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ACTIVATED CARBONS AS ODOR SCAVENGERS FOR RADIATION-STERILIZED BEEF [a, b]

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A major obstacle to the use of ionizing radiation in food preservation has been the production of objectionable qualities in the foods thus processed. In meats, and particularly in beef, off-odors and flavors have been the most prominent of the changes produced.

The use of activated carbons as in-package odor scavengers to remove irradiation-produced odors was considered because of proven utility with a variety of products *(3)* and also because the conditions under which radiation-sterilized meats will be used (i. e., storage at non-refrigerated temperatures) are such as to enhance any "scavenging" properties which might be exhibited by an adsorbent material. The complex nature of irradiation odors suggested that adsorbent materials other than charcoal also might prove useful. In the study outlined below, three separate experiments were performed.

Experiment No. 1. Heat enzyme-inactivated ground beef (internal temperature 175° F.) was vacuum- or nitrogen-packed into cans along with packets of the adsorbent material. Activated carbons used were: Pittsburgh Coke & Chemical Company, Type BPL (12-30 mesh), Type OL (20-50 mesh); West Virginia Pulp and Paper Company, Type Nuchar C (unground); the Barnebey-Cheney Company, Type T-33 Pac, and Ag^+, Cu^+ impregnated carbon. Other adsorbent materials used were: Porocel Corporation of International Minerals, bauxite desiccant (6-14 mesh); the Floridin Company, Florex B (fuller's earth), Calcined Florex B (fuller's earth), Florite (activated bauxite), Florosil (magnesium silicate). The packets were made by heat-sealing the adsorbent material within a bag made from heat-sealable non-woven fabric. All cans were irradiated (dose of 4.6 megarads), and stored at 72° F. for periods up to 6 months. Odor evaluations were performed at 2-month intervals by a 4-6 member informal laboratory panel. Results are shown in Table 1.

[a] Paper No. *898* in the series of papers approved for publication.

[b] Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists held in Chicago, Illinois, May 27, 1958.

TABLE 1

The effect of different adsorbent materials in removing "irradiation odor" from heat-enzyme-inactivated, 4.6 megarad irradiated ground beef during storage at 72° F.

Adsorbent	Odor intensity scale (1-9)				
	Storage (in months)				
	0	1	2	4	6
No adsorbent (vacuum pack)	9	9	9	9	8
Activated carbons (Ave.) (vacuum pack)	6	4	3.2	3.3	3.0
Activated carbons (Ave.) (nitrogen pack)	*	*	*	*	4.1
Non-carbon materials	9	9	9	**	**

* Nitrogen-packed samples only evaluated after 6 months storage.

** Odor evaluation on non-carbon adsorbents discontinued after 2 months.

Little difference was noted between the various activated carbon samples, and the values for these groups were averaged. A similar lack of differentiation and a general increase in odor intensity were observed with the group of non-carbon adsorbent materials. The significant variables for decreasing the irradiation odor intensity in heat-enzyme-inactivated ground beef were shown to be the use of activated carbon and storage[c]. Activated carbon with vacuum-packing exhibited a slightly greater efficiency of adsorption than that with nitrogen-packing; this was probably due to a higher rate of diffusion of the odor molecules from the meat to the adsorbent.

The increased intensity of irradiation odor which occurred during storage of samples packed with adsorbent materials other than carbon was of interest. This finding may be related to the post-irradiation reaction chemistry of irradiation odors and flavors and further investigations in this area may be enlightening. The result noted could be due solely to an increased content of oxygen in the sample cans because of the larger surface area of adsorbent materials. A similar increase in intensity occurring in samples with activated carbon could go unnoticed because of an adsorption of the oxidation products. Of the many factors which might be involved, the possibility of a catalysis of the volatile irradiation odor compounds on a metallic oxide surface seems worthy of mention, because metallic oxides are common to all five of the non-carbon adsorbent materials in question.

Experiment No. 2. Samples were vacuum-packed, irradiated, stored, and evaluated as in the previous experiment except (a) the adsorbent materials were various activated carbon materials supplied by the Barnebey-Cheney Company (b) both raw and heat-enzyme-inactivated samples (internal temperature 165° F.) were made up and (c) an additional odor evaluation was performed on the samples after cooking. Figure 1 illustrates the averaged odor-evaluation results.

