

# Retention of Selected Minerals in Enriched Pasta Products During Cooking<sup>1</sup>

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## ABSTRACT

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Four brands of three commercially produced enriched pasta products (spaghetti, egg noodles, and macaroni) were obtained from four major U.S. cities. Iron (Fe), calcium (Ca), phosphorus (P), magnesium (Mg), zinc (Zn), copper (Cu), manganese (Mn), sodium (Na), and potassium (K) were determined in cooked and uncooked products to assess possible losses during cooking. Results showed that the products were virtually free of Na

but contained significant amounts of the other minerals analyzed except Ca. True retentions following cooking were high with average values, 81-102% for all minerals except K. Potassium retention averaged only one-third the amount in dry products. A 10-oz serving of the cooked products provided 31, 24, 16, 16, 12, 9, 5, and 2% of the daily need for Mn, Fe, P, Cu, Mg, Zn, K, and Ca, respectively.

Most of the pasta products commercially produced in the United States are enriched, which means that iron and three B vitamins are added during production. Pasta products are also a good source of many naturally occurring minerals, but because cooking water is routinely discarded after use, minerals can be lost. In a related study reported earlier (Ranhotra et al 1982), significant losses were observed for potassium only. Only one brand of three popular pasta products (spaghetti, egg noodles, and macaroni) obtained from four major U.S. cities was analyzed in that study. To improve the sampling procedure and thus, the validity of the findings, we recently obtained four popular brands of the same three pasta products from four different U.S. cities; the popular brands from each city were not necessarily the same. The extent of retention, following cooking, of nine nutritionally significant minerals in these products was assessed. The four brands from Chicago were analyzed separately to estimate brand-to-brand variations. For the other cities, the four brands were composited into one sample for an estimate of variation among cities.

## MATERIALS AND METHODS

### Products and Cooking

During fall 1982, four popular brands each of spaghetti, egg noodles, and macaroni were obtained from Chicago, IL, Dallas, TX, Los Angeles, CA, and Washington, DC. All products were stored frozen in the original packages. At suitable intervals, all packages of a brand were mixed and a portion cooked and freeze-dried. The pasta was cooked in stainless steel cookware, using distilled deionized water. Package instructions were followed, except no salt or fat was added. The cooked products were drained, weighed, and freeze-dried in stainless steel trays. For each brand, part of the dry product was also freeze-dried. All freeze-dried products were weighed, thoroughly mixed, finely ground using a Waring blender with a glass container and stainless steel blades, bagged, and stored frozen in the dark.

### Compositing

All brands of a finely ground product from Dallas, Los Angeles, and Washington were composited (equal dry matter basis) before being analyzed. All brands from Chicago were analyzed separately.

### Analytical

Mineral elements were determined in both cooked and dry products. Total phosphorus was determined colorimetrically (AACC 1979). The other minerals were determined by atomic

absorption or flame emission (Na and K) spectrophotometry, using an IL model 251 spectrophotometer (Allied Analytical Systems, Andover, MA). Calcium and magnesium were determined on dry ash filtrates. Other minerals were determined, using filtrates obtained by wet (HNO<sub>3</sub>/HClO<sub>4</sub>) ashing. The National Bureau of Standards wheat flour was analyzed to verify the validity of the procedures; the percentage of recovery of each element varied less than 5% from the stated values.

### True Mineral Retention

True mineral retention (TMR) in cooked products was calculated by the method of Murphy et al (1975), as follows:

$$\text{TMR (\%)} = \frac{\text{Mineral content per g of cooked pasta} \times \text{g of pasta after cooking}}{\text{Mineral content per g of dry pasta} \times \text{g of pasta before cooking}} \times 100.$$

## RESULTS AND DISCUSSION

All pasta products tested were made with enriched semolina. According to the product labels, ferrous sulfate was the preferred source of enrichment iron. Table I shows the content of minerals, including iron, in the products as purchased. Moisture in products as purchased (all cities) averaged 11.6% for spaghetti, 12.4% for noodles, and 11.5% for macaroni. In cooked products, moisture levels averaged 66.1% for spaghetti, 70.9% for noodles, and 67.6% for macaroni. These moisture values were used with loss of solids during cooking to calculate nutrition information per serving of pasta.

