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HIGH RADIOPASTEURIZATION OF FOODS

Period May 21 to July 20, 1957

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SUMMARY

This is the fifth progress report of research performed at the Fission Products Laboratory of The University of Michigan in the field of high radiopasteurization of foods and of investigations made with the cooperation of the Kelvinator Institute for Better Living of the Kelvinator Division of American Motors Corporation.

During this reporting period, investigation of the changes in various fresh vegetables after irradiation has been continued. Included in this report are studies of beets, asparagus, green beans, peas, and spinach.

Several new products have been investigated; Hot Potato Salad, Chicken Supreme, Apple Pie, Cherry Pie, Banana Bread, and Apricot Bread.

Further storage data on Beef Swirls, Barbecued Pork Chops, and unbaked pastry are included.

FRUITS AND VEGETABLES

Investigation of the changes in various fresh vegetables after irradiation has been continued. At the time of this report, beets, asparagus, peas, green beans, and spinach have been studied.

APPLES

The increased storage life of apples subsequent to irradiation is most marked with Golden Delicious apples. Forty-six percent of the nonirradiated apples of this variety have spoiled while only 10% of the apples irraidated to 50,000 rep (46,500) rad) have deteriorated after 9 months of storage at 35°F. Twenty percent of the apples irradiated to 25,000 rep (23,250 rad) and 28% irradiated to 100,000 rep (93,000 rad) have spoiled after 9 months of storage.

Few apples of the other varieties under study have spoiled. There has been a 10% loss in the control samples as compared to a 7% loss of the irradiated Red Delicious Apples. Approximately equal amounts of irradiated (17%) and nonirradiated (16%) Northern Spy apples have spoiled. A further discussion of the storage properties of apples will be included in the annual report.

BEETS

In all the beet experiments, fresh beets of the "Detroit Dark Red" variety were used. These beets were cooked, peeled, sliced, packaged in polymylar envelopes, and irradiated to 1 megarep (930,000 rad). These samples were stored with the nonirradiated samples at 40°F.

In the first experiment, the cooked beets were irradiated without further treatment. Within 18 days the nonirradiated samples showed mold growth and breakdown while the irradiated samples showed no signs of mold or other evidence of degradation. At the time of this writing, the irradiated beets have been stored for one month and still show no deterioration except for a slight darkening in color.

Figure 1 shows the beets after 33 days of storage.

Immediately after irradiation to 1 megarep (930,000 rad), these beets were considered less flavorful when compared with the controls, but after two weeks of storage the freshly cooked beet flavor had returned to the irradiated samples.

After one month of storage at 40°F the flavor of the beets was still fresh; however, they had begun to lose their bright pigmentation and to turn a dark maroon.

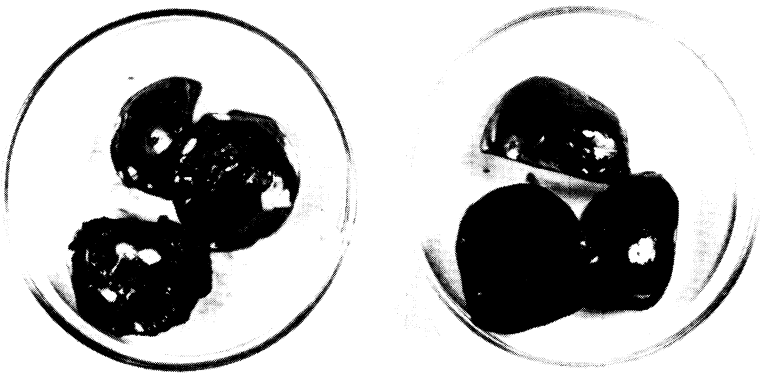

Fig. 1. Detroit Dark Red beets, photographed after 33 days of storage. Left: control sample; right: sample irradiated to 1 megarep (930,000 rad).

Because of the darkening color in the beets, various means were tried to develop a beet product that would retain its fresh appearance.

