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BRIEF OBSERVATION

Aluminum in Tobacco and Cannabis and Smoking-Related Disease

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ABSTRACT

PURPOSE: The study aimed to confirm the very high content of aluminum in tobacco and cannabis and to provide for the first time evidence that such aluminum could be biologically available.

METHODS: Complete digestion of tobacco and cannabis was achieved using a 50:50 mixture of 14 M HNO_3 and 0.1 M NaF. Total Al in digests was measured by graphite furnace atomic absorption spectrometry. A bespoke cigarette smoking apparatus was used to determine if aluminum in active or passive tobacco/cannabis smoke would be trapped by a surrogate lung fluid.

RESULTS: The aluminum content of tobacco and cannabis was confirmed to be high, as much as 0.37% and 0.4% by weight respectively. Aluminum in tobacco and cannabis smoke, whether actively (drawn) or passively inhaled, was shown to accumulate significantly in surrogate lung fluids, thus demonstrating its potential biological availability.

CONCLUSIONS: Active and passive smoking of tobacco or cannabis will increase the body burden of aluminum and thereby contribute to respiratory, neurological and other smoking-related disease.

KEYWORDS: Aluminum; Tobacco; Cannabis; Biological availability; Smoking-related disease

Aluminum (Al) is the major trace metal constituent of tobacco.[1] Jamaican cottage industry tobacco includes an exceptional 0.8-2.6 mg Al/g tobacco. Exceptional because the tobacco plant, unlike, for example, the tea plant, is not considered an aluminum accumulator (≥0.1% Al by weight in leaves).[2] Tobacco is not a known contributor to the body burden of aluminum, and yet there is indirect evidence that within particular cohorts, smokers excrete more aluminum in their urine than nonsmokers.[3,4] We have determined the aluminum content of commercially available tobaccos and investigated the potential biological availability of aluminum in tobacco. We looked at the same for cannabis, as its content of aluminum also is reported to be high (2.4-3.7 mg Al/g marijuana).[1]

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METHODS

We investigated 4 different tobaccos, 2 supplies of cannabis, and a cannabinoid extract, tetrahydrocannabinol (THC). Bangladeshi tobacco is a chewing tobacco (though also smoked) and was obtained in leaf form. Rothmans is tobacco taken from branded cigarettes. Natural and medium tobaccos were obtained in leaf form. Cannabis in leaf form was obtained via the police under Home Office license, and concentrated plant extract containing 68% THC was supplied by G.W. Pharmaceuticals (Salisbury, Wiltshire, United Kingdom). Tobacco or cannabis leaf was ground to a fine powder in an agate pestle and mortar and weighed (±0.1 mg) into screw-lid Teflon vials (Cowie Technology Ltd., Middlesbrough, UK). THC was a sticky gum-like material at room temperature and was spotted directly onto the base of preweighed vials. Complete digestion of tobacco, cannabis and THC was achieved using a 50:50 mixture of concentrated nitric acid (14 M HNO_3) and 0.1 M sodium fluoride (NaF), followed by gentle warming on a hot plate for 72 hours. Total aluminum was determined by graphite furnace atomic absorption spectrometry (GFAAS).[5] Five replicates of each tobacco, cannabis and THC were measured, and empty vials served as controls for contamination issues. The aluminum content of the tobaccos varied both within digests of a particular tobacco and between different tobaccos (Table 1). This demonstrated that the distribution of aluminum was not necessarily homogeneous within one particular type of tobacco or between different tobaccos. For example, the aluminum content of Bangladeshi tobacco at between 0.23% and 0.37% by weight was appreciably higher than that of 'Rothmans' at between 0.06% and 0.15% by weight. Natural tobacco had a higher content of aluminum than medium tobacco, which might suggest that aluminum was removed during processing of the latter. We analyzed two samples of cannabis of unknown origin. The distribution of aluminum was not homogeneous within samples, and the content at between 0.01% and 0.04% by weight was lower than for tobacco. The aluminum content of THC was also 0.01% to 0.04% by weight, which might imply that some of the aluminum in cannabis is associated with this fraction (Table 1).

We designed a simple smoking machine to determine the potential biological availability of aluminum in tobacco during smoking. Cigarettes containing known weights of either tobacco or tobacco and cannabis (10% by weight) were constructed using commercially available rolling papers and rolling machine. Each cigarette contained 0.5-0.6 g of tobacco and included a small plastic insert at its base to allow it to be plugged into the smoking machine. The latter consisted of a multi-channel peristaltic pump that drew air at a constant rate through a lit cigarette and bubbled the drawn air (active smoke) through 20 mL of a 1% HNO_3 solution. Smoke produced at the tip of the cigarette (passive smoke) was collected under an inverted funnel and drawn through a separate 20 mL volume of 1% HNO_3 solution by a second channel on the pump. Four one-way valves ensured that all drawn smoke was bubbled through the dilute acid solutions, which we designated as active and passive surrogate lung fluids (SLFs). We were not able to measure the volumes of active and passive smoke that passed through the SLFs, although a significant proportion of drawn smoke passed through them and exited into the atmosphere. We measured how much aluminum was retained by SLFs during smoking of 10 consecutive cigarettes containing known weights of tobacco or tobacco and cannabis. Three replicates of each experiment were carried out. Equivalent control experiments using unlit cigarettes determined the background contamination by aluminum to be 6.4 ± 3.4 μg/L (n = 40). All analyses of aluminum were carried out as before using GFAAS.

