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Preservation of foods by irradiation is a topic of keen interest today. The problems of this radically new process are reviewed in the following paper from the point of view of the Armed Forces, and a description is given of the program which has been developed to deal with them.

PRESERVATION OF FOODS BY IRRADIATION

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Military Needs and Food Irradiation

THE FEEDING of members of the Armed Forces is an important factor in effective operations. Not only must the food be nutritious but it must have an appeal that gives satisfaction to the consumer. The American soldier likes food variety; he likes a satisfying meal, and he likes to have it where he is and not at some inaccessible point. The concepts of military operations are changing rapidly, from concepts of static or slow-moving operations to those of extreme mobility, from concepts of concentrations in strength to those of dispersion with even greater strength. With these new concepts has arisen the necessity for versatile and effective new means of supply, one of the important segments being that of food supply.

To meet such a challenge it has become necessary to embark on a program of investigation to determine the best means of supplying food to operational troops, on land, in the air, or under the sea. To meet the need of the modern military forces the food must be nutritious, light in weight, occupy a minimum of space, be extremely stable without refrigeration, and be palatable to the soldier over a considerable period of time. Studies have led to improvement of existing ration items, the development of new types of items, and investigations into entirely new types of products. From these studies have come liquid foods and semisolid foods for the feeding of airmen at high altitudes, dehydrated precooked foods that require only the addition of water to prepare a complete meal for ground troops, and ration-dense foods for seamen. One of the boldest approaches contributing to solving food problems in this area is the use of ionizing radiation to preserve food items. This paper is concerned with this particular approach to the provision of ration items for the Armed Forces.

Successful preservation by irradiation would offer several advantages not apparent in other types of preservation. For example, preservation by ionizing radiation is a "cold process" and, therefore, can be used on foods sensitive to thermal processing. Also, such items as roast pork, fried chicken, bacon, or sandwich components can be preserved in their natural states without much change in flavor or loss of texture such as would be characteristic of thermal processing. While the density or weight of this type of food item can be altered very little other advantages indicate that this method of preservation would prove advantageous in certain areas.

Development of the Research Program

When the initial work was started on the use of ionizing radiation for food

preservation very little was known of the public health aspects, the effect on nutritive substances, or the means of reducing the method to practicable application to food processing. A great deal of basic scientific information was necessary before several of the questions could be answered, and since it was not practical to undertake all the investigations necessary to such a program within the laboratories of the Armed Forces a large contract research program was instituted under the guidance of the Quartermaster Research and Engineering Command, Office of the Quartermaster General.

The basic areas where information was required were delineated and research in these areas was started, under contract, in many university laboratories, industry laboratories, and in private research organizations. Such work included studies on the chemical changes in foods during irradiation, the sensitivity of various microorganisms to irradiation, changes in flavor and texture, and the very important area of effect of irradiation on the wholesomeness of treated foods. The latter area became a "must" in the program since the existence of any acute or residual toxicity or the adverse effects from eating such foods must be determined before approval would be provided by the Surgeon General for consumption of such food by troops.

The entire program was designed to cover a wide variety of research areas and to be comprehensive enough to obtain answers necessary to put such a process into operation should it prove to be advantageous to the system of Armed Forces food supply.

The food irradiation research program involves extensive work in several areas. During the year, July 1, 1957, to June 30, 1958, there were about 45 contracts involving the transfer of funds, 40 cooperative contracts with industry and 30 contracts in the area of wholesomeness under the supervision of the Office of the Surgeon General.

The Quartermaster Food and Container Institute for the Armed Forces is charged with the job of getting the research done and bringing together the threads of results of such research into a fabric of facts and information. While this tapestry is far from completed it presently reflects many facts and accomplishments and indicates a pattern for certain future developments. These include the proving of the process under a commercial type of condition. It has been truly a cooperative effort involving several hundred workers in many scientific disciplines. Some of the research and the accomplishments will be reviewed here.

