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ORIGINAL ARTICLE

Nutritional composition of infant milk formulas. Level of compliance in their manufacture and adequacy of nutritional needs☆

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Abstract
Introduction: A high percentage of infants are fed with infant formulas. The aim of this study was to assess compliance with Technical Sanitary Regulations on the manufacture of Spanish infant formulas, and analyse their compliance with recommendations relating to nutritional composition and the Dietary Reference Intakes for infants.
Materials and methods: A total of 31 formulas were analysed, of which 18 were infant formulas, 10 follow-on formulas, and 3 growing-up milks. The European Technical Sanitary Regulations, the Spanish Dietary Reference Intakes and the Institute of Medicine of the United States and Canada were used for the assessment of compliance and adequacy.
Results: The energy and macronutrient content of analysed infant formulas is placed in the middle of the range indicated in the Technical Sanitary Regulations, and meets the recommended amounts. However, most micronutrients such as phosphorus, calcium, retinol, vitamins D, E, C, B_6, B_{12}, thiamin, riboflavin, and folate are at the lower limit of the Technical Sanitary Regulations. However, the recommended consumption of infant formulas exceeded the Dietary Reference Intakes for vitamins E, C, retinol, vitamin B and folate, and vitamin B_{12} for follow-on formulas.
Conclusions: Infant formulas are within the reference values of the European Technical Sanitary Regulations in terms of energy and macronutrients, but we believe that the level of micronutrients should be reviewed, based on current scientific data on infant requirements and possible adverse effects.

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PALABRAS CLAVE
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Micronutrientes

Composición nutricional de las leches infantiles. Nivel de cumplimiento en su fabricación y adecuación a las necesidades nutricionales

Resumen
Introducción: Un porcentaje elevado de lactantes son alimentados con fórmulas infantiles. El objetivo fue valorar el cumplimiento de la Reglamentación Técnico-Sanitaria (RTS) en la fabricación de fórmulas infantiles españolas y analizar el grado de adecuación a las recomendaciones de composición nutricional y a las recomendaciones de ingesta diaria para lactantes.
Material y métodos: Se analizaron 31 fórmulas infantiles: 18 de inicio, 10 de continuación y 3 de crecimiento. Para la valoración de cumplimiento y su adecuación se utilizó la normativa europea de la RTS, las Ingestas Dietéticas Recomendadas (RDI) para la población española y las del *Institute of Medicine* de Estados Unidos y Canadá.
Resultados: El contenido de energía y macronutrientes de las leches infantiles analizadas se sitúa en el centro del margen indicado en la RTS y se adecua a las cantidades recomendadas. No obstante, la mayoría de los micronutrientes —tales como fósforo, calcio, retinol, vitamina D, E, C, B_6, B_{12}, tiamina, riboflavina y folatos— se sitúan en el límite bajo de la RTS. Sin embargo, la cantidad recomendada de leche de inicio superaba las RDI en vitamina E, C, retinol, vitaminas del grupo B y folatos, y de vitamina B_{12} para las de continuación.
Conclusiones: Las leches infantiles se encuentran dentro de los valores de referencia de la normativa europea de la RTS en cuanto a energía y macronutrientes; sin embargo, creemos que sería necesario hacer una revisión para los micronutrientes, basándose en datos científicos actuales de los requerimientos del lactante y sobre sus posibles efectos adversos.

Introduction

Scientific evidence gathered in recent years supports the nutritional quality of breast milk to feed newborns and infants, due to the specificity and bioavailability of its nutrients and the contribution of live cells, digestive enzymes, immunomodulators and growth factors.[1] However, a high percentage of 6-month (54.1%) and one-year-old infants (78.3%) are fed with infant formulas.[2] These milks attempt to reproduce the properties, composition and bioavailability of breast milk.[3]

Spain's Royal Decree 867/2008, of May 23, amending community directive (2006/141/EC), approves the Technical-Sanitary Regulation (TSR) that specifically deals with initiation and continuation infant formulas, establishing minimum and maximum values of nutritional content.[4] Its purpose is to provide values to establish the nutritionally adequate contributions of infant formulas. These values are independently established from scientific tests performed in human infants, taking breast milk composition as a reference.[5] There is no specific directive regarding the composition of growing-up milks, so manufacturers follow existing recommendations for continuation milks.[6] Notwithstanding, although the manufacture of artificial milks is assumed to comply with Royal Decree 867/2008 on the TSR[4], it would be interesting to find out whether they adhere to the maximum or minimum values allowed and their relationship with health.

It would also be interesting to analyse the degree to which the nutritional contribution of artificial milks complies with the recommended content, to verify that the artificial milks being prescribed to infants adequately meet their energy and nutritional needs.

In view of this situation, we intend to assess the degree to which infant formulas comply with the TSR and analyse whether the nutritional composition of these milks satisfies the daily recommended intake in infants.

Material and methods

Samples of initiation, continuation, growing-up and special artificial milks commercially available in Spain and related to the pharmaceutical environment have been selected. The nutritional composition figures were taken from the information provided by the manufacturer on the bottles and cartons available for sale and from the Parapharmacy Catalogue 2010.[7] Values are expressed in units/100 ml of milk reconstituted from dry extract.

