# Effect of Baking on Retention of Thiamine, Riboflavin, and Niacin in Arabic Bread[1]

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**ABSTRACT**

The effect of different baking conditions on the retention of thiamine, riboflavin, and niacin in Arabic bread was investigated. A microbaking technique, with a muffle furnace as baking oven, was used to bake experimental samples at 400°, 450°, and 500°C. for different time intervals. Destruction of thiamine was greater in brown than in white Arabic bread and was positively related to the intensity of heating. A uniform loss of riboflavin was observed in both white and brown Arabic bread; loss of niacin under all baking conditions was negligible. In vitamin-enriched samples, retention of riboflavin was higher than that of unenriched bread; also, added niacin was retained completely. It was found that the addition of 1 $\gamma$ of riboflavin, 5 $\gamma$ of thiamine, and 10 $\gamma$ of niacin per g. of white flour was sufficient to increase the vitamin content to that of brown flour.

The population of the Middle East exists on a predominantly cereal diet; wheat, in the form of bread, is the daily staple in most Middle Eastern countries. In Lebanon, as well as in other countries, the most popular type of bread is a flat, circular loaf (1 cm. thick, 10- to 30-cm. diam.) composed of two layers, with very little crust. Although white bread made from flour of 60–70% extraction is becoming more popular, Arabic bread, made from flour of 80–90% extraction, is also in common use.

There is no literature available on the effect of baking and vitamin supplementation on Arabic bread, but such studies on European bread are numerous. Bottomley and Nobile (1), working on European bread, reported an average loss of 29.5% of thiamine during baking. Coppock *et al.* (2) found a 20% loss of thiamine in bread baked at 475°F. for 30 min. Morgan and Frederick (3) found a definitely lower level of thiamine in the crust of whole-wheat bread than in the crumb; the maximum difference was 35%.

Working on the riboflavin content of bread, Auerman and co-workers (4) reported that flour of 72–85% extraction retained 64–88% less of its original riboflavin than did whole-wheat bread during breadmaking.

Many workers have agreed on the relatively high stability of niacin during breadmaking. For example, Sherwood (5) reported no loss of niacin during baking of bread at 425°F. for 30 min. In another study, 95–100% of the original niacin was retained under normal baking conditions (6).

Enrichment of white flour to restore vitamins lost in milling has been recommended by many workers, and different forms and combinations have been proposed. Dawson and Martin (7) recommended the addition of dried yeast as a supplementary source of vitamins, whereas Robertson (8) claimed that bread made from white flour fortified with thiamine, riboflavin,

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niacin, and iron is the best from the standpoint of nutrition. Menden and Cremer (6) have reviewed the method and levels of enrichment in various countries.

In the present study, emphasis was put on vitamin losses during the baking of white, brown, and vitamin-enriched white Arabic bread, baked at different temperatures for different time intervals. Particular interest was given to thiamine, riboflavin, and niacin, since wheat and wheat products are considered primary sources of these vitamins.

## MATERIALS AND METHODS

### Preparation of Bread Sample

A microbaking technique, similar in principle to that of the commercial procedure, was used for baking experimental loaves, 8 cm. in diameter and ¾ cm. thick. Flours used for this experiment, namely the white flour of 65% extraction and the brown flour of 85% extraction, were obtained from a local bakery in Beirut. For the preparation of the straight dough, the following ingredients were used: flour, 1,000 g.; water, 550 g.; salt, 12.5 g.; and yeast (compressed), 7.5 g.

The doughs were mixed for 12 min. in a small Crypto electric mixer (Model E.B. 12, Crypto Ltd., London). The rest of the operations, with fermentation at room temperature, were carried out as follows:

| | |
|---|---|
| a) First fermentation | 8 min. |
| b) Rounding by hand | |
| c) Second fermentation | 10 min. |
| d) Rolling to circular dough sheets of 8 cm. diam., 4 mm. thick | |
| e) Third fermentation | 45 min. |

A small muffle furnace (type 1500, Thermolyne Corp., Dubuque, Iowa) was used as a baking oven. To prevent direct contact between the dough sheets and the hearth of the furnace, a thin, elevated asbestos pad was used as a baking floor. The time-temperature combination most commonly used in commercial bakeries, namely 450°C. and 45 sec., served as the basis for establishing the time-temperature combinations in this study. Bread baked under these conditions was termed "choice." Two alternate time-temperature combinations giving rise to choice bread were determined with preselected temperatures of 400° and 500°C. To make more complete the analysis of time and temperature effects on vitamin retention in bread, time of baking was varied, to permit underbaked and overbaked samples, under each of the three temperatures. Thus, nine time-temperature baking conditions were used in the study (see Table I).

