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Impact of ingredients on the elemental content of baby foods

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Abstract

The levels of the minerals: Ca, K, Mg, Na, P, and the trace elements: Cd, Cu, Fe, Mn, Ni, Pb, Se, Zn were determined in foods for 4-6, 7+ and 10+ months old babies in a brand available on the UK market. The mineral contents in the vegetarian meals for all the age groups were similar, in contrast, when compared to the non-vegetarian options, the Ca, Na and P levels were higher in the former. Both the trace elements and minerals levels in the 4-6 months vegetarian meal were the lowest of all the products analyzed. The Cu, Se and Zn levels in all the meals were comparable to those in mature human breast milk. Calculations of the following molar ratios: Zn:Cu, Fe:Zn, and Fe:Mn, pairs of elements that have been shown to interaction antagonistically, were higher in the vegetarian meals.

KEY WORDS: baby foods, bioavailability, breast milk, dietary requirements, minerals, nutrients, trace elements, vegetarian, non-vegetarian

1. Introduction

Minerals and essential trace elements are crucial for the health, wellbeing and development of infants (Milner, 1990; Bosscher, Deelstra,& van Caillie-Bertrand, 2002; Zand, Chowdhry, Wray, Pullen, Snowden, 2012). Adequate levels of these macro- and micro-nutrients have to be provided in a timely manner in order to ensure that the development of the baby is not adversely affected. Indeed, retardation in development at this early stage of growth when vital biochemical functions are being established could result in effects that last for a lifetime (Caballero 2001; Bosscher et al., 2002; Moute & Gruglian, 2004; Melø, Gellein, Evje, Syversen, 2008; Domellof, 2011; Gregory, Dubois & Steele 2014). It is essential at each stage of development that the right proportions of trace elements and minerals are bioavailable to meet demand. In most parts of the world, complementary foods are used to supplement breast milk from about three months of age to meet the increasing needs of the growing infant, and for reasons of convenience and availability (Alvisi, Brusa, Alboresi, Amarri, Bottau,, Cavagni, Corrodini, Landi, Loroni, Marani, Osti, Povesi-Dascola, Caffarelli, Valeriani, & Agostoni 2015; Holla-Bhar,Iellamo, Gupta, Smith & Dadhich 2015). Ideally, the balance of the bioavailable chemical forms of the nutrients in the complementary foods should mirror those in breast milk. However, this is difficult to achieve in practice for two reasons. The chemical forms of the nutrients in the foods are different from those in breast milk. Moreover, the presence of other dietary components can affect the bioavailability of the minerals and trace elements even if they are present in the required chemical forms (Ekmekcioglu,2000;Windisch,2002; Freeland-Graves, Sanjeevi & Lee, 2015; De Smet &Vossen;2016; Kafaoglu, Fisher, Hill, 2016).

Therefore, it is essential that the amounts of these elements in the diet are not considered in isolation because of the synergistic or antagonistic effects that can result when the levels are not carefully balanced. For example, studies with cashew apple have shown that the bioavailability of copper is closely linked with that of iron and zinc (Silva de Lima, et al., 2014). High levels of zinc can depress the uptake of other elements such as copper and iron (Maret & Sandstead, 2006; Cherfi, Abdoun & Gaci, 2014) and thus affect the levels that are bioavailable. Similarly, high levels of phosphorous can reduce the bioavailability of calcium, iron, manganese and zinc. This is because the main stores of phosphorous in plants, phytates, bind to the mentioned elements decreasing their absorption (Martinez, Rincon, & Ibanez, 2006; Schlemmer, Frelich, Prieto & Grases 2009; Hurrell & Egli, 2010; Gibson, Heath & Szymlek- Gay, 2014). Nutrient bioavailability is extensively covered in a review by Gibson, 2008.

In a bid to deliver the recommended daily allowance for these elements it may be appropriate to fortifying these products with trace elements. In a comprehensive review by WHO/FAO (2006) fortification is recommended as a means of preventing deficiency in micronutrients in the general population. In a recent review on the micronutrient fortification of food and its impact on mother and child health, (Das, Salam, Kumar & Bhutta, 2013) concluded that fortification is an effective strategy but evidence of its impact on morbidity and mortality is lacking. The need to fortify plant-based complementary foods is greater because of the pronounced effects of other food components in limiting the bioavailability of these nutrients (Gibson, Carriquiry & Gibbs,2015) .

