

ASPECTS OF CHEMICAL ADDITIVES IN FOODS¹

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The history of man is closely associated with his food supplies; survival, migrations, community development, formation of government, military campaigns, religious worship, functions of politics. The ability of man to produce food in quantity for increasing populations is dependent upon effective use of fertilizers, insect, rodent, fungicide, miticide, weed, and simular controls, and mechanization. Insect control is an intense problem. The American farm enterprise is rapidly changing characteristics, in population, manpower output, available acreage, and acreage output. Food distribution practices also have changed markedly in the past decade. Military logistics have strong impacts on food production and utilization practices. The necessity for new forms of foods for shifting populations has resulted in re-evaluation of regulations governing the use of chemicals in foods, their functions, and effects.

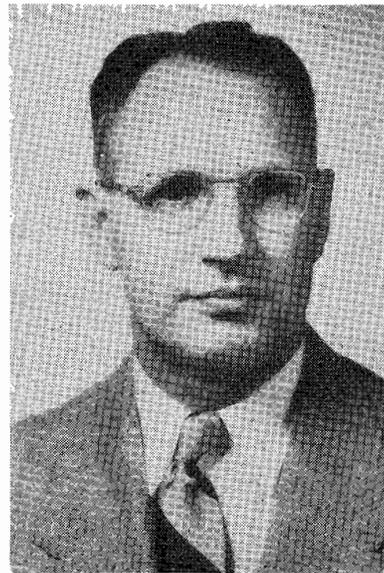
"Chemical food additives," as an expression, has become increasingly important in many respects. The use of chemicals must be appraised against the background history of man, and of his food requirements, and of his health. Their role must be appraised also in the newer knowledge of chemical substances, including foods, in food manufacture, and in physiology.

MAN AND FOOD

Food, per se, can be associated with every historical development of man; in his survival, his migrations, in the formation of domestic rather than migrant, communities, in the formation of governments, in the status of campaigns of war, in the commerce of nations, in man's freedom from toil and opportunity for development of cultures, in his religious worship, and in the functions of politics.

FOOD SUPPLY

Availability of food has always been one of man's greatest problems; its lack has determined the fall of empires, in government revolutions, and in social unrest. Literally, millions of people have perished in famines, and their aftermaths of plagues and scourges. History records these occurred as frequently as decennially only several hundred years ago. Food surpluses is for our generation and nation, momentarily, a social and political problem. It probably shall not always be so. It has been estimated the ill-fed people of the



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world outnumber the well fed two to one. For millions, physiological pain of hunger is a daily stark reality. It is apparent, as our knowledge improves, that virtually everyone suffers some degree of nutritional inadequacy. The perfect physiological balance has yet to be understood, less well, attained.

It has been only within the preceding century that Lavoisier established the oxygen balance resulting with the ingestion, and digestion of food. It has been only recently, historically, that John Beaumont's studies with the wounded Alex St. Martin provided information on what happened in the digestion of food. In the last 100 years, man has established some facts on the amount of food necessary for physiological work. In the past 30 years, biologists have elucidated information on the kinds of foods needed for improved health.

FOOD PRODUCTION AND CHEMICALS

The subject of chemical additives in foods must be considered also in the light of certain other aspects.

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The ability of this nation to produce food in abundance is dependent in great part upon several factors among them specifically, (a) mechanization of agriculture, (b) the use of chemical fertilizers, and (c) in agronomic techniques of insect, rodent, fungicide, miticide, weed, and similar controls. The control of insects is extremely important to food production. No plants, few, if any, animals are immune to them. The estimated values of the destruction of crops by insects ranges from 4 to 8 billion dollars annually. The per capita cost of such destruction has been suggested to be as much as \$100 annually. As much as 10 per cent of stored grain is lost or destroyed by insect damage (19). Currently, some 460 million pounds of pesticides are used annually in the control of crop insects (14). The necessity for these applications is so great that experimenters have come to admit untreated control crops are difficult to raise to maturity. The net effect of the use of the various insecticides has been estimated by some to account for the salvation of as much as 30 per cent of the total crop. In spite of the extensive use of the pesticides, the threat of newcomers in the insect world is ever with us (21). There has been a reappearance of the Mediterranean fruit fly in the citrus belt; the Khapra beetle, a grain destroyer, was found in 1953 in the far southwest states area; the spotted alfalfa aphid which is causing as much as 50 per cent destruction in southwestern states, has now appeared in the central and southeastern states; the citrus blackfly, a resident of Mexico, threatens infestation yearly. Some potential insect threats which have not arrived but which have caused devastation to crops elsewhere, include the Dura stem borer, the olive fly, the oriental fruit fly, the spiny bollworm, and the melon fly. Control of these pests ultimately will require further extensive use of pesticides to protect the food crops.

