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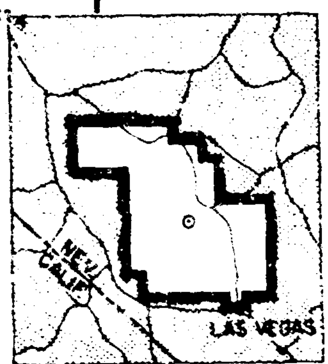

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EFFECT OF FALLOUT CONTAMINATION ON PROCESSED FOODS, CONTAINERS, AND PACKAGING

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CIVIL EFFECTS TEST GROUP

Report to the Test Director

EFFECT OF FALLOUT CONTAMINATION ON PROCESSED FOODS, CONTAINERS, AND PACKAGING

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ABSTRACT

The effect of a comparatively low level of fallout on the protective qualities of 18 packaging materials was examined. It was found that the plastics and paper tested were adequate for preventing contamination of foods packaged therein; by contrast, burlap and cloth offered poor protection. Oily or dusty surfaces proved more retentive for fallout than clean ones. Of the cleaning measures tried, wet or dry cloth wiping seemed to be the most effective, with detergent washing and brushing next in order. Many retail packages, particularly those with a waxed-paper overwrap, retained considerable amounts of fallout. There were, however, only two cases in which contamination of the contents of retail packages could be demonstrated.

ACKNOWLEDGMENTS

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Celanese Corporation of America	Koppers Company, Inc.
Dow Chemical Co.	Reynolds Metals Co.
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Goodyear Tire & Rubber Co., Inc.	Wilkins-Rogers Milling Co.

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Chapter 1

INTRODUCTION

1.1 BACKGROUND

Some preliminary observations on several kinds of packaging materials in the Operation Teapot tests on foods emphasized that fallout contamination could be related not only to the type of packaging surface but also to the condition of that surface, whether dirty, greasy, etc.[1]

1.2 OBJECTIVES

This was a limited study on fallout contamination; its object was to develop some information along the following lines:

1. To what degree are a variety of packaging materials contaminated by fallout?
2. How effective are packaging materials in preventing contamination of the contents of the package?
3. How effective are a few simple decontamination operations?

REFERENCE

1. Robert E. Hardenberg and A. Lloyd Ryall, The Effect of Nuclear Explosions on Semiperishable Foods and Food Packaging, Operation Teapot Report, WT-1214, February 1956.

Chapter 2

EXPERIMENTAL PROCEDURES

2.1 MATERIALS

The following three categories were examined: packaging materials, wholesale or bulk containers, and retail containers.

2.1.1 Packaging Materials

Eighteen different types of packaging material were selected for exposure. The list is obviously incomplete considering the multiplicity of such materials. It is believed, however, that it is fairly representative of present commercial uses.

75 Pliofilm	502 Reyseal
120 M. W. Pliofilm	Aluminum foil (0.00065)
CA43 cellulose acetate	P904 Celanese acetate, 120 gauge
322 Mylar	Polyethylene paper
50 Mylar C	Multiwall paper bagging
MSAD 86 Cellophane	Heavy weight Kraft paper wrapping
Dylan	Paper bagging for flour sacks
Super Dylan	Cotton flour bag cloth
Saran wrap	Burlap

2.1.2 Wholesale or Bulk Containers

The containers were filled with the product usually shipped or purveyed therein:

1. Burlap coffee bags: an open-weave bag with ($\frac{1}{8}$- to $\frac{1}{4}$-in. openings) containing green coffee
2. Burlap bean sacks: a tight-weave sack containing 100 lb of lima beans
3. Multiwall paper sacks: a four-layer brown-paper sack containing 25 lb of pancake mix
4. Multiwall paper sacks: a four-layer white-paper sack containing ten 5-lb bags of flour, the individual bags being of multiwall paper also
5. Muslin sacks: a tightly woven white muslin cloth sack containing 50 lb of baker's bran
6. Cardboard containers: corrugated shipping containers filled with cylindrical pressed-paper oatmeal boxes (filled)

2.1.3 Retail Containers

Many of the retail containers were individual serving packages of breakfast cereals:

1. Cardboard box with waxed-paper inner wrap
2. Cardboard box with waxed-paper overwrap
3. Cardboard box without inner or overwrap (shredded wheat)

Other types were as follows:

