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Acceptance of Irradiated Foods

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Once it was established that ionizing radiation could be used to preserve foods, work to determine the effects of the radiation treatment on the acceptability and stability of the foods was greatly intensified. The first large-scale tests to determine the acceptability of irradiated foods as components of meals were conducted in 1958 at Fort Lee, using troops as test subjects. These early tests involved a variety of irradiated foods, including chicken, pork, bacon, carrots, shrimp, fruit compote and pineapple jam. Test scores indicated that, except for carrots, all of the products tested were acceptable.

Unresolved problems relating to wholesomeness, however, made it necessary to suspend testing until it was clearly established that Cobalt-60 irradiated foods were safe. Wholesomeness was established, and since June 1963, when the first test of the present series was conducted, irradiated foods have been served to troops as components of approximately 10,000 meals on about 150 different occasions. These tests were conducted in cooperation with the U. S. Army Test and Evaluation Command, U. S. Army General Equipment Activity, Ft. Lee, Virginia.

In general, these tests were designed to determine: (1) consumer acceptance of irradiated foods when served as part of normal meals under garrison mess hall feeding conditions, and (2) effects on acceptance of the repeated consumption of irradiated foods.

Radiation sterilized foods (pork, bacon, ham, beef, chicken, shrimp, and pork sausage) and radiation pasteurized foods (haddock, sole, codfish, shrimp, and oranges) have been served as components of standard meals. All radiation sterilized foods were stored from 3 months to 13 months at room temperature before evaluation. Standard troop issue items, either refrigerated or frozen, were used as controls for the radiation sterilized items. The radiation pasteurized items were stored under refrigeration for a predetermined period of time, and their controls, with the exception of the oranges, were frozen from the same lots used for irradiation. The radiation pasteurized oranges were compared with biphenyl-treated oranges.

It is essential that the test foods be edible and have a good chance of scoring in the acceptable range before they are fed to the troops; therefore, all irradiated foods are

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pre-tested. The pre-testing, which includes recipe development and organoleptic evaluations, is done at the United States Army Natick Laboratories. In this program, the kitchen personnel test the irradiated item in a standard recipe taken from the Army cookbook, and it is then evaluated informally by expert technologists. If indicated as a result of this pre-test, the recipe is altered until a suitable item is developed. Once the item is judged to be acceptable, it is tested at least twice by a technical panel, and at least four consumer panels. The recipe, after it has scored in the acceptable range with both the technical and consumer panels, is forwarded for the troop test.

Testing at Ft. Lee consisted of 3 major phases: (1) laboratory analysis of the irradiated foods, (2) a review of the medical records of the participants, and (3) a soldier con-

sumer acceptance test. The methodology employed in the consumer testing followed conventional approaches and used the 9-point hedonic rating scale as a basic criterion. The details for conducting the tests and the results, are fully reported in publications issued by the U. S. Army General Equipment Test Activity (1-10).

Consumer Acceptance of Irradiated Foods

Table 1 shows the average ratings given to pork items. In only one test was there a significant difference between the irradiated test item and the control. However, the irradiated item, although significantly lower than the control, scored sufficiently high to be considered acceptable for use in mess halls.

Results of tests on bacon, shown in Table 2, clearly indicate that ir-

Table 1. Hedonic scale ratings for irradiated and non-irradiated pork

Item	Irradiated		Non-irradiated	Number of Ratings		Mean Hedonic Rating	
	Mrads	Storage		Irradiated	Non-Irradiated	Irradiated	Non-Irradiated
Barbecued	4.5-5.6	10 mo.	Fresh	60	60	7.80	7.82
Roast	4.5-5.6	10 mo.	Fresh	60	60	7.82	7.98
Chops	4.5-5.6	5 mo.	Fresh	560	670	7.2	7.3
Roast	4.5-5.6	3 mo.	Frozen	391	458	5.71	6.85*

* Difference between mean ratings is significant at the .05 probability level.

Table 2. Hedonic scale ratings for irradiated and non-irradiated bacon

Item	Irradiated		Non-irradiated	Number of Ratings		Mean Hedonic Rating	
	Mrads	Storage		Irradiated	Non-Irradiated	Irradiated	Non-Irradiated
Oven-Fried	4.5-5.6	12 mo.	Fresh	60	60	7.32	7.37
Oven-Fried	4.5-5.6	3 mo.	Fresh	282	391	5.62	6.52*
Oven-Fried	4.5-5.6	3 mo.	Fresh	274	286	5.57	6.53
Oven-Fried	2.5-3.1	9 mo.	Fresh	606	775	5.59	6.02*

* Difference between mean ratings is significant at the .05 probability level.

radiated bacon can be held for long periods of time without refrigeration and yet remain in an acceptable condition.

