Bromide Residues from Methyl Bromide Fumigation of Food Commodities

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Food commodities of a wide variety were fumigated with methyl bromide. Categories of foods fumigated include candy and confections, cereal products, animal products and fats, herbs, spices, beverages, and miscellaneous. A detailed description of an x-ray fluorescence method for determining bromide residues is given. Results of analyses of the foods are given, and a specific residue figure calculated for each. These varied from a high of 115 p.p.m. of bromide deposited per pound of methyl bromide used per 1000 cu. feet for powdered eggs, down to no residue deposited in a few of the foods.

The use of methyl bromide for commodity fumigation has greatly increased in the past few years. The product has distinguished itself as being unusually effective, fast acting, highly penetrating, safe to use with respect to the applicator and commodity when proper precautions are taken, and an easy and economical way of controlling certain pest infestations.

When any fumigant is used on any material on or in which it may be sorbed, there is the possibility of a residue. Methyl bromide, b.p. = 4.5° C. at 760 mm. of Hg, is a gas under normal fumigation conditions and diffuses rapidly from fumigated foods after the fumigation is terminated (Desbaumes and Desshusses, 1956; Shrader *et al.*, 1942). Because the residue remaining is inorganic bromide, the tolerances for residues established by the United States Food and Drug Administration (FDA) resulting from fumigation with methyl bromide are for "inorganic bromides calculated as Br" (*Federal Register*, 1966). Several papers giving data on bromide residues resulting from methyl bromide fumigations have been published. Stenger *et al.* (1939), Dudley *et al.* (1940), Dudley and Neal (1942), Laug (1941), and Desbaumes and Desshusses (1956) have reported bromide residues on a variety of food products. Roehm *et al.* (1943) reported residue values from fumigation of cheese, butter, and dried skim milk. Data are given by Getzendaner (1961), Gibich and Pederson (1963), Hermitte and Shellenberger (1947), Lewis and Eccleston (1946), Lindgren *et al.* (1962), Lindgren and Vincent (1959), Lubatti and Harrison (1944), Whitney (1963), and Winteringham and Harrison (1946) on residue accumulation of bromides in cereals and some cereal products from methyl bromide fumigation.

Residues resulting from fumigation of nuts were reported by Coulon *et al.* (1954) and Gerhardt *et al.* (1951), while Reeves *et al.* (1947) determined residues resulting from fumigating cotton seed. A study of bromide residues in cocoa beans fumigated with methyl bromide and milled fractions from fumigated beans was carried out by Getzendaner (1966). Lynn *et al.* (1963) gave data on the excretion of bromide in milk from cattle eating bromide-containing feed. Getzendaner (1965a) showed the level of bromide residue in tissues from chickens fed methyl bromide–fumigated feed.

Despite the data given above, there is a lack of published information useful for establishing tolerances from bromide residues on processed foods resulting from direct fumigation of foods in chambers or from fumigations of warehouses or other buildings which might contain foods.

The purpose of this study was to establish rates of accumulation of inorganic bromide residues in processed foods when subjected to such fumigations with methyl bromide for the purpose of permitting tolerances to be established under the Food Additives Amendment to the Federal Food, Drug, and Cosmetic Act.

Since methyl bromide is used under a variety of circumstances and for the control of insects in many foodstuffs, the task of establishing systematic residue information as a basis for establishing residue tolerances might prove impossible if all possible variables must be accounted for. Therefore, some simplifying assumptions were necessary.

At one time, consideration was given to an attempt to establish categories of food types based on composition. To this end, a fundamental study was conducted on the relationship of protein, fat, and moisture in cereal products to the amount of bromide residue formed per unit of methyl bromide (Getzendaner, 1961). The results of this study were not helpful in permitting categorization of commodities, but the data did indicate that cereal products from the same grain source would probably acquire similar bromide residue levels per unit of methyl bromide. In addition, the results confirmed other previously obtained results which showed residues to be a linear function of dosage.

