

Distribution of heavy metals and other elements in orange and pomegranate powders treated as natural tobacco filter in Indian and imported brands during inhalation

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Abstract

Pomegranate powder filter material treated for local and import cigarettes contained 51.33 and 64.06 mg/kg Fe, 8.52 and 7.92 mg/kg Cu, 4.74 and 11.45 mg/kg Mn, 287.02 and 270.12 mg/kg Na, 0.94 and 0.87 mg/kg Ni, 0.00 and 0.87 mg/kg Cd, 0.00 and 0.88 mg/kg Cr, 472 and 7.02 mg/kg Zn, and 28.34 and 24.60 mg/kg Boron (B), respectively. In addition, orange powder filter material treated for local and import cigarettes contained 36.67 and 26.98 mg/kg Fe, 6.8 and 4.17 mg/kg Cu, 5.13 and 3.61 mg/kg Mn, 0.00 and 0.31 mg/kg Mo, 221.42 and 58.19 mg/kg Na, 0.85 and 0.33 mg/kg Ni, 0.00 and 0.01 mg/kg Co, 0.00 and 0.04 mg/kg Cd, 0.00 and 0.18 mg/kg Cr, 4.27 and 3.43 mg/kg Pb, 5.15 and 4.96 mg/kg Zn, and 13.73 and 10.89 mg/kg B, respectively. Also, water treated for import and local cigarettes without orange and pomegranate filter during inhalation contained 0.03 and 0.01 mg/kg Fe, 0.04 and 0.03 mg/kg Cu, 4.75 and 4.64 mg/kg Na, 0.05 and 0.01 mg/kg Pb, 0.02 and 0.01 mg/kg Zn, and 0.01 and 0.00 mg/kg B, respectively. In general, the distribution of elements in pomegranate and orange filters of both local and imported brands was higher than the respective tobacco.

Keywords: cigarette, heavy metals, inhalation, smoking apparatus, ICP-AES

1. Introduction

Smoking is one of the leading causes of various cancers and diseases associated with inhalation of toxic chemicals produced by pyrosynthesis or released during combustion. Tobacco smoke is a source of toxic substances that constitute one of many classes of carcinogens, toxins, and addictive substances [1,2]. One of the leading main causes of various cancers and diseases is caused by toxic chemicals in cigarettes [1,3]. According to Ahmed et al. [4] and Zulfiqar et al. [5], it has been reported that there is a relationship between some diseases and the amount of microelements in the human body. Cigarette smoke contains various particles, gases and heavy metals such as Cd and they cause respiratory and cardiovascular diseases such as peripheral artery disease [6-9]. Heavy metals which toxic at lower doses for humans disrupt different biological systems of tissues [10,11].

Due to the toxic properties of Cr and Ni elements in recent years, high levels of these elements can cause death and dermal, lung, and nasal sinus cancers in humans [12,13].

Lead toxicity has been reported to cause anemia, headache, irritability and kidney damage [14]. Cobalt, an important trace element, has been reported to cause serious health problems when excessively inhaled [15,16]. Many fertilizers, most of which are known to be toxic and carcinogenic, are used in tobacco farming. The monitoring of pesticides is very important to protect our environment during tobacco cultivation [17]. The aim of present study was to determine the concentrations of heavy metals and other elements in tobacco, orange and pomegranate powders, treated tobacco filter (orange and pomegranate powder), treated water of local and imported cigarette brands during inhalation by the smoking apparatus.

2. Materials and Method

2.1. Material

A local and Imported cigarettes commonly used in Turkey were purchased from local markets. The moisture contents of local and import cigarettes were determined as 11.66 % and 12.40%, respectively. After removing the filters of randomly 15 cigarettes selected from a pack of 20, analysis samples dried in an oven at a temperature of 70 °C for 24 h, and allowed to dessicator of each brand were prepared [25]. Elements were analysed in fifteen cigarettes, orange and pomegranate powders, treated orange and pomegranate filter and treated waters.