The Process

One of the major requirements of a preservation method is that it kill microorganisms which cause deterioration and spoilage. Studies on the use of ionizing radiation indicate that the killing dose to insure preservation against spoilage by various types of microorganisms is about 250,000 rads for molds and yeasts and three to four million rads for spore-forming spoilage bacteria, other than Clostridium botulinum. From a public health point of view assurance of the killing of Cl. botulinum is very important. In the case of radiated foods the sterilizing dose must be based upon the killing of this organism as investigations have shown that this spore-forming microorganism is the most difficult to kill. In thermal processing certain spoilage organisms may survive a treatment that kills all Cl. botulinum but, with irradiation treatment, the reverse is true. Research calculations indicate that the required dose of irradiation to insure safety is approximately 4.5 million rads in foods above pH 4.5. This has been set as the present standard treatment, but some of the current research effort is directed at finding ways of lowering the dose required to sterilize.

The control of insect infestation, prevention of molding in acid products, sprout inhibition in vegetables and the extension of "shelf life" at cool storage temperatures can be accomplished at low doses of radiation and will be useful in meeting certain food supply problems. Under conditions where refrigeration is available radiation treatment offers possibilities of marked extension of storage life.

In order to assure that a given radiation dose actually is received by the food considerable work has been done in the area of radiation dosimetry. To make a given treatment practicable, it is necessary not only to have control over the application of the radiation but also to measure accurately the energy absorbed. The research program has developed a system of dosimeters of considerable accuracy for use in food irradiation. Ceric sulfate dosimeters for doses above 200,000 rads and cobalt glass for doses below 500,000 rads have been selected as the operating standard for integrated delivered dose. These dosimeters are in turn standardized against the Fricke (ferrous sulfate) dosimeter on a specially designed calorimeter.

It also is desirable to monitor the radiation source continuously for instantaneous dose rates. This is to be accomplished by elaborate variations of an ionization chamber.

In addition, it is mandatory to know that each and every food package has, in fact, gone through the radiation equipment. For this purpose a rough go-no-go-type of dosimeter is used. Here a definite color change in a dye indicates that the parcel has been irradiated. This information, coupled with that obtained by use of the radiation monitor and the precision dosimeter, leaves no room for error in determining that a given food parcel has received the radiation dose which was intended for it.

The amount of radiation necessary to inactivate the natural enzymes of plant and animal tissue exceeds that necessary to kill microorganisms. Since adverse flavor and texture changes increase as the radiation dose is raised it is advantageous to use the lowest dose possible to prevent spoilage. Enzymes can be inactivated by heating to a much lower temperature than that necessary to kill bacteria. Therefore, the most practicable approach to the problem is to preheat the food product to a point where the enzymes are inactivated and then to irradiate to the level necessary to kill the microorganisms. This is proving of value in foods that are sensitive to severe thermal processing. Such heating can be in water, live steam, or dry heat such as in an oven. Sterile products that undergo rapid deterioration at room temperature due to enzyme activity will remain in excellent condition if preheated prior to irradiation.

Two noticeable defects caused by irradiation in certain foods are the development of changed or off-flavor and a softening of the texture. These are aggravated by higher doses of radiation. The flavor defect is quite noticeable in beef and since beef is a very important item in the diet of the soldier, major effort is being exerted to solve problems encountered with this item. Pretreatment methods, elimination of oxygen from the package and absorption of certain odors within the package are showing considerable improvement in some irradiated products. It has also been demonstrated that the removal of certain volatile compounds formed during irradiation by vacuum distillation markedly improves the flavor quality of irradiated milk.[1]

Packaging for Irradiated Foods

Protection against deterioration and spoilage and reduction in weight and

over-all dimensions of packaged items are objectives of the Armed Forces supply system. Considerable saving in weight and reduction in cube could be attained if flexible film packaging could be substituted for the metal container used at present. Considerable work has gone into the investigations of flexible film packages for irradiated foods. Many problems have been encountered such as the evolution of odors from the film during irradiation, difficulty in obtaining satisfactory seals, stress cracking and stability of the films. It is necessary to have a package that cannot be penetrated by insects or by bacteria, has extremely low moisture and oxygen transfer rates, and will withstand a reasonable amount of rough handling. At the present time the metal container is the only satisfactory container for irradiated foods, although rapid strides are being made in overcoming some of the difficulties encountered in the use of flexible films.

