Report to the Test Director

EFFECT OF FALLOUT CONTAMINATION ON RAW AGRICULTURAL PRODUCTS

By

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ABSTRACT

Wheat, dried fruits, snapped corn (unhusked), soya beans, cotton seed, and potatoes were exposed to moderate contamination resulting from fallout under actual field conditions. It was found that water washing as applied to dried fruits, soya beans, and cotton seed was relatively ineffective in removing fallout contamination; scrubbing potatoes, followed by removal of the skins, was effective. The protecting layers of husk around ears of corn prevented the contamination of the grain inside. A complete milling operation on fallout-exposed wheat showed that a considerable amount of contamination could be removed by cleaning operations as well as by separation of the bran. Flour resulting from such contaminated wheat exhibited relatively low residual radioactivity. Because of the low degree of contamination of the wheat, caution should be used in extrapolating these results to more severe situations.

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INTRODUCTION

1.1 BACKGROUND

In Operation Teapot extensive exposures of a large variety of foodstuffs were made near Ground Zero (GZ) in order to determine the effects of blast and prompt radiation. Preparations had also been made to investigate the contamination of fallout on these foodstuffs at more remote distances. Unfortunately these experiments proved unsatisfactory because of unfavorable atmospheric conditions. Nevertheless enough was learned from this effort to emphasize very strongly the tremendous and sobering potentialities of widespread fallout contamination on our food supply. Raw agricultural products, in contrast to packaged products, are particularly vulnerable because serious contamination may occur in both preharvest and postharvest situations.

1.2 OBJECTIVES

The objectives of this study were to investigate (1) postharvest contamination of products in bulk storage or processing situations, (2) practical methods of decontamination, and (3) the influence of processing operations on the possible removal of contamination.

Chapter 2

EXPERIMENTAL PROCEDURES

2.1 PRODUCTS

The following raw agricultural products were exposed to fallout: (1) wheat, (2) snapped corn, (3) cotton seed, (4) soya beans, (5) potatoes, and (6) dried fruits.

2.2 EXPOSURE SITUATIONS

Five identical exposure stations at 2-mile intervals were set up in an arc approximately 25 miles from GZ. Final "fix" of the locations was made within 1 hr of shot time and was based on the best meteorological predictions for the path of the fallout cloud. Close liaison with Program 37, which was concerned with the measurement and evaluation of fallout, was maintained at all times.

2.3 METHODS OF EXPOSURE

All exposures were made under the open sky in an attempt to obtain the maximum of fallout from the cloud. Fifty bushels of wheat, approximately 10 to a station, were spread out on 18- by 20-ft tarpaulins to a depth of about 3 or 4 in. Dried fruit was spread out in a single layer on wooden drying racks of the type used by industry for sun-drying. Snapped corn, soya beans, cotton seed, and potatoes were spread out on plywood surfaces. Figures 2.1 and 2.2 show some of the methods used.

A simple experiment was devised to determine the depth of penetration of fallout in wheat. An open-top cardboard cylinder, 10 in. in diameter and 30 in. deep, was prepared by drilling $^1/_2$-in. holes in the side at 1, 2, 3, 4, 5, 6, 12, 18, 24, and 30 in. from the top. The holes were temporarily closed with tape, and the cylinder was filled flush with wheat. Following exposure, a grain trier was thrust through each hole, and a sample was withdrawn. The miniature "grain silo" is shown in Fig. 2.3.

2.4 INSTRUMENTATION AT SITE

The exposure stations were instrumented with continuous background recorders, gummed-paper plates, and plastic pellets to collect fallout for later studies. Evaluations of these sensing elements were made by Program 37.

Fig. 2.1 — Methods of exposure of dried fruit.

Fig 2.2 — Methods of exposure of soya beans and cotton seed.

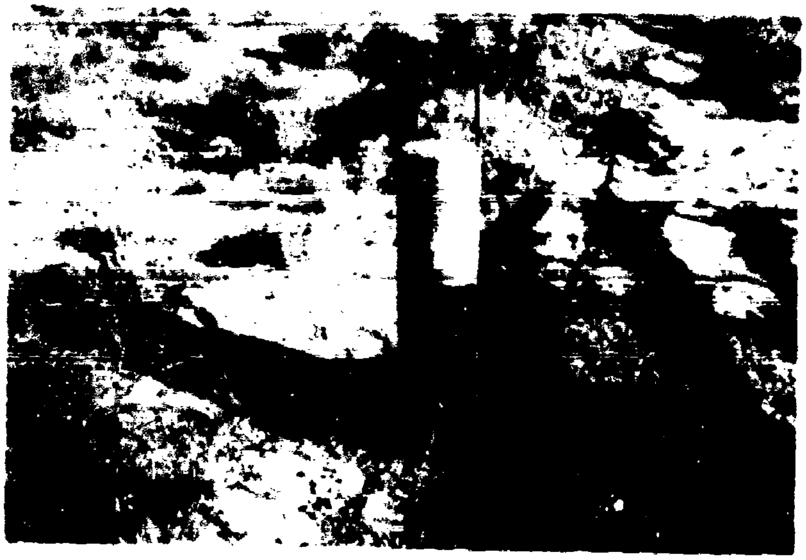

Fig. 2.3—Miniature wheat silo to test depth of penetration of fallout.

