Libyan Journal of Ecological & Environmental Sciences and Technology

(**LJEEST**)

LJEEST

ISSN: 2710-5237

www.srcest.org.ly/jou

http://aif-doi.org/LJEEST/050103

STUDY AND COMPARISON OF THE CONCENTRATION OF SOME TOXIC METAL ELEMENTS IN CIGARETTE ASHES AND ROLLING PAPERS

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ARTICLE INFO

Vol. 5 No. 1 June, 2023

Pages (17- 24)

Article history:

Revised form 07 April 2023

Accepted 09 May 2023

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Keywords:

toxic elements, atomic absorption spectrophotometer, device, cigarette rolling papers, tobacco

ABSTRACT:

This research included investigating the concentration of toxic elements (iron, copper, zinc, chromium, manganese, cobalt, lead, and nickel), which were detected using the (AAS) device. In five types of cigarettes (Rothman, Malboro, Karela, Sports, and M), an average of three samples for each type, where samples were taken from cigarette rolling papers (Bafra) and tobacco residues (ash and the data were treated statistically by using (T) test). The significance of the mean of heavy metals between the two groups (ash, cigarette rolling papers) is that there are differences at the level of probability (0.05 ≥P) for Rothman cigarettes for both (Fe, Pb, Ni), and Karela for (Cu, Mn, Co, Ni) As for the athlete, the differences were for the elements (Fe, Zn, Co, Ni), while the Malboro represented a statistical function between the two groups for all haevy metals also for all with a statistical significance except (Zn), it was not significant, while the results of measuring the elements using the (AAS) device showed) in cigarette rolling papers (0.22, 0.23, 0.08, 0.01, 0.06, 0.03, 0.13, 0.18 ppm) respectively, while in ash samples the mean was (0.30, 0.04, 0.03, 0.005, 0.05, 0.034, 0.110.16) ppm) respectively, which gives a clear indication and a close link that every part of the cigarette contains percentages of toxic heavy metals, and this reflects the amount of damage to the health of the person, for smokers.

دراسة ومقارنة لتركيز بعض العناصر المعدنية السامة في رماد وأوراق لف السجائر

تضمن هذا البحث تقصي تركيز العناصر السامة (الحديد، النحاس، الزنك، الكروم، المنغنيز، الكوبالت، الرصاص والنيكل)، وتم الكشف باستخدام جهاز(AAS). في خمسة أنواع من السجائر (الروثمان، المالبورو، الكاريلا، الرياضي وال ام)، بمعدل ثلاث عينات لكل نوع، حيث اخذت العينات من أوراق لف السجائر(البافرا) وبقايا التبغ (الرماد وعولجت البيانات إحصائياً باستخدام اختبار (T). وأظهرت النتائج ايجاد الفروق المعنوية لمتوسط العناصر الثقيلة بين المجموعتين (الرماد، وأوراق لف السجائر) أن هناك فروق عند مستوي احتمالية (P≤ 0.05) بالنسبة لسجائر نوع الروثمان لكلا من (Fe, Pb, Ni). وكاريلا لكل من (Cu, Mn, Co, Ni)، اما الرياضي كانت الفروق للعناصر (Fe, Zn, Co, Ni) بينما المالبورو يمثل دالة إحصائية بين المجموعتين لجميع العناصر المدروسة، اما إل إم جميع العناصر ذات دالة إحصائية ماعدا (Zn) غير معنوي. بينما أظهرت نتائج قياس العناصر باستخدام جهاز(AAS) في أوراق لف السجائر (0.22، 0.23، 0.08، 0.01، 0.06، 0.03، 0.13، 0.18 ppm) على التوالي. بينما في عينات الرماد كان المتوسط (0.30، 0,04، 0.03، 0.005، 0.05، 0.034، 0.110.16 ppm) على التوالي. مما يعطي مؤشراً واضحاً وارتباطاً وثيقاً أن كل جزء من أجزاء السيجارة تحوي على نسب من العناصر الثقيلة السامة وهذا يعكس مقدار الضرر على صحة المدخنين.

