Contents and Retentions of Sodium and Other Minerals in Pasta Cooked in Unsalted or Salted Water[1]

J. A. ALBRECHT,[2] E. H. ASP,[2] and I. M. BUZZARD[3]

ABSTRACT

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Elbow macaroni, egg noodle, and spaghetti samples were cooked in unsalted or salted tap water without rinsing or in salted tap water followed by rinsing with unsalted tap water. Additional samples of elbow macaroni were cooked in distilled water by the same three methods. Uncooked and cooked pasta samples were analyzed for sodium and eight other minerals (P, K, Ca, Mg, Fe, Mn, Zn, Cu) by inductively coupled plasma-atomic emission spectroscopy. The sodium content of elbow macaroni, egg noodles, and spaghetti cooked in unsalted tap water averaged 1.1, 3.9, and 0.9 mg/100 g, respectively. Cooking these products in salted tap water increased average sodium contents to 176.6, 191.9, and 107.4 mg/100 g, respectively. Rinsing pastas cooked in salted water decreased sodium content by approximately 30%. Elbow macaroni cooked in unsalted and salted tap water contained more calcium than that cooked in distilled water; other minerals were not affected by type of water and addition of salt.

The current popularity and rapidly increasing consumption of pasta products emphasize the need for more information about their nutrient content after cooking by methods consumers would use in the home. Per capita pasta consumption increased 124% (from 5.5 to 12.3 lb per person per year) between 1964 and 1984 and is still rising (USDA 1985). Pasta also is appearing more frequently on food intake reports by participants in dietary studies.

Contents of sodium and other minerals (P, K, Ca, Mg, Fe, Mn, Zn, Cu) in macaroni, noodles, and spaghetti cooked according to package directions in unsalted, distilled deionized water were reported by Ranhotra et al (1984, 1985). Sodium contents averaged 1.6, 21.6, and 2.0 mg/100 g for uncooked and 0.3, 1.0, and 0.4 mg/100 g for cooked macaroni, noodles, and spaghetti, respectively. Consumers cooking pasta according to package directions, however, are directed to add a recommended amount of salt to tap water if desired, cook until tender, and may be directed to rinse the cooked pasta in hot or cold water. One study reporting sodium contents of pasta cooked in salted water found 64 and 318 mg/100 g sodium in spaghetti and linguine, respectively (Anonymous 1979). Rinsing these cooked pastas decreased their sodium contents by approximately 50%. Interpretation of these values is difficult, however, because cooking, rinsing, and analytical methods were not described. Mineral contents (K, P, Mg, Ca, Zn, Fe, Mn, Cu, Mo) of two spaghetti products made from Italian wheat and cooked for different lengths of time were reported by Abdel-Rahman (1982). Mineral losses (K, P, Mg, Ca) from the spaghetti increased as cooking time increased. Trace element losses (Zn, Fe, Mn, Cu, Mo) occurred during the first 10 min of cooking but stabilized and appeared unaffected by longer cooking times. No information was given about the water used for cooking or the addition of salt to the cooking water.

Effects of the minerals in tap water on the mineral content of cooked pasta are not known. For vegetables cooked in tap water, Marston et al (1974) found that calcium and magnesium contents were higher when vegetables were cooked in tap water than when cooked in distilled water.

This study was initiated because analytical data for sodium and other minerals in pasta cooked in salted water were needed for the food composition table maintained by the Nutrition Coordinating Center at the University of Minnesota. This table is used for calculating the nutrient content of dietary intakes for subjects in diet-disease related studies. The purpose of this study was to determine contents and retentions of sodium and eight other minerals (P, K, Ca, Mg, Fe, Mn, Zn, Cu) in elbow macaroni, egg noodles, and spaghetti cooked in unsalted or salted tap water without rinsing or cooked in salted tap water followed by rinsing. Elbow macaroni also was cooked in distilled water to compare the effect of type of water on mineral contents and retentions.

MATERIALS AND METHODS

Pasta Products

Three brands of enriched elbow macaroni, egg noodles, and spaghetti were purchased from three local retail food stores during December, 1984. For each type of pasta, equal quantities from each of the three packages of each brand were mixed and stored in plastic containers at room temperature until cooked.

