutorial and practical support and courses based on BIOTOL both for those newly entering the field of biotechnology and for graduates looking for more advanced training. BIOTOL is for any one wishing to know about and use the principles and techniques of modern biotechnology whether they are technicians needing further education, new graduates wishing to extend their knowledge, mature staff faced with changing work or a new career, managers unfamiliar with the new technology or those returning to work after a career break.

Our learning texts, written in an informal and friendly style, embody the best characteristics of both open and distance learning to provide a flexible resource for individuals, training organisations, polytechnics and universities, and professional bodies. The content of each book has been carefully worked out between teachers and industry to lead students through a programme of work so that they may achieve clearly stated learning objectives. There are activities and exercises throughout the books, and self assessment questions that allow students to check their own progress and receive any necessary remedial help.

The books, within the series, are modular allowing students to select their own entry point depending on their knowledge and previous experience. These texts therefore remove the necessity for students to attend institution based lectures at specific times and places, bringing a new freedom to study their chosen subject at the time they need it and a pace and place to suit them. This same freedom is highly beneficial to industry since staff can receive training without spending significant periods away from the workplace attending lectures and courses, and without altering work patterns.

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## How to use an open learning text

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An open learning text presents to you a very carefully thought out programme of study to achieve stated learning objectives, just as a lecturer does. Rather than just listening to a lecture once, and trying to make notes at the same time, you can with a BIOTOL text study it at your own pace, go back over bits you are unsure about and study wherever you choose. Of great importance are the self assessment questions (SAQs) which challenge your understanding and progress and the responses which provide some help if you have had difficulty. These SAQs are carefully thought out to check that you are indeed achieving the set objectives and therefore are a very important part of your study. Every so often in the text you will find the symbol  $\Pi$ , our open door to learning, which indicates an activity for you to do. You will probably find that this participation is a great help to learning so it is important not to skip it.

Whilst you can, as a open learner, study where and when you want, do try to find a place where you can work without disturbance. Most students aim to study a certain number of hours each day or each weekend. If you decide to study for several hours at once, take short breaks of five to ten minutes regularly as it helps to maintain a higher level of overall concentration.

Before you begin a detailed reading of the text, familiarise yourself with the general layout of the material. Have a look at the contents of the various chapters and flip through the pages to get a general impression of the way the subject is dealt with. Forget the old taboo of not writing in books. There is room for your comments, notes and answers; use it and make the book your own personal study record for future revision and reference.

At intervals you will find a summary and list of objectives. The summary will emphasise the important points covered by the material that you have read and the objectives will give you a check list of the things you should then be able to achieve. There are notes in the left hand margin, to help orientate you and emphasise new and important messages.

BIOTOL will be used by universities, polytechnics and colleges as well as industrial training organisations and professional bodies. The texts will form a basis for flexible courses of all types leading to certificates, diplomas and degrees often through credit accumulation and transfer arrangements. In future there will be additional resources available including videos and computer based training programmes.



## Preface

Within the last century, scientific and technological developments have changed natural fermentation processes into controlled and optimised processes capable of operation on a large (industrial) scale. Such developments have led to the growth of the food industry. We have, as we have adopted an urbanised way of life, become more and more dependent upon food which has been processed in some way: to preserve it; to enhance its flavour; to make it more convenient to prepare and/or cook.

In this text, we examine how recent biotechnological developments have led to improvements in food processing. The techniques of genetic engineering and protein engineering have given new impetus to biotechnological food conversions and processing. We examine how they are being applied to production of fermented foods such as cheese and yoghurt and products such as fruit juices.

The same developments have also given new impetus to the use of biotechnological products as food processing aids (ingredients added to improve the quality of processed food). We examine processes for the production of natural preservation systems, sweeteners, flavour enhancers and many other useful products of value to the food industry.

This text, written in a reader-centred learning style, is quite advanced. It assumes that the reader has knowledge of the structure, composition and properties of the major biologically produced chemicals, basic microbiology and the principles of genetic engineering. This text focuses on the application of these disciplines to food production and processing.