1. Cardboard containers with heat-sealed polyethylene, paper lamination inner wrap (corn-bread mix)
2. Polyethylene heat-sealed bag (candy corn)
3. Polyethylene heat-sealed bag (marshmallow)
4. Polyethylene, paper, aluminum foil envelopes (onion soup)
5. Glass jar with screw cap (peanut butter)
6. Cylindrical cardboard container (oatmeal)
7. Plastic-impregnated milk carton (containing water)

2.2 METHODS OF EXPOSURE

Identical exposure stations were replicated at 2-mile intervals along an arc, approximately 25 miles from Ground Zero. Since it was desirable to obtain the maximum of fallout on the samples, exact placement of the stations was delayed until 1 hr before shot time in order to take advantage of the last-minute meteorological predictions. All exposures were made under the open sky with all packages intact but oriented in a variety of positions, which were marked. The wholesale and retail packages were placed on tables. Figures 2.1 and 2.2 show

Fig. 2.1—Some examples of exposure of wholesale and bulk packages.

the placement of the packages. The packaging materials were mounted in 6-in. squares on plywood boards. The squares were held down by cellophane attached to the edges. Three exposure boards were designed for each station and, as can be seen in Fig. 2.3, were placed directly on the ground. The squares on one board were clean; on a second, lightly soiled with dirt; and on a third, streaked with a film of oil.

2.3 INSTRUMENTATION

The exposure stations were instrumented with continuous background recorders, gummed paper, and plastic pellets. Evaluations of these sensing elements were made by Program 37 (WT-1488). Radioactivity of the samples was measured by standard portable field instruments of the beta-gamma survey type, using an open probe. In addition, many samples were also measured for gross activity with sensitive laboratory scaler equipment.

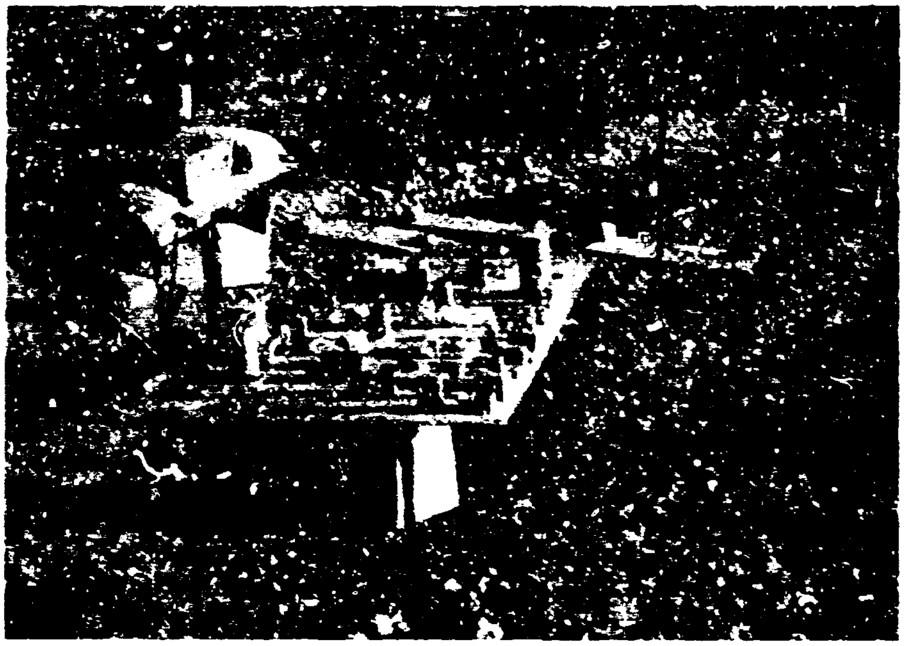

Fig. 2.2—Layout of retail packages for exposure.

