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EFFECT OF FORTIFICATION OF CANNED BREAD ON STABILITY [1]

SADIE BRENNER,[2] STUART G. DUNLOP,[3] and VIRGIL O. WODICKA

ABSTRACT

The stability of thiamine, riboflavin, and niacin was investigated in canned bread during fermentation, baking, and storage. Synthetic and dried yeast sources of enrichment were used and the effect of each on baking quality of the flour and palatability of the finished bread measured. Riboflavin and niacin were retained almost completely during fermentation, baking, and storage. Thiamine, however, regardless of source, was decreased by approximately 15% during baking and 20 and 50% during 6 months' storage at 72° and 100°F. respectively. A 1% level of yeast (flour basis) was preferable to a 3% level insofar as acceptability and baking quality were concerned. The protein quality of the whole wheat and yeast bread was significantly superior to that of the white bread fortified with synthetic vitamins.

During World War II adequate amounts of thiamine, riboflavin, and niacin in rations were provided chiefly through the fortification of the biscuit and cracker components with dried yeast.[5] The low moisture content of the biscuit component insured against losses of labile thiamine during long periods of storage at elevated temperatures. However, due to the general unpopularity of the biscuits and crackers, endeavors were made to find other stable carriers for these vitamins. Since canned bread was being developed with the intention of partially or completely replacing the biscuit and cracker components, intensive studies were undertaken to investigate the possibilities of this universally well-liked item as a carrier of the B complex vitamins.

Materials and Methods

Fortification of canned bread with synthetic vitamins and natural sources were both investigated. The latter type of enrichment was

[1] Manuscript received June 17, 1948.
[2] Food Research Division, QM Food and Container Institute, Chicago QM Depot, 1849 W. Pershing Road, Chicago 9, Illinois.
[3] University of Colorado, School of Medicine, Denver, Colorado.
[4] Libby, McNeill and Libby, Blue Island, Illinois.
[5] The dried yeast used in biscuit fortification was specified to contain not less than 600, 600, and 1,000 μg. of thiamine, riboflavin, and niacin per gram of dried yeast respectively. Such concentrations were obtained by adding the synthetic nutrient to the live yeast cells prior to drying.

ferred as it supplied, in addition to thiamine, riboflavin, and niacin, lesser known factors of the vitamin B complex, thus producing a re complete and natural food. The natural sources used to provide B complex vitamins were dried yeast (primary grown or debittered wers') and whole wheat. Combinations of synthetic and natural rces were also used to determine if the natural enrichment would ɔilize the synthetic enrichment.

Study 1. This study was undertaken to survey the potentialities of ned bread as a carrier for the vitamins of the B complex. It was ducted on the first test production run of the three contemplated es to be used in rations, namely, white, white with raisins, and whole eat bread. Both white types of bread were fortified with synthetic ımins.[6] Five cans of each type of bread were assayed initially and each storage time interval (bimonthly) for thiamine, by the thio- ome procedure (8), and for riboflavin and niacin by the chemical 6) methods. Stability at 72° and 100°F. was examined over a iod of one year.

Study 2. After Study 1 was in progress for several months, it was dily apparent that thiamine stability at 100°F. storage was poor. order to ascertain the reliability of these data, canned bread was ed in the laboratory[7] under the most rigidly controlled conditions l again the stability of added thiamine was tested. Dried yeast[8] (de- ered brewers') which had proved so satisfactory in the biscuit and cker component was also added to canned bread from this batch to dy the effect of the yeast on the stability of synthetic thiamine. liminary tests to determine the maximum amounts of debittered wers' yeast which could be employed for enrichment without pro- ing off-flavors showed the 3% level (flour basis) to be the most isfactory. This study also presented the opportunity of deter- ıing baking losses since the doughs were available. Stability tests e made only at 100°F. storage temperature and only two cans of ad were assayed initially and after 3 and 6 months' storage because he limited number of samples.

Study 3. This investigation was similar to that of Study 2 except t it was carried out on a test production run and the dried brewers' yeast used was "treated" yeast.[9] Stability of thiamine, riboflavin, and niacin at 72° and 100°F. storage was tested at bimonthly intervals for one year.

