CRRI Technology Bulletin No. 245

Smart milling & parboiling technology: A breakthrough in reducing arsenic in rice

2025

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1. Introduction

Arsenic contamination in rice has become a global health concern due to its potential impact on human health, particularly in areas where rice is a staple food and irrigation uses arsenic-contaminated groundwater. Arsenic, a toxic heavy metal, accumulates in rice plants, mainly in the husk and bran, and to a lesser extent in the edible endosperm. The health implications of arsenic exposure are grave, leading to chronic diseases such as cancer, cardiovascular diseases, and neurological impairments. Processing methods like parboiling and milling are known to affect arsenic levels in rice grains. This bulletin evaluates the effect of different parboiling, milling cooking methods on arsenic concentration in rice, aiming to provide insights into effective rice processing techniques that can help minimize arsenic intake through rice consumption.

2. Effect of parboiling on arsenic concentration

Parboiling, a common rice processing method involving soaking, steaming, and drying, can significantly alter the arsenic content in rice. There are several types of parboiling methods, including hot soaking (HS), cold soaking (CS), and pressure parboiling (PP).

- Hot Soaking (HS) involves soaking the rice in hot water before steaming. Paddy samples were soaked in hot water (65^{0}C) and maintained at that temperature for 4 hrs. After draining the water, parboiling was done by steaming for 10 mins
- Cold Soaking (CS) involves soaking the rice in cold water before steaming. Paddy samples were soaked in cold water and kept at ambient temperature overnight. After draining the water, parboiling was done by steaming for 10 mins
- Pressure Parboiling (PP) involves soaking the rice under pressure, followed by steaming. Paddy samples after cleaning, were allowed for open steaming for 20 mins, followed by steaming at 5psi for 10 mins and 10 psi for 10 mins

Parboiling increases arsenic concentration in the rice endosperm, with pressure parboiling resulting in the highest increase. Hot water soaking and cold water soaking follow, but the increases are generally lower. The observed increase in arsenic concentration compared to non-parboiled rice varied across parboiling methods. Pressure parboiling resulted in the highest arsenic accumulation in grain (around 32.7%)

3. Effect of milling on arsenic removal

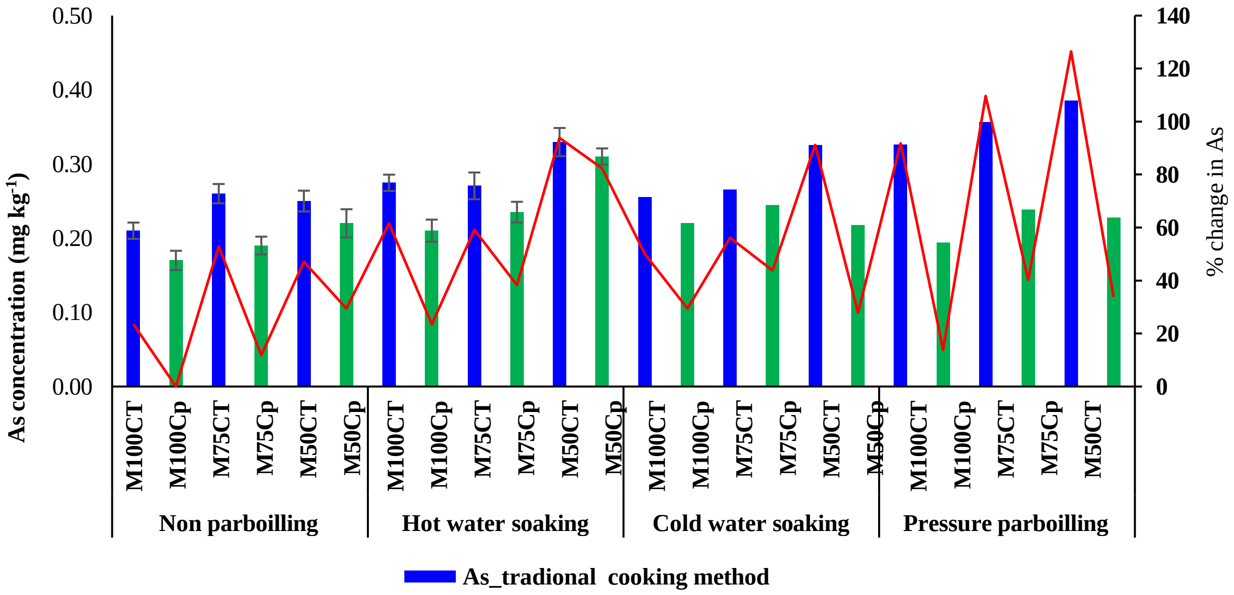
Milling, which involves the removal of the bran layer and polishing the grain, significantly influences the arsenic concentration in rice. The degree of milling determines the extent of arsenic removal, as arsenic is primarily concentrated in the outer layers of the grain (bran).

