CADMIUM, INORGANIC ARSENIC, NICKEL AND OTHER CONTAMINANT ELEMENTS IN RICE – DISTRIBUTION ACROSS PROCESSING STAGES, THERMAL TREATMENTS AND COOKING TESTS

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Introduction

This study, conducted between Ente Nazionale Risi's Chemistry, Commodity Science and Molecular Biology Laboratory and the Chemistry Department of University of Pavia, aimed to determine the concentrations of **inorganic Arsenic, Cadmium** and **Nickel** in rice and to assess how these levels change during processing from husked rice to milled rice, as these elements are subject to legal limits in food for human consumption. A further goal was to explore kitchen practices, such as rinsing and cooking in excess water, that consumers could use to reduce the content of such harmful substances. The effects of parboiling were also investigated concerning the possible migration of toxic elements from the husk to the rice grain. The study assessed whether cooking parboiled rice results in the same behavior as in non-parboiled rice.

Materials and Methods

Variety (paddy rice)	Type of grain	Classification	Starting value
Leonidas CL	Long A	Carnaroli Group	High Cd
Brio	Round	Round	High iAs
Luna CL	Long A	Ribe Group	High Ni

Sample Preparation

Paddy rice samples with high contents of Cd, Ni, and inorganic As were selected based on previous analyses. In the laboratory, samples underwent the following treatments:

- **Dehusking** (or dehulling) to obtain brown (or husked) rice (~80% yield)
- **Polishing** using a rice polisher to obtain white (or milled) rice (55–70% yield)
- **Parboiling**, consisting of soaking husked rice in water at 65°C until 30% hydration, autoclave cooking at 120°C, and air-drying. Parboiled rice was subsequently dehusked and polished.

Processed samples were subjected to triplicate cooking tests in distilled water, using both excess water and absorption methods, with and without rinsing. Cooked rice samples were dried at 85°C for 24 hours before grinding.

Sample Treatment and Analytical Measurements

Samples for iAs analysis were wet digested at 95°C with dilute HNO_3 and pre-reduced with KI. For all other metals, samples were digested with HNO_3 and H_2O_2 in a microwave digestion system, then filtered through 0.22 µm membranes. Calibrations were performed using external standard curves, and method accuracy was verified with certified reference materials (CRM 1568a Rice Flour and FAPAS).

Moisture content was determined following ISO 712-1:2024.

Cadmium was analyzed using **Graphite Furnace Atomic Absorption Spectrometry (GF-AAS)** while **inorganic Arsenic** was determined via **Hydride Generation AAS (FIAS system)** both according to standard UNI EN methods.

Multi-element analysis (total As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Zn) was performed using **ICP-MS** (iCAP RQ, Thermo Fisher Scientific) and **ICP-OES** (iCAP 7400, Thermo Fisher Scientific).

Results and discussion

Cd, which is evenly distributed in the endosperm, showed no significant change during processing or cooking.
However, parboiling led to a slight reduction in Cd content in both husked and milled rice, a trend confirmed across samples with high and low Cd levels.

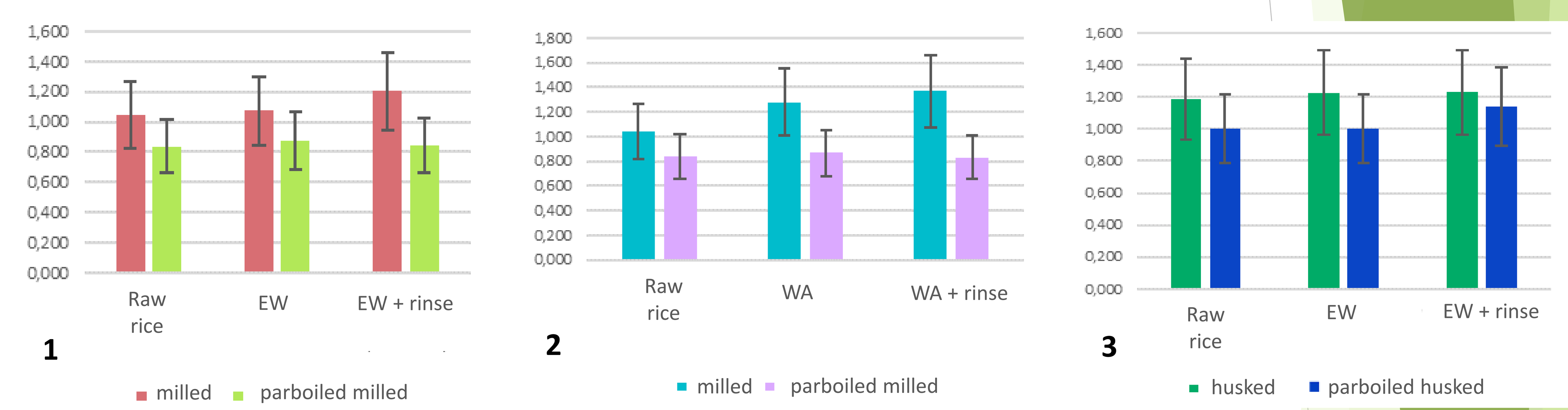

Figure 1. From left to right: Cadmium results on (1) milled rice and parboiled milled rice cooked in excess water (EW), (2) milled rice and parboiled milled rice cooked in total water absorption (WA), (3) husked rice and parboiled husked rice cooked in excess water (EW).

iAs, known to concentrate in the outer grain layers, showed a significant reduction during milling. Further decreases were observed with excess-water cooking, even though rinsing didn't significantly affect its concentration. Parboiling increased iAs content in milled rice but decreased it in husked rice.

