Letter to the Editor

Comparison of Mineral Contents in Three Different Tobacco Formulations

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We identified and quantified a variety of mineral elements in 18 tobacco samples purchased from a Tunisian market. In total, 25 mineral elements have been measured in cigarettes, water pipe tobacco, and smokeless tobacco using inductively coupled plasma-optical emission spectroscopy following microwave-assisted digestion. Statistical analyses were performed using SPSS™, version 18.0. The lowest concentrations of all studied elements were observed in water pipe tobacco. Significantly higher concentrations of Al, Fe, Mg, Na, Ca, Cr, and Co were found in smokeless tobacco, while cigarettes brands contained the highest concentrations of K, Mn, Ni, Ba, and Sr. There was no significant difference between the mineral contents of local and foreign cigarettes and conventional and light cigarettes. Our findings demonstrated that local smokeless tobacco appears to be the most hazardous tobacco type. The concentration of minerals in light cigarettes was not significantly different from the concentration in conventional cigarettes.

Smoking is a global public health problem due to its high prevalence and impact in terms of mortality and morbidity. Five million deaths per year are attributed to tobacco consumption[1]. The composition of tobacco is very complex. The types and number of chemical constituents vary in its different formulations.

Tobacco is known to be a significant source of toxic heavy metals, which get preferentially enriched in the tobacco leaves during plant growth[2]. In fact, toxic metals and metalloids constitute the less studied major carcinogenic chemical classes in smokeless tobacco products and tobacco smoke[3].

In Tunisia, the tobacco products consumed most widely include cigarettes, smokeless tobacco (commonly known as 'neffa'), and water pipe tobacco or 'nargile'.

This present work attempted to determine and compare the concentrations of 25 mineral elements in these different tobacco products as they are the most highly commercialized and consumed.

In the experiment, all chemicals used were of analytical grade. Deionized water with a resistivity of 18.2 MΩ cm, obtained by a Milli-Q PLUS water purifier system (Bedford, USA) was used for sample and standard preparation. Ultrapure nitric acid 69%, hydrogen peroxide 35%, and hydrochloric acid 37% from Scharlau (Barcelona, Spain) were used for sample treatment. Argon C45 (> 99.995%), used as the plasmogen and carrier gas in the inductively coupled plasma-optical emission spectroscopy (ICP-OES) system, was supplied by Carburos Metálicos (Barcelona, Spain).

Calibration standards were prepared daily by diluting stock standard solutions. For the minor and trace elements, we used a multi-element standard solution supplied by Scharlau (26 elements in 5% HNO_3). For the major elements such as Al, Ca, Fe, K, Mg, and Mn, single element standard solutions in HNO_3 (0.5 mol/L) supplied by Scharlau were used (1000 mg/L). Scandium (0.25 mg/L) from Fluka (Buchs, Switzerland) was added as an internal standard (IS) to correct for the matrix-induced signal fluctuations and instrumental drifts.

NIST 1573a tomato leaves supplied by NIST (National Institute of Standards and Technology, Gaithersburg, MD, USA) and IAEA-359 cabbage supplied by IAEA (International Atomic Energy Agency, Vienna, Austria) were used as certified reference samples.

The analysis of tobacco products was carried out using a dual-view spectrometer (Optima 5300 DV

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ICP-OES, Perkin Elmer, Norwalk, CT, USA) equipped with an autosampler (A-93-plus) and a cross-flow nebulizer, employing a 1.10 mL/min sample flow rate, 15 L/min argon plasma flow, 0.2 L/min argon auxiliary flow, 0.8 L/min argon nebulizer flow, 1300 W radio frequency power, radial plasma visualization for Ca, K, Li, Mg, Na, and Sr, and axial plasma visualization for the rest of the elements (3 replicates per reading).

A microwave labstation (Ethos SEL, Milestone, Sorisole, Italy) equipped with a thermocouple sensor for automatic temperature control, an automatic gas leak detector, and 10 high pressure vessels of 100 mL inner volume was employed for sample digestion. An automatic cleaning device (Trace-Clean from Milestone) was used to clean the vessels with sub-boiling HNO_3. Additional equipment including an ultrasound water bath of 9 L volume with 50 W power and 50 Hz frequency from Selecta (Barcelona, Spain) was used for sample pre-treatment.

