Chemical and Biological HAZARDS IN FOOD

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PREFACE

THE CONSUMER has become acutely aware of the fact that additives, intentional or otherwise, profoundly influence the desirability and edibility of his food products. Many added substances such as the vitamins, amino acids, and trace minerals with which foods are fortified not only improve the nutritional character of the products into which they are incorporated, but some additionally often satiate the appetite while others enhance gustatory appeal. Formerly, the principal role of added substances in foods was that of preservative agents, i.e., as bacteriostatic agents or inhibitors of chemical deterioration. More recently there have been many reasons for the presence, intentional or otherwise, of chemical additives in foods. While some of these materials are still used to retard or arrest decomposition, instability and other changes, others are specifically employed as nutrients, coloring and flavoring agents, plasticizers, neutralizers, humectants and coating agents. Also, a number of chemical agents serving as pesticides, plant growth regulators or synthetic animal estrogens, migrate into portions of products and so must likewise be considered as additives.

Growth of the food industry has been marked by rapid development of convenience items for the consumer, e.g., precooked frozen foods. Increasing awareness of the need for control of microorganisms having public health significance has accompanied this expansion. Microorganisms and their toxic products are, on occasion, associated with foods that have not been adequately protected during preparation, processing, or subsequent handling and storage.

During this century preparation of foods has changed from custom production in the home to mass production in processing plants. These developments have created great demands for

people trained in food technology. In recognition of this demand, curricula in food technology were set up in several universities. Iowa State University was one of the pioneers in this area. As interest in this program increased at I.S.U., it became apparent that new facilities were needed. Funds were provided by the Iowa legislature and the National Institutes of Health for constructing and equipping a food preservation laboratory. Upon completion of the new building, staff members of the Department of Dairy and Food Industry thought it appropriate to honor the occasion with an international conference on an important topic relating to food preservation. With this in mind, a symposium was organized to focus attention on various chemical and biological problems involving environmental hazards to the food supply.

Presentations by several of the world's foremost authorities on chemical and biological hazards in foods have been incorporated into the present volume. This book includes not only the papers presented but also a resumé of the thoughts and ideas exchanged by the several participants whose names are given in the Authors list.

The editors are indebted to all of the participants for the enlightening and spirited discussions which added significantly to the value of the symposium. Particular thanks are due the speakers for their fine cooperation in preparing their papers for publication. In addition, we wish to thank many on the staff at I.S.U. for their generous cooperation and enthusiastic help with the organization and execution of the symposium — without their support the task would have been far more difficult. We wish particularly to thank Dr. V. H. Nielsen, Head of the Department of Dairy and Food Industry for his support, encouragement and help with many of the problems that arose during this time.

Finally, this conference was supported, in part, by a Public Health Service research grant, EF-39, from the Division of Environmental Engineering and Food Protection, Public Health Service and, in part, by funds received from the I.S.U. Graduate College, the Dairy Creamery Fund and the Short Course Fund. We are most grateful for these sources of support and to the Iowa State University Press through whom publication was effected.

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Introduction

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IN THESE DAYS when there are so many meetings, conferences, and symposia, there must have been some very good reasons why this symposium was planned. Symposia, when properly planned and conducted, contribute substantially to scientific progress because they are an important means for determining the present status of knowledge in a particular field, for evaluating the progress of research, and for stimulating and directing greater effort to increase knowledge and solve problems.

In research, appraisals or evaluations must be carried out constantly. The independent scientist must evaluate and reevaluate his research continuously, not only in terms of what he himself has done, but also in relation to what others have done or are doing. This evaluation or appraisal provides a basis for determining what findings need to be reaffirmed and how this might be done, and provides the guidelines to delve deeper in search of new knowledge. Research directors, those who determine research policy, as well as those who wish to apply or make practical use of research results, also continuously evaluate.

