FOOD SCIENCE AND TECHNOLOGY

A Series of Monographs

# QUALITY CONTROL IN THE FOOD INDUSTRY

Volume 1

Edited by S. M. Herschdoerfer

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1. L. Maynard A. Amerine, Rose Marie Pangborn, and Edward B. Roessler, PRINCIPLES OF SENSORY EVALUATION OF FOOD. 1965
2. C. R. Stumbo, THERMOBACTERIOLOGY IN FOOD PROCESSING. 1965
3. Gerald Reed, ENZYMES IN FOOD PROCESSING. 1966
4. S. M. Herschdoerfer, QUALITY CONTROL IN THE FOOD INDUSTRY, Volume 1. 1967

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# Preface

The food industry covers such an enormous field that obviously no single person would be competent from personal experience to discuss all its quality control procedures. It was therefore deemed preferable to divide the subject into a number of separate chapters and to invite acknowledged experts in those different fields to deal with their quality control aspects. The authors were asked to consider quality control not in the narrow meaning of the term often used and which more suitably should be called "quality audit", a kind of post mortem on the quality of the finished product usually by means of a bacteriological and chemical examination. The authors were invited to look upon quality control as the sum of all those controllable factors that ultimately influence positively or negatively the quality of the finished products, e.g. selection of raw materials, processing methods, packaging, methods of storage and distribution, etc.

In adopting this approach, it was realized that the individual contributions would differ considerably from each other, not only in reflecting the personalities of the authors but also because of the different character and stage of development of the various industries. Some rely greatly on laboratory methods for quality control at all stages of manufacture; one such industry is that dealing with oils and fats. Other industries, e.g. the fishing industry, use laboratory techniques to a very limited extent.

The work is divided into three volumes, the first being devoted to general aspects of quality control affecting practically all branches of the food industry. It was assumed that most readers would be interested in all the subjects discussed in Volume 1, but might wish to refer in the subsequent volumes only to sections dealing with some specific industries. The contributions were therefore conceived more as a number of separate essays than as consecutive chapters in a text book. While considerable effort was made to reduce overlapping and repetition to a minimum, they could not altogether be avoided.

In spite of the considerable size of this work, it was impossible to deal with any subject exhaustively; however, numerous references to the relevant literature will enable the reader to pursue any enquiries further than could be dealt with within the limited scope of this book. Not included in the book were quality control methods applied to food additives such as organic or inorganic acids, bases and salts, colouring materials, preservatives, antioxidants, etc. The quality control of such additives lies mainly outside the province of the food manufacturer, and the field involved is so wide that its inclusion might have required a further volume.

To the authors of the individual contributions I am indebted for their willing co-operation and for their ready acceptance of the unavoidable delays between submission of manuscripts and publication. I gratefully acknowledge the editorial help given to me by some colleagues and in particular by Mr. D. H. Nokes on statistical matters. My thanks are also due to the staff of Academic Press for their help and advice.

It is hoped that these volumes will be of interest not only to the food scientist and technologist concerned with quality control but also generally to the management in the food industry which is constantly called upon to make decisions vitally affecting the quality of their products. To students in universities or at technical colleges they might serve as a useful introduction to this interesting field of the food industry.

London
January 1967

S. M. HERSCHDOERFER

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# The Organization of Quality Control

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## 1. INTRODUCTION

In the absence of direct evidence we must suppose that the acquisition of skill in the preparation and cooking of food began with the use of fire by primitive peoples. Certainly the early civilizations depended on knowledge of cereal crops and on methods of preparing them as foods. From such beginnings grew the crafts of the butcher, the miller, the baker, the confectioner and the chef, and the craftsman working on his own account or for a wealthy master has played a part in the daily life of the western world from earliest times to the present day. Often these crafts were associated with farming. The farm slaughter of pigs and the production of farm butter and cheese have continued down to recent times, and up to the nineteenth century the miller normally produced stone-ground flour for a group of farms or for a geographical region. At the same time high levels of culinary skill developed, especially in the homes of the wealthy landowners, who employed skilled cooks to garnish their tables.

The industrial revolution in England altered this slowly evolving pattern. Factories and mills brought high concentrations of populations to small areas of land, and the old relationship between the individual and the land from which he obtained his food was weakened. This break with the past became more clean-cut with the passage of time, until now even the agricultural worker obtains only a small fraction of his food from the land in his care.

In France at the beginning of the nineteenth century, Nicholas Appert's work on methods of food preservation culminated in the publication in 1810 of his book "Le Livre de tous les Ménages ou l'Art de Conserver pendant Plusiers Années Toutes les Substances Animales et Végétables", which described the preservation of food by heat sterilization. In England Bryan Donkin and Peter Durand studied the possibility of applying Appert's process to foods enclosed in steel containers. By the eighteen-twenties a canning industry had been established which soon acquired the characteristics of factory production, employing labour on a substantial scale to produce preserved foods for the armed services. This was in sharp contrast to the small-scale operations of the traditional food crafts, and marked the early stages of a process which still continues and which has already engulfed much that was formerly in the province of the trade guilds.

