HYGIENE IN FOOD MANUFACTURING AND HANDLING

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FOREWORD

ONE of the most noticeable and lasting changes in our way of life, stemming from wartime communal feeding, has been the spread to all sections of the community of the habit of eating away from home. This tendency has been further fostered by the enormous increase in the number of people who nowadays enjoy holidays spent not only in this country but in travel abroad. These changes have now created a situation in which one employed person in every three is engaged in some branch of the food production and distributive trades. The result is that a slip by food handlers, either through carelessness or ignorance, places a greater number of people at risk from food poisoning. It is not, therefore, surprising that during the last fifteen years or so attention has been focussed on the increased number of incidents caused by contaminated food. This increase was probably partly a true increase, and partly due to a wider knowledge of cases through notification and to advances in diagnostic facilities.

The trend in food-poisoning incidents is tabulated by the authors and it is particularly gratifying to note the maintenance of a decrease which started in 1959. One could easily ascribe this decrease to the impact of the Food Hygiene Regulations and the work of local authority health officers, but it would not be the full story. The wise manufacturer, processor and trader are also worthy of praise because of the early realization that the prevention of contamination of food, during storage, processing and handling, in addition to lessening the hazard from food poisoning, is reflected in the quality and in the cost of the article presented to the consumer. In short, good hygiene and improved handling repaid through less waste and a better article.

To this end many firms, for instance, arranged for their workers to take a short course in food handling leading to a Certificate examination, and many have then gone on to a more advanced course for a Diploma. The more people who become "clean food conscious" then the sooner will the battle against

illness be won, for although this country has probably the best recording system in the world we do know that not all cases of food poisoning are notified. Indeed, the figures may well be likened to the visible part of the iceberg, the invisible representing the large numbers who suffer a short, sharp attack of illness without bothering to call in their general practitioner. Complacency, therefore, is dangerous.

Most of the books and papers on this subject have stemmed from experts in the field of public health and could well come within the broad definition of directive. All the more pleasant for a change to have this publication from the "other side", not of course that there are "sides" in this field. There is just one road leading to one goal.

Practical advice abounds herein from the planning of premises to details of floor and wall finishes, and although much of this advice has been given before, it can stand repetition. A manufacturer or processor will find the answer to many of his problems so there is virtually no reason why the consumer should not be presented with a good-quality article, safe and clean. Such a need is further emphasized by the increasing tendency of the housewife to discriminatory purchasing, for the housewife has just as important a part to play and in recent years has been overcoming her natural reserve to objecting to unhygienic practices.

J. M. ROSS
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CHAPTER 1

AN INTRODUCTION TO THE PROBLEMS OF FOOD POISONING AND SPOILAGE

WHY should we be sufficiently concerned about food hygiene that it becomes a subject large enough to fill a book? How often do we hear "Plenty of soap and hot water is all we used in the old days and we had no trouble"?

Assuming the lack of trouble—which is doubtful—the same person is not likely to suggest that given enough horses and carts his products can be delivered to the markets as they were in the old days. His markets are bigger and more complex, and there are more efficient and rapid means of transport. So with food hygiene—his plant and processes are more complex and there are more rapid and efficient methods than just plenty of soap and hot water. The persistence of this attitude is due only to a lack of appreciation of the factors involved, including the changed pattern of the food industry.

At one time each small community was almost self-sufficient for its food raw materials, and each household prepared its own food. Gradually the pattern changed. The milling of the flour was centralized; bread was not baked at home but at a bakery. The increase in the rate of centralized preparation of food and the growth of prepared foods, leading to instant foods and other convenience foods, has been extremely rapid in the last few years. Larger and larger storage is required for the tons of raw food materials required. More and more complicated machinery is required to convert the raw material fast enough into the finished product and pack it. Larger warehouses are required to hold these finished goods. With these changes come the special hygiene problems.

Hygiene does not just mean cleaning. It is every aspect that plays a part in ensuring that the final product reaches the consumer in the most acceptable and nutritive condition.

The raw material must be in the best possible condition, free from disease or damage and stored properly so that it will

maintain this condition. The machinery used to process the food must not contaminate the product, nor reduce its nutritive value.

If food hygiene is neglected, what are the results? It will show itself in one of two main ways. The food will be spoiled, or it will cause food poisoning, at best it will reduce the shelf life of the food. An understanding of the agents that cause spoilage or food poisoning is therefore necessary. This means an elementary knowledge of bacteria and other micro-organisms, of chemical poisons and insects and other pests.

Having a knowledge of the agents that attack the food, and how they attack, the next stage is how to prevent it. This starts with the layout of the factory and construction of equipment, and includes how to clean equipment and what to use.