2.2. Method

2.2.1. Preparation of smoking system

According to modified method of *Ajab et al.* [2], about 100 ml distilled water was added into the glass apparatus. In one hole, a bent glass tube (sucking tube) was inserted such that its lower end is above the water level and in the other hole, a straight glass tube was inserted whose lower end was immersed into the water. At the top end, small rubber tube able to hold a burning cigarette was attached (Fig.1). It was inhaled 15 sticks of each brand from the same packet of cigarettes.

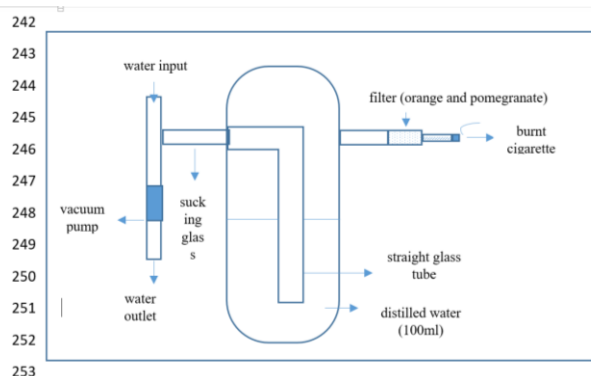


Figure 1. Smoking apparatus

2.2.2. Mineral content

About 0.2 g of ground cigarettes, orange and pomegranate powders, treated orange and pomegranate filter was put into burning cup with 15 ml of pure HNO₃ and 2 ml H₂O₂ (30%;w/v) in a closed system. The cigarette sample was incinerated in a MARS 5 microwave oven (CEM corporation Manufacturea at 210 °C.

After digested samples were filtrated (whatman No 42), the filtrates were collected in 50 ml flasks for element analysis in ICP-AES. In addition, treated waters were analysed directly in ICP-AES (Varian-Vista) [18].

2.3. Statistical Analyses

Results of the research were analysed for mean±standard deviation (MSTAT C) and statistical significance by analysis of variance of independent cigarette, natural filters and treated water samples [19].

3. Results and Discussion

The mean moisture content percentage in local and imported cigarette brands are given in material section. The average moisture contents of local and import cigarettes were determined as 11.66 % and 12.40%, respectively. In previous study, it changed between 4.9% and 17.2% [2]. Results showed partially differences. These differences can be probably due to storage conditions and moisture absorption capacity.

The quantities of elements held by pomegranate and orange peel powders used as filters are given in Table 1. Local and imported brands contained 1874.13 and 85.94 mg/kg P, 23590.63 and 582.21 mg/kg K, 30924.55 and 506.73 mg/kg Ca, 6432.17 and 108.44 mg/kg Mg, 3267.73 and 144.62 mg/kg S, 765.85 and 15.58 mg/kg Fe, 18.43 and 0.93 mg/kg Cu, 96.99 and 5.69 mg/kg Mn, 0.95 and 0.00 mg/kg Mo, 461.23 and 1.96 mg/kg Na, 2.86 and 0.00 mg/kg Ni, 0.94 and 0.00 Cd, 2.41 and 0.00 Cr, 9.08 and 2.73 Pb, 29.78 and 1.88 ppm Zn and 39.65 and 0.00 mg/kg B, respectively. In addition, ground pomegranate and orange powders contained 479.69 and 1659.82 mg/kg P, 12927.69 and 17640 mg/kg K, 2450.82 and 35648.38 mg/kg Ca, 451.92 and 9026.14 mg/kg Mg, 399.84 and 6642.14 mg/kg S, 40.40 and 233.66 mg/kg Fe, 8.88 and 5.59 mg/kg Cu, 4.02 and 165.93 mg/kg Mn, 0.00 and 0.80 mg/kg Mo, 361.64 and 259.47 mg/kg Na, 1.61 and 0.80 mg/kg Ni, 0.00 and 0.80 mg/kg Co, 0.00 and 0.80 mg/kg Cd, 0.00 and 0.80 mg/kg Cr, 6.45 and 4.81 mg/kg Pb, 6.41 and 19.32 mg/kg Zn, and 33.69 and 22.17 mg/kg B, respectively. Also, pomegranate powder filter material treated for local and imported cigarettes contained 414.99 and 410.68 mg/kg P, 11065.76 and 9233.31 mg/kg K, 2552.82 and 3374.45 mg/kg Ca, 464.81 and 545.00 mg/kg Mg, 458.31 and 638.20 mg/kg S, 51.33 and 64.06 mg/kg Fe, 8.52 and 7.92 mg/kg Cu, 4.74 and 11.45 mg/kg