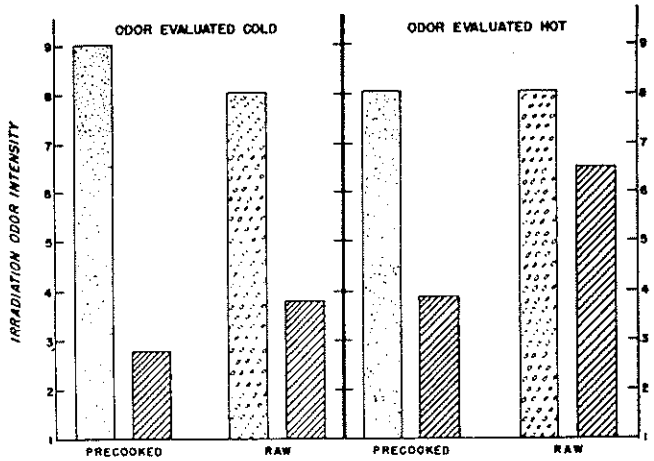

Figure 1. The effectiveness of activated carbon ▨ for removing "irradiated odors" from irradiated (4.6 megarads) cooked and raw ground beef during 72° F. storage for 2 to 4 months. Evaluations made on room temperature samples, and on samples heated under a low-fire gas broiler.

The slight increase in irradiation intensity noted in the carbon-packed pre-irradiation cooked ground beef upon heating is consistent with respect to the diffusion/temperature equilibrium expected where most of the volatile compounds have been removed. The large increase of odor intensity on heating the carbon-packed raw ground beef, however, suggests

[c] Two additional sets of cans were packed with raw meat and these cans were given the normal thermal-processing (45 minutes at 250° F. and 5 lbs. pressure). No effect of odor adsorption by activated carbon or non-carbon materials was noted in any of these samples after 72° F. storage periods of 2 and 6 months.

that the relatively wet mass of raw beef material prevented effective diffusion of such compounds from the interior of the sample to the surface, or that the volatile chemical compounds constituting the irradiation odor in cooked beef exist as non-volatile heat-labile precursors in the raw meat. The mechanism of the occurrence is mostly of academic interest at this time, however, since the storage of radiation-sterilized raw meats has been precluded until the enzyme activity can be controlled by non-thermal means *(2)*.

Experiment No. 3. Beef "rib-eye" steaks were randomly selected from three pairs of matched ribs, and were heat-enzyme-inactivated by heating on a grill in a steam retort at atmospheric pressure to an internal temperature of 165° F. (the drip was discarded). Carbons used were selected from those supplied by the Barneby-Cheney Company for Experiment No. 2 as follows:

No. 1. Material suitable for adsorption of large, high molecular weight compounds.

No. 2. Deodorizing carbon of extremely high activity.

No. 3. Blend of Nos. 1 and 2 (1:1).

Steaks were vacuum-packed along with the packets of carbon in No. 2½ beaded tinplate interior-enameled cans, irradiated (dose of 4.6 megarads), and stored at 72° F.. At 2, 4, and 6 months, samples were evaluated for intensity of irradiation odor/flavor using a formal panel. Mean intensity ratings based on 32 judgments for each sample were obtained. Flavor evaluation results are shown in Table 2.

TABLE 2

The effect of using activated carbons to decrease the intensity of "irradiation odor/flavor" during 72° F. storage of heat-enzyme-inactivated, 4.6 megarads irradiated beef rib-eye steaks

Activated carbon	Intensity scale (1-9)		
	Storage (in months)		
	2	4	6
Type I	3.10	3.06*	3.78*
Type II	4.13	2.59*	2.82*
Type I: Type II (1:1)	3.88	2.91*	3.00*
No carbon	3.35	4.63	5.84

* Significant (activated carbon vs. no carbon) at a confidence level of 1%.

CONCLUSION

Since the results obtained in Experiment No. 3 are based on an actual flavor evaluation by a large panel rather than on odor alone, they perhaps best indicate the potential of activated carbons for use in removing irradiation odor/flavors in radiation-sterilized meats. Such results also indicate that activated carbons should be a valuable research tool for identifying the nature of objectionable flavors produced in irradiation-sterilized meats, either by providing a method of isolating and concentrating the volatile compounds or by providing substrates in which quantitative differences in content of volatile compounds can be made.

In the interpretation of this study for a wider application of the use of activated carbons in radiation-sterilized foods, it is clear that considerably more information must be acquired. For example, the data indicate only that activated carbons are effective in reducing irradiation odor/flavor intensity. That lessening of this property should result in increased acceptance is, of course, inherent in the purpose of the experiment, but the specific evaluation of acceptability for such products is yet to be accomplished. This study also did not evaluate the extent to which adsorbents might remove