Eighteen different tobacco samples that are commercially available and consumed in Tunisia were purchased from different local markets. Three types of smokeless tobacco, two types of water pipe tobacco (one conventional type and one flavored type), and 13 different cigarettes (4 locally made brands and 9 foreign brands) were selected for analysis. Within the cigarette brands, 4 light and 4 conventional brands were analyzed. Envelope, paper, and filters were carefully removed from the cigarettes. Two grams of each sample was homogenized, dried at 60 °C for 12 h. Then, 0.5 g was immediately weighed in dry and clean Teflon vessels prior to microwave acid digestion. All samples were coded and identified as ST for smokeless tobacco, WPT for water pipe tobacco (flavored brand was labeled F), and C for cigarettes (light brands were labeled L).

After weighing the samples in Teflon vessels, 6 mL of HNO_3 (65%) was added to each. The prepared samples were sonicated in an ultrasound water bath for 30 min at room temperature. Subsequently, 2 mL of H_2O_2 was carefully added and the mixture was sonicated again for a further 30 min. Then 1 mL of HCl was added and the vessels were gently shaken and sonicated for 15 min. This pre-digestion step is required to avoid foam formation and evolution of gases, which could result in losses due to overpressure inside the vessels during the digestion step. Next, the vessels were introduced inside the microwave oven.

Microwave assisted acid-digestion was performed at high pressure (30 bar) and temperature (180 °C). The following program was run: 500 W exit power, 3 min to reach 85 °C, 9 min to reach 145 °C, 4 min to reach 180 °C, and 15 min at 180 °C[4].

After completing the digestion process, the vessels were cooled and placed again in the ultrasound water bath to remove nitrous vapors. Finally, the solutions were transferred to plastic flasks, and the volumes were made up to 25 mL with deionized water. Before use, all the plastic containers and vessels were previously washed in 10% HNO_3 for 24 h and then repeatedly rinsed with deionized water to avoid contamination.

All samples, standards, and reference materials were analyzed in triplicate. The signal integration (peak area) was obtained using four points per peak; two points were employed for the background correction. All analytes were measured at two different emission lines. In order to check the presence of matrix effects on sensitivity and selectivity, a scan of the emission lines was performed for a standard solution, a digested sample, and a digested spiked sample. The emission line was selected taking into account non-spectral interferences in samples and the best signal to-background ratio for each element. The background was corrected manually for all emission lines selected.

The employed calibration ranges were from 0.05 to 5 mg/L for Al, As, B, Ba, Be, Bi, Cd, Co, Cr, Cu, Fe, Li, Mn, Mo, Ni, Pb, Se, Sr, Ti, Tl, V, and Zn; from 20 to 160 mg/L for Ca, K, and Mg; and from 20 to 80 mg/L for Al, Fe, Mn, and Na. The linearity (r) value established for all cases was between 0.999 and 1.

The limit of detection of the instrument (LODi) was calculated as the analyte concentration corresponding to a signal equal to 3 times the standard deviation of 10 reagent blank solutions. Additionally, values for the limit of detection of the method (LODm) referred to the original samples (µg/g), taking into consideration the amount of sample digested and the final dilution employed in the recommended procedure. The limit of quantification of the instrument (LOQi) was determined in the same way as above, at 10 times the deviation of the blank measurements, and the limit of quantification of the method (LOQm) was calculated in terms of the concentration in the original sample (Table 1).

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) version 18.0 (SPSS, Chicago, IL, USA). Quantitative variables

are presented as mean ± SD and qualitative variable comparisons were performed using Chi-squared test (χ^2). Comparisons among different types of tobacco were performed using the analysis of variance (ANOVA). The statistical significance level was set at $P \leq 0.05$.

Results found in different types of tobacco products from the local market in Tunisia (expressed in μg/g) are summarized in Table 2. As, Bi, and Pb were not detected in any samples. Their limits of detection (LOD) were respectively 0.025, 0.036, and 0.023 μg/g. Be, Cd, and Se concentrations were below the limit of quantification (LOQ). Co, Mo, and V were determined only in smokeless tobacco; concentrations of these elements in other tobacco products were below the LOQ.