Study 4. This extensive study was made on laboratory-baked bread to compare synthetic, whole wheat, and "treated" yeast enrich- ment on the basis of vitamin B complex stability, contribution of pro- tein[10] and lesser known vitamin factors of the B complex, and palata- bility. The yeast was used at a 3% level. It was also possible to determine baking losses in each type of bread as well as fermentation losses.

Study 5. In this study other dried yeasts, primary grown and de- bittered brewers', were used in canned bread at a 1% level and in pan loaf bread at a 3% level to determine whether differences in the baking quality of the resulting bread varied with the different yeasts used. Pan loaves were scored for volume, color, and grain and photographs were taken. Canned breads were stored at 72° and 100°F. and tested for thiamine stability and palatability initially and at 3, 6, 9, and 12 months of storage.

TABLE I

PERCENTAGE LOSS OF B COMPLEX VITAMINS DURING FERMENTATION

Study 4	Thiamine	Riboflavin	Niacin
	μg./g.	μg./g.	μg./g.
Synthetic fortification			
After mixing	3.62	3.64	38.0
After proofing	3.46	3.59	39.3
Per cent loss	4.00	1.00	+ 2.0
Dried yeast fortification			
After mixing	4.26	3.87	41.8
After proofing	4.07	3.60	39.0
Per cent loss	4.00	4.00	7.0
Whole wheat fortification			
After mixing	3.88	3.14	39.9
After proofing	3.79	3.04	40.5
Per cent loss	2.00	3.00	+ 2.0
Average fermentation loss	3	3	1

Results

Vitamin Stability:

a. Fermentation Losses.

Fermentation losses included those incurred from the time that the ingredients were mixed into a dough until the time the dough was ready

[6] Winthrop high potency enrichment tablets were used, one tablet per 50 pounds of flour. The ts contained 115 mg. of thiamine, 60.5 mg. of riboflavin, 725 mg. of niacin, and 625 mg. of iron per t.

[7] Canned bread was baked by the Cereal and Baked Products Branch. The dough was placed in 2½ cans, the cover clinched on, and the bread allowed to proof. Following the proofing stage, the h was baked in a (450°F.) reel oven containing four trays (24 cans per tray), 96 cans being baked at ime. The cans were removed from the oven after 25–30 minutes, cooled to 190°F. (5 to 10 minutes om temperature) and then sealed. The basic formula for canned bread in any one study was identi- iffering only in the type of enrichment made, i.e., substitution of white flour for whole wheat flour ldition of synthetic vitamins instead of dried yeast.

[8] Dead yeast cells have a deleterious effect on the gluten structure of dough (4). A method of treat- he yeast to overcome this gluten-softening effect is essential before the yeast can be used successfully fortifying agent. The dry yeast used in Study 2 was not a "treated" yeast. Industry was con- d for the purposes of cooperating in the development of a yeast which would meet the above require- ts.

[9] This yeast was developed by Haffenreffer Yeast Company, Jamaica Plains, Boston, Massachu- setts.

[10] The three types of canned bread were evaluated for protein by Dr. P. R. Cannon, University of Chicago, on Committee on Food Research Project NU-3. A detailed report on this study is in press.

)e placed into the oven, a period of approximately three hours. It is n from Table I that there were no significant losses in thiamine,)flavin, or niacin in the three types of doughs studied.

TABLE II

CENTAGE LOSS OF B COMPLEX VITAMINS DURING BAKING OF CANNED BREAD

Study	Thiamine	Riboflavin	Niacin
	μg./g.	μg./g.	μg./g.
Study 2			
Synthetic fortification			
After proofing	9.44	2.62	30.2
After baking	8.12	2.43	31.2
Per cent loss	14.00	8.00	+ 3.0
Yeast fortification			
After proofing	6.65	5.95	55.9
After baking	5.41	5.22	54.7
Per cent loss	19.00	12.00	2.0
Study 4			
Synthetic fortification			
After proofing	3.46	3.59	39.3
After baking	2.72	3.63	41.1
Per cent loss	21.00	+ 1.00	+ 5.0
Dried yeast fortification			
After proofing	4.07	3.52	39.0
After baking	3.26	3.90	39.9
Per cent loss	20.00	+11.00	+ 2.0
Whole wheat fortification[1]			
After proofing	3.79	3.04	40.5
After baking	2.65	3.67	41.1
Per cent loss	30.00	+21.00	+ 1.0
Study 5			
Synthetic fortification			
After proofing	4.69	—	—
After baking	4.36	—	—
Per cent loss	7.00		
Yeast fortification (5 yeasts)			
After proofing	2.16–5.51	—	—
After baking	1.68–4.98	—	—
Per cent loss	10–20		
Average baking loss	16	+ 2	+ 3

[1] Not included in average since baking time was longer.

b. Baking Losses.