The mean values of energy and nutrients contained in each milk group (initiation, continuation, growth and special) have been calculated.

Compliance of artificial milk with Technical-Sanitary Regulations

The mean composition of initiation and continuation artificial milks has been compared with the TSR from Royal Decree 867/2008.[4] In the case of growing up milks, since there is no regulation available, their nutritional composition has been compared with cow's milk.[8] The mean value between the minimum and maximum indicated in the TSR

for each nutrient and energy has been defined for comparison with the mean value of energy and nutrients contained in infant formulas. This comparison has been calculated as the percentage of adequacy with respect to the TSR mean value. The following formula was used: composition in 100 ml of infant formula/TSR mean value by 100 ml × 100 = % of infant formula in compliance with TSR.

Compliance of artificial milk with Recommended Dietary Intake

The Recommended Dietary Intakes (RDI) for the Spanish population[9] have been used for energy, proteins and micronutrients, such as calcium, iron, retinol, vitamin D, vitamin E, vitamin C, thiamine, riboflavin, niacin, vitamin B_6, vitamin B_{12} and folates. For glucides and lipids, the *Dietary Reference Intakes* (DRI) of the *Institute of Medicine* of the National Academies of United States and Canada[10] were used. With regard to the breast milk and cow's milk composition table, data have been extracted from the Spanish food composition table: Mataix Verdú[8] for cow's milk, and breast milk from the nutrition treatise of Ángel Gil.[11] To determine the energy and nutritional contribution received by the infant, an intake of 910 ml has been considered at 3 months, taking into account that they are only breast-fed, and of 500 ml at 9 and 18 months, when they also receive complementary feeding, according to the recommendations made by the Clínica Universidad de Navarra.[12]

Statistical analysis

The qualitative variables were described as percentages, and quantitative variables as mean and standard deviation. For the qualitative variables the chi-square test was used and for the quantitative ones, the Student's *t*-test was used. A value below 0.05 was accepted as statistically significant. The analysis was performed with the package of statistical programmes SPSS 17.0.

Results

A total of 31 infant formulas were assessed, of which 18 were initiation formulas, 10 were continuation formulas, and 3 were growth formulas. Tables 1a and 1b show their nutritional composition. The main differences between initiation and continuation formulas are a higher energy and nutrient content of the latter. Growing up have a higher energy content of energy (76 kcal/100 ml), proteins, phosphorus, calcium, retinol, vitamin D, riboflavin and folates compared to the continuation ones.

Table 1c shows the nutritional content of infant milks with their serum protein, polyunsaturated fatty acid, prebiotic and nucleotide content. Most infant formulas contain serum protein, nucleotides, arachidonic, docosahexaenoic, linoleic and α-linolenic acids, docosahexaenoic acid is also present in growing up milks. The most common prebiotics are galacto-oligosaccharides.

Table 2 indicates the mean energy and nutrient content. The percentage of compliance has been calculated for initiation and continuation artificial milks.

Initiation infant formulas comply with the regulation in regard to their macronutrient content. However, levels of micronutrients such as phosphorus, calcium, retinol, vitamins D, E, C, thiamine, riboflavin, vitamins B_6, B_{12} and folates are lower than mean reference values. They contain more iron and niacin.

As for continuation formulas, they comply with regulations in terms of macronutrient content, but not in terms of micronutrients, since their levels of vitamins D, E, C, retinol, thiamine, riboflavin, niacin, vitamins B_6, B_{12} and folates fall below mean reference values, while their mineral (phosphorus, calcium and iron) content exceeds regulation limits. These discrepancies between regulation and real levels are minor, and all micronutrients are within the limits permitted by the regulation and never at their extreme values.

The mean concentrations of energy and nutrients in breast milk and initiation artificial milks in Table 1a are presented in Table 3, as well as the comparison between initiation milk and breast milk and between growing up milks and cow's milk.

When comparing breast milk with initiation milk, we observed that the mean concentration of proteins in the latter is higher. This is also true of micronutrients such as phosphorus, calcium and iron, and vitamins such as retinol, D, E, thiamine, riboflavin, niacin, B_6, B_{12} and folates. Growing up milks, when compared with cow's milk, present a higher energetic content (76 kcal/100 ml), and higher levels of carbohydrates, iron, vitamins D, E, C, retinol, niacin and folates.

Table 4 shows that the intake of 910 ml of initiation milk provides, and in several cases exceeds, the daily recommended amount. The contribution of phosphorus, retinol, vitamin E, C, thiamine, riboflavin, niacin, B_6, B_{12} and folates is higher than recommended.

Intake of 500 ml of continuation milk has been shown to meet 36% of energy requirements, about 50% of macronutrients, vitamin B_6 and niacin requirements, between 60% and 70% of the requirements of calcium, iron, retinol and vitamin D, and over 80% of the requirements of phosphorus, vitamin E, vitamin C, thiamine, riboflavin, vitamin B_{12} and folates.

The daily intake of 500 ml of growing up milk provides 30% of the energy recommended, about 50% of proteins and vitamin C, between 60% and 70% of the requirements of calcium, iron, niacin and folates and more than 80% of the requirements of phosphorus, retinol, vitamin D, riboflavin and vitamin B_{12}. As for the content of glucides, vitamin E, B_6 and thiamine, growing up milk does not fufil 50% of the recommendations.

