Stability of Enrichment Vitamins in Bread and Cookies[1]

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ABSTRACT

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The stability of enrichment vitamins was examined in samples collected during various stages in bread and cookie production. Whereas riboflavin and niacin seemed to be quite stable in both products, the stability of thiamin differed widely. Thiamin was quite stable in bread, but about three-fourths of the thiamin in cookies was destroyed during baking. Compared to fresh products, shelf-stored products (bread for one week; cookies for four weeks) showed minimal additional loss of the three vitamins.

Most bread and cookie products produced in the United States are made with enriched flour. Enrichment adds iron and three B vitamins—thiamin, riboflavin, and niacin. Calcium, an optional enrichment nutrient, is sometimes added. There is little or no loss of iron and calcium during bread and cookie production. However, the enrichment vitamins are labile nutrients (Ranhotra and Bock 1986) and are more likely to undergo losses as some studies (Kennedy and Joslyn 1966, Maleki and Daghir 1967, Tabekhia and D'Appolonia 1979) seem to indicate. With some exception (Ranhotra et al 1980) these studies were, however, limited to bread products. Not all of these and related studies examined all three vitamins or steps during breadmaking, nor did they investigate the stability of vitamins in shelf-stored finished products. This current study compares two different baked products to fill these gaps in knowledge. Enrichment increases the level of the three B vitamins in the flour five to 10 times, but assessing the stability of these vitamins in foods is more important in determining the nutritional significance of the enrichment program.

MATERIALS AND METHODS

Product Making

Bread and cookies were made twice (studies A and B). Both studies used commercially produced flours that had been enriched with iron and three B vitamins (Table I). The same flour was used to make bread and cookies in study A; in study B, the flour for each product was different. Bread was made by AACC (1983) method 10-11 and cookies by AACC method 10-50D (Table II). The steps involved in breadmaking were: sponge mixed for 1 min at speed 1 and 1 min at speed 2 (Hobart mixer); fermented 4 hr; dough ingredients mixed for 0.5 min at speed 1; sponge added and mixed 0.5 min at speed 1 and 6 min at speed 2; dough rested (bench time) 15 min; one-pound loaves scaled and rounded; intermediate proof, 12 min; mould; pan proof, 1 hr; baked (425° F) 22 min; cooled, 1 hr; and double bagged in plastic bags. Cookie-making steps were: shortening, sugar, and salt mixed for 0.5 min at speed 1 and 3.5 min at speed 2; flour and soda added; mixed 0.5 min at speed 1; fluids added; mixed (speed 1), 1 min; dough rolled (1 cm thickness); cookies cut (8 cm across); time elapsed, 15 min; baked (360° F) for 15.5 min; cooled, 1 hr; and double bagged in plastic bags.

Sampling

Doughs and finished products were sampled (sample size, 150 g or more) at various steps identified in Table III. The sampling also included shelf-stored bread (one week) and cookies (four weeks at room temperature). Sufficient dough and products were made to allow for each sampling. All samples were stored frozen until needed for analysis, when they were freeze-dried and finely ground.

Analytical

The standard AACC (1983) methods were used to measure moisture (44-15A), thiamin (86-80), riboflavin (86-70), niacin (86-50), and pH (02-52). All determinations were made in triplicate. Changes (gain or loss) in vitamin content were calculated relative to the amounts in sponge (bread) or dough (cookies) initially mixed.

RESULTS AND DISCUSSION

Studies on vitamin stability have rarely documented the level of vitamins in flours used. The level of enrichment vitamins in flours used in this study met or exceeded the prescribed (CFR 1980) enrichment standards (Table I). Other than the yeast in bread, flour was the only source of vitamins in products tested (Table II). Table I lists the content of vitamins in yeast; these values closely match the values reported (Watt and Merrill 1963) for compressed yeast. Yeast was analyzed only in study B.