Twelve loaves of bread were baked at each time-temperature combination, and the appearance of each group was compared with that of commercially baked Arabic bread (Tables I and II). For analysis, the loaves were air-dried in the dark at room temperature for 72 hr., then ground to 20-mesh and stored at −18°C. in dark glass containers. A sample of dough was kept frozen for comparative analysis.

Dough for vitamin-enriched bread was prepared in exactly the same

TABLE I

EFFECT OF BAKING TIME AND TEMPERATURE ON THE APPEARANCE OF WHITE ARABIC BREAD, AND ON ITS CONTENTS OF THIAMINE, RIBOFLAVIN, AND NIACIN

| Baking Time | Baking Temp. | Appearance | Thiamine Content | Thiamine Retention | Riboflavin Content | Riboflavin Retention | Niacin Content | Niacin Retention |
|---|---|---|---|---|---|---|---|---|
| *sec.* | *°C.* | | *γ/g. dry matter* | *%* | *γ/g. dry matter* | *%* | *γ/g. dry matter* | *%* |
| 30 | 400 | Underbaked | 2.13 | 99.57 | 0.49 | 87.5 | 29.77 | 94.40 |
| 60 | | Choice | 1.61 | 75.37 | 0.51 | 89.8 | 30.50 | 97.13 |
| 90 | | Overbaked | 1.31 | 61.10 | 0.49 | 87.5 | 30.33 | 96.50 |
| 30 | 450 | Underbaked | 1.99 | 93.43 | 0.40 | 71.4 | 31.46 | 101.59 |
| 45 | | Choice | 1.62 | 75.75 | 0.46 | 81.3 | 30.74 | 97.77 |
| 60 | | Overbaked | 1.31 | 61.10 | 0.45 | 79.8 | 31.58 | 100.64 |
| 15 | 500 | Underbaked | 2.12 | 99.26 | 0.49 | 87.5 | 30.52 | 97.13 |
| 30 | | Choice | 1.68 | 76.41 | 0.46 | 81.4 | 30.82 | 98.09 |
| 45 | | Overbaked | 1.31 | 61.34 | 0.46 | 81.4 | 30.63 | 97.45 |
| Unbaked dough | | | 2.14 | 100 | 0.56 | 100 | 31.38 | 100 |

TABLE II

EFFECT OF BAKING TIME AND TEMPERATURE ON THE APPEARANCE OF BROWN ARABIC BREAD AND ON ITS THIAMINE, RIBOFLAVIN, AND NIACIN CONTENTS

| Baking Time | Baking Temp. | Appearance | Thiamine Content | Thiamine Retention | Riboflavin Content | Riboflavin Retention | Niacin Content | Niacin Retention |
|---|---|---|---|---|---|---|---|---|
| *sec.* | *°C.* | | *γ/g. dry matter* | *%* | *γ/g. dry matter* | *%* | *γ/g. dry matter* | *%* |
| 30 | 400 | Underbaked | 10.49 | 95.58 | 1.03 | 74.8 | 40.69 | 98.30 |
| 60 | | Choice | 6.07 | 57.02 | 1.06 | 77.0 | 41.89 | 101.45 |
| 90 | | Overbaked | 4.43 | 41.64 | 1.09 | 79.7 | 41.44 | 100.24 |
| 30 | 450 | Underbaked | 8.32 | 78.22 | 1.04 | 76.2 | 41.83 | 101.21 |
| 45 | | Choice | 6.98 | 65.75 | 1.06 | 77.0 | 43.09 | 104.36 |
| 60 | | Overbaked | 5.85 | 54.94 | 1.06 | 77.0 | 42.55 | 102.90 |
| 15 | 500 | Underbaked | 8.55 | 80.34 | 1.03 | 74.8 | 42.24 | 102.18 |
| 30 | | Choice | 7.33 | 68.85 | 1.02 | 74.1 | 41.89 | 101.45 |
| 45 | | Overbaked | 3.94 | 37.03 | 1.02 | 74.1 | 40.07 | 97.09 |
| Unbaked dough | | | 10.64 | 100 | 1.37 | 100 | 41.27 | 100 |

way as the white Arabic bread, except that the water used in its preparation contained the desired level of vitamin. Since baking at 450°C. for 45 sec. produces the most acceptable bread (Tables I and II), these conditions were used for the preparation of the enriched samples. The levels of enrichment of each vitamin are reported in Table III.