Discussion

The study performed on nutritional compliance of the leading brands of Spanish infant milks and their ability meet the infant's nutritional needs shows the need to review this regulation in the light of new scientific advances achieved in recent years in some nutrients. The analysis performed has shown that the energy and macronutrient content of the main infant milks is located in the centre of the range indicated in the TSR[4] and matches the

Table 1a Energy and nutrient content of initiation, continuation and growing up artificial milks.

Artificial milk (100 ml)	Energy (kcal)	Proteins (g)	Glucides (g)	Lipids (g)	SFA (mg)	MUFA (mg)	PUFA (mg)	Fibre (g)	Na (mg)	Mg (mg)	P (mg)	K (mg)	Ca (mg)
Initiation													
Almirón 1	66	1.3	7.3	3.5	1.5	1.4	0.6	0.8	17	5	28	63	50
Blemil Plus 1 Forte	66	1.35	7.2	3.5				0.8	24	5.7	31	73	57
Enfalac 1 Premium	73	1.5	7.6	4	1.6				19.3	5.7	33	80	48
HeroBaby 1	66	1.4	7.2	3.5	1.5				20	6	30	65	50
Nativa 1	67	1.2	7.5	3.6					17	5.7	24	68	43
Nidina 1 Premium	67	1.2	7.5	3.6					17	5.7	24	68	43
Novalac 1	65	1.6	7.2	3.3					18.2	5.9	35.1	58.5	58.5
Nutribén 1	67	1.4	7.2	3.5				0.4	20	6	30	65	50
Nutribén Hidrolizada	67	1.6	7.2	3.5					31	6	43	65	67
Puleva 1	65	1.4	7.1	3.5	1.4	1.4	0.7	0.3	19.2	5.1	28.2	66.6	
Sanutri Natur 1	67	1.4	7.8	3.3					18	6.4	23.4	62	
Initiation[a] *Special*													
AL 110	66	1.4	7.7	3.3					22	6.6	32	79	55
Alfaré	70	2.1	7.6	3.5					34	8.3	36	87	54
Almirón 1 Digest	66	1.5	7.1	3.5				0.8	20	6	26	73	48
Blemil 1 AE	68	1.6	7	3.6				0.8	21	5.5	37	66	67
Blemil Plus 1 arroz hidrolizado (hydrolysed rice)	68	1.6	7.6	3.4					30	6.1	34	61	61
Nidina AR	67	1.2	7.5	3.6					15	4.6	21	59	41

Table 1a (*Continued*)

Artificial milk (100 ml)	Fe (mg)	Retinol (μg)	Vit D (μg)	Vit E (mg)	Vit C (mg)	Thiamine (μg)	Riboflavin (μg)	Niacin (mg)	Pantothenic acid (mg)	Vit B6 (μg)	Vit B12 (μg)	Pholates (μg)
Initiation												
Almirón 1	0.53	55	1.2	1	8.3	50	101	0.43	0.329	40	0.18	12
Blemil Plus 1 Forte	0.7	78	1	2	9.5	70	84	0.5	0.4	57	0.14	9.5
Enfalac 1 Premium	0.85	66	1.1	1	8.7	57	102	0.73	0.35	44	0.22	11.7
HeroBaby 1	0.78	70	1.2	0.87	9.1	59	91	0.47	0.33	39	0.16	10
Nativa 1	0.7	68	0.9	0.9	9.5	75	137	0.6	0.6	52	0.2	9.5
Nidina 1 Premium	0.7	68	0.9	0.9	11	75	137	0.6	0.6	52	0.2	9.5
Novalac 1	0.9	58.5	1	1.7	7.8	39	104	1.1	0.3	39	0.1	5.9
Nutribén 1	0.78	70	1.2	0.87	9.1	59	91	0.47	0.32	39	0.16	10
Nutribén Hidrolizada	0.78	70	1.2	0.87	9.1	60	90	0.96	0.33	40	0.16	10
Puleva 1	0.7	64	1.1	1	12.8	57.6	102.4	0.8	0.4	57.6	0.2	10.2
Sanutri Natur 1	0.7	65	1.3	0.8	16	53	94	0.7	0.3	43	0.1	12
Initiation[a] *Special*												
AL 110	0.7	71	0.9	0.9	11	66	73	0.7	0.7	46	0.2	11
Alfaré	0.7	73	1	1.2	6.9	49	104	0.7	0.3	56	0.2	6.8
Almirón 1 Digest	0.54	49	1.2	0.8	8.1	49	100	0.85	0.31	40.4	0.1	8.3
Blemil 1 AE	0.7	62	1	2.1	9.6	69	82	0.5	0.4	55	0.14	9.6
Blemil Plus 1 arroz hidrolizado (hydrolysed rice)	0.7	61	1	1.4	9.5	68	81	0.7	0.4	54	0.14	8.1
Nidina AR	0.8	70	7	0.5	6.7	46	155	0.7	0.3	50	0.2	6.1

MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; SFA: saturated fatty acids; Ca: calcium; Fe: iron; Mg: magnesium; Na: sodium; P: phosphorus; Vit: vitamin. Blank cells: information is not available. Values are expressed in units/100 ml of product reconstituted to liquid. Nutritional information on initiation and special milks has been taken from the Parapharmacy Catalogue (pharmacopoeia) 2010, from the Spanish General Council of Pharmaceutical Associations and from the information provided to the consumer in bottles and cartons available for sale.

