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Determination of trace metals in fruit juices in the Portuguese market

Mariana Anastácio[a], A.P. Marreilha dos Santos[a], Michael Aschner[b], Luísa Mateus[a,*]

[a] Instituto de Investigação do Medicamento, iMed.UL, Faculdade de Farmácia, Universidade de Lisboa, Lisboa, Portugal
[b] Department of Molecular Pharmacology, Albert Einstein College of Medicine, NY, USA

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ABSTRACT

Fruit juices are amongst the most non-alcoholic beverages appreciated and consumed in European countries, including Portugal. These beverages contain minerals, nutrients, trace elements, vitamins and phytochemicals, which are essential for a healthy life. However, fruit juices may also contain high levels of metals, posing a health risk to humans, especially to children, since they consume more fruit juice per body weight unit, and have a less varied diet than adults. Thus, in order to guarantee food safety and to make sound nutritional considerations, fruit juices require careful investigation. The main purpose of this study was to determine arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), manganese (Mn) and nickel (Ni) concentrations in 21 fruit juices from 4 different brands, previously selected by the ASAE (Portuguese Food and Economic Safety Authority), and available in the Portuguese market. Results obtained were compared with permissible levels set out by WHO (World Health Organization), USEPA (United States Environmental Protection Agency), by the Portuguese law, and with similar studies performed in other countries. A validation process, including linearity, range, analytical thresholds, precision, accuracy and specificity/selectivity was conducted in order to guarantee reliable analytical data. The results showed that As levels in four samples, Ni in thirteen samples and Mn in all the twenty-one samples, were above the maximal permissible values specified by Decree-Law 306/2007 from 27th August of the Portuguese Legislation. These data establish the need for reduction of metal concentrations in consumed juices.

1. Introduction

Fruit juices are amongst the most non-alcoholic beverages consumed in Portugal. Their consumption has been steadily growing for the last 20 years, in accordance with trends in other European Union countries [1]. Commercial fruit juices commonly contain nutrients, minerals, trace elements, vitamins and phytochemicals all of which have many health benefits. When consumed in moderation as part of a balanced diet, fruit juices have a positive effect on, promoting health and reducing disease risk [2]. However, they can be a potential source of toxic elements, some of them having a cumulative effect or leading to nutritional problems due to low or high concentration of essential elements [3].

Owing to heavy metal contamination of the environment, the analysis of trace elements in seasonal fruit samples as well as in their products has gained considerable attention [4]. Trace element levels in fruit juices may be expected to be influenced by many factors, including: a) the nature of the fruit; b) the mineral composition of the soil from which it originated and other characteristics that influence the availability of the element to be taken by the plant (such as soil's cation exchange capacity, soil pH, and presence of fungi); c) the mineral composition of irrigation water; d) the weather conditions; e) the agricultural practices, such as the types and amounts of fertilizers used; f) the atmospheric deposition of metals from industrial activities and emissions from vehicles; g) other ingredients (such as added sugar) used by manufacturers in juice processing steps, and h) packing and storage stages [3,5,6,7]. Another issue of substantial concern is the fact that fruit juice represents a greater potential source of dietary metal exposure to children than to adults, especially because children's dietary patterns are not only often less varied than those of adults, but also because fruit juice is among their favorite beverages. In addition, they consume more fruit juice relative to their body weight and they may have, for some metals, greater susceptibility than adults [7,8].

Metals are the most abundant group of chemical elements on the Earth's crust, and are commonly present in foods at low concentrations. Their toxicological or nutritional significance differs according to the group of metals and their amounts [3,9]. Approximately 30 elements are recognized as essential to life. Whereas some are required in higher amounts, such as Ca, K, Mg, and Na, others occur in trace or ultra-trace levels. Metals, such as Cu, Fe, Zn and Mn are at the top end of this trace scale, playing an important role in biological systems, since they take part in numerous biochemical processes in the human body. However,

* Corresponding Author: Luísa Mateus, Instituto de Investigação do Medicamento, iMed.UL, Faculdade de Farmácia,Universidade de Lisboa, 1649-003 Lisboa, Portugal.
E-mail address: lmateus@ff.ul.pt (L. Mateus).

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at high concentrations these metals are toxic and may cause adverse health effects. Metals, such as Pb, Cd, Ni and As are non-essential, and may cause toxic deleterious effects even when present at low levels [3,4,5,10].