**Analyses**

Moisture, riboflavin, and niacin were determined according to methods of the AOAC (9). For thiamine analysis, the method described by Mickelsen and Yamamoto (10) was followed. The fluorescence of the isobutanol extract was measured with a Farrand spectrofluorimeter (Farrand Optical Co. Inc., New York), with wave lengths of 365 mμ for the exciting radiation and 435 mμ to measure the emitted fluorescence.

## RESULTS AND DISCUSSION

The effects of baking time and temperature on thiamine, riboflavin, and niacin in Arabic bread are shown in Tables I and II. Bread samples, baked in the laboratory at 400°, 450°, and 500°C. for 60, 45, and 30 sec. respectively, were similar in appearance to commercially baked bread (choice).

Reports on work with European-type bread show that 15–20% of the thiamine is destroyed during normal baking (7,11). In the present work, the baking conditions used to produce loaves of Arabic bread with choice appearance resulted in a 25% loss of thiamine in white bread in all three treatments (Table I) and 43, 34, and 31% loss, respectively, in brown Arabic bread (Table II). Though in brown bread high-temperature, short-time treatment resulted in the retention of more thiamine than did other treatments, there seemed to be a generally greater loss of this vitamin in Arabic bread than in the European-type bread. This difference is probably due to the higher temperature and greater penetration of heat into the thin loaf of Arabic bread, as compared to the thicker loaf of European bread.

As shown in Tables I and II, the loss of riboflavin in choice and over-baked bread seemed to be less than the loss of thiamine. With one exception, there was a loss of 10–20% of the original riboflavin in all white bread samples; in brown bread, losses were greater. These findings are in contrast to those obtained with European bread; according to Sherwood (5), normal baking of European bread caused no loss of riboflavin, and Meckel and Anderson (12) reported an increase of up to 21% of this vitamin. The experimental results on the niacin content of bread samples (Tables I and II) indicate that 95–100% of the niacin was retained in all samples of both white and brown Arabic bread. These findings confirm the high stability of niacin to heat, light, and other baking conditions (13).

Table III shows the effect of baking on the retention of these vitamins in enriched white Arabic bread. Enrichment of flour with synthetic thiamine at a level of 5 γ/g. flour caused an increase in the thiamine content of the

TABLE III

EFFECT OF BAKING ON RETENTION OF THIAMINE, RIBOFLAVIN, AND NIACIN IN ENRICHED WHITE ARABIC BREAD

| Vitamin | Level of Enrichment | Bread | | Dough | |
|---|---|---|---|---|---|
| | | Vitamin Content | Retention | Vitamin Content | Retention |
| | *γ/g. flour* | *γ/g. dry matter* | % | *γ/g. dry matter* | % |
| Thiamine | 0 | 1.62 | 75.6 | 2.14 | 100.0 |
| | 2 | 4.06 | 82.4 | 4.94 | 100.0 |
| | 5 | 8.76 | 92.3 | 9.53 | 100.0 |
| | 10 | 13.38 | 92.5 | 14.47 | 100.0 |
| Riboflavin | 0 | 0.46 | 81.3 | 0.56 | 100.0 |
| | 1 | 1.38 | 84.5 | 1.63 | 100.0 |
| | 3 | 2.89 | 86.5 | 3.34 | 100.0 |
| | 6 | 6.50 | 91.2 | 7.12 | 100.0 |
| Niacin | 0 | 30.74 | 97.8 | 31.38 | 100.0 |
| | 10 | 41.90 | 103.9 | 40.34 | 100.0 |
| | 40 | 70.32 | 98.6 | 71.34 | 100.0 |
| | 60 | 85.58 | 99.7 | 85.83 | 100.0 |

corresponding dough greater than could be attributed to the added vitamin. This increase may be explained by the multiplication of yeast cells during fermentation. Thorn and Ross (14) reported 35% yeast growth in straight dough fermented for 3.0–3.5 hr.

The retention of riboflavin during baking was higher in enriched than in unenriched bread (Table III). For example, when 6 $\gamma$ of riboflavin was added per g. flour, retention was 91% compared to 81% in plain bread. These results are in agreement with those of Loy *et al.* (15), who claimed that riboflavin in enriched flour was stable even in artificial light and sunlight.

The results in Table III show that losses of niacin in enriched bread were negligible; thus, it is evident that supplementary niacin is as stable to the baking conditions of Arabic bread as to those of European bread.

Comparing the values in Tables I and II with those in Table III, it can be concluded that the addition of 5 $\gamma$ thiamine, 1 $\gamma$ riboflavin, and 10 $\gamma$ niacin per g. flour would be sufficient to increase the vitamin content of white flour of 65% extraction to that of brown flour of 85% extraction.

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