Obviously, there are other ways than the symposium by which the value of research and the progress made in solving problems can be judged. The independent scientist is aided in appraising his own research efforts by having a thorough acquaintance with the scientific literature with which he is most concerned. Another way is through personal conferences with his laboratory or institutional associates, even though they may not be working in the same specific field. Such conferences are highly desirable in judging techniques, results, and theories which are being developed. They are also usually stimulating to the researcher because responses are immediate and on a personal basis. Communication with scientists who may be working in the same or

related fields elsewhere can provide assistance and guidance with excellent results. Getting a few persons of similar interests together in conferences is another means now rather widely used.

Meetings of scientific societies provide opportunities for presentation of the scientist's findings and exposing them to analysis by others, as well as for learning from presentations of others. Publication of research findings exposes the scientist's procedures and results to many more scientists and may evoke immediate or delayed confirmation, refutation, or suggestions for new research.

These, as well as other methods, can be applied to individual studies in determining their value, merit, or excellence in themselves. But when there must be judgment as to the contribution of these studies to solving a rather well defined yet broader problem, the situation becomes more difficult because there are more scientific disciplines to consider. The symposium has great value in this situation by bringing together scientists who work on separate phases of a complex problem. Each can place his contributions before the others so that all can evaluate the total accomplishments toward solving the whole problem. This also reveals phases which need more attention or may expose newly recognized problems or phases.

The Symposium on Food Protection permits an appraisal of the present status of knowledge, and of the progress being made in solving chemical and biological problems involving environmental hazards to the food supply. Each participant reports progress to date in a phase in which he is a highly competent scientist. At the conclusion of the symposium we will have a clearer picture of how real these hazards are today and what may be required to remove them.

The Department of Dairy and Food Industry at Iowa State University is to be complimented for sponsoring a symposium on the subject of food protection. There has not been, to my knowledge, a symposium previously which has such broad coverage of the subject of chemical and biological hazards in food as this one. Thus we should be able to appraise possible food hazards in the broadest sense and estimate the safety of our total food supply as never before. This will make a genuine contribution in the interest of public health.

Finally, the Department of Dairy and Food Industry should be thanked for permitting the participants and those attending the symposium to become better informed on a complex subject in so short a period of time. However, it should be expected that the symposium may contribute to the dilemma of science by exposing new vistas of ignorance. Dr. Warren Weaver, Vice-President

for the Natural and Medical Sciences, Rockefeller Foundation, describes our science dilemma as follows:

"We keep, in science, getting a more and more sophisticated view of our essential ignorance. Is science really gaining in its assault on the totality of the unsolved? As science learns one answer, it learns several new questions. It is as though scientists were working in a great forest of ignorance, making an ever-larger circular clearing within which, not to insist on the pun, things are clear. But, as that circle becomes larger and larger, the circumference of contact with ignorance also gets longer and longer. Science learns more and more. But there is an ultimate sense in which it does not gain; for the volume of the appreciated but not understood keeps getting larger."

CONTENTS

PART ONE

Food Additives: Appraisal

1

Technical Benefits of Food Additives

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THE MEANING of the term food additives seems to vary with individuals and attitudes. In this paper I have taken the definition of the Food Protection Committee which is: "A substance or mixture of substances, other than a basic foodstuff, which is present in a food as a result of any aspect of production, processing, storage, or packaging." The term, of course, does not include chance contaminants; but it does include two broad types of food additives — intentional and incidental.

Intentional additives are substances such as salt added purposely to perform specific functions. Incidental additives, on the other hand, are substances which, though they have no function in the finished food, become a part of the food product through some phase of production, processing, storage, or packaging. An incidental additive could be an agricultural chemical applied to the crop or a substance that migrates into food from a packaging material.

It is apparent, therefore, in discussing the technological benefits of food additives, that we must include chemicals used in agricultural production, processing, packaging, and even those used in the home.

In developing this paper I tried to determine when chemicals were first used in foods. The beginning is lost in antiquity; however, I believe there is some relationship to the great revolutions in the history of man as given by Darwin. For example, the first great revolution came with the discovery of fire which resulted in the process of smoking. This method of preservation, of course, meant the inclusion of certain components of smoke such as pyroligneous acid, formaldehyde, and even potential "carcinogens" in the food.

