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Cadmium Content of Cameroonian Cigarettes: Comparison with Other Foreign Brands Sold in Cameroon

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The exposure of the general population to toxic metals (eg: lead, cadmium and mercury) has caused much concern for many years. These elements are not quickly eliminated by the body (Mertz 1986). Cadmium (Cd) is virtually absent from the human body at birth and accumulates with age (Mertz 1986). However, the daily intake of cadmium by man is quite variable depending on the nutritional habits and the environment. Cadmium content in cigarettes has been shown to be relatively high (0.50-2.00μg Cd/g) and smoking cigarettes constitutes the major source of the daily cadmium intake coming from food (Mertz 1986; Nandi et al. 1969; Lewis et al. 1972; Jawaid et al. 1983; Elinder et al. 1983; Nwankwo et al. 1977; Friberg and Vahter 1983; Brooks and Trow 1979). Studies have established that cadmium exposure from cigarette smoking can vary with time and with the country where the cigarettes are made (Mertz 1986; Elinder et al. 1983; Nwankwo et al. 1977; Brooks and Trow 1979). Given the increasing concern about heavy metal and in particular cadmium toxicity, the present study has two objectives:

1) To measure and compare the amount of cadmium found in Cameroonian cigarettes and in foreign brands sold in Cameroon.

2) To measure the amount of cadmium in smoke, ashes and the amount retained by filters of some Cameroonian cigarettes after using a smoking machine.

MATERIALS AND METHODS

A Buck 200 Atomic Absorption Spectrometer equipped with a

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micro-computer (Apple) and printer was used for cadmium measurements at 228.8 nm, with a hollow-cathode lamp and a deuterium-lamp background correction. An air-acetylene flame was used with a three-slot burner head. The smoking simulation tests were done with a smoking machine (Filtroma) with Cambridge filters. Average puff frequencies were determined using the Baumgartner apparatus. Both the smoking machine and the Baumgartner apparatus were from the Bastos Tobacco Company in Yaounde, Cameroon.

The nitric acid, perchloric acid and sulfuric acid (Fischer and Merck "Supra-pur") were delivered in glass containers. Cadmium standards were prepared by appropriate dilutions of a commercial "Standard" solution (Fischer,1ml=1mg Cd) 1000 ppm $\pm$1%. Fresh working standards were prepared daily, immediately before use. Water was distilled and subsequently demineralized. All glassware was carefully washed with dichromate-sulfuric acid and rinsed several times with demineralized water. The cigarettes were all purchased in Yaounde supermarkets and some were obtained from Bastos Tobacco Company in Yaounde, Cameroon. These cigarettes were air dried under standard conditions used at The Bastos Tobacco Company (optimal humidity 11.5% and 12.5% respectively for cigarettes made from blond or black tobacco leaves). The samples (20 cigarettes/sample), used for Cd level determinations, were randomly selected from the different cigarette brands after drying. Some were randomly taken immediately after the manufacturing process at the Bastos Tobacco Company.

Previous studies have used dry ashing for cadmium analysis in cigarettes (Nandi et al. 1969; Lewis et al. 1972; Jawaid et al. 1983; Nwanko et al. 1977; Friberg and Vahter 1983; Brooks and Trow 1979). This is a good method because large samples can be readily handled and reagent blanks are generally low which is advantageous for trace element work. However, many workers have reported low recoveries of specific elements such as zinc, copper, silver, and lead (Christian and Feldman 1970; Allen et al. 1974; Gorsuch 1959). Our laboratory is more familiar with wet digestion techniques (acid-digestion) which have a number of advantages compared to dry ashing procedures (Christian and Feldman 1970; Allen et al. 1974;

Gorsuch 1959). A mixture of nitric, sulfuric and perchloric acids in a ratio of (10:1:2; v/v/v) was added to the cigarette or the filter after smoking, into 100ml Kjeldal flask. The contents were swirled gently and digested at moderate heat (temperature of 50-120°C). The digestion proceeded until the appearance of white fumes, and then cooled. The cold digest, usually colourless, was diluted with a small quantity of demineralized water (20ml) and filtered into a 50ml volumetric flask which was then diluted to volume. The working standards (concentration range of 0-2ppm, Buck 200 manual) were ran following the same digestion procedure. The determination of the amount of cadmium was done directly in the solution after dilution, using a built-in linear regression program in the Buck 200 and the micro-computer. The area under the atomization-signal peaks were integrated by the instrument, and these values were used for evaluating the amount of cadmium in the sample digests. The amount of cadmium was calculated using the standard curve, the dilution factors and the weight of the sample. A filter blank was ran without smoking. However, the value of the reagent blank was always below the detection limit, showing that the filter was not contaminated prior to the smoking of cigarettes. Replicate analysis of the same samples was performed.