Several harvard beet recipes were tried and the product irradiated to 1 megarep (930,000 rad). The incorporation of a harvard beet sauce has helped the beets retain their original color. However, upon storage the flavor of the vinegar from the sauce has penetrated into the beets and masked their flavor.

PEAS

At the end of this reporting period, the peas in the storage experiment previously reported are 6-1/2 months old. The peas in experiment "A," which are one week older than those in experiment "B," have a strong odor. Their flavor is not characteristic of peas and mold has been found in one of the remaining packages. Out of 100 packages, 9 remain and none of these could be considered in good condition.

In experiment "B" none of the packages has spoiled. During the course of the experiment, ten samples were opened and examined; all the rest (110 samples) have been kept in storage. These have bleached in storage. No mold has been found in any packages, and the peas are still firm. Small brown spots have developed in a few peas in 6 packages. In the past month the peas have developed an off-flavor and are also very sweet.

When peas became locally available another experiment was started using "Thomas Loitors" peas. These peas were fresh, young, and tender. The peas were shelled and divided into two groups. Each group was blanched in boiling salted water, one group for 1-1/2 minutes, the other for 2-1/2 minutes. Both groups were packaged in polymylar envelopes, irradiated to 1 megarep (930,000 rad), and refrigerated with the controls at 40°F. Two and one-half weeks after

irradiation, some of the peas had bleached to a light green. The peas blanched for a longer time seemed to retain their bright color longer.

Those controls blanched 1-1/2 minutes had spoiled within 2-1/2 weeks. Of the controls blanched 2-1/2 minutes, 14% had spoiled at 2-1/2 weeks and 72% spoiled at 4 weeks.

After 4 weeks of storage the irradiated peas were still firm; the color range was from light green to a dark bright green. There appeared to be no difference in the color of the peas after one month of storage due to blanching time.

No mold or other evidence of deterioriation, other than bleaching, has appeared in any of the irradiated samples.

ASPARAGUS

"Martha Washington" asparagus was irradiated at two different dose levels, 0.1 megarep (744,000 rad) and 1 megarep (930,000 rad), and two different dosage rates, 153,000 rep/hr (142,290 rad/hr) and 80,000 rep/hr (74,400 rad/hr).

The treatment of the asparagus prior to irradiation was the same as in the asparagus packaging experiment. Polymylar envelopes were used for packaging. One group was irradiated to 1 megarep (930,000 rad) and the other to 0.8 megarep (744,000 rad). The samples were refrigerated with the controls at 40°F.

GROUP A. Dose 1 megarep (930,000 rad): Rate 153,000 rep/hr and 80,000 rep/hr.—After irrdiation, the asparagus irradiated at the higher rate was slightly strong in flavor, the color was good and the product was judged acceptable. Those packages irradiated at the lower dosage rate were judged unacceptable because they developed an extremely objectionable strong flavor. After three weeks, mold was discovered on 17% of those samples irradiated at 153,000 rep/hr and on 50% of the samples irradiated at 80,000 rep/hr.

After 6 weeks of storage, 16% of those samples irradiated at 153,000 rep/hr and 17% of the samples irradiated at the lower dose rate were in good condition. After 7 weeks all the irradiated samples showed breakdown and were discarded.

GROUP B. Dose 0.8 megarep (744,000 rad): Rate 153,000 rep/hr and 80,000 rep/hr.—After irradiation, the asparagus irradiated at the higher rate in this group was brighter green, was more flavorful, and had less off flavor than the asparagus irradiated at the lower dose rate.

In 10 days mold was found on the spears in 22% of the packages irradiated at a rate of 80,000 rep/hr; no mold was found on the spears irradiated at the higher rate. After 17 days 15% of the asparagus irradiated at the higher rate had some mold, and 82% of those irradiated at the lower rate showed mold.

Twenty-five percent of the samples irradiated at 153,000 rep/hr and 11% of the samples at the lower dose rate lasted 5 weeks. All these samples were discarded at the end of 6 weeks.

