NOTE

The Use of Magnesium Powder in Fortified Bread

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Magnesium is one of the 10 nutrients included in the expanded cereal fortification program (NAS/NRC 1974). It is also the fortification nutrient that has the greatest adverse effect on product quality. For example, bread pH is elevated when magnesium (at the recommended level of 44.05 mg/100 g of flour) is used in the form of oxide, hydroxide, or carbonate (Ranhotra et al 1976). Total fortification with all 10 nutrients appears to have less effect on product quality than does the addition of magnesium alone, especially if the addition of magnesium is adjusted for the amount contributed by wheat flour (Ranhotra et al 1980, Winterringer 1981).

Cost, convenience of storage, and use dictate that the potential enrichment source, be it a compound of iron, calcium, zinc, or magnesium, should be low in nutritionally nonfunctional moieties. Such considerations prompted these studies with magnesium powder, which, theoretically, is all magnesium.

MATERIALS AND METHODS

Flour obtained from hard red wheat was first analyzed for iron, calcium, zinc, and magnesium and then fortified with the 10 proposed nutrients (Table I). Except for iron, which was added at the current (upper limit) enrichment level, all other nutrients were added at the proposed levels. These additions were not adjusted for amounts in wheat flour. Magnesium (as magnesium powder) was added at both the unadjusted and adjusted (for magnesium in flour) levels. The magnesium powder used was a very fine (less than 325-mesh) preparation and was obtained from a commercial source (Table I).

Breadmaking

Vitamin-mineral premixes were prepared the day before breadmaking. Breads were made by the four different methods shown in Table II. These were the straight-dough, no-time dough, and sponge-dough methods, and the brew system.

Straight-Dough Method. The dough was mixed for 0.5 min at speed 1 and for 8 min at speed 2 in a Hobart A-120 Mixer (McDuffy bowl and hook). It was then fermented (86° F, 92% rh) for 2 hr, scaled (to 18.5 oz), and rounded. An intermediate proof was done for 10 min. The dough was then molded, proofed (88° F, 92% rh) to a template height of 5/8 in., and baked for 20 min at 430° F.

No-Time Dough Method. The dough was mixed for 1 min at speed 1 and for 5 min at speed 2, scaled (to 18.5 oz), rounded, and proofed for 10 min at 77° F. The dough was then proofed again (88° F, 92% rh) to a template height of 5/8 in., and baked for 20 min at 430° F.

Sponge-Dough Method. Sponge ingredients were mixed for 1 min at speed 1 and for 1 min at speed 2. The dough was then fermented 86° F, 92% rh) for 3.5 hr. Dough ingredients were mixed with sponge ingredients for 1 min at speed 1, and for 4 min at speed 2. The dough was fermented for 20 min, scaled (18.5 oz), rounded, proofed after 10 min, molded, proofed (88° F, 92% rh) to a template height of 5/8 in., and baked for 20 min at 430° F.

Brew System. All ingredients were placed in a bowl, stirred with a wire wisk until well incorporated, and fermented for 2 hr at 86° F, with stirring every 30 min. The brew was cooled to 50° F in 30 min by adding ground ice and placing in a freezer (0° F). The brew was added to the dough ingredients and mixed for 1 min at speed 1 and for 7.5 min at speed 2. The dough was then fermented for 20 min, scaled (to 18.5 oz), rounded, and proofed for 10 min, molded, proofed (88° F, 92% rh) to a template height of 5/8 in., and baked 20 min at 430° F.

Determinations

Atomic absorption spectrophotometry (model 251 spectrophotometer; Instrumentation Laboratories, Inc.) was used to determine magnesium, calcium, zinc, and iron in flour, magnesium in magnesium powder, calcium in calcium sulfate, zinc in zinc oxide, and iron in ferrous sulfate (Table I).

Bread weight and volumes (rapeseed displacement) were measured approximately 1.5 hr after baking. This information was used to calculate specific loaf volumes (Table III). Bread pH was measured by the standard AACC method (1976).