RESULTS AND DISCUSSION

In this study the cadmium concentration was measured in the whole cigarette, including the filter tip of some brands. Table 1 shows the cadmium content of Cameroonian cigarettes. As can be seen, some variation is observed when the cadmium content of one brand is compared to other brands. Brand G has the lowest level of cadmium. On the average, Cameroonian cigarettes have 1.08µg Cd/g.

The results in Table 2 show that most foreign brands sold in Cameroon have about the same amount of cadmium as Cameroonian brands. However on an average, American cigarettes have a higher cadmium content than the other brands (1.17µg Cd/g as compared to 1.03, 1.00, 1.02 and 1.05µg Cd/g respectively for French, English, Holland and German brands). The data of Table 2 also confirm earlier results where high cadmium levels were found in cigarettes from industrialized countries (Mertz 1986; Nandi et al. 1969; Lewis

Table 1. Cadmium content in Cameroonian cigarettes.*

Brand	Cd (µg/cig.)	Cigarette weight (g) [a]	Cd (µg/ g)
A	1.02 ± 0.01	1.03 ± 0.01	0.99 ± 0.01
B	1.10 ± 0.02	0.99 ± 0.03	1.11 ± 0.01
C	1.09 ± 0.02	1.05 ± 0.02	1.03 ± 0.02
D	1.05 ± 0.02	0.94 ± 0.02	1.11 ± 0.01
E	1.08 ± 0.02	1.03 ± 0.01	1.05 ± 0.01
F	1.04 ± 0.02	1.05 ± 0.02	0.99 ± 0.03
G	1.10 ± 0.02	1.18 ± 0.03	0.93 ± 0.01
H	1.20 ± 0.02	1.15 ± 0.01	1.04 ± 0.01
I	1.11 ± 0.02	0.98 ± 0.01	1.13 ± 0.02
J	1.36 ± 0.01	1.02 ± 0.01	1.33 ± 0.02
K	1.01 ± 0.01	1.00 ± 0.01	1.01 ± 0.02
L	1.15 ± 0.01	1.00 ± 0.01	1.15 ± 0.02

*results are means of 6 -10 determinations for each brand.
[a] Weight including filter tip when present ± SD

Table 2. Cadmium content of foreign brand of cigarettes sold in Cameroon.*

Country	Brand	Cd (µg/g)	Cigarette wt (g) [a]
	M	1.01 ± 0.02	1.05 ± 0.02
	N	1.21 ± 0.01	0.99 ± 0.05
France	O	1.11 ± 0.04	1.04 ± 0.01
	P	0.95 ± 0.01	1.00 ± 0.01
	Q	0.87 ± 0.01	1.34 ± 0.02
	R	0.92 ± 0.04	1.07 ± 0.01
England	S	0.88 ± 0.01	1.20 ± 0.01
	T	1.20 ± 0.01	1.00 ± 0.02
	V	1.28 ± 0.005	1.00 ± 0.02
	W	1.20 ± 0.03	0.90 ± 0.02
USA	X	1.17 ± 0.01	0.98 ± 0.01
	Y	1.00 ± 0.01	0.97 ± 0.01
	Z	1.23 ± 0.005	0.99 ± 0.02
	1	1.11 ± 0.01	1.01 ± 0.01
Holland	2	0.94 ± 0.01	1.09 ± 0.02
	3	1.00 ± 0.01	1.02 ± 0.01
Germany	4	1.12 ± 0.01	0.97 ± 0.01