Mn, 287.02 and 270.12 mg/kg Na, 0.94 and 0.87 mg/kg Ni, 0.00 and 0.87 mg/kg Cd, 0.00 and 0.88 mg/kg Cr, 472 and 7.02 mg/kg Zn, and 28.34 and 24.60 mg/kg B, respectively. In addition, orange powder filter material treated for local and imported cigarettes contained 517.77 and 554.75 mg/kg P, 6552.40 and 5910.00 mg/kg K, 3621.12 and 3144.85 mg/kg Ca, 852.54 and 760.74 mg/kg Mg, 618.69 and 510.42 mg/kg S, 36.67 and 26.98 mg/kg Fe, 6.85 and 4.17 mg/kg Cu, 5.13 and 3.61 mg/kg Mn, 0.00 and 0.31 mg/kg Mo, 221.42 and 58.19 mg/kg Na, 0.85 and 0.33 mg/kg Ni, 0.00 and 0.01 mg/kg Co, 0.00 and 0.04 mg/kg Cd, 0.00 and 0.18 mg/kg Cr, 4.27 and 3.43 mg/kg Pb, 5.15 and 4.96 mg/kg Zn, and 13.73 and 10.89 mg/kg B, respectively. Also, water used for import and local cigarettes with orange powder filter during inhalation contained 0.02 and 0.01 mg/kg P, 0.49 and 0.32 mg/kg K, 2.75 and 2.66 mg/kg Ca, 0.33 and 0.31 mg/kg Mg, 3.83 and 9.86 mg/kg S, 0.01 and 0.00 mg/kg Fe, 0.02 and 0.01 mg/kg Cu, 4.16 and 5.14 mg/kg Mg, respectively. In addition, water treated for import and local cigarettes with pomegranate powder filter during inhalation contained 0.01 and 0.01 mg/kg P, 0.68 and 0.60 mg/kg K, 6.54 and 5.66 mg/kg Ca, 0.64 and 0.56 mg/kg Mg, 10.45 and 4.25 mg/kg S, 0.01 and 0.01 mg/kg Fe, 0.00 and 0.02 mg/kg Cu, 5.16 and 5.54 mg/kg Na, 0.02 and 0.01 mg/kg Zn, and 0.36 and 0.03 mg/kg B, respectively. Also, water treated for import and local cigarettes without orange and pomegranate filter during inhalation contained 0.08 and 0.01 mg/kg P, 4.56 and 0.67 mg/kg K, 13.23 and 7.73 mg/kg Ca, 1.19 and 0.72 mg/kg Mg, 12.81 and 7.10 mg/kg S, 0.03 and 0.01 mg/kg Fe, 0.04 and 0.03 mg/kg Cu, 4.75 and 4.64 mg/kg Na, 0.05 and 0.01 mg/kg Pb, 0.02 and 0.01 mg/kg Zn, and 0.01 and 0.00 mg/kg Boron, respectively. It was observed statistically significant differences among element contents depending on natural filter types ($p < 0.05$). The distribution of elements in pomegranate and orange filters of both local and imported brands was higher than the respective tobacco. In previous study, while Cd contents of cigarettes are determined between 0.44 (C8) and 1.55 mg/kg (C7), Co contents of cigarette samples varied between 0.26 (B5) and 2.19 mg/kg (B3). Also, while Cr contents of tested cigarettes are