Cooking Treatments

Pasta samples were removed from storage, weighed, and analyzed either uncooked or after being cooked in unsalted or salted (sodium chloride, Analytical Reagent, Mallinckrodt, Inc.) St. Paul, MN, tap water without rinsing, or in salted tap water, followed by rinsing with cold tap water (one-half the amount of water used for cooking). To compare effects of water type, macaroni was cooked in distilled water by the same three cooking treatments. Mineral contents of the salt and water used are presented in Table I. Three replications of each cooking treatment were completed for each brand of each type of pasta. The proportions of ingredients used to cook the pasta (Table II) were derived from the package cooking directions. The unsalted or salted water was brought to a boil in a 1,420 ml (1½-quart)

TABLE I
Mineral Contents of Salt and Water (ppm)

Mineral	Salt	Water[a]	
		St. Paul Tap	Distilled
Sodium	393,171.00	10.31 a	0.34 b
Phosphorus	2,280.00	0.59 a	0.27 a
Potassium	3,110.00	2.53 a	0.39 b
Calcium	480.00	22.52 a	0.48 b
Magnesium	330.00	6.09 a	0.07 b
Iron	5,112.90	0.04 a	0.01 a
Manganese	64.38	0.02 a	0.01 a
Zinc	108.66	0.11 a	0.02 b
Copper	70.00	0.13 a	0.01 b

[a] Values for water not followed by the same letter are significantly different at the 1% level.

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[2] Department of Food Science and Nutrition, University of Minnesota, 1334 Eckles Avenue, St. Paul 55108.

[3] Nutrition Coordinating Center, University of Minnesota, Suite 526, 2829 University Avenue S.E., Minneapolis 55414.

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aluminum saucepan, the pasta was added, the pan was covered, and the cooking time was started immediately. Each sample was cooked 8 min and drained 2 min in a strainer placed over a beaker. For the rinsing treatment, cold water was poured evenly over the drained pasta in the strainer, and the pasta was drained an additional 2 min. Each cooked pasta sample was weighed immediately after being drained.

Analytical

The moisture content of representative samples of uncooked and cooked elbow macaroni, egg noodles, and spaghetti was determined using AACC method 44-15A (AACC 1983). Pasta samples for mineral analysis were dried and ground to a number 20 sieve size. One gram of each ground sample was ashed at 485° C for 10 hr. The ash was dispersed in 10 ml of 2*N* HCl and mineral analysis was performed according to AOAC method 49.004 (AOAC 1980) as modified by Dahlquist and Knoll (1978), Munter and Grande (1981), and Munter et al (1984). Samples of uncooked and cooked pasta, salt, and tap and distilled waters were analyzed for Na, P, K, Ca, Mg, Fe, Mn, Zn, and Cu using an inductively coupled plasma-atomic emission spectrometer (ICP-AES) model QA 137 (Applied Research Laboratory).

True Mineral Retention

Mineral retention in the cooked pasta products was calculated using the formula for true mineral retention (TMR) reported by Murphy and co-workers (1975).

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

Statistical Analysis

Analysis of variance was used to compare mean mineral contents for each cooking treatment for elbow macaroni, egg noodles, or spaghetti. Duncan's multiple range test was used to rank cooking treatment means for each type of pasta (SAS 1982).

RESULTS AND DISCUSSION

The mineral contents of pasta before and after cooking in unsalted or salted tap water are presented in Table III. Contents of sodium, calcium, iron, manganese, and copper in the three cooked pastas were within the ranges reported by Ranhotra et al (1982, 1984, 1985) and Douglass and Matthews (1982). Also within these ranges were the contents of phosphorus in uncooked egg noodles and spaghetti, and magnesium and zinc in uncooked egg noodles. Mineral contents higher than those previously reported were potassium in all the uncooked pastas, magnesium and zinc in macaroni and spaghetti, and phosphorus in macaroni. Brand differences contributed to the variation in mineral contents in the uncooked pastas in the present study.