All brands of the test products met U.S. enrichment standards for iron (2.86-3.63 mg/100 g). Because noodles from Dallas surpassed the upper limit of iron enrichment (Table I), average all-cities iron values for noodles exceeded the average iron values for Chicago products. For spaghetti and macaroni products, such differences were minimal. Most of the iron in the test products was well retained following cooking; the percentage of retention averaged a minimum of 86% (Table II). Several individual brands from Chicago retained higher levels of iron. Earlier, we reported (Ranhotra et al 1982) that "apparent" iron retentions exceeded 100%. This may be because apparent retentions, which do not consider loss of solids during cooking, often tend to give falsely high values (Murphy et al 1975).

Because the optional ingredient, calcium, was not a part of enrichment, calcium content of the pasta products was quite modest (Table I). Virtually all of this calcium was retained in the cooked products (Table II). The retention of phosphorus following cooking was somewhat lower than that of calcium, but the average (all cities) retention values still exceed the 80% level. Very little difference was detected in the content of phosphorus (Table I) from brand-to-brand (Chicago averages) or city-to-city (all-cities averages). A "light" spaghetti and a light macaroni product from Chicago, which were exceptionally high in phosphorus (spaghetti,

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**TABLE I**  
**The Content of Selected Minerals in Dry Pasta Products (As-Purchased) from Major U.S. Cities<sup>a</sup>**

| Mineral    | Product   | Content (mg/100 g) |             |            |                      |                         |
|------------|-----------|--------------------|-------------|------------|----------------------|-------------------------|
|            |           | Dallas             | Los Angeles | Washington | Chicago <sup>b</sup> | All Cities <sup>b</sup> |
| Iron       | Spaghetti | 4.62               | 4.18        | 3.96       | 4.46 ± 0.51          | 4.37 ± 0.42             |
|            | Noodles   | 7.81               | 3.95        | 4.40       | 3.82 ± 0.60          | 4.49 ± 1.54             |
|            | Macaroni  | 4.94               | 3.62        | 3.67       | 4.12 ± 0.97          | 4.10 ± 0.81             |
| Calcium    | Spaghetti | 17.7               | 23.2        | 15.5       | 16.1 ± 1.7           | 17.2 ± 3.0              |
|            | Noodles   | 24.6               | 32.7        | 23.3       | 25.7 ± 1.7           | 26.2 ± 3.2              |
|            | Macaroni  | 15.2               | 21.4        | 14.1       | 16.5 ± 1.6           | 16.6 ± 2.6              |
| Phosphorus | Spaghetti | 171                | 159         | 151        | 160 ± 12             | 160 ± 10                |
|            | Noodles   | 219                | 177         | 221        | 217 ± 17             | 212 ± 20                |
|            | Macaroni  | 158                | 146         | 150        | 157 ± 4              | 154 ± 5                 |
| Magnesium  | Spaghetti | 50.1               | 44.4        | 45.6       | 45.5 ± 3.1           | 46.0 ± 2.9              |
|            | Noodles   | 55.4               | 46.7        | 59.6       | 59.7 ± 11.6          | 57.2 ± 9.6              |
|            | Macaroni  | 45.0               | 42.5        | 43.5       | 45.1 ± 2.0           | 44.5 ± 1.7              |
| Zinc       | Spaghetti | 1.50               | 1.27        | 1.11       | 1.14 ± 0.09          | 1.21 ± 0.15             |
|            | Noodles   | 1.83               | 1.45        | 1.62       | 1.57 ± 0.17          | 1.60 ± 0.17             |
|            | Macaroni  | 1.27               | 1.22        | 1.08       | 1.14 ± 0.05          | 1.16 ± 0.07             |
| Copper     | Spaghetti | 0.37               | 0.34        | 0.20       | 0.29 ± 0.06          | 0.30 ± 0.07             |
|            | Noodles   | 0.33               | 0.30        | 0.24       | 0.32 ± 0.03          | 0.31 ± 0.04             |
|            | Macaroni  | 0.30               | 0.32        | 0.27       | 0.27 ± 0.04          | 0.28 ± 0.04             |
| Manganese  | Spaghetti | 0.89               | 0.76        | 0.64       | 0.74 ± 0.11          | 0.75 ± 0.10             |
|            | Noodles   | 0.82               | 0.74        | 0.75       | 0.78 ± 0.11          | 0.77 ± 0.08             |
|            | Macaroni  | 0.74               | 0.69        | 0.61       | 0.68 ± 0.07          | 0.68 ± 0.06             |
| Sodium     | Spaghetti | 3.3                | 2.1         | 0.9        | 1.9 ± 0.2            | 2.0 ± 0.8               |
|            | Noodles   | 24.8               | 15.3        | 17.0       | 24.2 ± 8.7           | 21.6 ± 7.0              |
|            | Macaroni  | 2.0                | 1.8         | 1.0        | 1.5 ± 1.0            | 1.6 ± 0.7               |
| Potassium  | Spaghetti | 189                | 188         | 179        | 202 ± 17             | 195 ± 15                |
|            | Noodles   | 217                | 201         | 220        | 233 ± 26             | 224 ± 22                |
|            | Macaroni  | 184                | 187         | 187        | 193 ± 9              | 190 ± 7                 |