[a] Milks designed to meet the nutritional needs of infants with some type of physiological or metabolic disorder that may alter the absorption, digestion or metabolism of some substances.

Table 1b Energy and nutrient content of initiation, continuation and growing up artificial milks.

Artificial milk (100 ml)	Energy (kcal)	H_2O (g)	Proteins (g)	Glucides (g)	Lipids (g)	SFA (mg)	MUFA (mg)	PUFA (mg)	Fibre (g)	Na (mg)	Mg (mg)	P (mg)	K (mg)	Ca (mg)
Continuation														
Almirón 2	68		1.4	8.6	3.2	1.4	1.3	0.5	0.8	20	4.8	34	61	62
Blemil Plus 2	68		2	8.1	3.1					34	7	56	91	84
Blemil Plus 2 Forte	69		1.8	8.34	3.2				0.4	32	8	58	87	87
Hero Baby 2	70		1.7	9.1	2.9	1.2			0.4	26	8.3	53	83	72
Nativa 2	67	90.3	1.3	8.2	3.2					25	6.8	49	75	77
Nidina 2 Premium	67	90.3	1.3	8.2	3.2					25	6.8	49	75	77
Nutribén 2	68		1.7	8.8	2.8				0.38	25	8	51	80	70
Sanutri Natur 2	68		2.2	8.4	2.8					28	7	55	91	74
Continuation[a] *Special*														
Almirón 2 Digest	68		1.6	8.2	3.2	1.5	1.2	0.5	0.8	31	7.1	35	81	64
Blemil Plus 2 arroz hidrolizado (hydrolysed rice)	69		2	8.1	3.1					36	7	46	87	70
Growth														
Nestlé crecimiento protección 1	80	84	2.3	9.5	3.6	0.8		0.7	0.2	26	8.3	62	98	109
Puleva 3 crecimiento	67		2.35	7.25	3.15	0.55	2.27	0.33	0	40	12	75	196.4	108
Puleva peques 3 con cereales	81		2.8	10.45	3.15	0.55	2.27	0.33	0.1	40		75	196.4	108

Table 1b (*Continued*)

Artificial milk (100 ml)	Fe (mg)	Retinol (μg)	Vit D (μg)	Vit E (mg)	Vit C (mg)	Thiamine (μg)	Riboflavin (μg)	Niacin (mg)	Pantothenic acid (mg)	Vit B6 (μg)	Vit B12 (μg)	Pholates (μg)
Continuation												
Almirón 2	1	66	1.4	1.2	9.4	54	109	0.44	0.372	40	0.17	12
Blemil Plus 2	1.1	63	1.1	2.1	9.8	70	84	0.6	0.4	56	0.14	9.8
Blemil Plus 2 Forte	1.2	78	1.2	2.2	10.2	78	93	0.6	0.5	64	0.15	10.2
Hero Baby 2	1.1	71	1.3	0.87	13	71	135	0.45	0.42	44	0.23	11
Nativa 2	1	72	1.1	1.3	12	123	203	0.6	0.9	76	0.2	14
Nidina 2 Premium	1	72	1.1	1.3	11.5	123	203	0.6	0.9	76	0.2	14
Nutribén 2	1.1	69	1.2	0.84	13	68	131	0.43	0.4	42	0.22	11
Sanutri Natur 2	0.9	70	1.4	0.8	18	57	112	0.7	0.4	42	0.1	8.3
Continuation[a] *Special*												
Almirón 2 Digest	1	58	1.4	1.1	9.2	50	120	0.34	0.34	40	0.15	8.5
Blemil Plus 2 arroz hidrolizado (hydrolysed rice)	1.1	63	1.1	1.4	9.8	73	87	0.7	0.4	59	0.14	8.4
Growth												
Nestlé crecimiento protección 1	1.3	141	2.6	1.5	13	20	200	3.2	0.9	30	0.2	31
Puleva 3 crecimiento	0.9	75	1.3	1.3	2	30	120	0.09	0.23	40	0.3	6
Puleva peques 3 con cereales	0.9	75	1.3	1.3	2	30	120	0.09	0.23	40	0.3	6

MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; SFA: saturated fatty acids; Ca: calcium; Fe: iron; Mg: magnesium; Na: sodium; P: phosphorus; Vit: vitamin. Blank cells: information is not available. Values are expressed in units/100 ml of product reconstituted to liquid. Nutritional information on initiation and special milks has been taken from the Parapharmacy Catalogue (pharmacopoeia) 2010, from the Spanish General Council of Pharmaceutical Associations and from the information provided to the consumer in bottles and cartons available for sale.

[a] Milks designed to meet the nutritional needs of infants with some type of physiological or metabolic disorder that may alter the absorption, digestion or metabolism of some substances.

Table 1c Nutritional composition of initiation, continuation and growing up artificial milks.