The cooking treatments differed in their effects on the mineral contents of the three pastas studied. Sodium contents of all pastas were vastly increased when salt was added to the cooking water (Table III). Rinsing after cooking decreased the sodium content of macaroni by 31% and of egg noodles and spaghetti by 28%. Although St. Paul tap water contained more sodium, potassium, calcium, magnesium, zinc, and copper ($P < 0.01$) than distilled water (Table I), only the sodium and calcium contents were higher ($P < 0.01$) in elbow macaroni samples cooked in unsalted tap water than those cooked in unsalted distilled water (Tables III and IV). However, sodium contents were very low in macaroni cooked in

TABLE II
Proportions of Ingredients for Cooking Pasta

Pasta Type	Amount		
	Dry Pasta[a] (g)	Water (ml)	Salt[b] (g)
Macaroni	65	473	2.8
Egg noodles	38	317	1.8
Spaghetti	71	592	2.6

[a] Based on 130, 38, and 71 g per cup of macaroni, egg noodles, and spaghetti, respectively (USDA 1977).
[b] Based on 5.5 g per teaspoon (Adams 1975).

TABLE III
Mineral Contents (mg/100g) of Uncooked and Cooked Pasta[a]

Mineral	Pasta Type	Uncooked	Cooking Treatment[b]		
			Unsalted Tap Water	Salted Tap Water	Salted Tap Water and Rinsed
Sodium	Macaroni	1.6 ± 0.9	1.1 ± 0.2 b	176.6 ± 10.6 c	121.3 ± 6.3 d
	Egg noodles	23.1 ± 11.3	3.8 ± 1.4 b	191.9 ± 14.3 c	138.1 ± 9.7 d
	Spaghetti	1.8 ± 0.7	0.9 ± 0.1 b	107.4 ± 3.3 c	77.1 ± 4.0 d
Phosphorus	Macaroni	199.0 ± 60.5	64.2 ± 23.6 b	69.5 ± 23.4 b	75.4 ± 25.1 b
	Egg noodles	201.2 ± 40.3	61.3 ± 12.7 b	84.7 ± 11.5 b	87.2 ± 12.3 b
	Spaghetti	162.9 ± 32.0	52.6 ± 18.0 b	92.3 ± 23.9 c	86.2 ± 22.6 c
Potassium	Macaroni	243.7 ± 56.3	42.1 ± 15.4 b	34.4 ± 10.7 b	26.2 ± 8.4 b
	Egg noodles	227.2 ± 23.7	33.4 ± 5.1 b	27.0 ± 3.5 b	25.3 ± 4.1 b
	Spaghetti	233.8 ± 43.4	43.5 ± 13.5 b	46.5 ± 12.9 b	39.0 ± 11.5 b
Calcium	Macaroni	19.1 ± 2.8	10.8 ± 2.1 b	10.8 ± 2.0 b	10.7 ± 2.0 b
	Egg noodles	27.2 ± 5.9	13.1 ± 1.6 b	16.3 ± 1.0 c	17.4 ± 1.4 c
	Spaghetti	16.4 ± 1.7	9.0 ± 1.8 b	13.3 ± 2.1 c	12.6 ± 2.0 c
Magnesium	Macaroni	75.5 ± 32.6	30.9 ± 15.4 b	29.9 ± 14.9 b	28.3 ± 14.3 b
	Egg noodles	56.6 ± 11.8	19.4 ± 3.9 b	24.8 ± 3.6 b	27.0 ± 3.9 b
	Spaghetti	63.2 ± 19.3	23.4 ± 10.2 b	36.0 ± 14.0 b	33.7 ± 13.2 b
Iron	Macaroni	3.7 ± 0.9	1.3 ± 0.4 b	1.7 ± 0.4 b	1.6 ± 0.4 b
	Egg noodles	3.4 ± 1.2	1.0 ± 0.2 b	2.1 ± 0.8 c	2.0 ± 0.2 c
	Spaghetti	2.8 ± 0.6	0.9 ± 0.3 b	2.1 ± 0.4 c	2.0 ± 0.4 c
Manganese	Macaroni	0.9 ± 0.3	0.4 ± 0.1 b	0.4 ± 0.1 b	0.3 ± 0.1 b
	Egg noodles	0.7 ± 0.1	0.2 ± 0.0 b	0.3 ± 0.1 c	0.4 ± 0.1 c
	Spaghetti	0.9 ± 0.1	0.3 ± 0.1 b	0.5 ± 0.1 c	0.5 ± 0.1 c
Zinc	Macaroni	1.7 ± 0.6	0.7 ± 0.3 b	0.7 ± 0.2 b	0.6 ± 0.2 b
	Egg noodles	1.6 ± 0.2	0.6 ± 0.1 b	0.7 ± 0.1 b	0.9 ± 0.2 c
	Spaghetti	1.8 ± 0.4	0.7 ± 0.2 b	1.0 ± 0.3 b	1.0 ± 0.3 b
Copper	Macaroni	0.2 ± 0.1	0.0 ± 0.0 b	0.2 ± 0.0 c	0.2 ± 0.0 c
	Egg noodles	0.3 ± 0.2	0.0 ± 0.0 b	0.2 ± 0.0 c	0.2 ± 0.0 c
	Spaghetti	0.1 ± 0.1	0.0 ± 0.0 b	0.2 ± 0.0 c	0.2 ± 0.0 c

