Radiation Sterilization of Foods

by

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RADIATION STERILIZATION OF FOODS

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The discovery of a new tool, a new method or a new principle often sets off a wave of speculation about the impact of the new discovery on adjacent areas of interest. The appearance of atomic power on the scene in the Hiroshima incident engendered just such an effect—first with regard to the destructive effects which might be expected in full scale military use of atomic power and then, as further developments occurred and the latent possibilities of the new tool were brought into focus, in considering the broad spectrum of peace-time uses.

The possible use of atomic power for constructive purposes has roots which extend deep into the scientific literature. Radium and X-ray therapy are two outstanding examples of the use of atomic emanations which have been very fruitful.

The effect of radioactivity on biological systems has many facets, among them the field of food irradiation. Advances in food research have indicated that preservation of food by heat, dehydration, fermentation, addition of chemicals and biologicals most often produces a product possessing a set of characteristics radically different from those inherent in the fresh product.

As a result, the discovery of a method for preservation of food which would leave the quality of the fresh product virtually unaltered has been a constant motivation to food technologists. Sterilization of foods by irradiation with beta or gamma emanations appears to offer promise of attaining this goal.

The work of researchers in industry, academic institutions, the Atomic Energy Commission, and other agencies has currently developed food irradiation to a point where some of the highlights are clearly evident.

At present atomic power of high intensity is available from mechanical accelerators as well as from fission products. The future promises to provide more powerful accelerators as well as a continuous and growing source of fission products. Research adds daily to our understanding of the characteristics of this powerful tool.

In its present state of development, food research has indicated how much energy is necessary to attenuate or destroy types of microorganisms important in the preservation of food. It has also shown the possibility of eliminating insect infestation in certain cereal products. Enzymes have been found highly resistant to radioactivity and with most food products, the effect on odor, flavor, and color has been found to be destructive in one or another degree.

These facts were confirmed in a survey conducted by the Quartermaster Corps in April of 1953. A need for integration of efforts was noted and the decision was made to set up a program which would bring together scattered efforts and provide impetus for research aimed toward proving that preservation of food by irradiation either is or is not a reasonable possibility.

The responsibility for conducting this program was placed with the Quartermaster Food & Container Institute, and in cooperation with the Atomic Energy Commission and researchers in this field, plans were made for carrying on the project.

Areas in need of attention were:

1. The cause of off-flavors and odors, to determine the nature of chemical changes in foods due to irradiation.

The opinion of workers in the field of food irradiation appears to be practically unanimous with regard to the effect of irradiation on the flavor of food. No case has been reported in which the flavor has been enhanced by these means, and in most instances off-flavors commensurate with the amount of irradiation applied have been noted. It is for this reason that studies of off-flavors and odors have been placed high on the list of priorities. In this complex situation, the most profitable approach appears to lie in the direction of determining the mechanism of changes in odor and flavor in the hope that knowledge of this mechanism will lead to the formulation of methods for the control or elimination of such negative effects.

From a technological point of view, it may be profitable to survey reactions of all of the important food items to the various levels of irradiation which it is now possible to use to determine whether there are some important commodities which will survive either pasteurization or sterilization processes without the accumulation of sufficient quality losses to make them unacceptable.

2. Fundamental research on the nature of volatile off-flavors and odors of irradiated food to provide means of identification and elimination.

A slightly different approach to the flavor problem, and certainly not a new one, lies in identifying the chemical constituents of flavors and odors produced by irradiation. Again, the objective is to use this information, if possible, in prescribing methods for the use of radiation processes which will eliminate off-odor and flavor.

3. Further work on the mechanism of destruction of insects.

Research to date on the destruction of insects has indicated that these organisms may be killed with relatively small amounts of irradiation. Considering the importance of ridding such commodities as stored cereal products of insect infestation without altering the useful properties of the product, it is clearly important to have further details concerning the application of irradiation to the various types of insects and commodities ordinarily involved.

4. Microbiological studies on food poisoning and spoilage organisms.

The microbiology of food spoilage is a well developed area of science which has been remarkably productive in allowing the production of a wide variety of satisfactory food products. As with any new process however, it will probably be necessary to ramify and extend our knowledge in this area for assurance that the concepts already established with regard to food commodities conventionally processed will hold also in the field of irradiation.

5. A comparison of the chemical effects of irradiation of foods by (a) cathode rays and X-rays and (b) fission products to determine whether one type possesses any singular advantages in food preservation.

Physicists, in general, appear to agree that the prospects of important differences in effect from the several radioactive emanations available for

processing are very unlikely. At the present time, however, there does not appear to be any complete evidence for or against this stand. This fact, coupled with the inherent characteristics of the machines or fission product sources dictate the necessity for some attention to this area.

6. Studies to determine the mechanism of enzymic changes in foods as affected by irradiation.

Work on enzyme systems has already given considerable indication that inactivation of many enzyme systems requires considerable more irradiation than is necessary, in general, to kill bacterial spores. Further work is needed to determine the effects of enzyme systems on quality.