It is clear from the above discussion that the levels of these elements have to be carefully controlled in order to ensure that adequate amounts are provided to meet demands but also that the levels are appropriate as not to have detrimental effects on the health of the child. The recommended allowable limits for a variety of elements published by World Health Organization (WHO); European Food and Safety Authority (EFSA) Food and Nutrition Board, Institute of Medicine and National Academies are summarized in Table 1.

A variety of studies have been carried out on the levels of trace elements in baby foods (Melø, Gellein, Evje & Syversen, 2008; Ljung, Palm, Grander & Vahter,2011; Pandelova, Lopez, Michalke

& Schramm 2012; Zand et al., (2012); Carbonell-Barrachina, Ramirez-Gandolfo, Wu, Norton, Burló, Deacon & Meharg, 2012; Chevallier et al., 2015; Daşbaşi, Saçmaci,Ǚlgen & Kartel, 2016). In the study by Pandelova, et al., (2012) the levels of Ca, Cd, Cu, Fe, Hg, Mn, Ni, Pb, Se and Zn were determined in infant beverages, formulae and solid foods sold in the EU market. Daily/weekly intakes of soy-based infant formulae were assessed for 0-9 months old infants who were not breast fed to compare with the safe limits. Results showed that intake of calcium, copper, iron, manganese, selenium, zinc and non-essential elements (lead and nickel) were within the safety limits by European Food and Safety Authority (EFSA). A study by Zand, et al., (2012) in which vegetable and fish based foods for 6-12 months infants were analyzed for Ca, Cu, Fe, K, Mg, Na, Se and Zn found the values below the minimum levels essential for declaration on labels. It is not yet mandatory to declare the mineral and trace element contents of complementary foods. However, it is essential that parents have the information to enable them make informed choices particularly since deficiency or excess in these elements can have adverse consequences for growth and development of the baby.

In all of the above investigations, the focus was on the determination of the levels of the various minerals and trace elements and to compare these to the recommended safe limits. In this study, the levels of eight trace elements namely: Cd, Cu, Fe, Mn, Ni, Pb, Se and Zn and five minerals: Ca, K, Mg, Na and P in a baby food brand from the UK market for 4-6, 7+ and 10+ months old babies were determined in order to establish the impact of food ingredients on elemental content and to compare results in each age category to published breast milk values and safe limits. In addition, the trace elements balance was examined with a view to establish whether there are likely to be adverse interaction effects. The aim of this paper is to highlight an approach that may be useful for a better understanding of the results from the determination of minerals and trace elements in baby foods.

2. Materials and Methods

Twelve baby food samples from a popular brand in the UK were purchased in June 2015. The foods were for three age ranges: 4-6 months, 7+ and 10+ months. Preliminary results from the analysis of similar products were comparable to those reported here. Planned follow-up work will focus on variation between batches and across brands. The age ranges, ingredients and nutritional information declared for the analysed samples are shown in Table 2.

2.1 Reagents

TraceSELECT grade, for trace analysis, nitric acid (69.0% concentrated, Sigma Aldrich, Poole, UK)) was used for sample digestion. Mixed calibration standard solutions of the analytes were made from dilutions of individual 1000mg/L stock solutions (supplied by Sigma Aldrich (Poole, UK) of cadmium, calcium, copper, iron, lead, magnesium, manganese, nickel, phosphorous, potassium, sodium, selenium and zinc. Ultrapure water was prepared in the laboratory (18.2 MΩ/cm at 25^{o}C) using a Millipak 2Φ Millipore (Direct-Q® 8UV, 0.2μm) equipment. Ultrapure water was used throughout.

All the glassware and plastic ware were cleaned in an acid bath made up of 5% nitric acid (laboratory grade, Fischer Scientific, UK), for 24 hours to remove impurities, rinsed with deionised water and dried before use.

2.2 Sample preparation

Samples as received were transferred into 50mL falcon tubes with screw caps and weighed to establish the wet weight. Parafilm was used to seal the falcon tubes with holes made to allow evaporation of water during the freeze drying process in a freeze drier (Labconco FreeZone[6], Fischer Scientific, UK) at -50^{o}C and a pressure of 0.100mbar for 36 hours. The samples were freeze dried to a constant weight then stored in the falcon tubes with screw cap on at room temperature, away from direct sunlight.

