International Scholars Journals

International Journal of Anatomy and Physiology ISSN: 2326-7275 Vol. 9 (3), pp. 001-008, March, 2020. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Determination of toxic metal concentrations in flame-treated meat products, *ponmo*

W. Okiei*, M. Ogunlesi, F. Alabi, B. Osiughwu and A. Sojinrin

Chemistry Department, University of Lagos, Akoka, Lagos, Nigeria.

Accepted 14 September, 2019

Cowhides '*ponmo*' prepared by various and unknown processing methods were purchased from several markets in Lagos and environs and the contents of lead, cadmium, chromium, zinc, mercury and arsenic were determined before and after boiling. Significantly high levels of these metals except cadmium and zinc were found in all the samples obtained after boiling. The highest levels of Pb (1.54 mg.kg^{-1}), Cr (0.79 mg.kg^{-1}) and As (2.85 mg.kg^{-1}) were found in singed hides processed with flame fuelled by plastics mixed with refuse while Hg (6.74 mg.kg^{-1}) content was highest in singed hides processed with burning tyres. However, cadmium (0.10 - 0.38 mg.kg^{-1}) was detected in three samples of hides randomly obtained from the open market and hence of unknown processing methods. The lowest levels of the metals were usually found in hides processed through the traditional method of boiling in water followed by shaving. A sample of the 'black oil' used as fuel in one of the processing methods was found to have lead content as high as 31.4 mg.dm^{-3}. Some samples of the ash scraped from the singed cowhides were found to have high levels of Pb, Cd, Cr, Zn, Hg and As. The ash is usually carelessly handled and often disposed into streams by food processors thus causing extensive water pollution. Several of the samples were found to be toxic and suggestions are made about how to obtain cowhide samples that are fit for consumption and eliminate pollution and health hazards associated with processing cowhides.

Key words: Heavy metal concentrations, meat products, cowhides.

INTRODUCTION

Nigeria, with an estimated population of 140 million is the most populous country in Africa. Hides of cow meat popularly called '*ponmo*' in South-Western Nigeria and 'wele' in Southern Ghana are served as food delicacy in several parts of Africa. Removal of the hair from the hides is traditionally done by tenderizing the hides in hot water followed by shaving with razor blade to give the finished product '*ponmo*'. Hides obtained through this traditional processing method of boiling in water may contain pieces of metals from the shavers used in removing the hair.

However, other methods have been introduced and adopted by several meat processors in the last few decades. Such methods include singeing off the hair in flames fuelled by various substances such as wood mixed with spent engine oil, plastics mixed with refuse or tyres. These materials contain toxic substances which can contaminate the hides and render them unfit for human consumption. The burnt hides are scraped to remove ash and thereafter boiled in water for about one hour to obtain the finished product, *ponmo*.

Hides processed with flame fuelled by firewood and spent engine oil may contain toxic organic compounds such as polyaromatic hydrocarbons (PAHs), dioxins, furan and benzene. Lead, a highly toxic metal present in spent engine oil, can also contaminate the hides. Dioxin released during wood burning is a potential carcinogen implicated in extreme skin diseases (US EPA, 1994; ATSDR, 1998).

Burning of hides with plastics mixed with refuse presents a significant health hazard to the population. Burning of polystyrene polymers releases styrene vapour which can readily be absorbed by the hides. Long-term exposure to styrene affects the central nervous system, causes headaches, depression, fatigue while short-term exposure can cause eye and throat irritation (ATSDR, 2007). Polychlorinated biphenyls (PCBs) are also released when plastics are burnt, contaminating not only

*Corresponding author. E-mail: wesleyokiei@yahoo.com. Tel: +2348028334124.

the cowhides but also the environment. The processors are also at risk because of the associated health hazards through inhalation of these toxic compounds.

Environmental pollution is also caused by burning of tyres which contain hazardous substances such as styrene and 1,3-butadienes (Holder et al., 1991; Reisman, 1997; IAFC, 2000). Styrene and butadienes are suspected human carcinogens which may be present in tyre-derived fuel. Tyres also contain several metals such as lead, mercury, cadmium, chromium, zinc and arsenic which can contaminate hides when burnt tyres are used as a source of fuel (IAFC, 2000; Pechan and Associates, 1997; OECD, 2004).

In this study the levels of heavy metals in cowhides processed by various methods were determined in order to assess their suitability for human consumption.

MATERIALS AND METHODS

Collection of Samples

Processed cowhides were obtained at the abattoirs to ensure the particular processing method used. A total of 36 samples were collected from six abattoirs in Lagos metropolis on different days between July and September, 2007.

Analysis of samples

The burnt hides were scraped to remove ash. Flakes of 3 - 5 mm thick of the processed hides weighing between 34 g and 122 g were oven dried at 50^{o}C for 2 hrs and reweighed. A known weight (20 g) of the dried cowhide flakes was ashed at 500^{o}C and digested with 2 - 3 cm^3 concentrated HNO_3 and processed for AAS analysis on a Perkin Elmer atomic absorption spectrophotometer, model AA-200. The blank solution was made from concentrated HNO_3 and distilled water. The metals determined were Pb, Cd, Cr, Zn, Hg and As. Samples of the same cowhides were boiled for about one hour and processed for AAS analysis. Samples of finished products, '*ponmo*' of unknown processing methods were randomly obtained from the open market and processed for AAS analysis. The determinations were carried out in triplicates.

