TB 1055 (1952) USDA TECHNICAL BULLETINS UPDATA

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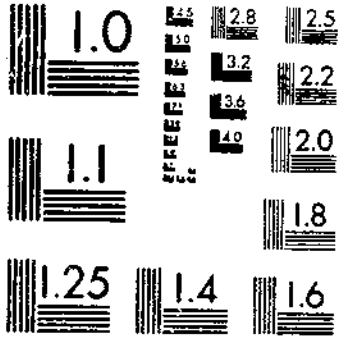

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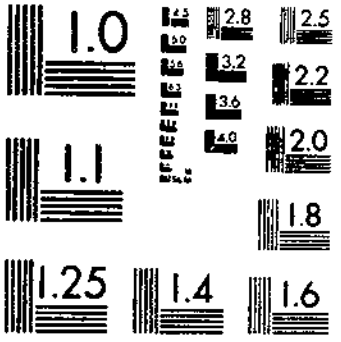

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Technical Bulletin No. 1055 . July 1952

UNITED STATES
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

The Calcium Content of Commercial White Bread[1]

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SUMMARY

Bread samples, collected in 41 States and the District of Columbia in the spring of 1949, were analyzed for calcium content.

In order to evaluate the sources and forms of calcium found in commercial white bread, the data from laboratory analyses for total calcium in the samples were studied in relation to calculated values for calcium from milk in the same samples.

Results from analyses of 402 samples showed an average value of 74 milligrams of calcium per 100 grams of bread, original moist weight as purchased, or 334 milligrams per pound loaf of bread. It is estimated that approximately one-third of this amount was derived from milk, meaning that a pound loaf of commercial white

[1] Submitted for publication January 4, 1952.

[2] Grateful acknowledgment is made to Elsie F. Doehterman and Albert B. Parks, of the Bureau, for their statistical assistance.

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bread contained, on the average, milk calcium equivalent to that in about three-eighths cup of fluid whole milk, or approximately 3.5 percent nonfat dry-milk (flour basis), as used in the baker's formula.

In addition to milk, bread formulas may include calcium-containing substances in the form of mold inhibitors, dough conditioners and improvers, yeast nutrients, and calcium salts added as optional enrichment agents. From the standpoint of calcium content of bread, the most important of these proved to be the calcium enrichment agents and the calcium-containing mold inhibitors, since their presence, revealed by label information, was associated with total calcium levels that were higher than the average for all samples. On the other hand, there appeared to be no relationship between the presence of surface-active agents (softeners) in bread and total calcium content.

Total calcium of the bread samples showed greater variability in levels than did the calcium from milk; there was little relationship between the two. The correlation was positive but very low.

PURPOSE OF THE STUDY

Because of the importance of commercial white bread in the diets of the people of this country, enrichment of white bread with thiamine, riboflavin, niacin, and iron was mandatory in the United States during World War II. It is now compulsory in 26 States and 2 Territories. Enrichment with calcium, although permissible by law, is not widely practiced. However, the widespread use of milk solids and various other calcium-containing constituents in the modern production of white bread could affect significantly the total calcium content of present-day bread as compared with analytical results reported some years ago.

Food consumption surveys of urban families by the Bureau of Human Nutrition and Home Economics (*28*)[3] in 1948 revealed that calcium was the nutrient in which the diets most frequently were below the National Research Council's recommended dietary allowances (*13*). Six out of 10 of the families with low incomes (under $1,000 a year) had diets providing less than the recommended allowance. Even among groups with incomes over $7,500 a year, 4 out of 10 families had diets below this level.

Milk supplies most of the calcium in the average diet of this country—the 1948 surveys indicated that two-thirds of the total calcium in urban family diets was contributed by milk and other dairy products such as cream, ice cream, and cheese—but it is apparent that many families do not have enough of these foods. Therefore, analytical data on the calcium content of various foods, including bread, are of importance for planning and evaluating diets.

This study was undertaken to determine the total calcium content of commercial white bread in order to make an appraisal of the contribution of the calcium in bread to the day's dietary and to ascertain the variation to be expected in bread calcium—information needed in developing tables of food composition. Further purposes

[3] Italic numbers in parentheses refer to Literature Cited, p. 24.

of the study were to determine the contribution of milk to total calcium in bread, to evaluate the relation of the presence of noncalcium-containing components, such as surface-active agents commonly referred to as "emulsifiers" or "softeners," to the calcium content of bread, and to look for possible evidence of substitution of these compounds for milk or other sources of calcium.

LITERATURE REVIEW

Early Reports on Calcium Content of White Bread

The first edition of Sherman's Chemistry of Food and Nutrition, published in 1911 (*20*), carried a table giving ash constituents of foods in percentage of edible portion, in which white bread was reported as containing 0.03 percent calcium oxide (equivalent to 0.021 percent calcium). Subsequent editions, 1918, 1926, and 1932, reported calcium percentage as 0.027, which was in exact agreement with the value reported by Waller in 1936 (*30*) for white bread made with water. Sherman's fifth edition, 1937 (*20*), reported 0.031 percent calcium.

In 1920, Rose (*17*) reported the calcium values of a number of foods, including bread, in connection with a study of availability of the calcium from carrots. Two different values given for bread samples were 0.032 and 0.048 percent. Neither the source of the bread samples nor the formula was given, but it is possible that the higher value represented bread made with some milk.

Underhill's value for calcium in bread, reported also in 1920 (*26*) as a result of analyses on foods made in connection with a metabolic study, agreed with the lower value reported by Rose, namely 0.032 percent.

Influence of Milk on Calcium Content

Values reported by Sherman in Chemistry of Food and Nutrition from 1911 to 1937 (*20*) do not distinguish between bread made with water and that made with milk. The sixth and seventh editions, published in 1941 and 1946, reported calcium in white bread as 0.05 percent. In arriving at this value, Sherman probably took into account the effect of milk, in some bread formulas, upon the over-all calcium content of white bread, since the item was footnoted "Uncertain because of varying methods of breadmaking."

In 1925, Frank and Wang (*9*) reported a study of the variation of calcium in bread and in other common foods selected from a regular hospital supply. Calcium values were determined once or twice each month for 10 months. Water bread and milk bread were studied and reported separately. The range of values for water bread was 0.036 to 0.046 percent, with an average of 0.040; the range for milk bread was 0.055 to 0.061 percent, with an average of 0.059. The authors did not state whether the bread analyzed was commercial. They gave no formulas but indicated that some of the bread analyzed might have been made with part milk and part water.