2.3 Sample digestion

Before acid digestion, the freeze dried samples were each homogenised to a fine powder in individual pestle and mortar that had been cleaned in the acid bath for 24 hours, rinsed thoroughly with deionized water and dried before use. About 0.5g of each sample was weighed separately into five XP-1500 microwave vessels (CEM, UK) transferred into the fume hood before adding 4ml of concentrated nitric acid. Blank samples consisted of 4ml of nitric acid (69% TraceSELECT for trace analysis grade, Sigma Aldrich, Poole, UK). Both the samples and blanks were left in the fume hood for one hour with their caps left loose in order to allow any gases generated to escape. This was to reduce excess pressure build-up in the microwave vessels during digestion. The caps were tightened, and the samples and blanks vessels were transferred to the carousel, and arranged as recommended by the manufacturer. The carousel was placed securely on the turntable in the microwave oven, and the samples were digested using the following temperature programme: Step 1: Ramp to 210 ^{o}C for 20 mins; Step 2: Hold at 210 ^{o}C for 15 mins.; Step 3: Allow cooling for 30 mins to room temperature.

The vessels were transferred to the fume hood and opened slowly to release the built-up pressure. Acid droplets on the stopper and the interior sides of the vessel were washed down with the minimum volume of ultrapure water and then the whole sample solution was transferred into a 50ml volumetric flask. The vessel was then rinsed twice with 10ml of ultrapure water, and each rinse was carefully transferred into the flask. The volumetric flask was made up to mark with ultrapure water. A 5ml aliquot of the sample was transferred into a 20ml volumetric flask, and 25µl of 1000mg/L stock solution of indium used as the internal standard was added to give a concentration of 1.25µg/ml.

2.4 ICP-MS measurements

Mixed standards for ICP-MS (NexION 350X, Perkin Elmer, US) calibration were prepared by transferring 1mL each of the 1000mg/L stock solutions of cadmium, copper, iron, lead, manganese, nickel, selenium and zinc into a 50mL volumetric flask. The solution was made up to mark with ultrapure water. This 20mg/L intermediate mixed standard was used to prepare calibration standards between 0-100µg/L in 20mL volumetric flasks each containing the same concentration of indium (1.25µg/mL) as in the samples.

2.4.1 Analysis by ICP-MS

The samples were analysed using the conditions recommended for the analysis of elements in food matrices (Perkin Elmer, Application Note on the analysis of elements in food matrices)

2.5 ICP-AES measurements

Five elements (calcium, magnesium, phosphorous, potassium, sodium) were analysed by ICP-AES. Mixed standards for ICP-AES ACTIVA ULTIMA 2 system (Horiba JobinYvon, UK) were prepared by taking 10ml aliquot of 1000mg/L stock solution of each standard (Ca, Mg, K, Na and P) into 100ml volumetric flask. Ultrapure water was added to make up to the mark. Calibration standards between (0-75µg/mL) were prepared in 20ml volumetric flasks to which indium internal standard (1.25µg/mL) had been added.

2.5.1 Analysis by ICP-AES

The analysis was carried out using radial ICP-OES ACTIVA ULTIMA2 system (Horiba JobinYvon, UK). The analysis parameters were similar those recommended by the manufacturer (HORIBA Jobin Yvon, Application Note 48, ICP)

2.6 Recovery Experiments

In order to establish the accuracy of the analyses, similar concentrations of each element as was in the original sample were added to the freeze dried samples and subjected to the same digestion procedure as the samples. For the minerals and the trace elements Cu, Fe, Mn, Ni and Se the recovery values ranged between 80-120%. In contrast, the recovery for Cd and Pb, present at much lower concentration in the samples, ranged between 60-90%

3. Results and Discussion

3.1 Trace elements and minerals in the baby foods

Table 3 presents the levels of trace elements and minerals in the four products designed for the age range between 4-6 months. Product W1 is a vegetable meal with cheese whereas product W2 and W3 contain more vegetables with same amounts of chicken, with apple juice and apple added to the latter. In product W4, chicken is replaced with the same amount of beef. The trace elements and mineral contents in product W2 were the highest in the samples analyzed, with levels up to 4-fold higher than for similar elements in the comparable product W3 to which apples had been added. The trace element levels were all lower in the vegetable based product W1 compared to the non-vegetarian products. In contrast, except for potassium, magnesium and phosphorous, the other minerals (Ca and Na) were higher in product W1 reflecting the cheese content. It is noteworthy that the non-essential elements, cadmium and lead were either undetected or less than 1.2µg/100g.