Baking losses were determined in three studies. Ten and one-half ices of dough were placed in a No. 2½ can and white dough baked at °F. for 25–30 minutes and whole wheat dough for 40 minutes.)le II shows the percentage loss of thiamine, riboflavin, and niacin ich occurred during the baking process.

It is seen that laboratory-baked bread lost approximately 15% of thiamine during the baking process. This figure is in good agreement with those found by others for this baking time (5, 9, 11, 13). The niacin and riboflavin content showed no significant changes on baking. There were no demonstrable differences in the baking losses of synthetically fortified and dried yeast-fortified bread. The thiamine loss in whole wheat bread, however, was somewhat higher due to the longer baking time (30% loss).

c. Storage Losses.

The stability data on canned bread fortified with various sources of the B complex indicated that canned bread was as good a carrier as

TABLE III

STABILITY OF B COMPLEX VITAMINS IN STORED CANNED BREAD, FORTIFIED WITH SYNTHETIC AND NATURAL SOURCES OF ENRICHMENT [1]

Source of fortification	Thiamine				Riboflavin				Niacin			
	72°F.		100°F.		72°F.		100°F.		72°F.		100°F.	
	6 mo.	12 mo.	6 mo.	12 mo.	6 mo.	12 mo.	6 mo.	12 mo.	6 mo.	12 mo.	6 mo.	12 mo.
	Per cent retention				Per cent retention				Per cent retention			
Natural												
Dried yeast	84	73	50	31	112	105	105	103	98	94	96	98
Whole wheat	82	75	46	30	88	96	109	100	95	96	93	95
Synthetic												
White	89	75	54	37	114	104	106	109	95	97	96	95
White and bleached raisin	66	60	44	31	100	100	100	100	86	100	90	100
Avg. retention	80	72	49	32	104	101	105	103	93	97	94	97

[1] The retentions in this table represent the average of all storage data taken from Studies 1–5.

ration biscuits for riboflavin and niacin but not for thiamine. Table III summarizes the retention of the thiamine, riboflavin, and niacin in canned bread. Retention of thiamine, riboflavin, and niacin followed the same pattern in the synthetic, yeast, and whole wheat breads. In general, the thiamine content decreased as in other moist carriers (approximately 50 and 20% loss after 6 months' storage at 100° and 72°F. respectively). The riboflavin and niacin content remained at the initial level at both storage temperatures throughout the storage period.

Upon further storage for an additional 6 months, the thiamine content continued to decline but at a slower rate than in the initial 6

months' storage period. The thiamine loss at the end of this time was approximately 70 and 30% at the 100° and 72°F. storage temperatures respectively. The thiamine loss in raisin bread was somewhat greater than in the other types of bread at 72°F. storage, and was in part attributed to the possible action of the bleaching agent used on the raisins.

This pattern of stability characterized by significant decreases in thiamine content with little if any decreases in the riboflavin and niacin content has been reported for other canned foods. The thiamine losses (6 months' storage at 100°F.) for canned meats were found to be higher than for canned bread ranging from 60 to 70% (7). In canned fruits and vegetables the thiamine losses were found to be somewhat lower than in canned bread averaging 40% (1, 10, and 12).

