Effect of Thickening Agents, Based on Soluble Dietary Fiber, on the Availability of Calcium, Iron, and Zinc From Infant Formulas

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Although it is accepted that dietary fiber probably is not needed in the diets of infants younger than 1 y, babies suffering from regurgitation are often fed with infant formulas thickened with considerable amounts of fiber. The effect of increasing amounts of alginic acid, locust-bean gum, and guar gum was studied from casein and whey-based infant formulas. A dialysis in vitro method with preliminary intraluminal digestion, adapted to the conditions of infants younger than 6 mo, was used. Human milk was used as the reference standard. Elemental contents of samples and dialysates were determined by atomic absorption spectrometry. Soluble dietary fiber inhibited mineral availability more in casein than in whey-based formulas. Mineral availabilities from casein- and whey-based formulas supplemented with 0.42 g of locust-bean gum/100 mL were 9.4% (0.7) and 10.4% (0.6) for calcium ($P < 0.05$), 0.32% (0.08) and 1.45% (0.17) for iron ($P < 0.05$), and 3.2% (0.2) and 5.6% (0.5) for zinc ($P < 0.05$), respectively. Calcium availability from the whey formula decreased in the presence of each fiber source, especially guar gum and alginic acid. Supplementing 2 g of alginic acid–based agents per 100 mL depressed calcium availability from 13.3% (1.2) to 5.3% (0.3; $P < 0.05$). With respect to iron and zinc, availabilities increased from 1.28% (0.28) to 6.05% (0.96; $P < 0.05$) and from 6.7% (0.6) to 10.2% (1.0), respectively, with the addition of 2 g of alginic acid ($P < 0.05$). Both gums lowered iron and zinc availabilities, and guar gum affected iron availability more severely than locust-bean gum did. Iron availabilities were 1.45% (0.17) from formula thickened with locust-bean gum (0.42 g/100 mL) and 0.92% (0.15) from formula thickened with guar gum ($P < 0.05$). Adding thickening agents based on soluble dietary fiber to traditional infant formulas probably affects calcium, iron, and zinc availability in various ways. *Nutrition* 2001;17: 614–618. ©Elsevier Science Inc. 2001

KEY WORDS: availability of micronutrients, bioavailability, soluble dietary fiber, calcium, iron, zinc

INTRODUCTION

Dietary fiber encompasses various complex substances, mainly non-starch polysaccharides and lignin that resist hydrolysis by human alimentary enzymes. These non-digestible carbohydrates are insoluble, like cellulose and certain hemicelluloses, or soluble, generally pectins, β-glucans, gums, mucilages, seaweed polysaccharides, and oligosaccharides. Non-digestible polysaccharides have important health benefits: they promote normal laxation[1,2] and can help in reducing the risk of some cancers,[3] cardiovascular disease,[4,5] and adult-onset diabetes mellitus.[3,6,7]

There are concerns that high-fiber diets also have adverse effects such as compromising caloric intake[8,9] and reducing the bioavailability of essential minerals and trace elements.[10] Cereals contain high amounts of phytates and dietary fibers, such as lignin and cellulose, that depress nutrient bioavailability.[10] Evidence is increasing that soluble dietary fibers, e.g., gums, reduce the bioavailability of minerals and trace elements in the small intestine.[11] Although there is less concern that deficiencies will develop during adulthood, the safety of high-fiber diets has not been established in growing children. Therefore, fiber was believed to be unnecessary in the diets of infants younger than 1 y.[12,13]

Nevertheless, infants who regurgitate often are fed with formulas thickened with considerable amounts of dietary fiber.[14,15] Commercial high-viscosity infant formulas are commonly thickened with 0.42 g of soluble dietary fiber per 100 mL. In daily practice, however, greater amounts are often added. Because regurgitation is not a long-term condition, thickened formulas are frequently used during infancy and even through the second year. Therefore, the decrease of element availability is of real concern on a long-term basis. It is very important to establish the concentration from which dietary fiber might exert an adverse effect and specify the kind of dietary-fiber components that might cause this effect.

