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Full Length Research Paper

Assessment of contamination of singed hides from cattle and goats by heavy metals in Ghana

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Many local butchers in Ghana have been using scrap tyres as substitute for firewood to singe slaughtered ruminants. This study analysed such singed hides from seven goats and three cattle in unregulated local slaughtering operations near the Kumasi abattoir, for risk of heavy metal contamination (Mg, Mn, Cu, Ni, Cd, Pb and Zn) using atomic absorption spectrometry. Relative to un-singed control hides, singed treatments generally elevated heavy metal levels in both goats and cattle hides. Magnesium, Mn, Cu, Ni and Cd concentrations in un-singed goats hide increased by 23, 29, 54, 24 and 20% respectively to 108.63 ± 3.85, 0.83 ± 0.13, 1.63 ± 0.13, 2.15 ± 0.29 and 2.26 ± 0.20 mg/kg in the singed material. Similarly, singeing increased Mg, Mn, Cu, Ni, Cd and Zn concentrations in cattle hide by 94, 49, 130, 33, 174 and 1055% to 80.0 ± 5.25, 2.13 ± 0.26, 5.67 ± 1.24, 3.50 ± 0.17, 4.20 ± 0.17, and 204.49 ± 36.69 mg/kg respectively. Lead concentration in cattle hide on the other hand decreased by 34% upon singeing, from 4.61 ± 0.30 mg/kg in un -singed controls to 3.06 ± 0.26 mg/kg in singed material. High concentrations of the metals in singed hides could not be entirely attributed to the singed treatment alone, in view of considerable background levels of heavy metals recorded in the un-singed samples; a situation that probably reflected a larger problem of heavy metal pollution in the local environment. Concentrations of Cd and Pb in hides were above maximum permissible levels (MPLs) of 0.05 and 0.01 mg/kg respectively set by the European Commission Regulation, whilst Zn was also above MPL of 50.0 mg/kg, according to the Meat Food Products Order of India. It was concluded that the hides were potentially unsafe for human consumption.

Key words: Heavy metal contamination, meat products, singed treatments, consumed animal hides

INTRODUCTION

The risk of heavy metal contamination in meat is of great concern for both food safety and human health because of the toxic nature of these metals at relatively minute concentrations (Santhi et al., 2008; Mahaffey, 1977). Instances of heavy metal contamination in meat products during processing have been reported (Santhi et al., 2008; Brito et al., 2005). In other cases, contaminated animal feed and rearing of livestock in proximity to polluted environment were reportedly responsible for heavy metal contamination in meat (Miranda et al., 2005; Sabir et al., 2003; Koréneková et al., 2002).

In Ghana, Essumang et al. (2007) have reported on elevated levels of some heavy metals in singed cattle hide, a locally produced meat product called *wele*. Singed treatment of carcass, thus, is an important factor affecting meat quality in Ghana. Slaughtered ruminants such as goats, sheep and cattle are normally singed to get rid of the fur. Singeing is largely favoured in many respects in African countries as it maintains the carcass hide for consumption and evokes flavours in meat that are highly acceptable by the local populace (FAO, 1985). Traditionally, singeing proceeds in open fire using firewood as fuel. But the relative scarcity of firewood lately has resulted in local butchers using scrap tyres as alternative source of fuel to singe slaughtered livestock. The practice, though unconventional and potentially dangerous, is increasingly favoured by local butchers; reasons being that fire from the scrap tyres is able to selectively burn off t he animal fur without cracking the hide.

In view of the fact that tyres contain many potentially harmful substances (USFA, 1999), singed treatment with scrap tyres imposes enormous risk of deposition of toxic

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Table 1. Percentage increase in heavy metal concentrations in singed hides relative to controls.

Heavy Metals	Cattle Hide (%)	Goats Hide (%)
Mg	93.63	23.08
Mn	48.85	28.93
Cu	129.71	54.12
Ni	32.93	23.75
Cd	174.00	19.67
Pb	33.54*	ND
Zn	1054.59	ND

* Percentage decrease ND: No Data

elements and compounds into the animal hide, which could significantly compromise meat quality. In this case, continuous consumption of such potentially contaminated meat product poses a great source of health risk (Costa, 2000; Jayasekara et al., 1992; Leita et al., 1991). It is against this background that the present study investigated local singeing practices in Ghana with respect to the use of scrap tyres to singe slaughtered ruminants. The singeing practice was assessed as a potential source of heavy metal contamination in goats and cattle hides consumed locally in Ghana.