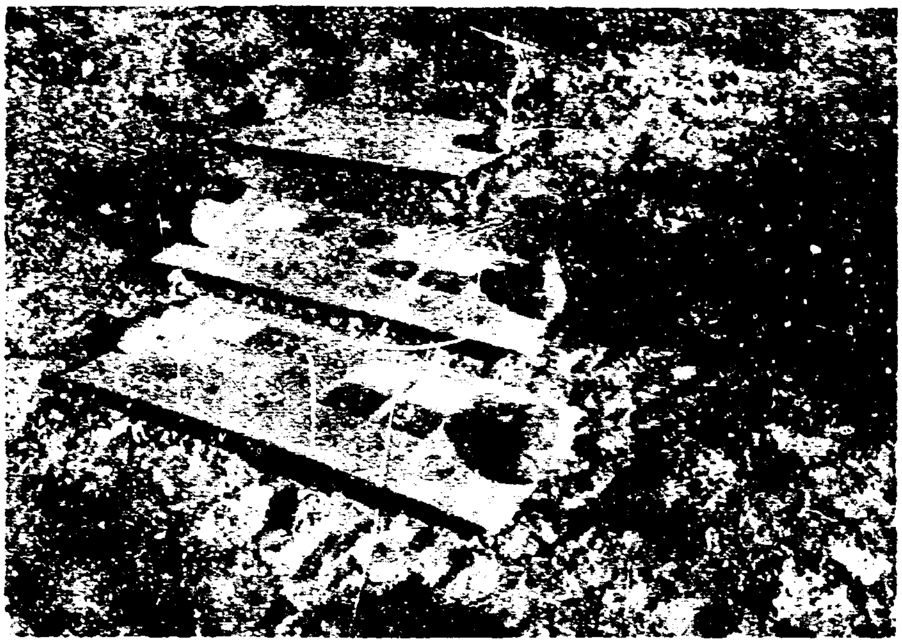

Fig. 2.3—Method of exposing test squares of packaging materials.

2.4 TREATMENT OF SAMPLES

Following exposure, samples were selected from the two stations that received the largest amount of fallout. All others were omitted from consideration. Samples to be studied were carefully moved from the exposure area to one that was "uncontaminated" as shown by a series of background readings made with survey instruments. Decontamination procedures consisted of brushing, wiping with moist and dry cloths, washing with detergents, etc. Readings were made with the open probe held in contact with the surface. In addition to the field readings, many of the samples were shipped to the Food and Drug Administration (FDA) laboratories for more detailed examination. The small packages were sealed in pliofilm bags for shipping; surfaces were immobilized by covering them with cellophane tape.

Chapter 3

RESULTS

The results reported here are chiefly those from stations 4 and 5 where radioactivity at H + 12 hr was 9.5 and 114 μc/sq ft, respectively.

3.1 PACKAGING SURFACES

Survey of the boards containing the 6-in. packaging squares from station 4 at approximately 36 hr following exposure showed essentially no difference between the soiled and unsoiled (clean) surfaces. It was found that dust had also been deposited on the clean squares by the action of a surface wind that blew across the boards. Each of the dusty squares was individually monitored by passing the open probe slowly over the surface and taking an average reading. Following this, the squares were vigorously brushed with a stiff brush, and readings were taken again. The results are shown in Table 3.1. It is apparent that the brushing operation removed somewhat more than half the contamination from all the surfaces except the last four. The latter, because of either a rough or a woven texture, presumably entrapped the radioactive dust so that it could not be readily removed. It is noteworthy that the multiwall paper bagging, in contrast to the Kraft paper, is relatively smooth. This would seem to explain the difference in response of the two surfaces of the same material. Variation in the amount of removal ranging from 50 to 70 per cent in the first 14 surfaces should not be considered significant since all these field measurements are at best only approximate.

Tests showed, as might be expected, that oily surfaces could not be readily cleaned by brushing. Therefore, after preliminary measurement, the surfaces were wetted with a household detergent and then rinsed with clean water. The results of this before-and-after treatment are shown in Table 3.2. Although the oily surfaces retained considerably more radioactivity than the dusty surfaces (shown in Table 3.1), it is notable that the treatment with a detergent removed a relatively greater amount than did the brushing of the dusty surface. Again burlap stands out as a material that tenaciously resists cleaning processes.

Squares of packaging surfaces exposed at station 5 (114 μc/sq ft) carried a considerably larger burden of radioactive contamination. It was considered possible that enough of this contamination could be retained on the surface for later measurements to be taken with a scaler. Accordingly the clean, dusty, and oily squares were each marked off into equal areas. One-half of each square was carefully cleaned by rubbing with a cloth (dry for the oily surface and moist for the dusty surface). The cleaned and uncleaned areas were then overlayered with wide cellophane adhesive tape. The samples were shipped to the FDA laboratories where a 1-in.-diameter steel cutter was used to stamp out disks of the cleaned and uncleaned surfaces. These disks were then placed in planchettes and read with a scaler using a thin window (1.2 mg/cm^2) Geiger tube. The three uncleaned surfaces are compared in Table 3.3. The data clearly show the influence of the oily surface in retaining many times more radioactivity than either the dusty or the clean surfaces. The trend to higher values for the dusty surfaces as compared to the clean surfaces is also evident. Too much significance to individual values