When the cause is understood, and the facilities available to combat it are known, the problem becomes relatively simple.

The sceptic will say this is all very well, but cleaning time reduces production time, and all the special storage and equipment is expensive. These things are all very fine when you're making large profits and can afford them, but we must keep a sense of proportion in this matter of hygiene.

We must indeed keep a sense of proportion, but what are the proportions. Reliable figures are very difficult to obtain for annual losses of foodstuffs due to spoilage, but those that are quoted by reliable sources are usually astronomical. The amount of cereals lost annually due to damage by rodents and insects alone has been quoted as 10 to 15%. When all other forms of spoiled foods are also considered, it becomes obvious that a vast quantity of food never reaches the consumer at all.

The food manufacturer, wholesaler or retailer is very interested in preventing food spoiling whilst in his possession as it affects his balance sheet, although the precise amount is not usually known. Good food is essential to produce healthy people and they cannot be more healthy than the quality of their food allows. Therefore it is essential that food is maintained at the highest quality possible. Everyone concerned with food should do his utmost to attain this, and not be content just with ensuring that it is not spoiled.

What about food poisoning? Surely this is not an important problem in modern times? Not only is this a serious problem, but it is one that has increased since pre-war days.

In England and Wales between 1954 and 1959 there were between 12,000 and 20,000 cases each year, and thirty or forty of these were fatal (Table 1).

Table 1

Food Poisoning Outbreaks in England and Wales

	Salmonella Typhi-murium	Other Salmonella	Total Number of Food Poisoning Incidences	Total Number of Cases	Fatal Cases
1954	2,988	520	6,016	11,800	34
1955	4,199	1,070	8,961	20,000	39
1956	3,176	1,147	7,713	18,000	44
1957	2,931	1,287	7,071	15,100	36
1958	3,329	1,512	7,300	14,900	35
1959	3,198	1,840	7,846		27
1960	2,907	1,047	6,428		25
1961	2,503	1,268	5,387		22
1962	1,864	982	4,521	9,696*	23

In 192 cases in 1959, information was available about the type of food that carried the infection, and in 171 cases meat products were involved. Table 2 shows a breakdown of meat products involved between 1954 and 1959. (All these figures are taken from the *Monthly Bulletin of the Ministry of Health Public Health Laboratory Service*.)

Compared with pre-war figures, the present incidence has shown a tremendous increase of possibly tenfold. It is true that methods of diagnosis and notification have improved, and that previously some cases would not be recorded, but this would not account for the difference. Beginning during the war, due to rationing, the habit of eating away from home increased. More

* Including 554 symptomless excretors.

Table 2

Food Poisoning Outbreaks Associated with Processed or Made-up Meats

	1954	1955	1956	1957	1958	1959	1960	1961	1962
1. Reheated Meat	41	49	48	49	40	45	33	33	21
2. Meat Pies	37	41	45	31	20	34	26	21	11
3. Cold Meat	8	40	17	14	16	21	29	19	17
4. Cold Ham, Boiled Bacon	17	28	8	20	7	12	7	12	6
5. Brawn, Meat in Gelatine, Meat Roll, Potted Meat	21	16	16	10	7	6	3	3	1
6. Pressed Meat	21	23	15	6	5	8	5	2	1
7. Once-cooked Stew	5	10	15	5	8	5	3	2	
8. Sandwiches	8	8	7		4	6	2	4	1
9. Sausages	12	5	8	8	5	2		6	4
10. Pork Products		1			2	4	1		
11. Bath Chaps		5	1	2	2			2	
12. Chawl					1				
13. Haslet				1					
14. Corned Beef, Tongue, Black Pudding			1						
15. Various Meats, Stuffed Meat		2						2	4
Total:	170	228	181	137	117	143	109	106	66

(*Monthly Bulletin of the Ministry of Health Public Health Laboratory Service*)

and more people ate out at factory canteens and restaurants. This communal feeding increased the risk of widespread food poisoning because one member of the kitchen staff, for example, could spread a food-poisoning germ to possibly several hundred people instead of just one family. More housewives were beginning to go out to work and consequently buying many prepared foods which previously would have been made at home. As was said earlier, food preparation became more concentrated, moving away from the household kitchen to the canteen, restaurant and food factory. The risk of a single source of contamination spreading to a large part of the population increased. Very often, due to the method of preparation and distribution, the food would be handled by several people, each a potential cause, directly or indirectly, of contamination.

We now have our sense of proportions, therefore—that food spoilage and food poisoning are real and serious problems. The size of the problem is in no small way due to the concentration of food-preparation facilities.