Methyl bromide is used both as a vault fumigant and as a building fumigant. Dosage variables are most prevalent

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in building fumigation where leakage is often a factor. Temperature variations are also encountered and in actual practice may call for varying dosages; however, Shrader *et al.* (1942) showed that when temperature and dosage are varied proportionately, the residues are similar.

Since it is desirable, in establishing tolerances, to use conditions that result in the maximum residue which might be encountered at the dosages of chemical used, sealed vaults were employed in this study, where no leakage was involved. In most cases, foods were fumigated at two dosages to give more data for an estimation of the specific rate of bromide accumulation than would be given by fumigation at a single rate.

EXPERIMENTAL

The bromide content of cereal and other dry products was determined by x-ray fluorescence. All other materials were analyzed by the Shrader *et al.* (1942) method. The x-ray method was described briefly by Getzendaner (1961). Both methods determine the total bromine content in the sample, with the Shrader method sensitive to 1 p.p.m. and the x-ray method sensitive to 5 p.p.m. in most substrates.

Procedure. PREPARATION OF SAMPLE. Materials of a hard, coarse nature such as noodles, coffee beans, macaroni, and feed mixtures are ground. Grains requiring milling include millet, corn, and oats. All other materials are run as received.

SAMPLE LOADING. Sufficient sample is loaded into the sample press (Figure 1) which will completely fill the sample ring after pressing, usually at 30,000 pounds, with a hydraulic press. The surface should be level and smooth, while the sample thickness should not vary from the dimensions of the retaining ring. The sample ring plus sample is then inserted into a magnesium cell, which is shaped to fit the sample ring. A Philips Electronics spectrometer 60 KVP, and 50 MA, was used for this work. It was equipped with a motor-driven goniometer unit, scintillation counter, voltage and current stabilizers, and fluorescence analysis attachment. The latter used a LiF analyzing crystal, FA 60 tungsten target or FA 60 molybdenum target x-ray tube. A helium atmosphere attachment, used in this work, is optional.

ANALYTICAL CONDITIONS. The conditions were: voltage—50 kv.; current—20 ma.; operation—fixed count (25,600); total counts—204,800; goniometer—29.97°. One run is made on each of two separate sample loadings from each specimen.

Calibration. The calibration curves for representative commodities were obtained by running chemically analyzed samples using the above-mentioned analytical conditions. Counts per second are obtained by dividing the total counts by the time interval in seconds. No background corrections were used.

Once a curve has been established only one or two standards need be checked when running unknown samples. Experience has shown that a calibration curve can be used for all commodities of similar nature.

Since only bromine is being sought, the intensity of the BrKα line is measured by the counting technique—i.e., by setting the goniometer unit, upon which are mounted the crystal and scintillation counter, at the indicated angular location for the BrKα line and measuring the counts per second. The concentration of bromine is determined by referring to the calibration curves which relate concentration *vs.* counts per second.

For a study of the precision of the method, one sample was picked at random and run 12 times using a fresh portion of the sample each time. The bromine content varied from 31 to 37 p.p.m., with an average of 34.4 p.p.m.

This indicates a precision of $\pm 10\%$ of the amount present at this concentration level. The average time required for a complete analysis is about 10 minutes per sample not counting calibration time.

Fumigation Procedure. FIRST SERIES. Chambers of two sizes previously described by Getzendaner (1965b, 1961) were used, depending on the quantity to be fumigated. Both were hermetically sealed and designed to introduce the fumigant by sweeping it into the partially evacuated chamber. Several cereal products were fumigated together in the 27-cu. foot chamber so that it could be filled to about 75% of capacity. The other commodities were put with similar materials and fumigated in small batches in the 25-liter chambers. For all fumigations, the chamber was 75% full. After the 24-hour exposure, the foods were aerated at least 24 hours before the samples were removed for analysis.