TABLE 3.1—EFFECT OF BRUSHING ON REMOVAL OF FALLOUT CONTAMINATION FROM PACKAGING SURFACES*

Surface	Radioactivity		
	Before brushing, mr/hr	After brushing, mr/hr	Per cent removed
75 Pliofilm	1.2	0.6	50
120 Pliofilm	2.0	0.9	55
CA43 cellulose acetate	1.2	0.6	50
322 Mylar	1.8	0.6	67
50 Mylar C	2.0	0.6	70
MSAD 86 Cellophane	2.0	0.7	65
Dylan	2.0	0.9	55
Super Dylan	2.5	0.9	64
Saran wrap	3.0	0.9	70
502 Reyseal	2.5	1.0	60
Aluminum foil	1.5	0.9	40
P904 Celanese acetate	1.5	0.9	40
Polyethylene on paper	1.8	1.0	44
Multiwall paper bagging	2.8	1.5	46
Heavy weight Kraft paper	2.8	1.1	60
Paper bagging for flour sacks	2.8	1.1	60
Cotton cloth	2.8	2.7	3
Burlap	12	12	0

*Station 4, 9.5 μc/sq ft: all measurements were made at H+36 hr with an open sidewall probe.

TABLE 3.2—EFFECT OF DETERGENT ON REMOVAL OF FALLOUT CONTAMINATION FROM OILY PACKAGING SURFACES*

Surface	Radioactivity		
	Before detergent, mr/hr	After detergent, mr/hr	Per cent removed
75 Pliofilm	11	1.8	84
120 Pliofilm	9.0	2.0	78
CA43 cellulose acetate	9.0	3.0	67
322 Mylar	10	2.0	80
50 Mylar C	10	1.9	81
MSAD 86 Cellophane	10	2.0	80
Dylan	8.0	2.1	74
Super Dylan	11	4.5	60
Saran wrap	11	2.5	78
502 Reyseal	10	2.1	79
Aluminum foil	9.0	2.1	77
P904 Celanese acetate	10	3.5	65
Polyethylene on paper	9.0	1.1	88
Multiwall paper bagging	8.0	4.0	50
Heavy weight Kraft paper	8.0	3.8	53
Paper bagging for flour sacks	6.0	2.0	67
Cotton cloth	16	4.5	72
Burlap	12	12	0

*Station 4, 9.5 μc/sq ft: all measurements were made at H+36 hr with an open sidewall probe.

TABLE 3.3—EFFECT OF THE CONDITION OF THE PACKAGING SURFACE ON RETENTION OF FALLOUT CONTAMINATION*

Surface	Radioactivity, counts/min/sq in.		
	Clean	Dusty	Oily
75 Pliofilm	218	507	1,400
120 Pliofilm	173	493	19,000
CA43 cellulose acetate	59	202	4,350
322 Mylar	61	263	16,000
50 Mylar C	88	281	8,000
MSAD 86 Cellophane	158	514	7,400
Dylan	486	563	12,000
Super Dylan	182	462	13,[illegible]00
Saran wrap	331	897	9,600
502 Reyseal	650	439	2,900
Aluminum foil	170	181	8,700
P904 Celanese acetate	50	113	13,700
Polyethylene on paper	117	245	1,200
Multiwall paper bagging	221	316	9,460
Heavyweight Kraft paper	483	237	1,600
Paper bagging for flour sacks	66	177	1,660
Cotton cloth	547	475	6,200
Burlap	874	550	15,000

*Station 5, 114 μc/sq ft: all measurements were made on D + 20 day.

should again not be inferred because it must be remembered that the assay surface was relatively small and may have easily reflected "hot spots" or uneven deposition of fallout particles, a well-known phenomenon. Table 3.4 shows the results of wiping a contaminated oily surface with a dry cloth and a contaminated dusty surface with a moist cloth. It is very evident that this procedure is extremely effective in removing nearly all the contamination. Outstanding exceptions are again the papers, cotton cloth, and burlap. Referring to Tables 3.1 and 3.2, which show the brushing and detergent-washing results, it may be inferred that the wiping procedure is the more efficient, with removals averaging over 90 per cent as compared with 60 to 75 per cent.

An experiment was also performed to determine to what extent, if any, fallout contamination penetrated each of the packaging surfaces. This was accomplished by placing a layer of the same material under each of the exposed squares of packaging. All edges were sealed so that no transfer could occur except through the surface. Table 3.5 shows the results. It is clear that, except for the cotton and burlap, no significant transfer of contamination occurs. The conclusion is therefore that intact packaging made of the first 16 materials effectively prevents contamination of foodstuffs that they may contain.