So it is essential that everyone who handles food should appreciate the risks and know how to avoid them. They should all appreciate food hygiene in its widest sense.

Food hygiene involves a number of subjects—factory layout, machinery construction, microbiology, chemistry and even law. Each subject has its own literature, but the people who need this information most—factory managers, production managers, technicians and foremen—do not have the time, and sometimes do not have the background knowledge or facilities to cull the information from several sources.

In the following chapters no previous specialized knowledge is assumed, and the reader is taken through the fundamental principles involved in each section.

A detailed cleaning programme for a factory will not be found itemized in detail, but sufficient information will be found to enable the reader to devise his own for his own particular circumstances.

The reader will also obtain that necessary background knowledge to extend his reading in the more specialized works, if he so wishes.

Food must be handled with the greatest care as it is a valuable commodity, a basis of our well-being—and is scarce: a fact often overlooked by many people in the more fortunate

countries. There is a serious world food shortage and half the world population (about 1,500,000,000 people) is hungry. Therefore we must not abuse or waste what we are fortunate in having.

CHAPTER II

BACTERIA, MOULDS AND YEASTS

EVERYWHERE around us are bacteria, moulds and yeasts. They are in the air, on our bodies and on our food—literally everywhere. It is almost impossible to think of an object from which they cannot be obtained. These living organisms cannot be seen individually by the naked eye, but when sufficiently large numbers are present they become visible, as is well known from the mould growth which may occur on jam. They are of the simplest form of life and occur in bewildering variety—the number of species of moulds alone runs into several thousand.

Most people are familiar with moulds as white, green or black growth on jam or bread, or as mildew on fabric, and with yeast for breadmaking. Bacteria, however, are usually thought of as germs and consequently associated with disease only. Whilst bacteria can be bad from man's point of view, causing disease and spoiling food, they can also play a useful and essential part in the cycle of life. Some of the same species which spoil our food also break down organic plant and animal material, returning it to the soil as nutrients for new plant growth. Bacteria also play an important part in the soil by making nitrogen, sulphur and phosphorus available in soluble form for the plants. Whether a bacterium is good or bad, therefore, depends upon its type and where it is.

Man has harnessed many of these organisms to his own use. Bacteria are used as starters in the manufacture of butter and cheese to curdle the milk; they are also used to prepare fermented milks such as yoghurt. Moulds are used to ripen such cheeses as Camembert and Roquefort, and to produce citric acid and several antibiotics, the best known of which is penicillin. Yeasts are used in the fermentation of beers and wines.

The actions of these micro-organisms can be most useful when used under controlled conditions in the right place. In

the wrong place, however, they can do considerable harm by spoiling food or causing illness, including food poisoning—which may be fatal.

BACTERIA

Bacteria are single cells only, but display different behaviours, according to their species, in respect of the material which they utilize as food and the conditions which favour their growth and reproduction.

Size and Appearance

Bacteria are so small that they can be seen individually only by the aid of a microscope, and so the usual units of length are too large to conveniently describe their size. The MICRON (μ) has therefore been adopted for this purpose; there are 1,000μ to a millimetre, or approximately 25,000 to an inch.

Most of the common bacteria appear under a microscope as dots, known as COCCI (sing. Coccus) or rods known as BACILLI (sing. Bacillus) and less frequently as commas or spirals. The diameter of the cocci is usually about 0·5μ to 1·0μ, as is the width of the rods. A medium rod will be 3μ to 5μ in length, but others may be much smaller, approaching the cocci, or up to 70μ or 80μ in length.