Artificial milk (100 ml)	Serum Protein (g)	Linoleic a. (mg)	AA (mg)	Linolenic α acid (mg)	DHA (mg)	Prebiotics		Nucleotides (mg)
						FOS (g)	GOS (g)	
Initiation								
Almirón 1	0.80	466	12	86	7		0.8	3.20
Blemil Plus 1 Forte	#	569	15.8	49	11.2	–	0.8	2.92
Enfalac 1 Premium	#	607.2	2.8	47.5	11.5	–	0.2	2.70
Hero Baby 1	#	442	6.9	62	6.9	–	0.4	3.25
Nativa 1	#	529	–	68	–	–	–	2
Nidina 1 Premium	#	529	7.9	65	7.9	–	–	2
Novalac 1	#	500	–	52	–	–	–	–
Nutribén 1	0.83	442	6.9	62	6.9	–	0.4	3.25
Initiation[a] *Special*								
Nutribén Hidrolizada	–	429	–	60	–	–	–	3.25
Puleva 1	#	604.2	6.4	90.9	6.4	–	0.3	3.20
SanutriNatur 1	0.80	–	6.6	–	6.6	–	–	2.70
AL 110	–	527	7	66	7	–	–	2.10
Alfaré	#	494	–	–	–	–	–	–
Almirón 1 Digest	#	400	–	80	–	–	–	–
Blemil 1 AE	–	424	7.1	46	7.1	0.8	–	2.95
Blemil Plus 1 arroz hidrolizado (hydrolysed rice)	–	472	–	38	–	–	–	2.92
Nidina AR	–	539	–	69	–	–	–	–
Nutribén 1 AE	0.84	438	–	55	–	–	–	–
Continuation								
Almirón 2	0.70	62	–	79	–	0.8	6.42	
Blemil Plus 2	#	453	–	64	–	–	–	–
Blemil Plus 2 Forte	#	533	10.2	78	10.2	–	0.4	2.94
Hero Baby 2	#	353	3.1	50	3.1	–	0.4	3.45
Nativa 2	#	486	–	62	–	–	–	–
Nidina 2 Premium	#	486	5.9	62	5.9	–	–	#
Nutribén 2	0.93	341	–	49	–	–	0.38	3.28
SanutriNatur 2	1.20	608	12	101	6	–	–	2.70
Continuation[a] *Special*								
Almirón 2 Digest	1.60	387	–	77	–	0.8	6.42	
Blemil Plus 2 arroz hidrolizado (hydrolysed rice)	–	437	–	34	–	–	–	2.84
Growth								
Nestlé Crecimiento Protección 1	–	664	–	90	–	–	–	–
Puleva 3 Crecimiento	#	320	–	6	12	–	–	–
Puleva Peques 3 con cereales	–	250	–	6	9	–	–	–

AA: arachidonic acid; DHA: docosahexaenoic acid; FOS: fructooligosaccharides; GOS: galactooligosaccharides.
Values are expressed in units/100 ml of product reconstituted to liquid. Nutritional information on continuation, special and growth milks has been taken from the Parapharmacy Catalogue (Pharmacopoeia) 2010, from the Spanish General Council of Pharmaceutical Associations and from the information provided to the consumer in bottles and cartons available for sale.
[a] Milks designed to meet the nutritional needs of young children with some type of physiological or metabolic disorder that may alter the absorption, digestion or metabolism of some substances. (–) Does not contain supplements. (#) Indicates their presence in the label but it does not specify quantity

amounts recommended.[9,10] Infant milks provide more iron and micronutrients than breast milk due to their lower bioavailability.[13] The main micronutrients in initiation milks are vitamins E, C, B-group vitamins and folates, and vitamin B_{12} in continuation milks. The amounts of vitamins and minerals contained in initiation milks, as well as in continuation milks, fall within the average range of the TSR European directive.[4] When comparing the nutritional content of cow's milk with that of growing up milks, much higher levels of glucides, iron, retinol, vitamin D, vitamin E, vitamin C, niacin and folates is observed, as well as a higher retinol and vitamin B content.[12]

This study also presents the nutritional composition of a wide range of infant milks commercially available in Spain,

Table 2 Percentage of compliance of artificial milks with the Technical-Sanitary Regulation.

