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Food Contamination Survey: Content of Arsenic (As) in rice from supermarkets in North Africa and the Middle East.

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ABSTRACT

The results of a market basket investigation conducted to determine the total levels of Arsenic (As) in rice purchased from supermarkets in North Africa and the Middle East (NA & MIDEA). Two hundred eighty samples of rice were collected from numerous large food supermarkets in towns and cities in NA and MIDEA: Morocco (MR), Libya (LB), Algeria (AL), Tunisia (TN), Egypt (EG), Jordan (JO) and Syria (SY). The average level of As in rice from NA & MIDEA is 0.22 mg/kg, comparable with average levels in Australia, although not representative of the levels in rice from the USA. The differences in As levels in rice from the nine countries of origin were found to be significant. The rice with the lowest grain As concentration, 0.05 mg/kg, was a short grain variety from Egypt, while the highest, 0.22 mg/kg, was found in a long grain rice from Australia.

1. Introduction

The world population has increased by 35 % since 1950–1955; it is predicted to reach *c.* 8100 million by 2030 (Greenland, 1997), resulting in significant additional food requirements. Concurrently, water demand from non-agricultural sectors will continue to increase in both developed and developing countries. Nearly 30% of the world's land mass are under arid or semi-arid climatic conditions (Greenland,1997, Malagnoux, 2007). It is estimated that by 2030, agricultural production in 93 developing countries will have increased by 49 % in rainfed and 81 % in irrigated regions from 1998 levels. Simultaneously, however, increases in the area under irrigation in developing countries are reducing. It increased twice as much in 1988 as in 1992 and is predicted to grow by only 23 % over the period 1998–2030.

Rice (*Oryza sativa* L.) was the first cultivated crop in Asia and is the main grain produced and consumed by more than 50% of the world's population (Milford *et al.*, 1990). The world production of rice is *c.* 550,200 million tons (Mt). Seed composition is 880, 20 and 80 g/kg of carbohydrate, oil and protein, respectively .(Egli, 1998). Rice has supported a huge number of people, much greater than other crops, for a long time and is the staple food for *c.* 50 % of the world's population, with the average adult, reported to consume up to 0.5 kg rice daily (Williams *et al.*, 2005). It is grown widely in South and Southeast Asia, Southern Europe, South America, the Middle East and Africa. Cereals in general,account for *c.* 60 % of the world's human food crops consumption (Gallagher *et al.*, 1984). Major exporters of rice are Thailand, the United States, Vietnamand Pakistan (36, 19, 10 and 7 %, respectively, of the world's market). However, Australia, China, India and Uruguay each account for 1–3 % of the market (Milford *et al.*, 1990). 20 years ago rice was considered a luxury food in West Africa but now it is a staple, accounting for more than a quarter of cereal consumption. It is now the main grain produced and consumed in Africa: in 1996, Africa consumed a total of 11.6 million tonnes (Mt) of milled rice. Nigeria produces *c.* 80 % of its total rice consumption; however, as a result of the rapidly increasing consumption rate its imports of rice are also increasing (Africa Focus, 2004).

Africa is a net importer of rice, with Nigeria, South Africa, Senegal and Cote d'Ivoire ranking among the top 10 rice importers in the world. In Kenya, annual production has halved to 45,000 Mt since 2006 due to drought (Gambia News Community,2008), while in the last 30 years, Uganda has doubled its rice production. Consumption of rice in Africa is growing faster than for any other crop and, according to the Africa Rice Centre, has done so at an average of 5 % per year since 1960 (Gambia News Community,2008). An estimated 20 million hectares of rain-fed lowlands could be used for growing rice in Africa.

Wheat, rice and barley are three of the most important food crops and are extensively grown throughout the dry areas in the WANA region (FAO, 2007b); as populations grow and the need for food increases, production of these crops is expected to increase to meet the demand. Net food requirements have been estimated for 2000–2005 and are shown in Table 1 (FAO, 2007a).
Although it was found in the present study that the Australian rice had higher As contents than American rice, the American rice had the highest mean level of rice grain As, 0.26 mg/kg (Williams *et al.*, 2007a).

No previous studies have been conducted to investigate levels of total As and other trace elements in rice purchased from supermarkets in NA & MIDEA. To address this, a market basket survey of As and Se concentrations in rice was conducted in NA and MIDEA, to determine variations in concentrations for grain from Africa (North African) and Asia (the Middle East) and to complement global As and Se baseline estimates for rice imported to both countries from other global markets.

