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CADMIUM AND NICKEL--COMMON CHARACTERISTICS OF LETTUCE LEAF AND TOBACCO CIGARETTE SMOKE

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ABSTRACT

Lettuce leaf cigarettes, a tobacco substitute, have been found to contain significant levels of Cd, Ni and Zn. A lettuce cigarette contains 1.39 μg of Cd and 5.3 μg of Ni per cigarette. These levels indicate significantly higher Cd and Ni content of lettuce cigarettes in comparison with tobacco cigarettes. Our results show that only 5% of the Cd and none of the Ni appeared in the mainstream smoke (LSC). By metal analysis of LSC, ash and butt portions remaining after smoking, it was estimated that 80% of the cadmium and 10% of the nickel left the smoked cigarette portion as part of the sidestream smoke, which is inhalable by individuals in the vicinity of the smoker.

The occurrence of the toxic trace metals cadmium and nickel is widespread in the environment from natural processes as well as from man-made sources. Thus, certain amounts of these metals can be found in many types of foliage. A recent publication has indicated the presence of a significant level of cadmium and nickel in the side-stream as well as in the mainstream smoke of tobacco products[1] which revealed a potential danger to the health of individuals inadvertently inhaling such smoke. Tobacco products have also been found to contain lead; however, after smoking, most of the lead (85-90%) became part of the ash and only 2% or less was found in the smoke condensate (TSC)[1]. Thus, although cigarettes (tobacco or lettuce) contain metals, the metals are not necessarily transferred to the smoke inhaled by the smoker (mainstream smoke).

In an effort to lessen some of the side effects of smoking, cigarettes made from specially processed lettuce leaves have recently been offered as a substitute for those made from tobacco[2]. Although it has been shown that these cigarettes do not contain nicotine[3], this does not eliminate the possible presence of other chemicals in the smoke which may adversely affect human health.

The specific aim of this report has been focused on the question of whether the high concentration of the toxic trace metals Cd and Ni and their distribution after smoking were unique to tobacco products, or whether they could be generally related to smoked or burned vegetable matter, in this case, lettuce leaf cigarettes.

EXPERIMENTAL

Materials and Methods

The atomic absorption standards were prepared by dilution of stock 1000 ppm standard solutions (Fisher Scientific Co.). The lettuce leaf cigarettes were obtained from Bravo Laboratories, Ltd., New Jersey and were used after removal of the filters.

Smoking Procedure. The 65-mm cigarettes were mechanically smoked on a 24-port Mason Mark III Rotory Smoker providing a 2-second puff per minute per cigarette and a 17.5 cc/sec flow volume to a 23-mm butt length. The ash was collected in metal-free 100 ml beakers, which were used for the wet ashing process. The smoke condensate (LSC) was collected in acetone traps maintained at 0°C according to the method reported by Michael et al[4].

Determination of Metals. The ash, LSC, and butt samples of the lettuce leaf cigarettes were wet-ashed

with concentrated nitric acid (20 ml). After concentration to ca. 1 ml, the solutions were made up to 10 ml with 10% HNO_3.

The samples were subsequently analyzed for Cd, Ni and Zn utilizing a Perkin-Elmer Model 303 atomic absorption spectrophotometer with a Boling burner and a recorder read-out. The recoveries were 92.5% for Cd, 95.0% for Ni and 94.5% for Zn.

RESULTS

A comparison of metal concentration between lettuce and tobacco cigarettes and the metal distribution after smoking the lettuce cigarette are given in Table 1. The major differences in the physical characteristics between the lettuce and tobacco cigarettes were that the lettuce cigarette was 65-mm in length and weighed 0.72 g while the tobacco cigarette was 85-mm in length and had an average weight of 1.12 g. The results show that the amounts of Cd and Ni per cigarette found in a lettuce cigarette were comparable to those in a tobacco cigarette, but on a weight basis, the levels of Cd and Ni are higher in the lettuce cigarette.

Metal Distribution in Smoked Cigarettes

The metal content of the ash, LSC and butt portions and the calculated values for the smoked portion and the sidestream smoke are shown in Table 1. The metal levels in the sidestream smoke (the smoke that drifts from the

TABLE 1

Metal Content of Lettuce Cigarette Fractions[a]

Sample	Metal Concentration, μg/cig		
	Cd	Ni	Zn
Lettuce Leaf Cigarettes	1.39±0.04	5.3±0.6	15.5±0.3
Smoked Portion (65% of Total)	0.90	3.4	10.0
Smoked Butt[b]	0.52±0.04	1.94±0.31	6.5±0.4
LSC	0.02-0.01	<0.01	0.07±0.07
Ash	0.13±0.02	3.0±0.4	8.5-0.5
Sidestream[c]	0.72	0.34	0.45
Kentucky Reference Cigarettes[d]	1.56±0.19	4.5±0.2	33.4±2.4
Percent Dispersed in Sidestream			
Lettuce Cigarette	80%	10%	4.5%
Kentucky Reference Cigarettes[d]	38%	33%	3%

[a]Values are means - S. D. of 4 samples except for calculated quantities.

[b]Butt enrichment can be estimated by substracting the calculated values for the unsmoked butt from the experimental value given.

[c]Sidestream was calculated by subtracting the values of smoked butt, LSC and ash from the total cigarette value.

[d]Values taken from Menden *et al*[1].

end of the cigarette between puffs) was determined by subtracting the amounts in the ash, LSC and butt portions from that of the whole unsmoked cigarette.

The LSC contained only about 3% of the Cd and no detectable Ni (< 0.01 µg/cig). The amounts of Cd and Ni released into the sidestream were 0.72 and 0.34 µg per lettuce cigarette respectively, which is equivalent to 80% of the Cd and 10% of the Ni originally present in the smoked portion. In comparison, tobacco cigarettes (Kentucky Reference Cigarettes) dispersed 0.43 µg Cd and 10.3 µg Ni representing 38% and 33% respectively, of the initial amount in the smoked portion.

Since zinc has low volatility, zinc determinations were performed to obtain a set of values to serve as a control on the analytical procedure. The ash contained 85% of the original zinc and $< 5\%$ was possibly lost in the sidestream.

DISCUSSION

The data which we have presented gives a comparison of non-tobacco (lettuce leaf) and tobacco cigarettes. The significant characteristics were that both types of cigarettes contain the trace metals Cd, Ni and Zn and that 80% of the Cd and 10% of the Ni in the smoked portion of a lettuce leaf cigarette were dispersed as part of the

sidestream smoke while less than 3% of these metals were found in the LSC (mainstream smoke).

In the case of tobacco, cadmium and nickel have been implicated as health hazards to the smoker[8,9,10] and their presence in sidestream smoke suggests a potential hazard not only to the smoker but also to anyone in the vicinity of the smoker[1]. These implications are equally applicable in the case of lettuce leaf cigarettes and in fact, probably generally apply to the combustion of other dried vegetable matter.

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