In similar products for the 7+ months age group (see Table 4), the levels of manganese and zinc were higher in product X1 which is the vegetarian option and with similar ingredients as in product W1 but with corn starch and parsley added. Product X4 in which the beef content had been kept about the same level as in product W4 but with other additional ingredients such as wheat, egg albumen and apple juice as concentrate, the levels of copper, iron, manganese and zinc, and mineral calcium, potassium, magnesium, sodium and phosphorous had dropped to about half of those found in product W4. Except for iron and zinc, the levels of the other elements in the products X1, X2 and X3 were comparable to those in W1, W2 and W3, respectively. Here, as in the previous age category, the cadmium and lead levels were either not detected or less than 1.1µg/100g.

The levels of the elements in the 10+ months meals (see Table 5) were similar to those in the other age groups except for the vegetarian option, Y1 in which the Cu, Fe, Mn and Zn contents were about 3-fold higher than in W1 but similar to those in X1.

As in the other two age groups, the cadmium and lead levels were not detected or less than 0.7 µg/100g.

3.2 Effect of ingredients on elemental content

For this study, we chose to analyze the products from a single manufacturer in order to limit variations in the elemental concentrations due to the sources of the ingredients. Although, there were variations in minor ingredients, but in the main, the major constituents were similar. More importantly, the differences in the mineral and trace element contents could be linked to the quantity of the ingredients used rather than any variations due to their provenance. This observation is borne out when results from similar products are compared. Preliminary examination of all the data from the three age groups indicates that in the non-vegetarian meals, the ratios of the elements remained relatively constant whereas those in the vegetarian meals when compared to the values found in the product W1 and those in products X1 and Y1, respectively showed changes.

These changes in concentrations particularly for an element such as iron for which it has been suggested that its stores are depleted at about six months of age if adequate levels of intake are not maintained are noteworthy. Therefore, it is essential to maintain or boost intake as demand increases with growth (Qasem, Fenton & Friel, 2015) if deficiency is to be prevented. The low levels of trace elements in the vegetarian option in the 4-6 months category is compensated for in the older age categories, even though as expected, the higher concentrations of iron were found in the three non-vegetarian products in all the age categories.

In order to put into context the determined contents of minerals and trace elements in the meals, it is instructive to compare the figures to those in breast milk. The widely quoted breast milk values are those published by WHO in 1989. In putting together the information in Table 6, the results reported in more recent publications have been added. The milk values have been split into two categories: transitory and mature milk, respectively. Infants in the age categories discussed here will obtain their nutrients from mature milk. For easy of comparison, it is assumed that the density of breast milk is similar to that of water. Therefore, the concentration of µg/100ml is taken as equivalent to µg/100g.

The Cu, Se and Zn contents in the meals were comparable to those found in breast milk. The iron contents in all of the meals except in product W1 were at least twice as high as in breast milk. Of the minerals, the potassium and phosphorous levels were consistently higher than in breast milk. The potassium levels in the products W2, X2 and Y2 were four times higher than in mature milk. The high phosphorous content in these products is most probably due to the doubling of the quantity of vegetables. In the case of potassium, it is likely that the high levels may be as a result of its addition in order to reduce the amount of sodium.

In the main, the levels of minerals and trace element nutrients in the meals are comparable to those in breast milk. A variety of studies have shown that based on the contents of these nutrients in breast milk, exclusively breast fed infants may not meet the recommended dietary daily allowances for these elements as they get older (Meinzen-Derr, Guerrero, Altaye, Ortega-Gallegos, Ruiz-Palacios, & Morrow,2006). The combination of these complementary meals with breast milk will undoubtedly increase the levels of the nutrients delivered to the baby. Nevertheless the presence of other constituents in the meals may affect the bioavailability of the trace elements and minerals. It has been suggested that less than 50% of these nutrients are bioavailable in the presence of other food components in a vegetarian diet (Gibson et al, 2014).