The commodities, which are normally packaged prior to commercial distribution, were purchased in commercial packages. They were transferred to containers which would allow penetration of the methyl bromide gas, such

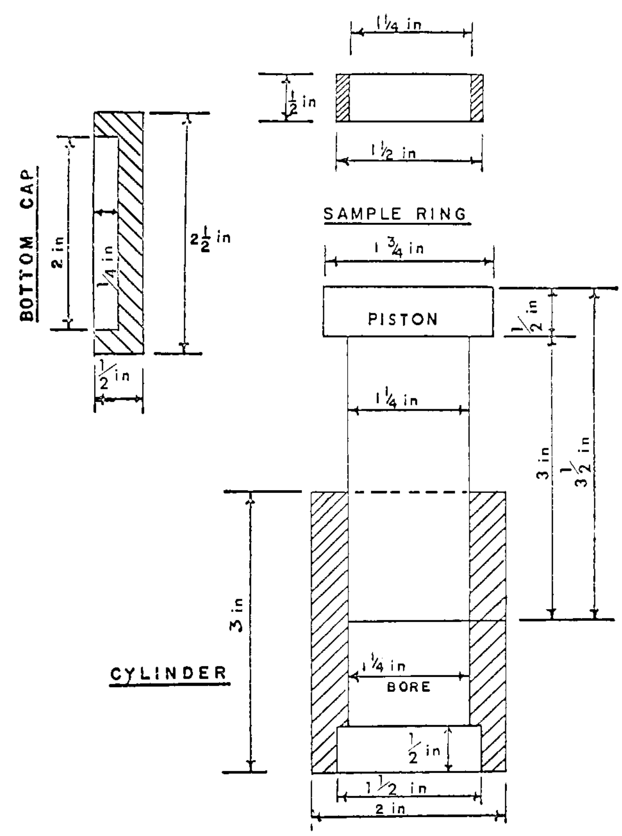

Figure 1. Sample press mechanism

as paper bags or waxed paper cups, if there was any doubt about methyl bromide penetrating the package. The cups were fumigated with the lids removed or holes punched in them. In most cases where the commercial package had a waxed inner bag in a cardboard box, holes were punched through both. Samples of all commodities were taken before fumigation, and the opened packages were not resealed. This procedure was followed so that maximum residues would result.

SECOND SERIES. A gastight 100-cu. foot fumatorium was used in the second experimental series. It was operated at either 80° F. with 2.5 pounds of methyl bromide per 1000 cu. feet (lb./M.) or at 60° F. with 3.75 pounds per 1000 cu. feet for a period of 12 hours at atmospheric pressure. There were 16 commodities in the chamber for each fumigation. During fumigation, the concentration of methyl bromide was measured at intervals with a gas chromatograph (Lindgren and Vincent, 1959). Table I gives the concentration found. A 2-meter Perkin-Elmer Corp. C column of DC-200 fluid on 60- to 100-mesh diatomaceous earth was used at 80° C. with a helium flow rate of 110 ml. per minute. The sample was introduced with a 5-ml. gas sampling loop and detected by a thermistor detector.

RESULTS AND DISCUSSION

Table II gives the results of analysis of the fumigated goods. Each value in the "treated" column is from a separate fumigation. The net bromide residue in treated samples has been corrected for the amount of bromide in the untreated samples. Since these commodities were taken from commercial channels, there is no way of knowing whether the inorganic bromide content before fumigation was the result of a previous fumigation history or is the natural content of the particular foods involved.

The last column in Table II, labeled "Specific Residue," is calculated as the net increase from fumigation divided by the rate in pounds per 1000 cu. feet at which methyl bromide was used in the fumigation. The specific residue figure can be calculated because of the linear relationship between methyl bromide dosage and the level of inorganic bromide residue deposited under given storage conditions of temperature and exposure period.

The preponderance of data are from fumigations at 80° F., a normal maximum temperature of fumigation. In almost all of the cases where the commodity was also fumigated at 60° F., the specific residue increase is higher at the higher temperature.

In Table III, the commodities having approximately the same specific residue are grouped. This table can be used as a basis for predicting the increase in bromide residue from a fumigation. For any given commodity, the residue increase should not exceed the specific residue multiplied by the rate at which methyl bromide is used in pounds per 1000 cu. feet.