The variation in calcium content of bread resulting from use of formulas differing in content of milk solids was demonstrated by Morison in 1925 (*12*) through analysis of laboratory-baked bread.

He compared bread samples made with 2.5, 8, and 10 pounds of dried whole milk per 100 pounds of flour. The percentages of calcium in the bread, on a 38-percent moisture basis, were 0.044, 0.067, and 0.080, respectively. The only ingredients used, other than flour, water, and dried whole milk, were yeast, sugar, salt, and shortening.

Rose, in the third and fourth editions of her Laboratory Handbook for Dietetics, 1929 and 1937 (*18*), reported separate values for calcium in white bread made with water and with whole milk—27 and 63 mg. per 100 gm., respectively.

In 1950, calculated calcium values reported by this Bureau (*31*) for white bread made with 2, 4, and 6 percent milk, in terms of nonfat dry-milk solids on a flour basis, and also containing small amounts of calcium salts added as dough conditioners and mold inhibitors, were 65, 79, and 92 mg. per 100 gm. bread, respectively.

Influence of Other Calcium-Containing Constituents on Calcium Content

Sullivan and Howe in 1929 (*24*) and Sullivan again in 1933 (*28*), reported calcium values for bread baked in a commercial bakeshop. As they were studying the inorganic constituents in wheat, flour, and bread, it was interesting to note that calcium content of wheat was 0.05 percent, of patent flour, 0.016, and of bread made from patent flour, 0.080 percent on the dry basis. Fluid condensed milk, 5.6 pounds per 100 pounds of flour, was included in the formula, but this could account for very little of the calcium content. A yeast food, Arkady, which contributed some calcium, was used in the formula. The calcium content may have been augmented also by calcium in the water.

The influence of the calcium-containing constituents on calcium in commercial white bread was more clearly presented in a report in 1939 by Prouty and Cathcart (*16*), working at the American Institute of Baking. Thirty-nine samples of the most popular types of commercial white bread were analyzed and 10 samples of laboratory-baked bread containing varying quantities of dry skim milk and dry whole milk studied for comparison. The average moisture content of the latter bread was approximately 29 percent, as compared with 35 percent for the commercial. Water bread, baked with no milk, contained from 28 to 30 mg. calcium per 100 gm. on a 38-percent moisture basis. The commercial samples ranged from 48 to 145 mg. per 100 gm., with an average value of 80 mg. calcium per 100 gm., or 363 mg. per pound. This value was equivalent to the calcium content of the laboratory-baked product containing 8 percent dry milk solids and 0.25 percent yeast food (flour-weight basis). The increase in calcium content of commercial white bread was attributed by the authors not only to an increased use of dry milk solids, but also to the use of various calcium-containing constituents, such as dough conditioners, yeast foods, and yeast nutrients or stimulators.

In 1948, an average value of 88 mg. calcium per 100 gm., or 401 mg. per pound loaf of bread, was reported by the American Institute of Baking (*1*). The 1950 report, by Crespo and Bradley (*4*), showed that the calcium content of 258 samples of bread from 26 States and the District of Columbia was about the same as that reported in 1948—

89 vs. 88 mg. per 100 gm., or 403 vs. 401 mg. per pound of bread, on a 38-percent moisture basis. The range of total calcium for the 258 samples was 110 to 656 mg. per pound loaf of bread. One hundred twenty-three of the samples were purchased in the summer of 1948; the remaining 135, which represented mainly duplicates of the original samples, in the winter of 1948–49.

The most recent report by Crespo and Bradley (*5*) presented the results of the study of 135 samples of commercial white bread purchased in 34 large cities. The range in total calcium for this group was 190 to 638 mg. per pound on a 38-percent moisture basis. The average was 404 mg. per pound. Calcium from nonfat dry milk solids represented approximately one-third of the total calcium in the bread. The remaining two-thirds was attributed to the adjuncts or additives used by the baker as production aids.

EXPERIMENTAL PROCEDURE

Samples Used

For the present study, 402 samples of commercial white bread bought on the open market from 41 States and the District of Columbia, were made available to this Bureau by the United States Food and Drug Administration. The sampling, which was made on wrapped, sliced white bread, was designed to furnish a general sample representative of the United States as a whole.

In addition to the contribution of bread samples for this study, results of the following analyses performed on the same bread samples by the Food and Drug Administration were made available for use by this Bureau in the interpretation of the total calcium data: Air-dry and total solids, based on weight at time of collection; nonfat dry milk solids in 260 samples, estimated from determined lactose content; polyoxyethylene monostearate compounds, determined by a semiquantitative test and reported as positive, negative, or doubtful.

Statements on the bread labels gave information on enrichment with vitamins and minerals. Of the 402 samples, 92.3 percent were enriched with thiamine, riboflavin, niacin, and iron. Some of the labels gave information on types of flour used and indicated the presence of such components as milk (various forms); yeast and yeast foods, nutrients, or improvers; dough conditioners; mold inhibitors; sugar, malt or malt sirup; shortening; wheat germ, egg yolks, water, and salt.

Analytical Method

Total calcium content of all bread samples was determined by a procedure involving the dry-ashing of air-dry bread, preparation of a proper solution of the ash, and precipitation of calcium oxalate from an acid filtrate with dry urea and ammonium oxalate solution, according to a modification of the rapid and improved method of Ingols and Murray (*10*). (For details, see appendix.)

Total calcium and milk calcium were calculated for each sample according to its moisture content. All figures relate to the original moist weight of the samples unless otherwise indicated.

TABLE 1.—*Total calcium content of 402 samples of commercial white bread*

Moisture basis	Moisture content	Total calcium			
		Average	Range	Average	Range
	Percent	*Milligrams per 100 grams*	*Milligrams per 100 grams*	*Milligrams per pound*	*Milligrams per pound*
Moist weight, as purchased	36	74 ± [1] 1	12–153	334 ± [1] 4	54–694
Air-dry weight	7	104	17–214	471	77–970
Dry weight	0	115	22–242	521	100–1, 098
Uniform moisture [2]	38	71	12–150	323	53–680

[1] Standard error.
[2] Calculated for comparison with data cited in literature review.