Our results showed that mineral profiles were significantly different ($P \leq 0.05$) between the types of tobacco products. The lowest concentrations of all studied elements were detected in water pipe tobacco. Al, B, Ca, Co, Cr, Fe, Mg, Mo, Na, Ti, and V concentrations were significantly higher in smokeless tobacco. Cigarette brands contained the highest concentrations of Ba, K, Mn, Ni, and Sr.

The concentration of minerals in local cigarettes was not significantly different from the concentration in foreign brands (Table 3); even though, the foreign cigarettes were richer in Al, B, Ca, Cr, Fe, K, Mg, Mn, Ni, Ti, and Zn. On the other hand, the average concentrations of Ba, Li, Na, and Sr were slightly higher in the local Tunisian cigarettes, except one local light brand LC2, which showed very low mean concentrations of all elements. The concentration of minerals in light cigarettes was not significantly different from the concentration in conventional ones, except for LC2 (Table 3).

Table 1. Figures of Merit of ICP-OES Analysis of Mineral Elements in Tobacco Samples

Elements	Wavelength	LODi	LODm	LOQi	LOQm
Aluminium	396.153	0.040	1.250	0.133	4.150
Arsenic	188.979	0.025	0.781	0.085	2.650
Boron	249.772	0.008	0.25	0.027	0.844
Barium	233.527	0.004	0.125	0.014	0.438
Beryllium	313.107	0.001	0.031	0.002	0.063
Bismuth	223.061	0.036	1.120	0.121	3.780
Calcium	317.933	0.450	14.06	1.500	46.87
Cadmium	228.802	0.009	0.281	0.031	0.969
Cobalt	228.616	0.006	0.188	0.020	0.625
Chromium	205.560	0.011	0.344	0.036	1.120
Copper	324.752	0.019	0.594	0.063	1.960
Iron	238.204	0.059	1.840	0.196	6.120
Potassium	766.490	0.252	7.870	0.841	26.28
Lithium	670.784	0.005	0.156	0.015	0.469
Magnesium	285.213	0.022	0.688	0.074	2.313
Manganese	259.372	0.008	0.250	0.026	0.813
Molybdenum	202.031	0.007	0.219	0.023	0.719
Sodium	589.592	0.140	4.460	0.475	14.84
Nickel	231.604	0.008	0.250	0.026	0.813
Lead	220.353	0.023	0.710	0.076	2.370
Selenium	196.026	0.026	0.810	0.088	2.750
Strontium	407.771	0.001	0.031	0.003	0.094
Titanium	334.940	0.005	0.150	0.016	0.500
Vanadium	310.230	0.014	0.420	0.046	1.420
Zinc	213.857	0.015	0.460	0.050	1.560

Note. LODi: limit of detection of the instrument; LODm: limit of detection of the method; LOQi: limit of quantification of the instrument; LOQm: limit of quantification of the method.

Table 2. Comparison of Mineral Concentrations of Smokeless Tobacco, Water Pipe Tobacco and Cigarettes Purchased from the Tunisian Market (Mean ± SD, µg/g)

Elements	Smokeless Tobacco (*n* = 3)	Water Pipe Tobacco (*n* = 2)	Cigarettes (*n* = 13)	*P* Value
Al	3133.33 ± 650.103	190.5 ± 113.844	463.08 ± 159.18	$< 10^{-3}$
B	75.67 ± 25.106	10 ± 4.243	33.69 ± 10.291	$< 10^{-3}$
Ba	54 ± 20.421	15.5 ± 13.435	97.38 ± 35.846	0.009
Be	< 0.063*	< 0.063*	< 0.063*	-
Ca	81833.33 ± 25181.011	9420 ± 3931.514	23433.08 ± 7257.572	$< 10^{-3}$
Cd	< 0.969*	< 0.969*	< 0.969*	-
Co	0.219	< 0.625*	< 0.625*	-
Cr	3.33 ± 0.577	< 1.125*	2.08 ± 0.862	0.001
Cu	16 ± 12.53	7 ± 4.243	14.15 ± 5.161	0.316
Fe	1898.67 ± 360.146	288 ± 299.813	447 ± 168.782	10^{-3}
K	21780 ± 12922.275	9230 ± 5190.164	29438.46 ± 9384.166	0.039
Li	8.6 ± 4.509	6.5 ± 6.364	16.62 ± 9.648	0.201
Mg	15910 ± 7192.517	1339 ± 1002.677	5471.69 ± 1741.254	$< 10^{-3}$
Mn	74 ± 44.508	25.5 ± 21.92	156.77 ± 55.739	0.006
Mo	0.83	< 0.719*	< 0.719*	0.001
Na	15200 ± 13523.313	593 ± 550.129	360.62 ± 230.465	0.001
Ni	1.33 ± 0.577	0.5 ± 0.707	2 ± 0.707	0.027
Se	< 2.75*	< 2.75*	< 2.75*	-
Sr	< 0.094*	33.5 ± 31.82	127.23 ± 45.268	$< 10^{-3}$
Ti	137 ± 45.211	6.5 ± 4.95	21.38 ± 8.617	$< 10^{-3}$
V	5.33 ± 1.528	< 1.425*	< 1.425*	$< 10^{-3}$
Zn	52.33 ± 54.418	13 ± 5.657	32.23 ± 10.457	0.172