Nutrient	Initiation milk				Continuation milk			
	Composition in 100 ml of AM[a]	TSR by 100 ml[b]		AM Compliance % with the TSR[c]	Composition in 100 ml of CM[a]	TSR by 100 ml[b]		CM Compliance % with the TSR[c]
	Mean (SD)	Min.	Max.	Mean (SD)	Mean (SD)	Min.	Max.	Mean (SD)
Energy (kcal)	67.10 (1.87)	60	70	103.24 (2.88)	68.20 (0.91)	60	70	104.92 (1.41)
Proteins (g)	1.45 (0.21)	1.08	2.1	89.67 (12.98)	1.70 (0.30)	1.08	2.45	94.44 (17.17)
Glucides (g)	7.36 (0.23)	5.4	9.8	94.37 (3.05)	8.40 (0.33)	5.4	9.8	107.74 (4.25)
Lipids (g)	3.51 (0.15)	2.64	4.2	98.90 (4.41)	3.07 (0.17)	2.4	4.2	90.29 (5.00)
SFA (mg)	1.50 (0.81)	–	–	–	1.36 (0.15)	–	–	–
MUFA (mg)	1.40 (0)	–	–	–	1.25 (0.07)	–	–	–
PUFA (mg)	0.65 (0.07)	–	–	–	0.50 (0.00)	–	–	–
Ca (mg)	51.63 (8.01)	30	98	79.91 (12.40)	73.70 (7.93)	30	98	114.08 (12.27)
Fe (mg)	0.72 (0.09)	0.18	0.91	131.7 (16.60)	1.05 (0.08)	0.36	1.4	116.02 (9.39)
Retinol (μg)	66.03 (6.93)	36	126	80.81 (8.49)	68.20 (5.77)	36	126	83.47 (7.06)
Vit D (μg)	1.40 (1.40)	0.6	1.75	87.76 (7.50)	1.20 (0.13)	0.6	2.1	89.78 (9.76)
Vit E (mg)	1.09 (0.43)	0.3	3.5	58.46 (23.09)	1.31 (0.48)	0.3	3.5	70.10 (26.16)
Vit C (mg)	9.54 (2.16)	6	21	70.17 (15.92)	11.59 (2.66)	6	21	85.22 (19.62)
Thiamine (μg)	58.92 (10.16)	36	210	48.09 (8.29)	76.70 (25.97)	36	210	62.61 (21.20)
Riboflavin (μg)	101.08 (21.46)	48	280	61.93 (13.15)	127.70 (43.24)	48	280	78.24 (26.49)
Niacin (mg)	0.70 (0.18)	0.18	1.05	110.9 (30.55)	0.50 (0.12)	0.18	1.05	91 (20.44)
Vit B6 (μg)	46.80 (0.03)	21	122.5	65.50 (10.11)	53.90 (14.40)	21	122.5	75.38 (20.19)
Vit B12 (μg)	0.16 (0.03)	0.06	0.35	80.21 (18.79)	0.17 (0.04)	0.06	0.35	82.92 (20.17)
Pholates (μg)	9.42 (1.87)	6	35	46.18 (9.19)	10.72 (2.12)	6	35	52.54 (10.41)

MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; SFA: saturated fatty acids; Ca: calcium; SD: standard deviation; Fe: iron; CM: continuation milk; AM: artificial milk; Tr: Traces; Vit: vitamin.

–: Data is not available.

[a] Mean values of artificial milks composition.

[b] TSR: Technical-Sanitary Regulation from Royal Decree 867/2008.

[c] The compliance percentage has been calculated with the mean minimum and maximum values of the Technical-Sanitary Regulation using the formula: Composition in 100 ml of infant formula/TSR mean value by 100 ml × 100 = infant formula compliance % with TSR.

Table 3 Energy and nutrient content of breast milk and initiation artificial milk. Compliance percentage.

Nutrient	Breast milk Composition in 100 ml[b]	Initiation milk[a] Composition in 100 ml[c], Mean (SD)	Adequacy % of AM in comparison with BM[d] Mean (SD)	Growth milk Composition in 100 ml[c], Mean (SD)	Cow milk Composition in 100 ml[e]	Adequacy % of GM in comparison with CM[d], mean (SD)
Energy (kcal)	70	67.10 (1.87)	95.85 (2.84)	76 (7.37)	62	119.76 (11.48)
Proteins (g)	0.9–1.1	1.45 (0.21)	145.27 (21.03)	2.48 (0.45)	3.2	73.03 (8.09)
Glucides (g)	6–7	7.36 (0.23)	113.23 (3.39)	9.06 (1.61)	4.6	161.33 (32.86)
Lipids (g)	4.2	3.51 (0.15)	83.57 (4.18)	3.3 (0.02)	3.6	89.18 (7.02)
Ca (mg)	34	51.63 (8.01)	151.84 (23.56)	108.33 (2.31)	119	90.27 (0.48)
Fe (mg)	0.076	0.72 (0.09)	947.36 (104.48)	1.03 (0.17)	0.1	2183.3 (577.3)
Retinol (μg)	55	66.03 (6.93)	120.05 (12.61)	97 (16.74)	39	323.33 (127)
Vit D (μg)	0.1	1.40 (1.40)	1400 (207.84)	1.73 (0.46)	Tr	–
Vit E (mg)	0.35	1.09 (0.43)	341.66 (134.96)	1.36 (0.05)	0.07	1518.5 (128.3)
Vit C (mg)	44	9.54 (2.16)	21.69 (4.92)	5.66 (3.69)	1	193.33 (67.35)
Thiamine (μg)	15	58.92 (10.16)	392.81 (67.75)	26.66 (0.1)	50	52.07 (15.60)
Riboflavin (μg)	35	101.08 (21.46)	288.79 (61.33)	146.66 (0.04)	170	81.48 (25.66)
Niacin (mg)	0.23	0.70 (0.18)	391.50 (107.82)	1.12 (1.62)	0.9	123.12 (11.47)
Vit B6 (μg)	13	46.80 (0.03)	360.25 (55.60)	36.66 (0.09)	46	79.71 (12.55)
Vit B12 (μg)	0.05	0.16 (0.03)	328.88 (77.07)	0.26 (0.05)	0.18	89.49 (13.74)
Pholates (μg)	5.2	9.42 (1.87)	181.15 (3.06)	14.33 (12.12)	3	458.33 (360.8)

Ca: calcium; SD: standard deviation; Fe: iron; GM: growing up milk; AM: artificial milk; BM: breast milk; CM: cow milk; Vit: vitamin; –: no data available.