27 samples of the ash scraped from burnt hides using each of the processing methods were also digested with 2 - 3 cm^3 concentrated HNO_3 and processed for AAS analysis. Analysis of metals present in two random samples of the black oil used by the processors to aid combustion of firewood was carried out on Spectroil M ICP-OES.

Figure 1 Finished product ponmo, obtained by the traditional method of boiling in water followed by shaving.

Figure 2. Finished product, ponmo obtained by burning off hair with flame (observe the dark colouration from burning).

RESULTS

Figure 1 shows the finished product ' *ponmo*' processed by the traditional method of boiling in water followed by shaving. Figure 2 shows the finished product '*ponmo*' obtained by singeing off the hair with flame. The dark colouration usually obtained is due to burning. The results of the concentrations of the metals determined in the cowhides obtained by the traditional method of boiling the hides are presented in Table 1. It should be noted that the cowhides thus treated were not exposed to naked flame. The corresponding values for cowhides processed by other methods are presented in Table 2 under the subheading 'before boiling' for those cowhide samples that were treated with flame. The samples were scraped to remove ash and boiled for about one hour. The metal concentrations in the boiled samples are presented under the subheading 'after boiling'. Cowhide samples which were purchased from the open market had already been processed by any of the four methods discussed but not known to the buyers.

The metal concentrations in such samples are presented under "Random samples of unknown processing methods" in Table 2. The ranges of values of metal concentrations in the cowhides are presented in Table 3 which is a summary of Tables 1 and 2. All the data presented in Tables 1 - 3 are based on dry weight. The relevant metal contents in two randomly selected samples of the black oil are presented in Table 4 to demonstrate the presence of these metals in the materials used to process the hides. The results show the presence of toxic levels of Fe, Cr and Pb.

Table 1. Metal content in cowhides processed by the traditional method of boiling in water.

Date of collection	Market	Pb $mg.kg^{-1}$	Cd $mg.kg^{-1}$	Cr $mg.kg^{-1}$	Zn $mg.kg^{-1}$	Hg $mg.kg^{-1}$	As$mg.kg^{-1}$
Jul-07	A	0.68 ± 0.01	ND	0.19 ±0.04	4.73 ± 0.07	2.02 ± 0.89	0.76 ± 0.14
Jul-07	A	0.30 ± 0.04	ND	0.12 ±0.02	3.36 ± 0.06	0.46 ± 0.14	0.65 ± 0.05
Jul-07	A	0.17 ± 0.01	ND	0.11 ±0.01	2.66 ± 0.06	0.50 ± 0.12	0.48 ± 0.03
Jul-07	D	ND	ND	ND	5.20 ± 0.12	1.05 ± 0.39	0.30 ± 0.03
Jul-07	D	0.08 ± 0.02	ND	0.24 ±0.05	3.47 ± 0. 10	0.78 ± 0.25	0.05 ± 0.01
Jul-07	D	0.23 ± 0.03	ND	0.31 ±0.06	2.90 ± 0.05	0.92 ± 0.40	0.41 ± 0.05
Jul-07	F	0.32 ± 0.04	ND	0.20 ±0.04	2.99 ± 0.07	0.16 ± 0.06	0.76 ± 0.16
Jul-07	F	ND	ND	0.27 ±0.06	4.30 ± 0.10	0.13 ± 0.05	0.48 ± 0.03
Jul-07	F	0.08 ± 0.02	ND	0.25 ±0.05	3.62 ± 0.11	1.37 ± 0.50	0.65 ± 0.06

ND = Not detected.

The effect of boiling the singed hides is evident in Table 2 and Figure 3 where there are remarkable reductions in the metal content. For example the metal content was reduced by 40 - 100% in twenty one samples for lead, fourteen samples for chromium, eight samples for zinc, seventeen samples for mercury and nineteen samples for arsenic.

Lead was not detected in two samples (22%) of hides processed by the traditional method of boiling in water followed by shaving. Two samples (22%) of such hides had levels of lead of 0.08 ± 0.02 $mg.kg^{-1}$ that are below the permissible maximum value of 0.1 $mg.kg^{-1}$ (USDA, 2006; OJEC, 2001). However, the concentrations of lead in some of such hides were found to be high. Five samples (56%) had lead content in the range 0.17 ± 0.01 - 0.68 ± 0.01 $mg.kg^{-1}$ which appreciably exceed the permissible maximum. Lead was not detected in two samples (22%) of hides processed with firewood mixed with spent engine oil. However, seven samples (78%) of such hides were found to have toxic lead content in the range 0.18 - 1.20 $mg.kg^{-1}$.