RESULTS AND DISCUSSION

Total Calcium

The ranges and averages of total calcium, calculated for different moisture contents for the 402 bread samples, are shown in table 1. The average calcium content was found to be 74 mg. per 100 gm., or 334 mg. per pound. This value is much higher than values reported prior to 1939, but lower than those reported by workers at the American Institute of Baking since 1939. It is in line with calculated values reported earlier by this Bureau (*31*).

The moisture content of the 402 samples ranged from 27 to 40 percent, with an average of 36 percent. The distribution of calcium content according to moisture content of the bread samples as purchased is shown in table 2. Calcium averaged 0.11 percent of total solids.

The calcium content of the samples showed great variability, the over-all range being 12 to 153 mg. per 100 gm. Figure 1 shows the 402 samples sorted into groups by 10-mg. intervals. Approximately 75 percent of all samples fell between the limits of 50 to 90 mg. per 100 gm. bread, or 227 to 408 mg. per 1-pound loaf of bread, moist weight. Maximum distribution was at the 70–79 mg. class interval.

Some of the variation may be accounted for by the well-known facts that no single component furnishes the calcium in commercial white bread and that practice in the use of different components varies widely. Of the basic ingredients, milk is the largest single source; wheat flour, though highly variable in content, sometimes contains nutritionally significant amounts (*21*); water varies with local-

TABLE 2.—*Number of samples of commercial white bread having specified moisture and calcium content*

Total calcium (milligrams per 100 grams)	Percentage moisture content [1]													
	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Under 30						1		2		1	1	1		
30–39							1	3	1	3	1		1	
40–49							1	1	4	4	2		1	
50–59				1	1		6	10	12	18	11	2	1	
60–69					1	2	1	6	14	15	22	12	3	1
70–79				2		2	10	6	12	22	25	13	5	
80–89	1		1				7	5	15	14	13	7	4	
90–99					2	1		2	5	6	10	2	1	1
100–109		1	1		1		1		5	9	4		1	
110–119							1		6	2	2		1	
120–129										1				
130–139											1			
140–149														1
150 and over										1	1			

[1] Middle of class interval; for example, 27 percent includes 26.51–27.50.

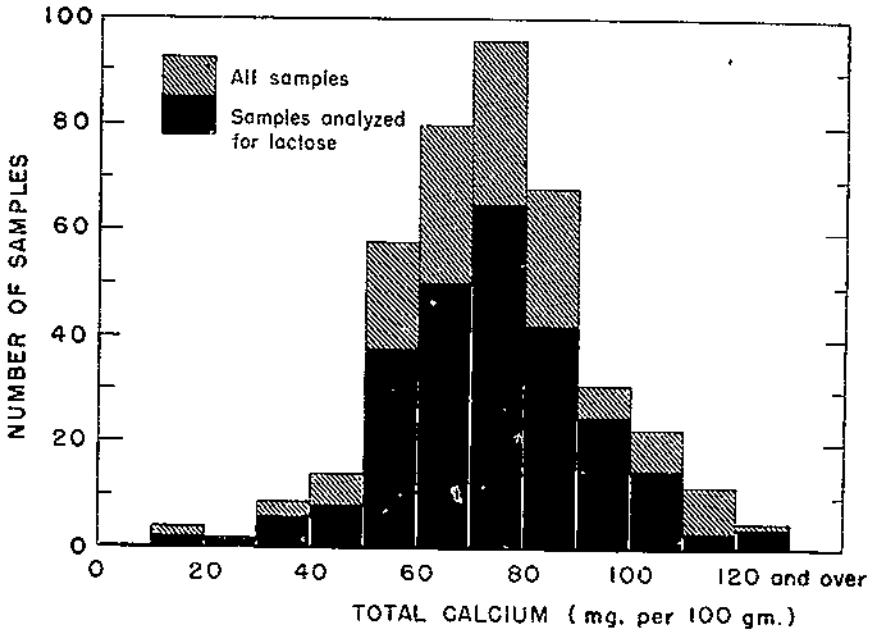

Figure 1.—Distribution by total calcium content of 402 samples of commercial white bread and of the 260 analyzed for lactose from which milk calcium was calculated.

ity and other factors, such as use of water softeners. Other sources include mold and rope inhibitors, yeast foods and nutrients, dough conditioners, and extra calcium which is sometimes added as an optional enrichment agent.

Other calcium-containing components may include a sizable list of both organic and inorganic compounds of calcium, such as calcium propionate, the mono-, di-, and tri-phosphates, the sulfates, the carbonates, and the peroxides. A number of workers have shown that some of the calcium salts used in the production of bread can be utilized by the human body (*11, 14, 15, 19, 22*).

Assuming that nonfat dry milk and flour were used in the ratio of 3 to 100, workers in the American Institute of Baking (*1, 4*) estimated that in a pound loaf of commercial white bread an average of 48 mg. of calcium would come from the flour used, 15 mg. from water, 56 mg. from yeast foods, and 222 mg. from milk—a total of 341 mg. of calcium. If calcium propionate were used as a mold inhibitor, the calcium content might be increased by approximately 205 mg. per loaf.

Calcium From Milk

Of the total 402 bread samples, the content of nonfat dry milk solids was estimated in the 260 in which lactose had been determined by the United States Food and Drug Administration. Fifteen samples, about 6 percent of the 260, contained no milk. Forms of milk used were reported variously on bread labels as nonfat dry milk solids, skimmed milk powder, whole milk powder, defatted milk powder,

skim milk solids, dried skim milk, powdered skim milk, milk solids, condensed and powdered milk (mixture), fat-free milk solids, fresh whole milk, and fresh milk.

To determine whether the 260 samples for which milk solids had been estimated represented an adequate sample of the total, their distribution was compared with that for the 402 samples (fig. 1). The average calcium content of the 260 samples, representing 29 States and the District of Columbia, was the same as the average for the 402 samples for the entire United States, namely, 74 mg. per 100 gm. of fresh bread. Calcium content of these samples ranged from 15 to 153 mg. per 100 gm. The average calcium content of 15 samples which contained no milk was 57 mg. per 100 gm. and was considerably lower than that of the 245 samples which contained milk, 75 mg. per 100 gm. Some individual samples made without milk, however, contained more calcium than the average amount for the entire group.

In calculating the calcium furnished by milk, it was assumed that lactose accounts for one-half of the nonfat dry milk solids and that the calcium content of nonfat dry milk solids is 1.3 percent. The range of calcium from milk in the 260 samples was estimated to be from 0 to 73 mg. per 100 gm., with an average of 25 mg. per 100 gm. This average would be equivalent to the calcium of three-eighths of a cup of whole milk per pound loaf of bread.