Bread and cookies were made according to the standard AACC procedures (Table II). Samples were collected for vitamin analysis at various stages of production. For bread, this included sampling

TABLE I
Vitamins in Flour and Yeast

	Vitamins (mg/100 g)		
Ingredient	**Thiamin**	**Riboflavin**	**Niacin**
Flour			
Study A (bread and cookies)	0.79	0.42	5.75
Study B (bread)	0.81	0.56	6.60
Study B (cookies)	0.70	0.46	5.84
Yeast (compressed)[a]	0.95	1.32	15.25
Enrichment standards	0.64	0.40	5.29

[a]Study B only.

TABLE II
Bread and Cookie Formulas

	Bread		
Ingredient (g)	**Sponge**	**Dough**	**Cookies**
Flour	60	40	100
Compressed yeast	2	···	···
Yeast food	0.5	···	···
NaCl	···	2	0.93
Shortening	···	3	28.4
Sucrose	···	5	57.8
Sodium bicarbonate	···	···	1.1
Dextrose	···	···	0.9[a]
Calcium propionate	···	0.2	···
Water	Variable	Variable	Variable

[a]In 14.7 ml of water.

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of the sponge before and after the 4-hr fermentation, the dough (sponge plus dough mix) before and after proofing, and the bread, both fresh and one week old. Cookies were sampled after mixing the dough, cutting the cookies, baking, and storing (four weeks) (Table III). For uniformity and ease of comparison, vitamin values in Table III are expressed on a moisture-free sample basis. Table III shows changes (gain or loss) in vitamin content. These changes (retentions) are graphically presented in Figure 1.

Vitamin Stability in Bread

A 100-g sample of sponge (added water not considered) contains 96 g of flour and 3.2 g of yeast (Table II). Based on these amounts and the moisture differential, the calculated thiamin values for the sponge were similar to the determined thiamin values (Table III). Little measurable change in thiamin occurred during fermentation of the sponge. This finding agrees with the results of Kennedy and Joslyn (1966) but contrasts with those of Tabekhia and D'Appolonia (1979). Total dough (sponge plus dough mix) in both studies contained less thiamin than the corresponding sponge. This

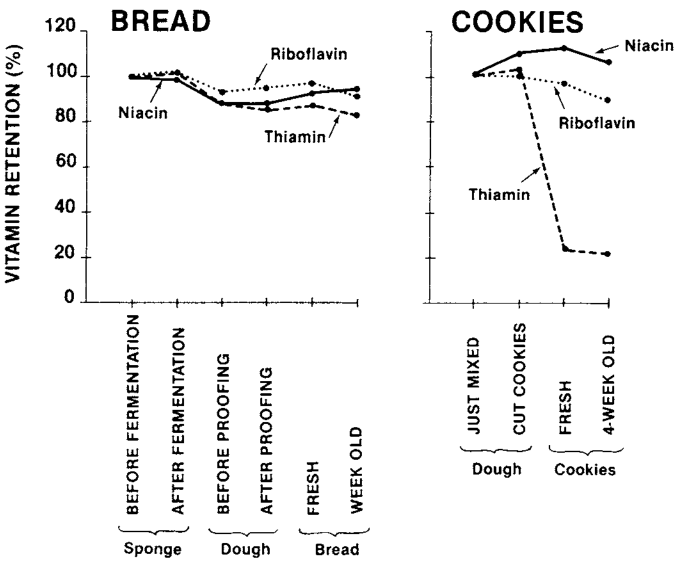

Fig. 1. Retention of enrichment vitamins at different stages of bread and cookie making.

apparently resulted from the dilution of vitamins in flour and yeast resulting from the incorporation of other formula ingredients. Some loss of thiamin may have also occurred; however, 88% of the thiamin contributed by flour and yeast remained stable (Table III and Fig. 1) caused, in part, by the acidic pH. Pan proofing of the dough had little effect on thiamin stability. No measurable thiamin loss occurred when proofed doughs were baked into bread, and the thiamin loss in stored products was minimal.