determined between 0.88 mg/kg (C5) and 1.72 mg/kg (B2), Mo contents of cigarettes ranged from 0.39 (C7) to 1.13 mg/kg (B2) [20]. In addition, Cu contents of cigarettes varied between 10.36 (C11) and 30.47 mg/kg (C18), while Fe contents of cigarette samples range between 306.03 (C5) and 595.42 mg/kg (C16). In addition, while Ni contents of cigarettes vary between 1.00 (C7) and 3.17 mg/kg (C1), Pb contents of brands varied between 0.16 (B4) and 7.37 mg/kg (B1) [20]. It has been revealed in the literature that the most of heavy metals contained in cigarettes are passed to mainstream smoke [21]. Amounts of heavy metals in tobacco were comparable with previous studies [2,17]. Current results both in local and imported cigarette brands showed significant deviation from estimation. The Cd levels are in good agreement with Watanabe et al. [22] which report the Cd content in cigarettes sampled from various countries ranging from 0.290 to 3.338 μ /g. In other study, considerable concentrations of Ni in burning cigarette are transferred to mainstream smoke [23]. Brands had greater concentration of elements in smoke due to the release of elements from burning of cigarette wrapping paper because they too contribute metals to mainstream smoke. Ajab et al. [2] reported that cigarette ash accounts for about 65-75% of the metal mass. Pappas et al. [3] reported the levels of heavy metals in mainstream smoke correlate well with filter ventilation design. In other view, it is reported that these additives can be found in approximately 600 and 1400 additives used in cigarette production [24]. In addition to additives, it has been reported that the main sources of metallic pollutants in cigarettes are cigarette wrapping paper [2]. Heavy metal and other element levels of tobacco can be found at low or high levels depending on geographical location, industrial or mining activities, agricultural practices [3,25]. Especially, the tobacco plant absorbs toxic metals mostly from soil, pesticides, air and other fertilizing products. Due to the effects of these toxic metals on health, a stricter quality control is required for the tracking of heavy metals during tobacco cultivation, processing and smoking to minimize health hazards for both active and smokers and those exposed to tobacco smoke.

Table 1. Element contents of local and imported brands during inhalation (mg/kg)

