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Elemental Contents of Milk-based and Soy-based Infant Formulas Marketed in Kuwait

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ABSTRACT

Twenty-three milk-based and six soy-based infant formulas marketed in Kuwait were analyzed for their elemental contents. Mean contents of major elements for milk- and soy-based formulas, respectively, were (mg/100 kcal); Na 40·8, 42·5; K 125·2, 102·7; Ca 97·9, 81·2; P 62·7, 52·0; Mg 13·1, 11·4. Mean contents of trace elements for milk- and soy-based formulas, respectively, were (μg/100 kcal); Zn 707, 655; Cu 52, 77; Mn 17, 55. Mean Fe contents were (mg/100 kcal); 0·6 and 1·39 for milk-based and Fe fortified formulas, respectively, and 1·43 for soy-based formulas. Differences between mean levels of milk- and soy-based formulas for Fe, Cu and Mn were significant ($P < 0{\cdot}05$). Mean elemental contents were above Codex Alimentarius *recommended minimums except for means of products from four brands that were low in Cu. Mean Ca:P ratios were 1·7 and 1·6 for milk- and soy-based formulas, respectively. The overall mean levels as % of label claims were: Na 113, K 102, Ca 103, P 96, Mg 134, Fe 103, Zn 106, Cu 97, Mn 205.*

INTRODUCTION

Human milk is well recognized as being an ideal food for the first 6 months of an infant's life. However, in circumstances where breast feeding is not possible, alternative nutritionally adequate foods, prepared under proper hygienic conditions, can be used to feed infants. Numerous infant products that are formulated to meet the nutritional needs of healthy full-term infants, have been produced. Because of variation in nutrient contents in food sources used for preparation of formulas, specifications of nutrient levels, including mineral elements, have been set to simulate levels of these nutrients in human milk (CON/AAP, 1976; FAO/WHO, 1982).

A number of recent reports compared analytical values of elemental content of infant formulas to that of human milk and to the manufacturers' label claims. Gilles and Neal (1985) showed that formulas marketed in New Zealand meet the *Codex Alimentarius* recommendation (FAO/WHO, 1982) for Ca, Mg and Na. They reported differences between analytical values and label claims. Lonnerdal *et al.* (1983) reported wide differences in concentrations of Fe, Zn, Cu and Mn in infant formulas produced in the United States, Japan and six European countries. More than half the samples studied by Lonnerdal *et al.* (1983) were low in Cu, one-third were low in Zn and about one-sixth were low in Fe, when compared with published values for human milk. Gunshin *et al.* (1985) showed that milk powders marketed in Japan had higher ratios for Fe and Mn relative to Mo when compared to ratios calculated for human milk. Recently, Hamill *et al.* (1989) showed that infant formulas manufactured in the United States (135 samples) met the proposed standards of the Committee on Nutrition of the American Academy of Pediatrics (CON/AAP, 1976). Results of this study indicated that elemental content of formulas differ significantly between products of different firms. They also found that soy-based formulas contained significantly higher levels of Ca, P, Mg, Cu, Mn, Na and K than milk-based formulas.

There are no published data on elemental content of infant formulas marketed in Kuwait. The objective of this study was to determine elemental content of infant formulas consumed in Kuwait, as part of our efforts to establish nutrient composition data for infant foods marketed in Kuwait, and to evaluate the nutritional quality of the different products.

MATERIALS AND METHODS

Chemicals

All reagents and chemicals used for analysis and preparation of the standards were analytical grade (BDH Limited, Poole, UK).

Samples

Infant formulas marketed in Kuwait at the time of the study (1989) were 23 milk-based and 6 soy-based dried powders. Samples for different kinds of formulas were collected from local agents of firms from different European countries (UK, Ireland, France, Denmark, Switzerland, Holland, West Germany) and the United States (one product) before marketing. All formulas were for healthy full-term infants. Nine of the milk-based formulas were fortified with Fe.