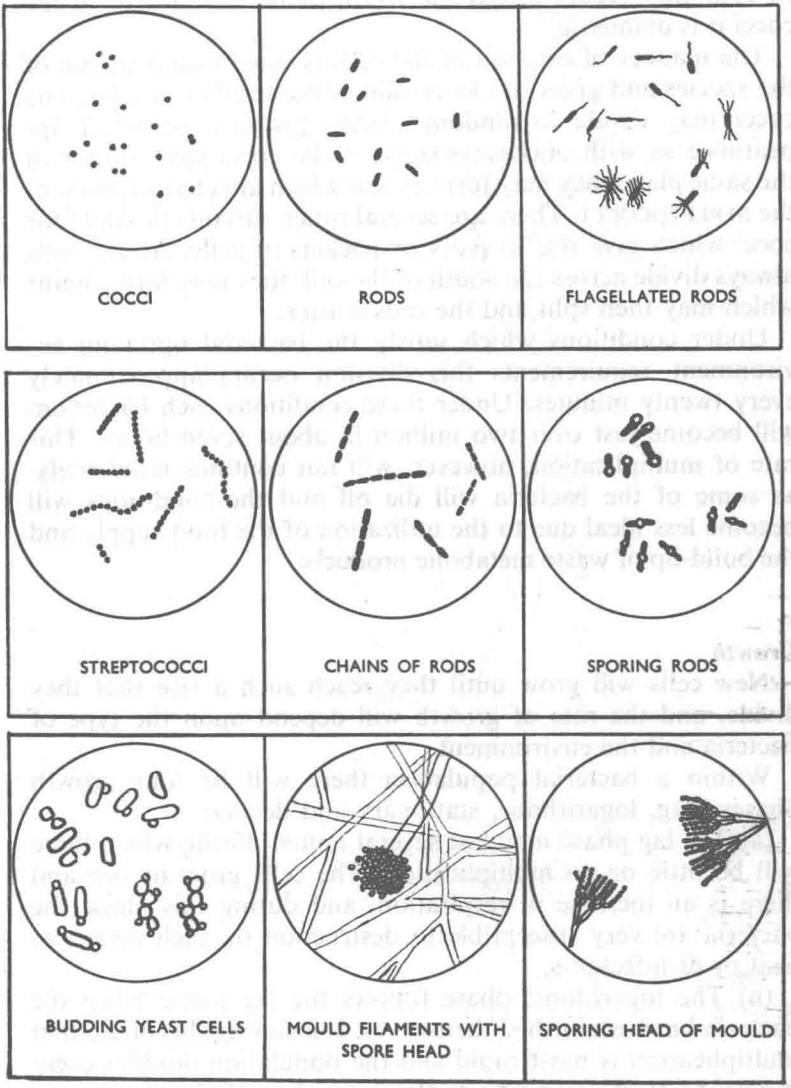
Motility

Many rods and a few cocci are motile; that is, they are able to move about in a liquid medium. This motility is achieved by a rhythmic motion of hair-like appendages called FLAGELLA (sing. Flagellum).

The form of flagellation may vary from a single terminal flagellum to flagella completely around the periphery of the cell.

Multiplication

As would be expected with such primitive organisms as bacteria, the method of reproduction is very simple, each bacterium dividing in half and becoming two independent bacteria. The cell begins to constrict at the centre and the constriction becomes more pronounced until it splits into two cells.


COCCI
RODS
FLAGELLATED RODS
STREPTOCOCCI
CHAINS OF RODS
SPORING RODS
BUDDING YEAST CELLS
MOULD FILAMENTS WITH SPORE HEAD
SPORING HEAD OF MOULD

In rods this occurs across the width of the cell and with the cocci it is diametric.

The manner of division of the cells is often characteristic of the species and gives rise to certain patterns of formation. The cocci may divide in random planes, giving a scattered appearance as with STAPHYLOCOCCI; if the cocci split always in the same plane they may form chains which are characteristic of the STREPTOCOCCI. There are several other variants possible for cocci which give rise to pairs or packets of cells. As the rods always divide across the width of the cell, they may form chains which may then split and the cells scatter.

Under conditions which satisfy the bacterial optimum environment requirements this division occurs approximately every twenty minutes. Under these conditions each bacterium will become just over two million in about seven hours. This rate of multiplication, however, will not continue indefinitely, as some of the bacteria will die off and the conditions will become less ideal due to the utilization of the food supply and the build-up of waste metabolic products.