CLINICAL SIGNIFICANCE

- Tobacco and cannabis are hitherto unrecognized potent contributors to the body burden of aluminum.
- Aluminum that is inhaled either from active or passive smoking is biologically available and is likely to be absorbed systemically.
- Aluminum entering the lung and the olfactory system as either particulates or gaseous complexes may contribute toward smoking-related disease including asthma and neurological dysfunction.

Table 1 The Aluminum Content of Tobaccos and Cannabis

Brand/Type of Tobacco/ Cannabis	Range of Al Content; mg Al/g Product
Bangladeshi tobacco	2.3–3.7
Rothmans	0.6–1.5
Natural tobacco	1.2–2.0
Medium tobacco	0.8–1.4
Cannabis (2 types)	0.1–0.4
Cannabinoid extract (THC)	0.1–0.4

Range shows the highest and lowest values for 5 (10 for cannabis) different samples. All loose leaf except Rothmans, which was obtained from cigarettes, and THC, which was a gum-like fluid.

RESULTS

Smoking 10 consecutive cigarettes resulted in SLFs changing from clear to yellowish solutions. Peristaltic tubing and one-way valves also yellowed quickly and were replaced between replicate experiments. The aluminum contents of all SLFs were increased relative to the background level of aluminum contamination (Table 2). For tobaccos, the aluminum content of active SLFs were higher than passive SLFs, whereas there were no differences in this respect for the medium tobacco + cannabis SLFs. Significant differences in the aluminum content of SLFs between replicate experiments for the natural tobacco probably reflected the lack of homogeneous distribution of aluminum in this tobacco. The combination of medium tobacco ±10% cannabis did not have a significant influence upon the concentration of aluminum in active SLFs, although the aluminum concentration in the passive SLFs was significantly increased by the inclusion of cannabis. These experiments have shown that both active and passive smoking resulted in aluminum in smoke being retained by simple surrogate lung fluids.

DISCUSSION

We have confirmed the reported high content of aluminum and extended this observation to provide the first direct evidence that aluminum in tobacco could be biologically available during both active and passive smoking. Might this explain why, within any particular cohort, smokers have

Table 2 The Concentration of Aluminum in SLFs Following Active and Passive Smoking of 10 Consecutive Cigarettes Containing Known Weights of Either Natural Tobacco, Medium Tobacco or Medium Tobacco + 10% Cannabis

Cigarette/Replicate			1	2	3	Mean (SD)
Natural tobacco	Weight	g	6.27	6.87	6.06	6.40 (0.42)
	Active SLF	μg/L	40.7	22.1	85.4	49.4 (32.5)
	Passive SLF	μg/L	10.7	15.8	34.1	20.2 (12.3)
Medium tobacco	Weight	g	6.16	6.22	6.00	6.13 (0.11)
	Active SLF	μg/L	43.6	31.4	37.3	37.4 (6.1)
	Passive SLF	μg/L	19.0	21.5	21.5	20.7 (1.4)
Medium tobacco +10% cannabis	Weight	g	6.23	5.82	5.81	5.95 (0.24)
	Active SLF	μg/L	37.1	33.7	17.7	29.5 (10.4)
	Passive SLF	μg/L	30.5	35.3	25.4	30.4 (5.0)

Results are given for 3 replicate experiments. Background [Al] = 6.4 ± 3.4 μg/L (n = 40).

a higher body burden of aluminum than nonsmokers?[3,4] Aluminum, in some form, is volatilized during smoking and will enter the lung in particulates and probably as gaseous moieties. The proportion of the total volatilized aluminum that was trapped in our SLF was a conservative estimate of that which would be trapped in the lung during smoking. The period of time that drawn smoke was in contact with our SLF was short relative to that for smoke that is inhaled into the lung, and additionally, the opportunity for the lung to trap aluminum would be significantly increased by its high surface area, its additional hydrophobicity, and the presence in lung fluids of substances, such as mucin,[6] which are capable of binding and retaining aluminum. The form in which aluminum enters the lung during active or passive smoking will determine its eventual fate and potential biological availability. Gaseous complexes may be rapidly dissolved in cell membranes, allowing their systemic entry and subsequent clearance in urine. This may explain the rapid absorption and excretion of aluminum in individuals exposed to volcano plumes.[7] Particulate aluminum may either be diverted to the gut via mucociliary clearance or retained in the lung where it has the potential to induce inflammatory-like reactions,[8] perhaps involving pro-oxidant effects.[9] Exposure to aluminum in aerosols has been associated with respiratory disease[4,8,10] and neurological conditions.[11,12] Smoking has also been linked to respiratory disease[13] and neurological dysfunction.[14,15] Is it time to ask if some of the known tobacco-related illnesses are caused or compounded by aluminum in tobacco?

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