Note. *, Limit of quantification of the method, $P \leq 0.05$ (statistical significance).

Table 3. Comparison of Mineral Concentrations of Cigarettes Brands Purchased from the Tunisian Market (Mean ± SD, µg/g)

Elements	Local Cigarettes (*n* = 4)	Foreign Cigarettes (*n* = 9)	*P** Value	Conventional Cigarettes (*n* = 4)	Light Cigarettes (*n* = 4)	*P*** Value
Al	443 ± 283.118	472 ± 87.51	0.776	515.00 ± 136.748	390.50 ± 241.801	0.405
B	27 ± 17.795	36.67 ± 2.784	0.122	34.50 ± 4.655	27.50 ± 17.711	0.474
Ba	100.5 ± 66.385	96 ± 16.363	0.845	113.75 ± 22.780	84.25 ± 58.380	0.383
Be	< LOQ	< LOQ	-	< LOQ	< LOQ	-
Ca	20892.5 ± 13729.684	24562.22 ± 1912.549	0.424	25775.00 ± 3970.202	18217.50 ± 11818.625	0.271
Cd	< LOQ	< LOQ	-	< LOQ	< LOQ	-
Co	< LOQ	< LOQ	-	< LOQ	< LOQ	-
Cr	2 ± 1.414	2.11 ± 0.601	0.841	2.75 ± 0.500	1.75 ± 1.258	0.190
Cu	14.5 ± 10.017	14 ± 1.5	0.880	16.75 ± 4.500	11.25 ± 7.805	0.268
Fe	414.75 ± 288.485	461.33 ± 103.783	0.666	502.50 ± 147.507	361.50 ± 255.148	0.376
k	26450 ± 17158.38	30766.67 ± 3903.844	0.468	34000.00 ± 2449.490	25000.00 ± 16444.655	0.321
Li	19.25 ± 16.317	15.44 ± 5.897	0.535	18.00 ± 14.877	11.50 ± 8.813	0.481
Mg	5033 ± 3276.525	5666.67 ± 618.951	0.568	6150.00 ± 932.738	4328.00 ± 2809.346	0.264
Mn	131.5 ± 86.52	168 ± 37.31	0.295	159.00 ± 28.717	126.25 ± 79.273	0.467
Mo	< LOQ	< LOQ	-	< LOQ	< LOQ-0.22	-
Na	395 ± 275.406	345.33 ± 224.441	0.736	422.75 ± 179.903	257.75 ± 194.080	0.259
Ni	1.5 ± 1	2.22 ± 0.441	0.08	2.25 ± 0.500	1.50 ± 1.000	0.228
Se	< LOQ	< LOQ	-	< LOQ	< LOQ	-
Sr	129.5 ± 83.317	126.22 ± 21.609	0.910	136.25 ± 36.700	102.00 ± 73.408	0.436
Ti	20.5 ± 12.923	21.78 ± 6.942	0.817	23.25 ± 7.411	20.25 ± 11.843	0.683
V	< LOQ	< LOQ	-	< LOQ	< LOQ	-
Zn	30.25 ± 19.822	33.11 ± 3.723	0.669	38.75 ± 4.646	27.50 ± 17.711	0.265

Note. LOQ, Limit of quantification of the method; *P**, *P* value between local and foreign cigarette; *P***, *P* value between light and conventional cigarettes.