The lead content in one sample (11%) of hides singed with plastics mixed with refuse was 0.06 $mg.kg^{-1}$ which is below the maximum permissible value. However, the highest levels of lead, 6.82 $mg.kg^{-1}$, before boiling and 1.54 $mg.kg^{-1}$, after boiling, were found in such hides. Eight samples (89%) of such hides after boiling had lead content in the range 0.25 - 1.54 $mg.kg^{-1}$ which exceed the permissible limit.

None of the samples of hides processed with flame fuelled by tyres had levels of lead that were within the safe limit before and even after boiling. All samples of hides processed by this method had lead contents in the range 0.48 - 1.52 $mg.kg^{-1}$ (before boiling) and 0.16 - 0.50 $mg.kg^{-1}$ (after boiling).

It is noteworthy that in our study a level of 10.37 $mg.kg^{-1}$ of lead was found in a sample of hides of unknown processing method obtained from the open market where the cowhides are sold to the public after processing. The maximum value of lead content of burnt cowhides which were boiled in our laboratory was 1.54 $mg.kg^{-1}$. The ash of the cowhide sample with a lead content of 10.37 $mg.kg^{-1}$ might not have been scraped properly as analysis of the ash from hides processed with plastics indicated lead content of up to 207 ± 11.81 $mg.kg^{-1}$.

Cadmium was not detected in any of the samples of hides obtained by the various processing methods before or after boiling. However, three samples of hides of unknown processing method purchased randomly from the open market had cadmium levels of 0.1 - 0.38 $mg.kg^{-1}$ that exceed the permissible level of 0.05 $mg.kg^{-1}$ (USDA, 2006).

The levels of chromium in all the processed hides before and after boiling were below the maximum permissible level of 1.0 $mg.kg^{-1}$ (USDA, 2006). However, samples of cowhides of unknown processing methods purchased from the open market had chromium concentration of up to 1.22 $mg.kg^{-1}$ which exceed the safe limit for chromium. The presence of unscraped ash might be responsible for this as the ash was found to contain levels of chromium as high as 59.23 ± 24.36$mg.kg^{-1}$.

The levels of zinc in the burnt hides were all in the range of 3.01 - 24.52 $mg.kg^{-1}$ with the maximum value being obtained when plastics mixed with refuse were used to singed the hides. After boiling the hides the levels were within the range of 2.35 - 11.80 $mg.kg^{-1}$ for all the samples. Thus, the zinc levels in all the samples were within the maximum permissible value of 50 $mg.kg^{-1}$ (USDA, 2006; OJEC, 2001). When tyres were used for processing, the zinc concentrations in the hides were 3.72 - 11.80 $mg.kg^{-1}$ before boiling and 2.36 - 6.62 $mg.kg^{-1}$ after boiling.

All the samples (100%) of hides processed by the traditional method of boiling in water had mercury levels in the range 0.13 - 2.02 $mg.kg^{-1}$ which exceed the permis-sible limit of 0.05 $mg.kg^{-1}$(USDA, 2006; OJEC, 2001). The ash scraped off from the burnt hides contained mercury with the concentrations as high as 200.08 ± 23.56 $mg.kg^{-1}$. All samples of hides processed with firewood mixed with spent engine oil had mercury levels in the range 0.34 - 3.50 $mg.kg^{-1}$ after boiling which exceed the permissible limit.

Table 2. Heavy metal content in processed cowhides before and after boiling.

