Original Article

Evaluation of Heavy Metals in Various Brands of Tobacco Cigarettes Marketed in Pakistan and Their Implications in Public Health

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Abstract

Background: Tobacco cigarette consumption in Pakistan poses significant health risks due to the presence of toxic substances. Cigarette smoke contains over 4000 chemicals, including toxic heavy metals like cadmium (Cd), chromium (Cr), copper (Cu), cobalt (Co), manganese (Mn), zinc (Zn), iron (Fe), lead (Pb), and nickel (Ni), which can cause severe health issues.

Objective: This study aimed to evaluate heavy metal concentrations in various cigarette brands in Pakistan and assess public health implications.

Methods: Five cigarette brands—Capstan, Gold Leaf, Embassy, Red & White, and Pine—were analyzed. Samples were collected from local markets, oven-dried for eight days, and digested using sulfuric acid and hydrogen peroxide. The concentrations of heavy metals were determined using Atomic Absorption Spectrophotometry. Statistical analysis was conducted using SPSS version 25, with significance assessed using Two-Way ANOVA at a 0.05 significance level.

Results: Mean concentrations of heavy metals in tobacco samples were: Cd (0.35-0.43 mg/kg), Cr (10-14 mg/kg), Cu (17-23 mg/kg), Co (0.7-0.9 mg/kg), Mn (45-62 mg/kg), Zn (60-70 mg/kg), Fe (40-46 mg/kg), Pb (1.8-2.3 mg/kg), and Ni (5-8 mg/kg). Concentrations varied significantly among brands ($P < 0.05$).

Conclusion: The study found significant heavy metal concentrations in Pakistani cigarette brands, highlighting the need for regulatory oversight and public health interventions. Toxic metals in tobacco pose serious health risks, necessitating strict regulatory limits and increased public awareness to protect health.

1 Introduction

Tobacco cigarette consumption remains a prevalent habit worldwide, posing significant health risks due to the presence of various toxic substances. In Pakistan, smoking is widespread among men, women, children, and adults, leading to both active and passive exposure to harmful compounds. Cigarette smoke contains a complex mixture of over 4000 identified chemical compounds, many of which exhibit toxic and carcinogenic properties detrimental to human health (1). Among these, heavy metals such as cadmium (Cd), lead (Pb), chromium (Cr), and nickel (Ni) are of particular concern due to their potential to cause severe health issues. Inhalation of these

metals through smoking results in their deposition in body tissues and fluids, exacerbating health risks. Notably, cadmium is classified as a Group I carcinogen, while lead has been elevated from Group IIB to Group IIA, underscoring their carcinogenic potential (2, 3).

Globally, the prevalence of smoking has shown diverse trends, with certain regions witnessing a decline due to effective anti-smoking initiatives. However, in many areas, including Saudi Arabia, smoking rates continue to rise. Reports indicate that smoking prevalence is higher among young to middle-aged individuals, particularly those aged 21-50 years. Moreover, smoking is more common among married individuals, those with lower education levels, and specific occupational groups such as manual workers, businessmen, army officers, and office workers (4). This widespread habit not only affects the smokers but also exposes non-smokers to the detrimental effects of second-hand smoke, which contains the same harmful compounds.

The toxicity of trace metals in biological systems is well-documented. Metals such as cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), lead (Pb), and cadmium (Cd) exhibit toxic properties that can adversely affect living organisms (5). Elevated concentrations of cobalt, for instance, can inhibit cellular respiration and disrupt the enzymes of the citric acid cycle (5). Nickel, often found in high concentrations in untreated liquid waste, poses environmental and health hazards (6). Moreover, a deficiency in essential trace elements like selenium in food and water is associated with increased risks of cancer, cardiovascular diseases, arthritis, and other health conditions (7).

The primary objective of this study is to evaluate the mineral composition and toxicity levels of various brands of Pakistani tobacco cigarettes. By analyzing the concentrations of heavy metals in popular brands such as Capstan, Gold Leaf, Embassy, Red & White, and Pine, we aim to establish correlations between the metal contents and assess the statistical significance of these correlations using a Two-Way ANOVA test at a 0.05 significance level. This study also seeks to compare the results with international data to provide a comprehensive understanding of the toxic metal content in Pakistani cigarettes.

Understanding the heavy metal content in tobacco products is crucial for public health. It provides essential data for health authorities, enabling them to formulate policies and interventions to mitigate the risks associated with smoking. Additionally, raising awareness among smokers about the presence of toxic metals in cigarettes is vital for promoting healthier lifestyles. Given the extensive use of tobacco products in Pakistan, this study offers significant insights into the health implications of smoking and underscores the need for stringent regulatory measures to control the quality and safety of tobacco products.