3.2 WHOLESALE OR BULK CONTAINERS AND CONTENTS

In line with the observations on the squares of cloth and burlap (Sec. 3.1), it seemed readily apparent that foods packed in such types would be extremely vulnerable to fallout contamination. For example, in Table 3.6 it can be seen that contamination is readily transferred to coffee beans and lima beans contained in burlap. In the case of the coffee beans, even greater activity was manifested inside the bag. By contrast the paper packages shielded their contents from contamination. Generally attempts at decontamination of these and other bulk types of packages were not too successful. Crimps and folds used in forming the packages seemed to retain radioactivity tenaciously. In the case of burlap and cloth, brushing actually aggravated the condition by forcing particles into the weave and onto the contents. Even the use of a damp cloth on paper simply served to "set" the contamination in the folds and creases of the package. One may assume that a vacuum-cleaning operation would be very effective and could be superior to mechanical brushing or wiping. As a practical procedure to avoid con-

TABLE 3.4—EFFECT OF WIPING ON REMOVAL OF FALLOUT CONTAMINATION FROM OILY AND DUSTY PACKAGING SURFACES*

	Radioactivity, counts/min/sq in.					
	Oily surface			Dusty surface		
Surface	Before	After†	Per cent removed	Before	After‡	Per cent removed
75 Pliofilm	1,400	37.	97	507	26	95
120 Pliofilm	19,000	1,270	93	493	9.0	98
CA43 cellulose acetate	4,250	65	98	202	5.8	97
322 Mylar	16,000	697	96	263	5.8	98
50 Mylar C	8,000	464	95	281	4.2	99
MSAD 86 Cellophane	7,400	505	93	514	17	97
Dylan	12,000	166	99	563	22	96
Super Dylan	13,700	133	99	462	37	92
Saran wrap	9,600	117	99	897	26	97
502 Reyseal	2,700	563	79	439	42	90
Aluminum foil	8,700	672	92	181	6.4	97
P904 Celanese acetate	13,700	155	99	113	5.8	95
Polyethylene on paper	1,200	200	83	245	8.0	97
Multiwall paper bagging	9,460	1,030	89	316	13	92
Heavy weight Kraft paper	1,600	740	54	237	160	32
Paper bagging for flour sacks	1,660	225	66	177	105	41
Cotton cloth	6,200	2,360	62	475	454	46
Burlap	15,000	12,000	20	550	269	51

* Station 5, 114 μc/sq ft: all measurements were made on D + 20 day.
† Wiped with dry cloth.
‡ Wiped with moist cloth.

TABLE 3.5—PENETRATION OF PACKAGING SURFACE BY FALLOUT CONTAMINATION*

	Radioactivity, counts/min/sq in.	
Surface	Exposed overlayer	Protected underlayer
75 Pliofilm	218	0
120 Pliofilm	173	0
CA43 cellulose acetate	59	0
322 Mylar	61	0
50 Mylar C	88	0
MSAD 86 Cellophane	158	0
Dylan	486	0
Super Dylan	182	0.16
Saran wrap	331	0
502 Reyseal	650	1.9
Aluminum foil	170	0
P904 Celanese acetate	50	0
Polyethylene on paper	117	1.4
Multiwall paper bagging	221	2.4
Heavy weight Kraft paper	483	0
Paper bagging for flour sacks	66	0
Cotton cloth	547	83
Burlap	874	734

* Station 5, 114 μc/sq ft: all measurements were made on D + 20 day.

TABLE 3.6—SOME EXAMPLES OF CONTAMINATION OF BULK CONTAINERS AND CONTENTS*

	Radioactivity, mr/hr	
Product and container	Outside of container	Contents
Coffee in burlap (open weave)	2.0	4
Pancake flour in multiwall paper	0.6	Background
Lima beans in burlap (tight weave)	2.0	0.25
Flour in multiwall paper	1.5	Background
Oatmeal in cardboard	0.5	Background

*Station 4, 9.5 μc/sq ft: all measurements were made at H + 36 hr with an open sidewall probe.