[a] Initiation milks from Table 1.

[b] Data extracted from Tratado de Nutrición Ángel Gil, 2010.

[c] Mean compositional values of artificial milks.

[d] To calculate the compliance % the mean values of energy, proteins, glucides and lipids in breast milk has been calculated.

[e] Data taken from the Spanish food composition table, Mataix Verdú.

which has been used to perform the analysis of their nutritional composition.

Our results show that the content of energy and macronutrients in initiation and continuation milks complies with the TSR European directive.[4]

Likewise, these milks have an energy and macronutrient content that is close to the values established in the RDI in the period from 0 to 6 months; and for children aged 6–12 months these values meet 36% of energy requirements and between 40% and 50% of macronutrient requirements. Initiation and continuation milks contain vitamins and minerals within the average range of the TSR,[4] but the nutritional content is much higher than the values established by the RDI for retinol (133.5%) vitamin E (166%), vitamin C (174%), thiamine (179%), riboflavin (230%), niacin (151%), vitamin B_6 (142%), vitamin B_{12} (500%) and folates (214%) in initiation milks, and for vitamin B_{12} (283%) in continuation milks. This may imply an excessive, and even harmful, nutritional content, since the RDIs are based on the appropriate intake to maintain the health of practically every healthy individual in the group,[14] and they are calculated by organisations and corporations expert in nutrition that edit their own reference values.[15,16] The concentration of micronutrients in initiation milks exceeds E, C, B-group vitamin and folate content by 140%. The toxicity of vitamin C, since it is a hydrosoluble vitamin, is very low, as excess intake increases renal excretion.[17] Different studies have associated the high levels of vitamins in infant formulas with an increase in fat mass, obesity and diabetes,[18] but these studies should be interpreted with caution, since there are other genetic and environmental factors that may affect the development of these pathologies. In accordance with Gale et al.,[19] feeding with infant formulas leads to a higher accumulation of fat, which may later represent a higher risk of obesity. This study shows a difference in body composition between breast-fed children and formula-fed children. Breast-fed children have higher fat mass until they are 8 months old and this tendency is reversed at 12 months. There is no further follow-up, and it is therefore unclear how these children develop later. The PROBIT study[20] does not show any difference in weight, size or adiposity at 6.5 years when comparing breast-fed children and artificial milk-fed children, although there was a difference at 1 year of age. Several studies show that an above-normal weight increase in children during the first 2 years of their life is associated with a greater risk of obesity in the future.[21,22]

Continuation milks contain levels of vitamin B_{12} (283%) that exceed the daily RDI values. It is interesting to note that, at 6 months of age, the child does not only receive this type of milk but also complementary feeding, so the intake of micronutrients would be more elevated. This does not breach regulations, since it complies with the TSR,[4] but it should be reviewed because it could be harmful.

Another reason why the TSR[4] should be reviewed in initiation milks is that if we compare them with breast milk, which is the *gold standard* of childhood feeding and whose nutritional composition is taken as reference, we find elevated concentrations of proteins and much higher levels of micronutrients such as calcium (152%), iron (947%), vitamin D (1400%), vitamin E (342%), thiamine (393%), riboflavin

Table 4 Percentage of nutritional requirements met artificial milks.

