Journal of Food Composition and Analysis 49 (2016) 78–86

Contents lists available at ScienceDirect

Journal of Food Composition and Analysis

journal homepage: www.elsevier.com/locate/jfca

Original research article

Essential and non-essential elements in Brazilian infant food and other rice-based products frequently consumed by children and celiac population

Tatiana Pedron[a], Fabiana Roberta Segura[a], Fabio Ferreira da Silva[b], Alexandre Luiz de Souza[c], Heloisa França Maltez[a], Bruno Lemos Batista[a,*]

[a] Centro de Ciências Naturais e Humanas, Universidade Federal do ABC, 09210-580 Santo André, SP, Brazil
[b] Agilent Technologies, 06460-040 Barueri, SP, Brazil
[c] Faculdade de Saúde Pública, Universidade de São Paulo, 01246-904 São Paulo, SP, Brazil

ARTICLE INFO

Article history:
Received 5 November 2015
Received in revised form 15 March 2016
Accepted 19 April 2016
Available online 22 April 2016

Keywords:
Food analysis
Food composition
Baby food
Arsenic speciation
Celiac
Daily intake
Rice
HPLC-ICP-MS

ABSTRACT

Rice and its derivatives are important source of essential and non-essential elements. Essential elements as cobalt (Co) and selenium (Se) are vital for human homeostasis. However, non-essential elements such as arsenic (As), cadmium (Cd) and lead (Pb) may be present in rice-based food and consequently, people can be exposed—especially children and the celiac population. This study aimed to determine essentials and non-essentials elements in rice-based products and baby food and also to evaluate nutritional risk by estimating the daily intake of non-essential elements. Regarding essential elements, Co and Se presented the highest concentrations in rice flour (56 $\mu g\,kg^{-1}$) and porridge (254 $\mu g\,kg^{-1}$), respectively. For non-essential elements, the highest concentrations of As, Cd and Pb were 104 $\mu g\,kg^{-1}$ (porridge), 16 $\mu g\,kg^{-1}$ (flour), and 188 $\mu g\,kg^{-1}$ (bread), respectively. Total As concentration in Brazilian rice-based baby food was $<29\,\mu g\,kg^{-1}$. However, As-speciation revealed inorganic-As (i-As) as the main specie. The highest estimated daily intake of Cd, Pb and i-As were 1.37 (rice-based baby food); 10.39 (pasta); and 3.34 (pasta) $\mu g\,d^{-1}$, respectively. Therefore, continuous food monitoring for nutritional and toxicological purpose is necessary, especially concerning these particular populations and discussions for maximum levels of non-essential elements.

1. Introduction

In Brazil, some of the first solid food that weaning babies eat is rice and rice containing foods, because of its mildness, lack of allergic reactions and properties to make a palatable porridge. In addition, rice products are essential for celiac disease diet, once rice is gluten-free (FENACELBRA, 2016). Celiac disease is a digestive disease caused by gluten intolerance. Gluten is a protein found in barley, wheat and rye (Los Santos Moreno et al., 2012) Celiac disease leads to membrane damage of the small intestine, interfering on nutrients absorption (Husby et al., 2012; Taminiau, 1996). According to Niewinski (2008), at least one person in 266 suffers from celiac disease in the world.

Rice and its derivatives are source of essential elements. These elements are important because they assure the occurrence of several biochemical processes that play a fundamental role in human homeostasis (Soetan et al., 2010). These essential elements have many functions. Copper (Cu), for example, is present in enzymes and proteins responsible for the reduction-oxidation processes, protecting the body from free radicals (Klaassen, 2008). Zinc (Zn) is connected to the metalloproteinases, that are involved in processes of gene regulation (Tapiero and Tew, 2003).

Since rice-based foods are widely consumed by high-risk groups – children and celiac – the exposure to non-essential elements such as arsenic (As), cadmium (Cd) and lead (Pb) is a global concern (EFSA, 2009a; Munera-Picazo et al., 2014b; OJEU, 2015). For instance, As in adults cause numerous effects: skin cancer, cardiovascular diseases, bladder cancer and diabetes (Klaassen, 2008). Regarding diabetes mellitus, a study showed that celiac disease occurs mainly in patients type 1 (prevalence of 4.4% to 11.1%) compared to the general population (prevalence of

* Corresponding author at: Centro de Ciências Naturais e Humanas, Universidade Federal do ABC, Rua Santa Adélia 166, Vila São Pedro, 09210-170 Santo André, SP, Brazil.
E-mail addresses: bruno.lemos@ufabc.edu.br, brlemos@hotmail.com (B.L. Batista).

http://dx.doi.org/10.1016/j.jfca.2016.04.005
0889-1575/

0.5%) (Camarca et al., 2012). So, studies involving As intake and celiac are help for public health strategies.

Food and Agriculture Organization of the United Nations (FAO) has discussed the tolerable intake for several food contaminants, including As, Cd and Pb (FAO, 2010). Susceptible specific groups such as children and celiac should be carefully considered. For instance, studies concerning the age which children would be more exposed to As are still scarce. On the other hand, for adults there are several epidemiological studies for As and As-species (EFSA, 2009a; Rahman et al., 2008).