The average content of nonfat dry milk solids in the samples was calculated to be 2.0 percent (moist basis), with a range of 0 to 5.9 percent. This would be equivalent to approximately 3.5 pounds of nonfat dry milk solids per 100 pounds of flour, with a range of 0 to 9.7 pounds.

The variability of the amount of milk in the bread samples accounted for some but not all of the variation in total calcium. Figure 2 shows the relationship between calcium from milk and total calcium. For this figure, samples were grouped by 10-mg. increments according to total calcium and averages computed for both total and milk calcium content. There was a very low positive correlation (r=0.332) between total calcium and calcium from milk. Roughly, 11 percent of the variation in total calcium was associated with the variation in calcium provided by milk. This variability is vividly depicted in figure 3, in which the 260 samples are arrayed according to increasing total calcium and the corresponding figures for calcium from milk are plotted.

Experimental results indicated that, although milk calcium represented an average of 35 percent of the total calcium in 258 bread samples, the range was from 0 to 99.5 percent. (Of the total 260, 2 samples, upon analysis, contained 100 percent of the total calcium as milk calcium. This doubtful result was probably due to the fact that total calcium was determined in the laboratory and milk calcium was estimated as accurately as possible from the lactose content of the samples.)

The results for calcium provided by milk agree with the findings recently reported by Crespo and Bradley (5) that one-third of the calcium in their samples was from milk included in the baker's formula. Figure 2 shows that the percentage contribution of milk to the total calcium decreased after a total calcium content of about 70 mg. per 100 gm., and leveled off to about 25 percent in bread containing 110 mg. per 100 gm. and above.

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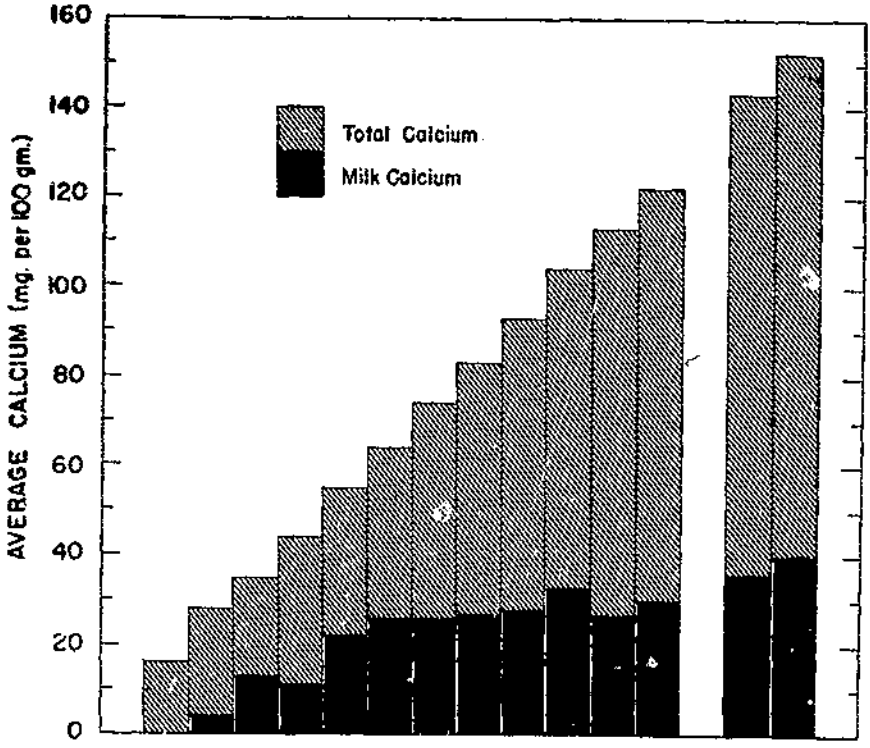

Figure 2.—Distribution of calcium in 260 samples of commercial white bread, showing average total calcium (analyzed), grouped by 10-milligram increments, and average milk calcium (calculated from estimated dry milk solids).

Calcium Content and Geographical Source of Samples

The 402 samples of commercial white bread from 41 States and the District of Columbia were grouped as to origin from 4 regions, using as a guide the standard United States Census classification of States into regions and divisions. The classification used in this study included the Northern States, divided into the Northeastern and the North Central States; the Southern States; and the Western States.

Because the variability in the calcium content of bread sold in a given locality or area is of interest both to consumers and to dietitians and nutritionists who plan and evaluate diets, averages of total calcium and calcium from milk in bread samples from the four regions and the constituent States were obtained (table 3). The samples were not drawn to represent the States, however, and may not have been typical of them.

In total calcium content of fresh bread, averages for each of 21 States and the District of Columbia were equal to or above the average for the United States (74 mg. per 100 gm.). Of the regions, the North Central had bread of the highest average calcium content, 78 mg. per 100 gm., and the Western region the lowest, 68 mg. per 100 gm. An analysis of variance was used to determine whether the means of the calcium content of the bread from the regions differed from one

