Mineral Concentrations in Bottled Water Products: Implications for Canadians' Mineral Intakes

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ABSTRACT

Purpose: The popularity of bottled water products (BWPs) is growing in Canada. Concentrations of minerals with important implications for health were compared in different types of BWPs.

Methods: One sample of each brand and type of plain BWP (purified, remineralized, spring, mineral, and artesian), flavoured BWP, and nutrient-enriched BWP sold in major stores in Ottawa, Ontario, was purchased to allow determination of mineral concentrations by flame atomic absorption or emission spectroscopy. A total of 124 BWPs representing 37 brands were analyzed.

Results: In general, spring and mineral water contained higher amounts of magnesium and calcium than did purified, remineralized, artesian, flavoured, or nutrient-enriched water. Most plain BWPs contained little sodium and potassium, whereas 15% to 35% of flavoured and nutrient-enriched products had considerably higher concentrations. Only magnesium and calcium concentrations were highly correlated ($r=0.76$, $p<0.001$). Calculation of the percentage of Dietary Reference Intakes that could be supplied by each product revealed that, if they are consumed habitually, many products can contribute substantially to recommended intakes of these minerals.

Conclusions: Mineral concentrations in most types of BWP varied, but distinct differences between types of products were identified. Consumers should be aware of the mineral content of BWPs because some could influence intakes of certain minerals significantly.

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RÉSUMÉ

Objectif. La popularité des produits d'eau embouteillée (PEE) ne cesse de croître au Canada. Les concentrations de minéraux ayant des répercussions importantes sur la santé ont été comparées dans différents types de PEE.

Méthodes. Un échantillon de chaque marque et type de PEE ordinaires (eau purifiée, reminéralisée, de source, minérale et artésienne), de PEE aromatisés et de PEE enrichis en nutriments vendus dans les grands magasins à Ottawa, en Ontario, a été acheté afin de déterminer les concentrations en minéraux au moyen d'une spectrométrie d'absorption atomique par la flamme ou d'une spectrométrie d'émission atomique. Un total de 124 PEE représentant 37 marques ont été analysés.

Résultats. En général, l'eau de source et l'eau minérale contenaient des quantités plus importantes de magnésium et de calcium que l'eau purifiée, reminéralisée, artésienne, aromatisée ou enrichie en nutriments. La plupart des PEE ordinaires contenaient peu de sodium et de potassium, alors que 15 à 35 % des produits aromatisés et enrichis en nutriments comportaient des concentrations considérablement plus élevées. Seules les concentrations de magnésium et de calcium étaient fortement corrélées ($r = 0,76$; $p < 0,001$). Le calcul du pourcentage de l'apport nutritionnel de référence qui pouvait être fourni par chacun des produits a révélé que, s'ils sont consommés de manière habituelle, de nombreux produits peuvent contribuer de façon considérable aux apports recommandés de ces minéraux.

Conclusions. Les concentrations en minéraux dans la majorité des PEE variaient, mais des différences distinctes entre les types de produits ont été identifiées. Les consommateurs devraient être conscients de la teneur en minéraux des PEE, car certains d'entre eux pourraient grandement influencer leurs apports en certains minéraux.

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INTRODUCTION

Consumption of bottled water products (BWPs) is increasing in Canada (1,2). Statistics Canada has reported that 30% of Canadian households drank predominantly bottled water in 2007 (3). Surveys in Ontario have shown that 27% to 34% of the respondents consumed primarily (more than 75%) bottled water (4,5).

Various types of plain BWP are available, including purified, remineralized, spring, mineral, and artesian water (6). Flavoured and nutrient-enriched BWPs are relatively new products that

constitute a significant fraction of the market. Some minerals are present in substantial amounts in various BWPs (7-9), and therefore regular consumption of these products can increase mineral intakes.

PURPOSE

Concentrations of mineral nutrients with important implications for health were compared in different types of BWPs.

METHODS

Sample collection

One bottle (including large carboys) of each brand and kind of BWP sold in Ottawa stores was purchased from November 5 to 30, 2010. Bottled water products were purchased from a list of major chain stores/supermarkets (n=9) and convenience stores (n=2). Three BWPs were purchased from a bottled water distributor and one product was purchased from a cafeteria. In total, 124 different BWPs were collected, representing 37 different brands.