Table 3 shows the average rating given to ham. Although the irradiated items scored lower than the non-irradiated controls in two of the three tests, the irradiated ham scored sufficiently high to be considered acceptable for use in mess halls. In the third test, both the irradiated ham, which has been stored for 13 months, and the nonirradiated ham scored in the unacceptable range.

It is difficult to explain these results. It may be that the unacceptable scores are explainable by faulty test methodology, the effect of the preparation for serving procedure, or to products of poorer quality. Research is being planned to determine the effect of preparation procedures on the ratings. Effort to develop irradiated ham and to obtain a consistently acceptable product will be continued.

Table 4 shows the ratings given to beef items. Techniques have been developed so that it is possible to produce irradiated beef with acceptable sensory characteristics. The results indicate that although two of the three tests show that the scores of irradiated beef were significantly lower than those of the control, they were sufficiently high to consider the products to be acceptable for standard meals.

Irradiated chicken has good acceptability as is shown by the average ratings (Table 5). In only one of the total of 6 tests, the irradiated item scored significantly lower at the 0.05 probability level than the corresponding control.

Table 6 shows the results of studies on pork sausage and shrimp; these were the only irradiated items with questionable acceptability at the time of testing. Since recent advances in technology have made it possible to produce shrimp with very high acceptability scores, as judged by small

Table 3. Hedonic scale ratings for irradiated and non-irradiated ham

Item	Irradiated		Non-irradiated	Number of Ratings		Mean Hedonic Rating	
	Mrads	Storage		Irradiated	Non-Irradiated	Irradiated	Non-Irradiated
Baked	4.5-5.6	9 mo.	Frozen	553	790	6.53	7.20*
Grilled	2.5-3.1	3 mo.	Frozen	375	438	5.79	6.86*
Grilled	2.5-3.1	13 mo.	Frozen	318	339	4.99	5.46*

* Difference between mean ratings is significant at the .05 probability level.

Table 4. Hedonic scale ratings for irradiated and non-irradiated beef

Item	Irradiated		Non-irradiated	Number of Ratings		Mean Hedonic Rating	
	Mrads	Storage		Irradiated	Non-Irradiated	Irradiated	Non-Irradiated
Barbecued	4.5-5.6	3 mo.	Fresh	515	660	6.11	6.79*
Steak	4.5-5.6	3 mo.	Frozen	376	478	5.85	6.39*
Sandwich	4.5-5.6	3 mo.	Frozen	366	464	6.06	6.45

* Difference between mean ratings is significant at the .05 probability level.

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Table 5. Hedonic scale ratings for irradiated and non-irradiated chicken

Item	Irradiated		Non-irradiated	Number of Ratings		Mean Hedonic Rating	
	Mrads	Storage		Irradiated	Non-Irradiated	Irradiated	Non-Irradiated
Fried	4.5-5.6	3 mo.	Fresh	107	104	7.37	7.58
Fried	4.5-5.6	3 mo.	Fresh	101	103	7.38	7.95*
Fried	4.5-5.6	5 mo.	Fresh	451	552	6.7	7.2
Fried	4.5-5.6	3 mo.	Frozen	312	324	6.3	6.4
Fried	4.5-5.6	3 mo.	Frozen	280	279	5.9	6.1
A la King	4.5-5.6	3 mo.	Canned	313	372	5.7	5.7

* Difference between mean ratings is significant at the .05 probability level.

Table 6. Hedonic scale ratings for irradiated and non-irradiated pork sausage and shrimp

Item	Irradiated		Non-irradiated	Number of Ratings		Mean Hedonic Rating	
	Mrads	Storage		Irradiated	Non-Irradiated	Irradiated	Non-Irradiated
Pork Sausage Patties	4.5-5.6	3 mo.	Frozen	489	567	5.16	5.82*
Pork Sausage Links	4.5-5.6	3 mo.	Frozen	303	272	5.28	6.28*
Fried Shrimp	4.5-5.6	3 mo.	Frozen	107	101	6.95	7.69*
Fried Shrimp	4.5-5.6	3 mo.	Frozen	438	594	5.84	7.0 *

* Difference between mean ratings is significant at the .05 probability level.

panels, our plans are to test shrimp again in the near future using the improved product. Additional research is being planned on pork sausage to upgrade its organoleptic quality after irradiation.