The values found here may not represent the full range of residues that may result in specific situations. However, they should serve as a basis for judging whether a fumigation will result in an excessive residue if the bromide content of the commodity is known prior to the fumigation.

The data given in Table II were used by the FDA as part of the information on which the Food Additive Tolerances for bromide residues in processed foods were established, as published in the *Federal Register* (1966). The tolerance levels of bromide residues established were based on rate of accumulation of inorganic bromide and the number of times commodities may be fumigated under practical conditions. In addition, the safety was considered.

To protect the health of consumers, tolerances were established so that if all foods eaten should have the tolerance limit of bromide residue, there would still be an adequate safety factor. As long as the tolerances are not exceeded, methyl bromide can be used safely to fumigate food commodities to take advantage of its potential to control a wide variety of pest infestations.

All food commodities have the potential of being fumigated several times. They could be fumigated before processing, at the port of entry into the country, if imported, in the processing plant, in the manufacturer's warehouse, in a warehouse of a wholesale handler, and, finally, in a grocery store. Commodities may also be fumigated while in transit between any of the above locations. The geographical areas in the warmer parts of the country are more prone to build-up of pests, and therefore more subject to repeated fumigations. As the requirements for insect fragments and other evidence of infestation become more stringent, more fumigations become necessary.

In addition to the residues from fumigation, many commodities contain bromide from natural sources. Because the residue is bromide ion in either case, there is no difference between the bromide which is natural and that resulting from fumigation. Examples of commodities (Table II) which contained a residue prior to the laboratory fumigations are rice flour, powdered eggs, gelatin, dried milk,

Table I. Concentration of Methyl Bromide in Fumatorium During Second Series Fumigations

Sampling Time Interval, Hrs.	Mg./Liter	Sampling Time Interval, Hrs.	Mg./Liter
80° F. Chamber, 2.5 Lb./M. = 40 Mg./Liter			
1/4	33.2	6	24.4
1/2	33.2	6[a]	19.9
1	32.9	7	19.8
2	32.5	8	19.8
2[a]	25.2	9	19.6
3	24.9	10	19.6
4	24.9	11	19.4
5	24.4	12	19.4
60° F. Chamber, 3.75 Lb./M. = 60 Mg./Liter			
1/4	50.8	6	37.5
1/2	50.5	6[a]	29.5
1	50.1	7	29.2
2	48.4	8	29.5
2[a]	38.2	9	29.4
3	37.8	10	29.4
4	37.5	11	29.2
5	37.2	12	29.2

[a] Concentration reduced artificially by air dilution.