CHANGING NATURE OF THE FARM ENTERPRISE

Still another aspect of this problem of man and his food supply is in the changing nature of the American farm enterprise (4). In the past 15 years, the total output of American farms has increased one-third. The output per man hour has doubled. The number of farms, however, has decreased 15 per cent; the number of people on farms has decreased 27 per cent. In 1800, 80 per cent of the people of the nation lived on farms. In 1940, 25 per cent of the people lived on farms, and in 1956, only 12 per cent lived on farms. Since 1940, about 17 million acres of the nation's better lands have been taken out of production. Some 40 per cent of the nation's farmers now produce 90 per cent of the total agricultural output. It is, therefore easier to sell to, and to transfer to

the fewer agricultural producers, new techniques and new materials for more intensive agricultural production. Not only are fundamentals on insecticides and fertilizers transmitted to farmers, but facilities and know how for the use of rodenticides, fungicides, miticides, weedicides, herbicides, antibiotics, plant bactericides, growth regulators, thinners, and so forth, have become standard tools in farm practices. Literally dozens of such materials have been found useful, necessary, and proven satisfactory within the past decade. Dozens more will be conceived and tested (16, 18, 19). On a world basis, food production has never been geared to the full of its potentialities.

FOOD DISTRIBUTION CHANGES

The manner in which food is distributed has undergone tremendous change in the past 15 years. There have been also, marked shifts in the per capita consumption of various crops; declines in potatoes, and cereals goods, increases in processed packaged juices, and canned and frozen fruits and vegetables. Pre-cooked foods and pre-packaged fruits, vegetables, cereal mixes, meats, sea foods, are now standard diet items. The some 1500 items of the serve and delivery store of a few years ago has increased to 4 to 6 thousand items of the supermarket self service store of today. The social security of the food stock formerly in the home cellar has given way, in our current scheme of life, to a compressed kitchen cupboard, to be implemented with a constant flow of the new and convenient.

It should be noted that the volumes of food in raw crude form in the citrus fruit, or vegetable, areas or in the grain fields and on the hoof, on the western plains, is of no value unless transposed into a useful form, and delivered to the dependent masses elsewhere. Transposition of foods, in a modern concept, involves extensive refining. Moreover, there is an increased time-space interval between processing, distribution, and consumption, that imposes many technical problems.

FOOD AND MILITARY REQUIREMENTS

The impact of food science coupled with the demands of military logistics on food processing is too frequently not recognized. Military campaigns must include consideration of food supplies, both as force material, and as enemy target. Historical nuances in this area might be recalled in the light of the dual use, by Ghengis Khan, of brood mares as beasts of burden, and for fresh milk, and of Napoleon's stimulation of development of synthesized fats, and the genetic up-breeding and extraction of beets for sugar

following the British fleet embargo. Modern warfare, with large masses of personnel, involves tremendous demands on quartermaster qualifications. Among these may be cited the integration of food stores to the timing of campaigns; the logistics of storage, packaging for shipment, of food transportation, adaptability to mobility of forces, dispersion of personnel, of problems of space, of weight, of ease of preparation, of stability of palatability, of variety, and of being served hot. The inventions of the tools of war demand counterparts in foods for the armed forces. Availability, and acceptability of food for the civilian forces now appears to be an increasingly greater problem of military defense logistics. The research developments in foods for military purposes, and in specifications for quartermaster procurement, has its ultimate and lasting effects on foods, and their processed packaged forms, for domestic purposes.