The bioavailability of these elements does not only depend on their levels and form in the diet, but also the likely synergistic and antagonistic interactions between them (Windisch,2002; Freeland-Graves, Sanjeevi, Lee, 2015). One such antagonistic interaction is between copper and zinc. The zinc to copper molar ratio in the vegetarian meals, product W1, X1 and Y1 were 23, 31 and 12, respectively whereas similar ratios in the non-vegetarian meals range between4-10. The other likely interactions: Fe and Zn, and Fe and Mn both gave higher ratios in the vegetarian meals. These interactions have been demonstrated at concentration levels that are much higher than those reported here. In a review of the bioavailability of trace elements in vegetarian diets, Gibson, 1994, reported that only at excessive doses of zinc, 150mg Zn/day for 1-2 years that it was found to produce signs of copper deficiency. Similar observations have been made for Fe and Zn, and Fe and Mn interactions for which antagonistic effects were reported when tens of mg/day were ingested. It is therefore probable that at the levels found in these meals, which are lower than the recommended daily allowances for the nutrients elemental interactions are less likely to occur. Of concern is the impact of other food constituents on the bioavailability of the elements present in the foods. Indeed the author concluded that the bioavailability Cu, Zn and probably Mn and Se are adversely affected by the high phytic acid and fibre found in vegetarian diets. For infants on exclusively vegetarian diets, suboptimum uptake of Cu, Fe and Zn is particularly critical as these elements are required for growth and development.

5. Conclusions

Complementary foods are used to supplement breast milk in providing the nutrients that are required for the growth and development of the infant. Not only must the levels of the trace elements and minerals meet the requirements but also the balance of the elements must be such that their bioavailability is not impaired in the gut. The levels of minerals and trace elements in the analyzed meals were comparable to those in breast milk. Furthermore, in the light of evidence from the literature, the expected interactions are thought to be less likely to occur because of the comparatively low levels of the elements in the meals. However, the limiting effects on the bioavailability of the elements by other foods components present in the meals cannot be discounted.

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Tables

Table 1: Safety limits for trace elements and minerals published by the Food and Nutrition Board, Institute of Medicine, National Academies, World Health Organization, and the European Food Safety Authority

Element type	Element	Limits	Units	Source
Non-essential	Cd	2.5µg/kg body weight (bw)	Tolerable Weekly Intake (TWI)	European Food Safety Authority, (EFSA, 2011)
		7µg/kg bw	Provisional Tolerable Weekly Intake (PTWI)	Joint FAO/WHO Expert Committee on Food Additives (JECFA, 2003)
	Pb	25µg/kg bw	PTWI	JECFA, 2002
	Ni	11µg/kg bw	Tolerable Daily Intake (TDI)	WHO, 2007
Essential				
	Se	15µg/day for 0-6 months old 20µg/day for 6-12 months old	Adequate Intake (AI)	Food and Nutrition Board, 2002, Institute of Medicine, National Academies
	Cu	200µg/day for 0-6 months old. 220µg/day for 6-12 months	AI	Food and Nutrition Board, 2002, Institute of Medicine, National Academies
	Fe	0.27mg/day for 0-6 months old. 11mg/day for 6-12 months old	AI Recommended Dietary Allowances (RDA)	Food and Nutrition Board, 2002, Institute of Medicine, National Academies
	Zn	2mg/day for 0-6 months old 3mg/day for 6-12 months	AI RDA	Food and Nutrition Board, 2002, Institute of Medicine, National Academies
	Ca	200mg/day for 0-6 months 260mg/day for 6-12 months	AI	Food and Nutrition Board, 2002, Institute of Medicine, National Academies
	Mn	0.003mg/day for 0-6 months old 0.60 mg/day for 6-12 months old	AI	Food and Nutrition Board, 2002, Institute of Medicine, National Academies
	K	0.4g/day for 0-6 months old 0.7g/day for 6-12 months old	AI	Food and Nutrition Board, 2002, Institute of Medicine, National Academies
	Na	0.12g/day for 0-6 months old 0.37g/day for 6-12 months old	AI	Food and Nutrition Board, 2002, Institute of Medicine, National Academies
	Mg	30mg/day for 0-6 months old 75mg/day for 6-12 months old	AI	Food and Nutrition Board, 2002, Institute of Medicine, National Academies
	P	100mg/day for 0-6 months old	AI	Food and Nutrition Board, 2002, Institute of Medicine,

