Determination of Total Strontium in Uruguayan Rice by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)

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The alkali earth metal strontium has four naturally occurring isotopes: Sr-84, -86, -87, and -88.
Twelve other isotopes are radioactive and Sr-90 (half-life 28.78 years) is of greatest importance. In 1986, the world's worst nuclear power accident occurred at Chernobyl in the former USSR (now Ukraine), introducing a large amount of 90Sr into the environment Strontium-90 presents a health problem since it substitutes for calcium in bone, and prevents its removal from the body. Owing to its chemical and biochemical similarities to calcium, more than 99% of Sr is efficiently incorporated into bone tissue and teeth. Therefore, knowledge about total Sr in foods is of extreme importance to prevent and control contamination; mainly for those foods that are staples for millions of people.
Currently, rice is the predominant staple food for more than half of the world's population. Due to its importance, rice plays a fundamental role for world food security as well as for socio-economic development.
Uruguay is Latin America's major rice exporter. Therefore, the quality of rice produced in Uruguay is very important and well known all over the planet.

Experimental

Instrumentation:

All analyses were performed using a PerkinElmer® Optima™ 2100 DV ICP-OES (PerkinElmer Life and Analytical Sciences, Shelton, CT, USA), equipped with a dual view torch, Scott-type spray chamber, and GemTip™ cross-flow nebulizer. A PerkinElmer AS-90 autosampler was used for sampling.
The optimum instrumental conditions determined for this study are given in the Table I.
Water purification was carried out using a Milli-Q™ Plus purifier system (Millipore Corporation, Bedford, MA, USA).

TABLE I
Instrumental Operating Conditions

Parameter	Optima 2100 DV
RF Power	1300 W
Nebulizer Flow	0.80 L/min
Auxiliary Flow	0.2 L/min
Plasma Flow	15.0 L/min
Sample Flow	1.50 ml/min
Plasma Height	15 mm
Plasma Viewing	Axial
Processing Mode	Area
Read Delay	30 sec
Rinse Delay	60 sec
Replicates	5
Wavelength	407.771 nm

Procedure:

93 samples were collected from the main rice production areas throughout Uruguay.

The sample (~5 g) was weighed into a beaker resistant to high temperatures and, while continuously shaking the suspension, 5 mL ashing aid solution [10% (w/v) $Mg(NO_3)_2$ in ethanol] was added.
Next, the following temperature program was used: Heating at 125°C until nearly dry, then heating from 125°C to 450°C for 2 hours, and holding at 450°C for 12 -14hours. If white ashes are not obtained after this temperature cycle, 1 mL HNO_3 should be added dropwise (brown fumes should be seen) and then 1 mL 30% H_2O_2 added. Afterwards, repeat the heating cycle until white ashes are observed.

Direct calibration against acidified standard solutions was carried out for the determination of total Sr in the solution using the dry ashing treatment. The calibration curve covers the range of 10 - 2000 ng L-1.

TABLE II
Total Sr Content in Milled (long and short grain), Parboiled Milled, Brown (long and short grain), Parboiled Brown, and Paddy Rice, and in Rice Husk

Rice Type	Grain	Total Sr Concentration (µg g^{-1}) Min	Max	Mean	n	LOD (ng g^{-1})	Spike Recovery (%)
Milled	Long	0.190±0.059	0.421±0.065	0.281±0.048	11	5	91±12 95±11
Parboiled Milled	Long	0.135±0.026	0.439±0.028	0.287±0.02*	14	5	91.6±8.9 91.5±9.4
Milled	Short	0.169±0.028	0.351±0.054	0.247±0.041	13	6	89±13 89±12
Brown	Long	0.35±0.05*	0.78±0.11	0.55±0.085	13	5	95.1±11.2 93.2±8.7
Parboiled Brown	Long	0.658±0.088	0.86±0.11	0.73±0.11	14	7	91.5±9.1 93±10
Brown	Short	0.554±0.089	0.695±0.097	0.578±0.092	14	6	91±12 98.2±5.7
Paddy	Long	0.97±0.14	1.41±0.19	1.16±0.16	7	7	92±10 92±11
Husk	-	2.88±0.39	3.91±0.51	3.44±0.47	7	7	90±13 93.1±9.9

Measurement of Uncertainty:

EURACHEM/CITAC (EuroAnalytical Chemistry/Co-Operation on International Traceability in Analytical Chemistry) guide.

Results and Discussion

In the samples studied here, logical values of Sr were obtained from the rice's husk to the milled rice.
The removal of the outer layers of the rice shows a reduction in the Sr content. Paddy rice (rice which has retained its husk after threshing) presented the highest values of Sr (0.97- 1.41 µg g-1). The complete elimination of the husk from the paddy rice produces brown rice; therefore, it is reasonable that the Sr content in brown rice is lower (0.35 - 0.78 µg g-1) than in paddy rice. With the milling process of brown rice, total removal of husk and bran is performed; consequently, this type of rice presented the lowest value of Sr (0.281 µg g-1).

From the rice samples studied here we found that the mean level of Sr in parboiled brown rice (0.73 µg g-1) is higher than in parboiled milled rice (0.287 µg g-1) which is in good agreement with the idea that most of the Sr in rice is situated in the outer layers. The Sr is solubilizated and introduced into the endosperm, so the milling and polishing process used to obtain parboiled milled rice causes a significant reduction in Sr concentration.

Conclusion

- This is the first study reporting the concentration of Sr in different types of rice cultivated in Uruguay. The methodology employed for the determination of Sr was validated against a certified reference material.
- The good recoveries obtained make us conclude that the method used was appropriate.
- Removal of the outer layers of the rice grain results in a large reduction of Sr concentration. Although further studies should be carried out, the results here presented suggest that there is no Sr contamination from the atmosphere in rice produced in Uruguay and its consumption, therefore, presents no health threat.