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# Effect of Active Carbon on the Storage Stability of Irradiated Meats [a]



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## SUMMARY

**This study was undertaken to evaluate the use of active carbon to improve the palatability of irradiated cooked (4.5 megarad) pork chops, pork loin, chicken parts, and beef rib-eye steak during storage at unrefrigerated temperatures. Preference score by a consumer-type panel improved when active carbon (0.2% by weight) was used with pork chops and chicken parts, but not with pork loin or beef steaks. Irradiated cooked chicken parts were stable at 22 and 38°C during a 16-month storage period. Beef rib-eye steaks, pork chops and pork loins were stable during 25 months at 22°C, whereas preference decreased with 38°C storage at 25 months with beef steaks and pork chops, and at 16 months with pork loin. During storage at 38°C, particularly after nine months, the pork and beef meats had a tendency to pull apart in the direction of the meat fibers. Preference ratings were "like moderately" for all products throughout storage.**

LONG-TERM unrefrigerated storage of irradiated meats has been generally unsuccessful. Failures with raw meat in early experiments were due primarily to fat oxidation, enzymic spoilage, and flavor changes caused by irradiation itself. In time it was found that lipid oxidation could be minimized by using low oxygen tensions during irradiation and storage (Sribney *et al.*, 1955; Groninger *et al.*, 1956), and that a heat treatment at the time of processing would inactivate the meat enzymes (Drake *et al.*, 1957; Chiambalero *et al.*, 1959). Control of flavor changes has been more difficult, although some progress may well result from insights gained in continued experiments with freezing temperatures during irradiation (Ingram *et al.*, 1959).

A different approach to the flavor problem has been to incorporate packets of active carbon within the container to adsorb objectionable volatiles during storage. A panel of experts judged that the intensity of irradiation flavor of cooked beef was significantly lowered by such a carbon treatment (Tausig and Drake, 1959). It is generally believed that the taste of the products should improve as irradiation flavor is avoided, but no specific correlation has yet been established. Further, no report has been made on the effectiveness of carbon with other irradiated meats, particularly in relation to the extent that natural flavors might be adsorbed.

A study was made of the use of active carbon with irradiated cooked pork, chicken, and beef during storage. The meat products were evaluated by a consumer-type panel for the combined characteristics of flavor, appearance, and texture, rather than just the single parameter of irradiation flavor.

## EXPERIMENTAL

**Material.** The meats were fresh, chilled, standard-cut boneless pork loins, U. S. Good Grade beef rib-eye steaks, and U. S. Grade A broilers and fryers. The pork loins were trimmed of excess surface fat. For pork chops, the trimmed loins were cut into slices ½ in. thick. For pork loin roasts, the trimmed loins were paired, rolled, and tied with twine. The chicken parts used were thighs, legs, and breasts.

**Enzyme-inactivation.** The meat was placed in a single layer on screens and cooked in a saturated steam atmosphere at atmospheric pressure to an internal temperature of 74–79°C. Immediately thereafter it was cooled in circulating 4°C air to an internal temperature of 10°C or less.

**Canning, freezing, and irradiation.** Within an hour thereafter the product was filled into beaded No. 10 cans (603 x 700), and the cans were sealed under a vacuum of 7–12 in. Hg. A Viskon packet containing 4 g of active carbon (Nuchar C) was included in one-half of the cans of each meat item. Within 1 hr of being sealed, the cans were quick-frozen and held at −18°C. All cans were irradiated in the frozen state by fuel-rod gamma radiation (4.5-megarad dose) at Dugway, Utah, or at the Materials Testing Reactor Facility, Idaho Falls, Idaho.

**Storage.** The products were kept frozen at all times until put into 22°C or 38°C storage cabinets. The cans placed in storage were selected by use of a random sampling list.

**Microbiological and toxicity testing.** All irradiated samples were subjected to microbiological examination before taste-panel analysis. This consisted of a standard plate count, a qualitative test for anaerobes, and a 72-hour mouse injection *Clostridium botulinum* toxin assay. The samples opened for microbiological analysis were covered with aluminum foil and held 72 hr at 2–3°C before preparation for panel evaluation.

**Preference evaluation.** Samples of each product were evaluated at 0, 1, 4, 9, 16, and 25 months except that the chicken was used up at 16 months. Two cans per treatment were withdrawn for each evaluation so as to obtain a measure of product variability, i.e., two panels were used for each product at each evaluation period. Four samples—with carbon at 22 and 38°C storage, and without carbon at 22 and 38°C—were presented to each panel.