<sup>a</sup> All brands of a product from each city other than Chicago were composited. All brands from Chicago were analyzed individually.

<sup>b</sup> Average of four (Chicago) or seven (all-cities) values ± standard deviation. Averages for phosphorus and sodium do not include the "light" spaghetti and macaroni brands from Chicago, which had excessively high levels of these elements.

**TABLE II**  
**The Retention of Selected Minerals in Cooked Pasta Products**

| Mineral    | Product   | Retention (%) |             |            |                      |                         |
|------------|-----------|---------------|-------------|------------|----------------------|-------------------------|
|            |           | Dallas        | Los Angeles | Washington | Chicago <sup>a</sup> | All Cities <sup>a</sup> |
| Iron       | Spaghetti | 73            | 85          | 62         | 95 ± 20              | 86 ± 19                 |
|            | Noodles   | 78            | 96          | 99         | 90 ± 11              | 90 ± 10                 |
|            | Macaroni  | 119           | 96          | 95         | 87 ± 19              | 94 ± 18                 |
| Calcium    | Spaghetti | 89            | 93          | 94         | 97 ± 19              | 95 ± 14                 |
|            | Noodles   | 114           | 88          | 105        | 101 ± 19             | 102 ± 15                |
|            | Macaroni  | 111           | 105         | 100        | 96 ± 14              | 100 ± 11                |
| Phosphorus | Spaghetti | 88            | 85          | 89         | 75 ± 4               | 81 ± 7                  |
|            | Noodles   | 92            | 92          | 88         | 85 ± 3               | 87 ± 4                  |
|            | Macaroni  | 86            | 90          | 87         | 75 ± 12              | 82 ± 10                 |
| Magnesium  | Spaghetti | 89            | 91          | 88         | 86 ± 15              | 88 ± 11                 |
|            | Noodles   | 96            | 93          | 93         | 88 ± 6               | 90 ± 5                  |
|            | Macaroni  | 90            | 92          | 89         | 87 ± 14              | 88 ± 10                 |
| Zinc       | Spaghetti | 96            | 103         | 96         | 95 ± 12              | 96 ± 9                  |
|            | Noodles   | 97            | 97          | 99         | 92 ± 6               | 94 ± 5                  |
|            | Macaroni  | 95            | 98          | 95         | 96 ± 12              | 96 ± 9                  |
| Copper     | Spaghetti | 83            | 96          | 94         | 101 ± 17             | 97 ± 14                 |
|            | Noodles   | 100           | 103         | 106        | 77 ± 8               | 88 ± 15                 |
|            | Macaroni  | 96            | 95          | 85         | 109 ± 28             | 102 ± 22                |
| Manganese  | Spaghetti | 93            | 95          | 95         | 95 ± 18              | 95 ± 13                 |
|            | Noodles   | 105           | 99          | 94         | 86 ± 5               | 92 ± 8                  |
|            | Macaroni  | 96            | 95          | 101        | 100 ± 13             | 99 ± 9                  |
| Sodium     | Spaghetti | 7             | 22          | 23         | 89 ± 31              | 53 ± 44                 |
|            | Noodles   | 29            | 31          | 36         | 36 ± 1               | 34 ± 4                  |
|            | Macaroni  | 56            | 52          | 26         | 49 ± 21              | 47 ± 17                 |
| Potassium  | Spaghetti | 42            | 36          | 47         | 37 ± 7               | 39 ± 7                  |
|            | Noodles   | 30            | 25          | 33         | 39 ± 4               | 35 ± 6                  |
|            | Macaroni  | 50            | 40          | 40         | 31 ± 10              | 36 ± 10                 |

