Effects of Processing Steps and Baking on Thiamine, Riboflavin, and Niacin Levels in Conventional and Continuous Produced Bread[1]

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ABSTRACT

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The levels of thiamine, riboflavin, and niacin in conventionally produced bread dough after mixing, fermentation, and proofing were compared with levels in continuous produced bread dough after premixing, extrusion, and proofing. Retention values of those vitamins after baking times of 8, 13, 18, 23, and 30 min at 430°F in the crust, crumb, and whole bread for the two baking procedures were determined. Thiamine levels decreased as a function of baking time, with the greatest decrease occurring in the crust. Thiamine retention was higher for the continuous produced bread than for the conventional bread. Riboflavin showed essentially no change in content with baking. The amount retained in crust, crumb, and whole bread ranged from 93 to 100% and 97 to 100% after 30 min of baking for conventional and continuous bread, respectively. Likewise, no significant change for niacin levels with baking was noted, the retention values ranging from 97 to 102% and 98 to 100% for conventional and continuous bread, respectively.

A national program for enriching cereals and cereal products with protein, minerals, and vitamins makes it desirable to determine the stability of these nutrients during preparation procedures, particularly bread baking.

Bread is a staple food for many countries. Bread is produced in the United States primarily by two methods: the conventional and the continuous. Conventional bread relies on bulk yeast fermentation, whereas continuous bread depends on rapid mechanical development of the dough. Hoffman et al (1940) and Dawson and Martin (1941) indicated that loss of thiamine during baking varies from 5 to 30%. Schultz et al (1942) analyzed the crust and crumb portion of bread and found that the major part of thiamine destruction occurred in the crust. They mentioned that thiamine content of the crust is reduced by 50% as the baking time is extended from 10 to 40 min, whereas the crumb lost only 17% of its thiamine during the same period. The extent of thiamine destruction was markedly influenced by the baking time. Additional loss of thiamine occurs during toasting (Coppock et al 1956). Kennedy and Joslyn (1966) found that thiamine content in the mixed sponge and dough produced by the conventional sponge-dough procedure was very close to the calculated value. During fermentation of the sponge, little change in thiamine occurred; after baking, however, thiamine in the crust decreased slightly. Kennedy and Joslyn (1966) also found that riboflavin content in the mixed sponge and dough was appreciably below the calculated value and that an apparent slight increase in riboflavin content occurred as a result of baking. The data of Gassmann and Schneeweiss (1959) on the destruction of B vitamins in various portions of bread indicated a higher destruction of thiamine in the crust than in the center portions of the crumb. These workers also reported appreciable loss of riboflavin. Hepburn (1971) estimated total and free niacin in white bread produced by conventional and continuous procedures and reported that niacin in the free form was higher in the bread than in the original flour.

Our study was conducted to compare the relative retentions of thiamine, riboflavin, and niacin during dough preparation and baking using the conventional and continuous bread systems.

MATERIALS AND METHODS

Flour Sample

Flour used to produce the bread was commercially milled and was malted, bleached, and enriched with thiamine, riboflavin, and niacin.

Bread Samples

Conventional Bread Baking. Bread was made using a straight dough procedure with 3-hr fermentation, 55-min proofing, and baking times of 8, 13, 18, 23, and 30 min at 430°F. The baking formula, with percentage of ingredients based on flour weight, was: flour, 1,700 g (14% mb); sugar, 5%; salt, 2%; shortening, 3%; yeast, 3%; nonfat dry milk, 2%; and water, 62%.

After the 3-hr fermentation period, the dough mass was divided into 1-lb loaves, shaped into balls, allowed to rest 10 min, and then sheeted, molded, and placed into bread pans. Samples of dough (50 g) collected after the mixing, fermentation, and final proofing stages were frozen and freeze-dried in preparation for vitamin analyses. Bread was removed from the oven after the different time intervals, allowed to cool, and sliced. Portions of the crumb, crust, and crumb plus crust (whole bread) were frozen and freeze-dried. The crumb of the bread slice was separated from the crust by hand, leaving about ⅛ in. of crumb attached to the crust. The freeze-dried products were ground on a Wiley mill to pass through a 40-mesh sieve and then stored in airtight containers at 5° C before analyses.

Continuous Bread Baking. The same flour used to produce the conventional bread was used with a Wallace and Tiernan Laboratory Model Continuous Unit (Baker Process Co., Belleville, NJ) to make the continuous bread, according to the procedure described by D'Appolonia (1973). The baking formula was: flour, 5,000 g; sugar, 8%; salt, 2.25%; nonfat dry milk, 2%; shortening, 3.25%; yeast food, 0.50%; compressed yeast, 2.75%; potassium bromate, 60 ppm; potassium iodate, 12 ppm; and water, 64%.

Samples of dough (50 g) collected after the premixing, extrusion, and final proofing stages were frozen and freeze-dried in preparation for vitamin analyses. Bread was baked for the same time intervals used for the conventional bread. Portions of the crumb, crust, and crumb plus crust (whole bread) were frozen and freeze-dried and used for vitamin analyses.

Vitamin Analyses. Thiamine, riboflavin, and niacin were analyzed by AACC methods (1960, 1968, and 1966).

Moisture Determination. Moisture in the samples was determined by AACC method 44-15A (1967).

RESULTS AND DISCUSSION

The levels of thiamine, riboflavin, and niacin in bread dough at different stages of preparation are shown in Table I. Values after mixing, fermentation, and proofing are given for the conventional bread system and after premixing, extrusion, and proofing for the continuous bread system.

