An Executive Summary

Determination of Essential and Trace Elemental Content in Infant Foods by ICP-MS

How ICP-MS can ensure adequate infant nutrition and monitor toxic contaminants.

Dr. Piyush Deokar
Application Specialist, TEA, CMD
Thermo Fisher Scientific
India Pvt. Ltd

Chandrakant Pawar
Application Specialist, TEA, CMD
Thermo Fisher Scientific
India Pvt. Ltd

Dr. Biswajayee Airaraj Patra
Senior Product Manager
Thermo Fisher Scientific
India Pvt. Ltd

Introduction

The first year of human life is a critical period in the development of a child. Adequate nutrition during infancy and childhood is essential to ensure the growth, health, and development of children. Nutritional deficiencies during the first two years of life increase the risk of certain chronic problems in adulthood and the failure to achieve full growth potential.

The ability of breast milk to support a baby's requirements for macronutrients and micronutrients decreases as the baby grows. So, timely introduction of complementary food during infancy and early childhood may be necessary for both nutritional and developmental reasons. These complementary foods must be sufficient in terms of their nutritional composition, consistency, and bioavailability of nutrients. Microbial contamination of infant food and beverages as well as the replacement of breast milk by less nutritious alternatives should be avoided.

Figure 1 summarizes the recommended amounts of several essential elements for proper nutrition for infants ages seven to 12 months old. *Adequate intake* (AI) is the recommended average daily nutrient intake based on observed or experimentally determined approximations of nutrient intake by healthy individuals. *Recommended daily allowance* (RDA) is equivalent to recommended nutrient intake (RNI) and is the average daily nutrient intake that is sufficient for nearly all (97–98%) healthy individuals in a particular age and gender group to meet the nutrient requirements. One can see that nutritional requirements vary by region.

Given the importance of proper nutrition during infancy and early childhood, it is important to determine the essential and trace elemental content in complementary foods for babies.

Analysis of Complementary Infant Foods: Sample Preparation and Experimental

A study examined the essential and trace elemental constituents in commercial infant foods intended for the six to 12-month age group. Using a Thermo Scientific™ iCAP™ RQ Inductively Coupled Plasma Mass Spectrometry (ICP-MS) system, analyses were conducted on three randomly chosen commercial products available in a local market.

SPONSORED BY

ThermoFisher SCIENTIFIC

LC|GC north america

Spectroscopy Solutions for Materials Analysis

Sample preparation. For powdered products, the researchers employed coning and fractioning to ensure homogenization before digestion. If the samples are in puree form (which contains 80–85% water), then they must be dried and then digested.

Digestion. The resulting fine powder moves to open-vessel or closed-vessel microwave-assisted digestion. Open-vessel microwave digestion has some major drawbacks. In addition to taking longer, the acid quantity may vary from product to product, and it frequently does not result in a clear solution. Most importantly, volatile elements such as arsenic and mercury may be lost during the digestion process.

In contrast, closed-vessel microwave digestion has gained worldwide acceptance for food samples. A combination of microwave heating and sealed pressure: it is fast, safe, and yields a clear solution. Most importantly, it prevents the loss of volatile elements, thus avoiding the generation of erroneous data. In this infant food study, 250 mg of dry sample was added to 3 mL of nitric acid (HNO_3) and 1 mL of hydrochloric acid (HCl) for a closed vessel digestion process. The digestion yielded a clear solution that was diluted with deionized water before being introduced into the ICP-MS system.

Due to the complexity of the food matrix, four internal standards were used. Recoveries were acceptable, ranging from 80% to 120% of their expected concentrations. To ensure even better data quality, spike recovery studies were performed at 10, 20, and 30 parts per billion (ppb). Spikes are a known quantity of standard that are added to each sample and then undergo the entire preparation process. The final data was calculated to confirm that the known amount was observed.

Helium gas introduction and the kinetic energy distribution (KED) technique were used to overcome polyatomic interferences. Macronutrients, micronutrients, and toxic elements were analyzed simultaneously on the iCAP RQ ICP-MS instrument. Instrument parameters are noted in **Figure 2**.

Figure 1: Recommended daily intake values of essential elements.