2. Materials and methods

2.1 Country of purchase rice survey

Two Hundred and eighty samples of rice were collected from numerous large food supermarkets in towns and cities in NA & MIDEA: Morocco (MR), Libya (LB), Algeria (AL), Tunisia (TN), Egypt (EG), Jordan (JO) and Syria (SY). Classification of the rice was by country of origin: Australia (n = 6), USA (n = 70), Italy (n= 9), Egypt (n=108), Spain (n=21), Pakistan (n=10), India (n=31), Thailand (n=22), China (n=3), L.C. (rice from USA, packaged locally in

the country of origin and carrying no specific information about where in the USA it originated from; n=39) and *NA (unpackaged rice from the USA, origin carrying no specific information about where in the USA it originated from; n=14). Information on the amounts of As in Egyptian, Italian and Thai rice has previously been published in Meharg *et al.*, (2009), and for Se in Williams *et al.*, (2009). From the country of origin survey in NA & MIDEA, rice samples from Egypt, USA and Thailand accounted for 38.2, 24.7 and 7.8%, respectively, of imported white rice samples collected fromEgypt, Jordan and Syria, respectively. Most of the Australian rice collected was from Jordan's major supermarkets. However, according to the country of purchase rice survey in NA & MIDEA, Egyptian rice was more readily available.

Table 1
Mean grain production, import, and consumption (FAOSTAT 2007).

Mean 2000–2005/ Countries	Algeria	Egypt	Libya	Morocco	Tunisia	Syria	Jordan
Rice production (1000 tonnes)	0.22	5998	0	28	0	0.1	0
Rice Import standardized (1000 tonnes)	134	19	209	14	24	349	188
Rice consumption (g/capita/day)	9	170	60	3	5	52	162

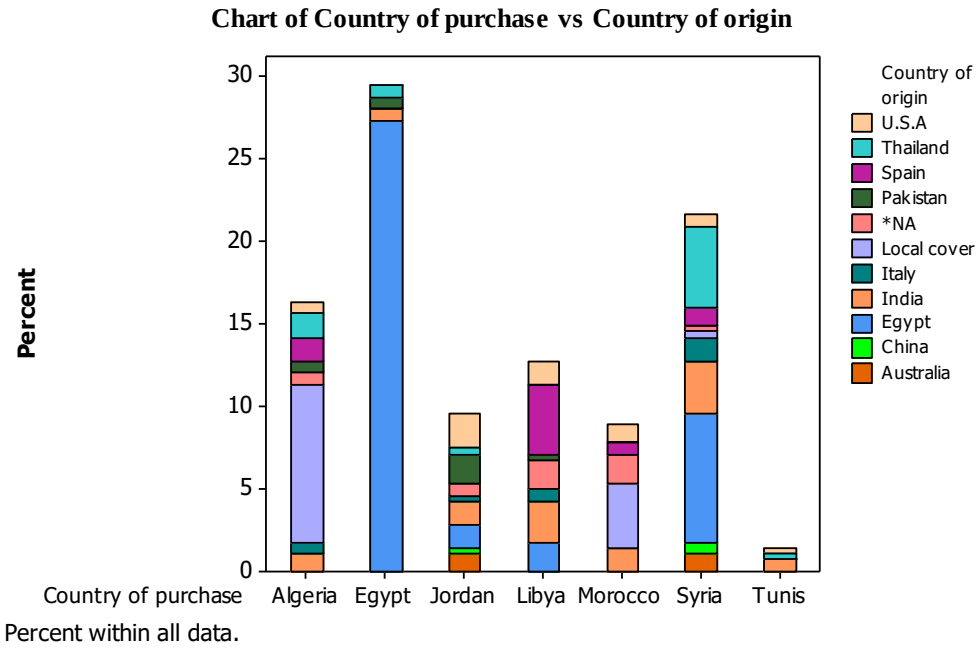

Fig. 1 The distribution of country of origin of rice samples purchased from supermarkets in NA & MIDEA.

The market basket survey for this study was conducted across two continents, NA & MIDEA, and seven countries of purchase (MR, LB, AL, TN, EG, JO and SY), collected from markets and supermarkets, and all chosen for human consumption (Fig. 1). The principle aim of the study was to assess geographical variation in As levels in rice from the major countries of purchase in NA & MIDEA.