To determine whether a difference in an irradiated product might occur because of the packaging material used, "Martha Washington" asparagus was packaged in three different kinds of packaging material: polyethylene, polymylar, and aluminum foil-mylar.

The asparagus was washed, and trimmed, and the stalks sorted according to size. The small stalks were blanched in boiling salted water for three minutes, and the larger stalks were blanched for four minutes.

The asparagus was divided, packaged in the three above-mentioned packaging materials, irradiated to 1 megarep (930,000 rad), and stored at 40°F with nonirradiated samples in each packaging material.

Immediately after irradiation there was no noticeable difference in the samples. The color of each samples appeared to be the same, bright dark olive. The odor was slightly acrid, the flavor was flat, and considered not acceptable.

A. Polyethylene.—After 10 days the controls had soured and disintegration had begun,and these samples were discarded. The irradiated samples had developed a sweet taste. After 17 days all irradiated samples showed some breakdown and excess liquid was found in the packages. These samples showed complete breakdown after 22 days.

B. Polymylar.—After 10 days the control sample packages showed milky liquid, and breakdown was just beginning. These controls developed mold growth in 17 days. After 10 days the flavor of the irradiated samples had not changed; they were still off-flavor and slightly acrid. After 17 days the irradiated asparagus in polymylar envelopes was still firm; there was no evidence of mold. These samples were discarded after 27 days because of breakdown. No mold had developed.

C. Aluminum foil-mylar.—After 10 days the control samples had a slight souring odor, disintegration was beginning and the stems were slightly slimy. After 10 days the color of the irradiated samples were good, the flavor of the product had improved and was judged acceptable and characteristic of asparagus. After 20 days these samples were found to be acceptable, the stalks were still firm, and there was no breakdown. These samples lasted 36 days.

The asparagus packaged in aluminum foil-mylar was judged to have the best flavor of the samples in the three different packaging materials. The flavor of the irradiated samples packaged in polyethylene was preferred over the polymylar samples. There was little discernible difference in color between the polyethylene and polymylar samples; the aluminum foil-mylar samples appeared a more brilliant green. The aluminum foil-mylar samples lasted a week longer than the polymylar samples, and two weeks longer than the polyethylene samples.

SPINACH

"American" variety spinach was purchased locally, washed, and the damaged leaves were removed. The spinach was then packaged without further treatment. Half of the spinach was packaged in polyethylene, the other half in polymylar envelopes. These samples were irradiated to 1 megarep (930,000 rad) and to .1 megarep (93,000 rad) and refrigerated with the control samples at 40°F.

Polyethylene.—After 12 days of storage at 40°F, the control samples showed a slight amoung of bleaching, and very slight rotting of the leaves. These controls were in fairly good condition. The samples irradiated to.1 megarep (93,000 rad) showed breakdown and slight bleaching, while all the samples receiving 1 megarep (930,000 rad) showed extreme breakdown and were discarded.

After 18 days of storage, the envelopes of the control samples contained a slight amount of brownish liquid and had an unpleasant odor. The samples receiving .1 megarep (93,000 rad) exhibited more breakdown and a strong off odor. After 25 days the controls and the irradiated samples were mushy and were discarded.

Polymylar.—At the end of 12 days of storage at 40°F, the control samples were in good condition. The leaves were crisp and the flavor was normal. The samples irradiated to .1 megarep (93,000 rad) were wilted and were milder in flavor. Those samples that had received 1 megarep (930,000 rad) appeared almost as if cooked and had an off flavor. Two-thirds of the 1 megarep (930,000 rad) samples were discarded.

After 18 days of storage, all control samples were judged to be spoiled. Sixty-six percent of the .1 megarep (93,000 rad) samples had spoiled, and all the 1 megarep (930,000 rad) samples were spoiled. After 25 days of storage all the .1 megarep (93,000 rad) samples had spoiled.

Throughout the storage period,the controls and samples receiving .1 megarep (93,000 rad), packaged in polyethylene, retained a more appetizing appearance than the controls packaged in polymylar or any of the samples that had received 1 megarep (930,000 rad).