Table II. Bromide Residues in Food Commodities

Food	H₂O, %	° F.	Hours	Rate, Lb./M.	Bromide Residues, P.P.M. Untreated	Treated (net)[a]	Specific[b]
Candy and Confections							
Candy bar[c]	1.3	80	24	1	1, 1	8, 5	6
Brand 1		80	24	3		26, 18	7.3
Chocolate bar	1.6	60	12	3.75	0, 0	25	6.7
Brand 2		80	12	2.5		26	10
Chocolate bar	1.3	80	24	1	2, 2	6, 7	6.5
Brand 3		80	24	3		18, 17	5.8
Candy bar[c]	1.2	80	24	1	1, 4	8, 7	7.5
Brand 4		80	24	3		28, 13	6.8
Candy bar[c]	1.2	80	24	1	3, 2	10, 8	9
Brand 5		80	24	3		31, 31	10
Fudge	0.6	80	24	1	2, 2	3, 3	3
Brand 6		80	24	3		11, 4	2.5
Chewing gum	2.1	80	24	1	0, 1	4, 3	3.5
		80	24	3		9, 10	3.2
Marshmallows,	0.7	60	12	3.75	0, 0	6	1.6
large		80	12	2.5		7	2.8
Marshmallows,	1.4	80	24	1	0, 0	0, 0	0
miniature		80	24	1.5		0, 0	0
Mints[c]	0.8	80	24	1	1, 2	5, 1	3
		80	24	3		6, 12	3
Peanuts[c]	1.8	80	24	1	4, 13	27, 5	16
		80	24	3		59, 55	19
Sugar, cane[d]	0.1	80	24	1	7, 7	0, 0	0
		80	24	1.5		0, 0	0
Cereal Products							
Corn flakes	3.9	80	24	1	5, 6	0, 0	0
Brand A		80	24	1.5		0, 2	0.7
Corn flakes	4.7	80	24	1	5, 6	0, 2	1
Brand B		80	24	1.5		0, 2	0.7
Hominy grits	8.2	80	24	1	4, 3	6, 11	8.5
		80	24	1.5		10, 11	7.0
Oat cereal	4.3	80	24	1	0, 0	8, 7	7.5
		80	24	1.5		15, 14	9.7
Puffed rice	4.1	80	24	1	0, 0	7, 9	8
Brand A		80	24	1.5		6, 7	4.3
Puffed rice	5.8	80	24	1	0, 0	9, 9	9
Brand C		80	24	1.5		10, 14	8
Cream of wheat	11.1	80	24	1	12, 25	17, 17	17
		80	24	1.5		34, 44	26
Puffed wheat	4.9	80	24	1	0, 0	6, 8	7
		80	24	1.5		9, 11	6.7
Shredded wheat	6.9	80	24	1	0, 10	5, 8	6.5
		80	24	1.5		11, 4	10
Flaked cereal	7.9	60	12	3.75	8, 5	14	3.7
Brand D		80	12	2.5		7	2.8
Baking powder	11.6	60	12	3.75	0, 0	0	0
		80	12	2.5		0	0
Noodles, egg	6.7	80	24	1	0, 0	15, 16	16
		80	24	1.5		23, 20	14
Starch, corn	10.6	80	24	1	3, 3	3, 2	2.5
		80	24	1.5		5, 5	3.3
Macaroni	9.6	60	12	3.75	0, 0	12	3.2
		80	12	2.5		12	4.8
Dog food, dry	8.9	60	12	3.75	8, 11	98	26
		80	12	2.5		81	32
Cattle feed, mixed	10.3	60	12	3.75	8, 0	68	18
		80	12	2.5		81	32
Cornmeal	11.9	60	12	3.75	0, 0	68	18
		80	12	2.5		68	27
Flour, rice	8.5	80	24	1	106, 107	0, 0	0
		80	24	1.5		13, 53	22
Flour, soy	6.0	70	42.5	1	0	49	49
Flour, tapioca		70	42.5	1	0	0	0
Flour, white wheat							
Brand 1[e,f]	8.5	80	24	1	14, 16	41, 41	41
		80	24	1.5		53, 61	38
Brand 2[e,g]	11.3	80	24	1	12, 13	21, 18	20
		80	24	1.5		26, 30	19

Table II. (Continued)

