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Determination of iodine in human milk and infant formulas

Luisa Maria Fernández-Sánchez[a,*], Pilar Bermejo-Barrera[a], José Maria Fraga-Bermudez[b], Joanna Szpunar[c], Ryszard Lobinski[c]

[a]*Department of Analytical Chemistry, Nutrition and Bromatology, Faculty of Chemistry, 15782 Santiago de Compostela, Spain*
[b]*Department of Pediatrics, Hospital Clinico Universitario, 15706 Santiago de Compostela, Spain*
[c]*LCBAIE, UMR 5254 CNRS, Hélioparc, 2 Avenue Du Pr. Angot, 64053 Pau-Pyrénées, France*

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Abstract

The aim of this study was to develop a method to determine iodine in human milk and infant formulas using ICP-MS. The milk samples were digested using an alkaline digestion (5% NH_3, 45 W, 2 min and 30 s), and the method was validated using a certified reference material (CRM) BCR CRM151. On the other hand the milk was separated in three fractions, whey, fat and caseins using ultracentrifugation (15 min, 4 °C, 50,000 rpm) and the iodine was determined in the different fractions. About 27 samples of different infant formulas and 14 samples of human milk have been studied. In the human milk the values found were between $144 \pm 93.2\,\mu g\,kg^{-1}$, whereas in the infant formulas the values were 53.3 ± 19.5. For both types of samples the bigger amount of iodine is in the whey fraction, between 80% and 90%, whereas in the fat there is about a 2% of the total iodine and in the casein fraction the levels are between 5% and 10% depending on the type of sample.

Keywords: Human milk; Infant formulas; Iodine; Alkaline digestion; ICP-MS

Introduction

Iodine is an essential micronutrient to animals and man. It is a constituent of the thyroid hormones the lack of which causes poor mental and physical development in children and goiter in adults [1]. In early infancy, breast milk and formulas are the only dietary source of essential trace elements. The mother's milk provides an adequate supply of all micronutrients for the full-term infant. The concentrations of the essential trace elements in human milk are therefore used as in Ref. [2]. In infant nutrition the iodine level in breast milk is known to be affected by the maternal diet whereas infant formula needs to be supplemented with iodine [3]. Since excessive intake of iodine can cause toxic goiter (thyrotoxicosis) the supplementary iodine should be strictly limited and controlled by manufacturers and government institutions [4].

Due to the low levels of iodine in milk it is necessary to use an analytical technique with low detection limit, for example the ICP-MS. Since problems were encountered during the direct determination of iodine in milk by ICP-MS, the sample digestion it is necessary [5,6]. In this paper a rapid open-vessel focussed microwave assisted digestion was developed for this purpose.

Material and methods

Instrumentation

An ELAN 6000 ICP mass spectrometer (PE-SCIEX, Thornhill, Ontario, Canada) was used as the element-

*Corresponding author.
E-mail address: lusfersan@gmail.com (L.M. Fernández-Sánchez).

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specific detector. The sample was introduced into the ICP via cross-flow nebulizer fitted in a Ryton spray chamber. For quantification of iodine the samples were fed by means of a Minipuls 3 peristaltic pump (Gilson, Villiers-le-bel, France) that also served for draining the spray chamber.

A Hitachi Model Himac CS 120GX refrigerated ultracentrifuge (Jouan, Saint Herblain, France) was used for the separation of the milk whey. The samples were digested in a 22 mL open vessel of borosilicate glass fitted with a 10 cm condenser using Synthewave S402 microwave digester (2.45 GHz, maximum power 300 W) (Prolabo, Fontenay-sous-Bois, France).

Reagents, standards and samples

Analytical-grade reagents purchased from Sigma-Aldrich (St. Quentin Fallavier, France) were used throughout unless specified otherwise. 18 MΩ Milli-Q

Table 1. Total iodine in different infant formulas

	[I] μg per 100 g infant formula			
	Whole milk $n = 3$	Milk whey $n = 3$	Fat $n = 3$	Casein $n = 3$
"*Nestlé*"				
Nativa-1	46.5±2.8	18.5±2.5	2.5±0.9	1.5±0.9
Nidina-1	41.5±4.0	40.2±3.4	4.1±1.1	2.3±1.1
Nativa-1'	43.5±2.1	37.8±4.3	2.9±1.2	1.2±0.7
Nidina-1'	66.9±8.9	61.9±5.7	12.4±2.5	2.2±0.9
Nan-1	57.6±3.5	34.6±2.6	5.3±1.9	6.7±1.8
Nidal	47.4±3.3	24.4±5.1	3.1±1.2	3.5±2.1
"*Milupa*"				
Aptamil	50.0±3.7	20.0±4.2	1.9±0.6	6.4±2.1
Milumil 1	48.8±2.9	25.9±5.1	8.7±1.1	7.3±1.7
"*Ordesa*"				
Blemil Plus 1	51.2±3.6	30.0±3.4	5.2±1.8	4.1±2.1
Blevimat	54.2±5.8	52.7±2.6	2.1±0.9	1.8±0.5
"*Meed Johnson*"				
Enfalac-1	43.6±0.21	30.1±1.2	2.5±0.7	4.9±1.2
Enfalac-1'	52.8±3.9	14.9±1.1	3.1±0.7	2.50±1.1
Enfamil	62.2±1.3	42.1±4.2	6.5±1.6	5.1±1.2
"*Sandoz-Nutrición*"				
Modar 1	33.0±1.2	22.1±2.1	2.1±0.4	1.7±0.2
Adapta 1	36.1±3.2	16.1±1.7	3.2±0.6	4.3±0.9
Damira	21.1±4.1	15.1±2.1	1.2±0.3	1.1±0.8
Modar digestión	54.9±2.1	49.8±1.6	2.7±0.4	2.3±0.7
"*Nutricia*"				
Almirón-1 A.R.	53.8±1.6	50.4±1.8	1.5±0.5	1.2±0.6
Almirón-1	109.8±5.0	100.6±4.2	7.3±1.2	1.9±0.9
Almirón PEPTI	101±10.4	80.6±4.2	4.1±1.3	3.3±1.2
"*Granja Castelló*"				
Nadó	68.8±4.0	48±2.5	15.7±0.6	3.8±1.0
"*Miltina*"				
Miltina	35.6±2.2	24.1±2.5	2.5±1.1	1.6±0.9
"*Wyeth*"				
S-26	38.3±3.9	31.7±3.5	2.7±1.0	1.8±0.6
Natal SMA-Nutribén	58.3±1.5	39.9±2.5	6.3±2.2	5.3±1.4
"*Similac Ross Products*"				
Similac Ross Pediatric-1	42.1±6.7	31.3±3.3	8.3±3.4	4.1±0.7
Similac Ross Pediatric-1'	82.3±5.6	74.7±4.7	2.1±1.1	7.7±0.8
"*Hero*"				
Hero baby	38.9±1.1	10.5±0.7	6.2±2.4	6.7±2.1