The consumer-type panel consisted each time of 20 subjects from a population of about 600 untrained persons who had agreed to test irradiated foods. Panel members were not specifically informed that the products were irradiated; they were told only what meat product was being presented. A nine-point hedonic scale was used (Peryam and Pilgrim, 1957), and salt and pepper were provided for use *ad libitum.*

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Table 1. Mean hedonic ratings[a] by consumer-type panel for 4.5-megarad gamma-irradiated cooked meats stored for various periods.

| Storage time (months) | Storage temperature 22°C (70°F) With carbon | 22°C (70°F) Without | 38°C (100°F) With carbon | 38°C (100°F) Without |
|---|---|---|---|---|
| Pork chops | | | | |
| 0 | 7.2 | 7.0 | 6.8 | 7.0 |
| 1 | 7.0 | 6.7 | 7.2 | 6.8 |
| 4 | 6.7 | 6.5 | 7.5 | 6.7 |
| 9 | 7.6 | 6.7 | 7.3 | 7.0 |
| 16 | 7.5 | 7.0 | 6.9 | 6.9 |
| 25 | 7.5 | 6.4 | 6.4 | 6.1 |
| Av. | 7.3 | 6.8 | 7.1 | 6.8 |
| Pork loin | | | | |
| 0 | 6.5 | 5.7 | 6.6 | 6.4 |
| 1 | 6.9 | 7.1 | 7.2 | 6.7 |
| 4 | 7.0 | 7.0 | 6.9 | 6.8 |
| 9 | 7.0 | 7.2 | 7.2 | 6.6 |
| 16 | 7.2 | 6.8 | 6.4 | 6.4 |
| 25 | 7.0 | 7.2 | 5.4[b] | 6.2 |
| Av. | 6.9 | 6.8 | 6.6 | 6.5 |
| Chicken parts | | | | |
| 0 | 7.3 | 6.9 | 7.2 | 7.2 |
| 1 | 6.9 | 6.7 | 7.2 | 7.0 |
| 4 | 7.2 | 7.2 | 7.4 | 7.0 |
| 8 | 7.2 | 7.0 | 7.0 | 7.2 |
| 16 | 7.2 | 6.8 | 7.3 | 7.3 |
| Av. | 7.2 | 6.9 | 7.2 | 7.1 |
| Beef rib-eye steak | | | | |
| 0 | 7.3 | 6.9 | 6.9 | 7.2 |
| 1 | 6.7 | 6.5 | 7.1 | 6.8 |
| 4 | 6.8 | 7.1 | 7.4 | 6.9 |
| 9 | 6.9 | 6.9 | 6.9 | 7.0 |
| 16 | 7.1 | 7.2 | 7.0 | 6.8 |
| 25 | 7.0 | 6.9 | 5.8 | 6.2 |
| Av. | 7.0 | 7.0 | 6.8 | 6.8 |

[a] Average of two panel means (20 evaluations/panel/can; 2 cans/treatment); scale of 9.

[b] Meat from one can overcooked during preparation; that panel mean was 4.5.

The products were prepared for serving by appropriate cooking methods: steaks and chops were pan-fried, pork loins were roasted, and chicken parts were floured and deep-fat fried. Since these meats had been cooked already, browning and heating to a proper serving temperature were all that was required. All cooked samples were kept in a covered casserole at 140°F until served.

The data for each item were subjected to an analysis of variance. The statistical design for the sensory evaluation was a full factorial in which the in-can variable was confounded with the judge group.

## RESULTS AND DISCUSSION

Tables 1 and 2 contain the results of the sensory evaluations, and analyses of variance. The most significant result is that all of the products received mean hedonic ratings in the range of "like moderately" throughout storage at either 22 or 38°C. Thus, the irradiated products were initially well-received by the consumer-type taste panel used, and had excellent storage stability properties.

The fact that the preference ratings did not markedly fluctuate or decline during storage could be due to a general lack of discrimination of the taste panels used. That the panel would discriminate, however, is indicated by a rating of 4.5 given the Can 2 38°C 25-month storage sample (inadvertently overcooked during preparation for serving) and by significant temperature-time interactions with the pork and beef products.

Those interactions occurred because the samples were less stable at 38°C than at 22°C. This was not apparent until the 16th month, however, and could be related to an increase in fragility of the meat during storage. Thus, a Hobart slicer could be used to slice the loins for serving in the early withdrawals, but by 16 months the meat tended to shred in the direction of the meat fiber and could be cut only with a sharp carving knife carefully used. A similar fragility was noted with both the pork chops and the beef steak; at 16 and 25 months, the slices easily broke into pieces during preparation. This was particularly troublesome with beef steaks stored at 38°C since the slices

Table. 2. Analysis of variance.