Products were categorized according to the descriptions written on the bottle labels. Plain BWPs (i.e., without flavouring or added vitamins and other nutrients) that underwent a purification process were categorized as purified water. Purified BWPs that simply stated "remineralized water" or "minerals added" were considered remineralized water. Plain BWPs labelled as spring, mineral, or artesian water were put in these categories. Regardless of type (purified, spring, or mineral), BWPs indicating any flavouring were categorized as flavoured water. Bottled water products indicating nutrient enrichment with vitamins and other nutrients were considered nutrient-enriched water.

Table 1
Mineral concentrations in bottled water products

Water type	n[a]	Mg (mg/L)	Ca (mg/L)	Na (mg/L)	K (mg/L)
Purified	7				
Mean ± SD		0 ± 0	0 ± 0	0 ± 0	0 ± 0
Median		0	0	0	0
Range		0-0	0-1	0-0	0-0
Remineralized	2				
Mean ± SD		3 ± 1	2 ± 3	1 ± 0	4 ± 0
Median		3	2	1	4
Range		2-3	0-4	1-1	3-4
Spring	29				
Mean ± SD		19 ± 10	61 ± 28	12 ± 14	1 ± 1
Median		22	69	6	1
Range		4-34	13-131	1-48	1-4
Mineral	6				
Mean ± SD		52 ± 37	123 ± 99	103 ± 164	8 ± 11
Median		37	89	34	2
Range		17-103	41-306	5-429	0-28
Artesian	4				
Mean ± SD		8 ± 8	10 ± 8	18 ± 15	4 ± 4
Median		7	11	13	4
Range		0-15	1-17	6-40	1-10
Flavoured	49				
Mean ± SD		2 ± 5	18 ± 39	45 ± 60	143 ± 165
Median		0	2	10	104
Range		0-20	0-147	1-242	0-522
Nutrient-enriched	27				
Mean ± SD		14 ± 20	43 ± 61	16 ± 33	139 ± 199
Median		10	27	2	42
Range		0-80	6-206	1-96	5-704
Municipal[b]	7				
Mean ± SD		16 ± 12	47 ± 27	47 ± 27	3 ± 2
Median		17	54	52	4
Range		2-35	9-77	16-80	1-6

Ca = calcium; K = potassium; Mg = magnesium; Na = sodium; SD = standard deviation

[a] Number of different bottled water products analyzed or municipal water sources
[b] Values were obtained from City of Ottawa 2009 reports (13).

Mineral analyses

Mineral concentrations were measured by flame atomic absorption spectroscopy (magnesium, calcium, and potassium) or emission spectroscopy (sodium), with a PerkinElmer AAnalyst 400 spectrometer. A matrix modifier (18 mmol/L La_2O_3, 15 mmol/L CsCl, 0.3 N HCl, final concentrations) was added to both standards and samples. All samples were analyzed in triplicate and the mean value was reported.

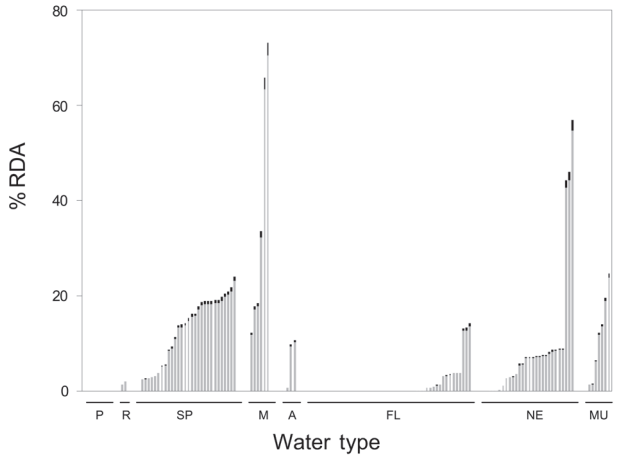
Calculations and statistical analyses

To determine the possible contribution of BWPs to recommended intakes for magnesium, calcium, sodium, and potassium, the percentage of Recommended Dietary Allowances (RDAs) or Adequate Intakes (AIs) for adults (10-12) fulfilled by each BWP was calculated, assuming a daily consumption of 2.2 L for women and 3.0 L for men. These are approximately the amounts of water ingested from all beverages, including drinking water, for adults at the 50th percentile (12). A study in Ontario showed that daily bottled water intakes at the 90th and 99th percentiles for bottled water users were 2 L and 4 L, respectively (4). Correlations between minerals were determined by linear regression. Results were reported as the range, median, and mean ± standard deviation. Data were analyzed using SigmaPlot 11.2.0 (Systat Software Inc., Chicago, IL, 2009).