We investigated the effect of a high-fiber diet on the bioavailability of essential minerals and trace elements. We compared the effects of the thickening agents alginic acid (AA; E400), a soluble dietary fiber, and locust-bean gum (LBG; E412) and guar gum

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This study was supported by the Institute for the Promotion of Innovation by Science and Technology in Flanders (IWT).

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Date accepted: January 18, 2001.

Nutrition 17:614–618, 2001

0899-9007/01/$20.00
PII S0899-9007(01)00541-X

(GG; E410), two neutral polysaccharide food gums, on the availability of calcium, iron, and zinc from casein-based and whey-based infant formulas. Human milk was used as the reference standard.

MATERIALS AND METHODS

Materials and Reagents

Newborn-infant formulas containing AA (Gaviscon, Qualiphar N.V., Bornem, Belgium), LBG (Viscogum FA, SKW Biosystems, Brussels, Belgium), and GG (Viscogum HV) were kindly provided by the manufacturers. Gaviscon contains a large fraction of AA (500 mg/g) and various other minor components. Viscogum FA and Viscogum HV contain pure fractions of LBG and GG, respectively.

All chemicals (Merck, Darmstadt, Germany) were of analytical grade, except nitric acid and H_2O_2, which were suprapure. Deionized water (MilliQ water, Millipore, Bedford, MA, USA) was used throughout the study. Pepsin (P-7000, from porcine stomach mucosa) and bile salts (B-8631, porcine) were purchased from Sigma (St Louis, MO, USA), and pancreatin (107133 0500, porcine) was purchased from Merck. A pepsin solution was prepared by dissolving 10 g of pepsin in 100 mL of 0.1 mol/L of HCl. The mixture of pancreatin and bile contained 3 g of pancreatin and 7 g of bile in 1 L of 0.1 mol/L of $NaHCO_3$.

Sample Preparation

Before homogenization, increasing amounts of LBG and GG were added to the whey-based infant formula (60:40 casein:whey): 0.14, 0.27, 0.42, 0.71, and 1.44 g per 100 mL of formula. For the experiments with LBG, a casein-based formula also was used (80:20 casein:whey) because such formulas have become easily available. 0.55, 1.09, 1.80, 2.44, and 3.06 g of the AA-based agents were added to 100 mL of the whey-based formula. The amounts used were chosen according to the manufacturers' formulations prescribing 1 to 2 g of agent/100 mL.

In Vitro Dialysis Model With Preliminary Digestion

The method used is a modification of the continuous-flow dialysis in vitro model,[16,17] with a preliminary intralumenal digestive phase adapted to the upper gastrointestinal tract of infants younger than 6 mo.[18]

The method consists of two phases: gastric and intestinal. Before gastric digestion, the sample pH was adjusted to 4.0 (6.0 mol/L) and 3 mL of pepsin solution was added. The sample was incubated further in a shaking water bath (37°C, 120 strokes/min) for 2 h. After gastric digestion, the titratable acidity was measured in an aliquot of the pepsin digest. Titratable acidity is the number of equivalents of NaOH required to titrate the amount of gastric digest to 7.5 after adding the mixture of pancreatin and bile (15 mL). The intestinal stage was done in an Amicon stirred cell and takes 2 h 30 min. A small dialysis bag containing 1 mol/L of $NaHCO_3$, equivalent to the titratable acidity, was added to the cell, resulting in a gradual pH change from acid to neutral.[17] After 30 min, 15 mL of the pancreatin/bile mixture was added to the neutralized digest, and dialysis was continued for another 2 h. The entire procedure consisted of four replicates of each food sample.

