Principles of Microbiology for students of food technology

Second edition

Thelma J. Parry and Rosa K. Pawsey

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Contents

Preface to the first edition

Our aim is to introduce food microbiology in such a way that the student will gain a basic grounding in this subject. The student will then be in a position to understand more authoritative texts on the subject if this proves necessary.

We have directed this book towards the needs of those students who possess no formal knowledge of microbiology but are pursuing post Ordinary-level courses in the various branches of the food industry.

We anticipate that the book will be suitable for students following courses in food technology, catering, RSH and the various bakery technology subjects – all of which require a knowledge of microbiology. We also think the text suitable for the requirements of dietitians and home economics teachers in training.

Thelma J. Parry and Rosa K. Pawsey 1973

Preface to the second edition

The original text has been rearranged to a certain extent, and expanded. Two entirely new chapters on water in food operations and quality control have been added. The chapter on pest infestations has been removed from the main text to make it more distant from the microbiology text, but it is retained to form a second appendix in recognition that this subject area is often included in 'hygiene' courses. In the ten year period since the publication of the first edition, courses have changed both in content and style, but the aim of this edition remains the same – to provide a basic grounding in food microbiology for those students whose careers will in some way be bound up with the production, sale or service of food.

Rosa K. Pawsey 1983

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Finally, I would again like to thank Mr Edward Meyrick, now in the PHLS at the Central Public Health Laboratory, Colindale, London, who has supplied the photographs for Figures 1, 2, 3, 6, 15, 20, 22, 24, 54 and 69, for which I am most grateful.

Introduction

The presence of micro-organisms in the environment around us is so common that it rarely attracts notice. We are so used to the fact that milk left in the sun will 'go off' and that vegetable material in a compost heap will 'rot' that we give little thought to the underlying causes of such changes. Both these processes and many others are brought about by the growth and activity of micro-organisms whose existence has been known to man for about three hundred years.

Serious microbiological research was initiated by a Dutchman, Antonij van Leewenhoek (1632–1723), who ground lenses of sufficiently good quality to enable him to examine small drops of water and other material under the microscopes he made. In so doing he noticed the presence of small organisms moving about in the liquids. Interesting though his discovery was, it was treated by his contemporaries merely as a scientific curiosity and not as significant to man's well being. The task of showing this remained for the scientists of the nineteenth century.

There were a number of eminent workers in this field foremost among whom was Louis Pasteur (1822–1895), now recognized as one of the founders of the science of microbiology. He studied fermentation and demonstrated that it was the growth of yeasts and bacteria which caused wine to ferment or sour when it was bottled or casked. He developed a process of heating wine to 50 to 60°C to kill the organisms which caused the spoilage without altering the quality of the wine. In so doing he rendered a great service to the French wine industry which had been losing trade due to its products souring during export. The process is now widely applied and is known as *pasteurization*.

Joseph Lister (1827–1912) working in Scotland heard of Pasteur's work and applied the knowledge to surgery. He realized that many people died because they were infected with harmful bacteria during and after operations. He pioneered antiseptic surgery (destruction of germs) by applying neat phenol (carbolic acid) to wounds. The phenol was effective but rather damaging to the skin, and Lister spent many years improving the technique. He attempted to provide a germ-free atmosphere in the operating room by spraying the room with a 5 per cent aqueous solution of phenol. Eventually the irritating effect of the spray led to its abandonment and was replaced by the technique of asepsis – scrupulous cleanliness.

Robert Koch (1843–1910) demonstrated that anthrax, the fatal disease of sheep and cattle is caused by a bacterium *Bacillus anthracis*. Scientific contemporaries of Koch made many other discoveries in the field of microbiology. Once the importance of micro-organisms had been realized, and with the advances in scientific methods, there was little to hold back research into their activities.

During the twentieth century, great strides have been made in understanding the causes of diseases in man, animals and plants which have led to the control and eradication of some diseases. Bovine tuberculosis – TB contracted from cattle – was rampant in the nineteenth century in the United Kingdom but with the

pasteurization of market milk, tuberculin tested herds, and the discovery of drugs such as streptomycin, together with better nutritional standards and better housing, this disease has today been largely eradicated. Other food borne diseases which have been brought under control in this country are diptheria and scarlet fever (although other streptococcal infections are commonly occurring).

In addition to causing disease in man and animals, micro-organisms cause plant and animal material to break down – 'rot' – an activity which has both advantages and disadvantages. It is to our benefit that micro-organisms breakdown dead vegetation and 'garbage' so that the elements of which they are composed are returned to the soil. However it is disadvantageous that stored food should be broken down – spoilt, for changes in appearance and flavour lead to its wide scale wastage.