TABLE IV

ANALYTICAL VALUE FOR VARIOUS STORAGE STUDIES, CORRECTED TO 38% MOISTURE

	Storage time	Thiamine μg./g.		Riboflavin μg./g.		Niacin μg./g.	
		72°F.	100°F.	72°F.	100°F.	72°F.	100°F.
Study 1							
White bread + synthetic vitamins	Initial	1.95	—	2.27	—	29.4	—
	6 mos.	1.97	1.20	2.38	2.51	27.2	28.7
	12 mos.	1.65	0.83	2.23	2.78	27.3	29.3
Raisin bread + synthetic vitamins	Initial	1.08	—	1.69	—	24.7	—
	6 mos.	0.73	0.48	1.57	1.64	21.3	23.6
	12 mos.	0.65	0.33	1.62	1.77	25.0	24.9
Whole wheat bread	Initial	2.09	—	1.56	—	37.9	—
	6 mos.	1.59	0.87	1.42	1.47	37.2	36.7
	12 mos.	1.61	0.64	1.42	1.56	34.8	33.7
Study 2							
White bread + synthetic vitamins	Initial	8.61	—	2.56	—	33.1	—
	6 mos.	—	3.77	—	2.26	—	33.7
	12 mos.	—	—	—	—	—	—
Yeast fortification	Initial	5.75	—	5.54	—	58.1	—
	6 mos.	—	2.60	—	5.22	—	58.8
	12 mos.	—	—	—	—	—	—
Study 3							
White bread + synthetic vitamins	Initial	2.23	—	2.69	—	25.1	—
	6 mos.	1.65	1.20	3.05	3.00	24.8	24.5
	12 mos.	1.42	0.73	3.05	3.21	23.3	21.6
Yeast fortification	Initial	2.82	—	3.11	—	30.9	—
	6 mos.	2.27	1.54	3.40	3.16	34.0	31 9
	12 mos.	1.91	0.82	3.39	3.25	30.3	31.4

TABLE IV—*Continued*

	Storage time	Thiamine μg./g.		Riboflavin μg./g.		Niacin μg./g.	
		72°F.	100°F.	72°F.	100°F.	72°F.	100°F.
Study 4							
White bread + synthetic vitamins	Initial	2.81	—	3.93	—	41.9	—
	6 mos.	2.64	1.62	4.89	4.64	39.2	38.3
	12 mos.	2.36	1.14	3.92	3.79	41.7	39.8
Yeast fortification	Initial	3.20	—	3.72	—	42.5	—
	6 mos.	2.80	1.73	4.32	4.47	36.2	36.2
	12 mos.	2.50	1.08	4.00	3.82	40.7	39.8
Whole wheat	Initial	2.57	—	3.29	—	40.9	—
	6 mos.	2.27	1.29	3.03	4.08	37.9	37.3
	12 mos.	1.95	0.75	3.25	3.28	41.5	40.0
Study 5							
White bread + synthetic vitamins	Initial	3.89	—				
	6 mos.	3.42	1.77				
	12 mos.	3.07	1.35				
Yeast fortification A.	Initial	4.48	—				
	6 mos.	3.92	2.05				
	12 mos.	3.79	1.40				
B.	Initial	5.22	—				
	6 mos.	4.15	2.49				
	12 mos.	3.86	1.23				
C.	Initial	4.21	—				
	6 mos.	3.39	1.91				
	12 mos.	3.41	1.24				
D.	Initial	3.89	—				
	6 mos.	3.27	2.19				
	12 mos.	3.16	1.55				
E.	Initial	3.06	—				
	6 mos.	—	1.50				
	12 mos.	—	—				

Protein Quality. The protein of the three types of canned bread in study four was evaluated by feeding the dried bread at a 9% protein level to protein depleted adult rats for 14 days and determining the resulting weight recovery at the end of that time (2). The weight gains for rats fed these breads showed that both the whole wheat and the yeast enriched bread was approximately 30% superior in protein quality to the white synthetically enriched bread.

Evaluation for Lesser Known Vitamin Factors.[11] The presence of the lesser known vitamin factors in the canned breads was determined

[11] Evaluation of the canned breads for the lesser known vitamin factors by their growth-promoting value for rats was conducted by Capt. C. French of the Medical Nutrition Laboratory, Surgeon General's Office.

by comparative growth rates of rats fed on equicaloric diets containing 80% bread and 20% basal supplement. The basal supplement contributed adequate amounts of protein, fat, mineral, thiamine, riboflavin, niacin, choline, tocopherol, and vitamins A and D. Growth rate obtained from the three bread diets when compared to a control group receiving Purina Laboratory Chow indicated that no significant rat growth deficiency was involved in any of the three bread diets.

