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Report of

AN ASSESSMENT OF THE POSSIBLE TOXIC EFFECTS TO HUMAN BEINGS OF SHORT-TERM CONSUMPTION OF FOOD STERILIZED WITH GAMMA RAYS

by

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Conclusions stated are subject to change on the basis of additional evidence.

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AN ASSESSMENT OF THE POSSIBLE TOXIC EFFECTS TO HUMAN BEINGS OF SHORT-TERM CONSUMPTION OF FOOD STERILIZED WITH GAMMA RAYS

OBJECT:

The assessment of possible toxic effects to human beings of the short-term consumption of food exposed to gamma rays at a dosage of 3 million rep.

SUMMARY:

Eighteen human volunteers consumed for short periods of time (15 days) food exposed to 3 million rep gamma rays and stored frozen until used. Four such studies were conducted in which 35%, 60%, 80% and virtually 100% of the calories were supplied by irradiated items of food. These studies were separated by intervals of several months. Careful clinical and laboratory observations revealed no evidence that these irradiated foods produced any toxic effects in the human beings consuming them.

RECOMMENDATION:

Further tests should be made in human beings of the safety of a wider variety of irradiated foods, and also of irradiated foods which have been stored at room temperature.

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INTRODUCTION

The two major objectives of food preservation are the destruction or inhibition of micro-organisms and of proteolytic enzymes. In canning, both bacteria and enzymes are destroyed by heat, while in freezing the action of bacteria and enzymes are effectively retarded. The treatment of food with ionizing radiation in sufficient dosage to kill micro-organisms offers a new approach to food preservation.

Important sources of ionizing radiations now available for this purpose are high voltage electron accelerators and gamma emitting radioisotopes from atomic reactors. Micro-organisms are effectively destroyed in food which is irradiated at a dosage of one to three million roentgen-equivalents-physical (rep) (20). At a dosage of three to 10 million rep the enzymes in food may be inactivated. Doses far smaller than these are effective in controlling insect infestation of grain (5), in destroying trichinae in meat products (6), and in preventing the sprouting of potatoes and onions (2, 23).

None of these levels of radiation are sufficient to induce radioactivity in the food so treated. However, some chemical changes are produced which, although of small magnitude, are detectable and result in changes in flavor, texture, color and odor. There are three potential hazards to health from the chemical changes in food induced by ionizing radiation. The first is the destruction of essential nutrients such as vitamins and amino acids (1, 7, 19). The second hazard is the production of toxic compounds (9). The third is the production by irradiation of substances which upon prolonged ingestion may be carcinogenic (24).

The Office of the Quartermaster General of the United States Army has organized an elaborate program to explore the potentialities of the use of radiation in food preservation. The investigation of the nutritional aspects and possible toxic effects of such irradiated foods is under the auspices of the Office of the Surgeon General of the United States Army. Individual irradiated foods are first fed to animals (8, 15, 16, 17, 18). If there are no detrimental effects in animals, the palatability of such foods is evaluated by a panel of professional testers. These individuals are under continuous careful medical supervision. Foods considered palatable are then fed to human beings. The present report describes the results of four feeding studies performed on the Metabolic Research Ward of the U. S. Army Medical Nutrition Laboratory, Fitzsimons Army Hospital, Denver, Colorado.

Irradiated foods were fed to human volunteers for periods of 15 days. The men who received these foods were followed carefully by physical examinations and clinical laboratory tests for a period of a year after feeding. It is obvious that this program cannot be expected to detect nutritional deficiencies or possible carcinogenic effects. The tests should, however, detect the presence of significant amounts of chemical compounds resulting from irradiation which could produce toxic changes manifested after a short latency period. It must also be pointed out that the irradiated food used in these studies was stored frozen until used. The study, therefore, is not a test of the ability of

irradiation to preserve food but only of possible health hazards of irradiation alone. The acceptability of the foods used in these studies and the measurements of metabolizable energy and digestibility of the macronutrients are reported elsewhere (10, 13).

METHODS

Test Subjects.

Eighteen men have taken part in this program to date. The test subjects were conscientious objectors of the Mennonite Faith who volunteered for the program as a means of fulfilling their obligation to Selective Service. These men were all between 18 and 22 years of age and passed a careful medical examination before admission to the test. One subject (RED) was later found to have had an acute attack of infectious hepatitis the year before the test. Although he was apparently well, on some occasions tenderness was noted in the region of the liver and his thymol turbidity test was persistently slightly elevated.

During the study the men lived on the Metabolic Ward. They were enthusiastic supporters of the program, almost all of them with previous experience in metaboli study programs. Table I summarizes the subject participation in the four studies.

General Plan of the Studies.

Each study consisted of two 15-day periods separated by an interval of three to seven days of rest. During the first 15-day study period, half of the subjects received the diet containing the irradiated food items and the other half received the control diet. During the second 15-day period the situation was reversed. In order to prevent accumulation of possible toxic effects several months intervened between studies. Successive studies provided a greater variety of irradiated foods and an increasing percentage of total calories from irradiated items. In the first study approximately 35% of the total calories were supplied as irradiate food; in the second, 60%; and in the third, 80%. In the last study, essentially all of the calories were provided as irradiated food; only cocoa was unirradiated. In the first three studies, metabolic balances were performed in order to measure digestibility and metabolizable energy. These studies required that the foods be as homogeneous as possible. The fourth study was not a metabolic balance study so that it was possible to present a greater variety of foods in a more attractive manner. In the first three studies, three daily menus were used; in the fourth study, five rotating menus were used (tables III, IV, V, VI).