P.M	Date	Market	Pb mg.kg^{-1}			Cd mg.kg^{-1}		Cr mg.kg^{-1}			Zn mg.kg^{-1}			Hg mg.kg^{-1}			As mg.kg^{-1}		
			Before boiling	After boiling	% Red	Before boiling	After boiling	Before boiling	After boiling	% Red.	Before boiling	After boiling	% Red.	Before boiling	After boiling	% Red.	Before boiling	After boiling	% Red.
F+E	Jul-07	A	0.47	0.46	2.1	ND	ND	0.30	0.28	6.7	7.56	7.02	7.1	1.84	0.87	52.7	0.67	0.61	9.0
	Sept-07	A	1.38	0.69	50	ND	ND	0.82	0.73	11.0	6.71	5.48	18.3	4.34	3.50	19.4	0.85	0.59	30.6
	Sept-07	A	1.11	0.18	83.8	ND	ND	0.67	0.16	76.1	10.37	2.67	74.2	1.09	0.70	35.8	1.76	0.79	55.1
	Sept-07	B	0.41	0.33	19.5	ND	ND	0.49	0.07	85.7	9.11	8.45	7.2	1.80	1.15	36.1	ND	ND	0
	Sept-07	B	0.09	0.03	66.7	ND	ND	0.69	0.31	55.0	8.47	6.57	22.5	1.88	1.27	32.4	1.85	ND	100
	Sept-07	B	ND	ND	0	ND	ND	0.69	0.42	39.1	3.14	2.35	25.1	3.72	3.39	8.9	2.4	ND	100
	Jul-07	C	1.33	1.20	9.8	ND	ND	0.35	0.22	37.1	5.83	5.13	12.0	3.78	1.19	68.5	0.99	0.83	16
	Jul-07	C	0.82	0.40	51.2	ND	ND	0.23	0.06	73.9	9.64	9.39	2.6	2.47	0.62	74.9	1.46	ND	100
	Aug-07	C	1.02	0.59	42.2	ND	ND	0.92	0.31	66.3	6.11	3.59	41.2	4.09	0.34	91.7	0.14	0.01	92.9
P+R	Jul-07	A	1.38	0.74	46.4	ND	ND	0.56	0.06	89.3	11.20	2.70	75.9	2.20	0.50	77.3	1.12	ND	100
	Jul-07	A	6.75	1.27	81.2	ND	ND	2.10	0.60	71.4	24.52	4.98	79.7	7.29	1.29	82.3	0.32	0.30	6.3
	Sept-07	A	0.38	ND	100	ND	ND	0.67	0.66	1.5	6.14	5.73	6.7	3.22	1.06	67.1	2.94	2.85	3.1
	Sept-07	D	1.46	0.76	47.9	ND	ND	0.51	0.19	62.7	9.77	7.97	18.4	1.98	ND	100	1.68	0.36	78.6
	Sept-07	D	1.28	0.25	80.5	ND	ND	0.37	0.21	43.2	3.01	2.24	25.6	ND	ND	0	0.66	0.40	39.4
	Sept-07	D	2.48	1.54	37.9	ND	ND	0.78	0.23	70.5	4.70	3.04	35.3	2.62	1.43	45.4	1.09	0.10	90.8
	Jul-07	E	0.22	0.06	72.7	ND	ND	0.76	0.25	67.1	8.09	3.05	62.3	2.47	0.28	88.6	0.03	ND	100
	Jul-07	E	6.82	1.49	78.2	ND	ND	2.51	0.76	69.7	17.13	8.18	52.2	7.59	2.50	67.1	0.11	ND	100
	Jul-07	E	1.95	0.26	86.7	ND	ND	1.31	0.79	39.7	8.10	7.30	9.9	4.40	0.50	88.6	3.92	0.57	85.4
T	Jul-07	A	1.52	0.30	80.3	ND	ND	0.19	0.16	15.8	11.80	4.60	61.0	7.63	6.74	11.7	3.11	0.33	89.4
	Jul-07	A	0.99	0.57	42.4	ND	ND	0.39	0.36	7.7	9.11	6.62	27.3	0.62	0.59	4.8	2.28	1.10	51.8
	Jul-07	A	0.96	0.42	56.2	ND	ND	0.67	0.52	22.4	9.45	6.55	30.7	3.50	3.11	11.1	1.55	0.53	65.8
	Sept-07	D	1.31	0.38	71.0	ND	ND	0.60	0.48	20.0	6.58	5.15	21.7	4.20	2.43	42.1	5.66	1.22	78.4
	Sept-07	D	0.69	0.50	27.5	ND	ND	0.30	0.24	20.0	3.72	2.36	36.6	ND	ND	0	1.53	0.88	42.5
	Sept-07	D	0.50	0.25	50.0	ND	ND	0.38	0.31	18.4	4.44	3.69	16.9	0.50	ND	100	0.77	0.50	35.1
	Jul-07	F	0.55	0.16	70.9	ND	ND	0.58	0.44	24.1	5.57	3.45	38.1	1.36	ND	100	0.04	ND	100
	Jul-07	F	0.48	0.17	64.6	ND	ND	0.02	0.01	50.0	6.77	2.86	57.8	2.23	0.37	83.4	2.23	0.37	83.4
	Jul-07	F	1.19	0.40	66.4	ND	ND	0.10	0.01	90.0	6.57	5.15	21.6	5.18	2.16	58.3	5.18	2.16	58.3
U.P.M	Jul-07	A		1.86			ND		0.92			8.14			2.63			1.98	
	Jul-07	A		2.39			ND		0.52			11.96			0.77			1.97	
	Jul-07	B		ND			ND		0.27			4.18			0.08			1.89	
	Jul-07	D		7.36			0.38		0.34			4.22			ND			0.07	
	Jul-07	D		0.39			0.23		0.33			4.60			ND			ND	
	Jul-07	D		3.27			0.10		0.28			5.59			ND			1.30	
	Jul-07	D		10.37			ND		1.22			4.16			ND			0.90	
	Jul-07	E		1.23			ND		0.18			6.45			0.83			1.47	
	Jul-07	F		0.52			ND		0.19			1.78			0.57			0.43	
	Jul-07	F		0.64			ND		0.09			4.40			0.53			0.10	

P. M. = Processing Method; F + E = Firewood mixed with spent engine oil; P + R = Plastic mixed with refuse; T = Tyre;
U. P. M. = Uknown processing method; Date = Date of collection of samples, ND = Not detected.

Table 3. Ranges of metal concentrations of hides obtained by various processing methods.