MATERIALS AND METHODS

As singeing directly affects the hides of carcass, this study concentrated on analysing singed hides processed by local butchers near the Kumasi Abattoir in Ghana. Approximately 130 - 150 goats and 35 - 40 cattle are processed by the local butchers daily. Samples were taken directly from the butchers. Slaughtered goats were singed in open fires fuelled with scrap tyres. Slaughtered cattle on the other hand were first skinned and the hide put on metal stripes obtained from the burnt tyres. The metal stripes were kept red-hot with limited firewood underneath, to slowly burn the fur off the skinned cattle hide. Such treatment transformed the cattle hide into a local meat product called *wele*.

The study analysed singed hides from seven different slaughtered goats and three slaughtered cows. Approximately 5 g portions of hide were carefully cut from each animal. In each case, hides were cut before singeing, after singeing and when singed carcass was washed. In all, there were six treatment groups as follows:

(i) Un-singed goats hide as controls.
(ii) Singed goats hide.
(iii) Singed and washed goats hide.
(iv) Un-singed cattle hide as controls.
(v) Singed cattle hide.
(vi) Singed and washed cattle hide.

The samples were put in air tight bags (sandwich sealers), placed in an ice-chest and transported to the laboratory for chemical analysis.

Each sample was oven dried at $105^{O}C$ to constant weight, homogenised using porcelain mortar and pestle into a powdered form and wet digested. Methods of wet digestion were adopted from Association of Official Analytical Chemist (1979) and Levinson (1968) . One (1) g of powdered hide sample was carefully weighed into a 50 ml volumetric flask. Five (5) ml conc. acid mixture, HNO_3:$HClO_4$ (1:1) was added to the powdered sample and the flask was swirled gently for the content to mix. Five (5) ml conc. H_2SO_4 was then added and the mixture again swirled to mix. The volumetric flask was placed on a hot plate and heated at 200˚C for 30 min in a fume chamber to obtain clear solution. When solution was not clear, acid treatments (with HNO_3:$HClO_4$ mixture and H_2SO_4) were repeated and heated. The flask was allowed to cool and distilled water added to 30 ml and thoroughly shaken to mix. Flask content was further topped with distilled water to the 50 ml mark and shaken to mix.

Blank solution consisted of the binary acid mixture (HNO_3:$HClO_4$), H_2SO_4 and the distilled water used for the sample digestion. It was prepared similarly as the entire digestion process but without the meat sample. Standards for atomic absorption analysis were prepared from commercial stock metal standards of each metal.

Levels of Mg, Mn, Cu, Ni, Cd, Pb and Zn in each digest were determined in triplicates using Atomic Absorption Spectrophotometry, with the blank solution set as zero (0) and the standards used for calibration of the spectrophotometer.

Concentrations of heavy metals were expressed as mean ± SEM (standard error of mean). One way ANOVA was used to compare means among treatments and differences resulting in $p<0.05$ were considered significant. Manitab 15 statistical software was used for ANOVA computation.

RESULTS AND DISCUSSION

Analysis of the hides of goats and cattle carcass revealed substantial levels of heavy metals (Figures 1 and 2) that may constitute some toxicological concerns to the meat consuming public in Ghana. The levels of Mn, Cu, Ni, Cd and Mg in fresh, un-singed goats hide were respectively 0.64 ± 0.12, 1.06 ± 0.12, 1.74 ± 0.24, 1.89 ± 0.27 and 88.26 ± 12.06 mg/kg. On singeing however, the levels increased to 0.83 ± 0.13, 1.63 ± 0.13, 2.16 ± 0.29, 2.26 ± 0.20 and 108.63 ± 3.85 mg/kg respectively. These observed increases were not statistically significant except for Cu ($p = 0.006$) (Figures 1 and 2). Similar trend of increased heavy metal levels were observed in cattle hide upon singeing. Magnesium, Cu, Ni, Cd, Mg and Zn in un-singed cattle hide, respectively 1.43 ± 0.12, 2.47 ± 0.26, 2.63 ± 0.12, 1.12 ± 0.48, 41.30 ± 2.49 and 17.71 ± 3.48 mg/kg, increased significantly to 2.13 ± 0.26, 5.67 ± 1.24, 3.50 ± 0.17, 4.20 ± 0.17, 80.00 ± 5.25 and 204.49 ± 36.68 mg/kg with singeing ($p<0.05$) (Figures 1 and 2). Singed treatments introduced greater concentrations of heavy metals in cattle hide than in goats hide (Table 1). This marked difference might stem from differences in the singeing process for the respective animals. Whilst goats carcass were singed in open fires fuelled with scrap tires (Figure 3), skinned cattle hides were singed slowly by placing the hides directly on metal stripes obtained as residues from the burnt tyres (Figure 4). Perhaps, the direct contact effect of the metal stripes in the latter process might have contributed to the comparatively greater concentrations of heavy metals in the cattle hide.