During the smoking process, the tobacco complex is subjected to high temperatures (up to 950 °C) and a varying concentration of oxygen. This leads to incomplete combustion, which generates a large number of components. Some of these compounds are toxic and carcinogenic. Levels of chemical constituents in tobacco smoke vary and depend on a series of mechanisms during the formation of smoke, including the generation of products by pyrolysis and combustion, aerosol formation, and physical mass transfer and filtration processes[5].

In addition, the act of smoking cigarettes may increase the concentrations of the metals in the body and also interrupt metal homeostasis, leading to potential health problems. Therefore, the determination of minerals in tobacco products is important for evaluating their health impacts.

In our study, all tobacco products were differently enriched with a wide range of mineral elements. However, elements such As, Bi, and Pb were not detected. Be, Cd, and Se, could not be determined because of the sensitivity of the method. In fact, Fresquez et al. reported that some elements like Cd, Pb, and As could be under the LOQs and that their concentration in tobacco may not be entirely predictive of the resulting concentrations of metals transported in smoke[6].

In Tunisia, the consumption of smokeless tobacco is spread in the southern regions. Consumers place it between the gum and cheek or behind the upper or lower lip. Tunisian smokeless tobacco appears to have a greater content of major elements like Na, Fe, Mg, Ca, Cu, Al, Cr, and Co, while cigarette brands were richer in K, Mn, and Li. In medical practice, it is interesting to elucidate the physiological and pathological implications of these elements.

Significantly higher amounts of sodium were detected in smokeless tobacco than water pipe tobacco and cigarettes (15,200 ± 13526.313; 593 ± 550.129; 360.62 ± 230.465 μg/g). Potassium contents in the selected cigarette brands ranged from 26,000 to 37,000 μg/g. Levent et al.[7] reported similar findings in Turkish cigarettes (17784.3-28381.9 μg/g, 6,690-21,159 μg/g).

Tunisian smokeless tobacco showed a significantly higher content of iron than water pipe tobacco and cigarettes. Musharraf et al.[8] reported similar Fe concentrations in dipping tobacco and smoked tobacco from Pakistan (840-7,400 and 190-2,600 μg/g). Regular smoking may interfere with the body's ability to absorb vital nutrients such as iron. Especially for women, tobacco consumption even at low doses impairs Fe homeostasis, causing a condition known as iron-deficiency anemia that can be harmful to their unborn children. Besides these findings, it is also suggested that elevated Fe could be hazardous and promotes cardiomyopathy, arthropathy, and an array of endocrine, neurodegenerative, and other chronic diseases[9].

Within our studied tobacco products, manganese levels varied significantly. The highest concentrations were found in cigarettes. All plants have a specific requirement of Mn and apparently the most important Mn function is related to the oxidation-reduction process[10]. Bernhard et al.[11] reported similar Mn concentrations in tobacco (155-400 μg/g).

Calcium (Ca) contents were found to be 61,500-110,000 μg/g, 21,000-31,300 μg/g, and 6,640-2,200 μg/g, respectively, in smokeless tobacco, cigarettes, and water pipe tobacco. Similar levels of Ca were reported in Brazilian cigarettes[12] while lower concentrations were determined in Turkish ones[7]. In plants, Ca is absorbed as Ca^{2+} ions. This mineral element is a component of calcium pectate, which is found in the middle lamella and acts as an activator of enzymes like ATPase, some kinases, phospholipases, and succinate dehydrogenase. Ca also counteracts the toxicity of other metallic ions[10].

In addition to Ca, magnesium (Mg) is a very important element required for plants. It is a component of chlorophyll and magnesium pectate and is essential for the formation of carotenoids. A large number of enzymes use Mg as a catalyst[7]. Mg contents in smokeless tobacco, cigarettes, and water pipe tobacco were (11,330-24,200, 4,820-7,200, and 630-2,048 μg/g) respectively. Turkish and Brazilian cigarettes showed similar contents of Mg[7,12].

We found that smokeless tobacco was richer in copper (Cu) than water pipe tobacco and cigarettes. Cu content in normal plant tissues is usually within the range of 1-25 μg/g dry matter[7].