Nutrient	Initiation milk			Continuation milk			Growing up milk		
	Content in 910 ml of AM, mean (SD)	RDI 3 m	% of requirements met with 910 ml, (SD)	Content in 500 ml of CM[a], mean (SD)	RDI 9 m	% of requirements met with 500 ml, (SD)	Content in 500 ml of GM[a], mean (SD)	RDI 18 m	% of requirements met with 500 ml, (SD)
Energy (kcal)[b]	610.71 (17.06)	650	93.95 (2.62)	341 (4.59)	950	35.89 (0.48)	380 (39.05)	1250	30.40 (3.12)
Proteins (g[b])	13.22 (1.91)	14	94.43 (13.67)	8.5 (1.54)	20	42.50 (7.72)	12.41 (1.37)	23	53.98 (5.98)
Glucides (g)[c]	66.98 (2.16)	60[a]	111.64 (3.60)	42.02 (1.66)	95[a]	44.23 (1.74)	45.33 (8.21)	130	34.87 (6.32)
Lipids (g)[c]	31.95 (1.42)	31[a]	103.06 (4.60)	15.35 (0.85)	30[a]	51.16 (2.83)	16.50 (1.29)	NA	–
Ca (mg)[b]	469.81 (72.92)	500	93.96 (14.58)	368.50 (39.65)	600	61.41 (6.60)	541.66 (2.88)	800	67.70 (0.36)
Fe (mg)[b]	6.59 (0.83)	7	94.17 (11.87)	5.25 (0.42)	7	75 (6.07)	5.16 (1.15)	7	73.80 (16.49)
Retinol (μg)[b]	600.85 (63.13)	450	133.52 (14.02)	341 (28.84)	450	75.77 (6.41)	485 (190.52)	300	161.66 (63.50)
Vit D (μg)[b]	9.65 (1.40)	10	96.56 (14.00)	6.15 (0.66)	10	61.50 (6.68)	8.66 (3.75)	10	86.66 (37.52)
Vit E (mg)[b]	9.94 (3.93)	6	165.82 (65.50)	6.55 (2.44)	6	109.25 (40.78)	6.83 (0.57)	66	10.35 (0.87)
Vit C (mg)[b]	86.85 (19.71)	50	173.70 (39.42)	57.95 (13.34)	50	115.90 (26.68)	28.33 (31.75)	55	51.51 (57.73)
Thiamine (μg)[b]	536.19 (92.48)	300	178.73 (30.82)	383.50 (129.87)	400	95.87 (32.46)	133.3 (28.86)	500	26.66 (5.77)
Riboflavin (μg)[b]	919.80 (195.34)	400	229.95 (48.83)	638.50 (216.21)	600	106.41 (36.03)	733.33 (230.94)	800	91.66 (28.86)
Niacin (mg)[b]	6.05 (1.66)	4	151.41 (41.70)	2.73 (0.61)	6	45.50 (10.22)	5.63 (8.97)	8	70.41 (112.22)
Vit B6 (μg)[b]	426.18 (65.78)	300	142.06 (21.92)	269.50 (72.20)	500	53.90 (14.44)	183.33 (28.86)	700	26.19 (4.12)
Vit B12 (μg)[b]	1.49 (0.35)	0.3	498.81 (116.89)	0.85 (0.20)	0.3	283.33 (68.94)	1.33 (0.28)	0.9	148.14 (32.07)
Pholates (μg)[b]	85.74 (17.06)	40	214.35 (42.66)	53.60 (10.61)	60	89.33 (17.69)	71.66 (72.16)	100	71.66 (72.16)

CM: continuation milk; GM: growing up milk;AM: artificial milk; Ca: calcium. SD: standard deviation; Fe: iron; NA: not available; Vit: vitamin; –: no data available.

[a] AI: Adequate Intake. (a, b, c) children aged 3, 9 and 18 months consume 910, 500 and 500 ml of formula respectively according to the recommendations made by the Clínica Universidad de Navarra, 2011.

[b] RDI: Recommended dietary intakes for the Spanish population, 2009.

[c] DRI: Dietary Reference Intakes from the Institute of Medicine of the National Academies of the United States and Canada, 2002.

(289%), niacin (392%), vitamin B_6 (360%), vitamin B_{12} (329%) and folates (181%), although they all fall within the permitted range. According to the study by Weber et al.,[23] the excess of proteins in infant formulas affects the body mass index (BMI) and increases the risk of suffering from obesity during school years. However, the protein content of the milks included in this study is higher than that of our study, since the amount of proteins contained in initiation formulas in Spain, which are included in the study tables, ranges from 1.2 to 1.6 g/dl, in comparison with 1.25–2.05 g/dl in the study by Weber et al. As for continuation milks, the case is, if applicable, more remarkable, since Spanish formulas range from 1.3 to 2 g/dl, in comparison with 1.6–3.2 g/dl in the study by Weber et al.

As for iron intake, an elevated daily intake may have negative consequences with regard to the absorption of other minerals,[24] pro-oxidant effects[25] and harmful symptoms in diseases in which iron absorption is increased.[26] Since the bioavailability of iron is lower in artificial milks than in breast milk, the amounts that should be provided in artificial milks are higher.[13] As for vitamins, several studies have demonstrated that babies fed with infant milks have higher plasma vitamin levels than breast-fed infants.[27–29] Moreover, it is widely known that feeding with infant formula[30,31] and breast milk enriched with micronutrients[32,33] may lead to a rapid weight increase, which is a risk factor for the development of obesity.[34–36] As for growth milks, they are supplemented with micronutrients such as iron (2583.3%), retinol (232.33%), vitamin D (2889%), vitamin E (1518.5%), vitamin C (193.33%), niacin (1251.85%) and folates (358.33%). However, we believe supplementary vitamins and minerals would not offer any benefit to the average infant population, as observed in adults,[37–39] although it would be necessary to perform specific studies in children on the extra contribution of vitamins and minerals.

Taking into account the recommendations in force for artificial milks with respect to energy and nutrient intake, all these fall within reference values, so they comply with the TSR.[4] Although initiation milks comply with the reference values, their consumption guarantees, and in most cases exceeds, the RDI, so there is an excess of nutrient supplementation. After reviewing the different aspects of the composition and supplementation of infant formulas, we are concerned that the reference values for artificial milks and the RDI for 0- to 6-month infants appear to be significantly elevated when compared with breast milk.

The standard analysis of artificial milks in Spain shows that they comply with the nutritional needs with regard to energy, macronutrients, calcium and iron, most requirements.

In conclusion, although the nutritional composition of infant milks falls within the TSR reference values[4] with regard to energy and macronutrients, it would be necessary to review and improve the contribution of micronutrients based on the infant's nutritional requirements and taking into account the possible adverse effects.

At present, there is insufficient scientific basis to conclude that infant formulas rich in vitamins may be ''to a large extent'' the cause of the current obesity epidemics.

Conflict of interest

The authors declare that there are no conflicts of interest.

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