In some manufacturing industries micro-organisms are used at certain stages. Their activities are essential in the formation of foods such as bread, beer, wine and pickles. Some antibiotics are produced as a result of microbial activity and vitamins are extracted from some species grown on a large scale. It is also the case that new types of food made primarily from concentrated micro-organisms which have been grown on industrial by-products and wastes are now on the market. Certain strains of yeasts, for example, can be grown either on heavy fuel oil or pure normal paraffins. In feeding trials, animals have been given feeds substituted with these yeast concentrates. It has been found that the animals accept the food and do not appear to tire of it, and in addition show growth rates comparable to those of animals on normal feeds. Conversion of microbial concentrates into a form acceptable to human beings can be achieved by feeding them to animals which themselves are destined to be human food. Biotechnology – the production of food and other materials by exploiting microbial activities – is the fastest growing area of food production technology.

The importance of micro-organisms

Advantages

Micro-organisms are involved in:

1 Decomposition of organic material – 'compost'.
2 Fermentation of processes in the manufacture of foods such as bread, beer, wine and pickles.
3 Manufacture of vitamins; for example proprietary brands of yeast extract are high in vitamins of the B complex.
4 Potential uses as food or as food supplements.

Disadvantages

Micro-organisms cause:

1 Disease in people and animals, for example food poisoning, the food and water borne diseases of typhoid and dysentery.
2 Spoilage of food.
3 Hold-ups in industrial processes by growing in and blocking pipes as, for example, in sugar refining.

Chapter 1

Introduction to micro-organisms

Micro-organisms are not all alike but they share a common feature in that for the most part they are individually invisible to the naked eye and can only be seen when magnified. Size alone determines which organisms are included in this class.

Micro-organisms differ from one another in appearance and activity. The types to be discussed in this book may be divided into six major groups:

1 Protozoa
2 Algae
3 Viruses
4 Bacteria
5 Yeasts
6 Moulds

Protozoa

These are simple unicellular animals of which there are many known species. They live in an aqueous environment such as pond or ditch water, sea or soil water. The majority are free living and harmless to man, a well known example being the amoeba. A few species of protozoa are of considerable importance because they cause diseases such as malaria, sleeping sickness and amoebic dysentery in man and animals. Amoebic dysentery is a water and food borne disease caused by *Entamoeba hystolytica*, a pathogenic protozoan which fortunately is seldom encountered in this country but which is, on occasion, imported by people from overseas.

Algae

This is a group of simply constructed plants, some of which are large (macroscopic), for example the large types of seaweed. Others are very tiny (microscopic) and are only visible under the microscope. All algae manufacture their own food by the process of photosynthesis (the manufacture of carbohydrate by the combination of water and carbon dioxide in the presence of chlorophyll using light as a source of energy). The microscopic algae are usually free living organisms found where there is water and sunlight available to them. They are commonly seen as green slime on the surface of ponds and aquaria.

Viruses

Viruses are the smallest of all micro-organisms varying from 10 nm to 300 nm diameter*. Viruses can only be seen when viewed under the electron microscope which gives magnifications in excess of 25,000 diameters. Viruses are themselves metabolically inert, but they can enter living cells and redirect the activities of the cells towards replicating themselves. This process of multiplication causes the death of the infected cells and results in disease of the host organism. In this process the viruses undergo

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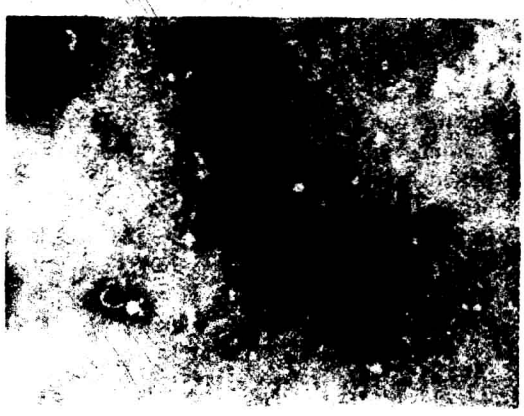
* nanometre (nm) = 10^{-9} metre
micrometre (μm) = 10^{-6} metre

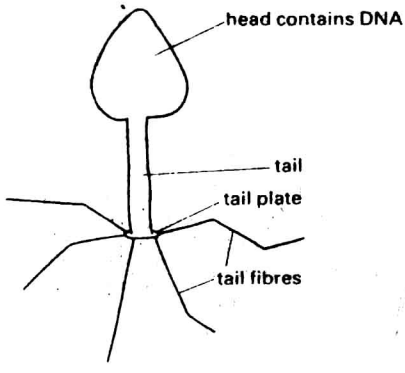
(a) Molluscum contagiosum (× 185,000)

(b) Herpes simplex (× 380,000)

(c) Vaccinia (× 120,000)



(d) Hong Kong flu (× 160,000)



(e) Bacteriophage

Figure 1 *Viruses*