Elements	USA and Canada (AI)	Australia & New Zealand (AI)	WHO (RDA)	Europe (RDA)
Ca (mg/day)	260	270	400	450
Cr (μg/day)	5.5	5.5		10
Cu (μg/day)	220	220		400
Fe (mg/day)			7.7	8
K (g/day)	0.7	0.7		0.7
Mg(mg/day)	75	75	54	75
Mn (mg/day)	0.6	0.6		0.7
Mo (μg/day)	3	3		15
P(mg/day)	275	275		350
Se(μg/day)	20	15	10	15
Zn (mg/day)			4	4

Figure 2: Parameters used on the Thermo Scientific iCAP RQ Inductively Coupled Plasma Mass Spectrometry system for the analysis of essential and trace elements in baby food.

Parameters	Value
Forward Power	1550 W
Nebulizer Gas	1.145 L/min
Auxiliary Gas Flow	0.8 L/min
Cool Gas Flow	14 L/min
QCell Conditions	4.272 mL/min at ^{2}He, 3V KED
Sample uptake/wash time	45 s each
Dwell Time	0.05 s
Number of Repeats per sample	3

Analysis of Complementary Infant Foods: Analysis and Results

Four-point calibrations of 50 to 300 ppb of the macronutrients sodium, magnesium, phosphorus, and potassium were performed in 0.1% HNO_3 and 0.05% HCl. **Figure 3** shows the quantities of these nutrients that were found in the three infant food samples. All nutrients were in the range of 90–100% of their labeled claims with the exception of sodium content in the third sample, which was found to be low.

"ICP-MS facilitated the simultaneous determination of multiple elements in the complex matrix, leading to the discovery of quality issues in one of the food products."

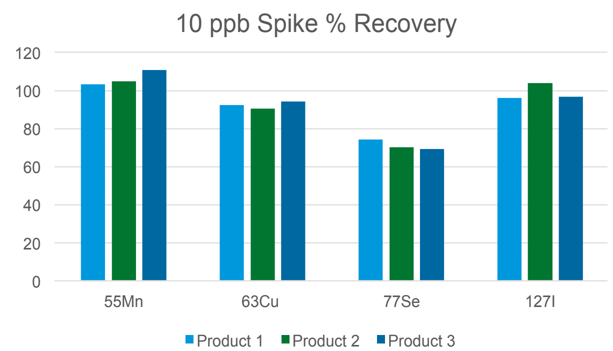
Micronutrients, also referred to as trace elements, included manganese, iron, copper, zinc, selenium, and iodide. Eight-point calibrations were generated for each, from 0.1 ppb to 100 ppb in 0.1% HNO_3 and 0.05% HCl. Measured concentrations of these trace elements in infant foods are shown in **Figure 4**. The data for Sample 3 revealed variations from claimed amounts for almost all of the micronutrients, while concentrations in Samples 1 and 2 ranged from 80% to 120% of their claims.

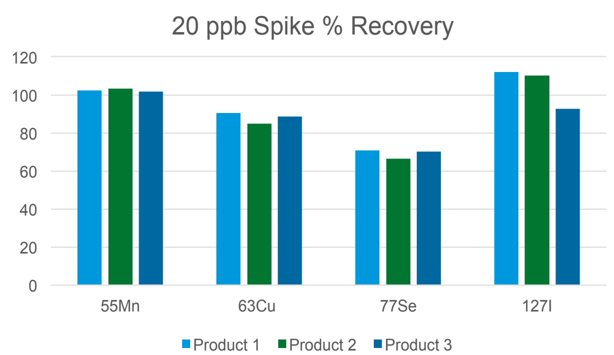
Figure 3: Measurememts of macronutrients found in three samples of baby food.

Isotope	IDL (LOD) (ppb)	Sample 1	Sample 2	Sample 3
		Measured	Measured	Measured
^{23}Na	0.247	0.388%	0.386%	0.160%
^{24}Mg	0.147	0.063%	0.050%	0.066%
^{31}P	1.676	0.438%	0.452%	0.421%
^{39}K	0.554	0.664%	0.662%	0.627%
^{44}Ca	3.840	0.435%	0.460%	0.463%

Figure 4: Measurememts of micronutrients (i.e., trace elements) found in three samples of baby food.