FOOD REGULATIONS

In the light of these aspects, it is necessary to review briefly the development and status of regulations, particularly as they relate to chemicals used in food processing. The use of chemicals in food processing is not new; nor are many of the basic principles of food preservation as used today really new, such as acidification, salting, smoking, drying, cooking and roasting. Many of the techniques of modern food processing are merely extrapolates of so called "natural" techniques used formerly. The laws of Congress on foods are relatively few in number: the Tea Act of 1800; the Federal Meat Inspection Act of 1890; the Adulterated Food Import Act of 1890; the Butter Law of 1923; the Wiley bill of 1906; the Food Drug and Cosmetic Act of 1938, and its subsequent amendments; the Federal Insecticide, Fungicide, and Rodenticide Act of 1947, the Nonfat Dry Milk Law of 1944 and 1956 and the recent Miller Pesticide Residue Amendment to the Federal Food Drug and Cosmetic Act.

The Wiley bill is notable for its specific prohibition of harmful adulteration, and of mis-branding of foods. It was developed to meet problems of extensive economic adulteration of foods. Two outstanding events of the period of development and use of this act were in the methods of proof of harm of chemical preservatives, and in the public debates on the use of certain chemicals as alum in leaveners, and as conditioners of bread dough. The controversies which flared in the technical and news press of the times affected the thinking about chemicals in foods over a period of many years. The Food Drug and Cosmetic Act of 1938 is notable for the change in concept of law from a premise of "caveat emptor" to that wherein a consumer or user of foods has every right in court

to assume its safety and healthfulness. This act, as it pertains to chemicals: (a) specifically prohibits the shipment of foods containing poisonous or deleterious substances; if these are naturally occurring the shipment is forbidden unless it is not injurious, and (b) the use of added substances, if poisonous, or deleterious, is forbidden altogether, except where they cannot be avoided in production or in good manufacturing practice, and then only to the extent permitted by tolerances. The administration is empowered to establish tolerances limited to safe levels of the quantity of additives remaining in foods. Where a poisonous or deleterious substance is not necessary, it cannot be used in any amount, regardless of whether it might be used at a "safe" level. In the two decades of use of the act, during which tremendous changes have occurred in food production and processing practices, in population characteristics and requirements, experience has brought light on several major problems (1, 2, 3, 5, 6, 7, 8, 9, 10, 12, 15, 17). Among these may be cited the following:

1. The blanket terms of prohibition against the use of poisonous and deleterious substances in foods is difficult of interpretation. There is provided no specific delineation between a hazard, and toxicity of chemical substances. Virtually every substance consumed by man has a toxic limit. It is difficult to establish absolute freedom of toxicity of chemical substances except in a relative manner. Ultimate tests would require large population samples of varying age ranges, freedom of usage of foods, and variations of diet.
 2. The ultimate decision, in disputes, is left to courts; the evaluation of toxicity tests in themselves is frequently very difficult, and the possible legal distinction between harmless, and poisonous or deleterious, is difficult to appraise in advance.
 3. The act requires no one to give advance information to the government of the intent to use or distribute a new chemical additive in foods; consequently, an unsafe or inadequately tested chemical could be used for a considerable period prior to its detection, and even then there would have to be developed the evidence that the chemical had poisonous or deleterious, characteristics.
 4. The hazard or toxicity of chemical substances to man must be determined by translation from tests with animals; in many instances the effects may be clear-cut, but in others, there can be involved problems of statistical sampling, the mode of application of the chemical, the level and frequency of dosage, the criteria of measure, and, if necessary, extrapolation of results.
- Because of the many interwoven and new problems

involved in the administration of the 1938 Act, and in the procurement and distribution of foods for an expanding and shifting population, the Congress in 1950, established a Committee known as the Delaney Group Committee, to investigate its uses. In the 1950-1952 period, it held 59 public hearings in various sections of the country and heard 217 witnesses representing various national and smaller organizations. The reports of the Delaney Group Committee were extremely critical, by implication, of the use of chemicals in foods processing, and resulted in a large number of popular press and technical reviews of the problem. Much apprehension evolved because of statements in the reports. In the lay press, for example, a statement, such as that a definite large number of chemicals were used in foods did not clarify the consumers' minds that many of the chemicals are approved for use, nor that the extent to which they are used, and the frequency of use in a diet, should be considered in their evaluation. The Delaney report stated some 704 chemicals were being used in foods.

