Feeding arsenic-containing rice bran to growing pigs: arsenic distribution in major tissues

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Introduction

- Although arsenic (**As**) is required by pigs, inorganic As is a non-threshold carcinogen to humans (Lokuge et al., 2004; Mohammed et al., 2015)
- The unique physiology of rice plant allows rice to take up As from water and soil in a very efficient manner (Williams et al., 2007), and rice bran (**RB**) contains more As than the milled rice grain (Sun et al., 2008. 42)
- As animal feed or human food (Gul et al., 2015), RB can be a potential source of As contamination in the chain from animal feed to human food
- Using RB as a feedstuff raises a critical question: whether or not the As-containing RB contaminates the meat or other edible tissues of food animals
- Therefore, it is crucial to study the accumulation of residual As in different tissues of the pigs fed As-containing RB

Objective

- To investigate the As distribution among various pig tissues after a chronic exposure to an As-containing RB

Materials and Methods

- **Experiment design**: Twenty crossbred gilts (Initial body weight 26.3 ± 2.18 kg) were used in an experiment with a completely randomized experimental design and pigs as experimental units.
- **Treatment groups:** As shown in Tables 1 and 2, Diet I was the control diet (n = 6), Diet II was a moderate RB-containing diet (n = 7), and Diet III was a high RB-containing diet (n = 7).
- **Animals feeding:** Pigs had *ad libitum* access to their respective diets for 6 weeks.
- **Samples collection:** Blood and hair samples were collected at the beginning and the end of the 6 weeks, while liver, kidney, and skeletal muscle samples were collected at the end of the 6 weeks (slaughter).
- **Arsenic determination:** The As concentrations were determined at the Midwest Laboratories in Omaha, NE, using a standard protocol of Inductively Coupled Plasma – Mass Spectrometry (EPA: Method 6020).
- **Statistical analysis:**
  - Data were analyzed with ANOVA. However, Tobit model was used in cases where some dependent variables were imprecisely measured (Tobin, 1958). Significance was set at $p \leq 0.05$.

Experimental Diets

Table 1. Composition (%, as-fed basis) of the three experimental diets formulated for the three groups of pigs

	Diet		
Item	Diet I	Diet II	Diet III
Corn	78.475	43.958	0.000
Rice bran[1]	0.000	36.732	73.464
Soybean meal	18.400	14.400	18.500
Poultry fat	0.000	2.100	6.000
L-Lysine•HCl	0.450	0.480	0.290
DL-Methionine	0.060	0.065	0.050
L-Threonine	0.120	0.170	0.100
L-Tryptophan	0.030	0.030	0.001
L-Isoleucine	0.000	0.040	0.000
L-Valine	0.040	0.070	0.000
L-Cysteine•HCl, anhydrous	0.060	0.090	0.080
Limestone	0.850	1.200	1.200
Dicalcium phosphate	1.200	0.350	0.000
Salt	0.180	0.180	0.180
Mineral premix[3]	0.070	0.070	0.070
Vitamin premix[3]	0.065	0.065	0.065

[1]The As concentration in the RB used was 833 ppb.
[3]Ttrace mineral premix (NB-8557D) and vitamin premix (NB-A16508A0) were obtained from Nutra Blend, LLC (Neosho, MO).

Results and Discussion

Table 2. Calculated and analyzed nutrient composition (%, or as indicated) of the three experimental diets (as-fed basis)

	Diet		
Item	Diet I	Diet II	Diet III
Calculated composition[1]			
Net energy, kcal/kg	2518	2508	2528
Total crude protein	15.7	15.6	18.7
SID[2] lysine	0.98	0.98	0.99
Arsenic, ppb	0.00	306	612
Analyzed composition			
Dry matter	88.2	90.3	92.2
Gross energy, kcal/kg	3957	4729	5227
Crude protein	15.1	15.5	18.2
Crude fat	1.8	10.2	18.2
Crude fiber	3.16	3.36	4.36
Ash	4.83	6.99	9.46
Arsenic, ppb	134	448	633

[1]The calculated values for some other nutrients including various essential amino acids are not shown.
[3]SID = standardized ileal digestible.