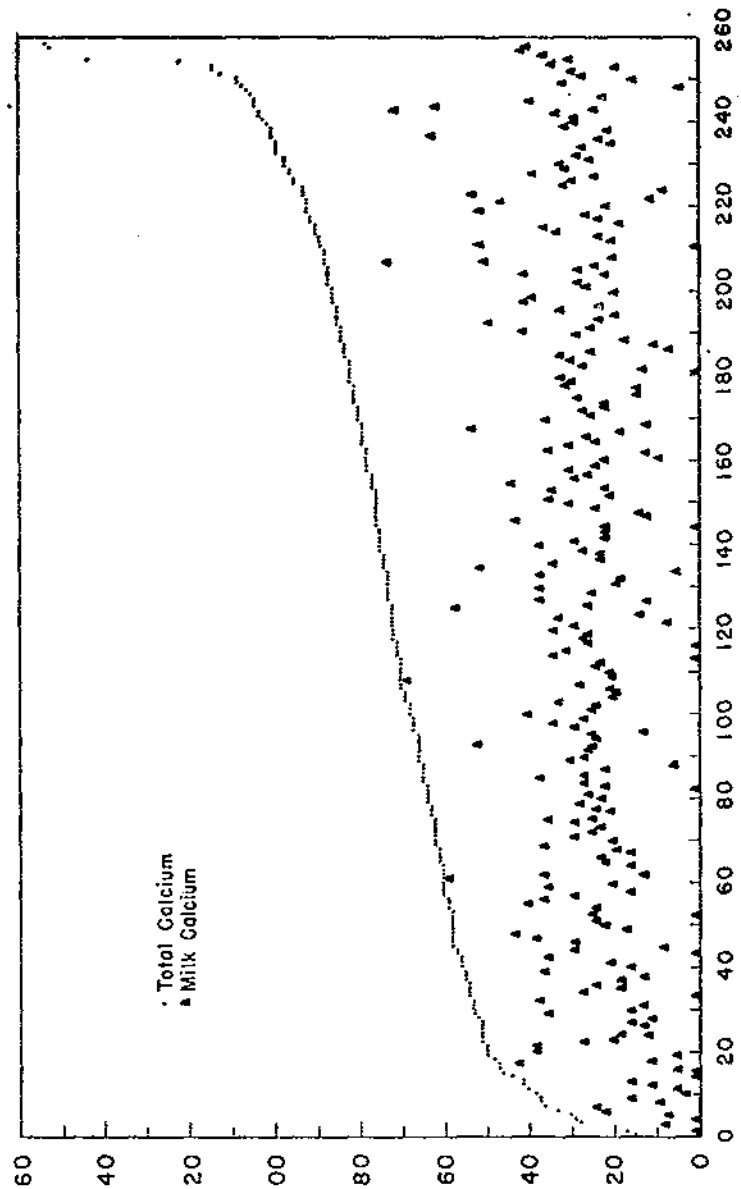

Figure 3.—Distribution of calcium in 260 samples of commercial white bread, showing relationship between total calcium (analyzed) and milk calcium (calculated from estimated dry milk solids).

another. Results showed no significant differences between means for the Northeastern, North Central, and Southern regions but the mean for the Western region was significantly lower than the others.

As information was not available on the calcium provided by milk for all samples of bread from each State (only 200 samples were analyzed for lactose), conclusions as to the extent of the use of milk in bread in a particular State might be inaccurate. However, of the 50 samples analyzed for milk in the Southern region, 49 samples—98 percent—contained it. In the Northeastern, North Central, and Western regions, the percentages were 93, 93, and 94, respectively. Actual content of calcium from milk in the bread was higher in the Northeastern and Southern than in the North Central and Western regions. Moreover, in the North Central region, a lower percentage of the total calcium appeared to be provided by milk than in the remaining three regions. However, there was more uniformity in the amount of milk in bread produced in this region than in the others.

Distribution of Calcium in Samples by Brands

As shown in table 4, the total calcium and the calcium from milk found in the different brands of bread were often variable, although a few brands were fairly uniform in calcium content. Figure 4 shows variation in total calcium content and milk calcium in the same brand from State to State. The three bars represent the samples with the lowest, median, and highest total calcium content. All these samples represent brands from "group plants," which are groups of two or more plants whose buying is done by central purchasing offices. For each brand shown in figure 4, four or more samples were analyzed for total calcium. These data may be compared with the averages for all samples from the different States as shown in table 3.

For further analyses of the samples according to brand and producer, information was obtained from the 1950 Selected Directory of Bakeries [4] on the type and size of company from which 253 of the bread samples were purchased. Table 5 shows the average values for total calcium and calcium from milk of the samples grouped according to type of plant producing the bread. The average calcium for the group plants was higher than that for independent plants, although the range of values was greater. Independent plants with sales volume of no more than $50,000 to $150,000 a year averaged the lowest total calcium. There appeared to be little difference in calcium from milk among the types of plants.

Calcium From Sources Other Than Milk

Calcium Enrichment.—Thirty bread samples were labeled as being enriched with from 20 to 40 percent of the minimum daily requirement of calcium as furnished by 6 to 8 ounces of bread. Of these, seven contained calcium propionate according to the labels. The average calcium content of samples "enriched with extra calcium," 105 mg. per 100 gm., was much higher than that of unenriched samples (table 6).

[4] Compiled by Bakers Weekly, 45 West 45th Street, New York 19, N. Y.

TABLE 3.—*Total calcium and calcium from milk in commercial white bread from different regions of the United States*

Region and State	Total calcium (analyzed)					Milk calcium (calculated)			
	Samples	Average (moist weight)		Average (dry weight)		Samples [1]	Average (moist weight)		Percent of total calcium
	Number	*Milligrams per 100 grams*	*Milligrams per pound*	*Milligrams per 100 grams*	*Milligrams per pound*	*Number*	*Milligrams per 100 grams*	*Milligrams per pound*	
All regions	402	74	334	115	515	260	25	112	35
Northeastern	113	74	328	113	513	81	28	128	39
Connecticut	8	76	347	117	531	1	57	257	79
Massachusetts	20	69	311	106	483	15	18	79	24
New Hampshire	5	79	360	120	546	5	6	27	7
New Jersey	5	77	347	120	546	5	30	135	40
New York	37	70	318	110	499	22	31	143	44
Pennsylvania	33	79	355	123	558	33	28	129	38
Rhode Island	2	62	283	99	450	0	-------	-------	-------
Vermont	3	68	307	109	493	0	-------	-------	-------

[1] Analyzed for lactose.

TABLE 3.—*Total calcium and calcium from milk in commercial white bread from different regions of the United States*—Continued

Region and State	Total calcium (analyzed)					Milk calcium (calculated)			
	Samples	Average (moist weight)		Average (dry weight)		Samples [1]	Average (moist weight)		Percent of total calcium
	Number	*Milligrams per 100 grams*	*Milligrams per pound*	*Milligrams per 100 grams*	*Milligrams per pound*	*Number*	*Milligrams per 100 grams*	*Milligrams per pound*	
North Central	98	78	353	120	545	59	22	100	29
Illinois	12	78	352	120	543	12	36	164	48
Indiana	7	76	344	113	512	7	27	124	36
Iowa	9	90	419	140	633	1	0	0	0
Kansas	5	77	351	119	542	5	21	96	28
Minnesota	11	71	323	110	504	0			
Missouri	25	83	375	131	593	25	25	114	30
Nebraska	3	79	358	121	549	3	22	98	29
Ohio	18	71	322	111	502	0			
Wisconsin	8	74	338	117	531	6	23	104	32