INTRODUCTION

A cigarette consists of the tobacco plant. It is a cylindrical coil with a length of 120 mm and a diameter of 10-12 mm. It contains a filter surrounded by loose leaves surrounded by a paper envelope wrapped in a spiral around a group of tobacco leaves (Saeda et.al 2021). In addition to some chemicals that number more than (4000) chemicals, including hydrogen cyanide, vinyl chloride, ammonia, nicotine, carbon oxides, arsenic, cadmium, lead, hydrogen sulfide, nitrogen dioxide, and formaldehyde (Al-Sharif et al. 2016). The cigarette goes through three different stages during its manufacture, and each stage has its own conditions until it gives the final shape to the cigarette, and from these stages according to the layers of tobacco (Tso, 2007). The inner layer containing the filling is made of chopped tobacco. The middle layer is the leaves from the tobacco that embrace the filling and act as a cover for it. The outer layer is a thin-looking tobacco leaf that includes the cigarette and wraps around the middle layer. Guadagnini 2000)). Tobacco is composed of a mixture of hundreds of chemicals, including toxic elements that pose a threat to human health (Verm, Yadav 2010). Where heavy metals are transported from contaminated water and soil to the tobacco plant, which is then manufactured and packaged. For this reason, plants have been used in environmental research as sensitive indicators to monitor the deposition, accumulation, and distribution of heavy metals. Especially the papers that ecologists and pollution scientists have used as a tool to monitor air, soil, and water pollution. (Kazi et.al 2009). In addition to the polluted air, which is one of the sources of contamination of the tobacco plant with toxic elements. Afira, 2010). (Cevik et.al 2003) indicated that tobacco leaves have the ability to precipitate heavy metals, which are initially released with dust particles to the atmosphere, then settle on plant surfaces, and then absorbed through stomata. Therefore, the tobacco plant is more sensitive to environmental pollution. The danger of the elements increases when smoking and burning the cigarette due to the high temperature (Navas et.al 2004), which leads to the interaction of chemicals with each other and the formation of other compounds that are more dangerous and deadly to the health of the smoker (Rolling, Papers 2021). Tobacco rolling leaves (Albafra) also contain levels of toxic elements (Yebbella, 2001). Especially since they are made of special paper that is commercially manufactured from plant fibers such as cannabis, crab, straw, rice, and allies (Navas et.al 2004), and these plants may contain proportions of toxic elements (Ibrahim 2003) from the soil in which they are grown and the water from which they are watered (rolling papers 2021). In addition to the processes of manufacturing and preserving these papers may provide them with proportions of toxic elements, and these papers have porosity commensurate with the type of tobacco and contain additives that regulate burning (Rolling Papers 2o21). Among the fillers used is calcium carbonate affects permeability and color, magnesium carbonate improves the color of ash, titanium oxide is responsible for white ash, sodium-potassium tartrate, and sodium-potassium citrate as a combustion regulator in cigarette paper (Shehata, 2006). These components interact with toxic elements present in tobacco or rolling papers and form compounds that are highly toxic to smokers' health (Tso, 2007). Whereas minerals share a lot in their natural characteristics, but their chemical reactions are different (Al-Nuaimi 2020), and this applies to their health effects. Some of these minerals, such as mercury, lead, and cadmium, pose a threat to public health (WHO 2011), while other minerals such as chromium, iron, and copper are limited to their effects on workplaces that occur It contains exposure for long periods, and therefore it is less dangerous than other metals, such as lead, which has increased in popularity recently and is present in abundance in water air, and food (Rubio et. 2015). There are many factors that determine the toxic effects that occur as a result of exposure to toxic metals, and these factors include the dose, the method of absorption of the dose, the sensitivity of the smoker, the status of the smoker's diet and immunity (Stevenson, Proctor 2008). Finally, the study aims to: Determine the levels of toxic elements in cigarette rolling papers (bafra) and burnt cigarette butts. This type is not available in general, and this study came to fill part of the void that exists in this type of study.

MATERIALS AND METHODS

This study was conducted on different types of cigarettes, namely: (Marlboro, Rotman, LM, Sportsman, and Karela). The samples were collected from the local markets of the city of Sebha (Southern Libya). The samples were transferred to the environment laboratory at the Faculty of Science, Sebha University. The sorting process was carried out and the sorting process was as follows: Samples of cigarette butts (ashes): They were collected from smokers' cigarette butts, as shown in picture (1), and the ashes were placed in clean and sterile tubes. Samples of cigarette rolling papers (bafra) The contents of new cigarettes were discharged. Leaves were taken, as shown in the image (2), and preserved in sterile glass tubes. To avoid changing the color of the samples to prevent any addition to them and avoid moisture, they were placed in the laboratory at a temperature of (23-24) degrees Celsius until the samples were digested (Saida et al. 2021).

Picture. (1): shows the sample of ash resulting from cigarette butts

Picture. (2): shows a sample of cigarette rolling papers (bafr)

Chemical digestion: The wet incineration method was followed (Al-Sharif et al. 2016), where (2) grams of the dry sample were placed in a conical flask with a capacity of (100) ml, to which (20) ml of a mixture of acids (nitric, sulfuric, and pyrochloric) was added at a ratio of (2:5:1) respectively, the mixture was heated at a low temperature for (10) minutes, then the temperature was gradually raised, until the fumes escalated, and the heating continued until the volume decreased, and after the solution was cooled, the filter was filtered into a standard (100) beaker. ml and then complete the volume with ion-free water. Toxic elements (iron, copper, zinc, chromium, manganese, cobalt, lead, nickel) were estimated using an atomic absorption device (AAS) type "NOVAA400" at the Research and Scientific Consultation Laboratory of Sebha University.