Lead concentration in cattle hide on the other hand decreased by 33.54% upon singeing, from 4.61 ± 0.30 mg/kg in fresh, un-singed hide to 3.06 ± 0.26 mg/kg in singed hide ($p = 0.002$). Thus, singeing did not introduce Pb into the hide, but rather proceeded with lost of Pb

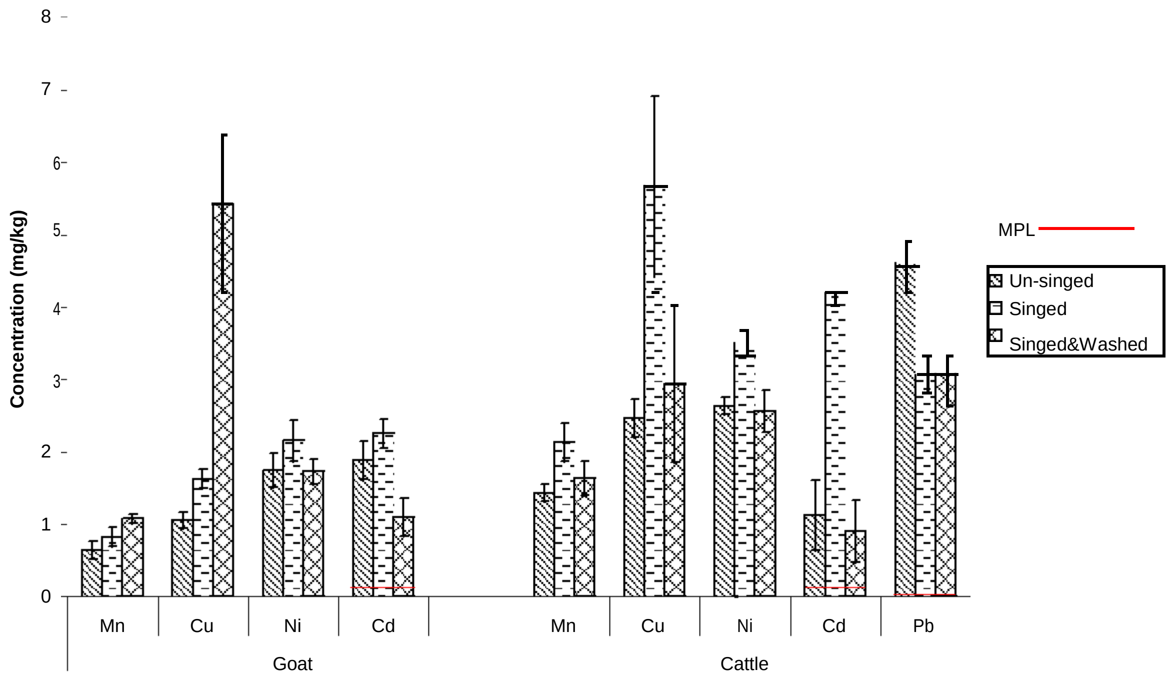

Figure 1. Concentrations of Mn, Cu, Ni, Cd and Pb in the hides of singed goat and cattle carcass.