Figure 2. From left to right: inorganic Arsenic results on (1) milled rice and parboiled milled rice cooked in excess water (EW), (2) milled rice and parboiled milled rice cooked in total water absorption (WA), (3) husked rice and parboiled husked rice cooked in excess water (EW).

Unexpectedly, Ni behaved similarly to iAs, showing reductions during milling and excess-water cooking, although in the literature it appeared to have a distribution in the endosperm similar to Cd. Parboiling increased Ni levels in milled rice, which were again reduced by cooking. Similar trends were observed in husked and parboiled husked rice.

Preliminary data on additional elements (e.g., Se, total As, Cu, Mn, Zn, Fe) showed overall decreases after cooking and processing, while parboiling produced mixed effects. Further research is needed to confirm these trends, especially for elements below the LOQ (e.g., Hg, Cr, Pb).

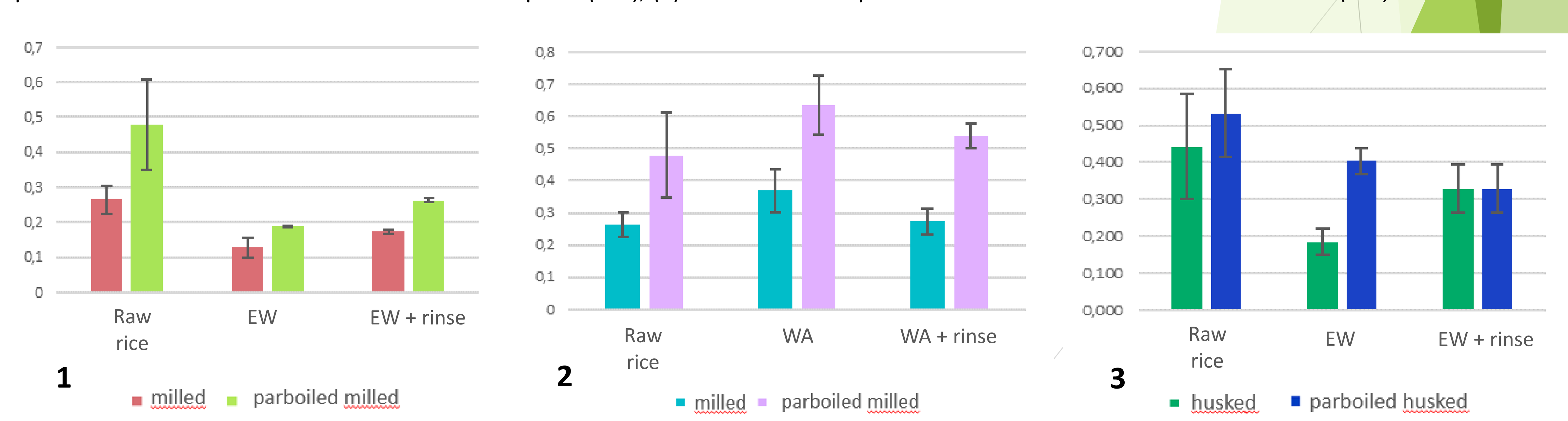

Figure 3. From left to right: Nickel results on (1) milled rice and parboiled milled rice cooked in excess water (EW), (2) milled rice and parboiled milled rice cooked in total water absorption (WA), (3) husked rice and parboiled husked rice cooked in excess water (EW).

Future perspectives

Further studies will investigate different rice varieties and metal concentrations, including samples with Cd close to the legal limit and higher levels of iAs and Ni. The relationship between inorganic and total arsenic during cooking and parboiling will be examined. The effect of parboiling on Cd reduction will be investigated, along with mercury analysis, in future tests.

Bibliography

C. Simonelli et al., Storia del riso: un cereale millenario tra i diversi continenti, La Rivista di Scienze dell'Alimentazione, Italy, 2020, Anno 48, n°3, 7-26.

E. Fantozzi, F. Trivero, et al., Aspetti normativi delle analisi dei metalli nel riso: cadmio e arsenico inorganico. Regole decisionali con incertezza di misura, Poster 13° Convegno AISTEC, Torino 19-21 giugno 2024.

UNI EN 14083:2003 "Determinazione di elementi in tracce – Determinazione di piombo, cadmio, cromo e molibdeno mediante spettrometria ad assorbimento atomico con forno di grafite dopo digestione sotto pressione".

UNI CEN/TS 16731:2014 "Determinazione dei composti dell'arsenico reagenti all'idruro nel riso mediante spettrometria ad assorbimento atomico (AAS-idruro) in seguito di estrazione acida".