The samples irradiated to 1 megarep (930,000 rad) and packaged in polyethylene were all discarded after 12 days, while the samples receiving the same dose and packaged in polymylar were acceptable up to 18 days after irradiation.

No advantage was shown in irradiating untreated spinach at this level of radiation.

For a second experiment, spinach was purchased from the same source and given the same preliminary treatment as in the above experiment. In this experiment, however, the spinach was blanched 90 seconds in boiling water, and quenched in cold tap water. This spinach was packaged in polymylar envelopes, irradiated to 1 megarep (930,000 rad) and kept with the controls at 40°F.

In this group the control samples were judged unacceptable after 12 days, due to off-flavor. The samples irradiated to 1 megarep (930,000 rad) were considered to be in good condition after 12 days. The leaves were distinct, the color was bright dark green, the flavor was sweet but still resembled spinach. A slight off flavor was beginning to develop.

At the end of 18 days of storage there was a slight bleaching of the irradiated samples, the flavor was judged to be flat, unpleasant and not characteristic of cooked spinach.

After 33 days the flavor of the irradiated samples was not improved. The samples were discarded because the polyethylene mylar laminated bags had separated, although no further change in the samples could be noted.

GREEN BEANS

A variety of fresh green beans, "Tender Green," with a known history were purchased from a local farmer. These beans were washed, blanched in boiling salted water, cooled, drained, packaged in polymylar, and irradiated to 1 megarep (930,000 rad). After irraidation these samples were held at refrigeration temperature with the control samples.

When examined after irradiation, the color of the green beans had bleached to a dull olive. The flavor was sweet, grassy, and not characteristic of green beans.

After a month of storage at 40°F, some of the green beams had bleached to light green and others to a cream color. Translucent liquid had developed, the odor was unpleasantly sweet, and the flavor was not characteristic of green beans.

Green beans will receive further study as different varieties become available locally.

COOKED PRODUCTS

BEEF SWIRLS

After 4 months of storage, some of the packages of beef swirls developed a mushy consistency. The color of the tomato paste in some samples ranged from orange to dull pink. An occasional package had a slight strong flavor, but generally the flavor was normal.

By the end of the fifth month of storage, gas was developing in some of the packages. In these packages the swirls were beginning to breakdown, consider-

able quantities of liquid were forming, and the flavor of those samples opened ranged from flat to strong. Few were characteristic of the product.

BARBEQUED PORK CHOPS

Four months after irradiation the pork chops were still in good condition. The only spoilage that had been observed was in those packages in which a bone had punctured the package.

Out of the original 150 pork chops, all remain except those mentioned above or those removed for organoleptic examination. Except for "dryness" in texture, those remaining are still good.

Further storage data on pork chops and beef swirls will be included in the annual report.

HOT POTATO SALAD

Potato salad has proved to be another satisfactory menu item. The ingredients include, in addition to potatoes, bacon, onions, salt, pepper, vinegar, sugar, flour, and water. A preliminary study showed no discoloration of the product which had received 1 megarep (930,000 rad), after storage for three weeks at 40°F. Examination showed no degrading of the product.

CHICKEN SUPREME

2 c cooked chicken, cut up
3 c chicked stock
1 pt sliced mushrooms (sautéed)
2 c cooked noodles
1/4 c sliced pimento
2 T flour (all purpose)
1/3 c water
1/4 t pepper
1 t salt

Remove fat from the chicken stock. Sauté mushrooms in hydrogenated fat, and add along with other ingredients (pimento and noodles) to the chicken stock. Blend flour with water. Gradually add to mixture, stirring constantly. Season with salt and pepper. Cook until thickened.

The above recipe was prepared, the product packaged in polymylar envelopes, and irradiated to 1 megarep (930,000 rad). The irradiated samples were refrigerated at 40°F with the control samples.

When tasted immediately after irradiation the Chicken Supreme was judged to be an excellent product. Each ingredient was flavorful, the noodles were still intact, and the flavor of the chicken and mushrooms was excellent.