7. A study of the effects of irradiation on the quality of pre-processed foods.

It may be possible to combine conventional processing techniques with irradiation to produce products possessing quality characteristics better than those which would be found in the product completely processed by either means alone. Considering the number of important foods and useful processes already available the testing of these combinations in differing proportions is one which may require considerable effort.

8. Toxicological studies designed to determine wholesomeness of irradiated foods and to determine whether residual radioactivity is a problem.

In initiating any new process for foods it is always necessary to determine whether nutrients are destroyed and whether toxic substances are formed. Information available at the present time indicated in general only a small loss in nutritive value for the foods investigated and gives no indication of the formation of toxins. Taking into account the nature of the ionizing radiations used in the irradiation process, however, it is reasonable to be more than ordinarily militant about possible changes in these two areas. As a result, effective precaution will be exercised in work on this portion of the problem.

9. Research on vitamins and other food components to determine the extent of losses due to irradiation.

Research on vitamins will, of course, be very similar in scope to the other categories in this group which deal with the mechanism of chemical changes due to irradiation. Work on other food components in this area may be centered on the use of purified chemicals such as proteins, amino acids, etc.

10. Determination of the quality and acceptability of irradiated foods.

Determination of acceptability is a dominant note in most of the research carried on at the Quartermaster Food & Container Institute. It is equally important in this project because ultimately the utility of any process involving irradiation will be measured directly in terms of acceptability of the final product to the military personnel using it.

11. A study of the chemistry, microbiology, and acceptability of irradiated foods in long-term storage.

This is another familiar item in Army ration research. Its emphasis arises from necessities for long supply lines, far-flung storage operations, and widely varying climatic conditions encountered in military operations. All these things combine to emphasize the need for food items with high stability for military use. It is very likely that the same criteria that usually are used in judging new developments for the stability of Armed

Forces rations will be applied in this case.

12. Evaluation of present containers and study of new containers suitable for radiation processing.

It is difficult to guess at the moment what the requirements will be for containers for irradiated food products. In common with other processes however, a container will be necessary which will prevent recontamination of the food after processing and which will allow most efficient use of the radiation process in promoting sterility. For this purpose it may be necessary to investigate the use of plastic or other special containers which may be found to have especially favorable characteristics.

13. Investigation of asceptic processes for use in conjunction with irradiation.

One possibility which presents itself in connection with irradiation is the use of asceptic filling and closing operations to be applied to the already processed food item. At the present time and with conventional processes this method has found use primarily with liquid products but might conceivably be used for solid or semi-solid items which have been rendered sterile by irradiation.

14. Provision of radiation service to collaborators in the project.

This is not a research category but has been set up instead to service research teams and provide them with irradiated material which has been treated according to the needs of the experimentor. Difficulties in carrying out such a supply operation are many and are quite plainly apparent. The alternative, however - that of having adequate radiation facilities at each location where research is done - is at present certainly no more attractive. A great amount of effort will have to be placed in this area to assure a smooth and effective operation.

From these fourteen areas four were selected for immediate activation. These are:

1. Mechanism of off-odor and flavor development.
2. Toxicology.
3. Technological studies.
4. Supply of radiation energy.

Mechanism of off-odor and flavor development has been sub-divided where possible, to give emphasis to research on the important food components such as fats, carbohydrates, and proteins. Each part of the work is being done by research teams possessing special capabilities in one of these fields.

The objective is to find out which chemical systems contribute to quality losses and the mechanism of the changes involved with a view to finding methods for their prevention.

Studies of toxicology and nutritive changes are being conducted in direct cooperation with the Office of the Surgeon General, U.S. Army, since this group has the responsibility for the protection of the soldier's health and in addition has the trained personnel necessary to carry on these studies.

Technological studies are designed to include work on the effects of the physical characteristics of the source and the method of treatment on food commodities as well as investigations of stability and acceptability of the final product.

Energy level, dose rate, geometry of the source, effective intensity, and the duration of irradiation treatment are under study. Results avail-

able at present have been accomplished using only relatively low intensity sources over long periods of treatment. With the higher intensity sources now available, it is hoped that more rapid progress may be made and, in addition, that the effects of the physical characteristics of the source and method of treatment may be catalogued for all of the food items of importance in Army rations.

Evaluations of irradiation processes require for their implementation sources of supply of food materials treated according to experimental plans evolved by collaborators in the program and designed to fit a specific pattern of research. It is intended that this supply operation will be maintained by the Quartermaster Food & Container Institute in close cooperation with individual research groups.

Within the next fiscal year, efforts will be made to activate virtually all of the areas of interest originally outlined, as well as to continue support of those areas now in action.

As soon as research makes processes available for preparation of a highly acceptable food product, these processes will be tested on a commercial scale to determine industrial feasibility.

The economic picture, while not yet complete, suggests decreased costs for both machine and fission product energy.

If decreased energy costs can be coupled with savings in quality resulting from radiation sterilization of food commodities, the result should be an important advance in food preservation.