Elemental analysis

Composite samples were prepared under aseptic conditions and analyzed immediately for their elemental content. Weighed dried (105°C) samples were ashed in duplicate according to the dry ash method of AOAC (AOAC, 1984). The ash was dissolved in 25% HCl. Solutions and final dilution were made using double distilled deionized water. Flame Emission Spectrophotometry was used to determine Na and K, and Air-acetylene Flame Atomic Absorption Spectrophotometry to determine Ca, Mg, Fe, Cu and Mn (spectro AA 30. Varian Techtron, Mulgrave, Australia). The final diluted solution for Ca and Mg contained lanthanum oxide (5·865% w/v) to avoid interference by other elements (APHA, 1985). Phosphorus was determined colorometrically (APHA, 1985).

Energy content

Caloric content was determined by bomb calorimetry (Ballistic Bomb Calorimeter, Model CBB-330-010L, Gallenkamp, London, UK). The system was calibrated using thermochemical grade benzoic acid as a standard (6·32 kcal/g).

Statistical analysis

Descriptive statistics, one-way ANOVA and Student's *t*-test were performed on a PC computer using a statistical analysis package (Minitab, Minitab Inc., 1988). Brands with only one product were not included in the statistical analysis.

RESULTS AND DISCUSSION

The means of Na and K levels for formulas of each brand and the ratios of Na:K mean levels are presented in Table 1. Mean levels of both Na and K of milk-based formulas did not vary significantly between different brands ($P > 0{\cdot}05$). Significant differences in Na and K contents between products of different manufacturers have been reported (Hamill *et al.*, 1989). Gilles and

TABLE 1
Sodium and Potassium Levels in Milk- and Soy-Based Infant Formulas[a] (mg/100 kcal)

Sample	(n)	*Na*		*K*		*Na/K ratio*
		Mean	*SD*	*Mean*	*SD*	*Meq basis*
Milk-based						
Brand A	2	35·8	0·3	109.9	1·8	0·55
Brand B	5	43·7	8·4	108·7	21·7	0·68
Brand C	2	51·5	41·1	140·4	79·2	0·57
Brand D	6	38·9	5·9	121·5	24·7	0·55
Brand E	1	29·1	0·0	86·8	0·0	0·57
Brand F	5	41·1	11·5	153·4	19·8	0·46
Brand J	1	37·4	0·0	100·0	0·0	0·41
Brand H	1	40·4	0·0	97·0	0·0	0·68
Totals						
Milk	23	40·8	12·0	125·2	38·0	0·56
Soy	6	42·5	12·0	102·7	24·2	0·74
CAC/RS Min.[b]		20·0		80·0		—
CAC/RS Max.[b]		60·0		200·0		—
Human Milk[c]		—		—		0·55

[a] Column means are not significantly different ($P > 0{\cdot}05$).
[b] Minimum and maximum levels according to *Codex* Stan. 72-1981 (FAO/WHO 1982).
[c] Ratio calculated from values given by Packard (1982).

Neal (1985) reported a low K level in one of the formulas analyzed relative to the minimum recommended level (FAO/WHO, 1982). All products analyzed in the present study met the *Codex Alimentarius* minimum and maximum recommendation (FAO/WHO, 1982) for Na and K level in infant formulas. The Na and K levels of formulas, reported here also did not vary significantly between milk- and soy-based formulas. Hamill *et al.* (1989) reported low Na:K ratios for milk-based formulas manufactured in the United States. Except for one brand mean level and one product of another brand, formulas analyzed in this study (Table 1) showed higher Na:K ratios compared to the value of 0·55 calculated from values reported for human milk (Packard, 1982).

The mean levels for Ca, P and Mg showed no significant differences ($P > 0{\cdot}05$) between milk- and soy-based formulas (Table 2). All formulas had Ca, P and Mg levels well above the recommended minimum levels, ranging from 154% to 360% of the minimum recommended levels. Tanner (1982) reported higher levels for Ca (178%), P (273%) and Mg (177%) when compared to minimum requirement specified in the United States (CON/APP, 1976). In this study, one product (brand F) showed a very high Mg level. The Ca:P

TABLE 2
Calcium, Phosphorus and Magnesium Levels in Milk- and Soy-Based Infant Formulas[a] (mg/100 kcal)