2.5 TREATMENT OF EXPOSED SAMPLES

Following exposure, all products were removed from the exposure stations and monitored with portable beta-gamma survey equipment. Several simple and readily applied decontamination techniques were tried. All wheat exposed on the tarpaulins was mixed, packaged, and sent to an expe.imental pilot wheat mill for conversion to flour. A total of 60 samples was drawn from the various stages of the milling operation to determine the course of the radioactive contamination. For control, samples from the identical c'eck points were drawn from a batch of uncontaminated wheat originating from the same lot. In addition to field measurements. many of the samples (including the milled wheat) were shipped to the Food and Drug laboratories where portions were dry-ashed and examined by more refined methods.

Chapter 3

RESULTS

Based on extrapolation back to H+12 hr by the $t^{1.2}$ law, microcuries of total activity per square foot were as follows:

Station No.	Activity, μc/sq ft
1	0.79
2	10.3
3	8.6
4	9.5
5	114

With the exception of the bulk wheat used for the milling experiment where all samples were collected from all stations, no further examination of products exposed at station 1 were undertaken because of the low activity.

3.1 DEPTH OF PENETRATION

The miniature wheat silos from stations 3, 4, and 5 were analyzed for depth penetration; Table 3.1 shows the results. It can be seen that measurable penetration of fallout to a depth of at least 3 in. does occur and that the penetration increases with the increase in surface burden. However, it appears that, even with a fairly severe surface contamination of an unprotected wheat dump, a satisfactory skimming operation could be practiced without too extensive a wastage of the total.

3.2 POTATOES

Potatoes exposed in a single layer on a table surface receiving 9.5 μc/sq ft were decontaminated by scrubbing with a vegetable brush in running water (Table 3.2). Although this operation proves that a considerable amount of fallout can be removed, some does remain, for the skin still exceeded background. However, even this residue was completely removed when the potato was peeled.

3.3 SNAPPED CORN

This is dried unshucked whole corn on the cob. Nine ears from station 5 were examined for radioactivity and then shucked. The results in Table 3.3 show that all contamination is removed by this operation. It is concluded that leaving corn in the unshucked state offers complete protection of the grain from fallout.

TABLE 3.1—PENETRATION OF RADIOACTIVE FALLOUT INTO WHEAT

Depth, in.	Radioactivity of wheat,* counts/min/g Station 3 (8.6 μc/sq ft)	Station 4 (9.5 μc/sq ft)	Station 5 (114 μc/sq ft)
0	19	13	69
1	3.1	7.4	60
2	1.5	3.9	34
3	1.5	1.9	11
4	1.4	2.0	3.9
5	1.3	1.8	2.4
6	1.4	1.7	2.6
12	1.5	1.9	2.3
18	1.4	1.9	2.2
24	1.2	1.6	1.5
30	1.2	1.6	1.9

* Measurements were made on 100-mg ashed samples at D + 30 days. Radioactivity of unexposed control wheat was 1 count/min/g; this was due to natural K^{40} content of samples.

TABLE 3.2—EFFECT OF WASHING POTATOES CONTAMINATED WITH FALLOUT (STATION 4, 9.5 μC/SQ FT)

Potato	Contamination,* mr/hr Before washing	After washing
1	1.4	·0.1
2	1.5	0.5
3	2.0	0.6
4	0.7	0.1
5	1.2	0.1
6	1.0	0.1
7	1.5	0.6

* Readings were made with a portable beta-gamma survey meter at H + 36 hr with an open probe held in contact with the sample. Background was 0.08 mr/hr.

TABLE 3.3—EFFECT OF SHUCKING SNAPPED CORN CONTAMINATED WITH FALLOUT (STATION 5, 114 μC/SQ FT)

Sample	Contamination,* mr/hr Before shucking	After shucking
1	0.3	0.08
2	1.2	0.08
3	2.2	0.08
4	0.8	0.08
5	0.8	0.08

* Readings were made with a portable beta-gamma survey meter at H + 36 hr with an open probe held in contact with the sample. Background was 0.08 mr/hr.