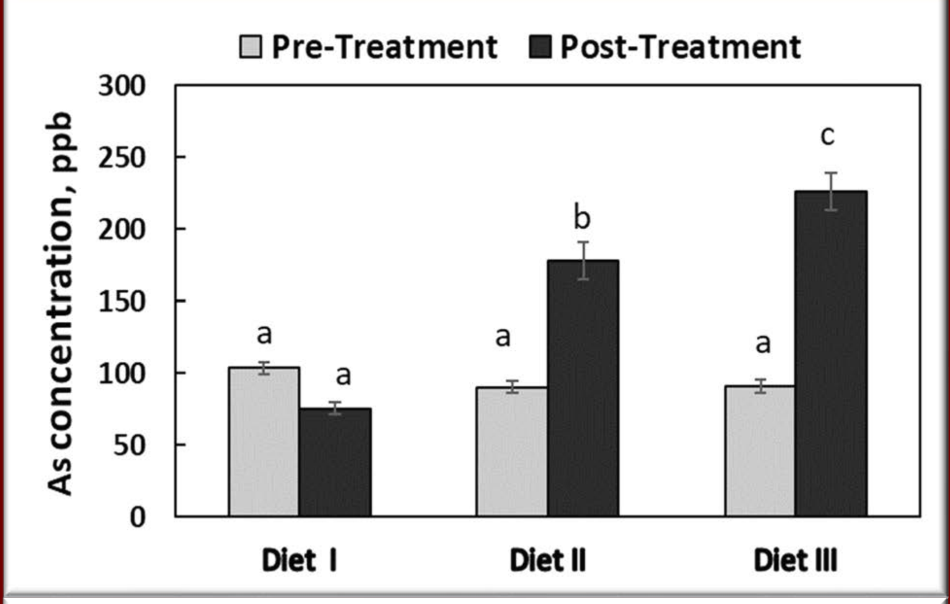

Fig. 1. The concentrations of As in the hair of the pigs fed with three experimental diets. The means/bars labeled with different letters differ ($p < 0.05$).

Table 3. The As concentrations (ppb, as is) in different tissues of the pigs

	Diet				*p*-value		
Tissue	Diet I	Diet II	Diet III	F-stat[1]	II vs I	III vs I	III vs II
Blood	< 10	< 10	< 10	NA	NA	NA	NA
Muscle	< 10	< 10	< 10	NA	NA	NA	NA
Liver	< 10	19.6	13.6	0.16	0.296	0.272	0.696
Kidney	< 10[a]	21.0[b]	18.0[b]	1.40	< 0.001	<0.001	0.249

[1]F-stat = the F statistic shown here only for the hypothesis test of Diet III vs. Diet II.
[a,b]Means within a row that have different superscripts differ ($p < 0.05$).

Results and Discussion

- As shown in Table 3 and Fig. 1, the As concentrations in the blood were below the detection limit, whereas the As concentrations in the liver and kidney were above 20 ppb when the pigs were fed the moderate to high level of As-containing RB. The As concentrations in the hair were the highest among all the tissues tested. These results are consistent with some previous reports (Ledet et al., 1973; Olguín et al., 1983; López-Alonso et al., 2007).
- The tissue As concentration data (Table 3 and Fig. 1) indicate that after absorption, most As must be cleared off rapidly from the blood stream with some being retained in various tissues in the body, which confirmed some previous reports that the As component in animal diets can be readily absorbed by the intestine and rapidly transported by the blood (Ledet et al., 1973; Chen et al., 2013).
- The As concentrations in the muscle, however, were below the detection limit, which suggests that the pork produced from the pigs fed a typical As-containing RB is safe for human consumption.

Conclusions

- The tissue distribution data indicate that the absorbed As was rapidly cleared from the blood with some being retained in various tissues. While pigs' hair retained the highest level of As, the retention is much lower in the liver and kidney. The muscle As data suggest that the pork produced from the pigs fed a typical As-containing RB is safe for human consumption.

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