RESULTS

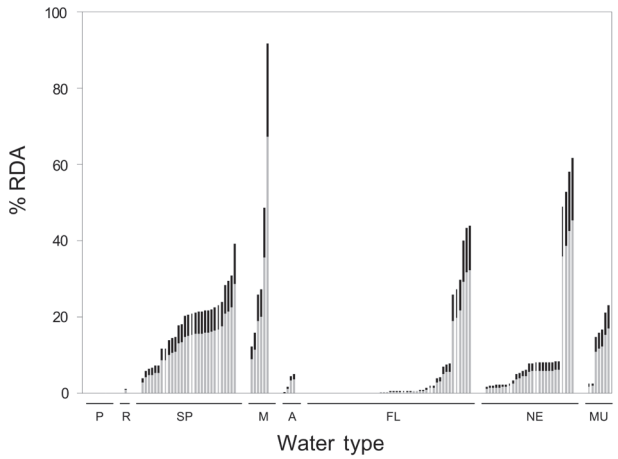
Purified and remineralized water contained very low levels of magnesium, calcium, sodium, and potassium (Table 1), and

Figure 1
Percentages of Dietary Reference Intakes for magnesium[a]



[a] Values are percentages of the Recommended Dietary Allowances (RDAs) fulfilled by bottled water products for adult women and men. The RDAs used were 320 mg a day (women) and 420 mg a day (men). Percentages of the RDA were calculated assuming consumption of 2.2 L a day (women) and 3.0 L a day (men) of the product. Each bar corresponds to one bottled water product or municipal water source and shows values for women (grey portion) and men (grey plus black portion). Values are displayed in ascending order (left to right) for each water type. Water types are purified (P), remineralized (R), spring (SP), mineral (M), artesian (A), flavoured (FL), nutrient-enriched (NE), and municipal (MU).

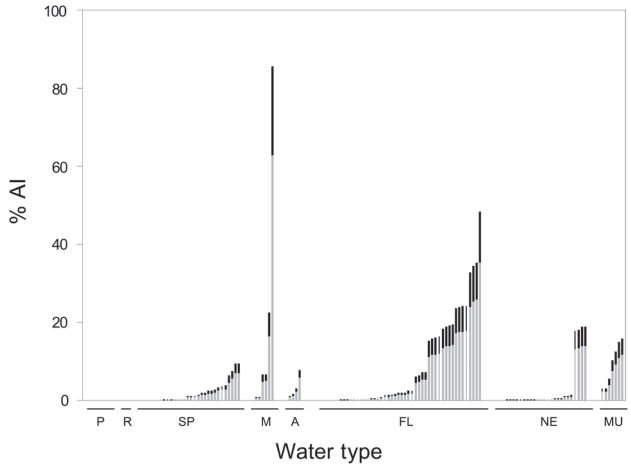
Figure 2
Percentages of Dietary Reference Intakes for calcium[a]



[a] Values are percentages of the Recommended Dietary Allowance (RDA) fulfilled by bottled water products for adult women and men. The RDA used was 1000 mg a day. Percentages of the RDA were calculated assuming consumption of 2.2 L a day (women) and 3.0 L a day (men) of the product. Each bar corresponds to one bottled water product or municipal water source and shows values for women (grey portion) and men (grey plus black portion). Values are displayed in ascending order (left to right) for each water type. Water types are purified (P), remineralized (R), spring (SP), mineral (M), artesian (A), flavoured (FL), nutrient-enriched (NE), and municipal (MU).