	P	K	Ca	Mg	S	Fe
Local tobacco	1874.13 ± 76.63 ^a	23590.63 ± 1994.74 ^a	30924.55 ± 199.01 ^b	6432.17 ± 252.21 ^b	3267.73 ± 170.26 ^b	765.85 ± 38.94 ^a
Import tobacco	85.94 ± 0.75 ^{h**}	582.21 ± 22.14 ^h	506.73 ± 30.11 ^h	108.44 ± 10.22 ^{hi}	144.62 ± 6.22 ^h	15.58 ± 1.10 ^h
Orange filter for local brand	517.77 ± 21.40 ^d	6552.40 ± 95.59 ^f	3621.12 ± 18.16 ^c	852.54 ± 9.46 ^c	618.69 ± 5.00 ^d	36.67 ± 0.94 ^f
Pomegranate filter for imported brand	414.99 ± 9.41 ^f	11065.76 ± 67.96 ^d	2552.82 ± 61.00 ^f	464.81 ± 9.57 ^f	458.31 ± 5.73 ^f	51.33 ± 1.25 ^d
Treated pomegranate filter for import brand	410.68 ± 9.54 ^g	9233.31 ± 90.80 ^e	3374.45 ± 75.77 ^d	545.00 ± 8.60 ^e	638.20 ± 5.32 ^c	64.06 ± 2.96 ^c
Treated orange filter for import brand	554.75 ± 0.11 ^c	5910.00 ± 3.68 ^g	3144.85 ± 16.44 ^e	760.74 ± 0.48 ^d	510.42 ± 4.72 ^e	26.98 ± 0.59 ^g
Pomegranate powder	479.69 ± 11.89 ^e	12927.69 ± 63.44 ^c	2450.82 ± 62.90 ^g	451.92 ± 5.72 ^g	399.84 ± 8.98 ^g	40.40 ± 2.05 ^e
Pomegranate powder	1659.82 ± 9.80 ^b	17640.17 ± 568.80 ^b	35648.38 ± 889.29 ^a	9026.14 ± 97.35 ^a	6642.14 ± 54.30 ^a	233.66 ± 4.50 ^b
Water without filter for importnat	0.08 ± 0.00 ⁱ	4.56 ± 0.24 ⁱ	13.23 ± 0.31 ⁱ	1.19 ± 0.03 ⁱ	12.81 ± 0.17 ⁱ	0.03 ± 0.00 ⁱ
Treated pomegranate water for import	0.01 ± 0.00 ^j	0.68 ± 0.02 ⁱ	6.54 ± 0.27 ^j	0.64 ± 0.03 ^k	10.45 ± 0.07 ⁱ	0.01 ± 0.00 ⁱ
Treated orange water for import brand	0.02 ± 0.00 ⁱ	0.49 ± 0.02 ^k	2.75 ± 0.18 ⁱ	0.33 ± 0.02 ^m	3.83 ± 0.12 ^m	0.01 ± 0.00 ⁱ
Water without filter for local brand	0.01 ± 0.00 ^j	0.67 ± 0.02 ⁱ	7.73 ± 0.11 ⁱ	0.72 ± 0.02 ⁱ	7.10 ± 0.05 ^k	0.01 ± 0.00 ⁱ
Treated pomegranate water for local brand	0.01 ± 0.00 ^j	0.60 ± 0.02 ^j	5.66 ± 0.15 ^k	0.56 ± 0.03 ⁱ	4.25 ± 0.09 ⁱ	0.01 ± 0.00 ⁱ
Treated orange water for local brand	0.01 ± 0.00 ^j	0.32 ± 0.01 ⁱ	2.66 ± 0.18 ^m	0.31 ± 0.02 ^{mn}	9.86 ± 0.11 ^j	0.00 ± 0.00

	Cu	Mn	Mo	Na	Ni	Co
Local tobacco	18.43 ± 0.96 ^a	96.99 ± 2.79 ^b	0.95 ± 0.01 ^a	461.23 ± 14.83 ^a	2.86 ± 0.06 ^a	-
Import tobacco	0.93 ± 0.01 ^g	5.69 ± 0.05 ^d	-	1.96 ± 0.06 ^h	-	-
Orange filter for local brand	6.85 ± 0.11 ^d	5.13 ± 0.08 ^e	-	221.42 ± 2.86 ^f	0.85 ± 0.03 ^e	-
Pomegranate filter for imported brand	8.52 ± 0.17 ^{bc}	4.74 ± 0.10 ^f	-	287.02 ± 9.80 ^c	0.94 ± 0.02 ^c	-
Treated pomegranate filter for import brand	7.92 ± 0.13 ^c	11.45 ± 0.11 ^c	-	270.12 ± 8.98 ^d	0.87 ± 0.02 ^d	-
Treated orange filter for import brand	4.17 ± 0.01 ^f	3.61 ± 0.20 ^{gh}	0.31 ± 0.00 ^c	58.19 ± 0.49 ^g	0.33 ± 0.02 ^g	-
Pomegranate powder	8.88 ± 0.10 ^b	4.02 ± 0.06 ^{fg}	-	361.64 ± 5.74 ^b	1.61 ± 0.03 ^b	-
Pomegranate powder	5.59 ± 0.29 ^e	165.93 ± 0.38 ^a	0.80 ± 0.02 ^b	259.47 ± 6.57 ^e	0.80 ± 0.02 ^f	0.80 ± 0.01
Water without filter for importnat	0.04 ± 0.00 ^h	-***	-	4.75 ± 0.12 ^j	-	-
Treated pomegranate water for import brand	0.02 ± 0.00 ⁱ	-	-	5.16 ± 0.11 ⁱ	-	-
Treated orange water for import brand	0.02 ± 0.00 ⁱ	-	-	4.16 ± 0.09 ⁱ	-	-
Water without filter for local brand	0.03 ± 0.00 ⁱ	-	-	4.64 ± 0.11 ^{jk}	-	-
Treated pomegranate water for local brand	0.02 ± 0.00 ⁱ	-	-	5.54 ± 0.18 ^h	-	-
Treated orange water for local brand	0.01 ± 0.00 ^j	-	-	5.14 ± 0.07 ^{hi}	-	-