<sup>a</sup> Average of four (Chicago) or seven (all-cities) values ± standard deviation.

**TABLE III**  
**Nutrition Information Per Serving of Cooked Pasta<sup>a</sup>**

| Mineral    | Amount <sup>b</sup><br>(mg/10 oz) | Percentage of |                          |
|------------|-----------------------------------|---------------|--------------------------|
|            |                                   | US-RDA        | Safe Intake <sup>c</sup> |
| Iron       | 4.34                              | 24            | ...                      |
| Calcium    | 22                                | 2             | ...                      |
| Phosphorus | 162                               | 16            | ...                      |
| Magnesium  | 48.9                              | 12            | ...                      |
| Zinc       | 1.4                               | 9             | ...                      |
| Copper     | 0.32                              | 16            | ...                      |
| Manganese  | 0.77                              | ...           | 31                       |
| Sodium     | 4                                 | ...           | 0.4                      |
| Potassium  | 84                                | ...           | 4.5                      |

<sup>a</sup>One serving equals 10 oz (285 g), with average moisture content of 68.2%.

<sup>b</sup>Calculated based on all-cities averages of three pasta products (Table I), retention values (Table II), and yield (2.54-fold increase) on cooking.

<sup>c</sup>Lower limits (Food and Nutrition Board 1980).

374 mg/100 g; and macaroni, 302 mg/100 g) and sodium (spaghetti, 422 mg/100 g; macaroni, 267 mg/100 g) content, were excluded from the average values for phosphorus and sodium. Brand-to-brand and city-to-city differences in magnesium content of the three pasta products were minimal (Table I). However, noodles, as with calcium, tended to be somewhat higher in magnesium than the other two pasta products. The average retention of magnesium following cooking reached or approached the 90% level (Table II).

Brand-to-brand differences in the content of trace elements (zinc, copper, and manganese) in test products were quite small (Table I). All three elements, zinc in particular, tended to be higher in noodles than in spaghetti and macaroni. Very little loss of these elements occurred during cooking (Table II).

Spaghetti and macaroni products did not contain much sodium, but noodles had some (Table I). Although retention values were also calculated for sodium, their nutritional significance is inconsequential considering the very low content in the products

purchased. The content of potassium averaged (all cities) 195, 224, and 190 mg/100 g for spaghetti, noodles, and macaroni products, respectively. These are substantive amounts. However, as found earlier (Ranhotra et al 1982), less than 40% of this potassium was retained in the cooked products (Table II).

Based on the amounts present (Table I) and retained (Table II), information was calculated to assess the contribution of a 10-oz serving of cooked pasta to meet the daily need for the minerals determined. This need was expressed as U.S.-RDA (National Nutrition Consortium 1975) or as safe intakes (Food and Nutrition Board 1980). Such calculations reveal (Table III) that pasta products are an excellent source of iron, manganese, phosphorus, copper, zinc, and magnesium. They also provide some potassium and calcium but virtually no sodium if salt is not added during cooking. Several other mineral elements not analyzed in this study may also be provided by pasta products.

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