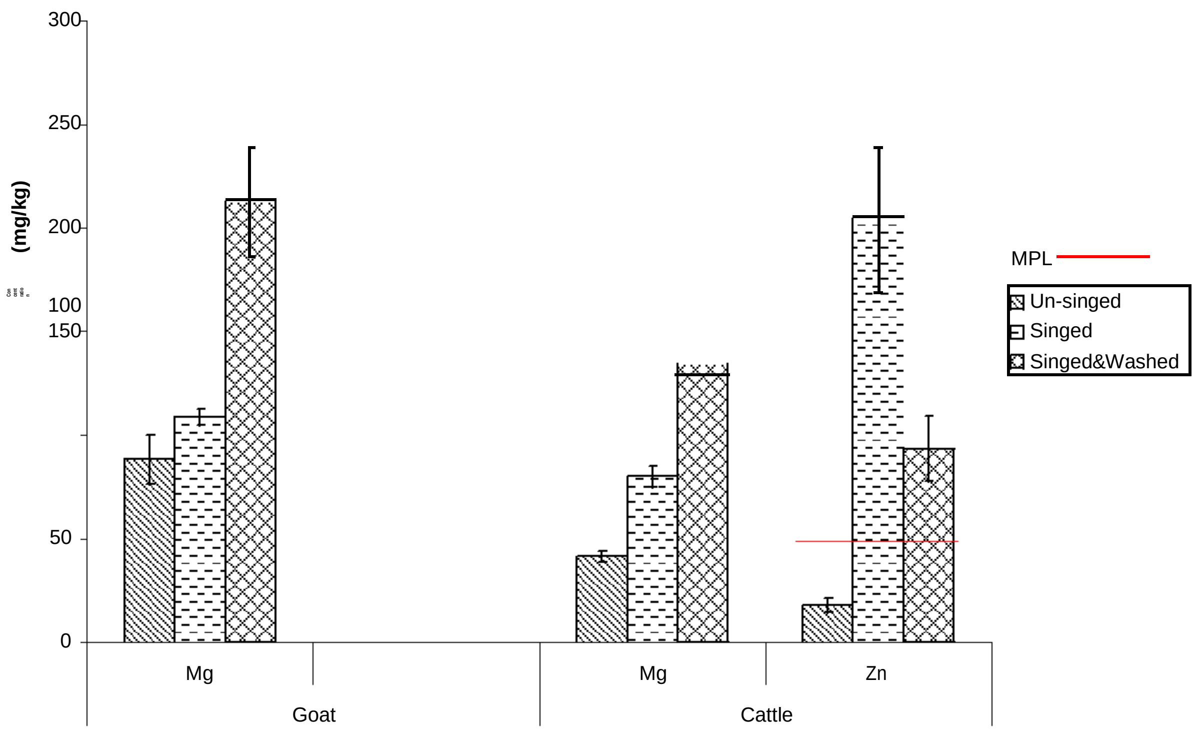

Figure 2. Concentrations of Mg and Zn in the hide of singed goat and cattle carcass.

from the hide. Apart from Pb, concentrations of all the other metals increased in the singed hides (Table 1). The levels of Pb, whether un-singed or singed, far exceeded the maximum permissible level (MPL) of 0.01 mg/kg (European Commission Regulation, 2006). Cadmium and Zn concentrations in the un-singed hides were also above the respective MPL of 0.05 mg/kg (European Commission Regulation, 2006) and 50.0 mg/kg (Meat Food

Figure 3. Singeing of goat in open fire fuelled with scrap tyres

Figure 4. Singeing of cattle hides placed directly on metal stripes derived from burnt tyres (metal stripes are kept red-hot with minimum burning firewood)

Products Order, 1973) . Thus, prior to singeing with the scrap tyres, the hides were already contaminated with unacceptable levels of Cd, Zn and Pb. This might be reflecting undue levels of heavy metal exposure in the local environment. The animals could potentially have picked heavy metals from the environment given the challenges of free-range grazing, scavenging in open waste dumps for fodder, drinking water from polluted drains and streams and exposure to atmospheric depositions especially from automobile fumes and open burning of solid waste. Indeed, close correlation have been reported between heavy metals concentration in cattle tissues with that in soil, feed, and drinking water (Qiu et al., 2008). Generally, toxic heavy metals such as Pb and Cd have slow rate of elimination such that harmful levels could accumulate in tissues after prolong exposure to even low quantities in the environment (Humphreys, 1991; Sharma et al. 1982; Doyle and Spaulding, 1978). The un-singed hides have levels of Cu falling within permissible limit of 20.0 mg/kg (Meat Food Products Order, 1973). With regards to Mg, Mn and Ni, it is unclear whether the background levels recorded in the hides may constitute significant problem to meat consumers; this is because of their role as essential heavy metals. As contaminants however, no MPL have been fixed for them in meat.