Food	H_2O, %	° F.	Hours	Rate, Lb./M.	Bromide Residues, P.P.M. Untreated	Treated (net)[a]	Specific[b]
Brand 2A[e,f,h]	11.3	80	24	1	15, 16	23, 24	24
		80	24	1.5		32, 45	26
Brand 3[e,g,h]	11.1	80	24	1	10, 7	28, 29	29
		80	24	1.5		32, 41	24
Brand 4[i]	8.8	80	24	1	6, 0	21, 23	22
		80	24	1.5		40, 51	30
Flour, whole wheat							
Brand 5[b]	10.5	80	24	1	14, 13	28, 32	30
		80	24	1.5		46, 44	30
Brand 6	8.2	80	24	1	7, 5	36, 41	39
		80	24	1.5		60, 52	37
Brand 7	11.4	60	12	3.75	0, 0	79	21
		80	12	2.5		92	36
Cake mix							
Brand 8	4.3	60	12	3.75	0, 0	24	6.4
		80	12	2.5		19	7.6
Brand 9	3.8	80	24	1	4, 5	3, 1	2
		80	24	1.5		7, 7	4.7
Brand 10	4.8	80	24	1	4, 4	3, 3	3
		80	24	1.5		6, 1	2.3
Brand 11	4.1	80	24	1	4, 5	5, 7	6
		80	24	1.5		10, 6	5.3
Pancake mix							
Brand 12	8.4	80	24	1	8, 8	7, 7	7
		80	24	1.5		10, 10	6.7
Brand 13	8.5	80	24	1	31, 32	0, 0	0
		80	24	1.5		0, 0	0
Pie crust mix							
Brand 14	6.4	80	24	1	14, 13	6, 7	6.5
		80	24	1.5		13, 16	9.7
Brand 15	6.2	80	24	1	5, 4	4, 2	3
		80	24	1.5		5, 8	4.3
Brand 16	7.2	80	24	1	22, 27	10, 16	13
		80	24	1.5		22, 28	17
Animal Products, Fats							
Cheese, cheddar	5.1	80	24	1	5, 4	8, 16	12
		80	24	3		31	10
Cheese, cottage, creamed	50	80	24	1	1, 2	7, 10	8.5
		80	24	3		30, 32	10
Cheese, pinconning	13	80	24	1	1, 2	8, 9	8.5
		80	24	3		37, 23	10
Cheese, parmesan, grated		80	24	1	7, 8	85, 75	80
		80	24	3		252, 190	74
Beef, roast, chuck	57	80	24	1	1, 2	24, 13	19
		80	24	3		37, 65	17
Beef, roast, loaf	36	80	24	1	4, 4	11, 16	14
		80	24	3		58, 30	15
Frankfurters, skinless	35	80	24	1	4, 5	31, 27	29
		80	24	3		85, 73	27
Pork, shoulder, smoked	37	80	24	1	3, 3	6, 8	7
		80	24	3		47, 21	12
Pork, steak	37	80	24	1	4, 2	28, 22	25
		80	24	3		50, 53	17
Bacon, sliced	11.7	80	24	1	6, 7	22, 29	25
		80	24	1.5		58, 37	32
Eggs, powdered		80	24	1	36, 36	83, 125	108
		80	24	3		354, 338	115
Gelatin, unflavored		80	24	1	18, 20	14, 13	14
		80	24	3		60, 53	19
Gelatin,[j] flavored	1.8	60	12	3.75	0, 0	0	0
		80	12	2.5		0	0
Milk, malted		80	24	1	9, 10	7, 3	5
		80	24	3		0, 5	1.7
Dry		80	24	1	10, 8	6, 7	6.5
Skimmed		80	24	3		5, 5	1.7
Milk, dry		80	24	1	34, 37	2, 1	1.5
Whole		80	24	3		14, 9	3.8
Pork sausage, link	19.5	80	24	1	3, 6	17, 14	16
		80	24	3		35, 50	14

(*Continued on page 270*)

Table II. (Continued)