Cereals, such as rice, may accumulate Cd at expressive levels (Klaassen, 2008). According to the European Food Safety Authority (EFSA), Cd daily intake through rice-based food contributes 2.1 and 31.1% for toddlers and other children, respectively (EFSA, 2012b). Lead exposure also occurs mainly through water and food consumption, where grains have a special contribution. Children's Pb daily intake varies from 0.80 to 5.51 $\mu g\,kg^{-1}$ of body weight (bw). Neurotoxicity is one of the effects observed on 2-3 years old children in matter of Pb-long term exposure, which seriously risks of mental retardation and other development complications may be associated (EFSA, 2010; ENHIS, 2009).

Once essential and non-essential elements are present in food at trace and ultra-trace levels, the determination of such analytes requires accuracy and a high sensitive and multi elemental analytical technique (Llobet et al., 2003; Orecchio et al., 2014). In this sense, the inductively coupled plasma mass spectrometry (ICP-MS) is a technique widely used to determinate trace elements for food safety issues (Batista et al., 2010; Batista et al., 2011).

As far as we know, there is a lack of studies, especially in Brazil approaching the occurrence of essential and non-essential elements in infant food and food developed for celiac population. Therefore, the present study evaluated the nutritional/toxicological risk of 157 food samples considering rice-based and non-rice based products frequently consumed by infant and celiac. For this purpose we performed: i) total determination of essential (Cr, Mn, Fe, Co, Cu, Zn and Se) and non-essential elements (As, Cd and Pb); ii) compare statistically the elements concentration in rice containing food to non-rice based food, aiming to evaluate the influence of rice in essential and non-essential elements content in each food-group; iii) estimated daily intake for As, Cd and Pb and; iv) As-speciation and evaluation of the risk associated to inorganic arsenic (i-As) intake.

2. Material and methods

2.1. Apparatus

High purity deionized water (resistivity 18.2 MΩ cm) used was obtained using the Millipore RiOs-DI™ purchased from Milli-Q (Billerica, MA, USA). All reagents used were from analytical grade purchased from Sigma (St. Louis, MO, USA). Solutions were stored in plastic bottles which were cleaned during 24 h in acid bath at 15% v/v HNO_3 65% w/w acquired from Synth (São Paulo, SP, Brazil), rinsed five times with ultrapure water and dried in laminar flow hood class 100 (FilterFlux, São Paulo, SP, Brazil). Total determination of chemical elements (Cr, Mn, Fe, Co, Cu, Zn, Se, As, Cd and, Pb) were carried by an inductively coupled plasma mass spectrometer (ICP-MS) Agilent 7900 (Hachioji, TY, Japan). Arsenic speciation was conducted by using a high performance liquid chromatograph (HPLC) Infinity 1260 equipped with BioInert Kit for speciation analysis obtained from Agilent (Waldbronn, KA, Germany) coupled to the ICP-MS. Operational conditions for ICP-MS and HPLC-ICP-MS are in Table 1.

2.2. Food sampling

During 2014–2015, rice-based products and food products for infants (baby food and others) were acquired from different markets in Brazilian states: São Paulo, Rio Grande do Sul, Distrito Federal, and Minas Gerais, which represent the main locations of food production and consumption. Brand and producer were considered during the sampling. In addition, in order to associate the levels of elements (especially As, Pd and Cd), were also collected products and infant food which are non-rice based.

The samples (rice and non-rice based products, n = 83) were grouped in: i) sweets, cookies, crackers and cereal bars (n = 20); ii) flour (n = 13); iii) milk (n = 6); iv) pasta (n = 22); v) porridge (n = 15) and; vi) bread (n = 7). For rice and non-rice based baby food (purée), 52 samples were collected. For comparison, baby food from other countries were imported from Canada (n = 6), Germany (n = 6) and, Mexico (n = 10).

2.3. Sample preparation and analysis for totals and arsenic speciation

All samples (triplicate), after homogenization, were weighted (~150 mg for solid and doughy samples, ~1.5 g for milk) in PFA

Table 1
Operational conditions for ICP-MS and HPLC-CP-MS.

HPLC Operational Conditions	
Column (anion exchange)	Hamilton PRP-X100, (5 μm;150 mm x 4.6 mm)
Mobile Phase	10 mM HPO_4^{-2}/$H_2PO_4^{-}$; pH 8.0; 5% (v/v) methanol
Mobile phase flow	1 mL min^{-1}
Column temperature	25 °C
Run time	9 min
Mode	Isocratic
Injection Volume	100 μL
Measurement	Peak Area
ICP-MS Operational Conditions	
Monitored Isotopes (Limit of Detection-μg L^{-1})	^{52}Cr (0.021), ^{55}Mn (0.058), ^{56}Fe (0.230), ^{59}Co (0.002), ^{63}Cu (0.021), ^{64}Zn (0.322), ^{80}Se (0.026), ^{75}As (0.017), ^{114}Cd (0.006), ^{208}Pb (0.003)
Internal Standards	^{45}Sc, ^{74}Ge, ^{89}Y, ^{115}In (25 μg L^{-1})
Radio Frequency power	1550 W
Argon flow rate	15 L min^{-1}
Nebulizer gas flow rate	0.9 L min^{-1}
Collision Cell	Helium (purity > 99.999%)
Nebulizer chamber	Scott (double pass)
Interface	Nickel cones
Sampling cone	*1 mm*
Skimmer	*0.9 mm*