Mineral profile and arsenic accumulation in brown rice (*Oryza sativa L.*) from organic and traditional agriculture consumed in Portugal

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Introduction

Portugal is the largest consumer of rice in Europe, with a consumption of 17 kg per capita per year. Only the outermost layer, the hull, is removed to produce brown rice. This process is the least damaging to the nutritional value of the rice and avoids the loss of nutrients that occurs with further processing. This cereal as a key role in the world's food. However rice could be one of the main source of arsenic . Therefore risks benefits associated with the consumption of rice in Portugal needs to be clarified.

Purpose

The aim of this study is correlate the profile of minerals with arsenic accumulation levels in brown rice from organic and traditional agriculture .

Materials and Methods

Mineral profile and the total and different species of arsenic levels were determined in 17 samples of different types of brown rice, from organic agriculture and traditional agriculture, grown in different areas of Portugal.

Samples were submitted to microwave digestion and analyzed as tables below:

Tabela 1 – Microwave digestion.

Step	Power (W)	Temperature (ºC)	Time (min)
1	1150	180	10
2	0	180	5
3	1250	210	12
4	0	210	5
5	650	90	6

Table 2 – ICP-OES operating conditions.

ICP-OES Thermo ICAP 6000 Series	
Auxiliar flow	0,5 L/min
RF power	1200 W
Speed peristaltic pump - Flush pump rate and Analysis pump rate (rpm)	50 rpm
Pump stabilization time (seg)	5 seg
Integration Time in the UV and visible	15 and 10 seg

Table 3– ICP-MS operating conditions

ICP-MS Thermo X series II	
Extraction	-113,7
Focus	10,0
Pole Bias	-0,1
Hexapole Bias	-3,0
Nebulizer flow rate (L min^{-1})	0,87
Forward Power (W)	1404
Cool gas flow rate (L min^{-1})	13,0
Auxiliary gas flow rate (L min^{-1})	0,90
Sampling Depth	120
Standard Resolution	135
High Resolution	150
Analogue Detector	1902
PC Detector	3353

- **Minerals**

The determination of minerals, manganese, copper, zinc, iron, magnesium, calcium, phosphorus, sodium and potassium was performed by Inductively Couple Plasma Atomic Emission Spectrometry – ICP-OES, while the arsenic was determined with a coupled mass spectrometry (ICP-MS / MS).

- **Arsenic**

Furthermore samples, with the highest content of arsenic, were analyzed to identify the different arsenic chemical species eventually present. The speciation analysis were carried by coupling an HPLC to the ICP-MS.

ICP- MS
Thermo X SERIES II

ICP-OES
Thermo I CAP 6000

Results and discussion

Total arsenic ranged from 71.7 to 252 µg/Kg (organic agriculture) and 98.0 to 237 µg/Kg (traditional agriculture).

The results, coherent for all samples, showed that the species present were mainly arsenite (AsIII), and dimethylarsinic acid (DMA).

