Can X-ray fluorescence predict mineral concentrations of ground meat?

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Beef and lamb contain many essential minerals and trace elements which are known for their health benefits. Heavy metals such as Cu, As, Cd and Pb beyond legal limits can render meat toxic and unsafe for human consumption, and have been detected in these animal proteins in previous studies (Fardy *et al.*, 1994). For a wide spectrum of elemental analyses, inductively coupled plasma mass spectroscopy (ICP-MS) is the gold standard analytical method (Fardy *et al.*, 1994). However, ICP-MS is limited by its high cost, non-portable nature and extensive sample preparation time. The use of a portable, non-destructive technology that provides rapid feedback, such as x-ray fluorescence (XRF), a tool traditionally used for mining and soil analysis, is trialled in the present study to provide an objective snapshot of the mineral concentrations of meat samples.

A total of forty-three beef and lamb samples collected from supermarkets and butchers were freeze-dried, oven-dried and ground to homogenise. Samples were scanned using XRF (120s) depending on the amount of freeze-dried material available. Following this, samples (200mg) were digested using 10mL HNO_3 (70%) in a microwave prior to determination of the concentration of minerals by ICP-MS. When inputting XRF data, samples below the detection limit were not considered for linear regression analysis. Medians and interquartile ranges (IQR) were obtained for each method and these data were subjected to a linear regression model to assess the relationship between both methods in RStudio.

Table 1. Median (± IQR) and coefficient of determination (R^2) following simple linear regression of the mineral composition (dry matter basis) using x-ray fluorescence (XRF) and inductively coupled plasma mass spectrometry (ICP-MS) from 43 dried meat samples.

	Concentration (ppm)				
	XRF	% above LOD	ICP-MS	R^2	P-value
Essential elements					
Zn	289.6 (198.4)	100	152.1 (108.6)	0.367	<0.001
Fe	115.0 (177.4)	66.0	83.85 (41.71)	0.015	0.438
Ca	422.1 (235.6)	98.9	309.2 (177.7)	0.075	0.079
P	14789 (3791)	100	7237 (1483)	0.167	0.007
Trace elements					
Se	< LOD	0	64.64 (70.70)	-	-
Mn	< LOD	0	0 (0.229)	-	-
Cr	< LOD	0	0.885 (0.861)	-	-
Heavy metals					
Cu	9.605 (0)	3.19	3.683 (2.344)	0.011	0.499
As	< LOD	0	0.095 (0.271)	-	-
Cd	19.54 (2.220)	100	4.849 (7.222)	0.000	0.918
Pb	< LOD	0	0.256 (0.729)	-	-

LOD: limit of detection; % above LOD: percentage of samples above XRF detection limit.

Table 1 shows the concentrations of various essential, trace and heavy elements measured in the meat samples. X-ray fluorescence showed a significant linear relationship with ICP-MS for Zn and P ($P<0.01$) although the precision was low ($R^2 < 0.40$). However, Se, Mn, Cr, As and Pb were all below the LOD of the XRF. The XRF would need major improvements for its use as an objective, non-destructive tool for measuring mineral concentration in meat. Toxic heavy metals were well below Australian legal limits (Fardy *et al.*, 1994). Compared to the ICP-MS study conducted by Fardy *et al.* (1994), Cd and Se showed higher, and Mn and Pb lower concentrations using ICP-MS in the present study. The XRF did not detect Se, Mn, Cr, As or Pb above LOD. Trials using fresh meat and further optimisation of XRF are required for successful application for analysis of meat samples.

References

Fardy JJ, Mcorist GD, Farrer YJ, Bowles CJ, Warner IM and Mingguang T (1994) *International Atomic Energy Agency, NAHRES-23*, Vienna, Austria. 19-70.

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