[a] Values are means and standard deviations for three replications of three brands.
[b] Within each pasta type for each mineral, cooking treatment values not followed by the same letter are significantly different at the 1% level.

both types of water. When elbow macaroni was cooked in salted water, type of water had no effect on its sodium content (Tables III and IV).

Moisture contents in the uncooked and cooked pastas in this study (Table V) were lower than those reported by Ranhotra et al (1984, 1985) or in Agriculture Handbook 456 (Adams 1975). The increase in moisture from the uncooked to the cooked pasta, however, was within two to four percentage points of the reported values for each pasta type; therefore, extent of cooking was comparable to that in the other studies.

Contents of the other eight minerals in these cooked pasta products (Table III) showed that six of the eight were not affected by addition of salt to the cooking water or by rinsing. Of the minerals affected, all were higher ($P < 0.01$) in samples cooked in salted than in unsalted tap water. These included copper in all three pastas, calcium, iron, and manganese in egg noodles and spaghetti, zinc in rinsed egg noodles, and phosphorus in spaghetti. All mineral contents except magnesium in the three pastas cooked in unsalted tap water were within the ranges reported by Ranhotra et al (1982, 1984, 1985) for the same types of pasta cooked in distilled deionized water. Magnesium contents were higher than the previously reported values.

Contents of the other eight minerals in macaroni cooked in tap or distilled water by the three cooking treatments showed that only calcium content was affected by the type of water used for cooking (Tables III and IV). Calcium contents of macaroni samples cooked in tap water were higher ($P < 0.01$) than those cooked in distilled water. Cooking macaroni in tap water, therefore, had an effect on the calcium content that was similar to that found by Marston et al (1974) for vegetables cooked in tap water. Calcium content of the salt (Table I) did not appear to affect calcium uptake by the macaroni, because for each water type, calcium content of macaroni samples cooked by the salted water treatments did not differ ($P > 0.01$) from those cooked in the corresponding unsalted water (Tables III and IV).

Retentions of the minerals in cooked elbow macaroni, egg noodles, and spaghetti (Tables VI and VII) varied with the type of pasta, type of cooking water, and whether or not salt was added to the cooking water. Retentions greater than 100% indicated that sodium was absorbed by macaroni and spaghetti, and calcium was absorbed by all the pastas when they were cooked in unsalted tap water. When egg noodles and spaghetti were cooked in salted tap water, retentions indicated that all the minerals except potassium were absorbed. Macaroni absorbed only iron and copper from salted tap water and iron, zinc, and copper from salted distilled water (Table VII).

Mineral retentions in pasta cooked in unsalted tap water (Table VI) were within the ranges reported by Ranhotra et al (1982, 1985) for potassium, magnesium, and manganese in all pastas and phosphorus and iron in macaroni and spaghetti; they were lower than the ranges reported for copper in all pastas, phosphorus and iron in egg noodles, and zinc in spaghetti, and higher than the ranges reported for sodium and calcium. When macaroni was cooked in unsalted distilled water (Table VII), retentions were within the values previously reported for all minerals except iron, manganese, and copper. Retentions for these minerals were lower than the reported values.