Destruction Process of Organic Matrices

About 0.4 g of the sample, or 2 mL of human milk, was placed into a Teflon vial of a polypropylene destruction bomb. Deionized water (1 mL), H_2O_2 (suprapure, 30%, 500 μL), and HNO_3 (suprapure, 65%, 2 mL) were added and the closed vessel was placed in a microwave digestion oven containing a turntable. The destruction program was described by Hendrix et al.[19] Destruction of the fiber sources was carried out in duplicate, and the sample mixtures were analyzed in quadruplicate.

Atomic Absorption Spectrometry

Stock standard solutions (1000 ± 2 mg/L) were used for preparing calibration-standard solutions of calcium, iron, and zinc. The calcium, iron, and zinc contents of the reagents, destruction liquids, and dialysate fractions were determined by flame atomic absorption spectrometry (flame-AAS; Analyst 300, Perkin-Elmer, Norwalk, CT, USA). Due to the low concentrations of iron in the dialysate fractions, electrothermal atomic absorption spectrometry (ET-AAS; 4100 ZL, Perkin-Elmer) was used to detect this element.

Calibration curves were linear in the working ranges of 0 to 20 mg/L for calcium, 0 to 10 mg/L for iron, and 0 to 0.5 mg/L for zinc for flame-AAS. Linearity with ET-AAS was 0 to 50 μg/L for iron. Trueness of the analytical techniques was checked by analysis of standard reference material before the start of every assay: 1.30 ± 0.05% (NBS 1549) for calcium, 46.1 ± 2.2 μg/g (NBS 1549) for zinc, 368 ± 7 mg/kg (NIST 1573a) for flame-AAS iron, and 300 ± 20 μg/g (NBS 1571) for ET-AAS iron. Characteristic concentrations of the technique (as an indication of the sensitivity) were 0.19 mg/L for calcium, 0.14 mg/L for iron, and 0.03 mg/L for zinc in the acid-destruction solutions and 0.18 mg/L for calcium and 0.03 mg/L for zinc in the dialysate fractions. Characteristic mass (sensitivity) was 14.0 pg of iron for ET-AAS. Detection limits were 0.56 mg/L for calcium, 0.60 mg/L for iron, and 0.15 mg/L for zinc in the destruction solutions. In the dialysates, detection limits were 0.03 mg/L for calcium and 0.01 mg/L for zinc. The detection limit for iron with ET-AAS was 1.06 μg/L. Reagent blanks were taken through the entire procedure, and calcium and zinc contents were measured and subtracted from the results. For iron, the levels were below the limit of quantification.

Calculation of Availability

The availability of the element was calculated from the amount of element that had passed the dialysis membrane proportional to the total element content of the food sample. The following equation was used:

$$\text{availability (\%)} = \frac{D}{W \times A} \times 100\%$$

D is the total content of the element in the dialysate after intralumenal digestion (in micrograms), *W* is the weight of the food sample used for the intestinal stage (in grams), and *A* is the concentration of the element in the food sample (in micrograms per gram).

Assessment of the Analytical Performance of the In Vitro Procedure

Two aqueous solutions high and low in calcium, iron, and zinc were prepared to measure recovery. Solution 1 contained 25 mg of calcium/100 mL, 0.1 mg of iron/100 mL, and 0.1 mg of zinc/100 mL. To solution 2, 50 mg of calcium/100 mL, 0.5 mg of iron/100 mL, and 0.5 mg of zinc/100 mL were added. Recovery was calculated from the amount of element in the dialysate and retentate fractions. Recoveries were 95% (2) for calcium, 104% (7) for iron, and 103% (1) for zinc from solution 1 and 94% (4) for calcium, 115% (7) for iron, and 110% (5) for zinc from solution 2. Repeatability of the procedure (expressed as coefficient of variation, CV) for calcium, iron, and zinc was determined on human milk and infant formula by four replicates during a single day

TABLE I.