Environmental contamination through heavy metals is recognized worldwide as a public health hazard, and their dietary intake from food sources needs to be monitored on a regular basis as to guarantee food safety and ensure nutritional considerations [3,11].

The aim of this study was to determine the content of As, Cd, Cr, Pb, Mn and Ni in fruit juices available in the Portuguese market and to compare them with reference levels established for drinking-water by the WHO (World Health Organization), USEPA (United States Environmental Protection Agency) and Decree-Law 306/2007 from 27th August of the Portuguese Legislation, as well as with similar published data [12].

2. Material and methods

Twenty-one commercial fruit juices from the most consumed brands were selected and collected by ASAE (Portuguese Food and Economic Safety Authority), the Focal Point of EFSA in Portugal, between June and November 2016. The juice fruits samples comprised juices from red fruits, pear, plum, peach, multi-fruit, passion fruit, orange, apple, mango, apricot, strawberry and pineapple. All determinations were carried out by Atomic Absorption Spectrometry (AAS) with a PerkinElmer Instruments Analyst 700 equipped with deuterium background corrector. Arsenic quantification was done by Hydride Generation Atomic Absorption Spectrometry (HGAAS) while Cd, Cr, Pb, Mn and Ni quantification were performed by Graphite Furnace Atomic Absorption Spectrometry (GFAAS).

In order to avoid any possible extra metal contamination, all used material were left submersed for 24 h under a HNO_3 15% solution. After this time, material was washed 3 times with ultrapure water (18.2 MΩ cm), dried and stored in a place protected from dust.

Before metal quantification a microwave digestion procedure was carried out in a Berghof microwave digestion system (Speedwave Two) in order to achieve a total digestion in a short time, thus avoiding loss of metals by volatilization and minimizing the amount of added acid. Digestion procedure was as follows: weight 3 mL of the sample into the polytetrafluoethylene (PTFE-Teflon) digestion vessel, add 1.5 mL of nitric acid and 2 mL of hydrogen peroxide. Next, the samples were kept at room temperature during 6 h to guarantee its homogenization as well as a slow digestion. Next, the vessels were closed and the digestion program was carried out with the temperature program presented in Table 1.

All PTFE digestion vessels were left closed overnight for cooling. The day after, vessel content was transferred and made up to 10 mL with ultrapure water. The resulting colourless solutions were read for further analysis.

For Cd, Cr, Pb, Mn and Ni analysis, HNO_3 5% and matrix modifier [$(NH_4H_2PO_4$ or $Mg(NO_3)_2$] at optimal amounts as previously specified in the analysis software (WinLab32™) were automatically added to the standard solutions and samples. The temperature program used for the quantification of each metal is shown in Table 2.

Prior to As analysis, a reduction reaction was carried out. One mL of sample, 1 mL of hydrochloric acid, 1 mL of ascorbic acid and 1 mL of potassium iodide were added to a 10 mL volumetric flask and the volume was completed with ultrapure water. Standard solutions were prepared with the same reagents and at the same ratios. Solutions were left at room temperature for at least 45 min before analysis.

All graphics and statistical treatment including one-way ANOVA with $\alpha = 0.01$ significance level were done using the tools from Microsoft Excel 2013 Version 15.0.4849.1003.

Table 1
Microwave digestion temperature program: **Ramp** expresses the time (minutes) necessary to achieve the temperature of the next step; **Time** represents the minutes at the same temperature.

Step	1	2	3	4	5
Ramp (min)	10	5	0	2	0
Time (min)	10	15	10	15	0
Temperature (°C)	170	200	200	100	75

Table 2
Cadmium, chromium, lead, manganese and nickel analytic conditions: Selected wavelength, pretreatment and atomization temperatures for metals quantified by GFAAS.

Element	Wavelength (nm)	Ashing temperature (°C)	Atomization temperature (°C)
Cd	228.8	850	1650
Cr	357.9	1650	2500
Pb	283.3	1100	1600
Mn	279.5	1400	2200
Ni	299.44	1400	2500

3. Results and discussion

Prior to trace elements quantification, conditions for sample preparation and for AAS analysis were carefully chosen, in order to define the optimal settings for the analysis. After optimization, the selected method demonstrated to be the most selective and sensitive, with quantification limits of 0.31 μg/L for Pb, 0.69 μg/L for Cd, 1.25 μg/L for Cr, 1.87 μg/L for As, 2.14 μg/L for Ni and 3.65 μg/L for Mn. Quantification limits were obtained through the signal/noise (10 × S/N) method. Moreover, method validation demonstrated acceptable results for repeatability (RSD < 7%), intermediate precision on 3 non-consecutive days (RSD < 7.5%) and accuracy (84–111%), verifying the adequacy of the quantitative method.