Acceptability Testing

The acceptability of food items plays an important part in the morale of a soldier and in maintaining good nutrition. The men will not eat food of low acceptability and, in consequence may lose effectiveness because of poor nutrition. Radiation-stabilized foods are subjected to palatability testing at each stage in the development of an item. When a product of potential military value has been developed it becomes necessary to present it to larger taste panels and to troops representative of those that may eventually subsist on such an item. To accomplish this extensive testing, plans of procedure are drawn up and the food items fed to volunteer troops by the Field Evaluation Agency, a division of the Quartermaster Research and Engineering Command, at Ft. Lee, Virginia. The radiation-stabilized product is fed as a part of a full meal. The men do not know which is the test item. They are asked to evaluate all of the items on the menu according to a nine-point scale designed to represent acceptance from "like extremely," to "dislike extremely." To date two radiation-stabilized meat items stored at room temperature for more than six months have been tested by such a troop panel with very encouraging results. No significant differences were found between the acceptability of such radiation-stabilized products and the same items prepared from fresh material. Other radiation-stabilized foods will be troop-tested as rapidly as they can be prepared and volunteer troops are available.

Assurance of Wholesomeness

The Research and Development Division, Office of the Surgeon General, has been supervising a very energetic and comprehensive program to establish the wholesomeness of radiation-stabilized foods. The work is being carried out at the U. S. Army Medical Research and Nutrition Laboratory and through the efforts of some 30 contractors. This is probably the most extensive investigation of its kind ever undertaken. The objectives of these wholesomeness studies are to demonstrate that foods preserved by ionizing radiation for human consumption (1) cause no untoward physiological response, (2) are nutritionally adequate to maintain normal physiological functions incident to all life processes, (3) are not carcinogenic, and (4) do not cause maladjustments in enzyme systems which may represent incipient disease. To accomplish this, radiation-stabilized foods are subjected to both short-term and long-term feeding studies using several species of animals (dog, rat, monkey, and chicken). When these studies have been completed the program is designed to proceed to longer term human-feeding studies using volunteers. It is planned to have these test subjects receive up to 95 per cent of their calories in the form of radiation-stabilized food over a definite test period.

This wholesomeness program will involve complete tests on approximately 21 foods and will be completed in about two years.

It can be seen that every effort is being made to cover adequately every facet having a bearing upon the health of the consumer. Studies to date have not revealed any untoward results in the foods under test.[2] A very careful analysis will be made of all data obtained before any clearance can be given to permit the inclusion of radiation-stabilized food in the normal diet of the soldier.

Application to Production

To be successful any method of food preservation must show potentials for production by industry. The radiation of foods is a new process and its practicability must be demonstrated not only to produce palatable, wholesome and nutritious food but also that commercial production is practicable and economical. To that end there is presently being planned a U. S. Army Ionizing Radiation Center. This planning is being done by the Radiation Planning Agency of the Quartermaster Research and Engineering Command. This food irradiation facility will be constructed at the Sharpe General Depot near Stockton, Calif., and is scheduled to start operation during the latter part of 1960. The plant will be of such capacity that practicable demonstration can be carried out in putting into production the treatments and systems evolved from the research and development programs described above and in obtaining economic data of value in estimating processing costs. It will be necessary to design, build, and demonstrate equipment and systems never before used in the food industry. Such demonstrations are necessary before the Armed Forces can profit from the advantages offered by the food irradiation process.

Summary

A radically new process for the preservation of foods is under investigation by the Armed Forces to determine its potentials in solving certain problems of food supply to troops. The Irradiation Preservation of Foods Program is a cooperative endeavor involving many workers in several fields of science. Studies are under way to prove the practicability of the process, the development of irradiated ration items of value to the military, and the proof of wholesomeness and public health significance of foods treated by this method. The objective is to produce wholesome, nutritious, and palatable types of foods that will keep without refrigeration or if radio-pasteurized will have a longer storage life under refrigeration, and to produce types of food not now available to troops.

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