ELEMENTAL CONTENT OF CALCIUM, IRON, AND ZINC IN THICKENING SUBSTANCES, HUMAN MILK, AND CASEIN- AND WHEY-BASED INFANT FORMULAS

	Elemental content		
	Calcium (mg)	Iron (mg)	Zinc (mg)
Thickening substances based on (per gram)			
Alginic acid (Gaviscon)	2.37 ± 0.03	0.27 ± 0.01	0.01 ± 0.00
Locust-bean gum (Viscogum FA)	1.13 ± 0.02	0.02 ± 0.00	0.01 ± 0.00
Guar gum (Viscogum HV)	0.57 ± 0.01	0.03 ± 0.00	0.01 ± 0.00
Human milk (per 100 mL)	27.0 ± 0.6	0.03 ± 0.00	0.10 ± 0.01
Infant formulas (per 100 mL)			
Casein-based (80:20 casein:whey)	70.7 ± 2.1	0.59 ± 0.02	0.58 ± 0.01
Whey-based (60:40 casein: whey)	54.2 ± 1.6	0.55 ± 0.02	0.56 ± 0.01

* Calculations were based on the normal reconstitution of infant formula powder with water (15 g of powder + 85 mL of water = 100 mL of infant formula).

TABLE II.

EFFECT OF THICKENING AGENT ON THE AVAILABILITIES OF CALCIUM, IRON, AND ZINC FROM CASEIN-BASED FORMULA

	% Availability		
Treatment	Calcium	Iron	Zinc
Human milk	13.1 (11.9–14.3)	8.12 (7.69–8.55)	13.1 (12.0–14.2)
Casein-based	21.2 (20.2–22.2)^{a}	0.48 (0.13–0.83)^{c}	8.5 (5.9–11.1)^{a}
formula + locust-bean gum (per 100 mL formula*)			
0.42 g	9.4 (8.3–10.4)^{d}	0.32 (0.19–0.45)^{d}	3.2 (2.8–3.6)^{d}
0.71 g	5.9 (5.1–6.7)^{g}	0.32 (0.24–0.40)^{d}	3.4 (2.8–4.1)^{d}
1.44 g	4.9†^{g}	0.23 (0.07–0.39)^{d}	2.5†^{d}

* 100 mL of infant formula = 15 g of powder + 85 mL of water. Data are presented as mean (range; $n = 4$).

† $n = 1$.

Superscripts a–i: multiple comparisons using one-way analysis of variance. Mismatching superscripts in each column denote significant differences ($P < 0.05$). Because of overlapping statistical results, mismatching superscripts were used to compare the non-thickened casein formula with the casein-based formula thickened with 0.4 g of locust-bean gum per 100 mL of formula, despite $P > 0.05$.

(intrabatch precision). Calcium, iron, and zinc concentrations in human milk were 0.27 mg/mL, 0.27 μg/mL, and 1.03 μg/mL, respectively. Element concentrations in infant formula were 4.23 mg/g for calcium, 51.5 μg/g for iron, and 25.2 μg/g for zinc. Repeatability data on human milk were 5.8% CV for calcium, 15.3% CV for iron, and 5.2% CV for zinc. Repeatability data on infant formula were 2.34% CV for calcium, 13.6% CV for iron, and 2.8% CV for zinc. Reproducibility was obtained from 16 digestions of human milk and infant formula each over 4 d (interbatch precision). Reproducibility values were 9.0% CV for calcium, 17.8% CV for iron, and 17.9% CV for zinc in human milk and 4.24% CV for calcium, 20.6% CV for iron, and 9.3% CV for zinc in infant formula.

Statistical Analysis

Statistical evaluation was done with SigmaStat, version 2.0, for Windows. All data were tested for normality and equal variances, followed by pairwise multiple comparisons of all test samples in a one-way analysis of variance and Duncan's posttest. Experimental results of iron and zinc from the AA agent were tested separately in a one-way analysis of variance.