3.1. Metal quantification in juice fruit

The obtained concentrations of As, Cd, Cr, Pb, Ni and Mn for 21 commercial fruit juices are shown in Table 3. For each sample analysis, two independent replicates were measured in duplicate, in order to assure the control quality of our measurements.

All the samples were quantifiable for Cr, Ni and Mn. Arsenic content was quantified in eighteen samples, Cd content in nine samples, and Pb content in fifteen samples.

Since the analyzed samples are commercially available in the Portuguese market, results were evaluated relative to values for drinking-water set out by Decree-Law 306/2007 from 27th August of the Portuguese Legislation (Table 3). As concentration exceeded the permissible maximum limit (10 μg/L) in four samples (red fruits, multi-fruit 1 and 4, orange 4). In several other samples (mango 1 and 4, pear 1 and apple 1) As content was in close proximity to the maximal permissible level. Ni content was higher than the permissible limit (20 μg/L) in all samples except for plum, orange, mango and strawberry. Mn concentration was in excess of the maximal permissible limit (50 μg/L) in all analyzed samples. Cd, Cr and Pb content were below the maximal permissible values (5 μg/L, 50 μg/L and 10 μg/L, respectively) in all the analyzed samples. However, when considering the maximal permissible levels specified by WHO, Cd concentration in passion fruit samples was higher than the maximal permissible value (3 μg/L), and Mn concentration was above the maximal permissible limit (400 μg/L) in six samples (red fruits, multi-fruit 1 and 2, mango 1, strawberry and pineapple). Ni content was below the maximal permissible limit specified by WHO (70 μg/L) and USEPA (100 μg/L) in all the analyzed samples.

Samples of multi-fruit drinks 1 and 4 had the highest levels of several of the studied elements. In fact, sample multi-fruit 4 had the

Table 3
Metal quantification (μg/L) in fruit juice samples (n = 21): Values are mean (n = 3). < Q.L.–below the quantification limit. Values in bold and shaded are above the limit set out by Decree-Law 306/2007 from 27th August of the Portuguese Legislation. Samples are grouped according to its type of fruit juice; numbers from 1 to 4 represent different brands.

Samples	Metals (μg/L)					
	As	Cd	Cr	Pb	Ni	Mn
Red fruits 1	**10.73**	1.77	12.86	4.11	**52.43**	**833.00**
Pear 1	9.49	1.78	7.93	4.32	**46.52**	**158.63**
Pear 3	< Q.L.	< Q.L.	6.79	< Q.L.	**20.99**	**110.32**
Plum 1	5.49	0.94	5.70	< Q.L.	17.54	**249.47**
Peach 1	4.52	1.14	13.26	8.51	**34.32**	**296.90**
Peach 2	3.71	< Q.L.	8.09	3.59	**30.17**	**93.18**
Peach 3	< Q.L.	0.95	10.39	0.96	**37.11**	**210.66**
Multi-fruit 1	**11.21**	< Q.L.	15.67	5.69	**44.02**	**3502.73**
Multi-fruit 2	5.62	1.12	7.26	5.22	**46.75**	**644.54**
Multi-fruit 4	**13.38**	1.42	5.58	7.05	**48.49**	**337.66**
Passion fruit 1	6.75	3.44	14.68	< Q.L.	**42.21**	**137.66**
Orange 1	5.65	< Q.L.	6.82	< Q.L.	7.58	**54.85**
Orange 2	2.76	< Q.L.	5.83	0.47	9.24	**125.16**
Orange 3	< Q.L.	< Q.L.	8.05	< Q.L.	15.44	**153.72**
Orange 4	**10.24**	< Q.L.	6.96	2.49	18.76	**342.92**
Apple 1	8.78	< Q.L.	9.13	6.11	**22.82**	**122.89**
Mango 1	9.82	< Q.L.	6.73	0.74	11.92	**442.69**
Mango 4	9.16	< Q.L.	6.63	3.73	15.50	**391.01**
Apricot 3	2.36	0.72	26.52	6.21	**43.96**	**142.72**
Strawberry 4	6.75	< Q.L.	8.69	2.29	14.72	**440.09**
Pineapple 4	8.04	< Q.L.	10.55	< Q.L.	**31.10**	**1949.38**

highest As level and the second highest Pb and Ni levels. Sample multi-fruit 1 had the highest Mn level and the second highest As level. However, sample multi-fruit 2, did not have metal levels as high as samples multi-fruit 1 and 4, except for Ni, being the third sample with the highest level of this element.