The levels of heavy metals reported in the singed products were generally quite high when compared to reported cases of heavy metals concentrations in different meat products (Santhi et al., 2008; Koréneková et al., 2002) . It appears that the substantial heavy metal levels in the un- singed hides contributed considerably to the overall high values recorded with singed treatment. This seems to suggest that other factors such as rearing conditions of animals, depicted by the relatively high levels of the metals in control hides, have also accounted for the quantum of heavy metals realised in the singed materials. Thus, the levels of heavy metals recorded in the singed hides cannot be entirely attributed to the tyre-singed treatment alone. This view is contrary to previous assertion that wholly attributed heavy metals in cattle hides (*wele*) in Ghana to tyre-singed treatments (Essumang et al., 2007).

Washing of singed hide is an important aspect of singe treatment of carcass as it represents the state in which the meat product is marketed. When hides were singed, it was assumed that heavy metals would accumulate both on and in the hide, such that washing would remove those deposited on the hide surface. Upon washing the char off the singed hides with water, Mg, Mn and Cu concentrations in the hide of goats carcass increased from 108.63 ± 3.85 to 212.66 ± 25.01 ($p = 0.001$), 0.83 ± 0.13 to 1.08 ± 0.06 ($p = 0.110$) and 1.63 ± 0.13 to 5.42 ± 0.92 ($p = 0.001$) mg/kg respectively (Figures 1 and 2). Magnesium concentration in singed cattle hide also increased when washed from 79.97 ± 5.25 to 134.53 ± 4.47 mg/kg (Figure 2), though not statistically significant ($p = 0.545$). This was contrary to the expectation that the heavy metal levels in singed hides would reduce when washed with water. It appeared that the water used in washing the hides introduced additional sources of Mg, Mn and Cu into the hides. The amount of Pb in singed hides did not change when washed. The rest of the metals, in both the goats and cattle hides, expectedl reduced in concentration when the singed hides were washed with water (Figures 1 and 2). Nickel and Cd in singed goats hide were reduced by 20 and 51% to 1.73 ± 0.18 and 1.10 ± 0.26 mg/kg respectively. Whilst Mn, Cu, Ni and Cd in singed cattle hides were respectively reduced by 24, 48, 27 and 78% to 1.63 ± 0.23, 2.93 ± 1.07, 2.57 ± 0.29 and 0.91 ± 0.43 mg/kg. The reduced concentrations of Ni, Cd, Mn and Cu in the singed and washed hides were not significantly different when compared to what pertained in the respective control samples. This meant that singeing with the scrap tyres imposed only temporary deposits of heavy metals on the hides with respect to Ni and Cd (in goats hide) and Mn, Cu, Ni and Cd (in cattle hide). Concentration of Zn in singed cattle hides also reduced when hides were washed, from 204.49 ± 36.69 to 93.50 ± 16.00; nonetheless, this reduced concentration was significantly greater than Zn levels in un-singed control hide (p = 0.000). This suggests that singeing using tyre as fuel introduced significant amounts of Zn into cattle hide that could not easily be washed. Indeed, singeing using tyre as fuel introduced more Zn into hide than any other metal (Table 1).

Conclusion

It could be concluded from this study that singeing with scrap tyres elevated heavy metal concentrations in the hides of both goats and cattle carcass. The extent of heavy metals deposited in hides from tyre fumes was dependent on the type of metal and mode of singed treatment. Singeing of goat carcass in open fire fuelled with scrap tyres introduced less amounts of heavy metals into hide relative to the amounts introduced into cattle hides that were placed directly on metal stripes from scrap tyres. The high levels of heavy metals in both goats and cattle tyre-singed hides were deduced as product of both animal rearing/environmental factors and singed treatment. Continuous consumption of the hides as meat product in Ghana might have significant health implications in view of the high heavy metals content. The greatest threats are presented by Pb, Cd and Zn, all of which far exceeded maximum permissible levels for meat. The hides as meat products are potentially unwholesome for human consumption. The study underscores an urgent need to regularise the activities of local butchers in Ghana to conform to best practices necessary for abattoir operations.

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