Elements	Product 1	Product 2	Product 3
^{55}Mn	1.108 ppm	0.904 ppm	3.34 ppm
^{56}Fe	100.7 ppm	96.99 ppm	118.9 ppm
^{63}Cu	3.319 ppm	3.495 ppm	5.652 ppm
^{66}Zn	33.53 ppm	39.27 ppm	35.45 ppm
^{77}Se	0.174 ppm	0.173 ppm	0.096 ppm
^{127}I	1.390 ppm	1.604 ppm	0.592 ppm





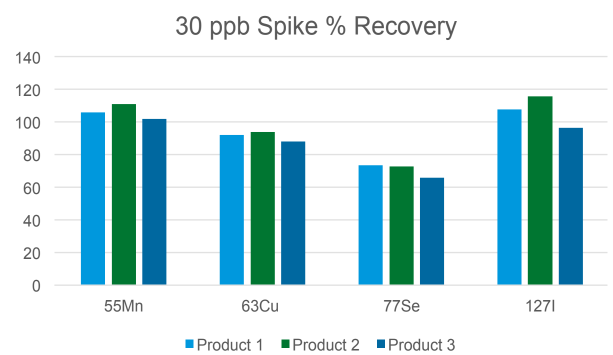
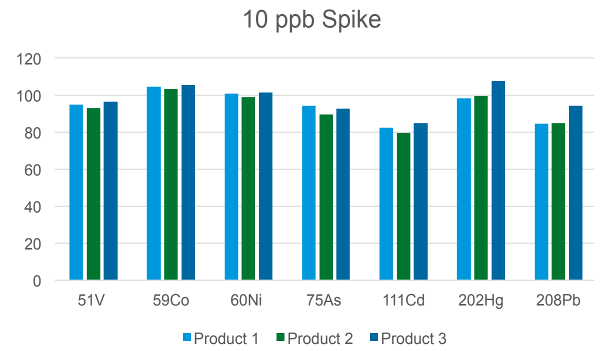
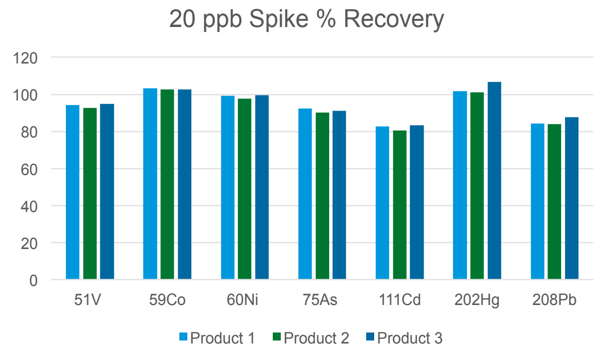
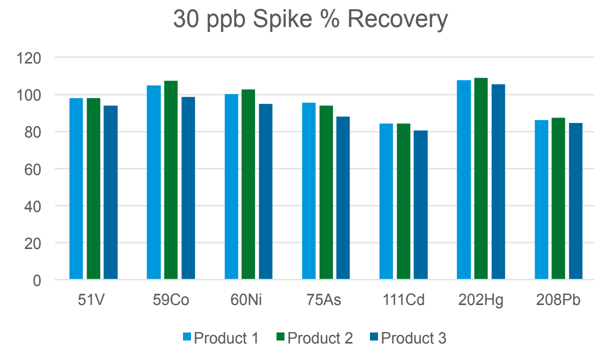


Figure 5: Measurememts of Class 1 and Class 2 elements found in three samples of baby food.

Elements	Product 1	Product 2	Product 3
^{51}V	0.018 ppm	0.021 ppm	0.026 ppm
^{59}Co	0.007 ppm	0.007 ppm	0.007 ppm
^{60}Ni	BDL	BDL	BDL
^{75}As	0.005 ppm	0.005 ppm	0.006 ppm
^{111}Cd	BDL	BDL	BDL
^{202}Hg	BDL	BDL	BDL
^{208}Pb	BDL	BDL	BDL







The study of infant food also included toxic class 1 and 2A elements that are mentioned in the *USP* Chapters <232> and <233>. Eight-point calibrations for vanadium, cobalt, nickel, arsenic, cadmium, mercury, and lead ranged from 0.1 to 100 ppb in 0.1% HNO_3 and 0.05% HCl. As shown in **Figure 5**, only negligible quantities were found in the samples, with most of the concentrations below the ppb detection limits.

Conclusion

The first year of life is a pivotal stage in a child's development. Thus, it is vital to fully assess the nutrient consumption of infants. In this study, 18 essential and toxic elements were analyzed in three dried samples of commercial infant food after closed-vessel microwave digestion. ICP-MS analysis facilitated the simultaneous determination of multiple elements in the complex matrix, leading to the discovery of quality issues in one of the food products.