Thiamine increased after mixing for both the conventional and continuous bread systems. The increase was probably due to the

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TABLE I
Effect of Dough Preparation on Vitamin Content[a]

	Thiamine (γ/100 g)	Riboflavin (γ/100 g)	Niacin (γ/100 g)
Flour	470 ± 12.6	290 ± 10.7	4,200 ± 17.6
Conventional bread system			
After mixing	531 ± 22.1	345 ± 15.9	4,830 ± 16.2
After fermentation	592 ± 6.7	301 ± 16.0	4,326 ± 15.7
After proofing	479 ± 14.5	290 ± 33.5	4,201 ± 8.9
Continuous bread system			
After premixing	596 ± 9.7	374 ± 11.1	4,872 ± 19.5
After extrusion	455 ± 18.7	269 ± 7.7	4,830 ± 20.5
After proofing	517 ± 9.6	313 ± 12.9	4,284 ± 15.1

[a]Results expressed on a moisture-free basis, with mean value and standard deviation reported; each mean represents two values.

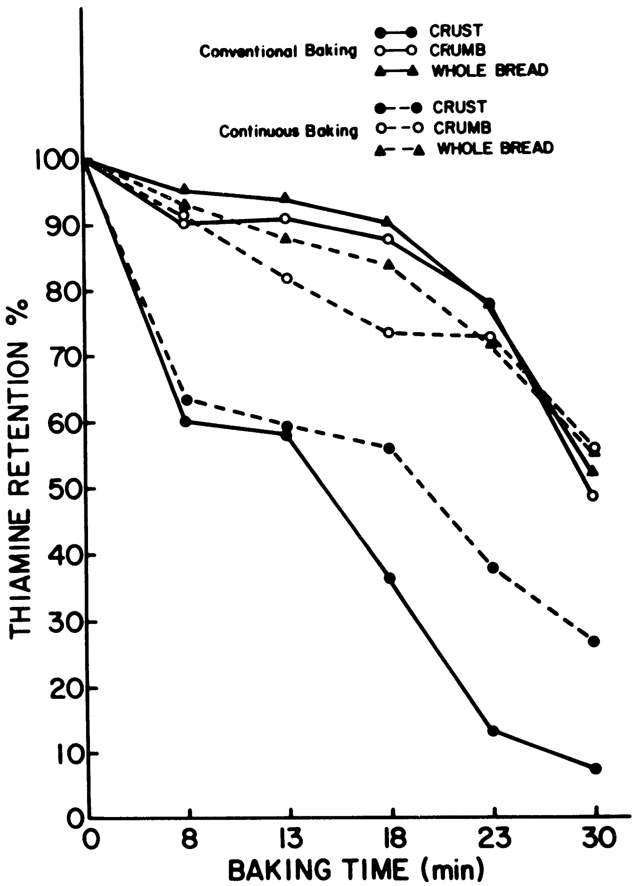

Fig. 1. Thiamine retention in crust, crumb, and whole bread of conventional and continuous bread baked for different time intervals.

addition of thiamine from the other ingredients. A further increase in thiamine was noted after fermentation in the conventional bread system. This could have been due to yeast multiplication. Thorn and Ross (1960) reported 35% yeast growth in a fermented straight dough after 3–3.5 hr. A slight decrease was noted in thiamine after extrusion in the continuous bread system. The level of thiamine after proofing was higher in the continuous than in the conventional system.

Riboflavin also increased after mixing for both bread procedures. As with thiamine, riboflavin decreased after extrusion in the continuous system, then increased after proofing. These results agree with those of Beetner et al (1974), Harmann and Harper (1972), and Harper et al (1971) that some degradation of thiamine and riboflavin occurred during the extrusion process of cereal dough and that the average retention was lower for thiamine than for riboflavin.

Niacin also increased after mixing for both bread systems. A reduction in niacin after extrusion was not noted, however, as with the other two vitamins.

The effect of baking time on the retention of thiamine in the crust, crumb, and whole bread for the two types of bread is shown in Fig. 1. Thiamine loss was greatest in the crust and was greater in the conventional than in the continuous bread system. After 30 min of baking, only 7% of the thiamine was retained in the conventional bread crust, whereas 26% was retained in the continuous bread crust. Thiamine retention in whole bread after 30 min of baking was 48 and 55%, respectively, for the conventional and continuous bread systems. European-type bread showed an average of 70.5% thiamine retention during normal baking (Bottomley and Nobile 1962). This difference is probably due to the longer baking time (30 min) of the present study.

There did not appear to be any significant decrease in the retention of riboflavin or niacin as a result of baking, regardless of the procedure used. These findings agree with those obtained with European bread by Sherwood (1943), who found that normal baking of bread caused no loss of riboflavin. Results with niacin confirm the high stability of this vitamin to heat, light, and other baking conditions (Melnick 1942) and indicate that niacin is retained regardless of the baking procedure.

Statistical analysis of the data indicated a significant correlation between baking time and thiamine destruction ($r = -0.61$) at the 1% level and nonsignificant correlations between baking time and destruction of the other two vitamins.

In conclusion, our study showed that an increase in thiamine, riboflavin, and niacin occurred after mixing the flour into a dough with the remaining bread ingredients. After fermentation, a definite increase in thiamine and a slight increase in riboflavin and niacin were noted. The extrusion process in the continuous procedure caused a reduction in thiamine and riboflavin. After proofing, however, these two vitamins again increased. Our study also indicated a greater retention of thiamine in bread crust produced by the continuous method than in that produced by the conventional system.

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