2.2 Sample preparation and analysis

In this study, total As, concentrations was determined by inductively coupled plasma-mass spectrometry (ICP-MS). The sample preparation and analytical procedures are identical to those published for total As determination (ICP-MS) by Meharg *et al.*, (2009) and Williams *et al.*, (2006). The same Aristar grade reagents cited in those studies were used exclusively throughout the analysis, and powdered rice NIST CRM 1568a, analytical blanks and spikes were used with each batch of market grain samples to monitor analytical performance.

3. Results and discussion

3.1 Arsenic

The average level of As in NA & MIDEA rice was 0.22 mg /kg, compared with average levels in Australia although not representative of the levels in rice from the USA (Williams *et al.*, 2007a). The mean and median As grain levels were 0.13 and 0.14 mg/kg, respectively for 70 samples of rice from the USA (Table 1). Levels of As for Spain were 23 % lower than for Australian rice, with a mean of 0.14 and median of 0.11 mg/kg for 21 samples. The differences between As levels in rice from the nine countries of origin were found to be significant (ANOVA, $P = 0.028$). The sample with the lowest As grain concentration (0.05 mg/kg) was a short grain variety from Egypt (Fig. 2), while the highest (0.22 mg/kg) was for long grain rice from Australia. Approximately 25 % of the rice samples collected that originated from the USA were from Jordan's major supermarkets and were found to have grain As levels with a mean of 0.11 and median of 0.10 mg/kg (Table 2 and Fig. 1). Egyptian rice had the lowest mean As levels (0.05 mg/kg), followed by rice from Pakistan (0.06 mg/kg) and India (0.07 mg/kg).

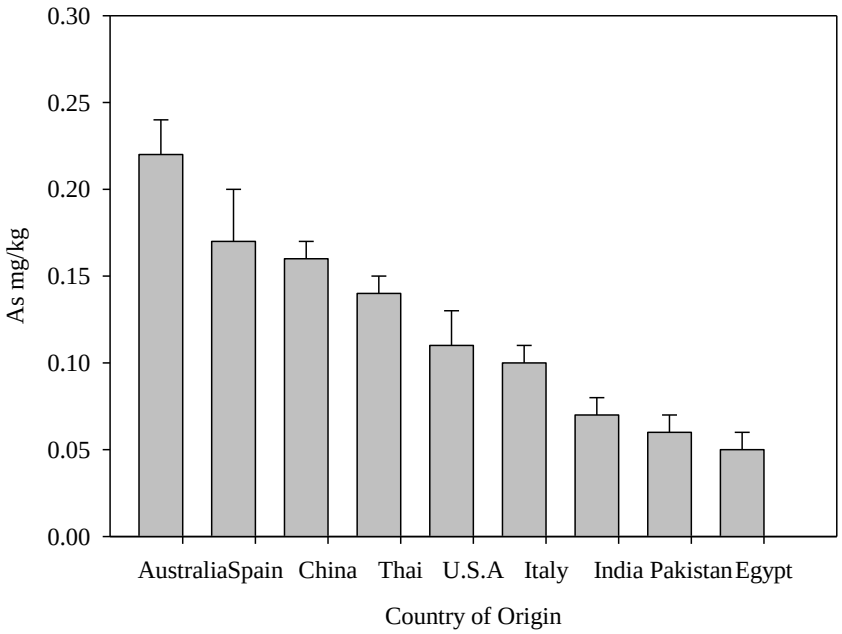

Fig. 2 Total As in rice purchased from supermarkets in NA & MIDEA, classified by country of origin.

Table 2
Descriptive statistic of total as contents for rice produced in different countries.

Element	Origin	N	Mean	Median	Minimum	Maximum	S.E.
As	Australia	6	0.22	0.23	0.17	0.27	0.02
	Spain	21	0.17	0.11	0.05	0.48	0.03
	China	3	0.16	0.17	0.15	0.17	0.01
	Thailand	22	0.14	0.16	0.01	0.22	0.01
	USA	70	0.11	0.10	0.03	0.22	0.02
	Italy	9	0.10	0.10	0.07	0.16	0.01
	India	31	0.07	0.06	0.01	0.18	0.01
	Pakistan	10	0.06	0.05	0.03	0.15	0.01
	Egypt	108	0.05	0.04	0.01	0.58	0.01

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