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Report of

ACCEPTABILITY OF IRRADIATED FOOD CONSUMED BY HUMAN SUBJECTS

by

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OBJECT:

To estimate acceptability of radiation preserved food items by human subjects.

SUMMARY:

Irradiated foods were fed to nine or ten human test subjects in four separate studies. In the first study irradiated foods provided approximately 35 per cent of the total calorie intake; in the second, 61 per cent, in the third, 80 per cent; and in the fourth study, 100 per cent. Acceptability data was obtained by use of questionnaires with an arbitrary hedonic scale, and by personal interviews with the individual subjects. Statistical analysis of the acceptability data showed significant differences between irradiated and control food in only 10 out of 42 items. Control foods were preferred to irradiated foods in nine of the 10 cases.

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INTRODUCTION

Radiation sterilization of food offers a new outlook in the field of food preservation (4, 8). Such sterilization is accomplished simply by the treatment of food products with gamma or beta rays from radioactive isotopes, or with x-rays (20). It should be emphasized that foods preserved by radiation sterilization are not radioactive (10).

The objectives underlying any method of food preservation are to check or delay chemical and enzymatic changes and growth of micro-organisms which would either produce an undesirable or a spoiled product. In canning, these objectives are accomplished by high temperatures; in freezing, they are attained with low temperatures; and in the case of irradiation, which is often referred to as cold sterilization, they are effected with hardly any rise in temperature.

As part of the general program of evaluating this method of food preservation, animal and human feeding experiments of irradiated food have been periodically conducted at this Laboratory since May, 1954 (9, 16, 17, 18). The present studies were devoted primarily to the detection of possible toxic effects of irradiated foods on human subjects. In addition, data on the acceptability of irradiated to non-irradiated foods have been collected as a part of the main study.

METHODS

Four feeding experiments were performed. Eighteen young men in good physical condition served as test subjects in groups of nine or 10 in each experiment. The subjects were conscientious objectors, between 19 and 20 years of age from farming communities in the Middle West. The first three experiments were metabolic balance studies, requiring complete consumption of food which averaged approximately 3200 Calories daily. The fourth study was not a balance study and, therefore, greater latitude in the preparation and serving of the food was permitted. However, subjects were required to consume all food served. The percentage of total calories supplied by irradiated food in each study was approximately as follows: first, 35 per cent; second, 61 per cent; third, 80 per cent; and fourth, 100 per cent.

Each study consisted of two 15-day periods. Three daily menus (Tables I, II, III) were rotated in the first three studies and five daily menus in the fourth study (Table IV). During the first 15-day period, one half of the subjects consumed the diet containing irradiated food, while the other half consumed a similar diet containing non-irradiated food. This pattern was reversed during the second 15-day period. The subjects were not told which foods were irradiated and which were not.

Forty-two foods, cleared by previous animal feeding experiments, were incorporated into the diets and are listed in categories as follows:

Meats: Bacon (ground and sliced), beef (ground and steak), corned beef, frankfurters, ham (ground and steak), haddock, salmon, sausage, shrimp, tuna.

Vegetables:	Asparagus, beets, Brussels sprouts, cabbage, carrots, cauliflower, celery, corn, green beans, Lima beans, mushrooms, peas, sweet potatoes, white potatoes.
Fruits:	Apricots (dried), cherries, melon balls, peaches, pears (dried), strawberries.
Cereal Products:	Bread, crackers, cereal bar, macaroni, nut roll, pound cake, rice.
Other Foods:	Dessert powder, peanut butter, powdered whole milk, strawberry jam, sugar.

All irradiated and control foods were ordered through the Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois.

Food items, except white and sweet potatoes, were placed in No. 2 or No. 10 cans. The cans of each item of food were numbered consecutively. All odd-numbered cans were shipped frozen by air freight to Dugway, Utah, or Arco, Idaho, to be irradiated. The even-numbered cans were shipped in the frozen state directly to this Laboratory to serve as control items. Potatoes, white and sweet, were irradiated in their original containers (boxes or gunny sacks) and stored at room temperature. The food which was neither irradiated nor control was purchased through the Post Commissary. Radiation sterilization of the food was effected with mixed fission products consisting essentially of a gamma ray source. All the irradiated foods were irradiated at 3×10^6 rep, with the exception of white and sweet potatoes which were irradiated at 20,000 rep. In the case of potatoes, the primary purpose was to prevent sprouting and, therefore, increase storage life, and this could be accomplished at the lower dosage level (22).

Since the first three irradiated food studies were balance studies, the methods of food preparation were limited. Foods to be cooked were weighed raw into individual containers and cooked with the addition of seasonings (salt, pepper, onion salt and celery salt).

Attempts were made to disguise two foods in which an objectionable flavor was present in one and an extreme color change in the other. An undesirable off flavor is produced in milk with radiation sterilization (1). In these studies it was of primary concern that all food be consumed by the subjects. This was accomplished by addition of cocoa and sugar to the reconstituted powdered milk in an effort to make the bitter taste undiscernable. Strawberries were the only food item in the initial studies which exhibited a marked color change with radiation sterilization. To prevent detection of the color change of the irradiated fruit in the first study, the strawberries were incorporated into carmine colored jello, and in the second study into strawberry jello. In the third and fourth studies in which additional foods with radiation induced color changes were served in the diets, the strawberries were served in their original form.

