Consumers can lower their toxic arsenic intake by selecting appropriate kitchen practices

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Introduction

- Unlike for other elements (cadmium, lead, mercury), it is not the total concentration of arsenic (As_{tot}) that determines the toxicity in food but the species distribution and concentration of the element.
- The inorganic forms of As (As_i) are considered as highly toxic and carcinogenic, methylated species methylarsonate (MA) and dimethylarsonate (DMA) are classified as possibly carcinogenic, while the organic arsenobetaine (AB) is considered as non-toxic. Toxicity of other organic forms is mostly unknown but not excluded.
- The growing analytical possibilities during the past 10 years resulted in the collection of As speciation data in food and the appearance of the first European legislation for As_i in rice and some rice products.
- In contrast with the high number of studies reporting As speciation data in various unprocessed food items, food processing studies are limited to few matrices and speciation is not always given attention.
- The goal of the present study was to gain insights in the effects of food preparation on As concentrations and speciation of different kind of foods. In this way, a more accurate insight can be obtained in the actual effect of food processing on the exposure to As (species).

Materials and methods

Food samples and preparation

The concentration of As_{tot} and arsenic species (As_i, DMA, MA, AB) was monitored in different foodstuff (rice, vegetables, algae, fish, crustacean, molluscs) before and after processing using common kitchen practices (Table 1).

Potential leaching effects were separated from apparent effects due to changes in moisture content upon food preparation, by measuring water content of the foodstuff and by reporting arsenic concentrations on a dry weight base.

	Raw	Boiled (no excess water)	Boiled (excess water discarded)	Boiled (soup)	Steamed	Fried	Prepared in microwave	Soaked
White rice	x	x	x					
Brown rice	x	x	x					
Carrots	x		x		x			
Leeks	x		x		x			
Onion	x					x		
Mushroom	x					x		
Cod	x					x	x	
Trout	x					x	x	
Scampi	x					x		
Mussels	x				x			
Scallops	x					x		
Nori	x			x				
Hijiki	x		x	x				x

Table 1 : Overview of the treatments of sampled foodstuff

Analytical methods

- Moisture content: weighing sample (20 g) before and after oven drying for 48h at 50°C
- As_{tot}: pressurized microwave digestion with HNO_3 + measurement by ICP-MS
- As speciation: see table 2

	Method 1	Method 2	Method 3
Matrices	Rice Vegetables Algae	Wine	Fish Molluscs Crustacean
Extraction solution	0.63 M HNO_3 3% H_2O_2	milliQ-H_2O	milliQ-H_2O
Column	PRP-X-100, Hamilton		IonPac AS7, Dionex
Injection volume (µL)	60		60
Mobile phase A	60 mM ammoniumcarbonate		0.05 mM benzenedisulfonic acid, 0.5 mM HNO_3, 0.5 % MeOH
Mobile phase B	milliQ-H_2O		0.05 mM benzenedisulfonic acid, 50 mM HNO_3, 0.5 % MeOH, (pH 1.8)
Flow rate	1.0 mL min^{-1}		1.0 mL min^{-1}

Elution gradient	Method 1/2						Method 3					
Time (min)	0	0.5	10	13	15	16	0	3	4	16	17	21
%A	20	20	100	100	20	20	100	100	30	30	100	100
%B	80	80	0	0	80	80	0	0	70	70	0	0

Table 2 : Overview of extraction and analysis methods for As speciation

Results

Arsenic (species) were released towards the broth during boiling, steaming, frying or soaking of the food.

Food preparation processes where **no broth was removed** after food processing did **not** significantly **affect** the As (species) concentration

When the **broth was removed**: **concentrations declined** with a maximum of 57% for As_{tot}, 65% for As_i and 32% for AB (Figure 1).