2　Material and methods

The study was conducted to evaluate the concentrations of heavy metals in various brands of tobacco cigarettes marketed in Pakistan and their implications for public health. The brands analyzed included Capstan, Gold Leaf, Embassy, Red & White, and Pine. Samples of these brands were collected from local markets across different regions of Pakistan. Each brand was represented by multiple samples to ensure comprehensive analysis and reliable results.

For sample preparation, one gram of each tobacco sample was initially oven-dried for eight days to remove moisture. The dried samples were then subjected to wet digestion using a mixture of 4 ml of sulfuric acid (H_2SO_4) and 8 ml of hydrogen peroxide (H_2O_2). The digestion process was carried out in a digestion chamber for approximately 30 minutes. Following the cessation of fume production, an additional 2 ml of H_2O_2 was

added, and the samples were reheated until they became colorless. The digested samples were then diluted to a final volume of 25 ml with distilled water and stored in labeled plastic bottles for subsequent analysis.

The mineral analysis was performed using an Atomic Absorption Spectrophotometer (AAS-5000, Perkin-Elmer Corp., 1980) and a Double Beam Spectrophotometer (U-2900/2910). The concentrations of cadmium (Cd), chromium (Cr), copper (Cu), cobalt (Co), manganese (Mn), zinc (Zn), iron (Fe), lead (Pb), and nickel (Ni) were determined in the tobacco samples. The detection limits for these metals were as follows: Cd (0.8 mg/kg), Cr (3 mg/kg), Cu (15 mg/kg), Co (9 mg/kg), Mn (1.5 mg/kg), Zn (1.5 mg/kg), Fe (5 mg/kg), Pb (15 mg/kg), and Ni (6 mg/kg).

Data collection adhered to ethical guidelines and was conducted with the approval of relevant authorities. The study followed the principles outlined in the Declaration of Helsinki to ensure ethical conduct and the welfare of participants. The statistical analysis of the collected data was performed using SPSS software, version 25. The results were expressed as mean values with standard deviations (SD). The significance of the differences between the heavy metal concentrations in the different cigarette brands was assessed using a Two-Way ANOVA test at a 0.05 significance level. Additionally, correlation matrices were used to explore the relationships between the various heavy metals in the tobacco samples.

The methodology employed ensured the accuracy and reliability of the results, providing valuable data on the presence of toxic metals in Pakistani tobacco products. This information is crucial for health authorities and policymakers to develop strategies to mitigate the public health risks associated with tobacco smoking. The findings also serve to raise awareness among smokers about the potential health hazards posed by the heavy metal content in cigarettes, thereby promoting informed choices and healthier lifestyles.

3   Results

The analysis of heavy metals in various brands of tobacco cigarettes marketed in Pakistan revealed significant findings. The concentrations of cadmium (Cd), chromium (Cr), copper (Cu), cobalt (Co), manganese (Mn), zinc (Zn), iron (Fe), lead (Pb), and nickel (Ni) in the different brands were measured and are presented in Table 1. The mean values and standard deviations (SD) for each metal across the five brands are shown, providing a detailed overview of the heavy metal content.

The mean concentrations of cadmium (Cd) ranged from 0.35 to 0.43 mg/kg, with the highest levels found in Red & White and the lowest in Capstan. Chromium (Cr) levels varied between 10 to 14 mg/kg, with Red & White again showing the highest concentration.

Copper (Cu) concentrations ranged from 17 to 23 mg/kg, with Embassy having the highest content. Cobalt (Co) was found in the range of 0.7 to 0.9 mg/kg, with the highest levels detected in Embassy and Red & White. Manganese (Mn) concentrations were notably high, ranging from 45 to 62 mg/kg, with Red & White showing the highest levels.

The statistical analysis using the Two-Way ANOVA test at a 0.05 significance level revealed that the heavy metal concentrations across the different brands were statistically significant ($P < 0.05$), indicating substantial variation among the brands. Zinc (Zn) content varied from 60 to 70 mg/kg, with Embassy and Pine exhibiting the highest concentrations. Iron (Fe) levels ranged from 40 to 46 mg/kg, with Pine showing the highest content.