Food Procurement and Preparation.

All test foods, both irradiated and control, were ordered through the Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois. All foods, except white and sweet potatoes, were placed in either #2 or #10 cans and frozen. Half of each food item stocked was shipped by air to Arco, Idaho or Dugway, Utah for irradiation by gamma rays of a mixed spectrum at a dosage of three million rep. All test foods, both irradiated and control, were held in the frozen state until the time of use, except those normally stored at room temperature. White and sweet potatoes, which were irradiated only to prevent sprouting, receive

a gamma ray dosage of 20,000 rep. All test foods, both irradiated and control, came from the same original batch, except in the second study. Non-test foods which were used to provide the balance of calories in the first three studies were procured through the Post Commissary.

Details of food preparation are given elsewhere (12). Whenever possible, food was weighed, cooked and served in the same containers. Each man received the same menu independent of his weight or caloric requirement. He consumed it totally; containers were literally licked clean and glasses were washed several times with water, the washings being consumed by the subjects.

Clinical Tests.

Each man received a careful physical examination and an electrocardiogram was recorded before, during and after each feeding of irradiated food and at intervals of three, six and 12 months after his last consumption of irradiated food. Six of the 18 subjects have now been followed for 12 months after their last feeding of irradiated food; the remaining men for six months. Every morning on arising, each man was weighed in the nude after voiding. Several times each day blood pressures, pulse, respiration and body temperature were measured. Every day each man was carefully questioned for any symptoms suggesting toxic effects from the irradiated food.

Laboratory Tests.

Before, during and at intervals after each irradiated food study, a series of laboratory tests were performed to detect any possible toxic effects of the irradiated food. The tests were as follows: hematology: hemoglobin (4), hematocrit, and total and differential white blood cell count (14); liver function: bromsulphalein retention after 45 minutes (22), total protein, albumin, globulin and albumin-globulin ratio in serum (3), alkaline phosphatase (21), total and direct bilirubin (11), and thymol turbidity (14); renal function: complete urine analysis and phenolsulfonephthalein excretion test (14).

RESULTS

Clinical Tests.

No evidence could be found of any toxic effects induced by the irradiation treatment of food. Physical examinations showed no abnormalities except those common in a group of young men observed for a prolonged period of time. There was the usual seasonal incidence of infections of the upper respiratory tract. Occasional headaches were noted, as was some muscle soreness apparently related to participation in athletics. There were no gastro-intestinal symptoms such as nausea, vomiting, diarrhea, constipation or rectal irritation that could be related to the ingestion of irradiated foods. One subject developed nausea and vomiting on the ingestion of shrimp which he had never consumed previously and disliked intensely. He was finally able to tolerate both control and irradiated shrimp when it was minced with potatoes and green beans and served in the form of a casserole. Another subject (SCH), an extremely "finicky" eater could not tolerate the variety of foods fed during the metabolic balance studies. His

intolerance was equally marked for the control and irradiated items; this obliged him to leave the experiment after the second study was completed. The remainder of the 18 test subjects tolerated the irradiated food without incident.

Electrocardiograms showed no significant abnormalities. There were no changes in blood pressure, pulse, respiration or body temperature except those associated with colds and other disorders unrelated to the study. In table VII the mean body weight of each subject before consumption of irradiated food is compared with his last observed weight. There were no significant changes. In general the weight of each man fluctuated as a function of the extent to which the test diet satisfied his caloric requirement. Thus, heavier men tended to lose while smaller men tended to gain weight.

Laboratory Tests.

The detailed laboratory data are given in the appendix. The average control values and the value of the last observation for each man are summarized in table VII. Urine analyses, the results of which were too voluminous to include in the report, showed no significant changes throughout the studies. Some of the men experienced difficulty with the first one or two phenolsulfonephthalein excretion tests. Later results were within normal limits. The differential white blood cell counts showed considerable variation within the normal range. Results of several of the laboratory tests, particularly those for hemoglobin and serum protein, tended to fluctuate from day to day. This variation was present in men on both irradiated and control foods and did not exceed the generally accepted normal values for the particular tests. In some men, certain values obtained before any irradiated food had been consumed were outside accepted normal range. Thus, one individual (SIE) showed a value for total serum bilirubin persistently above 1.0 mg per 100 ml. Such idiosyncrasies in laboratory tests showed no tendency to fluctuate with the feeding of irradiated food. It may be seen from table VII that the mean values of the last determination of a particular laboratory test are very close to the mean control value. Over all, there were no changes in any laboratory tests that could be related to the feeding of irradiated food.

DISCUSSION

Clinical and laboratory examinations of 18 human volunteers who consumed irradiated food failed to demonstrate any deleterious effect to general health or damage to blood forming organs, liver or kidneys, that could be related to the ingestion of irradiated food. As noted in the introduction, the study reported here could detect only evidence of short latency toxicity. The present study could not be expected to detect deficiencies in the food of vitamins or other essential substances or the presence in the food of carcinogenic materials. The negative results of the present report, however, do encourage further exploration of the use of irradiation in food preservation. The next step planned involves short term testing in humans of irradiated foods stored at room temperature between irradiation and consumption. The animal tests which must necessarily precede such a study are already under way. Long term animal studies

are also being carried out to evaluate nutritional adequacy or possible carcinogenicity. When a sufficient number of these studies are completed, long term human studies are planned to evaluate the nutritional adequacy of irradiated foods as well as any toxic effects.

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