	275 mg/day for 0-12 months old	National Academies

Table 2: Food samples and declared main ingredients

Food brand	Age in months	Weight (g)	Sample ID	Ingredients	Nutritional information
Baby Cauliflower cheese: Pureed cauliflowe	4-6	125	W1 Vegetable based	Baby grade cauliflower (33%), ground rice, skimmed milk, cheddar cheese	Typical values per 100g: Energy 329kJ/78kcal; fat 2.8g of which saturates 1.8g; carbohydrates 8.2g of which sugars 1.6g;

r and cheese				(9%), cooking water	fibre 0.9g; protein 4.5g; salt 0.2g
Grandpa's Sunday lunch: pureed chicken and vegetables	4-6	125	W2 Chicken based	Baby grade vegetables (43%) consisting peas, carrots, tomato, sweetcorn; potatoes; cooking water; chicken (10%); corn starch; rapeseed oil. No added egg, gluten free	Typical per 100g: Energy 309kJ/74kcal; fat 2.2 g; saturates 0.4g; omega 3 (ALA) 0.11g; carbohydrate 9g of which sugars 2.5g; fibre 2.5g; protein 3.3g; salt 0.05g
Orchard Chicken: pureed chicken vegetables and apples	4-6	125	W3 Chicken based	Baby grade vegetables (43%) consisting carrots, sweetcorn; cooking water; rice; chicken (10%); apple juice from concentrate (10%); apple (8%); butter; rice starch.	Typical values per 100g: Energy 33kJ/80kcal; fat 2.3g of which saturates 1.4g; carbohydrates109g of which 3.3g is sugars; fibre 1.6g; protein 3g; salt 0.05g
My first Bolognese : Pureed beef, tomatoes and carrots	4-6	125	W4 Beef based	Baby grade vegetables (58%) consisting tomatoes (18%), carrots (40%), potato, white beans, beef (10%), rapeseed oil. No added milk or lactose, no egg, gluten free. Has 62% recommended omega-3 intake (4-6 month) per jar.	Typical values per 100g: Energy 343kJ/82kcal; fat 3.4g; saturates 1.1g, omega-3 (ALA) 0.17g; carbohydrates 8.3g of which 2.2g is sugars; fibre 2.1g; protein 3.5g; salt 0.8 (contains naturally occurring sodium).
Creamy cauliflower cheese: cauliflower and cheese	7+	200	X1 Vegetable based	Baby grade cauliflower (36%), cooking water, skimmed milk, cheddar cheese (8%), rice, corn, starch, parsley. No added egg, gluten free suitable for vegetarians.	Typical values per 100g: Energy 263kJ/63kcal; fat 2.7g; saturates 1.6g; carbohydrates 5.8g of which 1.5g is sugars; fibre 1g; protein 3.3g; salt 0.18g.
Grandma's Sunday lunch: vegetable with turkey	7+	200	X2 Chicken based	Baby grade vegetables (34%) consisting parsnip, tomatoes, carrots, onion, garlic; cooking water; potato; turkey	Typical values per 100g: Energy 289kJ/69kcal; fat 2.4g; saturates 0.1g, omega-3 (ALA) 0.18g; carbohydrates 8.5g of which 1.5g is sugars; fibre 1.3g; protein 2.5g;

				(9%), wheat starch (gluten free) rapeseed oil, corn starch, sage, black pepper. No added milk or lactose.	salt 0.06 (contains naturally occurring sodium).
Yummy harvest chicken: chicken and apple with vegetables and parsley	7+	200	X3 Chicken based	Baby grade vegetables (40%) consisting tomatoes, carrots, onion; potato; cooking water; chicken (10%), apple juice, wheat starch (gluten free), rapeseed oil, parsley. No added milk or lactose, no egg.	Typical values per 100g: Energy 290kJ/69kcal; fat 2.4g; saturates 0.4g, omega-3 (ALA) 0.13g; carbohydrates 8.5g of which 2g is sugars; fibre 1.4g; protein 2.5g; salt 0.05 (contains naturally occurring sodium).
Scrummy spaghetti Bolognese : pasta with beef and tomatoes	7+	200	X4 Beef based	Baby grade vegetables (41%) consisting tomatoes (31%), carrots, onion, celery; pasta containing gluten (26%), durum wheat semolina, egg (albumen), cooking water, beef (9%), apple juice from concentrate, wheat starch, corn starch	Typical values per 100g: Energy 293kJ/70kcal; fat 1.9g; saturates 1g; carbohydrates 10.3g of which 1.7g is sugars; fibre 0.6g; protein 2.5g; salt 0.08 (contains naturally occurring sodium).
Broccoli cheese: Brocoli, cheese with rice	10+	250	Y1 Vegetable based	Baby grade vegetables (30%) consisting carrots, broccoli (8%), onion, potato, skimmed milk, rice, cooking water, cheddar cheese (contains milk (9%), tapioca starch, black pepper. No added egg, gluten free.	Typical values per 100g: Energy 349kJ/83kcal; fat 2.8g; saturates 1.7g; carbohydrates 9.9g of which 1.7g is sugars; fibre 1.3g; protein 3.9g; salt 0.2g.
Chicken Sunday lunch: chicken with potatoes	10+	250	Y2 Chicken based	Baby grade vegetables (43%) consisting carrots, broccoli, parsnip, onion, green beans, peas, garlic;	Typical values per 100g: Energy 272kJ/65kcal; fat 2.1g; saturates 0.2g, omega-3 (ALA) 0.19g; carbohydrates 7.1g of which 2.1g is sugars;