Flavor Test

Seven previously trained individuals used the triangle test procedure for testing flavor. Breads were sliced approximately 21 hr after baking. The 11 center slices were labeled with three-digit random numbers, placed in cellophane bags, closed with staples, and distributed to panel members. Panel members were instructed to refrain from eating or smoking for 30 min before tasting, rinse their mouths before tasting, wash their hands, dim overhead lights, sit in a comfortable position, and sample only the center bread crumb.

RESULTS AND DISCUSSION

The six vitamins added under the expanded fortification program (Table I) appeared not to adversely affect the bread quality (Vetter 1979). This also seems to be the case for zinc (Ranhotra et al 1977), iron, and calcium, the addition of which to bread has been well accepted by consumers since bread enrichment was introduced in the 1940s. Thus, magnesium remains the only proposed added nutrient that may cause flavor and quality

TABLE I
Nutrients in Test Flour and Flour Fortification

Nutrient	Test Flour (mg/100 g)	Flour Fortification: Proposed Levels[a] (mg/100 g)	Flour Fortification: Levels Used[b] (mg/100 g)
Vitamin A	ND[c]	0.29	0.29
Thiamin	ND	0.64	0.64
Riboflavin	ND	0.40	0.40
Niacin	ND	5.29	5.29
Pyridoxine	ND	0.44	0.44
Folic Acid	ND	0.07	0.07
Iron	0.87	8.81	3.63
Calcium	22.20	198.20	198.20
Zinc	0.67	2.20	2.20
Magnesium[d]	25.25	44.05	44.05, 18.80[e]

[a] Proposed by the NRC/NAS (1974).
[b] Added as vitamin A palmitate, thiamin mononitrate, riboflavin, niacin, pyriodoxine, folic acid, ferrous sulfate (iron, 29.9%), $CaSO_4 \cdot 2H_2O$ (calcium, 23.3%), ZnO (zinc, 78.2%), and magnesium powder (magnesium 85.0%).
[c] ND = not determined.
[d] Magnesium powder was obtained from Alpha Products (Danvers, MA 01923).
[e] Unadjusted (44.05) and adjusted (18.80) for Mg in flour.

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TABLE II
Bread Formulas

Ingredients	Sponge-Dough: Sponge (%)	Sponge-Dough: Dough (%)	No-Time (%)	Straight-Dough (%)	Brew: Brew (%)	Brew: Dough (%)
Flour[a]	70.0	30.0	100.0	100.0	40.0	60.0
Yeast (compressed						
New (fresh)	2.5	···	4.0	···	3.0	···
Old (four weeks)	···	···	···	3.0	···	···
Yeast food[b]	0.5	···	0.5	0.25	0.5	···
Salt	···	2.0	2.0	2.0	···	2.0
Sugar	···	6.0	6.0	6.0	1.0	5.0
Shortening	···	3.0	3.0	3.0	···	3.0
Reddi-sponge[c]	···	···	2.0	···	···	···
Water	44.45	19.05	65.5	65.5	55.0	3.5
Ice	···	···	···	···	5.0	···

[a]Contained 14.0% moisture, 11.66% protein, and 0.464% ash.
[b]Contains monocalcium phosphate, starch, salt, ammonium sulfate, calcium sulfate, and potassium bromate (Paniplus: C. M. Yeast Food).
[c]Contains dry whey, corn flour, monocalcium phosphate, and potassium bromate (Foremost McKesson, Inc.).

problems. High Mg sources (oxide, hydroxide, and carbonate) raise bread pH appreciably (Ranhotra et al 1976), as does Mg powder (Table III). However, pH elevation was within acceptable limits when Mg was added at levels adjusted for Mg in flour (B breads). When such an adjustment was not made (C breads), pH approached 6.0. Mg powder obviously would have to be added at the adjusted level. Bread flour provides 20–30 mg of Mg/100 g of flour (Ranum 1980). Thus, only about 20 mg would need to be added as Mg powder (or other external source) to achieve the proposed level of 44.05 mg/100 g. This addition can be further reduced if the contribution of Mg from other bread ingredients (ie, water, yeast, milk solids or replacers) can be considered.