* results are mean of 6 - 10 determinations for each brand ± SD
[a]Weight including filter tip when present

et al. 1972; Jawaid et al. 1983; Elinder et al. 1983; Nwankwo et al. 1977; Friberg and Vahter 1983; Brooks and Trow 1979). Some workers (Elinder et al. 1983; Nwankwo et al. 1977) using the same technique demonstrated that developing countries have the lowest levels of cadmium in cigarettes. Their conclusion was supported by earlier findings on the level of cadmium in Zambian cigarettes (Nwankwo et al. 1977). Zambian cigarettes on an average contain only 0.22µg Cd/g while one brand of Tanzanian cigarettes contains 0.14µg Cd/g. These same authors also show that unprocessed tobacco leaves in Zambia contained 0.32µg Cd/g, which was still lower compared to values found in foreign cigarettes. The high values obtained for Cameroonian cigarettes compared to those from Zambia or Tanzania might be explained by the origin of the tobacco used during the manufacturing process. In Cameroon the tobacco is usually imported from industrialized countries like U.S.A or Brazil. To support our hypothesis we have done a similar study on unprocessed tobacco before and at different stages of the manufacturing process. Levels of cadmium between 1.39-1.54µg/g of dry material were found. These levels decrease by 22-29% going down to the finished products, demonstrating that the manufacturing process helps in the reduction of the amount of cadmium. Another source of contamination might be the treatment of the tobacco with different aromas of plant origin and the "sauces" used during the manufacturing of Cameroonian cigarettes.

Table 3 indicates that during the smoking of Cameroonian cigarettes with filter tips, most of the cadmium passes out in the smoke and ashes (38-75%). While the filter plays a major role in retaining a good percentage (4 -23%) of the total cadmium per cigarette, some filters are more efficient in reducing the amount of cadmium inhaled than others. These results are compatible with earlier work (Nandi et al. 1969; Elinder et al. 1983) and the observation that the temperature at the ignited end of a cigarette can exceed the boiling point of cadmium (767°C), causing it to evaporate into the smoke (Schroeder 1961).

Cadmium, whether ingested, injected, or inhaled, is toxic to virtually every organ system in the animal. It has a long half-life in humans with values of 7.5-30 years having been

reported (Mertz 1986). While adverse health effects resulting from past occupational and environmental exposure to Cd have been extensively documented, the relationship between

Table 3. Percentage of cadmium retained in filters and passed into ashes and smoke after smoking some Cameroonian filter brand cigarettes.

Brand	Cd (µg/cig.)	Cd in filter after smoking		Cd in smoke and ashes	
		(µg/ cig.)	(%)	(µg/ cig.)	(%)
A	1.02 ± 0.01	0.14 ± 0.002	13.7	0.54 ± 0.01	52.9
B	1.10 ± 0.02	-	-	0.74 ± 0.02	67.3
C	1.09 ± 0.02	-	-	0.82 ± 0.01	75.2
D	1.05 ± 0.02	0.09 ± 0.002	8.6	0.49 ± 0.02	46.7
E	1.08 ± 0.02	0.25 ± 0.003	23.1	0.41 ± 0.04	38.0
F	1.04 ± 0.02	0.08 ± 0.002	7.7	0.57 ± 0.02	54.8
G	1.10 ± 0.02	0.05 ± 0.003	4.5	0.77 ± 0.03	70.0
H	1.20 ± 0.02	0.08 ± 0.002	6.7	0.82 ± 0.02	68.3

long-term, low-level exposure to cadmium and its early effects is less clear (Armstrong et al. 1983). It has been assumed that 25-50% of the cadmium inhaled during cigarette smoking is absorbed (Friberg 1974; CEC 1978). Taking the average value of 1.08µg Cd/cigarette with the filter tip, we can estimate that a person smoking, for example, a pack of twenty Cameroonian cigarettes a day, would increase his daily cadmium intake by about 5.4-10.8µg Cd (1.08µg Cd/cig. x 20 cigarettes x 20 to 50%). These values are high compared to the daily intake in industrialized countries by the same route (0.8-1.5µg Cd) (Elinder et al. 1983). This amount of metal inhaled by Cameroonian smokers is of toxicological importance and knowing that maternal exposure to cadmium greatly alters iron and copper metabolism in neonates (Mertz 1986), further studies should be done to confirm the hypothesis that Cameroonian smokers might have higher concentration of cadmium in tissues, by performing autopsy studies similar to those done in other countries (Friberg et al. 1974).

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