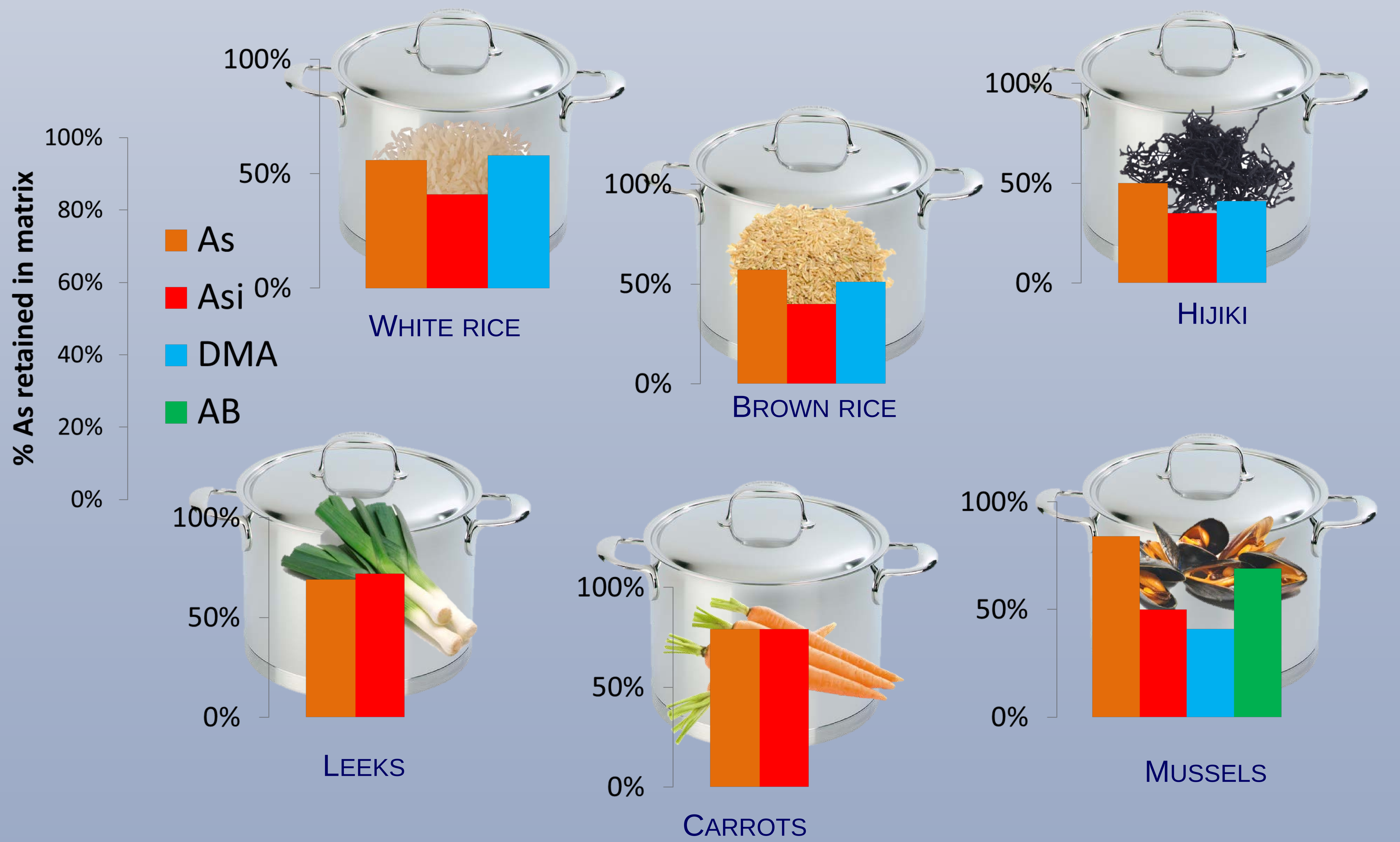

Figure 1: percentage of As retained in the foodstuff after removal of the broth

No transformation of As species was observed. This might be explained by the temperature during food preparation which did not exceed 100°C. Earlier species transformations were only observed at temperatures > 120 °C.

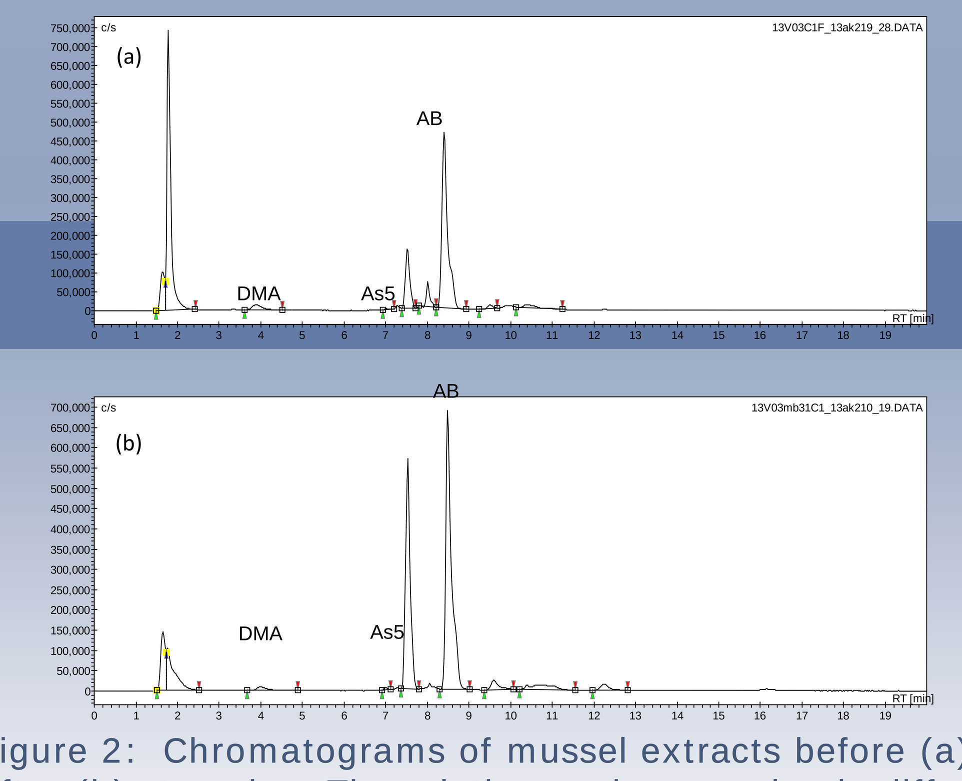

Figure 2: Chromatograms of mussel extracts before (a) and after (b) steaming. The relative peak areas clearly differ.

Discussion and conclusion

- Food preparation with water removal did decrease levels of As_{tot} and several As species in foodstuff
- High temperatures, increased contact times and/or water movement enhance the As release (e.g. soaking hijiki vs boiling)
- Our data confirm earlier observations of the species-dependent specificity of the As release process:
  - As_i is more easily released from rice compared to DMA
  - The release of As_i, DMA and AB from mussels was larger than the release of As_{tot}, suggesting that unidentified species were released to a lower extent. This is illustrated by the difference in relative peak areas in the chromatograms of mussels before and after steaming (figure 2)

The extent of As leaching tends to be species specific: inorganic arsenic > smaller organic As molecules > larger organic As molecules.
Extrapolation of these results to extractability efficiency supports the advise NOT to correct for recovery during As speciation analysis

Consumers can lower their toxic As intake by boiling rice and vegetables in an excess of water and discarding the broth

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