Southern	97	76	334	115	522	50	26	118	37
Alabama	2	64	291	101	460	2	23	106	37
Arkansas	1	54	245	85	386	1	0	0	0
Delaware	3	73	331	113	514	3	28	126	38
District of Columbia	5	79	360	124	564	5	40	180	49
Florida	14	73	332	116	528	0			
Georgia	12	79	360	124	564	0			
Kentucky	5	82	373	128	579	0			
Louisiana	11	83	379	131	594	11	21	93	27
Maryland	8	80	362	123	559	8	41	185	65
Mississippi	3	61	279	98	447	3	24	111	40
North Carolina	3	70	316	111	504	0			
Oklahoma	4	84	381	126	572	4	27	125	33
South Carolina	5	74	335	116	528	0			
Tennessee	8	63	285	98	446	3	33	152	56
Texas	10	77	349	119	538	7	18	82	25
West Virginia	3	82	371	125	567	3	31	139	37
Western	94	68	309	106	482	70	22	102	35
Arizona	4	61	278	96	434	4	19	87	31
California	38	64	291	100	452	38	20	91	31
Colorado	14	82	375	126	570	0			
Idaho	5	69	314	108	490	1	22	98	37
Montana	6	70	317	107	484	6	33	149	47
Oregon	6	59	266	93	420	6	19	88	32
Utah	6	73	330	117	529	0			
Washington	15	66	299	105	475	15	21	98	32

[1] Analyzed for lactose.

TABLE 4.—*Variability of total calcium and calcium from milk in different brands of commercial white bread* [1]

Brand by code	Number of States	Total calcium					Milk calcium		
		Number of samples	Milligrams per pound	Milligrams per 100 grams	Standard deviation	Coefficient of variation (percent)	Number of samples	Milligrams per 100 grams	Percent of total calcium
A	2	3	192	42	18	43	3	24	44
B	2	3	273	60	16	26	3	3	6
C	4	4	286	63	2	4	4	22	34
D	7	9	301	66	7	10	4	27	38
E	4	4	329	73	7	10	2	24	33
F	3	4	340	75	10	14	1	27	36
G	7	9	340	75	6	8	7	24	33
H	6	8	342	75	11	15	5	19	24
I	6	8	345	76	15	20	7	27	36
J	2	2	350	77	4	5	2	31	40
K	9	11	354	78	6	7	8	26	34
L	3	4	382	84	3	3	3	18	21
M	9	12	395	87	20	23	8	21	24
N	4	5	398	88	13	14	4	46	55
O	14	17	462	102	17	16	12	29	29
P	2	2	669	147	5	3	2	38	26

[1] All brands from group plants.

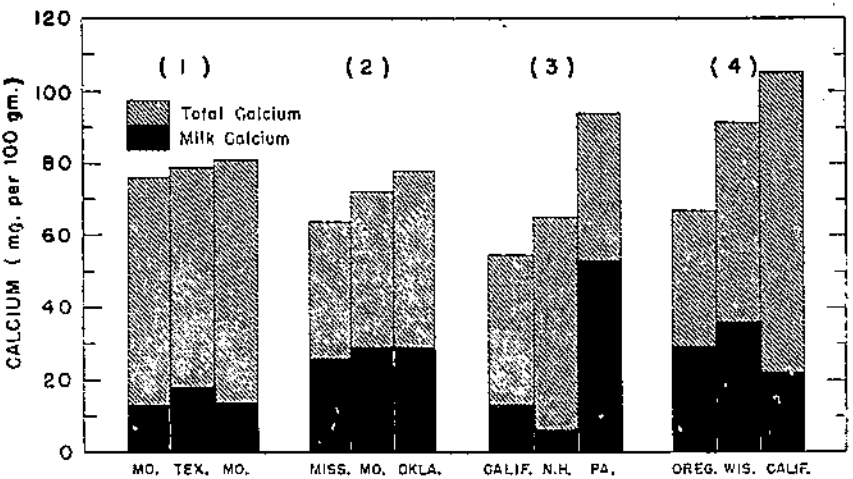

Figure 4.—Variation in total calcium (analyzed) and calcium from milk (calculated from estimated dry milk solids) in four brands of white bread from different places.

Mold Inhibitors.—Information on bread wrappers indicated that 95 samples, or 24 percent, of the total 402 contained some type of mold inhibitor. Of these, samples containing calcium propionate as the mold inhibitor had a higher calcium content, 82 mg. per 100 gm., than samples with sodium propionate or those with undefined mold inhibitors, 67 and 68 mg. per 100 gm., respectively (table 6). It is possible, however, that information pertaining to the use of mold inhibitors was not given on all bread wrappers. The data in table 6 show that the average values for calcium in samples with mold inhibitors were somewhat higher than those without mold inhibitors.

Twenty-one of the 96 samples that were positive or doubtful for content of polyoxyethylene monostearate compounds (surface-active agents sometimes used as softeners in bread) contained some type of mold inhibitor, according to information on the bread labels. When calcium propionate is used as the mold inhibitor, the average calcium content of bread may be expected to be higher than that of samples without mold inhibitors, regardless of the presence or absence of polyoxyethylene monostearate compounds.

Table 7 gives the frequency distribution as to total calcium content of samples in the presence and absence of polyoxyethylene monostearate compounds, and in their presence, without and with mold inhibitors as indicated by bread labels. Although the average calcium content is higher for the samples containing polyoxyethylene monostearate compounds and mold inhibitors (table 6), the modal class in all cases is 70 to 79 mg. (table 7).

Calcium data were evaluated in groups of samples that contained milk with or without calcium propionate and were positive, negative, or doubtful for the presence of polyoxyethylene monostearate compounds (table 8). As would be expected, calcium was higher in each case when the groups contained calcium propionate than when they contained none.

TABLE 5.—*Total calcium and calcium from milk in samples of commercial white bread, grouped according to type of production plant*

Type of plant [1]	Volume of sales per year	Total calcium			Milk calcium		
		Samples	Average	Range	Samples	Average	Percent of total calcium
	Dollars	*Number*	*Milligrams per 100 grams*	*Milligrams per 100 grams*	*Number*	*Milligrams per 100 grams*	
Group plants [2]		135	79	[3] 17–152	93	26	34
Independent plants: [4]							
Type A+	Over 1,000,000	40	70	47–104	30	25	37
Type A	500,000–1,000,000	22	75	43–114	13	21	27
Type B	150,000– 500,000	42	69	30–103	31	24	37
Type C	50,000– 150,000	14	60	14–87	8	24	38

[1] Total number of plants in all States, 5,010. Group plants, 1,010. Independent plants: Type A+, 166; Type A, 275; Type B, 1,665; Type C, 1,840; Type E (unclassified), 54.