Food	H_2O, %	° F.	Hours	Rate, Lb./M.	Bromide Residues, P.P.M. Untreated	Treated (net)[a]	Specific[b]
Veal loaf	40	80	24	1	6, 6	8, 8	8
		80	24	3		27, 25	8.7
Butter	4.7	80	24	1	1, 1	6, 4	5
		80	24	3		11, 11	3.7
Oleomargarine	4.4	80	24	1	3, 3	1, 0	0.5
		80	24	3		3, 7	1.7
Shortening	0.7	80	24	1	1, 1	1, 1	1
		80	24	3		2, 8	1.7
Herbs, Spices, Beverages, Misc.							
Cocoa	6.0	60	12	3.75	0, 0	47	13
		80	12	2.5		33	13
Coffee, ground	5.7	60	12	3.75	0, 0	25	6.7
Brand A		80	12	2.5		29	12
Coffee, ground	2.9	80	24	1.0	1, 1	11, 12	12
Brand B		80	24	1.5		10, 10	6.7
Coffee beans	2.7	80	24	1	0, 0	4, 4	4
Roasted		80	24	1.5		5, 5	3.3
Tea, green	5.3	80	24	1	6, 6	0, 0	0
		80	24	1.5		5, 7	4
Tea, orange pekoe	6.1	80	24	1	7, 8	0, 0	0
		80	24	1.5		1, 2	1
Allspice, ground	8.6	80	24	1	4, 4	15, 25	20
		80	24	1.5		26, 23	17
Cinnamon, ground	9.0	80	24	1	4, 3	12, 0	6
		80	24	1.5		19, 16	12
Ginger, ground	10.4	80	24	1	73, 71	8, 8	8
		80	24	1.5		6, 11	6
Nutmeg, ground	7.9	80	24	1			
		80	24	1.5	25, 24	7, 4	5.5
						16, 11	9.1
Pepper, red, ground	7.3	80	24	1	28, 28	9, 9	9
		80	24	1.5		6, 5	3.7
Yeast, dry	7.5	80	24	1	1, 1	0, 0	0
		80	24	1.5		0, 0	0

[a] Net = residue in treated − average residue in untreated sample. [b] Specific residue = $\frac{\text{av. p.p.m. increase from fumigation}}{\text{rate of fumigation (lb./M.)}}$. [c] Chocolate-covered. [d] Extra fine granulated. [e] Bleached. [f] Bromated. [g] Fancy patent. [h] Enriched. [i] Pastry flour. [j] Fumigated in commercial 6-oz. package.

Table III. Summary of Data on Specific Residues in Inorganic Bromide in Commodities from Methyl Bromide Fumigation

Maximum Specific Residue[a] Found	Commodities
0 to 5	Baking powder, butter, chewing gum, coffee (whole roasted), macaroni, marshmallows, oleomargarine, shortening, tapioca flour, tea, yeast (dry)
5 to 10	Breakfast cereals (precooked), cake mix, candy, cheese, ginger (ground), milk (dried), nutmeg (ground), pancake mix, pepper (red ground), veal loaf
10 to 15	Cinnamon (powdered), coffee (ground, roasted), cocoa
15 to 20	Allspice, beef cuts, gelatin, noodles, peanuts, pie crust mix
20 to 30	Corn meal, Cream of Wheat, frankfurters, pork cuts, rice flour
30 to 40	Bacon, cattle feed (mixed), dog food (dry), wheat flour (white and whole wheat)
40 to 50	Soy flour
75 to 100	Grated parmesan cheese
100 to 125	Eggs (powdered)

[a] Specific residue = $\frac{\text{p.p.m. bromide increase from fumigation}}{\text{rate of fumigation (lb./M.)}}$.

and ginger, which contained 107, 36, 20, 37, and 73 p.p.m. of bromide residue, respectively.

Because of this, it may be necessary to determine the residue in a food prior to fumigation, to make sure that the total accumulation of bromide after fumigation does not exceed the tolerance. This may be the only safe way to proceed if the previous history of the commodity is unknown. If the bromine content before fumigation is known, the total residue following fumigation can be predicted on the basis of the specific residue accumulation rate.

A hypothetical example of the way bromide residues can build up to the presently established tolerance of 125 p.p.m. can be shown for wheat flour. During storage of the unprocessed wheat, fumigations can legally bring the residue up to 50 p.p.m. of bromide. After milling, the flour may be fumigated in the mill with $1^1/_2$ pounds per 1000 cu. feet of methyl bromide for 24 hours at 80° F. Based on Table III, this could give an increase of as much as 60 p.p.m. of bromide residue, or bring it up to 110 p.p.m. If, on analysis, the residue is at this level, it is very likely that additional fumigation with methyl bromide would result in a residue exceeding the tolerance of 125 p.p.m. If the residue found by analysis shows a lesser increase, it may be possible to fumigate safely again. In a similar manner, when the residue content of a commodity is known before fumigation, the data given here can be used to predict the total residue of inorganic bromide resulting after an additional fumigation.

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