Fortification, with adjusted Mg addition, added two noteworthy attributes to the bread. First, the general bread quality (bread scores) improved (A breads vs B breads) by each of the four methods of breadmaking that were tested (Table III). This improvement was less, even nonexistent (sponge-dough method), when Mg was added at the unadjusted levels (C breads). Second, the loaf volume also improved. Three of the four tested methods of breadmaking showed this to be the case. This improvement was most striking when breads were made by the sponge-dough or brew (A breads vs B and C breads) system. Bayfield et al (1965) made similar observations when testing the effect of water hardness (due to Ca and Mg) on breads made by the brew system. The proof times tended to decrease when breads were fortified (Table III). Winterringer (1981) also observed this tendency. On close observation, a few specks of metal could be seen in the bread crumb.

Detailed studies of bread flavor were not undertaken. Limited evaluations (triangle test) revealed that bread flavor did not differ statistically, although the breads with the adjusted levels of Mg (B breads) were preferred over both the control breads (A breads) and breads with the unadjusted Mg levels (C breads).

TABLE III
Bread Quality (three bakes)[a]

Bread	Fortification	pH	Bread Score[b]	Specific Loaf Volume (cc/g)	Proof Time (min)
Sponge-Dough Procedure					
A	None (control)	5.00 ± .03	84.0 ± 0.0	5.64 ± .16	44
B_1	Yes (sponge)[c]	5.34 ± .08	91.5 ± 0.7	5.82 ± .07	43
B_2	Yes (dough)[c]	5.39 ± .13	90.0 ± 1.4	5.90 ± .05	42
C_1	Yes (sponge)[d]	5.88 ± .14	80.0 ± 1.4	6.01 ± .19	43
C_2	Yes (dough)[d]	5.94 ± .23	80.0 ± 1.4	6.02 ± .03	42
No-Time Procedure					
A	None (control)	5.26 ± .08	90.0 ± 5.7	5.65 ± .06	54
B	Yes[c]	5.38 ± .04	96.5 ± 0.7	5.62 ± .07	50
C	Yes[d]	5.70 ± .04	91.5 ± 0.7	5.65 ± .08	52
Straight-Dough Procedure					
A	None (control)	5.07 ± .08	81.0 ± 1.4	5.34 ± .33	46
B	Yes[c]	5.41 ± .15	90.0 ± 1.4	5.43 ± .24	43
C	Yes[d]	5.93 ± .11	83.0 ± 1.4	5.56 ± .05	44
Brew System					
A	None (control)	4.95 ± .04	84.5 ± 5.0	5.44 ± .22	42
B_1	Yes (brew)[c]	5.30 ± .04	92.5 ± 5.0	5.74 ± .29	42
B_2	Yes (dough)[c]	5.30 ± .14	96.0 ± 2.8	5.83 ± .06	41
C_1	Yes (brew)[d]	5.89 ± .11	88.0 ± 0.0	5.86 ± .01	41
C_2	Yes (dough)[d]	5.83 ± .25	89.0 ± 1.4	5.83 ± .10	39

[a]Values are mean ± standard deviation.
[b]Using 100-point scoring system: volume, 10; crust color, 8; symmetry of form, 3; evenness of bake, 3; crust character, 3; break and shred, 3; grain, 10; crumb color, 10; aroma, 10; flavor, 15; mastication, 10; and texture, 15 (developed by the American Institute of Baking).
[c]Magnesium addition (18.8 mg/100 g) adjusted for Mg in flour.
[d]Magnesium addition (44.05 mg/100 g) not adjusted.

CONCLUSIONS

Magnesium powder (Mg content, 85%) can be used to fortify bread. Total fortification (NAS/NRC 1974), with addition of Mg adjusted for Mg in flour (normal range of 20–30 mg of Mg/100 g of flour) appears to have no adverse effect on bread flavor. Fortification, in fact, improves both the general bread quality and loaf volume. Volume improvement is most dramatic in breads made by the sponge-dough and brew systems. The pH of bread remains within acceptable limits when Mg is added at the adjusted (for Mg in flour) level.

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