Acceptability data was gathered by the use of a hedonic scale questionnaire, and by a personal interview with the individual subjects. The subjects

filled out acceptability forms after each meal during the first and last three days of each 15-day period. During the first and second irradiated food studies, a nine-point hedonic scale (7) was used (Table V). However, since the subjects had not been chosen for their ability for taste discrimination, the investigators and the subjects felt that a simplification of this scale to five points would give a better indication of preferences. Such an abbreviated scale was used in the third and fourth studies (Table VI).

At the end of a study, each subject was interviewed in order to gather any impressions of differences they noted in color, texture, flavor, and odor between foods served. All items on the menu were discussed to avoid indicating to the subjects which items were irradiated.

RESULTS

The average values on the acceptability scale for irradiated and control foods are given in tables VII, VIII, IX, X. It can be seen that vegetables whether irradiated or control, in general, were not well liked. Analysis of variance (21) of these data show that only 10 of the 42 food items served had statistically significant differences in acceptability. Table XI presents a summary of foods in which significant differences were encountered between the irradiated and control food items. They were bread, cauliflower, crackers, dessert powder, macaroni, melon balls, pound cake, powdered whole milk (flavored with cocoa and sugar), rice and strawberries. Where significant differences occurred, control food was preferred to the irradiated food in all cases except one.

Tables XII, XIII, XIV, XV summarize differences in color, texture, odor and flavor between irradiated and control food observed by the subjects. The majority of subjects stated that they noted little or no difference in apricots, bacon, beets, cereal bar, corned beef, ground beef, haddock, ham, Lima beans, mushrooms, nut roll, peas, sausage, shrimp and white potatoes. Very few odor differences were observed. The major differences in irradiated versus control food items were in color, texture and flavor.

DISCUSSION

Some of the problems encountered in the irradiation sterilization of foods are the changes in color, flavor, texture, and odor that occur during the processing (2, 6). Many obvious changes between irradiated and control foods included in these studies were noted. White items such as cauliflower, crackers, macaroni, powdered milk, and rice acquired a yellow to tan cast upon irradiation. Fruits with red pigmentation (anthocyanins) displayed a variable loss of pigmentation. Strawberries became a pale pink, while cherries lost their bright red color and developed brown spots. A slight bleaching of some green vegetables (Brussels sprouts, Lima beans) was apparent. Of course, some bleaching of green vegetables occurs also in heat sterilization.

Texture differences were observed in vegetables and fruits. Vegetables, upon irradiation at 3×10^6 rep became softer, similar to the appearance of precooked vegetables. In correlation with this softer texture of irradiated

vegetables, Hannan (5) has found that the cooking time of these vegetables may be decreased by as much as 20 to 50 per cent. Irradiated fruits (strawberries, peaches, melon balls) were softer, "mushier" and, upon draining, were found to yield a greater percentage of juice as compared with fruits which had not been irradiated. Irradiated rice did not "fluff up" on cooking as did control rice.

Reports on the acceptability of some irradiated foods obtained from taste panel tests have been published (3, 12, 13, 14, 15). In such tests, the trained panel member tastes only a small portion of the food, and usually does not swallow it. The series presented here represents acceptability of irradiated food actually consumed by human subjects.

Limiting factors that may affect the interpretation and wider application of these acceptability data are: first, the subjects were untrained in procedures or techniques used in taste panels; second, they were men with an average age range of 19 to 20, from Middle West farming communities, whose scope of acquaintance with a large variety of different foods is perhaps limited; and third, the foods served on three of these studies had to be prepared so that they could be incorporated into a balance study, thus restricting methods of food preparation which contribute to the aesthetic appeal of the diet.

The personal interview relied heavily on the subject's ability to recall food that had been served over a 30-day period. However it must be remembered that only three or five rotating menus were used during an entire study. Therefore, the subjects consumed individual irradiated foods often enough to become familiar with them. Nevertheless, it is possible that if the subjects had been consuming irradiated and control food at the same time, they would have discerned more differences between the irradiated and control foods.

Five of the 10 foods in which a statistical significant difference was noted in acceptability between the irradiated and non-irradiated items belong to the cereal product group. They are bread, crackers, macaroni, pound cake, and rice. The primary objective for irradiating these items will be for the control of insect infestation (4). This is accomplished at a considerably lower radiation dosage (11) as compared with the 3×10^6 rep used on this study. Thus, it may be possible that with lower levels of irradiation these differences may be avoided.

No significant differences between the irradiated and non-irradiated items were observed in meats or fish. However the personal interview showed that some flavor differences were noted by the subjects. Schweigert (19) has found that meats which were irradiated at 2×10^6 rep had a different taste, but that this taste was not objectionable.

There was an indication as the studies progressed that the subjects who had been on previous studies became more sensitive in distinguishing differences between the irradiated and control food items. In general, flavor differences seemed to affect acceptability to a greater degree than color, texture or odor. Although there is a distinctly "different" odor in many of

the irradiated foods (particularly in meat and bread), few odor differences were noted by subjects.

The food items most acceptable to the subjects were meats and fruits, whether irradiated or control.

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