It is neither necessary nor desirable to detail the subsequent developments in factory processing of foodstuffs which have led to the present position. The development of methods of commercial refrigeration, roller milling and mechanized bread production to feed the growing cities was paralleled by developments in chemistry and bacteriology which were to provide support for the industrial operations. Yet the quality of the products produced by these operations depended on the self-taught skills of the operators, combined with such vigilance as management was able to provide. At best, it must have been variable; at worst, very poor indeed.

In the canning industry it soon became apparent that, for unknown reasons, packs which were believed to be properly processed sometimes deteriorated on storage. By about 1840 the firm of Donkin, Hall and Gamble (who were the pioneers of the canning industry in the U.K.) had invented an ingenious method for testing the cans they produced. In 1841 Encyclopaedia Britannica reported: "The cases thus hermetically sealed are exposed in a test chamber, for at least a month, to a temperature above what they are ever likely to encounter, from 90° to 110°F. If the process has failed, putrefaction takes place and gas is evolved, which in the course of time will bulge out both ends of the case so as to render them convex instead of concave. But the contents of whatever cases stand this test will infallibly keep perfectly sweet and good in any climate and for any length of time."

Thus a simple quality control test was introduced to the canning industry. A later event was to underline dramatically its worth. In 1841 a new figure appeared in competition with the old-established canning firms. Stephen Goldner filed a patent for preserving canned foods by heating them in a water-bath containing nitrate of soda to raise the boiling point of the water. Goldner soon obtained naval contracts to supply preserved provisions, and in 1845 he carried out a rushed contract to supply Franklin's expedition to the Canadian Arctic. The ships of this expedition disappeared and there were no survivors. However, relief expeditions found dumps of rotten canned food packed by Goldner, and it appeared that after the ships had been locked in the ice overland parties attempting to reach Hudson Bay had relied on such food for provisions. The resulting scandal was acerbated by reports of faulty tins from other contracts. In 1850 the Royal William Yard condemned 111,108 pounds of Goldner's meat. A Royal Commission was set up to investigate canning processes, in particular the methods used by Goldner, and it is clear from the proceedings that the best scientific advisers available at that time assumed that preservation depended on exclusion of air from the product. It was not until the eighteen-sixties that Pasteur's work enabled scientists to understand the canning process.

By the end of the nineteenth century mechanical refrigeration was in use in cold stores and in ships' holds for food preservation, an edible oil industry was developing Mège-Mourier's ideas of margarine manufacture, and the traditional methods of the miller were giving way to modern power-driven roller-milling systems. With the invention of the open-top can at the turn of the century, the stage was set for the application of scientific methods to food processing. The rapidly growing industrial population provided the markets for the mass-produced products which resulted.

World War I brought its inevitable food problems, and it was natural that the post-war years saw increased attention being paid to the study of foodstuffs. This movement was not confined to any one nation but perhaps reached its most intensive expression in the U.S.A., where conditions favoured its growth.

During the nineteen-twenties and nineteen-thirties most large food processing concerns in the U.S.A., Britain, Germany and elsewhere set up their own laboratories to assist with processing problems and with the establishment of quality standards. These early laboratories were often faced with problems which do not arise to-day. They were sometimes set up by men who thought of science as a modern form of magic, and the pioneers often had great difficulty in discovering the function they were expected to perform. Nevertheless, despite the misunderstandings and difficulties, systematic testing of raw materials was introduced on a useful scale and simple methods of quality control were worked out. Thus the way was prepared for the introduction of quality control, although World War II was to intervene before a widespread appreciation of the value of integrated quality control systems began to make itself generally felt in the food industry in the U.K. It would be quite wrong to give the impression that effective quality control systems were not in use before 1945 in some factories. Nevertheless, war-time experience underlined the need for such methods and post-war experience proved their value when normal trading conditions were restored.

There may be some confusion regarding the meaning of the word "quality" as applied to food. To the salesman a "quality" product means one of high quality and usually of an expensive nature. Thus caviare and champagne are considered to be "quality" products, whereas fish and chips are not. Yet no one would deny that well-cooked fish and french-fried potatoes can make an excellent meal. Thus the word quality as applied to a foodstuff should be used to refer to those attributes of the food which make it agreeable to the person who eats it. In its broadest sense this involves the positive factors of colour, flavour, texture and nutritional value, as well as the negative characteristics of freedom from harmful micro-organisms and undesirable substances, whether added deliberately or present adventitiously.

Furthermore, the term "control" may imply that a poor raw material can be converted into a good finished product. In food processing it is the general rule that the most carefully applied and effective methods can, at best, merely conserve the original qualities of the raw materials: it cannot improve them. There are a few apparent exceptions to this rule. For example, canned rhubarb is a product which very readily becomes an insipid pulp unless rather mature rhubarb, of a kind unacceptable for domestic cooking, is employed as the raw material. However, such exceptions are rare, and we must assume that it is generally true that process control conserves rather than improves the quality of the raw material.