Sample	(n)	*Ca*		*P*		*Mg*		*Ca/P*
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Wt basis*
Milk-based								
Brand A	2	82·3	2·5	41·3	1·7	9·6	0·2	2·0
Brand B	5	94·5	23·2	55·1	14·0	9·1	2·8	1·7
Brand C	2	105·7	59·7	87·4	60·7	14·0	2·7	1·3
Brand D	6	92·1	22·3	55·3	21·6	11·2	1·6	1·8
Brand E	1	77·6	0·0	31·0	0·0	9·4	0·0	2·4
Brand F	5	117·3	40·6	82·5	21·8	21·6	20·0	1·4
Brand J	1	81·7	0·0	70·2	0·0	10·2	0·0	1·2
Brand H	1	104·5	0·0	63·4	0·0	13·1	0·0	1·6
Totals								
Milk	23	97·9	28·8	62·7	25·6	13·1	10·0	1·7
Soy	6	81·2	15·8	52·0	12·3	11·4	2·5	1·6
CAC/RS Min.[b]		50·0		25·0		6·0		
Human Milk[c]								2·3

[a] Column means are not significantly different ($P > 0{\cdot}05$).
[b] Minimum levels according to *Codex* Stan. 72-1981 (FAO/WHO 1982).
[c] Ratio calculated from values given by Packard (1982).

ratios were less than those calculated for human milk (2·3), except for one product (brand E) with Ca:P ratio of 2·4.

The results presented in Table 3 show that the mean levels of Zn and Mn for all brands were higher than the recommended minimum levels, except for two products (brand F). Four of the eight brands of the milk-based formulas had mean Cu level less than the *Codex Alimentarius* recommended minimum level (Table 3). Low Cu levels in milk-based formulas produced in Europe and Japan, but not the United States, were reported by Lonnerdal *et al.* (1983). Soy-based formulas had significantly higher levels of Cu and Mn compared to milk-based formulas. A similar observation was also reported for infant formulas manufactured in the United States (Hamill *et al.*, 1989). Only five of the 23 milk-based formulas analyzed in the present study had Zn:Cu ratio within limits reported for human milk (Packard, 1982). A similar observation had been made by Lonnerdal *et al.* (1983). However, Hamill *et al.* (1989) showed that all formulas manufactured in the United States have Zn:Cu ratios that fall within limits reported for human milk (1·7–11·7). In the present study all soy-based formulas had Zn:Cu ratio within limits calculated for human milk (1·7–11·7).

TABLE 3
Zinc, Copper and Manganese Levels in Milk- and Soy-Based Infant Formulas (μg/100 kcal)

Sample	(n)	*Zn*		*Cu*		*Mn*		*Zn/Cu*
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Wt basis*
Milk-based								
Brand A	2	983	2	71	4	10	3	14
Brand B	5	876	170	56	5	13	5	16
Brand C	2	812	65	68	2	27	17	12
Brand D	6	680	178	54	9	23	8	13
Brand E	1	480	0	48	0	8	0	10
Brand F	5	497	158	31	21	14	6	26
Brand J	1	585	0	52	0	14	0	11
Brand H	1	658	0	54	0	17	0	12
Totals								
Milk	23	707	213	52	16	17	9	16
Soy	6	655	55	77[a]	20	55[a]	19	9
CAC/RS Min.[b]		500		60		5		—
Human Milk[c]		—		—		—		1·7–11·7

[a] Totals column means are significantly different ($P < 0{\cdot}05$). Column means of different brands of milk-based formulas are not significantly different.
[b] Minimum level according to *Codex* Stan. 72-1981 (FAO/WHO, 1982).
[c] Ratio range calculated from values given by Packard (1982).

Iron-fortified milk-based formulas had mean levels of Fe that were not significantly different from Fe mean levels of soy-based formulas. The Fe level for all the formulas was higher than the recommended minimum of 0·15 mg/100 kcal (FAO/WHO, 1982) or 0·18 mg/100 kcal (*Federal Register*, 1985) except for two products (brand F). The Fe levels of all formulas were also less than the maximum level specified by the infant Formula Act (3 mg/100 kcal) (*Federal Register*, 1985). The overall means of milk-based formulas (Table 4) were higher for non-fortified formulas and less for fortified formulas compared to values reported by Hamill *et al.* (1989). The overall means reported by Hamill *et al.* (1989) were 0·4 and 2·1 mg/100 kcal for milk-based non-fortified formulas and milk-based fortified formulas manufactured in the United States, respectively. Fe:Zn and Fe:Mn ratios of all formulas were higher than ratios for human milk (Packard, 1982). Higher Fe:Zn and Fe:Mn ratios for infant formulas relative to human milk were also shown by Lonnerdal *et al.* (1983). The soy-based formulas (Table 4) had higher Fe:Cu ratio and lower Fe:Mn ratio than milk-based formulas.