- 100% Milling (M100) refers to fully polished rice, which removes most of the bran. Running time of the milling unit (SATAKE) is 40-60 sec
- 75% Milling (M75) and 50% Milling (M50) refer to milled rice with varying degrees of bran removal. The running time of the milling unit (SATAKE) is 30-40 sec and 20-30 sec, respectively

Full milling (M100) is the most effective in reducing arsenic, with a reduction of up to 52.4% due to the removal of the arsenic-rich bran layer closely followed by 75% Milling (M75). The extent of arsenic reduction increases with the intensity of milling, but excessive milling leads to significant nutrient loss, including essential minerals like zinc and iron.

4. Effect of cooking on arsenic removal

Cooking methods significantly influence the final arsenic concentration in cooked rice. Traditional cooking, where excess water is discarded, is more effective in reducing arsenic content compared to pressure cooking, which retains water. On average, traditional cooking reduced As levels by 24.2% in high-yielding varieties (HYVs), 26.85% in hybrids, and 15.45% in local aromatic rice (LARs). In contrast, pressure cooking showed minimal impact, with less than 6% reduction in cooked rice across all varieties.



M100: 100% milling, M75: 75% milling, M50: 50% milling, CT: Cooking with excess water, CP: Cooking in limited water or in pressure cooker

Fig 1. Effect of Parboiling, milling and cooking methods on As concentration in cooked rice

5. Recommendations for safe rice

To minimize arsenic (As) exposure through rice consumption without compromising nutritional quality, a combination of optimized parboiling, milling, and cooking methods is recommended:

- **Parboiling:** Avoid pressure parboiling, especially in arsenic-prone areas, as it promotes greater arsenic migration into the endosperm. Non parboilled rice is more preferable for As prone areas. If parboiling is necessary for post-harvest handling or storage benefits, cold soaking are preferable due to their relatively lower impact on As accumulation in cooked rice. Cold soaking is especially recommended for maintaining a balance between arsenic levels and micronutrient (Fe and Zn) retention.

- **Milling:** Milling significantly reduces arsenic content in rice grain by removing the bran layer where most arsenic accumulates. Full milling (100%) should the highest arsenic reduction (up to 52.4%) from whole grain, but it also causes substantial loss of micronutrients like Fe and Zn. Therefore, moderate milling (50%) is suggested as a trade-off between reducing arsenic and preserving essential nutrients.

- **Cooking:** Traditional cooking methods that involve excess water draining are highly effective in reducing arsenic in cooked rice, especially when applied to partially milled and parboiled rice. Discarding the cooking water can eliminate up to 39.7% of arsenic. Pressure cooking, while convenient, retains more arsenic and should be avoided in high-As regions if rice is not properly milled.

These integrated practices like selective parboiling, balanced milling, and traditional cooking could collectively lower dietary arsenic exposure while maintaining nutritional quality. Stakeholders including rice millers, processors, policymakers, and consumers could adopt and promote these safe processing techniques, especially in arsenic-contaminated regions.

6. Acknowledgements

We extend our sincere thanks to ICAR-Central Rice Research Institute for all necessary supports.

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NRRI Technology Bulletin No. 245

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