Mode of Processing		Pb $mg.kg^{-1}$	Cd $mg.kg^{-1}$	Cr $mg.kg^{-1}$	Zn $mg.kg^{-1}$	Hg $mg.kg^{-1}$	As $mg.kg^{-1}$
Traditional		0.00 - 0.68	ND	0.00 – 0.31	2.66 – 5.20	0.13 – 2.02	0.05 – 0.76
Firewood mixed with spent engine oil	Before boiling	0.00 – 1.38	ND	0.23 – 0.92	3.17 – 10.37	1.09 – 4.34	0.00 – 2.40
	After Boiling	0.00 – 1.20	ND	0.06 – 0.73	2.35 – 9.39	0.34 – 3.50	0.00 – 0.83
Plastic mixed with refuse	Before boiling	0.22 – 6.82	ND	0.37 – 2.51	3.01 – 24.52	0.00 – 7.59	0.03 – 3.92
	After Boiling	0.00 – 1.54	ND	0.06 – 0.79	2.24 – 8.18	0.00 – 2.50	0.00 – 2.85
Tyres	Before boiling	0.48 – 1.52	ND	0.02 – 0.67	3.72 – 11.80	0.00 – 7.63	0.01 – 5.66
	After Boiling	0.16 – 0.57	ND	0.01 – 0.52	2.36 – 6.62	0.00 – 6.74	0.00 – 2.16
*Random Samples of unknown processing method		0.00 –10.37	0.10-0.38	0.09 – 1.22	1.78 – 11.96	0.00 – 2.63	0.00 – 1.98
Maximum permissible levels+		0.1	0.05	1.0	50	0.05	0.05

* - Samples (after boiling) obtained from open markets.
\+ USDA, 2006; OJEC, 2001; European Commission Regulation, 2006.

Table 4. Analysis of black oil used to aid combustion of firewood.

Metal	Concentration(mg/dm^3)
Fe	46.40 ± 10.61
Cr	1.8 ± 2.55
Pb	16.35 ± 21.28
Cu	11.35 ± 3.18
Al	14.25 ± 2.89
Si	22.46 ± 15.78

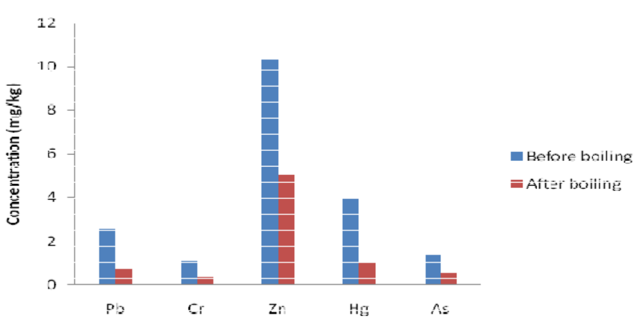

Figure 3. Effect of boiling on metal concentrations in singed hides processed with plastics.

Mercury was not detected in two samples (22%) of hides boiled after processing with flames fuelled with plastics and refuse. However, the mercury content in the remaining seven (78%) of such samples was in the range 0.28 - 2.50 $mg.kg^{-1}$ thus are toxic and are unfit for human consumption. Mercury was not detected in three samples (33%) of hides boiled after processing with burning tyres. The mercury content in the remaining six samples (67%) was in the range 0.37 - 6.74 $mg.kg^{-1}$. Mercury was not detected in 40% of the samples of unknown processing methods but six samples of hides purchased randomly from the open market had mercury levels of 0.08 - 2.63 $mg.kg^{-1}$ that exceed the permissible limit.

Only one sample (11%) of hides processed by the traditional method with arsenic content of 0.05 $mg.kg^{-1}$ was within the permissible limit of 0.05 $mg.kg^{-1}$ (USDA, 2006; OJEC, 2001) for arsenic. All the remaining eight samples (89%) had arsenic contents in the range 0.30 - 0.76 $mg.kg^{-1}$ which indicate toxic levels. Five samples (56%) of hides which had been processed with firewood and spent engine oil had zero and near zero levels of arsenic. The remaining four samples (44%) had arsenic content in the range 0.59 - 0.83 $mg.kg^{-1}$ which are far in excess of the maximum permissible value of 0.05 $mg.kg^{-1}$ and are thus, toxic and unfit for human consumption. No arsenic was detected in three (33%) samples of the hides processed with plastics mixed with refuse and subsequently boiled.

The remaining six samples (67%) had arsenic content in the range 0.10 - 2.85 $mg.kg^{-1}$ and are toxic and unfit for human consumption. No arsenic was detected in one sample (11%) of the hides processed with burning tyres and subsequently boiled. The remaining eight samples (89%) had arsenic content in the range 0.33 - 2.16 $mg.kg^{-1}$ and are thus toxic. Arsenic was not detected in some random samples of unknown processing methods but values as high as 1.98 $mg.kg^{-1}$ were obtained in some others. Some of the ash scraped from the burnt hides contained significant quantities of arsenic even as high as 240.0 ± 10.9 $mg.kg^{-1}$.