In the light of importance of the problem, The National Research Council, through its Food and Nutrition Board and its Food Protection Committee, and established subcommittees, undertook a review of certain aspects of the use of chemicals in foods. The Council has published, through its deliberation, several publications evaluating the problem (11). The publication, "The Use of Chemical Additives in Food Processing" deals with a survey of the extent of use, and functional benefits of use, of intentional chemical additives, including transient chemicals, and naturally occurring substances used as additives. The publication, "Safe Use of Chemical Additives in Foods" undertook to delineate the basic principles involved in evaluating safety in the use of chemical additives in foods, basic considerations in evaluating hazards encountered in the use of pesticides on foods, and in the development of new agricultural pesticides for food production. The publications: "Principles and Procedures for Evaluating the Safety of Intentional Chemical Additives in Foods," "The Safety of Artificial Sweeteners for Use in Foods," "The Safety of Polyoxyethylene Stearates for Use as Intentional Additives in Foods," and "The Safety of Mono- and Diglycerides for Use as Intentional Additives in Foods" are further considerations of this large problem. These have become guiding references in appraisal of the subject.

During the past session of Congress, a number of bills have been introduced for the purpose of clarifying the use of chemicals in or on foodstuffs. The Pesticide Chemicals Amendment was enacted in 1954. This amendment applies primarily to incidental additives and recognizes forthwith that dusts and sprays *are*

necessary to a continuing supply of food, and is designed to permit effective use without hazard to the consumer. The procedure required in the Act of 1938 involved a requirement of hearings to establish need for the chemicals. The 1954 Amendment provides that a raw agricultural commodity bearing a chemical residue shall not be marketed unless (a) the chemical is recognized as safe under conditions of use, (b) on the basis of scientific evidence, a safe tolerance for residues is established, or the chemical exempted and, (c) if tolerances are established, the residues remaining are within the tolerance level. Several proposed bills (Priest, O'Hara and Miller) on intentional additives in foods were not passed, and are subjects of much review. The areas of consideration center upon:

1. The definition of an additive.
2. The adequacy of pretesting of an additive.
3. Safety standards, and the establishment of tolerances.
4. Methods of appeal from decisions concerning the safety of proposed additives: both injunctive procedures to prohibit use of specific chemicals by the enforcement agency and, declaratory judgment by the court requiring evidence for consideration, and license procedure, have been proposed.
5. The use of reference scientific advisory Committees to evaluate submitted scientific evidence; this technique already has been provided for, and used, in the Pesticide Amendment.
6. The provision of a time limit within which decisions upon applications for use of chemicals must be considered.
7. Evidence of the utility of a chemical whether of toxic character, or not.

Undoubtedly, further proposed legislation will be considered on the need for and mode of use of intentional food additives. The beneficial use of nutritional additives has been well established. It is certain that with increased problems of translating raw food materials into forms for use at some other time and place, food technology must be encouraged to make the best and realistic use of every facility, with every reasonable safeguard, in the development of foods for public health at low cost, and with the enjoyment of high nutritional quality.

Many new chemicals have been produced in the past decade, and more are in prospect. Functions of these chemicals are uncovered applicable to foods uses. Much research is necessary to establish the facts required on the safety, hazard or toxicity of the individual chemicals. Generally speaking, the nutritional and other economic qualities of foods have been improved through the use of chemical additives.

There need be no hazard in the use of chemical additives in foods provided appraisal of their characteristics and biological limits is made prior to their use. The aspects in the requirements of man for food must be considered in our evaluation of food provided to man.

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