[2] Members of 129 companies operating 2 or more plants whose buying was done through central purchasing offices.

[3] Only 5 samples contained less than 51 mg. calcium per 100 gm.

[4] Classified according to volume of sales.

Source: Selected Directory of Bakeries, 1950.

TABLE 6.—*Total calcium content of commercial white bread with and without specified components*

Description of sample	Samples		Total calcium (milligrams per 100 grams)	
	Number	Percent of total	Average	Range
All samples	402	100	74	12–153
Samples labeled to indicate added calcium	30	8	105	40–152
With calcium propionate	7	2	121	103–152
Mold inhibitors not indicated on label	23	6	100	40–132
Samples containing mold inhibitors	95	24	78	17–153
Calcium propionate only	71	18	82	17–153
Sodium propionate only	14	4	67	42–88
Undefined mold inhibitors	10	2	68	44–86
Samples containing polyoxyethylene compounds [1]	96	24	75	29–152
With mold inhibitors	21	5	83	38–152
Without mold inhibitors	75	19	72	29–122

[1] Includes 15 samples doubtful for polyoxyethylene compounds determined by semiquantitative test.

In samples positive for polyoxyethylene monostearate compounds, the amount of calcium from milk was approximately the same as in negative and doubtful samples. In the positive samples containing calcium propionate, however, the percentage of calcium furnished by milk was lower than in the other groups because of higher total calcium.

It is concluded that, of the calcium-containing constituents, either calcium propionate or calcium incorporated in commercial white bread as an optional enrichment agent, definitely raises the average content of total calcium.

CALCIUM CONTENT IN RELATION TO POLYOXYETHYLENE MONOSTEARATE COMPOUNDS

In 1947, a new emulsifier, polyoxyethylene stearate, was found to increase the softness of bread (*8*). Other compounds having a similar effect on bread were subsequently reported—polyoxyethylene monostearate (*7*), polyoxyethylene distearate (*3*), mono and diglycerides (*25*), hydroxyphosphatides (*32*), glyceryl monostearate (*7*), glyceryl oleostearate, and sorbitan esters of the fatty acids (*6*).

TABLE 7.—*Distribution of values for total calcium content of commercial white bread without and with polyoxyethylene monostearate compounds, and without and with mold inhibitors*

Total calcium milligrams per 100 grams	Total		Without polyoxyethylene compounds		With polyoxyethylene compounds					
					Total		Without mold inhibitors		With mold inhibitors	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
All samples	402	100.0	306	100.0	[1] 96	100.0	75	100.0	21	100.0
10–19	4	1.0	4	1.3						
20–29	2	.5	1	.3	1	1.0	1	1.3		
30–39	9	2.2	8	2.6	1	1.0			1	4.8
40–49	14	3.5	10	3.3	4	4.2	4	5.3		
50–59	58	14.4	48	15.7	11	11.5	9	12.0	2	9.5
60–69	80	19.9	59	19.3	20	20.8	18	24.0	3	14.3
70–79	96	23.9	71	23.2	27	28.1	20	26.7	6	28.6
80–89	68	16.9	51	16.7	15	15.6	14	18.7	2	9.5
90–99	31	7.7	22	7.2	10	10.4	5	6.7	4	19.0
100–109	23	5.7	18	5.9	4	4.2	3	4.0	1	4.8
110–119	12	3.0	12	3.9						
120–129	1	.2			1	1.0	1	1.3		
130–139	1	.2	1	.3						
140–149	1	.2			1	1.0			1	4.8
150–159	2	.5	1	.3	1	1.0			1	4.8

[1] Includes 15 samples doubtful for polyoxyethylene compounds determined by semiquantitative test.

It is possible that the use of some of the emulsifiers has been discontinued since the proposed bread standards were issued in the Federal Register of August 1950 (*29*). These proposed standards would prohibit the use of polyoxyethylene compounds and certain other types of surface-active agents.

An attempt was made in the present study to determine the relationship, if any, between the calcium content of bread and the presence of polyoxyethylene monostearate compounds. No figures were available for the presence of other types of emulsifiers in the bread samples analyzed.

The problem of the relationship was approached in three ways in this study—to determine (1) whether the presence of polyoxyethylene monostearate compounds was associated with an increase or decrease in total calcium of bread, (2) whether there was any association between the presence of polyoxyethylene monostearate compounds and content of milk in bread, and (3) the influence of mold inhibitors when combined with polyoxyethylene monostearates on the total calcium of bread.

Ninety-six, or 24 percent, of the 402 bread samples were reported to be positive or doubtful for presence of polyoxyethylene monostearate compounds. Because the average calcium content of the 15 doubtful samples was the same as that of the 81 positive samples, the samples were combined for further evaluation. The calcium content of the 96 samples differed only slightly from that of the 402 samples, 75 versus 74 mg. per 100 gm. This fact is demonstrated more clearly in table 7, in which the 96 samples are compared with the total and remaining groups, giving a maximum percentage distribution at the 70 to 79 mg. class interval in each case. Thus, from the information available on the samples analyzed, it appears that the calcium content of bread was not influenced by the presence of polyoxyethylene monostearate compounds.

To obtain information on the possible substitution of polyoxyethylene monostearate compounds for milk, a study was made of data from the 260 samples of bread for which dry milk solids were estimated. The samples were classified for positive, negative, and doubtful content of the polyoxyethylene compounds. There was little difference between total calcium content of positive, negative, and doubtful samples (table 8). This applies also to data for calcium derived from milk, which supplied about 35 percent of the total calcium whether or not polyoxyethylene monostearate compounds were present. Eleven of the 15 samples that contained no milk did not contain the polyoxyethylene monostearate compounds. It was impossible to make any definite conclusion regarding omission of milk when polyoxyethylene monostearate compounds were used, because these were present in only three samples which contained no milk.

Table 8 shows also the relation of calcium content of bread with and without polyoxyethylene monostearate compounds to the use of calcium propionate and milk. Only about 15 percent of the samples containing milk contained calcium propionate also, whether or not polyoxyethylene monostearate compounds were present. From evidence available, the presence of polyoxyethylene monostearate compounds in bread did not influence either the average milk calcium or total calcium level.