Table 1: Concentrations of Heavy Metals in Various Brands of Tobacco Cigarettes

Brand	Cd	Cr	Cu	Co	Mn	Zn	Fe	Pb	Ni
					(mg/kg)				
Capstan	0.35 ± 0.03	11 ± 1.64	17 ± 2.60	0.7 ± 0.1	45 ± 6.58	60 ± 5	40 ± 2.94	1.8 ± 0.21	5 ± 1.14
Gold Leaf	0.40 ± 0.03	10 ± 1.64	17 ± 2.60	0.8 ± 0.1	55 ± 6.58	60 ± 5	45 ± 2.94	2 ± 0.21	8 ± 1.14
Embassy	0.42 ± 0.03	10 ± 1.64	23 ± 2.60	0.9 ± 0.1	60 ± 6.58	70 ± 5	40 ± 2.94	2.3 ± 0.21	6 ± 1.14
Red & White	0.43 ± 0.03	14 ± 1.64	20 ± 2.60	0.9 ± 0.1	62 ± 6.58	65 ± 5	45 ± 2.94	2 ± 0.21	6 ± 1.14
Pine	0.38 ± 0.03	11 ± 1.64	21 ± 2.60	0.7 ± 0.1	55 ± 6.58	70 ± 5	46 ± 2.94	2.3 ± 0.21	7 ± 1.14

Lead (Pb) concentrations varied between 1.8 to 2.3 mg/kg, with Embassy and Pine having the highest levels. Nickel (Ni) concentrations ranged from 5 to 8 mg/kg, with Gold Leaf exhibiting the highest content.
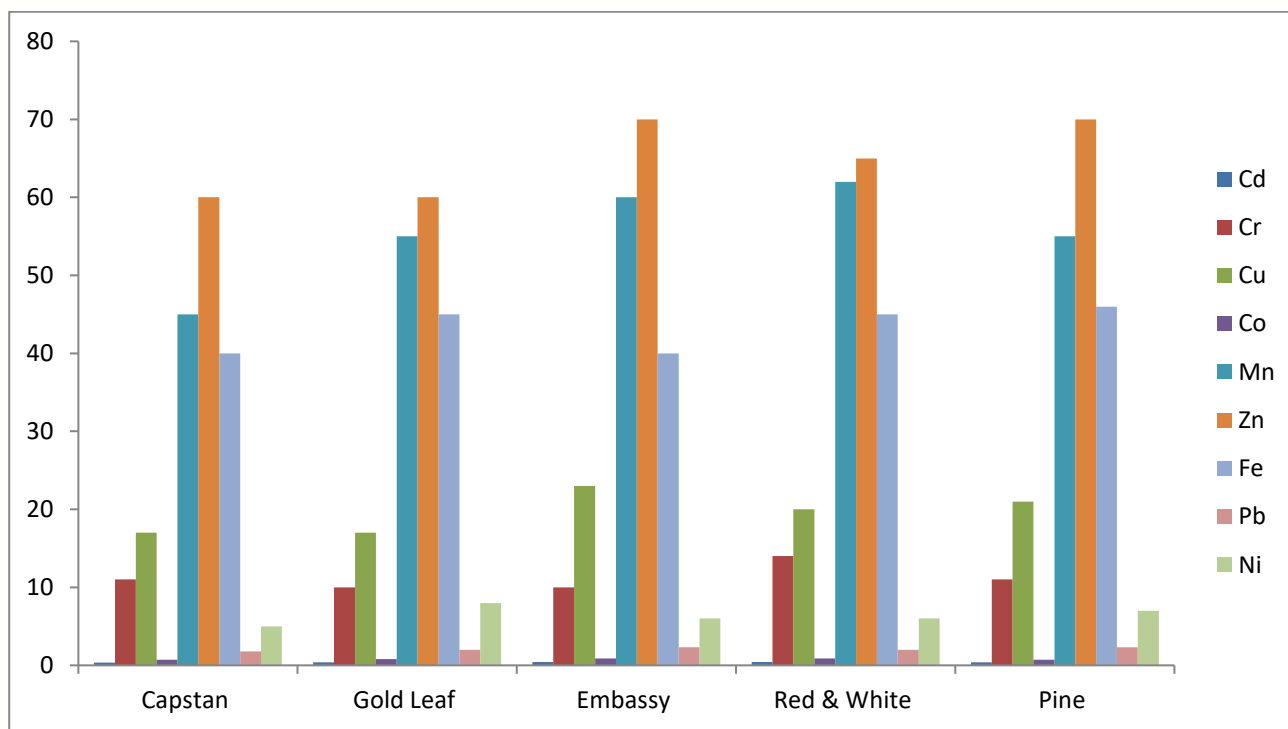

Figure 1: Fluctuation of various heavy metals is present in different brands of Cigarette

The correlation matrix (Table 3) showed the relationships between the heavy metals in different brands of tobacco cigarettes. Positive correlations were observed among Cd, Mn, Zn, Fe, Pb, and Ni, indicating strong associations between these metals.