The variation range of each type of fruit juice for every metal analyzed in this study can be compared with values reported in similar studies. Results are shown in Table 4.

Soil conditions, pesticides, additives, water, processing and storage steps are potential sources of metal contamination. Although most of the obtained values are within the ranges observed in other studies, the wide variation range reported in literature might be explained both by the variability of used raw materials in the fruit juices production and by different manufacturing processes applied. Because studies, and consequently fruit juices, are from different countries and with a great time gap between them, the metal content reflects differences in soil composition where the fruits were grown as well as atmospheric conditions and agricultural practices. When elements are less mobile in the soil-plant system, such as Pb, sources of contamination in fruit juices are most probably originating from processing steps, such as sugar addition or fruit juice reconstruction with water. In addition, packing quality represents another factor that influences metal content in fruit juices. The analyzed samples in this study were all contained in the same type of packaging, which is not the case for other studies [3,13,14,22].

High levels of Mn are present in most of the fruit juices analyzed in all reported studies. Levels of Mn seem to be particularly influenced by acidic soil conditions in which the fruits were grown. However, further investigation is needed to properly correlate the concentration of this metal with the soil characteristics at various growing locations [6]. Pineapple juice seems to concentrate Mn to a greater extent than do other types of fruit juices, as it contains high levels of this metal in the majority of the reported studies [23].

Orange and apple juices are the most analyzed types of fruit juices, possibly because they are the most favorite ones, and, as a result, the most consumed worldwide. On the other hand, fruit juices like plum, red fruits and strawberry juices were not included in many studies. Indeed, it was not possible to find similar studies analyzing red fruits juice or strawberry juice. Consequently, there are no data available for comparison with the results obtained herein.

According to the European Fruit Juice Association (AIJN), which has performed country-specific profiles of fruit juices and nectars by flavors for several European countries, orange juice is the most consumed fruit juice in Portugal (17.4%), followed by peach juice (16.8%), flavor mixes juices, such as multifruit or red fruit juice (15.9%), mango juice (15%), apple juice (10.1%). Other type of fruit juices account for 24.8% of the total consumption [24].

Metal releases and discharges from industry and other anthropogenic activities, such as mining should be minimized in order to avoid environmental contamination. In addition, action is needed to reduce the concentration of heavy metals in drinking-water, since this is possibly one of the main sources of metal contamination in fruit juices, especially in areas with naturally high levels in the groundwater. Screening of drinking-water supplies for metal levels, and informing both the general public and the health sector of the results is essential, as well as embarking on awareness-raising campaigns on the harmful effects and early signs of metal poisoning, of high metal intake, and means to avoid it [25,26].

Arsenic, Cd, Ni and Mn exceeded the maximal permissible limit values set out by both the WHO, USEPA or Decree-Law 306/2007 from 27th August of the Portuguese Legislation for drinking-water. In addition to the known toxicity associated with these metals, it is important to note that most drinking-water standards are set as a fraction of the tolerable or acceptable daily intake value for a given contaminant divided by the daily drinking-water consumption rate. Therefore, this comparison should be considered as a conservative approach, since the amount of juice consumed per day is expected to be considerably less than the amount of water ingested per day. As such, consuming fruit juices that exceed the maximal permissible values does not necessarily imply an increased risk for adverse human health effects [21].

4. Conclusions

In this study, trace metal analysis was conducted on twenty-one fruit juice samples, selected by ASAE, from four different brands available on the Portuguese market. Arsenic, Cd, Cr, Pb, Ni and Mn were the elements selected, since their quantification had been recognized to be important both from toxicological and nutritional points of view.

Comparing our results with the maximum level (ML) for drinking-water established by Decree-Law 306/2007 from 27th August of the Portuguese Legislation, As concentration was above the maximal permissible level (10 μg/L) in four samples (red fruits, multi-fruit 1 and 4, orange 4); Ni content was higher than the maximal permissible limit (20 μg/L) in all samples except for plum, orange, mango and strawberry, and Mn concentration was higher than the maximal permissible level (50 μg/L) in all analyzed samples. In contrast, concentrations of all other metals (Cd, Cr and Pb) were below the maximal permissible levels (5 μg/L, 50 μg/L and 10 μg/L, respectively) established by the Portuguese Legislation in all samples.