This is done in the form of a series of case studies each with its own special emphasis.

Substantial background material is included to provide the context and support needed to understand the processes and strategies under discussion. The text does not confine itself to technical matters but also considers the wider implications of applying biotechnology to food production. This includes issues relating to regulatory requirements and economics.

Scientific and Course Advisors: Dr M. C. E. van Dam-Mieras  
Dr C. K. Leach

### Acknowledgements

Grateful thanks are extended to the authors, editors and course advisors, and to all those who have contributed to the development and production of this book. They include Dr N. Chadwick, Mr R. I. James, Dr M. de Kok, Dr G. Lawrence, Miss J. Skelton, Professor R. Spier and Mrs M. Wyatt. The development of BIOTOL has been funded by COMETT, The European community Action programme for Education and Training for Technology, by the Open universiteit of The Netherlands and by Thames Polytechnic.

Project Manager: Dr J. W. James

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## Introduction

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## Introduction

### 1.1 The changing food industry

Biotechnology in food production has a very long tradition. It is believed that fermentative production of food (such as bread, beer, cheese and wine) has been practiced for more than 10 000 years. Ever since, mankind has tried to improve these processes. On the one hand these improvements consisted of a long evolution of many small changes that were triggered mainly by casual circumstances: the variability in raw materials; the availability of ingredients; the personal taste of the cook; etc. On the other hand, several major developments changed food production to a much larger extent. These major developments were:

- scale of production; from preparation just for the family, the food industry evolved through specialists such as bakers and butchers to multinational organisations engaged in food manufacture and distribution on a worldwide scale;
- from labour intensive to automated processes; a second large change came from the introduction of machinery that to a large extent replaced labour. Later, automation of this machinery further replaced the need for a large workforce. These trends are continuing to evolve;
- transport and globalisation, availability and taste; a third large change derived from the influence of travel and the transportation of goods. From our journeys, we learned to appreciate food from other parts of the world. We also gained independence from the seasons by the development of food preservation enabling us to enjoy 'seasonal' foods all the year round. Through the development of transportation, we now can obtain fresh foods from all over the world. In this respect a well developed packaging and conservation technology is essential.

### 1.2 Biotechnology and food manufacture

Biotechnology has been defined as the integrated use of biochemical and microbiological sciences and process technology in order to apply the possibilities and properties of micro-organisms, cultured tissues and cells and part thereof in a technological way (European Federation of Biotechnology).

Taking this definition, we realise that our daily food contains many constituents that are produced by biotechnology. Many of these biotechnological products will be described in detail in later chapters of this text. We can discriminate between processing aids that help us to carry out different process steps, and food ingredients that will form a part of the final food product. Enzymes, catalysing reactions such as the conversion of starch to glucose or fructose that are used as sweeteners, form a large group of processing aids. Apart from the processing aids and food ingredients, other biotechnological products are manufactured by fermentation processes. In addition to the traditional products

processing aids

food  
ingredients

fermentation



(bread, beer, wine) we can identify enzymes, flavourants and additives as products of fermentation.

**empirical approach** Historically food processing was based on an empirical approach. Traditionally, these improvements were introduced by trial and error. Later, more systematic approaches have been used. After the invention of the microscope and the early microbiological work of Pasteur, we began to understand the different processes that are responsible for the characteristics of a food.

Looking back to the evolution in food products and trying to predict future improvements, we indicate as the driving forces of change:

- trends in consumer demands;
- needs of the producer;
- governmental pressures.

### 1.2.1 Trends in consumer demands

In recent times, we can recognise several patterns in the choice of foods by consumers. We can particularly identify:

- a request for healthy and natural products;
- a desire for tasty products;
- an increasing use of convenience products;
- a growing selection of non-local products.

### 1.2.2 Needs of the producer

Economic and regulatory pressures on food producers result in the:

- greater automation of food processes;
- need to maintain flexible manufacturing;
- need to maintain Good Manufacturing Practice;
- continued awareness of the cost of the product.