The term "quality control" has been borrowed by the food industry from engineering, where almost all of the properties of the raw materials are effectively under the control of the designer and manufacturer. The food processer can only exercise a like control if he also has control of the production of his raw materials. To do this he has to pass beyond the farm gate and influence the growing of crops or the raising of stock. Since World War II the larger companies have moved in this direction, but much depends on the resources of the processer. To say this is not to exclude the smaller firms from the advantages of applying quality control methods, but merely to indicate that there are limits to the degree of control which can be exercised in a given set of circumstances.

*The aim of quality control is to achieve as good and as consistent a standard of quality in the product being produced as is compatible with the market for which the product is designed, and the price at which it will sell.*

## 2. THE PRINCIPLES OF QUALITY CONTROL

Quality control is often conveniently considered under the following three headings: (1) raw material control, (2) process control, (3) finished product inspection.

It is usually true that once a food product has been through a manufacturing process, little can be done to alter its quality. Thus the examination of finished products only permits acceptance of material reaching the desired standard and rejection of material which fails to reach this standard. Such a process is therefore one of inspection and not one of control. Indeed it can be claimed that if control of raw materials and control of process is perfect, the final product will not require inspection. After the product has been made, faults cannot be put right. Quality control is therefore concerned with the control of raw materials and control of the processes used. However, in practice it is seldom possible to guarantee complete control over raw materials and processing conditions, and thus a greater or lesser degree of finished product inspection will be necessary, depending on circumstances within the factory. It is economically desirable to concentrate on ensuring that inspection (and rejection) at the finished product stage is reduced to a nominal level by effective raw material and process controls.

The storerooms and warehouses of food factories often contain a large range of raw materials. Some of these, such as artificial colourings, spices, and essences, may be used slowly and may deteriorate on long storage. Others, such as cereal fillers, may be rapidly used and rapidly replaced. Some stores, such as meat, may be highly perishable and require refrigeration, whereas others, such as canned tomato puree, sugar and salt, may be very stable and may only require cool dry conditions to remain in excellent condition for long periods. If every single raw material, including those used in insignificant amounts, is to be subject to detailed examination and testing at frequent intervals, the cost will often far outweigh the advantages gained. In any product there is a dominant raw material (sometimes there may be several of these) upon which the quality of the finished product is mainly dependent. Thus, in canned tomato soup the tomato puree is of dominant importance, in canned peas the peas are of dominant importance, in bread production flour is the essential raw material, and so on. With other products, such as ice cream, chocolate biscuits, some types of pickles, and fruit salads, several raw materials are of almost equal importance in relation to the quality of the finished product. Nevertheless, it is clear that priority of attention must be given to the more important raw materials in planning a quality control system. (It may be worth noting that the dominant raw material is not always the raw material used in largest amount.)

*Rule 1.* The dominant raw material(s) are selected for priority of attention.

*Rule 2.* The selected materials are tested in relation to their contribution to product quality.

Now, Rule 2 follows from Rule 1, but perhaps a word of explanation is desirable. A given raw material may be examined in a host of different ways, depending on the information we wish to obtain. At the planning stage of quality control it is necessary to give the most careful thought to what we need to discover about any given batch of a raw material, and, in the light of this, to formulate the mode of sampling, the tests to be applied, the issue of authorization to the factory to use the material and the relationship between the test results and the product quality when the material comes to be used in bulk. In the early stages of planning quality control on a new product, the usual mistake is to specify more testing than is strictly necessary, in case the additional information is required subsequently. Once testing has started it tends to continue, even if it is providing information of only marginal value.

Since it has been the practice in the food industry to staff its laboratories with men trained as chemists and since quality control is normally regarded as a laboratory function, it is not surprising that chemical methods of testing are widely used. Nevertheless, many chemical tests are of limited value and some may be misleading. The protein content of flour is easily determined, but it bears no consistent relationship to the bread-baking quality of the flour. The caffeine content of coffee does not reflect the aroma characteristics which are sought in this beverage. Furthermore, chemical tests often take so long to perform that the results are available too late to be of practical value. This is not to deny the fact that some chemical testing is essential to many processes, but the successful quality control system will use whatever tests are most suited to the purpose, whether these be chemical, physical, bacteriological or organoleptic. The chemist entering this field for the first time must be prepared to accept methods foreign to his background and training. Furthermore, his training often gives him the impression that it is better to have a precise result irrespective of the time required to achieve it. In practice he must learn that a rough figure obtained in minutes may be more useful than a precise figure which takes hours to achieve.

*Rule 3.* The raw materials tested are released from store only after the test results have been properly recorded.

*Rule 4.* Process control must relate the processing results to the raw materials test.

The implementation of Rules 3 and 4 implies that careful planning is necessary if the factory is not to be deprived of an essential raw material while it awaits quality control clearance. Pressures of production are almost invariably high and nothing brings a quality control system more quickly into disrepute than delays while testing is carried out. The avoidance of delay often appears to present serious difficulty but can almost always be overcome by intelligent co-operation between stores control, quality control and factory management. The work of quality control must therefore be integrated with the factory management plan if it is to succeed.

It is difficult to discuss raw material control without reference to process control. It is equally difficult to talk of process control without assuming that