RESULTS

Calcium, iron, and zinc contents of the dietary-fiber sources, human milk and both infant formulas are given in Table I. The calcium content of the AA-based thickening agent was quite high but negligible compared with the amount of calcium in the infant formulas. The same was not true for iron: thickening infant formula with the AA agent increased iron content of the mixtures. Calcium, iron, and zinc contents of LBG and GG were low. Zinc concentrations of both gums were similar to that of the AA agent.

Quantitative comparisons of the availability of calcium, iron, and zinc from human milk and the sample mixtures are shown in Tables II and III and are presented as mean ± standard deviation. The negative effect of LBG on calcium, iron, and zinc availabilities was much more pronounced in the casein-based than in the whey-based formula, and this difference was significant at all fiber levels ($P < 0.05$): availabilities of calcium, iron, and zinc from the casein-based infant formula thickened with 0.42 g of LBG/100 mL of formula were 9.4% (0.7), 0.32% (0.08), and 3.2% (0.2), respectively. These values were significantly lower ($P < 0.05$) than those from the whey-based formula thickened with equal amounts of LBG: 10.4% (0.6) for calcium, 1.45% (0.17) for iron, and 5.6% (0.5) for zinc.

Calcium availability was markedly reduced by the addition of the AA agent and GG and less severly by the addition of LBG. In normal pediatric practice, addition of 2 g of AA agent (≈1 g of AA) 100 mL is usually recommended for thickening infant formula. Calcium availability from this kind of thickened formula is 5.3% (0.3), which is significantly lower than the availability from the non-thickened formula: 13.3% (1.2; $P < 0.05$). Calcium availability from formula thickened with 0.42 g of GG/100 mL of formula (5.7%, 0.1) was significantly lower than that from formula containing LBG in similar amounts (10.4%, 0.6; $P < 0.05$).

Thickening infant formula with the AA-based agent increased iron availability: the addition of 2 g of AA agent/100 mL increased availability to approximately five times (6.06%, 0.96) the normal value (1.28%, 0.28; $P < 0.05$). However, LBG and GG decreased iron availability, and GG exerted a greater effect than did LBG at all fiber concentrations. This effect was most pronounced at 0.42 g of fiber/100 mL, from which LBG exerted no significant effect (1.45%, 0.17; $P > 0.05$), whereas GG significantly reduced availability to 0.92% (0.15; $P < 0.05$).

The availability of zinc followed a pattern similar to that of iron. Thickening formula with 2 g of AA agent/100 mL increased zinc availability to nearly two times (10.2%, 1.0) the normal value (6.7%, 0.6). The addition of 0.42 g of LBG/100 mL lowered zinc availability to 5.6% (0.5), which was significantly higher than zinc availability from the GG-based formula (4.6%, 0.6). At higher fiber concentrations (0.71 g/100 mL and 1.44 g/100 mL), however, the reduction of zinc availability in presence of LBG rather than GG became more pronounced.

TABLE III.