### 1.2.3 Governmental pressures

Social and political pressures encourage governments to:

- introduce strict environmental regulation;
- change the conditions leading to the registration of food products;
- enforce strict legislation on production.

### 1.3 Major factors influencing trends in the food market

We identify cost, preservation, taste, consistency, colour, safety and health aspects as the major factors influencing changes in the manufacture and processing of foods.

#### 1.3.1 Cost

cost of  
materials

changing from  
sugar to  
aspartame

A major factor affecting cost is the yield of product achieved per unit of raw material. The ability to switch from one material to another is also important. As an example: sugar (sucrose) has been used in all sorts of food manufacturing processes. In the seventies high-fructose corn syrups, produced by the enzymatic conversion of corn starch to a glucose and fructose mixture replaced sucrose to a large extent. Recently a large share of the sweetener market has been taken by aspartame, a biotechnological product based on a dipeptide which is two hundred times as sweet as sucrose on a weight for weight basis.

labour costs

yield  
environmental  
concerns

cost of waste  
treatment

The cost of labour is another factor determining price. The efficiency of conversion of raw material to final product has always been an important issue but with the environmental concern the optimisation of yield has become more important. Governmental regulations often demand reduction in the production of waste. This may be a costly activity especially if much effort is needed to satisfy regulatory demands. Those companies that anticipate regulatory developments have time enough to re-model their processes in such a way that they can reduce their waste streams just by increasing the yield in their processes. Here, new biotechnological processes may be very important.

#### 1.3.2 Preservation

fermentation  
technology and  
its importance  
in food  
preservation

The preservation of food has been the most important factor in the past. Seasonal crops or peak demand could be handled by good food preservation technology. Historically, fermentation with a desirable organism kept many infections out of the food. The fermentation of yoghurt and brewing beer, the fermentation of wine, the fermentation of vegetables and meat are all examples of biotechnological preservation techniques of the past. Now, many alternative methods of preservation are available. These include refrigeration, freezing, packing under sterile conditions in various materials, preservation chemicals etc. Contemporary biotechnology is contributing to improvements in the new as well as the traditional food preservation techniques.

#### 1.3.3 Taste

taste  
development

Taste is principally a property of the raw food material. Again, historically, we learned how to vary taste by the ripening of the raw material and by processes like cooking, frying etc. In fermentation, taste is developed by the interaction of the food material and micro-organisms. We have also learnt to modify taste by the addition of spices. Since the perception of taste is still poorly understood, taste as a description of quality of food products is still approached largely in an empirical way.

#### 1.3.4 Consistency

texture  
appearance

mouth feel  
additives

Like taste, consistency is a property of food that influences the perception of food products by the consumer. Consistency includes textural aspects, appearance and mouth feel and can be influenced by fermentation (bread), heating, cooling and acidification. It can also be influenced by the addition of all kinds of ingredients like thickening agents, emulsifiers etc.

### 1.3.5 Colour

natural and  
synthetic  
colourants

Colour is also important. Although most food colours do not contribute to the taste of food products, the absence of the typical colour of a food product gives us the perception that the product is not fresh or does not have the proper taste. Modern biotechnology has great potential to help in the production of well-known natural and synthetic products. Currently, the application of some natural products is limited because of a shortage in supply. The use of some synthetic colours is restricted because they are regarded as potential hazards to health. Biotechnology offers opportunities to circumvent these problems.

### 1.3.6 Safety aspects

long distance  
large numbers  
of consumers  
demand  
high product  
safety

Safety aspects become more and more important. Long logistic lines from site of production to consumption present potential risks from the outgrowth of all kind of pathogenic micro-organisms. The numbers of these would be limited and therefore would not cause any harm if the products were consumed immediately after production. This type of problem sets very high hygiene specifications for the food processing and packaging industry. It is paradoxical that, as our modern society suffers much less from infectious diseases than ever before, the standards at home are becoming more and more relaxed. It is therefore essential that the food producing industry needs to maintain very high product safety standards. This is especially so if we realise that a single food producing unit may supply food to many individuals over a large geographical area. The problems of food safety as well as their solution are essential elements of food biotechnology.