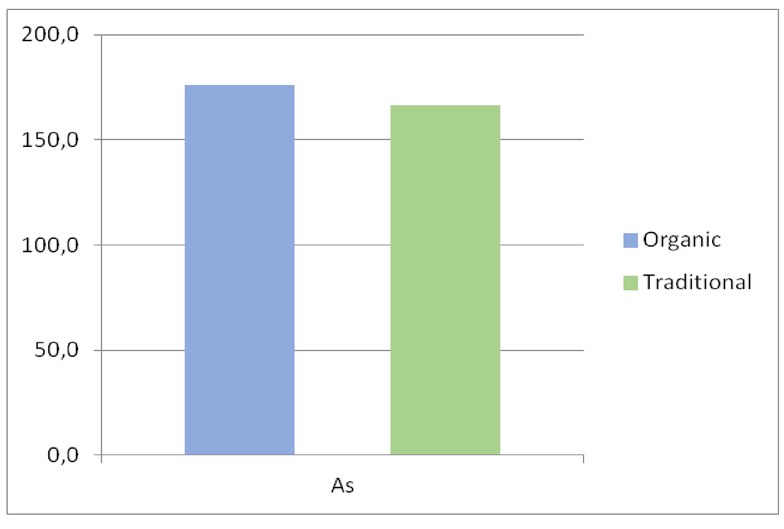
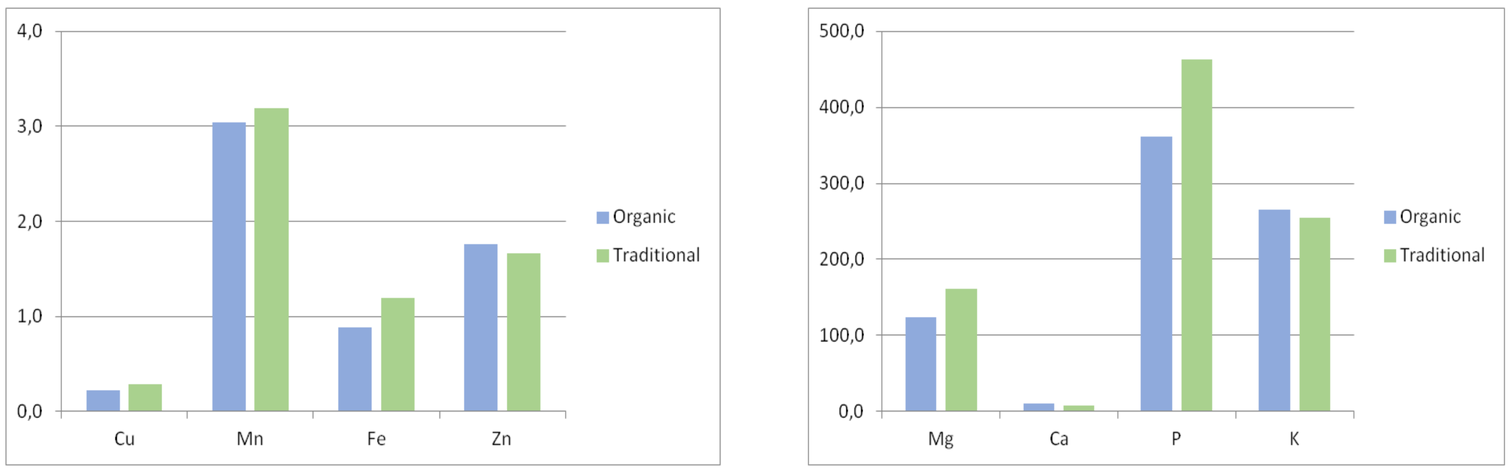


Figure 1 - Arsenic content in brown rice from organic and traditional agriculture , (µg/Kg), determined by ICP-MS.



Figures 1 and 2 – Mineral contents in brown rice from organic and traditional agriculture , (mg/100g), determined by ICP-OES.

In brown rice obtained from organic agriculture, copper ranged from 0.14 to 0.28 mg/100g, manganese from 1.61 to 4.27 mg/100g, iron from 0.76 to 0.97 mg/100g, zinc from 1.37 to 2.68 mg/100g, magnesium from 37.8 to 301 mg/100g, calcium from 7.40 to 13.9 mg/100g, phosphorus from 71.5 to 840 mg/100g and potassium from 69.6 to 497 mg/100g.

In brown rice obtained from traditional agriculture copper ranged from 0.17 to 0.77 mg/100g, manganese from 2.42 to 4.59 mg/100g, iron from 0.89 to 1.75 mg/100g, zinc from 1.33 to 2.66 mg/100g, magnesium from 111 to 290 mg/100g, calcium from 7.91 to 9.88 mg/100g, phosphorus from 308. to 870 mg/100g and potassium from 221 to 278 mg/100g.

Conclusions

Using ANOVA and Kruskal-Wallis to find differences between organic and traditional agriculture brown rice, regarding arsenic levels no differences between the different characteristics were observed. Using Spearman correlation between total arsenic and minerals in organic brown rice, for a significant level of 95%, it was observed positive correlation between arsenic and calcium, magnesium and phosphorus and a negative correlation between arsenic, copper and zinc. Also, between total arsenic and minerals in traditional brown rice, for a significant level of 95%, it was observed a positive correlation between arsenic and phosphorus and a negative correlation between manganese and iron.