Agriculture was another revolution caused by man. It is

difficult to determine just when this involved the use of chemicals, but we know that Indians in this country used dead fish for fertilization, the Chinese used ethylene gas for ripening, and the Greeks treated raisins with alkali (ashes) before drying. In more recent times, developments have been abundant. Dusting with sulphur was started by Duchatel in 1850. Bordeaux mixture was discovered by Mallaradet in 1882 when, interestingly enough, he tried to prepare a repugnant material which, when placed on his grapes, would discourage people from stealing them. This serendipity gave man one of the best fungicides of all times.

Tremendous advances in the use of agricultural chemicals have occurred in more recent years. For example, synthetic herbicides were introduced in 1938, synthetic organic fungicides in 1940, chlorinated hydrocarbons (DDT) in 1942, synthetic rodenticides in 1944, and organic phosphate insecticides in 1947. Since then, a multiplicity of chemicals has been developed for agricultural purposes, and these have had a tremendous impact on production, quality, and distribution of foods and food products.

Another great revolution caused by man was urbanization; and this, too, had an influence on the use of chemicals; but it is difficult to be specific. As cities developed it became necessary to transport foods to them from the country. At first livestock was transported on foot, but milk fermented and formed butter as it joggled along in bags on the backs of camels. Without doubt, the situation encouraged the use of preservatives such as salt and smoke. One can hardly start reading the story of the American westward movement without finding reference to "sowbelly and beans," or in other words, salt pork and beans. Some may doubt the technological benefits of this type of preservation, but it certainly helped people travel and keep alive though they may have suffered from dyspepsia, which in turn started the "corn flakes" crusade. As time went on, of course, other means of preservation, including the use of chemicals, were developed; and these enabled an easier and better movement of foods to the centers of population.

The industrial revolution of man is the most recent and is continuing, and this is the period in which an enormous increase in the use of chemical additives has taken place. At the same time in this period, our foods have become more abundant, nutritious, convenient, varied, acceptable, and widely distributed.

Now I should like to dwell a little on the technological advantages of agricultural chemicals, or those we call incidental additives. These chemicals are used for a variety of reasons, and they have had a profound effect on the availability, quality, and cost of our food. I hardly need to mention the benefits of synthetic

fertilizers, yet there are those who would outlaw all fertilizers except natural ones; and they would eliminate all fertilizer factories except the natural one.

We all know that weeds compete with cultivated plants for moisture and nutrients, so the development and application of weed killers has meant better crops and cheaper production.

The extensive use of insecticides and fungicides has enabled the farmer to remain in business; and he keeps many crops on the market that would have been eliminated or would have become so costly that only the wealthy could afford them. The destructive potential of agricultural pests is well indicated by the potato famines of Ireland. The potato blight (Phytophthora infestans) destroyed crops and caused thousands of people to die of starvation. Other fungi can be equally bad. In the past, ergot poisoning caused by the fungus Claviceps purpurea, which grows on cereal crops, was quite common. Only a few years ago, surprising as it may seem, several people died from ergot poisoning in Europe. Such destructive occurrences no longer take place in this country, and a substantial part of this advance can be attributed to the use of agricultural chemicals.

Food wastage during storage has been, and still is, a very serious problem. These losses caused by rodents, insects, and fungi annually amount to as much as 33 million tons of good food. Believe it or not, this is enough to feed the entire population of the United States for one year. According to Robert Brittain (1952) this means, "If one person out of every 14 or 15 in the world should die yearly from starvation because of the real lack of food to go around, we could say quite literally that he was done to death by these predators." The development of rodenticides has been important in the reduction of storage losses although we still have a long way to go.

Losses during shipment of fresh produce have been substantial. The development of "hydrocooling," which involves the use of chlorine, has greatly reduced such losses in items such as cherries and asparagus. In fact I have been told by one shipper that hydrocooling reduced his losses in fresh cherries during shipment from over 50 per cent to less than 10 per cent.

Defoliation of plants such as sorghum by use of chemicals is another procedure that has meant a reduction of the cost of production of feed crops, and hence, animal protein.

Hormone sprays are being used to prevent immature fruit from dropping (June drop) and experimentation is underway on "thinning" blossoms by use of sprays in order to produce larger and better fruit.

One rather interesting development has been the use of