Table 5 shows the mean analytical values of all elements as percentages of the manufacture label declaration for milk- and soy-based formulas. Except

TABLE 4
Iron Levels in Milk-Based. Iron-Fortified and Soy-Based Formulas

Formula	(n)	*Fe (mg/100 kcal)*		*Ratios on Wt basis*	
		Mean	*SD*	*Fe/Zn*	*Fe/Mn*
Milk	9	0·61	0·37	1·0	49·9
Milk + Fe	9	1·39[a]	0·22	1·8	75·9
Soy	6	1·43[a]	0·52	2·2	27·6
CAC/SR Min.[b]		0·15		—	—
Human Milk[c]		—	—	0·18	12·4–17·2

[a] Column means with like superscript are not significantly different ($P < 0{\cdot}05$).
[b] Minimum level according to *Codex* Stan. 72-1981 (FAO/WHO 1982).
[c] Calculated from values given by Packard (1982).

TABLE 5
Percentage of the Label Declaration for Major Elements and Trace Elements[a]

Sample	(n)	*Major elements*					*Trace elements*			
		Na	*K*	*Ca*	*P*	*Mg*	*Fe*	*Zn*	*Cu*	*Mn*
Brand A	2	113	100	107	74	172	132	143	99	213
		2	0·5	4	2	1	44	2	5	57
Brand B	5	113	93	97	95	119	104	106	84	134
		8	8	6	8	21	13	17	5	44
Brand C	2	116	110	103	115	158	114	128	96	127
		11	2	8	4	42	11	8	13	69
Brand D	6	109	103	100	87	124	106	98	91	356
		20	9	6	14	13	9	27	13	118
Brand E	1	117	93	104	85	133	125	90	90	81
		—	—	—	—	—	—	—	—	—
Brand F[b]	2	—	133	127	—	—	74	90	77	71
		—	25	7	—	—	22	7	13	6
Brand J	1	111	104	103	108	83	96	86	78	25
		—	—	—	—	—	—	—	—	—
Brand H	1	107	96	99	93	174	96	100	89	240
Totals										
Milk	19	109	103	103	92	137	105	106	88	199
		18	14	10	16	32	20	23	10	134
Soy	6	131	98	105	108	140	95	105	132	228
		27	3	11	8	13	25	12	35	129
Overall	25	113	102	103	96	134	103	106	97	205
		21	13	10	15	26	21	21	24	131

[a] Values are means followed by standard deviation in the next line for each brand.
[b] Only two products of brand F had label declaration which was for six minerals only.

for Mg and Mn all analytical values were found to be 96–106% of the label claim. Gilles and Neal (1985) reported analytical values for formulas marketed in New Zealand that were 82–140% of the manufacturer label declaration. The highest percent label claims in the present study were those for Mg (134%) and Mn (205%) (Table 5). Similarly, Hamill *et al.* (1989) found percent label declaration to be highest for Mg (136%) and Mn (154%) among other elements for formulas produced in the United States.

CONCLUSIONS

The results of this study show that the levels of mineral elements in different infant formulas marketed in Kuwait were above the *Codex Alimentarius* recommendation, except for a few products that were low in Fe, Zn and Cu. Variation from label claim was highest for Mn. Most of the milk-based formulas had Zn:Cu above limits reported for human milk and all formulas had Fe:Zn and Fe:Mn ratios higher than reported for human milk. One product (brand C) was found to have relatively high levels for six minerals, without a claim for special use. Low Cu content and large variation in Mn content seem to be the main drawbacks to maintaining good quality of elemental composition of infant formulas marketed in Kuwait.

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