TABLE IV
Mineral Content (mg/100 g) of Macaroni Cooked in Distilled Water[a]

Mineral	Cooking Treatment[b]		
	Unsalted	Salted	Salted and Rinsed
Sodium	0.3 ± 0.2 b[c]	174.9 ± 13.4 c	122.3 ± 15.6 d
Phosphorus	67.4 ± 29.6 b	78.4 ± 24.2 b	77.5 ± 24.5 b
Potassium	43.0 ± 15.6 b	38.5 ± 10.9 b	28.7 ± 8.1 b
Calcium	7.2 ± 1.8 b[c]	8.1 ± 1.4 b[c]	7.8 ± 1.4 b[c]
Magnesium	27.5 ± 15.4 b	29.3 ± 13.9 b	28.6 ± 14.1 b
Iron	0.9 ± 0.3 b	1.8 ± 0.4 c	1.7 ± 0.4 c
Manganese	0.3 ± 0.1 b	0.4 ± 0.1 b	0.4 ± 0.1 b
Zinc	0.6 ± 0.3 b	0.7 ± 0.2 b	0.7 ± 0.2 b
Copper	0.0 ± 0.0 b	0.2 ± 0.0 c	0.2 ± 0.0 c

[a] Values are means and standard deviations for three replications of three brands.
[b] Values not followed by the same letter are significantly different at the 1% level.
[c] Values significantly different at the 1% level from those for macaroni cooked in tap water by the same treatments (Table II).

TABLE V
Moisture Content of Uncooked and Cooked Pasta (%)[a]

Pasta Type	Uncooked	Unsalted	Salted	Salted and Rinsed
		Cooked in Tap Water		
Macaroni	8.2 ± 0.2	63.3 ± 0.4	62.4 ± 2.0	64.0 ± 1.6
Egg noodles	8.7 ± 0.1	64.3 ± 2.4	63.7 ± 2.2	65.4 ± 2.4
Spaghetti	9.0 ± 0.6	60.3 ± 1.4	59.2 ± 1.0	61.8 ± 1.6
		Cooked in Distilled Water		
Macaroni	8.2 ± 0.2	62.1 ± 1.6	61.3 ± 2.2	63.1 ± 1.8

[a] Values are means and standard deviations for three replications of three brands.

TABLE VI
Mineral Retention in Pasta Cooked in Tap Water

Mineral	Pasta Type	Retention (%)[a]		
		Unsalted	Salted	Salted and Rinsed
Sodium	Macaroni	161	26,120	18,634
	Egg noodles	41	2,050	1,535
	Spaghetti	115	12,978	9,673
Phosphorus	Macaroni	77	84	95
	Egg noodles	74	104	111
	Spaghetti	71	124	121
Potassium	Macaroni	41	34	27
	Egg noodles	36	29	29
	Spaghetti	41	44	38
Calcium	Macaroni	135	137	140
	Egg noodles	118	148	165
	Spaghetti	122	178	175
Magnesium	Macaroni	99	95	94
	Egg noodles	84	108	123
	Spaghetti	82	125	121
Iron	Macaroni	84	113	109
	Egg noodles	69	153	154
	Spaghetti	68	160	159
Manganese	Macaroni	92	91	89
	Egg noodles	84	111	141
	Spaghetti	85	134	131
Zinc	Macaroni	93	93	95
	Egg noodles	86	105	145
	Spaghetti	81	126	122
Copper	Macaroni	12	193	200
	Egg noodles	18	150	180
	Spaghetti	16	330	390

[a] Based on the true mineral retention formula of Murphy and co-workers (1975).

TABLE VII
Mineral Retention in Macaroni Cooked in Distilled Water[a]

Mineral	Retention (%)		
	Unsalted	Salted	Salted and Rinsed
Sodium	48	25,052	18,436
Phosphorus	80	92	96
Potassium	42	37	29
Calcium	89	99	100
Magnesium	86	91	93
Iron	56	116	115
Manganese	81	96	95
Zinc	87	100	101
Copper	12	198	197

[a] Based on the true mineral retention formula of Murphy and co-workers (1975).

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