EFFECT OF THICKENING AGENT ON THE AVAILABILITIES OF CALCIUM, IRON, AND ZINC FROM WHEY-BASED FORMULA

Treatment confidence interval	% Availability		
	Calcium	Iron	Zinc
Human milk	13.1 (11.9–14.3)	8.12 (7.69–8.55)	13.1 (12.0–14.2)
Whey-based formula	13.3 (11.4–15.1)^{b}	1.28 (0.58–1.98)†^{a,1}	6.7 (5.8–7.5)^{b,1}
Alginic acid (per 100 mL formula*)			
0.55 g	10.1 (8.5–11.7)^{c}	2.64 (2.05–3.23)^{1}	8.3 (7.8–8.9)^{2}
1.09 g	6.6 (6.0–7.2)^{f}	4.62 (3.59–5.65)^{2}	9.0 (8.1–9.9)^{2}
1.80 g	5.3 (4.7–5.8)^{g}	6.05 (4.52–7.58)^{3}	10.2 (8.7–11.7)^{3}
2.44 g	4.4 (3.9–4.9)^{h}	6.94 (5.91–7.97)^{3}	10.3 (9.7–11.0)^{3}
3.06 g	3.3 (2.9–3.6)^{i}	6.34 (3.51–9.17)†^{3}	10.2 (6.6–13.9)†^{3}
Locust-bean gum (per 100 mL formula*)			
0.14 g	14.0 (12.6–15.5)^{b}	1.65 (1.32–1.98)^{a}	6.9 (5.7–8.0)^{b}
0.27 g	12.5 (11.8–13.1)^{b}	1.53 (1.32–1.74)^{a}	5.5 (4.7–6.3)^{b}
0.42 g	10.4 (9.5–11.3)^{c}	1.45 (1.03–1.87)†^{a}	5.6 (4.7–6.4)^{b}
0.71 g	7.6 (6.9–8.2)^{e}	0.98 (0.86–1.10)†^{b}	4.4 (4.0–4.7)^{c}
1.44 g	5.0 (4.9–5.2)^{f}	0.69 (0.50–0.88)^{c}	3.0 (2.9–3.0)^{d}
Guar gum (per 100 mL formula*)			
0.14 g	11.0 (8.0–14.1)†^{c}	1.47 (1.22–1.72)†^{a}	6.5 (4.4–8.5)†^{b}
0.27 g	7.9 (7.2–8.6)^{e}	1.26 (0.64–1.88)†^{a}	5.1 (3.9–6.2)^{c}
0.42 g	5.7 (5.6–5.8)^{f}	0.92 (0.69–1.13)^{b}	4.6 (3.6–5.5)^{c}
0.71 g	5.7 (5.4–6.2)^{f}	0.74 (0.60–0.88)^{c}	4.9 (4.3–5.5)^{c}
1.44 g	7.7 (7.1–8.2)^{e}	0.50 (0.37–0.63)^{c}	5.5 (4.1–6.9)^{c}

* 100 mL of infant formula = 15 g of powder + 85 mL of water. Data are given as mean (confidence interval $n = 4$).

Superscripts a–i: multiple comparisons using one-way analysis of variance, except data of Fe and Zn from AA that were tested separately and are denoted by superscripts 1–3. Mismatching superscripts in each column denote significant differences ($P < 0.05$). Because of overlapping statistical results, matching superscripts were used for Ca: 0.1 g versus 0.3 g wLBG/100 mL and 1.4 g wLBG versus 0.5 g wAA/100 mL despite the $P < 0.05$. Similar for Fe: a difference exists between the nonthickened whey formula and 0.1 g of wLBG/100 mL and 0.1 g wLBG, and 0.3 g of wGG/100 mL. Mismatching superscripts were used for 0.7 g versus 1.4 g wLBG/100 mL, 0.4 g versus 0.7 g GG/100 mL, and 0.4 g versus 1.4 g GG/100 mL, despite $P > 0.05$. Zn data revealed mismatching superscripts for 0.4 g versus 0.7 g of LBG/100 mL, 0.1 g versus 0.3 g GG/100 mL, 0.3 g LBG versus 0.3, 0.4, 0.7, 1.4 g GG/100 mL, and 0.5 g versus 0.9 g AA, despite $P > 0.05$.

DISCUSSION

First, these findings show that calcium, iron, and zinc availabilities from the casein-based formula thickened with LBG were much lower than those from the whey-based infant formula thickened with equal amounts of LBG. When considering iron availability, the difference between the formulas is remarkable. Second, all three thickening agents seemed to reduce calcium availability, especially GG and the AA-based agent. With respect to iron and zinc, the AA-based agent increased their availabilities. LBG and GG lowered iron and zinc availabilities, whereas GG affected iron availability much more severely than LBG did.