3.4 DRIED FRUITS, SOYA BEANS, AND COTTON SEED

One-half of each lot of the dried fruits was washed three times with water; no detergents were used. This was a field operation, the results of which are recorded in Table 3.4. It can be seen that washing procedures are not too successful in removing contamination from these products. This could be anticipated, considering the rough and retentive surfaces. Remainders from these operations were measured at D+30 days, using 100 mg of ashed sample. These results are shown in Table 3.5 and essentially confirm the findings with field instruments. The retention of approximately one-half of the activity on the cotton seed and soya beans is noteworthy; and, particularly, in the latter case where better cleanup by water of the smooth-skinned beans might have been expected. An attempt to express oil from these seeds failed, but it is theorized that significant contamination of this oil would have occurred.

TABLE 3.4 — EFFECT OF WATER WASHING TO REMOVE FALLOUT CONTAMINATION FROM DRIED FRUITS (STATION 4, 9.5 μC/SQ FT)

	Contamination,* mr/hr	
Product	Before washing	After washing
Niobian figs	1.5	0.9
Asiatic figs	2.0	0.7
French prunes	1.0	0.6
Elberta peaches	2.0	1.3
Blenheim apricots	1.0	0.8
Pears	1.4	0.6

* Readings were made with a portable beta-gamma survey meter at H+35 hr with an open probe held in contact with the sample. Background was 0.025 mr/hr.

TABLE 3.5 — EFFECT OF WATER WASHING TO REMOVE FALLOUT CONTAMINATION FROM DRIED FRUITS, SOYA BEANS, AND COTTON SEED

	Contamination,* counts/min/g		
Product	Before washing	After washing	Unexposed control†
	Station 4 (9.5 μc/sq ft)		
Niobian figs	15	4.5	2.9
Asiatic figs	20	5.3	2.7
French prunes	12	18	2.7
Elberta peaches	45	25	6.1
Blenheim apricots	27	3.9	8.2
Pears	17	15	1.8
Niobian raisins	15	25	2.3
Soya beans	37	25	4.7
	Station 5 (114 μc/sq ft)		
Soya beans	103	45	4.7
Cotton seed	212	147	4.7

* Readings were made on 100-mg dry-ashed samples at D+30 days. Beta-counting efficiency was 30 per cent.
† Activity due to natural K^{40} content of samples.

3.5 WHEAT

Table 3.6 shows the comparison between control and contaminated wheat processed in an experimental flour mill. Although this operation took place on a pilot scale, it is believed to be representative of large-scale commercial practice. Radioactivity measurements tabulated in the two columns resulted from samples drawn from 20 identical check points during the operation. (The control batch was processed first, followed by the contaminated batch.) The radioactivity of the control samples is, of course, due to the presence of the natural K^{40} isotope. Samples of high ash content, notably bran, are high in potassium and have more radioactivity. It can be seen from the column of the contaminated wheat that relatively high activity (over and above that caused by potassium) is associated with the cleanings and the bran and that this activity falls off as the more highly purified flour emerges toward the end of the milling process. A follow-up "flush" of 50 bushels of wheat was run through the mill after the contaminated wheat. Analyses of samples from the same check points revealed no significant carry-over of radioactivity.

TABLE 3.6—RADIOACTIVITY OF CONTROL AND CONTAMINATED WHEAT AT VARIOUS CHECK POINTS OF THE MILLING PROCESS

	Radioactivity, counts/min/100 g	
Sample description	Control wheat*	Contaminated wheat
Wheat before cleaning	196	385
Wheat leaving millerator		294
Wheat leaving Wolf washer	198	239
Wheat leaving Howes scourer	164	292
Cleanings	362	1780
Bran	832	1210
Germ	502	602
Shorts	444	658
Shorts dust flour	175	534
B second low-grade flour	168	193
Bran and shorts dust flour	168	331
T second low-grade flour	113	340
Fourth break flour	60	163
Second tails flour	53	75
First tails flour	53	70
1, 2, and 3 break redust flour	50	64
First break flour	45	83
Sizings flour	37	60
Fifth middlings flour	36	31
Second middlings flour	30	33
First middlings flour	30	60
Combined flour	53	64

* Activity due to natural K^{40} content of samples.

Figure 3.1 shows the net radioactivity (excess over control) of the contaminated wheat in the various stages of the milling operation. Here it is clearly evident that the contamination "rides" with the bran. For example, the blocks of highest contamination coincide with bran, shorts dust flour, bran and shorts dust flour, T second low-grade flour, and fourth low-grade flour. This seems to be directly related to the bran, which tenaciously holds the residual radioactivity not removed by the millerator. It is interesting that some residual radioactivity is retained in the germ. Presumably this is due to the oily entrapment of radioactive particles.

The better grade or low-ash flours, such as the first tailings, the first, second, and third break mixed, second middlings, first middlings, and the final combined flour, show lowered residual radioactivity.