| Source | Pork chops DF[a] | Pork chops Mean sq. | Pork chops F | Pork chops Signif. | Pork loin Mean sq. | Pork loin F | Pork loin Signif. |
|---|---|---|---|---|---|---|---|
| Carbon | 1 | 43.7760 | 31.51 | beyond 0.1% | 2.2042 | 1.81 | n.s |
| Temperature | 1 | 1.5844 | 1.14 | n.s. | 25.3500 | 20.80 | beyond 0.1% |
| Can (w/n time)[b] | 6 | 4.7302 | 1.02 | n.s. | 6.5917 | 1.21 | n.s. |
| Time (linear)[b] | 1 | 4.9308 | 1.07 | n.s. | 0.1032 | $<1$ | n.s. |
| Carbon-temp.[c] | 1 | 2.9260 | 2.11 | n.s. | 0.0667 | $<1$ | n.s. |
| Carbon-time[c] | 1 | 8.1973 | 5.90 | at 5% | 11.7004 | 9.60 | at 1% |
| Temp-time[c] | 1 | 11.6358 | 8.38 | at 1% | 60.6229 | 49.75 | beyond 0.1% |
| Carbon-temp.-time[c] | 1 | 3.3951 | 2.44 | n.s. | 4.3667 | 3.58 | at 1% |
| Judge[d] | 228 | 4.6156 | | | 5.4327 | | |
| Judge-treatment[d] | 684 | 1.3892 | | | 1.2185 | | |
| Total | 959 | 2.31 | | | 2.46 | | |

| Source | Beef steaks DF[a] | Beef steaks Mean sq. | Beef steaks F | Beef steaks Signif. | Chicken parts DF[a] | Chicken parts Mean sq. | Chicken parts F | Chicken parts Signif. |
|---|---|---|---|---|---|---|---|---|
| Carbon | 1 | 2.1094 | 1.47 | n.s. | 1 | 4.9612 | 4.66 | at 5% |
| Temperature | 1 | 7.5260 | 5.25 | at 5% | 1 | 5.2812 | 4.96 | at 5% |
| Can (w/n time)[b] | 6 | 3.8094 | $<1$ | n.s. | 5 | 5.5512 | 1.30 | n.s. |
| Time (linear)[b] | 1 | 3.8258 | $<1$ | n.s. | 5 | 1.5440 | $<1$ | n.s. |
| Carbon-temp.[c] | 1 | 1.4260 | $<1$ | n.s. | 1 | 0.5512 | $<1$ | n.s. |
| Carbon-time[c] | 1 | 0.0151 | $<1$ | n.s. | 1 | 0.6200 | $<1$ | n.s. |
| Temp-time[c] | 1 | 36.4572 | 25.46 | beyond 0.1% | 1 | 4.7500 | 1.12 | n.s. |
| Carbon-temp.-time[c] | 1 | 3.2572 | 2.27 | n.s. | 1 | 0.5960 | $<1$ | n.s. |
| Judge[d] | 228 | 4.8726 | | | 190 | 4.2545 | | |
| Judge-treatment[d] | 684 | 1.4327 | | | 570 | 1.0645 | | |
| Total | 959 | 2.38 | | | 799 | 1.88 | | |

[a] Degrees freedom.
[b] Tested against judge.
[c] Tested against judge-treatment.
[d] Within group and with time.

had molded together to present almost a solid mass of meat. The selection of only large pieces of meat to prepare and serve, however, may have tended to prevent the fragility in the chops and the steaks from being noted by the panel until 25 months.

Carbon packets improved the preference rating of pork chops and chicken parts, though only slightly, and its importance is difficult to assess. Such a small difference is not unexpected, however, as a reflection of the relatively high preference ratings received throughout the storage period.

That carbon did not improve the ratings of the beef steak during storage is unexpected, particularly when one considers the rather dramatic decrease in intensity of irradiation odor during storage reported earlier (Tausig and Drake, 1959). However, 1% by weight of carbon was used in the previous study, and only 0.2% by weight in this one. Thus, it is possible that the small amount of carbon used here was not sufficient to adsorb the greater amount of "irradiation odor/flavor compounds" present in the beef products. This point must be studied further. On the other hand, the high preference ratings for the beef certainly tend to confirm the suggestion that the irradiation odor/flavor is not as predominant a factor in influencing flavor preference as has been thought (Drake *et al.*, 1960).

The panels evaluated only the "served" product. An additional desirable feature for the use of active carbon was its noticeable reduction of odors when the cans were first opened. This reduction was observed for all products through the first nine months. At 16 months, little difference in odor was noted between samples; indeed, all odors (both irradiation and natural) were markedly less than had been observed in earlier withdrawals.

The reason for the slightly significant temperature interaction (in which chicken parts held at the higher temperature were preferred) is not known. This result and the absence of a significant time interaction in all of the meat products considered as a group indicates that the typical rancidity one might expect (particularly in chicken and pork products) has not developed to any marked extent. Thus, the inherent storage stability of irradiated cooked meats has been demonstrated.

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