TABLE 3.7—EXAMINATION OF THE OUTSIDE OF RETAIL PACKAGES FOR FALLOUT CONTAMINATION*

Type of package	Contents	No. of packages showing no radioactivity	No. of packages showing pronounced radioactivity
Polyethylene paper, aluminum-foil envelope	Dehydrated soup	1	3 (400 to 800 counts/min)†
Individual serving cardboard box, with or without waxed-paper inner wrap	Breakfast cereal	13	2 (200 to 400 counts/min)‡
Individual serving waxed-paper overwrap on cardboard	Breakfast cereal	0	14 (300 to 3000 counts/min)§
Cellophane bag	Candy corn	0	4 (250 counts/min)¶
Polyethylene heat-sealed laminated bag	Marshmallows	0	4 (300 to 1000 counts/min)**
Cardboard box laminated paper with polyethylene inner wrap	Corn-bread mix	1	1 (500 counts/min)††
Glass jar, screw cap	Peanut butter	0	1 (100 to 200 counts/min)‡‡
Wax-impregnated 1-qt cardboard milk carton	Water	1	1 (200 to 300 counts/min)§§
Plastic-impregnated 1-qt cardboard milk carton	Water	1	1 (200 to 300 counts/min)§§

*Readings were made at approximately D + 20 days with a beta-gamma survey meter employing a special thin end-window probe.

† Most marked activity along crimp edge, which was slightly "tacky."

‡ Most activity noted along seams.

§ Activity distributed over whole package and not limited to seams; discrete hot spots noted.

¶ Around crimp edges only; none on body of package.

** Diffuse activity all over upside of package.

†† A single hot spot.

‡‡ Jar was upside down; under edges of screw lid collected the fallout.

§§ Diffuse activity distributed over body of package.

tamination of the contents of packages, the exteriors of which are so affected, it should be a rule never to open them at the seal but to open them always on the flat or belly side farthest from folds or crimps.

3.3 RETAIL PACKAGES

Most of the exposed retail packages, particularly the small breakfast-food type, showed activity when surveyed with a sidewall open probe. Activity was greater with the "up" position of the package and particularly at the closure seams. Most of these packages were encased in pliofilm bags and shipped to the FDA laboratories. There they were examined again with a thin end-window probe, which was better able to distinguish local variations or hot spots on the package surface.

The results of an examination of most of the retail packages are shown in Table 3.7. Fallout particles seem to have a special predilection for waxy surfaces. For example, only 2 of the 20 cereal boxes without overwrap showed radioactivity; by contrast, all the packages from another manufacturer, which had a wax overwrap, were contaminated. In many instances radioactivity is confined to edges, seals, folds, or crimps. Most notable is a soup envelope, the crimped closure seal of which was slightly tacky.

In Table 3.8 are given the results of analyses of the contents of some of the packages that showed surface contamination. Great care was taken in the opening of these packages to prevent mechanical transfer of the surface contamination to the contents.

TABLE 3.8—EXAMINATION OF THE CONTENTS OF RETAIL PACKAGES, THE OUTSIDES OF WHICH WERE CONTAMINATED BY FALLOUT

Food contents	Type of package	Radioactivity, counts/min/100 g* Exposed	Control
Raisin bran	Cardboard box with waxed-paper overwrap	205	326†
40% bran flakes	Cardboard box with waxed-paper overwrap	252	382†
Oatmeal	Cylindrical cardboard box	168	188†
"K" (high-protein cereal)	Cardboard box with waxed-paper inner wrap	46	69†
Shredded wheat	Cardboard box without inner or outer wrap	1123	272
Onion soup	Polyethylene paper aluminum foil envelope	1108	137
Buttermilk corn bread mix	Cardboard box laminated paper polyethylene inner wrap	234	181

*100 mg of ashed sample was read on a scaler. The background radioactivity is due to the presence of the natural K^{40} isotope.

†The fact that these control values are higher than the experimental values represents normal fluctuations which are not significant.

Significant differences between exposed and control packages occurred for shredded wheat and onion soup. In the case of the former the explanation is easy: this is a package without outer or inner wrap, and, since there are no completely tight closure seals, dust could easily have sifted in. It is more difficult to explain the contamination of the onion soup, because particular care was exercised not to open the envelope at the contaminated crimp edge.

Chapter 4

SUMMARY

Of the 18 packaging surfaces only cloth and burlap proved inadequate in preventing fallout penetration.

Although paper, and particularly waxed paper, proved to be quite retentive for fallout particles, none was conveyed to the contents of the package.

The condition of the surface determines the degree of fallout contamination. In descending order of retentiveness were oily, dusty, and clean package surfaces.

Dry or moist wiping proved to be the most effective means for removal of contamination from a package surface.