Growth

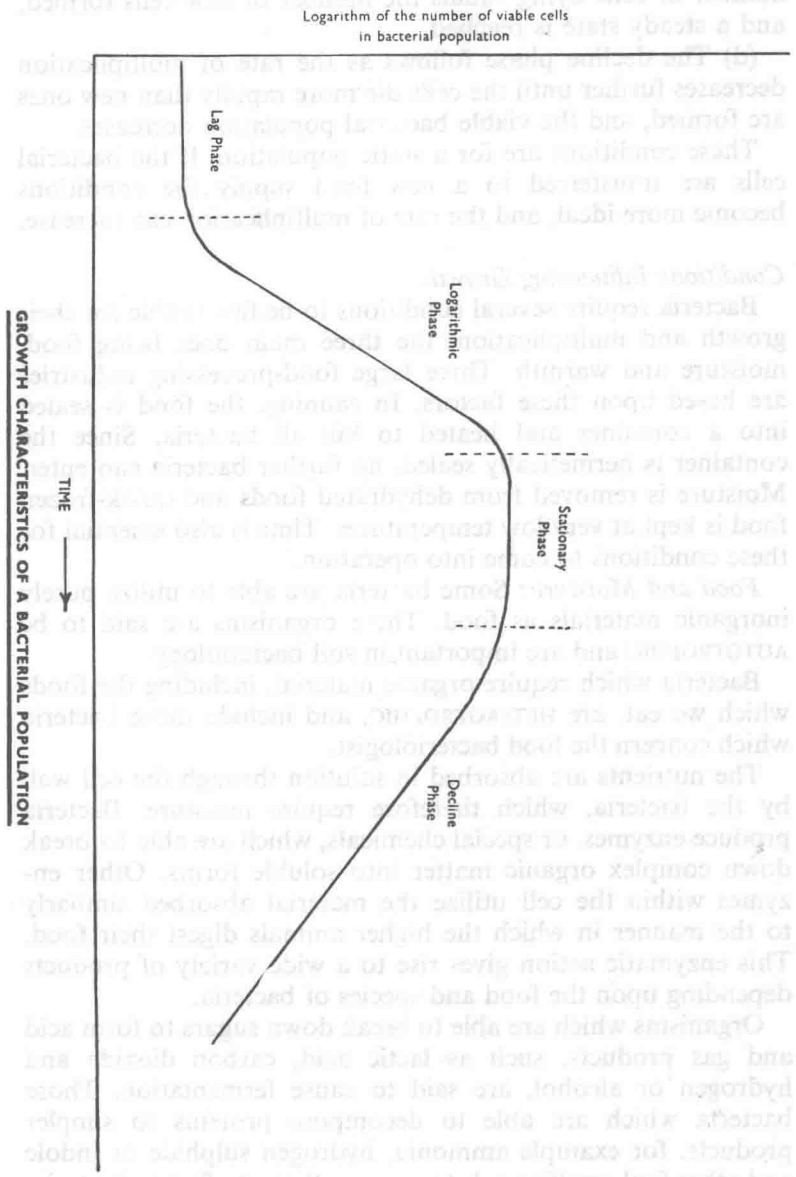
New cells will grow until they reach such a size that they divide, and the rate of growth will depend upon the type of bacteria and the environment.

Within a bacterial population there will be four growth phases—lag, logarithmic, stationary and decline.

(a) The lag phase may last several hours, during which there will be little or no multiplication. The cells grow in size and there is an increase in respiration, and during this phase the bacteria are very susceptible to destruction by such means as heat or disinfectants.

(b) The logarithmic phase follows the lag phase when the bacteria have established themselves. It is during this phase that multiplication is most rapid and the population doubles every twenty to thirty minutes. If the logarithm of the number of bacteria is plotted on a graph against time, a straight line is obtained, hence the name.

(c) The stationary phase is reached after a time when the number of viable bacteria reaches a maximum. As the conditions become less ideal, the rate of multiplication decreases until the



GROWTH CHARACTERISTICS OF A BACTERIAL POPULATION

number of cells dying equals the number of new cells formed, and a steady state is reached.

(d) The decline phase follows as the rate of multiplication decreases further until the cells die more rapidly than new ones are formed, and the viable bacterial population decreases.

These conditions are for a static population. If the bacterial cells are transferred to a new food supply the conditions become more ideal, and the rate of multiplication can increase.

Conditions Influencing Growth

Bacteria require several conditions to be favourable for their growth and multiplication, the three main ones being food, moisture and warmth. Three large food-processing industries are based upon these factors. In canning, the food is sealed into a container and heated to kill all bacteria. Since the container is hermetically sealed, no further bacteria can enter. Moisture is removed from dehydrated foods and quick-frozen food is kept at very low temperatures Time is also essential for these conditions to come into operation.

Food and Moisture: Some bacteria are able to utilize purely inorganic materials as food. These organisms are said to be AUTOTROPHIC and are important in soil bacteriology.

Bacteria which require organic material, including the foods which we eat, are HETEROTROPHIC, and include those bacteria which concern the food bacteriologist.

The nutrients are absorbed in solution through the cell wall by the bacteria, which therefore require moisture. Bacteria produce enzymes, or special chemicals, which are able to break down complex organic matter into soluble forms. Other enzymes within the cell utilize the material absorbed similarly to the manner in which the higher animals digest their food. This enzymatic action gives rise to a wide variety of products depending upon the food and species of bacteria.

Organisms which are able to break down sugars to form acid and gas products, such as lactic acid, carbon dioxide and hydrogen or alcohol, are said to cause fermentation. Those bacteria which are able to decompose proteins to simpler products, for example ammonia, hydrogen sulphide or indole and other foul-smelling substances, are the putrefactive bacteria. The end products which bacteria are able to produce are used to identify the type of bacteria under examination.