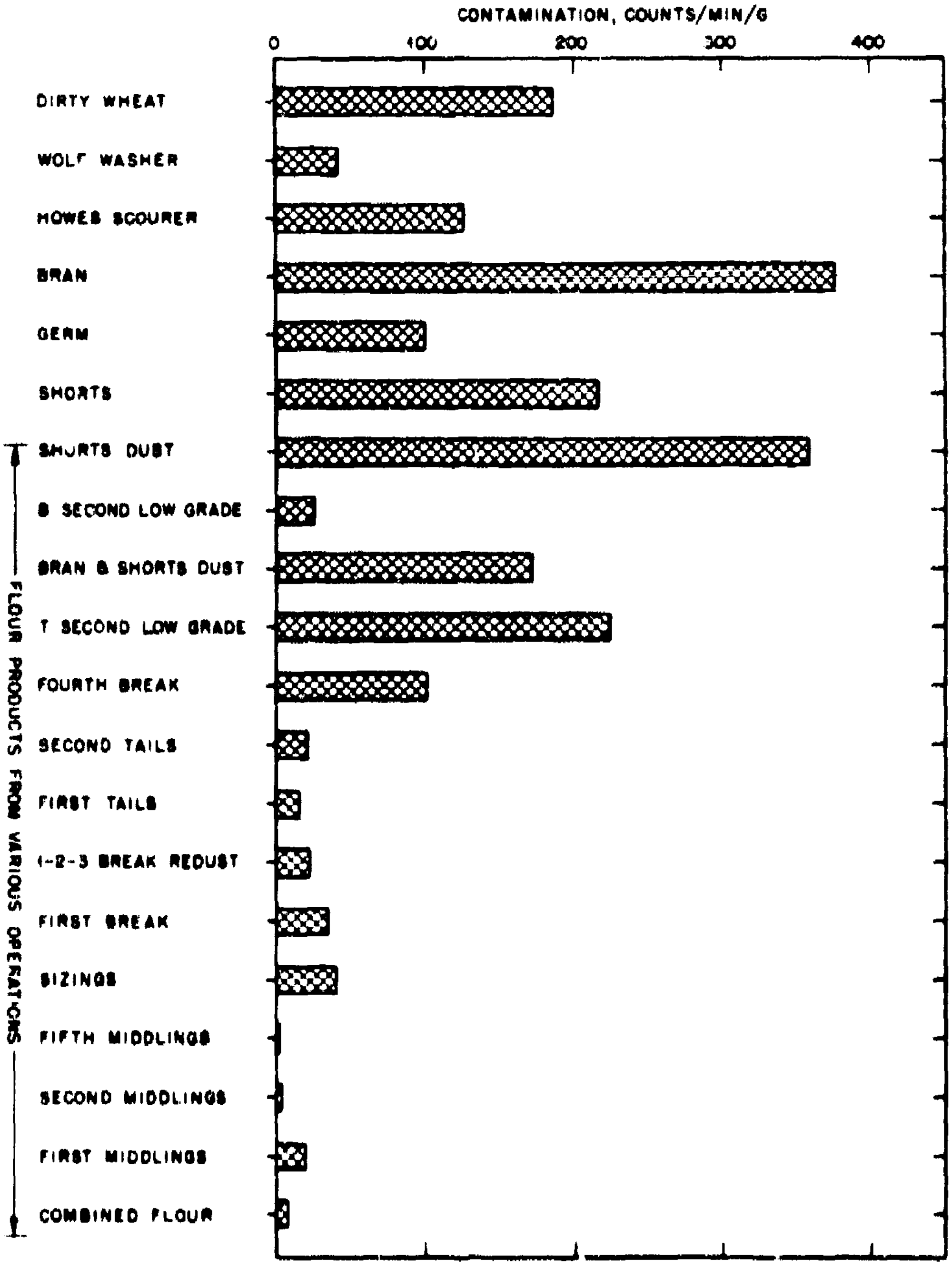

Fig. 3.1 — Amount of contamination of wheat products at various stages of processing into flour.

Therefore it can be concluded that the cleaning and milling operation removes a significant proportion of radioactivity from the final flour; however, in view of the relatively low degree of contamination, conservative extrapolations to more severe situations should be observed.

Chapter 4

SUMMARY AND CONCLUSIONS

The exposure of some raw agricultural products to fallout revealed the following:

1. Depending on the degree of contamination, fallout particles sift to a depth of 3 to 5 in. into the surface layers of undisturbed stored wheat.
2. Standard cleaning and milling operations remove a large measure of contamination from flour originating from fallout-exposed wheat.
3. Unshucked corn offers complete protection of the grain from fallout.
4. Water washing is relatively ineffective in removing fallout contamination from dried fruits, soya beans, and cotton seed.
5. Peeling preceded by thorough scrubbing in water is the method of choice for complete removal of fallout contamination from potatoes.