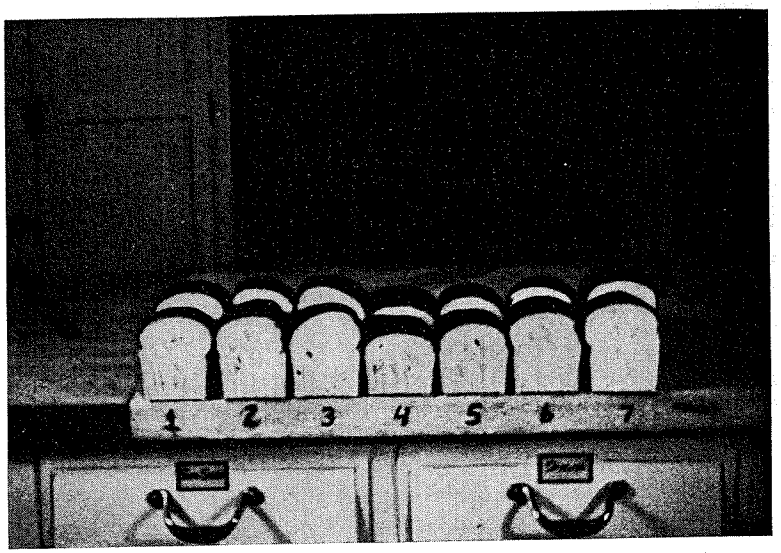

Fig. 1. Effect of 3% yeast addition (flour basis) on bread score.

Bread 1. Primary grown yeast
2. Debittered brewers' yeast (treated to overcome gluten softening effects)
3. Primary grown yeast
4. Debittered brewers' yeast
5. Primary grown yeast
6. Primary grown yeast
7. Control made with enriched flour

Palatability.[12] Examinations were made initially and during storage on the bread of Studies 4 and 6. Initially, the 3% yeast bread was judged to be not equal to the synthetically enriched bread in color, grain, and eating quality, and was described as having a bitter, undesirable after taste. The 1% yeast breads were rated as equally as acceptable as the synthetically enriched breads. There were no yeasty or bitter flavors and the color of the grain was lighter than at the 3% level although variations among the yeasts in degree of color produced were evident.

The effects of storage on palatability were more pronounced at the higher storage temperatures. All breads declined in acceptability on

[12] Palatability studies, by taste panels, were conducted by the Food Acceptance Research Branch, QM Food and Container Institute for the Armed Forces.

storage. The 3% yeast bread declined to a greater degree than either the synthetically enriched bread or the 1% yeast bread, the yeasty flavor becoming more apparent and undesirable on prolonged storage. There was no appreciable difference in acceptability of the stored 1% yeast breads and the synthetically enriched breads, thus indicating that the addition of 3% yeast is too high.

Baking Quality. This was determined from the bread score which was made up of individual scores on volume, crumb color, grain, texture, and flavor. The resulting pan loaves made from the six yeasts used at a 3% level (flour basis) are shown in Fig. 1. The amount of gluten softening effect produced by the various yeasts is reflected in the loaf volume. The deleterious effect of the dead yeast cells is especially evident in breads 4 and 5. Bread 2 was made with the treated yeast used in Study 4. The crumb color of all the yeast breads was darker than for synthetically fortified bread (bread 7), breads 4 and 5 having the darkest crumb color. Grain and texture was also scored lowest for breads 4 and 5. Taste tests indicated that the synthetically fortified sample was preferred over the yeast fortified samples with little or no preference for the different yeast breads.

Summary

1. Fortified canned bread was investigated as a possible carrier of the B complex vitamins. Comparisons of synthetic, whole wheat, and yeast enrichment were made for relative vitamin stability and palatability. Fermentation and baking losses were also investigated.

2. There were no significant losses of the B complex vitamins through the fermentation and proofing step. During baking the thiamine content of canned bread was decreased by approximately 15%; the riboflavin and niacin content remained unchanged.

3. During storage at 72° and 100°F. for 6 months the thiamine retention was approximately 80 and 50%, respectively, regardless of the source of enrichment. The use of bleached raisins in white bread increased the losses. Riboflavin and niacin were retained from 90 to 100% for all sources of enrichment at both storage temperatures.

4. There were no deficiencies of the lesser known vitamins in the three types of bread tested (whole wheat, synthetically fortified, and yeast fortified bread) as judged from their growth-promoting values.

5. Yeast and whole wheat bread had better protein value than synthetically fortified bread.

6. A 1% level of yeast fortification was more satisfactory than a 3% level (flour basis), the former producing a bread more nearly equal in color, grain, texture, and taste to bread fortified with synthetic vitamins.

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