The first controls spoiled at 27 days; at that time irradiated samples were still flavorful, and the texture and color were excellent.

More storage data will be given in the annual report.

BAKED PRODUCTS

PASTRY

The unbaked pastry shells in the storage experiments are now three months old, and 72% of the original packages are still good. The 28% that have spoiled developed a blue-green mold growth.

APPLE PIES

Apple pies were prepared, baked, packaged in polymylar envelopes, and irradiated to 1 megarep (930,000 rad).

The apples used were Northern Spies. Sugar, flour, salt, cinnamon, and lemon juice were incorporated. The pie shells were prepared according to the method outlined in Progress Report No. 4.

Following irraidation, the apple pies were stored at 40°F. When tasted immediately after irradiation, the apples were judged to the flavorful, and the spices could be distinguished. The pastry was flaky but slightly brittle.

However, a week after irradiation, the apple pies were judged to be unsatisfactory. The apples were still intact, but less flavorful than at the first evaluation. The pastry was soggy and had a fatty mouth feel. Occasional mold was found on the apples in one sample and on the crust of another.

CHERRY PIES

Nearly ripe Montmorency cherries with a known history were purchased from a local farmer. They were washed, packaged in polytethylene bags, and irradiated to 1 megarep (930,000 rad). After five days storage at 40°F these cherries were made into cherry pies.

When the pies were baked and tasted, they were judged to be excellent. The cherries had not lost flavor and were characteristic of Montmorency cherries.

A storage experiment using four packaging materials, polyethylene, polycellophane, polymylar, and aluminum foil-mylar, is underway. The effect of irradiation at 1 megarep upon Montmorency cherries in these materials is being explored and will be reported.

BREADS

The baked products that have been developed include a Banana Bread and an Apricot Bread. These two fruit breads have proved to be very satisfactory irraidated products.

Banana Bread

3 ripe bananas	2 c flour
3/4 c sugar	1 t salt
2 eggs, beaten lightly	1 t soda

Mash bananas. Add eggs, sugar, and sifted flour with salt and soda. Mix. Place in greased pans. Bake 1 hr at 325°F.

The above bread has been prepared, packaged in polymylar envelopes, and irradiated to 1 megarep. (930,000 rad), and stored with the nonirradiated samples at 40°F. This product, when tasted immediately after irradiation, was found to have very little banana flavor. However, after being stored at 40°F for several days the banana flavor again developed.

The nonirradiated samples developed mold growth at 35 days. At the end of 41 days of storage, the irradiated samples show no signs of mold or other evidence of deterioration. The flavor is excellent, the bread is moist and has an even texture.

Further data on the length of storage will be given in the annual report.

Apricot Bread

1-1/2 c dried apricots	1 c whole wheat flour
1-1/2 c boiling water	1-1/2 c pastry flour
1 c sugar	1 t soda
1 t salt	1 t orange extract
1 egg, well beaten	

Chop apricots. Add water, sugar, and salt. Cool. Add orange extract. Add other ingredients (sifted flours and soda). Place in greased floured pans. Bake 1-1/2 hr at 350°F.

Apricot bread has been prepared from the above recipe, packaged in polymylar envelopes, irradiated to 1 megarep (930,000 rad), and stored with the nonirradiated samples at 40°F.

Immediately after irradiation and on subsequent organoleptic evaluations, the irradiated apricot bread was found to be free of any flavor change.

A quantity of this bread has been prepared, irradiated to 1 megarep (930,000 rad), and stored at 40°F. It will be examined and tasted periodically for spoilage and flavor change.

After three weeks of storage, there has been no change in the irradiated samples of bread. The flavor is excellent, the apricot flavor is easily distinuishable. The bread is moist and has an appetizing appearance.

Figure 2 shows the irradiated apricot bread after 3 months of storage.

Fig. 2. Apricot Bread irradiated to 1 megarep (930,000 rad) shown after 3 months of storage.