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Analytical Methods

Mineral profile of Spanish commercial baby food

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A B S T R A C T

Commercial baby foods are an important part of the daily intake of babies from 6 to 12 months. The mineral profile of commercial baby foods in Spain was determined to establish levels of essential and non-essential elements, and their contribution to adequate intake (AI) and estimated average requirement (EAR). Thirty-five jars of commercial foods containing meat, fish, vegetables and fruit were obtained from the Spanish market and the mineral composition determined for 14 elements. In general, the baby foods analysed were sufficient for an adequate mineral intake, but contributions to AI and EAR for iron, zinc and calcium were very low (5–20%, 10–60% and 10–70%, respectively). This deficiency could be associated with growth problems or diseases in adulthood, and fortification of commercial products is recommended.

1. Introduction

Adequate nutrition during infancy and early childhood is essential to ensure the growth, health, and development of children to their full potential. Poor nutrition increases the risk of illness in adulthood. Early nutritional deficits are also linked to long-term impairment in growth and health (WHO, 2009). From the age of 6 months, infants' needs for energy and nutrients start to exceed that provided by milk alone and thus, complementary feeding becomes necessary to fill the energy and nutrient gap (WHO, 2008). Complementary foods must be introduced at this age and their absence or inappropriate composition can affect growth and development. Complementary foods need to be safe and nutritionally adequate meet energy and nutrient needs (WHO, 2009).

In recent years, commercial baby jars have become an important part of baby food due changes in lifestyle, and because many families do not have time to prepare homemade alternatives. These foods are sometimes the main source of food for babies between 6 and 12 months; therefore, detailed analysis of the mineral content is of particular interest to ensure infants have a balanced diet to develop properly (Melo, Gellein, Evje & Syversen, 2008; Okesli, González-Bermúdez, Vidal-Guevara, Dalmau & Ros, 2011). In the aforementioned context, there are different parameters to be determined in baby food. In the case of essential elements, the recommended daily allowance (RDA), the adequate intakes (AI) and the estimated average requirement (EAR) must be considered. RDA is 'the amount of a nutrient that a healthy person should eat each day on average through diet to maintain good health', defined by the Food and Nutrition Board of the US National Academy of Sciences (Food and Nutrition Board, 2004). AI are the recommended average daily intakes based on observed or experimentally determined nutrient intake in a group of apparently healthy people that are assumed to be adequate; used when a RDA cannot be determined. EAR is the average daily nutrient intake level that meets the needs of 50% of healthy individuals in a particular age and gender group. For iron and zinc, EAR can be used as an estimation of the risk (%) for low intakes (Butte et al., 2010). In the case of toxic elements, the tolerable upper intake level (UL) is the most common parameter for non-essential elements used to evaluate safety limits for babies. It is an estimate of the highest level of intake that carries no appreciable risk of adverse health effects (EFSA, 2006).

In the literature, there are a large number of studies on breast and formula feeding, but there are few studies of complementary feeding (as baby foods) between 6 and 12 months, which according to European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) is the period where major changes occur in both macronutrients and micronutrients intakes (ESPGHAN, 2008). Thus, an exhaustive analysis of baby food mineral composition for this age group is essential. Table 1 shows currently available literature describing the analysis of essential and

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Table 1
Published literature on the mineral composition of baby foods.

Sample	Country	n	Elements	Technique	References
Commercial baby food of vegetables (16) and fruits (16)	Belgium	32	Ca, Fe, Zn	FAAS	Bosscher et al. (2002)
Commercial baby food of chicken based (10) and hake based (4)	Spain, UK, China, USA	14	Ca, Na, Fe, Cu, Zn, Mn, Se, Cr, Co, Ni, As, Pb, Cd, Hg	ICP-MS, AAS	Carbonell-Barrachina, Ramirez-Gandolfo et al. (2012)
Commercial baby food of chicken based (11) and fish based (8)	Spain, UK, China, USA	19	As	ICP-MS, HPLC-ICP-MS	Carbonell-Barrachina, Wu et al. (2012)
Commercial baby food of vegetable based	Nigeria	4	Ca, Cu, Fe, K, Mg, Mn, P, Zn	ICP-OES	Fernandez et al. (2002)
Commercial baby food of meat, fish, vegetables and fruit	Norway	72	Al, Ca, Co, Cr, Cu, Fe, K, Mg, Mo, Na, Ni, Zn	HR-ICP-MS	Melo et al. (2008)
Commercial and homemade baby food of lamb (4), beef (4) and chicken (4)	Spain	12	Na	FAAS	Okesli et al. (2011)
Commercial baby food	Italy, Spain, Slovakia, Sweden	112	Cd, Zn	ICP-OES, ICP-sf-MS	Pandelova et al. (2012)
Total Diet Survey	New Zealand		Fe, Na, Se	ICP-OES	Thomson et al. (2008)
Commercial baby food of meat (12) and vegetables (12)	UK	24	Ca, Cu, Mg, Fe, Zn, K, Na, Se	ICP-OES, ICP-MS	Zand et al. (2011)
Commercial baby food of chicken based (4) and fish based (4)	UK	8	Ca, Fe, Mg, K, Na, Zn, Se, Mo, Co, Cu, Cr, Mn, As, Ba, Ni, Cd, Sb, Pb, Hg, Al	ICP-OES, ICP-MS	Zand et al. (2012)