and vegetables				cooking water, chicken (10%), potato, apple puree, corn starch, rapeseed oil, wheat starch (gluten free), parsley, sage, black pepper. No added milk, lactose or egg, gluten free.	fibre 2.3g; protein 3.1g; salt 0.03g.
Autumn orchard chicken: Rice with chicken, apple and vegetables	!0+	250	Y3 Chicken based	Baby grade vegetables (46%) consisting carrots, leek, sweetcorn, courgette, cauliflower; rice; cooking water; chicken (10%), apple (7%), apple juice (3%), wheat starch (gluten free), corn starch, rapeseed oil, parsley leaves.. No added milk, lactose or egg.	Typical values per 100g: Energy 315kJ/75kcal; fat 2.1g; saturates 0.4g, carbohydrates 10.4g of which 2.6g is sugars; fibre 1.4g; protein 2g; salt 0.08g (contains naturally occurring sodium
My favourite spaghetti Bolognese : spaghetti and beef with tomatoes and vegetables	10+	250	Y4 Beef based	Baby grade vegetables (53%) consisting carrots, peas onion; pasta (25%), durum wheat semolina (contains gluten), egg white, beef (10%); cooking water, corn starch, rapeseed oil, oregano, black pepper. No added milk or lactose.	Typical values per 100g: Energy 308kJ/75kcal; fat 2g; saturates 0.3g, omega-3 (ALA) 0.1g; carbohydrates 9.8g of which 2.1g is sugars; fibre 1.8g; protein 3.5g; salt 0.05g(contains naturally occurring sodium

Table 3: The levels (mean±1standard deviation (sd)) (n= 5) of trace elements (µg/100g) and minerals (mg/100g) in baby foods for age 4-6 months

Element	Product W1	Product W2	Product W3	Product W4
Cu	2.9±1.3	24.7±1.2	14.6±0.3	12.5±0.6
Mn	14.2±0.1	38.4±1.7	33.1±0.5	18.8±0.4

Fe	28±1.7	170.1±8.6	81.3±5.8	112.5±2.7
Zn	66.7±4.4	125.5±7.0	59±0.9	82.2±1.2
Cd	n.d.	0.4±0.2	1.2±0.7	n.d.
Ni	0.5±0.5	4.2±0.5	n.d.	2.5±0.5
Pb	0.2±0.3	n.d	n.d.	0.2±0.1
Se	0.4±0.2	1.2±0.6	0.9±0.2	0.6±0.2
Minerals				
Ca	33±0.3	15±0.4	7±0.2	9±0.1
K	39±0.4	202±4.0	64±0.4	110±1.0
Mg	4±0.0	15±0.1	5±0.0	8±0.1
Na	28±0.3	13±1.0	5±0.2	7±0.0
P	29±0.2	52±0.5	13±0.4	21±0.2

n.d. below the limit of detection of the instrument

Table 4: Levels reported as (mean±1sd) (n=5) of trace elements (µg/100g) and minerals (mg/100g) in foods for 7+ months babies