DISCUSSION

The maximum values of metal concentration in meat in $mg.kg^{-1}$ without the fear of risk or health hazard are 0.1 (Pb), 0.05 (Cd), 1.0 (Cr), 50 (Zn), 0.05 (Hg) and 0.05 (As) (USDA, 2006; OJEC, 2001; European Commission Regulation, 2006).

Boiling of the burnt hide is crucial to the processing because the product of this process is the form in which it is sometimes consumed. While some consumers would boil the product further and discard the water others would dice it and put it in thee soup, thus, all the heavy metals extracted on heating would still be ingested by the consumers. The colours of the samples in Figures 1 and 2 are a useful guide in the selection of the processed product as the lighter one in Figure 1 has not been singed.

The high level of lead found in some samples of hides processed by the traditional method of boiling in water is unexpected but may be due to the possibility that the hide was boiled in water that had been used for boiling burnt hides and thereby contaminated with lead which was found to be present in large quantities in the ash scraped off from the hides processed with firewood. It is also possible that some cattle might have grazed in areas in which the soil and water had been contaminated with toxic heavy metals including lead, mercury and arsenic. High levels of lead were found in some samples of hides processed with firewood mixed with spent engine oil. The high lead content is really not surprising because the ‘black oil’ used as fuel was found on analysis to be rich in lead as shown in Table 4. The black oil is widely distributed by auto mechanics to food processors who use it as source of fuel in singeing the cowhides and render them toxic and possibly cause life threatening diseases.

The highest level of lead was found in hides processed with refuse mixed with plastics. The plastics and refuse used to fuel the flame for burning off the hair were of undefined content. There is no guideline about disposal of refuse in several developing countries hence any substance, including lead accumulators that are found in refuse dumps could be responsible for the high levels of lead in such hides. Processing cow hides with tyres imposes enormous risk of deposition of toxic metals and other compounds on the hides. In a study carried out in Ghana (Obiri- Danso et al., 2008), the levels of heavy metals in the singed animal hides were generally high compared to the levels in some other meat products (Santhi et al., 2008; Korenekova et al., 2002). However, appreciable heavy metal concentrations were found in un-singed hides and in fact the concentrations of lead in cattle hide was reduced after they had been singed, although the concentrations of Mg, Mn, Cu, Ni, Cd and Zn increased appreciably.

However, another report (Essumang et al., 2007) attributed heavy metals in cattle hides (wele) in Ghana to tyre-singed treatments. Essumang et al. (2007) reported elevated levels of 206.40 $mg.kg^{-1}$, 245.80 $mg.kg^{-1}$, 14.40 $mg.kg^{-1}$ and 6.00 $mg.kg^{-1}$ for iron, zinc, chromium and nickel respectively in singed hides processed with vehicle worn out tyres.

In this report, the heavy metal contents in un-singed cattle hides are those processed by the traditional method of boiling in water. Examination of Table 1 shows that the lead contents are in the range of 0.00 – 0.68 ± 0.01 $mg.kg^{-1}$. If it is assumed that boiling has reduced the lead content by 60%, then the concentration of lead in the un-singed cattle hides would be in the range 0.00 - 1.13 $mg.kg^{-1}$ which is about one-quarter of that reported by Obiri-Danso et al., 2008. However the values reported by the authors are based on three slaughtered cows which can be regarded as a small population and may not capture the average lead concentration in the cattle hides in Ghana.

High levels of lead in foods can cause lead encephalopathy in adults. Early symptoms include dullness, headache, muscular tremor, loss of memory and hallucinations. This may develop into delirium, convulsion, paralysis, coma and death (Kumar et al., 1985). Exposure to toxic levels of lead can also cause insomnia, nausea, headache, constipation, weight loss, anaemia, malfunctioning of the kidney and reproductive organs (ATSDR, 2007b; Moore et al., 1987).

Cadmium was not detected in any of the samples of hides obtained by the various processing methods before or after boiling. In the report on similar studies in Ghana (Obiri-Danso et al., 2008), cadmium levels of 1.12 ± 0.48 $mg.kg^{-1}$ in the un- singed cattle hides increased to 4.20 ± 0.17 $mg.kg^{-1}$ after they were singed and reduced to 1.10 ± 0.26 $mg.kg^{-1}$ after washing. In the 37 samples reported in our study, cadmium was detected in only three which were of unknown processing method. Common symptoms in humans following ingestion of foods containing high concentrations of cadmium include nausea, vomiting, salivation, abdominal pain, cramps and diarrhea (Baker and Hafner, 1961; Buckler et al., 1986). In a reported case of fatal cadmium poisoning, the level of cadmium ingested was 25 $mg.kg^{-1}$ (Buckler et al., 1986).