Note: Parentheses indicate the number of samples of each type of baby food analysed in each study. FAAS: Flame atomic absorption spectroscopy. AAS: atomic absorption spectroscopy. ICP-MS: inductively coupled plasma mass spectrometry. HPLC–ICP-MS: high performance liquid chromatography–inductively coupled plasma mass spectrometry. HR-ICP-MS: High resolution-inductively coupled plasma mass spectrometry. ICP-sf-MS: inductively coupled plasma sector field mass spectrometry.

non-essential elements in complementary baby foods, and it can be seen there are only a few references, which are often based on a limited number of elements (1–3) or the analyses of only a reduced number of samples. Considering the analytical approaches, it is clear the analysis of baby food mineral content requires accurate and sensitive techniques that allow multi-element determination. The use of optical emission spectroscopy with inductively coupled plasma (ICP-OES) and inductively coupled plasma mass spectrometry (ICP-MS) can be useful for determining the mineral profile of infant foods, in particular pureed and hermetically packaged ready meal (jars).

The main purpose of this study was to determine the level of essential and non-essential elements in commercially available baby foods in Spain and evaluate intake of essential elements as well as assessing the risk of exposure to toxic minerals.

2. Materials and methods

2.1. Sample collection

Thirty-five baby food samples (four brands, 1–4) available across the Spanish market sector were purchased. The samples were classified based on basic composition; meat (17), fish (7), vegetables only (5) and fruits only (6). The composition of each baby food sample analysed in this study is detailed in Table 2. Baby foods collected were recommended for children aged 6–12 months.

2.2. Apparatus

ICP-OES measurements were performed using a Perkin Elmer, Model Optima 5300 DV spectrometer (Norwalk, CT, USA) equipped with an auto sampler AS 93-plus and a cross flow nebulizer. Argon C-45 (purity higher than 99.995%), supplied by Carburos Metálicos (Barcelona, Spain), was employed as plasmogen and carrier gas.

A microwave laboratory system, Ethos SEL from Milestone (Sorisole, Italy), equipped with a thermocouple probe for automatic temperature control and an automatic gas leak detector, was employed for samples digestion using high pressure Teflon vessels of 100 mL inner volume. Teflon vessels were cleaned with vapours of nitric acid (69%), using the Trace CLEAN from Milestone (Sorisole, Italy) to avoid cross-contamination.

Other equipment used for sample pre-treatment included a Cryodos 50 lyophiliser Telstar (Barcelona, Spain) and an ultrasound water bath from Selecta (Barcelona, Spain, 9 L, 50 W, 50 Hz).

2.3. Reagents

A multi-element standard solution (100 mg L^{-1}) containing 26 elements (Al, As, Ba, Be, Bi, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mg, Mn, Mo, Ni, K, Se, Na, Sr, Tl, Ti, V and Zn) dissolved in 5% HNO_3 from Scharlau (Barcelona, Spain) was used to prepare the calibration standards. Additionally, a 1 g L^{-1} sodium standard solution for atomic absorption and 1 g L^{-1} potassium standard solution for atomic absorption, both from Scharlau, were employed for calibration.

A 1 g L^{-1} scandium atomic spectroscopy standard solution was purchased from Fluka (Buchs, Switzerland) and used an internal standard.

Nitric acid (HNO_3 69%) for trace analysis and hydrogen peroxide (H_2O_2 35%) reagent grade, both from Scharlau, were used for sample digestion.

All solutions were prepared with analytical reagent grade chemicals and ultrapure water (18 MΩ·cm) obtained by purifying distilled water with the Milli-Q Millipore system (Molsheim, France).

2.4. Sample pre-treatment

Baby food purée samples were poured into different containers and frozen at −20 °C in a freezer before lyophilisation. They were lyophilised for a minimum of 48 h at a chamber pressure of 50 Pa. Powdered samples were homogenised in a domestic Braun mixer (Kronberg, Germany) and stored in polyethylene bottles until analysis.

The water content of samples varied between 76.6% and 87.6%, and moisture was independent of brand and composition of baby food.

Freeze-dried samples (1 g) were accurately weighed into the Teflon digestion vessels and 8 mL of nitric acid were added, before being sonicated in an ultrasound water bath for 30 min at room temperature. Then 2 mL of hydrogen peroxide were added and the mixtures sonicated again for further 40 min. This approach was used to avoid foam formation and gas leaks during digestion. After that, the reactors were closed and placed inside the microwave oven. The