In a previous study, we demonstrated that a casein-based formula considerably affects iron absorption.[18] Moreover, experiments with commercialized high-viscosity (AR-) formulas (based on casein and thickened with LBG) have shown a significantly lower availability of calcium, iron, and zinc compared with nonthickened whey-based formulas.[11]

Anionic polysaccharides such as AA have a strong affinity for alkali and earth alkali metals, especially calcium.[20,21] Berner and Lamartine showed reduced iron solubility in the presence of sodium alginate. Addition of calcium to the solutions depresses the amount of iron bound to alginate.[22] Therefore, calcium seems to be bound preferentially by alginate in the presence of iron, as might be concluded from our results. However, our data did not show reduced iron and zinc availabilities in the presence of AA, which might be explained by the fact that the digestion processes, specifically the pH changes during digestion, effectively dissolved the alginate–iron complexes.[22] Zemel and Zemel obtained similar results and showed that alginate exerts little effect on iron and zinc dialysability under conditions that simulate the lumenal occurrence of these gums from food systems.[23] The relatively high iron content of the AA-based thickening agent might account for the observed increase in iron availability in the whey-based infant formula in this study.

Ha et al.[21] and Camire and Clydesdale[24] observed some affinity of LBG and GG for calcium ions. Zemel and Zemel found substantial reductions in iron and zinc solubility when LBG and GG were added to a soy or milk system, with the effect of GG much more pronounced than of LBG.[23] Those findings are in accordance with our results and with those of Platt and Clydesdale who showed that high levels of GG bind iron more tightly than lignin, cellulose, pectin, and neutral detergent fiber.[25]

In addition to the formation of unabsorbable complexes, LBG might depress the availabilities of calcium and, to a lesser extent, iron as a consequence of its gel-forming capacities (D. Bosscher). LBG and GG[26] create a viscous environment in the small intestine, thereby impairing digestion of food components because they are suspended in the aqueous contents of the gastrointestinal lumen.

Although investigatory studies of dietary fiber have shown clear evidence of complexation, extrapolation of these effects in vivo has not been consistent. According to Levtchenko et al., the addition of 0.4 g of LBG to 100 mL of a casein-based formula does not influence the nutritional parameters of calcium, iron, and zinc metabolism in human infants.[27] Harmuth-Hoene et al.,[28] however, showed that the addition of LBG to a normal human-adult mixed diet (9.5 g of LBG/1000 kcal, which equals 0.6 g/100 mL) reduces the absorption of calcium, iron, and zinc when compared with a control diet.[29] Experiments in growing rats have found substantial reductions in iron absorption with sodium alginate. LBG and GG affected iron and zinc absorptions less severely.[28] Wolbling et al. showed that increasing doses of GG and sodium alginate inhibit the absorption of iron, with GG apparently more effective in inhibiting iron absorption that sodium alginate.[30]

For infants suffering from regurgitation, adding dietary fibers as thickening agents to traditional formulas is a common pediatric practice that often is misused. Adding these agents might impair the availabilities of calcium, iron, and zinc. It is noteworthy that these comparisons of mineral availability from thickened formulas with traditional formulas in vitro do not take into account the possibility that infants can adapt to these diets and achieve mineral balances by increasing absorption and reducing urinary excretion. Whether such adjustments occur with those high-fiber diets is unknown.

Research is needed to investigate how we can compensate for these losses. We believe that the availability of essential elements from high-fiber diets can be increased by fortifying the diet with element species that are highly bioavailable instead of adding large amounts of less bioavailable species.

The effect of milk thickeners based on soluble dietary fibers on the availabilities calcium, iron, and zinc was assessed using a continuous-flow dialysis in vitro method with preliminary digestive phase. A 25% to 50% reduction of the element's availability was observed if the fiber concentration increased 0.5 g/100 mL.

ACKNOWLEDGMENTS

The authors express their gratitude to Mrs. Veerle Van Vlaslaer for evaluation of the data. We acknowledge Dr. Tania Mahler for kindly providing some samples of pooled, mature human milk for analysis.

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