The levels of chromium in all the processed hides before and after boiling were within limits. In a comparative study of trace elements in certain meat products and meat products in Turkey (Demirezen and Uruc, 2006), the chromium content in meat was found to be 8.8 ± 0.12 $\mu g.100\ g^{-1}$ (0.088 $mg.kg^{-1}$) and 54 ± 0.99 $\mu g.100\ g^{-1}$ which are below the maximum permissible limit (USDA, 2006; OJEC, 2001). Thus, it appears that chromium may not be at toxic levels in meat although differences in the breed of cattle and environment limit the comparison of the two sets of results. Ingestion of toxic levels of chromium VI can lead to vomiting, diarrhoea, blood loss into the gas-trointestinal tract causing cardiovascular shock, skin ulcers, dermatitis and eczema, respiratory cancers-pri-marily lung and naso-pharyngeal (Braver, 1985; Olaguibel and Basomba, 1989).

The levels of zinc in the burnt hides were also within limits. The study in Ghana reported zinc values of 17.71 ± 3.48 $mg.kg^{-1}$ for un-singed hides which increased considerably to 204. 49 ± 36.68 $mg.kg^{-1}$ after they were singed. The marked difference in the values of zinc obtained in our study and that of Obiri-Danso et al. (2008) may be due to the singeing process employed in the studies as the hides were placed directly on metal stripes obtained as residues from burnt tyres in the study carried out in Ghana. The value of 17.71 ± 3.48 $mg.kg^{-1}$ for the un-singed hides is far in excess of the maximum value of 5.20 ± 0.12 mg.kg^{-1} obtained for hides processed by the traditional method of boiling in water even after allowing for the reduction effected by boiling. However, all the values are within safety limits. Zinc is essential for normal functioning of cells including protein synthesis, carbohydrate metabolism, cell growth and cell division (Cousins, 1996) . However, at very high concentrations it can depress the immune system, cause anaemia, copper deficiency and decrease high-density lipoprotein cholesterol in the blood (Black et al., 1988).

Mercury and arsenic levels in the processed hides were also found to be high and exceed the permissible limits. The highest level of mercury was found in cowhides processed with tyres. The mercury from the tyres could be the source of contamination. High levels of mercury in foods can cause damage to the central nervous system, endocrine system, kidneys, mouth, gums and teeth. It is also implicated in birth defects and low sperm count (ATSDR, 1999). Arsenic is a highly toxic metal that affects nearly all organs of the body. It is strongly associated with lung and skin cancers and may cause renal failure, peripheral vascular changes, gangrene of the extremities, peripheral neuropathy, hyperpigmentation, hyperkeratosis, bone marrow depression, spontaneous abortion and congenital malformation (Saady et al., 1989; Quatrehomme et al., 1992).

The results of this study lead to the pertinent question "how safe is the '*ponmo*' (processed cowhides) in the market? To some people, this product is a delicacy and they consume the '*ponmo*' daily.

Some samples of the ash scrapped from the cowhide after burning contained exceedingly high levels of Pb, Cd, Cr, Zn, Hg and As. The ash is often handled carelessly and disposed into streams thus increasing pollution in rivers and streams from which the cattle are watered and which ultimately empty into the lagoon and the ocean with the attendant risk of poisoning of these waters and marine life, several of which are consumed by man. Sometimes the ash is used as medication for cuts by the meat processors.

The various metal concentrations detected in the processed hides depend on several factors including the level of contamination of the grazing field, the quality of water, the level of contamination of the spent engine oil, the constituents of the refuse and the state of the scrap tyres, that is, the ratio of rubber to the metal stripe used for processing.

Conclusion

This study has been useful in elucidating the health risks to which several cowhides processors and millions of consumers of the processed hides are exposed. The toxic metals present in the hides can bioaccumulate in various organs in the body and may eventually lead to health impairment or premature death. The results of this study can be summarized as follows: cowhides processed by boiling in water and shaving may have pieces of metals from the shavers embedded in them, those cowhides processed by burning with firewood, plastics and tyres often contain toxic levels of Pb, Cr, Hg and As, processing of hides by burning with the various fuels cause environmental pollution because of the toxic compounds released to the atmosphere, cowhide processors are highly at risk because they handle ash containing toxic metals and they inhale vapours of toxic compounds emitted during the combustion of these fuels.

Thus only the traditional method of processing cowhides should be practised and the shavers should be made of sufficient gauge that will not crumble when used in shaving cowhides and all other processing methods involving flame treatment should be banned. Even when the traditional method is used, the cowhides should be boiled with clean water and the drums used in boiling should be changed to metals compatible with food processing. Those currently in use are containers for chemicals and oils of various origin. After several uses they crumble and release various metals and compounds into the water used for boiling the hides thus contaminating them. The regulatory agencies should enforce these suggestions and prolong the lives of their nationals.

ACKNOWLEDGEMENT

The assistance of Mrs. M. Adeeko of Mobil Oil Nigeria Ltd with the analysis on ICP-OES is gratefully acknowledged.

REFERENCES

ATSDR. Agency for Toxic Substances and Disease Registry (1998). Toxicological Profile for Chlorinated Dibenzo-p-Dioxins (update). US. Department of Health and Human Services, Public Health Service, Atlanta, GA.

ATSDR. Agency for Toxic Substances and Disease Registry (1999).Toxicological Profile for Mercury. Department of Health and Human Services, Public Health Service, Atlanta, GA.