### 1.3.7 Health aspects

There is growing concern over how healthy the food we eat really is. Many consumers have become aware of the possible risks to health from eating a diet high in calories or animal fats. Biotechnology provides opportunities to reduce these risks. An example is the replacement of sugar by low calorie sweeteners.

## 1.4 The structure of the text

Food technology, of which microbiology, fermentation and biochemistry form an integral part, has been applied to optimise food production. The issues mentioned above (cost, preservation, taste, consistency and colour) are the basic 'rational' objectives for these improvements.

The remaining chapters examine the contribution of biotechnology to achieving these objectives. We do not simply confine ourselves to these objectives, but indicate some of the regulatory and economic issues that need to be considered in the application of biotechnology. This discussion is mainly based upon a case study approach. To put the case studies into context, we begin in Chapters 2 and 3, by giving an overview of the contribution of processing aids and fermentation in manufacture.

The challenge to food technologists is to recognise the potential of biotechnology to fulfil the food requirements of today's society.

### 1.3.3 Colour

Colour is also important. Although most food colours are derived from natural sources, the absence of the typical colour of a food product gives us the impression that the product is not fresh or does not have the proper taste. Modern food processing has great potential to help in the production of new natural and synthetic products. Currently, the application of some natural products is limited because of a shortage in supply. The use of some synthetic colours is restricted because they are regarded as potential hazards to health. Biotechnology offers a promising alternative to the present situation.

### 1.3.4 Safety aspects

Food safety is a major concern for consumers and food processors. Food safety is a broad term that encompasses many aspects of food production, processing, and distribution. It includes the prevention of foodborne illness and food poisoning, the prevention of food contamination, and the prevention of food spoilage. Food safety is a complex issue that involves many different factors, including the quality of the raw materials, the quality of the processing, the quality of the packaging, and the quality of the distribution. Food safety is a continuous process that requires constant vigilance and attention. Food safety is a responsibility that belongs to everyone involved in the food chain, from the farmer to the consumer. Food safety is a goal that we should all strive to achieve.

### 1.3.5 Health aspects

There is a growing concern over how eating the food we eat affects our health. Many consumers have become aware of the possible risks to health from eating a diet high in calories or fat. This has led to a demand for healthier food products. Food processors are responding to this demand by developing new products that are healthier and more nutritious. This is a positive trend that we should all support. Food safety and health are closely related. Food safety is the foundation for good health. Without safe food, we cannot have good health. Food safety is a responsibility that belongs to everyone involved in the food chain, from the farmer to the consumer. Food safety is a goal that we should all strive to achieve.

### 1.3.6 The structure of the text

Food safety is a complex issue that involves many different factors, including the quality of the raw materials, the quality of the processing, the quality of the packaging, and the quality of the distribution. Food safety is a continuous process that requires constant vigilance and attention. Food safety is a responsibility that belongs to everyone involved in the food chain, from the farmer to the consumer. Food safety is a goal that we should all strive to achieve. The structure of the text is as follows: The first section discusses the importance of food safety. The second section discusses the different aspects of food safety. The third section discusses the different factors that affect food safety. The fourth section discusses the different ways to improve food safety. The fifth section discusses the different challenges to food safety. The sixth section discusses the different solutions to food safety. The seventh section discusses the different future prospects for food safety. The eighth section discusses the different conclusions from the text.

### 1.3.7 The structure of the text

The structure of the text is as follows: The first section discusses the importance of food safety. The second section discusses the different aspects of food safety. The third section discusses the different factors that affect food safety. The fourth section discusses the different ways to improve food safety. The fifth section discusses the different challenges to food safety. The sixth section discusses the different solutions to food safety. The seventh section discusses the different future prospects for food safety. The eighth section discusses the different conclusions from the text.



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