The Atomic Energy Commission and the Army have cooperated in several troop evaluations of radiation pasteurized seafoods and oranges (Table 7). Without exception, all of the products scored in the acceptable range. Shrimp is the only item that scored significantly lower than the control.

Effects of Repetitive Feeding on Acceptability

Irradiated chicken and irradiated pasteurized items have been served repetitively to determine the effect on the acceptability of the foods

under these conditions. Table 8 shows the average ratings given the irradiated chicken; the scores are lower than those of the standard items, yet they were high enough for the product to be considered acceptable. The chicken, prepared in a variety of ways, was served once a week over a 5-week period. The evaluations show in this Table were for troops who participated in the test for four consecutive weeks. Statistical evaluation of the data showed no effect on acceptability due to the repetitive feeding.

Table 9 shows the hedonic scale ratings for radiation pasteurized and non-irradiated frozen fish and fresh oranges served on a repetitive basis. The items were served twice each time before they were evaluated. The method of preparation varied with

Table 7. Hedonic scale ratings for irradiated and non-irradiated pasteurized foods ^a

Item	Processing		Number of Ratings		Mean Hedonic Rating	
	Mrads	Storage ^b	Irradiated	Non-Irradiated	Irradiated	Non-Irradiated
Haddock	0.15	7 days	228	238	6.19	5.90
		14 days	219	233	5.99	6.19
Shrimp	0.20	7 days	133	105	6.57	7.41*
		14 days	133	105	6.71	7.20*
Sole	0.30	16 days	158	175	5.90	6.41*
		28 days	158	175	6.52	6.57
Cod	0.45	17 days	159	289	6.54	6.59
		24 days	157	235	6.23	6.31
Oranges	0.15	17 days	182	277	6.65	6.82
		24 days	152	275	6.21	6.21

^a Fresh frozen and held at -20°C.

^b Days at 1-3°C prior to evaluation.

* Difference between mean ratings is significant at the .05 probability level.

Table 8. Hedonic scale ratings for irradiated ^a and non-irradiated chicken served on a repetitive basis ^b

Week of Test	Number of Ratings		Mean Hedonic Rating	
	Irradiated	Non-Irradiated	Irradiated	Non-Irradiated
1	224	325	6.0	7.0
2	255	344	5.9	6.6
3	225	339	5.3	6.4
4	184	272	5.5	6.6
5	197	258	5.6	6.3

^a 4.5 to 5.6 Mrad and stored for 3 months at room temperature.

^b Served once a week as southern fried chicken, oven fried chicken, or barbecued chicken.

Table 9. Hedonic scale ratings for irradiation pasteurization and non-irradiated frozen items served on a repetitive basis

Item	Processing		Number of Ratings ^b		Mean Hedonic Rating	
	Mrads	Storage ^a	Irradiated	Non-Irradiated	Irradiated	Non-Irradiated
Haddock	0.25	15	148	166	5.26	6.13
		29			5.80	6.70
Shrimp	0.20	7	133	105	6.57	7.41
		14			6.7	7.20
Sole	0.30	16	158	175	5.90	6.41
		21			6.52	6.57
Cod	0.15	17	120	142	6.48	6.43
		24			6.20	6.34
Oranges	0.15	28	126	186	6.27	7.00
		35			6.28	6.59

^a Days at 1-3°C.

^b Same panelists for both storage times on each product.

the item; however, each item was served the same way both times. As the data indicate, scores were unaffected by the repetitive feeding.

Future Plans

Testing the acceptability and utility of currently available and new items, as they are developed, will be continued. Tentative plans call for the evaluation of 60,000 test meals containing irradiated items by the end of 1971. The following radiation sterilized items will be tested: beef, pork, ham, chicken, bacon, shrimp, pork sausage, codfish cakes, lamb, veal, turkey, luncheon meats, and frankfurters; and pasteurized seafood, shrimp, and fruits.

Conclusion

Results of the troop feeding tests conducted by the U. S. Army General Equipment Test Activity of Ft. Lee, Virginia, have placed firmly on the record the fact that radiation processed foods—sterilized meats and poultry; and pasteurized shrimp, oranges, and fish items—are not only acceptable but can be adapted for use in military feeding situations.

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