ATSDRa. Agency for Toxic Substances and Disease Registry (2007). Toxicological Profile for lead. Draft Public Document. Division of Toxicology and Environmental Medicine, Atlanta, GA.

ATSDRb. Agency for Toxic Substances and Disease Registry (2007). Toxicological Profile for Styrene. Department of Health and Human Services, Public Health Service, Atlanta, GA.

Baker TD, Hafner WG (1961). Cadmium poisoning from a refrigerator shelf used as an improvised barbecue grill. Public Health Rep. 76: 543-544.

Black MR, Mederos DM, Brunett E, Welke R (1988). Zinc supplements and serum lipids in young adult males. Am. J. Clin. Nutr.,47:970-975.

Braver ER, Infante P, Chu K (1985). An analysis of lung cancer risk from exposure to hexavalent chromium. *Teratog. Carcinog. Mutagen* 5: 305-378.

Buckler HM, Smith WD, Rees WD (1986). Self poisoning with oral cadmium chloride. Br. Med. J. 292: 1559-1560.

Cousins RI (1996). zinc. In: Present knowledge in Nutrition. Ed. Zeigler EE, Filer LJ, Washington DC. ILSI Press.

Demirezen D, Uruc K (2006). Comparative study of trace elements in certain fish, meat and meat products. Meat Sci. 74: 255-260.

Essumang DK, Dodoo DK, Adokoh KC, Koka V, Nkrumah BN, Nuer ACD (2007). Heavy metal levels in singed cattle hide (*wele*) and itshuman health implications.
Proceedings – The First InternationalConference on Environmental Research, Technology and Policy ERTEP 2007, Accra, Ghana. Book of Abstracts, pp.19.
European Commission Regulation (2006). No 1881/2006, Setting maximum levels for certain contaminants in foodstuff. Official J. of the Eur. Union, L 364: 5-24
Holder C, Schneider R, Shirley C (1991). Toxics A-Z: A Guide to Everyday Pollution Hazards. Berkely, University of California Press.
International Association of Fire Chiefs (IAFC), Scrap Tyre Management Council (STMC) and National Fire Protection Association (NFPA) (2000). The Prevention and Management of Scrap Tire Fires.
Koréneková B, Skalická M, Nad' P (2002). Concentration of some heavy metals in cattle reared in the vicinity of metallurgic industry. Veterinarski Arhiv 72 (5): 259-267.
Kumar S, Jain S, Aggarwal CS (1985). Encephalopathy due to inorganic lead exposure in an adult. Jpn. J. Med. 26: 253-254.
Moore MR, Goldberg A, Yeung-Laiwah AAC (1987). Lead effects on the heme biosynthetic pathway. Relationship to toxicity. Ann.NY Acad. Sci. 514: 191-203.
Obiri-Danso K, Hogarh JN, Antwi-Agyei P (2008). Assessment of contamination of singed hides from cattle and goats by heavy metals in Ghana. Afr. J. Environ. Sci. OECD. Organization for Economic Cooperation and Development (2004). Emission Scenario Documents-Additives in the Rubber Industry' Federal Environmental Agency, Berlin, Germany.
Official J. of the Eur. Communities L 77/1 COMMISSION REGULATION (EC) No 6/200. Setting Maximum Levels for certain Contaminants in Foodstuffs, 8 March 2001.
Olaguibel JM, Basomba A (1989). Occupational Asthma induced by chromium salts. Allergol. Immunopathol. (Madr). 17 (3): 133-136.
Pechan EH,Associates Inc (1997). Air Emissions from Scrap Tire Combustion. A report prepared for the United States Environmental Protection Agency.
Quatrehomme G, Ricq O, Lapalus P (1992). Acute arsenic intoxication: Forensic and toxicological aspects (an observation). J. Forensic Sci. 37(4): 1163-1171.
Reisman JI (1997). Air Emissions from Scrap Tire Combustion. United States Risk Management Environmental Protection Research Laboratory. Agency Cincinnati, OH 45268.
Saady JJ, Blankc RV, Poklis A (1989). Estimation of the body burden in a child fatally poisoned by arsenite weedkiller. J. Anal. Toxicol. 13: 310-312.
Santhi D, Balakrishnan V, Kalaikannan A, Radhakrishnan KT (2008). Presence of heavy metals in pork products in Chennai (India). Am. J. Food Technol. 3(3): 192-199
USDA (2006). Foreign Agricultural Service GAIN Report Global Agriculture Information Network Voluntary Report-public distribution GAIN Report Number CH 6064, China Peoples Republic of FAIRS Product. Specific maximum levels of contaminants in Foods, Jim Butterworth and Wu Bugang.
US EPA (1994). Health Assessment Document for 2,3,7,8-Tetrachlorinated Dibenzo-p-dioxin(TCDD) and Related Compounds. External review draft. EPA report no. 600/6-88/001a-c. United States Environmental Protection Agency, Office of Health and Environmental Assessment, Office of Research and Development, Washington, DC.