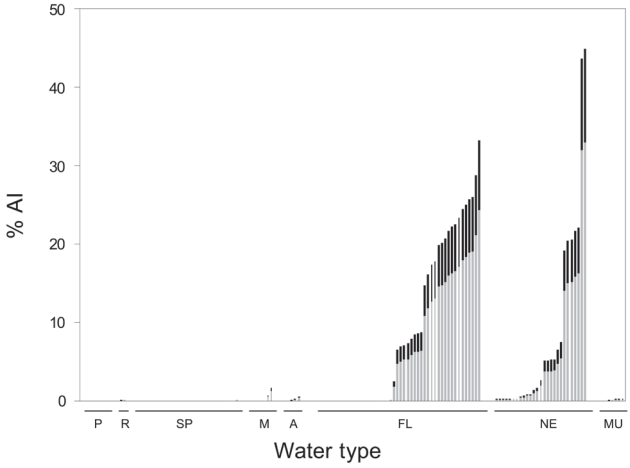
contributions to RDAs or AIs were negligible (Figures 1 to 4). Spring and mineral water had higher concentrations of magnesium and calcium than did artesian, flavoured, and nutrient-enriched water (Table 1). Percentages of RDAs for most spring and mineral BWPs were 5% to 20% for magnesium and 5% to 30% for calcium (Figures 1 and 2). Magnesium and calcium concentrations were strongly correlated in BWPs ($r=0.76$, $p<0.001$, $n=124$). Correlations between magnesium and sodium ($r=0.23$, $p<0.05$), magnesium and potassium ($r=0.24$, $p<0.01$), calcium and sodium ($r=0.00$, $p>0.05$), calcium and potassium ($r=0.23$, $p<0.05$), and sodium and potassium ($r=0.06$, $p>0.05$) were weak or insignificant.

Figure 3
Percentages of Dietary Reference Intakes for sodium[a]



[a] Values are percentages of the Adequate Intake (AI) for adult women and men. The AI used was 1500 mg a day. Percentages of the AI were calculated assuming consumption of 2.2 L a day (women) and 3.0 L a day (men) of the product. Each bar corresponds to one bottled water product or municipal water source and shows values for women (grey portion) and men (grey plus black portion). Values are displayed in ascending order (left to right) for each water type. Water types are purified (P), remineralized (R), spring (SP), mineral (M), artesian (A), flavoured (FL), nutrient-enriched (NE), and municipal (MU).

Figure 4
Percentages of Dietary Reference Intakes for potassium[a]



[a] Values are percentages of the Adequate Intake (AI) for adult women and men. The AI used was 4700 mg a day. Percentages of the AI were calculated assuming consumption of 2.2 L a day (women) and 3.0 L a day (men) of the product. Each bar corresponds to one bottled water product or municipal water source and shows values for women (grey portion) and men (grey plus black portion). Values are displayed in ascending order (left to right) for each water type. Water types are purified (P), remineralized (R), spring (SP), mineral (M), artesian (A), flavoured (FL), nutrient-enriched (NE), and municipal (MU).

Most plain BWPs had low concentrations of sodium and potassium and contributed little to recommended intakes (Figures 3 and 4). Several (15% to 35%) flavoured and nutrient-enriched products contained higher amounts. Percentages of AIs were 10% to 49% (Figures 3 and 4). Mineral concentrations for seven municipal water sources (13) were included for comparison.

DISCUSSION

Significance of mineral levels

This is the first Canadian study in which mineral concentrations in plain BWPs have been compared with those in flavoured and nutrient-enriched BWPs. As in previous reports (7-9), considerable variation was found in mineral concentrations of BWPs.

However, distinct differences between types of BWPs were identified.

Renal insufficiency can predispose individuals to hyperkalemia (14), which could result in life-threatening cardiac arrhythmia (15). Individuals susceptible to hyperkalemia need to monitor their potassium intakes and should be aware of the higher potassium content in some flavoured and nutrient-enriched BWPs. The higher potassium content in these products is a result of the addition of sweeteners and preservatives that contain potassium.

A national survey showed that more than 34% of Canadian adults had magnesium intakes below the Estimated Average Requirements, and median calcium intakes were below the new RDAs for most age groups (10,16). Individuals with diets low in magnesium and calcium, those with alcoholism (17), and those with diets high in phytic acid (18,19) or caffeine (20,21) are at increased risk for magnesium/calcium deficiency and could benefit from regular consumption of BWPs with a higher magnesium and calcium content.

The majority (78%) of Canadian adults had sodium intakes above the Tolerable Upper Intake Level (16). Individuals following a low-sodium diet should be conscious of the higher sodium concentrations in some mineral, flavoured, and nutrient-enriched BWPs.

Study limitations

A limitation is that consumption data were not used to determine the contribution of BWPs to recommended intakes. The distinct differences in mineral concentrations between types of BWPs reveal how important intake data are for determining the significance of consumers' choice of BWP for total mineral intakes. Intake data can also be used to monitor shifts in consumers' preference for certain BWPs over time and to assess potential health risks associated with changes in mineral intakes from BWPs. Also important will be determining whether differences in the mineral profile of BWPs sold in different regions of the country influence mineral intakes.