Unlike thiamin, the determined riboflavin values in the sponge were somewhat lower than the calculated riboflavin values. Kennedy and Joslyn (1966) reported the same observation. The loss of riboflavin during various steps in breadmaking and in finished and stored products seems to be even less than that of thiamin (Table III and Fig. 1). These results agree with those of Loy et al (1951), who claimed that riboflavin in enriched flour was quite stable in light, a major factor in riboflavin destruction in most other foods. As with riboflavin, niacin losses during breadmaking and in stored bread were minimal. In week-old bread, niacin loss averaged only 6% of the amounts in the sponge (Table III and Fig. 1). In Arabic breads, Maleki and Daghir (1967) reported niacin losses under all baking conditions to be negligible. Niacin is quite stable to heat and light and other possibly destructive conditions encountered in breadmaking. As with thiamin, the calculated niacin values in the sponge compared favorably with the determined values.

Vitamin Stability in Cookies

Although the stability of enrichment vitamins in nonbread baked products has probably been studied, the results have rarely been reported. Cookies were selected for this study to help provide missing information.

Flour was the only source of enrichment vitamins in the cookies tested. As with bread, the calculated thiamin values in the cookie doughs closely matched the determined values (Table III). During the 15 min required to mix and roll the dough and cut the cookies, little change in thiamin occurred. In contrast, the destruction of thiamin during cookie baking, when the pH became sufficiently elevated, was extensive. Vitamins, being labile nutrients (Ranhotra and Bock 1986), are often adversely affected by factors such as the duration and temperature of baking and pH. Thiamin, in particular, is highly unstable at alkaline pH. Therefore, using baking soda and baking cookies, with their high surface area, at higher temperatures caused extensive thiamin loss (Fig. 1). Large thiamin loss was also found in high-protein cookies (Ranhotra et al

TABLE III
Product Sampling and Changes in Vitamin Content

Product	Thiamin Study A	Thiamin Study B	Riboflavin Study A	Riboflavin Study B	Niacin Study A	Niacin Study B	pH[b]
	Vitamin (mg/100 g moisture-free sample)[a]						
	Bread						
Sponge							
Before fermentation	1.04 (0)	1.00 (0)	0.37 (0)	0.59 (0)	7.52 (0)	7.80 (0)	5.38
After fermentation	1.02 (−2)	1.04 (+4)	0.37 (0)	0.60 (+2)	7.35 (−2)	7.80 (0)	4.80
Total dough							
Before proofing	0.92 (−12)	0.88 (−12)	0.34 (−8)	0.53 (−10)	6.46 (−14)	6.92 (−11)	5.17
After proofing	0.93 (−13)	0.85 (−15)	0.36 (−3)	0.54 (−8)	6.56 (−13)	6.94 (−11)	5.02
Bread							
Fresh	0.93 (−11)	0.88 (−12)	0.37 (0)	0.54 (−8)	6.74 (−10)	7.55 (−3)	5.25
One week old	0.89 (−14)	0.80 (−20)	0.35 (−5)	0.53 (−10)	6.91 (−8)	7.51 (−4)	5.23
	Cookies						
Dough	0.46 (0)	0.36 (0)	0.18 (0)	0.27 (0)	3.38 (0)	3.40 (0)	7.25
Cut cookies	0.46 (0)	0.38 (+6)	0.19 (+6)	0.26 (−4)	3.41 (+1)	4.09 (+20)	7.35
Cookies							
Fresh	0.08 (−83)	0.11 (−70)	0.19 (+6)	0.24 (−11)	3.68 (+9)	3.85 (+13)	8.10
Four weeks old	0.07 (−85)	0.11 (−70)	0.16 (−11)	0.24 (−11)	3.58 (+6)	3.60 (+6)	7.40

[a] Values in parentheses indicate percent change (gain, +; loss, −) in vitamin content compared to sponge (bread) or dough (cookies) initially mixed. Values are expressed on a moisture-free basis.
[b] Study B only.

1980). Based on the analysis of 63 cookie and cracker products, Bednarcyk (*unpublished*) reported thiamin losses of 9–75% after baking. Bednarcyk (*unpublished*) observed little nutrient loss under normal storage conditions, especially in the case of low-moisture products such as most cookies. The current studies confirm this observation.

While the stability of thiamin in bread and cookies differed widely, riboflavin and niacin were quite stable. Riboflavin losses in baked and stored cookies were minimal, and there was no loss of niacin; in fact, the baked cookies contained more niacin than the corresponding doughs (Table III and Fig. 1).

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