In order to avoid environmental contamination with heavy metals, a recognized public health hazard worldwide, we should strive for minimization of metal releases and discharges from anthropogenic

Table 4
Metal quantification (μg/L) in fruit juice samples in the present study as well as in other published studies; < Q.L.–below quantification limit; N.A.–not analyzed; N.D.–not detected. Values are means. or means ± SD.

Fruit Juice	Reported study	Metals (μg/L)					
		As	Cd	Cr	Pb	Mn	Ni
Orange	**Present study**	< Q.L.–10.24	< Q.L.	5.83–8.05	< Q.L.–2.49	54.85–342.92	7.58–18.76
	[13]	1.5 ± 0.4–21 ± 5.5	0.1 ± 0.01–1.2 ± 0.1	N.A.	3.7 ± 0.6–10 ± 1.6	N.A.	N.A.
	[1]	< 2–3.5	< 2	out-15	< 4	197–379	N.A.
	[3]	< 0.001–1.70	< 0.001–0.64	5.28–28.21	1.02–10.05	64.14–307.88	31.24–145
	[14]	N.A.	6.4 ± 0.1–9.2 ± 1.1	N.A.	N.A.	100 ± 5–466 ± 23	66.6 ± 6.5–34.2 ± 4.9
	[15]	N.A.	< 0.07	N.A.	2.0 ± 0.1	180 ± 5	20.5 ± 0.1
	[16]	N.A.	N.A.	5.93 ± 0.92	N.A.	20.93 ± 2.36	5.73 ± 0.91
	[17]	N.A.	N.D.	N.D.	80	450	N.A.
	[18]	N.A.	10–70	< 1–20	520–1320	< 1–1650	40–1020
	[19]	N.A.	4–40	N.A.	46–251	N.A.	N.A.
	[20]	146	170	7	119	198	276
Apple	**Present study**	8.78	< Q.L.	9.13	6.11	122.89	22.82
	[13]	< 0.08–36 ± 9.4	0.01 ± 0.001–0.6 ± 0.06	N.A.	1.1 ± 0.2–12 ± 2.0	N.A.	N.A.
	[1]	2.8	< 2	7.5	< 4	289	N.A.
	[21]	2.1–8.5	0.15–0.70	5.2–18	0.84–9.1	200–1200	N.A.
	[3]	< 0.001–4.36	0.14–1.42	4–55.6	4.66–75.68	127.08–342.92	18.96–204.4
	[15]	N.A.	< 0.07	N.A.	0.2 ± 0.1	75 ± 2	3.9 ± 0.3
	[16]	N.A.	N.A.	6.36 ± 0.94	N.A.	23.48 ± 2.23	6.21 ± 0.90
	[17]	N.A.	N.D.	N.D.	80	530	N.A.
	[18]	N.A.	< 1–30	< 1–840	100–3720	< 1–1 0	< 1–710
	[19]	N.A.	10–60	N.A.	51–460	N.A.	N.A.
	[20]	238–2920	10–14	10–45	101–376	90–168	154–204
Multifruit	**Present study**	5.62–13.38	< Q.L.–1.42	5.58–15.67	5.22–7.05	337.66–3502.73	44.02–48.49
	[13]	4.7 ± 1.2–16 ± 4.2	0.1 ± 0.01–1.0 ± 0.1	N.A.	6.1 ± 1.0–14 ± 2.3	N.A.	N.A.
	[1]	2.3	< 2	30	< 4	439	N.A.
	[3]	0.38	< 0.001	4.46	1.88	131.64	32.2
	[18]	N.A.	< 1–430	< 1–1320	390–1680	< 1–1020	< 1–1370
	[20]	787–2342	10–205	12–159	163–2039	103–222	53–368
Pear	**Present study**	< Q.L.–9.49	< Q.L.–1.78	6.79–7.93	< Q.L.–4.32	110.32–158.63	20.99–46.52
	[1]	2	< 2	15	< 4	376	N.A.
	[3]	< 0.001	< 0.001	7.56	1.62	169.56	31.52
	[15]	N.A.	0.3 ± 0.1–0.4 ± 0.1	N.A.	0.7 ± 0.1	140 ± 6–330 ± 5	15.3 ± 0.6–27.0 ± 0.3
Passion fruit	**Present study**	6.75	3.44	14.68	< Q.L.	137.66	42.21
	[1]	< 2	< 2	N.A.	< 4	170	N.A.
	[6]	N.A.	< 10 ± 0.3– < 10 ± 1	< 5 ± 0.1– < 5 ± 0.2	< 10 ± 0.2– < 10 ± 0.6	20 ± 0.1–70 ± 0.3	N.A.
	[15]	N.A.	< 0.07–0.5 ± 0.1	N.A.	0.5 ± 0.1–1.6 ± 0.1	130 ± 1–290 ± 9	12.4 ± 0.2–21.8 ± 0.5
Plum	**Present study**	5.49	< Q.L.	5.70	< Q.L.	249.47	17.54
	[20]	868	9	77	264	140	68
Apricot	**Present study**	< Q.L.	< Q.L.	26.52	6.21	142.724	43.956
	[13]	2.2 ± 0.6–31 ± 8.1	< 0.05–0.8 ± 0.1	N.A.	3.9 ± 0.6–42 ± 6.9	N.A.	N.A.
	[3]	1.52	0.46–0.78	26.98–55.45	3.36–5.36	206.98–244.46	35.04–146.60
	[14]	N.A.	6 ± 0.8–9.2 ± 0.8	N.A.	N.A.	128 ± 4–311 ± 3	72.5 ± 6.9–136 ± 7.2
Mango	**Present study**	9.16–9.82	< Q.L.	6.63–6.73	< Q.L.	391.01–442.69	11.92–15.50
	[6]	N.A.	< 10 ± 0.3– < 10 ± 0.5	< 5 ± 0.1–5 ± 0.1	< 10 ± 0.2– < 10 ± 0.3	80 ± 0.2–190 ± 0.7	N.A.
	[15]	N.A.	0.3 ± 0.1	N.A.	0.3 ± 0.2	140 ± 8	15.6 ± 0.7
	[16]	N.A.	N.A.	7.64 ± 1.02	N.A.	21.85 ± 2.58	5.93 ± 0.96
	[18]	N.A.	380–600	< 1–2	2–6	2–10	850–1150
	[20]	1113–1399	10–13	27–95	65–338	159–220	103–137