RELEVANCE TO PRACTICE

Consumers, dietitians, and other health care practitioners should be aware of the variable mineral content of BWPs. This information will be useful in educating and planning diets for individuals vulnerable to mineral imbalances.

Acknowledgements

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References

1. International Council of Bottled Water Association. Global bottled water statistics; 2004 [cited 2012 Jan 16]. Available from: http://www.icbwa.org/2000-2003_Zenith_and_Beverage_Marketing_Stats.pdf
2. The Canadian Bottled Water Industry. Canadian bottled water market—volume 2004-2006; 2009 [cited 2012 Jan 16]. Available from: http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1171644581795&lang=eng
3. Statistics Canada. Households and the Environment Survey (HES) 11-526-XWE; 2009 [cited 2012 Jan 16]. Available from: http://www.statcan.gc.ca/daily-quotidien/090210/dq090210a-eng.htm
4. Jones AQ, Dewey CE, Dore K, Majowicz SE, McEwen SA, Waltner-Toews D. Drinking water consumption patterns of residents in a Canadian community. J Water Health. 2006;4:125-38.
5. Pintar KD, Waltner-Toews D, Charron D, Pollari F, Fazil A, McEwen SA, et al. Water consumption habits of a south-western Ontario community. J Water Health. 2009;7:276-92.
6. Posnick LM, Kim H. Bottled water regulation and the FDA; 2002 [cited 2011 Jun 22]. Available from: http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/BottledWaterCarbonatedSoftDrinks/ucm077079.htm#authors
7. Azoulay A, Garzon P, Eisenberg MJ. Comparison of the mineral content of tap water and bottled waters. J Gen Intern Med. 2001;16:168-75.
8. Garzon P, Eisenberg MJ. Variation in the mineral content of commercially available bottled waters: implications for health and disease. Am J Med. 1998;105:125-30.
9. Morr S, Cuartas E, Alwattar B, Lane JM. How much calcium is in your drinking water? A survey of calcium concentrations in bottled and tap water and their significance for medical treatment and drug administration. HSSJ. 2006;2:130-5.
10. Institute of Medicine. Dietary Reference Intakes for calcium and vitamin D. Washington: National Academies Press; 2011.
11. Institute of Medicine. Dietary Reference Intakes for calcium, phosphorus, magnesium, vitamin D, and fluoride. Washington: National Academy Press; 1997.
12. Institute of Medicine. Dietary Reference Intakes for water, potassium, sodium, chloride, and sulfate. Washington: National Academies Press; 2005.
13. City of Ottawa. Reports of drinking water quality in Ottawa; 2009 [cited 2012 Jan 16]. Available from: http://www.ottawa.ca/env_water/water_sewer/water_wells/wells/city_wells/index_en.html
14. Gennari FJ, Segal AS. Hyperkalemia: an adaptive response in chronic renal insufficiency. Kidney Int. 2002;62:1-9.
15. Yap V, Patel A, Thomsen J. Hyperkalemia with cardiac arrhythmia. Induction by salt substitutes, spironolactone, and azotemia. JAMA. 1976;236:2775-6.
16. Health Canada. Do Canadian adults meet their nutrient requirements through food intake alone?; 2009 [cited 2012 Jan 16]. Available from: http://www.hc-sc.gc.ca/fn-an/alt_formats/pdf/surveill/nutrition/commun/art-nutr-adult-eng.pdf
17. Abbott L, Nadler J, Rude RK. Magnesium deficiency in alcoholism: possible contribution to osteoporosis and cardiovascular disease in alcoholics. Alcohol Clin Exp Res. 1994;18:1076-82.
18. Gibson RS, Bailey KB, Gibbs M, Ferguson EL. A review of phytate, iron, zinc, and calcium concentrations in plant-based complementary foods used in low-income countries and implications for bioavailability. Food Nutr Bull. 2010;31:S134-46.
19. Bohn T, Davidsson L, Walczyk T, Hurrell RF. Phytic acid added to white-wheat bread inhibits fractional apparent magnesium absorption in humans. Am J Clin Nutr. 2004;79:418-23.
20. Kynast-Gales SA, Massey LK. Effect of caffeine on circadian excretion of urinary calcium and magnesium. J Am Coll Nutr. 1994;13:467-72.
21. Nawrot P, Jordan S, Eastwood J, Rotstein J, Hugenholtz A, Feeley M. Effects of caffeine on human health. Food Addit Contam. 2003;20:1-30.