Element	Product X1	Product X2	Product X3	Product X4
Cu	4.4±0.1	19±1.2	17.1±1.7	6.7±0.3
Mn	27±0.3	19.1±0.5	24.4±0.7	10.1±0.1
Fe	74.5±5.4	141.7±2.6	106.9±7.0	58.2±0.6
Zn	134.8±2.0	111.7±2.9	64.2±1.6	49±0.6
Cd	0.1±0.0	1.1±0.6	0.2±0.0	n.d.
Ni	1.2±0.2	1.7±0.3	0.6±0.4	0.6±0.2
Pb	n.d.	n.d.	0.3±0.1	0.1±0.1
Se	1.2±0.1	1.2±0.3	0.7±0.2	0.4±0.2
Minerals				
Ca	37±0.4	16±0.3	8±0.1	4±0.1
K	47±0.7	193±5.2	84±2.3	47±0.5
Mg	4±0.0	10±0.2	5±0.1	3±0.0

Na	31±0.1	18±0.5	8±0.3	6±0.2
P	30±0.1	39±0.5	15±0.4	10±0.1

n.d. below the limit of detection of the instrument

Table 5: Levels reported as (mean±1sd) (n=5) of trace elements (µg/100g) and minerals (mg/100g) for 10+ months babies

Element	Product Y1	Product Y2	Product Y3	Product Y4
Cu	13.4±0.5	19.8±0.6	15.2±2.1	8.9±0.4
Mn	38±1.8	48.1±1.1	39.7±1.9	13.9±0.2
Fe	91.5±6.8	195.5±4.5	116±16.9	93.5±1.3
Zn	156.3±3.7	97.3±8.9	77.5±5.3	91.7±0.8
Cd	0.4±0.1	0.5±0.2	0.5±0.7	n.d.
Ni	1.2±0.4	2.5±0.4	1.6±0.3	0.9±0.5
Pb	n.d.	n.d.	0.5±0.4	0.1±0.1
Se	1.1±0.2	1.4±0.6	1±0.2	0.6±0.2
Minerals				
Ca	40±0.3	21±0.9	4±0.2	5±0.2
K	68±1.2	197±7.7	55±0.8	62±0.6
Mg	5±0.0	13±0.3	4±0.4	4±0.1
Na	28±0.5	13±0.5	7±0.3	7±0.1
P	31±1.9	51±0.6	14±0.2	16±0.1

n.d. below the limit of detection of the instrument

Table 6: Reported levels (mean±1sd) of trace elements and minerals in breast milk

	Transitory Milk (up to 4 weeks postpartum)				Mature Milk		
Elements	Bjorklund et al	Yamawaki et al	Honda et al	Leotsinidis et al	Almeida et al	Elynn (1992)	WHO (1989)
Non-essential (µg/100ml)							
Cd	0.0086±0.0045		0.0277±0.182	0.0127±0.0121			0.010
Pb	0.015±0.090			0.015±0.025	0.094±0.105		1.7
Essential trace elements (µg/100ml)							
Cu	47.1±7.5	46±10	30.48±0.145	39.0±10.8	49.8±14.3	25	18.6
Fe	33.9±13.4	136±85		45.8±31.1		30	44.6
Mn	3.0±1.4	2.5±6.6			0.49±0.18		0.32
Ni	0.096±0.65				0.58±0.18	0.12	
Se	1.3±0.26	2.7±0.8			3.21±0.83	1.6	1.3
Zn	347.1±97.9	337±89	532±0.179	299.0±92	278.5±120.5	120	70.0
Minerals (mg/100ml)							

Ca	30.5±4.5	30.4±4.1	32.91±0.69	28	23.5
K	63.3±4.0	63.9±10.4	71.15±11.13	53	54.8
Mg	2.8±0.48	2.9±0.6	3.46±0.69	3.5	3.4
Na	21.7±7.7	24.2±10.1	34.0±0.14	18	8.8
P	17.2±2.3	17.6±3.0	18.6±4.45	14	14.2

*WHO (1989) values are based on median values from a study on Swedish women (n=64) adopted from Bjorklund et al. (2012).

Highlights

- Both vegetarian and non-vegetarian meals for 4-6, 7+ and 10+ months babies were analysed for the minerals: Ca, K, Mg, Na, P and trace elements: Cd, Cu, Fe, Mn, Ni, Pb, Se, and Zn.
- The ratios of both the minerals and trace elements were relatively constant in the non-vegetarian meals.
- The levels of the elements in the vegetarian meals for the 4-6 months age group were the lowest of the analysed meals.
- The Cu, Se and Zn contents in the meals where comparable to those in breast milk whereas the Fe, K and P levels were 2- to 4-fold higher than in milk.
- The reported antagonistic interactions between Cu, Fe, Mn and Zn are less likely to occur because of the relatively low levels of the elements in the meals.