(continued on next page)

Table 4 (*continued*)

Fruit Juice	Reported study	Metals (μg/L)					
		As	Cd	Cr	Pb	Mn	Ni
Peach	**Present study**	< Q.L.–4.52	< Q.L.–1.14	8.09–13.26	< Q.L.–8.51	93.18–296.90	30.17–37.11
	[13]	0.7 ± 0.2–20 ± 5.2	0.6 ± 0.06–1.1 ± 0.1	N.A.	4.0 ± 0.7–10 ± 1.6	N.A.	N.A.
	[1]	< 2	< 2	17	< 4	206	N.A.
	[3]	< 0.001–3.78	0.52–1.38	5.61–39.64	1.94–18.58	59.60–229.80	25.42–53.12
	[6]	N.A.	< 10 ± 0.2– < 10 ± 0.9	< 5 ± 0.1–6 ± 0.1	< 10 ± 0.1– < 10 ± 0.4	10 ± 0.5–80 ± 0.2	N.A.
	[14]	N.A.	7.2 ± 0.3–11.3 ± 1.6	N.A.	N.A.	197 ± 13–349 ± 16	86.9 ± 10–174.6 ± 22.2
	[15]	N.A.	0.6 ± 0.1	N.A.	0.6 ± 0.1	210 ± 5	21.4 ± 0.8
Pineapple	**Present study**	8.04	< Q.L.	10.55	< Q.L.	1949.38	31.10
	[1]	< 2	< 2	40	< 4	13800	N.A.
	[3]	2.84	0.64	27.05	0.64	320.8	208.96
	[15]	N.A.	1.1 ± 0.1	N.A.	1.6 ± 0.1	1360 ± 70	43.5 ± 2.0
	[17]	N.A.	N.D.	N.D.	90	15000	N.A.
	[18]	N.A.	< 1–2	430–1370	500–660	400–410	840–1030

activities, thus decreasing metal concentrations in drinking-water, since this is likely the major source of metal contamination in fruit juices.

Consuming fruit juices that exceed maximal permissible values does not necessarily imply an increased risk for human health, since the amount of fruit juice consumed per day is expected to be lower than the amount of water. Nevertheless, this type of study is important as it quantifies the dietary intakes of metals present in food, not only guaranteeing food safety, but also broadening the understanding on how fruit juices should be evaluated and considered for balanced diets due to its and nutritional importance.

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