Table 2: Significance of Heavy Metals in Tobacco Cigarettes by Two-Way ANOVA Test (P < 0.05)

Parameter	Range	P Value	Remarks
Cd	0.35 to 0.43 mg/kg	0.03	Significant

Cr	10 to 14 mg/kg	0.03	Significant
Cu	17 to 23 mg/kg	0.03	Significant
Co	0.7 to 0.9 mg/kg	0.03	Significant
Mn	45 to 62 mg/kg	0.03	Significant
Zn	60 to 70 mg/kg	0.03	Significant
Fe	40 to 46 mg/kg	0.03	Significant
Pb	1.8 to 2.3 mg/kg	0.03	Significant
Ni	5 to 8 mg/kg	0.03	Significant

Conversely, negative correlations were found between Fe and Cr, Cd, Pb, and Cr, Ni and Cr, and Cu, indicating weaker associations. These findings provide important insights into the presence and relationships of heavy metals in Pakistani tobacco products.

Table 3: Correlation Matrix of Heavy Metals in Different Brands of Cigarettes (P < 0.05)

Metal	Cd	Cr	Cu	Co	Mn	Zn	Fe	Pb	Ni
Cd	1								
Cr	0.351	1							
Cu	0.544	0.023	1						
Co	0.935	0.304	0.479	1					
Mn	0.968	0.361	0.667	0.836	1				
Zn	0.389	0.000	0.959	0.250	0.570	1			
Fe	0.248	0.351	-0.085	-0.085	0.368	0.085	1		
Pb	0.417	-0.267	0.867	0.231	0.585	0.923	0.203	1	
Ni	0.260	-0.320	-0.101	0.000	0.307	0.000	0.714	0.344	1

The significant variations in heavy metal concentrations among different brands highlight the need for regulatory oversight and quality control in the tobacco industry to protect public health.

4 Discussion

The evaluation of heavy metals in various brands of tobacco cigarettes marketed in Pakistan revealed significant differences in their concentrations, with implications for public health. The study found that the levels of cadmium (Cd), chromium (Cr), copper (Cu), cobalt (Co), manganese (Mn), zinc (Zn), iron (Fe), lead (Pb), and nickel (Ni) varied across different brands, indicating potential health risks associated with smoking these products. These findings are consistent with previous research that has identified tobacco smoke as a major source of heavy metal exposure [1, 2].

Cadmium, a known Group I carcinogen, was found in concentrations ranging from 0.35 to 0.43 mg/kg, with the highest levels in Red & White and the lowest in Capstan. This aligns with earlier studies that identified tobacco smoke as a primary source of cadmium exposure for smokers [3]. Similarly, lead, elevated from Group IIB to Group IIA carcinogen, was present in concentrations ranging from 1.8 to 2.3 mg/kg, which is concerning given its well-documented health risks [2]. These findings highlight the persistent issue of heavy metal contamination in tobacco products, posing significant health risks to smokers and passive smokers alike.

The study also revealed high levels of manganese and zinc, which ranged from 45 to 62 mg/kg and 60 to 70 mg/kg, respectively. These metals, while essential in trace amounts, can be toxic at higher concentrations. The presence of these metals in tobacco products indicates potential health risks, especially for individuals with prolonged exposure. Previous research has demonstrated that high concentrations of manganese can affect neurological functions, while excessive zinc intake can disrupt various biological processes (4, 5).

The correlations between the different heavy metals in the tobacco samples were significant, suggesting that these metals may have synergistic effects, exacerbating their individual toxicities. Positive correlations among metals such as Cd, Mn, Zn, Fe, Pb, and Ni indicate strong associations and potential cumulative effects when inhaled through smoking. Negative correlations between metals like Fe and Cr, and Cd and Pb, suggest complex interactions that warrant further investigation to fully understand their health implications.

The study was limited to five brands of tobacco cigarettes, which may not fully represent the diversity of tobacco products available in Pakistan. Additionally, the analysis was restricted to heavy metals, while other toxic compounds present in tobacco smoke were not evaluated. Future studies should include a broader range of tobacco products and consider the full spectrum of toxic substances present in tobacco smoke.

The findings underscore the need for stringent regulatory measures to control the quality and safety of tobacco products. Regulatory authorities should implement and enforce strict limits on heavy metal concentrations in tobacco products to protect public health. Moreover, public awareness campaigns are crucial to inform smokers about the health risks associated with heavy metal exposure from smoking.

5   Conclusion

The study revealed significant concentrations of heavy metals such as cadmium, lead, chromium, copper, cobalt, manganese, zinc, iron, and nickel in various brands of tobacco cigarettes marketed in Pakistan. These findings underscore the urgent need for regulatory oversight and public health interventions to mitigate the risks associated with smoking. The presence of these toxic metals in tobacco products poses serious health risks, including increased cancer risk and other chronic health conditions. Therefore, it is imperative to enforce strict limits on heavy metal concentrations in tobacco products and raise public awareness about the associated health hazards to protect and improve human health.

6   References

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Disclaimers