	Cd	Cr	Pb	Zn	B
Local tobacco	0.94 ± 0.01 ^a	2.41 ± 0.37 ^a	9.08 ± 0.20 ^a	29.78 ± 0.13 ^a	39.65 ± 2.65 ^a
Import tobacco	-	-	2.73 ± 0.08 ^f	1.88 ± 0.01 ^h	-
Orange filter for local brand	-	-	4.27 ± 0.07 ^d	5.15 ± 0.03 ^e	13.73 ± 0.20 ^f
Pomegranate filter for imported brand	-	-	-	4.72 ± 0.06 ^g	28.34 ± 0.28 ^c
Treated pomegranate filter for import	0.87 ± 0.01 ^b	0.88 ± 0.01 ^b	-	7.02 ± 0.09 ^c	24.60 ± 0.46 ^d
Treated orange filter for import brand	0.04 ± 0.00 ^d	0.18 ± 0.01 ^d	3.43 ± 0.04 ^e	4.96 ± 0.04 ^f	10.89 ± 0.45 ^g
Pomegranate powder	-	-	6.45 ± 0.10 ^b	6.41 ± 0.07 ^d	33.69 ± 0.97 ^b
Pomegranate powder	0.80 ± 0.00 ^c	0.80 ± 0.01 ^c	4.81 ± 0.05 ^c	19.32 ± 0.34 ^b	22.17 ± 0.85 ^e
Water without filter for importnat	-	-	0.05 ± 0.00 ^g	0.03 ± 0.00 ⁱ	0.01 ± 0.00 ^j
Treated pomegranate water for import	-	-	-	0.02 ± 0.00 ⁱ	0.36 ± 0.01 ^h
Treated orange water for import brand	-	-	-	-	0.01 ± 0.00 ^j
Water without filter for local brand	-	-	0.01 ± 0.00 ⁱ	0.01 ± 0.00 ^j	-
Treated pomegranate water for local brand	-	-	-	0.01 ± 0.00 ^j	0.03 ± 0.01 ⁱ
Treated orange water for local brand	-	-	0.03 ± 0.00 ^h	-	0.10 ± 0.02 ⁱ

* standard deviation;

** values within each column followed by different letters are significantly different at P < 0.05;

*** non identified

4. Conclusions

Mn, Mo, Ni, Co, Cd and Cr have not been detected in any of the waters through which the smoke from inhaled cigarettes with and without filters pass. In general, the element contents of the local cigarette were quite high compared to that of the import cigarette. The element contents of orange and pomegranate peel powders used as filters are sometimes higher than the elements in local and import cigarettes.

Therefore, both natural filter sources have bound elements significantly. However, according to these results, it is estimated that the majority of the elements are in smoke and ash which are considered as waste. The vast majority of these elements are thought to be captured by the polyphenolic components in both orange and pomegranate. Current interest in the physiological effects of smoking makes it desirable to study metallic contaminants not only in tobacco but also in smoke condensate and ash.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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