The analyzed smokeless tobacco showed elevated levels of aluminum (3133.33 ± 650.103 μg/g). Musharraf et al.[8] reported that Al content ranged from 670 to 6,500 μg/g in dipping tobacco samples and between 150 and 2,100 μg/g in cigarettes from Pakistan. This highly toxic metal is capable of causing serious effects on the brain and the nervous system and may contribute toward smoking-related diseases[13]. Various data provide evidence that an increasing level of Al is associated

with Alzheimer's disease (AD)[13-14].

When compared to the tobacco products studied here, chromium (Cr) was at very high levels in Indian (4.48-10.27 µg/g) and Nigerian (2.77-11.40 µg/g) smokeless tobacco[15-16]. Cobalt concentrations were below under the limit of quantification in the majority of studied tobacco brands except in the smokeless tobacco (ST2 sample). Similar concentrations were reported in Pakistan dipping tobacco[8], while higher levels were determined in Nigerian smokeless tobacco[16].

It is interesting to mention that lithium (Li) was maximally enriched in cigarettes (16.62 ± 9.64 µg/g) compared to the other products. Actually, Li is prevalent in soils while concentrations in plants are much lower, ranging from 20 ppb to 0.3 ppm. In humans, high doses of Li interfere with glucose metabolism and lead to teratogenesis and hypothyroidism[13]. In the medical field, Li is used in the treatment of affective disorders[17]. Since approximately 55% of smokers have ever met the criteria for a psychiatric disorder[18], Li could be implicated in tobacco addiction, probably through its effects on mood. Elements such B, Ba, Ni, Sr, Ti, V, and Zn were present in very low concentrations in the studied tobacco products.

Current knowledge about the toxicity of some of these elements like boron, strontium, titanium, and vanadium is yet to be discussed. Levels of zinc in the studied products were not significantly different. Chiba and Masironi stated that about 70% of the zinc contained in a cigarette's tobacco and paper is transferred to the smoke and a part is trapped by the filter, and does not reach the smoker[19]. Another metal of interest is nickel. Ni accumulates in tobacco leaves (0.64-1.15 µg/g) and its concentration increases dramatically through the manufacturing process via the additives used to cure the tobacco (0.078-5 µg/g)[19]. It varied significantly within the tobacco products in our study. Torjussen et al.[20] stated that Ni in a burning cigarette might form the volatile gaseous compound nickel tetracarbonyl, which is carcinogenic at very low doses.

Ni is mainly known for its mutagenicity and has been reported to induce sister chromatide exchanges, thereby causing a number of different forms of cancer, especially those of the respiratory tract[11]. The comparison of mineral contents between the local and foreign cigarettes did not show any significant difference. Among the cigarette brands, the foreign brands were richer in Al, B, Ca, Cr, Fe, K, Mg, Mn, Ni, Ti, and Zn. On the other hand, the average concentrations of Ba, Li, Na, and Sr were slightly higher in the local Tunisian cigarettes, except one local light brand that shows very low mean concentrations of all elements. These findings suggest that irrespective of the provenance of the cigarettes (local or foreign burden) the potential risk of exposure to toxic elements is the same.

Conventional and light cigarettes showed very similar mineral contents and no significant differences were noticed. Hence, it appears that no brand can be considered safer than another. This reflects the dark side of the tobacco industry and the advertising policy for light cigarettes as being less hazardous than the regular ones. Tobacco manufacturers have been redesigning cigarettes and the use of 'light' and 'ultra light' cigarettes has increased since the 1950s and 1960s. The cigarettes labeled as 'lights', 'ultra-lights', 'mild', or 'low-tar' are considered to have a lighter, less pronounced flavor than regular cigarettes. They are redesigned with the following features: cellulose acetate filters (to trap tar), highly porous cigarette paper (to allow toxic chemicals to escape), and ventilation holes in the filter tip (to dilute smoke with air). These brands contain lower levels of tar, nicotine, or other chemicals[21].

We think that switching from one product to another does not reduce the health risks of smoking or lower the smoker's exposure to toxic chemicals and carcinogens. There is no such thing as a safe cigarette.

In summary, Tunisian smokeless tobacco is the most hazardous of tested samples and may enhance serious health risks. A lack of comprehensive surveillance or updated data on smokeless tobacco use and its adverse effects may limit the ability to introduce regulatory policies and design programs to combat smokeless tobacco use in our country. We cannot deny the potential health risk associated with cigarettes (conventional or light) and water pipe tobacco. Adoption of reasonable behavior is needed to preserve public health.

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