TABLE 8.—*Total calcium and calcium from milk in 260 samples of commercial white bread containing polyoxyethylene monostearate compounds and/or calcium propionate*

Description of sample	Samples		Total calcium		Milk calcium	
			Average	Range	Average	Percent of total calcium
	Number	*Percent*	*Milligrams per 100 grams*	*Milligrams per 100 grams*	*Milligrams per 100 grams*	
Samples analyzed for milk	260	100	74	15–153	25	35
Milk found	245	94	75	15–153	27	37
No milk found	15	6	57	15– 89	0	0
Samples containing milk and negative for polyoxyethylene compounds	183	100	74	28–153	27	37
With calcium propionate	32	17	81	58–153	27	35
Without calcium propionate	151	83	73	28–114	27	38
Samples containing milk and positive for polyoxyethylene compounds	52	100	77	38–152	27	35
With calcium propionate	8	15	92	38–152	25	26
Without calcium propionate	44	85	75	41–122	27	37

Samples containing milk and doubtful for polyoxyethylene compounds	10	100	73	50–106	26	40
With calcium propionate	1	10	106	----------	4	4
Without calcium propionate	9	90	70	50–100	28	44
Samples containing no milk [1]	15	100	57	15– 89	0	0
Polyoxyethylene compounds:						
Positive	3	20	66	37– 82	0	0
Negative	11	73	57	15– 89	0	0
Doubtful	1	7	29	----------	0	0

[1] Only one sample in this group contained calcium propionate.

NUTRITIONAL SIGNIFICANCE OF FINDINGS

The nutritional significance of baking practices in the use of calcium-containing components in commercial white bread may be illustrated by applying values from this study to data on bread consumption. Studies of urban family food consumption in the spring of 1948, made by the Bureau of Human Nutrition and Home Economics, showed the United States average consumption of white bread, enriched and unenriched, to be 1.44 pounds per person per week, with some families consuming as much as 3 pounds per person per week (*27*). At either of these levels of consumption, breads high or low in calcium content make widely different contributions to the recommended daily allowance of 1.0 gm. calcium for adults (*13*). At a consumption level of 1.44 pounds per week, bread containing 74 mg. calcium per 100 gm., the average for the samples in this study, would contribute about 7 percent of the allowance, whereas, with the range in calcium content found, bread could contribute as little as 1 percent or as much as 16 percent. For the consumer of 3 pounds a week, bread might contribute as little as 2 percent or as much as 32 percent of the recommended daily calcium allowance. Thus it is important to know the calcium content of the bread that consumers are using.

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TABLE 9.—*Calcium content of calcium solutions and bread samples analyzed by two methods*

Method	Calcium solutions [1]				Bread samples	
	Samples	Theoretical calcium	Mean analyzed calcium	Calcium recovered	Samples	Mean calcium in 3-gram sample
	Number	*Milligrams*	*Milligrams*	*Percent*	*Number*	*Milligrams*
Urea hydrolysis	6	12.61	12.52±0.03	98.49	19	3.00±0.13
	14	5.58	5.57± .01	99.82		
	14	5.58	5.59± .01	100.18		
Modified McCrudden	4	12.61	12.53± .01	99.37	19	2.99± .13
	8	5.58	5.61± .01	100.54		

[1] A standard solution of calcium carbonate was used for these analyses.

APPENDIX

Analytical Methods for Determining Calcium Content of Bread

Total calcium content of all bread samples was determined by a rapid and improved procedure involving the dry-ashing of air-dry bread, preparation of a proper solution of the ash, and precipitation of calcium oxalate from an acid filtrate with dry urea and ammonium oxalate solution. The precipitate was adequately washed, dissolved in dilute sulfuric acid, and titrated with a standard solution of potassium permanganate.

A 3-gm. sample was accurately weighed and ashed in accordance with the method of the Association of Official Agricultural Chemists (*2*). The ash was dissolved in 5 ml. concentrated hydrochloric acid and evaporated to dryness on a steam bath. The residue was redissolved in hydrochloric acid, transferred with hot water, and filtered into a 250-ml. beaker. Calcium in the filtrate for each sample was precipitated by one or by two methods. The established method (McCrudden) was used in verifying the less well-known one (urea-hydrolysis).

Urea-hydrolysis Method.—The urea-hydrolysis precipitation of calcium oxalate was a modification of the rapid and improved method of Ingols and Murray (*10*): 2 ml. of 1:1 hydrochloric acid was added to the filtrate to produce a pH of approximately 1.0. Then 5 drops of methyl red indicator, 15 gm. dry urea, and 15 ml. saturated ammonium oxalate were added. The mixture was stirred, covered, and digested on a hot plate until the color of methyl red changed to yellow. It was possible to filter the large crystals of calcium oxalate precipitated by this method as soon as the solution was cool, thus shortening the time required for the analysis. Washing of the precipitate with 2 percent ammonium hydroxide was hastened by using filter tubes (30 mm. porcelain fritted discs) in a suction apparatus.

The precipitate was dissolved in hot dilute sulfuric acid (approximately normal) and titrated at 65°–70° C. with a standardized solution of 0.02N potassium permanganate. Triplicate determinations were made on all samples.

Modified McCrudden Method.—Calcium was precipitated from the filtrates for 19 of the bread samples by a modification of the McCrudden method and results were compared with those obtained on the same samples by use of the urea-hydrolysis technique for calcium precipitation. Recoveries were performed by both methods, replacing the sample by a standard solution of calcium carbonate (table 9).

The procedure used for precipitation of calcium oxalate by the modified McCrudden method was as follows:

Fifteen milliliters of saturated ammonium oxalate solution and 5 drops of methyl red-methylene blue indicator were added to each filtrate. The sample was heated to boiling and cooled, then ammonium hydroxide was added dropwise until a green color developed. The solution was buffered with 10 milliliters of a 20-percent solution of sodium acetate, followed by normal hydrochloric acid until the color of the solution became slate gray. The sample was left overnight to allow the fine precipitate to settle.

After the precipitate was washed and dissolved as described previously, 10 milliliters of concentrated sulfuric acid was added to the sample prior to titration. In the rapid method, this step was found unnecessary.

Comparison of analyses by the two methods shows that reliable results may be expected from the use of either method (table 9).

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