Statistical analysis: All experiments were treated in the form of three replications, where the (T) test was used to find out the differences in the studied heavy metals between samples of cigarette butts (ash) and samples of cigarette rolling papers, and arithmetic means and standard deviations were calculated at the level of statistical significance (0.05), And using the statistical test (T-test). Important note: values that were below the sensitivity of the device (ND) were not treated statistically, because the statistical value would be zero.

RESULTS AND DISCUSSION

Through the results of the statistical analysis attached in the appendices (1, 2, 3, 4, 5) to find out the significant differences in the studied heavy elements between the ash samples and the cigarette rolling paper samples, the results showed the following: (copper, zinc, manganese, chromium, cobalt) where the probability values of the average heavy elements were greater than the significance level (0.05). While there are statistically significant differences for the elements (iron, lead, nickel), where the probability values of the average heavy elements were less than the significance level (0.05). While the results of Marlboro cigarettes: There were significant differences for the studied heavy elements between the ash samples and the cigarette rolling papers samples, and all the values for the studied elements were less than the level of significance (0.05). As for Carella cigarettes: There are statistically significant differences in the mean of the elements (copper, manganese, cobalt, and nickel) between the ash and the rolling papers, where the probability values were less than the significance level (0.05), while the rest of the elements did not represent a statistical function. As for the sports-type cigarettes: there are significant differences in the elements (iron, zinc, cobalt, and nickel) between the ashes and the rolling papers, where the probability values were less than the significance level (0.05), while the rest of the elements did not represent a statistical function. As for LM cigarettes: There are significant differences between all elements except for zinc, which is not statistically significant.

The obtained results are shown in Table (1) (2): To measure the concentrations of the elements, which are (Fe, Cu, Zn, Cr, Mn, Co, Pb, and Ni), using the atomic absorption device, they were as follows:

Concentrations of toxic elements in cigarette butts (ash): It is shown in Table (1) that the concentrations of toxic elements varied from one brand to another and from one element to another, and the results of our study recorded the highest concentration of iron in the Rotman (1.24) ppm, followed by Marlboro, where nickel was recorded with the highest concentration (ppm (0.25), then lead in LM (0.142) ppm, copper and manganese at the same concentration (0.07ppm) in Karela and Rothman, then zinc and cobalt at the same concentration (0.06ppm) in both Rothan and Karela. The reason for this difference may be attributed to the concentrations of heavy elements of the brand to others in cigarette butts, the chemical composition of raw tobacco according to the country of manufacture, and the materials and additives used in the product. For the country of manufacture, the characteristics of the filter, the length of the cigarette, and the weight of the cigarette, the same study indicated that the rate of cadmium in Korean cigarettes was high (2.4 µg/g), followed by cigarettes made in France at a rate of (1.96 µg/g), followed by the English (1.92 µg/g) such as cigarettes (Rotman) followed by pain Pot at a concentration of (1.74 µg/g), then the Swiss at a rate of (1.51 µg/g) represented by Marlboro. ((Saeda et.al 2021) indicated that there are other reasons that lead to different rates of toxic elements in tobacco, especially during the cultivation period, such as the use of fertilizers and the different quality and composition of the soil. Tobacco is distinguished by its expensive ability to absorb heavy elements from the soil, which are highly concentrated in the leaves more than Roots As confirmed by a (Navas et.al 2004) in his study, substances that improve tobacco are added to help the combustion process and give it a special flavor, estimated at about (600-1400) substances, and most of these additives contain heavy elements.

Table (1): Traces of toxic elements in cigarette butts (ash)

Ni	**Pb**	**Co**	**Mn**	**Cr**	**Zn**	**Cu**	**Fe**	**Metallics / Type**
0.11	nd	0.037	0.07	0.003	0.06	0.06	1.24	**Rothman**
0.25	0.11	0.053	0.04	0.006	0.004	0.04	0.07	**Marlboro**
0.178	0.097	0.06	0.06	Nd	0.05	0.07	0.089	**Karela**
0.0002	0.11	0.011	0.03	0.003	0.017	0.03	0.068	**Riyadhi**
0.28	0.142	0.011	0.06	0.01	0.034	0.03	0.079	**L . M**
0.164	0.115	0.0344	0.052	0.0055	0.033	0.046	0.3092	**average**

(Nd =element without device sensitivity)

Concentrations of toxic elements in cigarette rolling papers: The results obtained indicate that the highest concentration of nickel in karela leaves is (0.298) ppm, followed by athlete leaves, where the highest concentration of iron (0.214) ppm, then copper in karela leaves is (0.62) ppm, followed by the lead in LM leaves (0.17) ppm, followed by zinc in Marlboro leaves (0.166) ppm, then manganese in karela leaves (0.11) ppm, followed by cobalt in Rothman leaves (0.053) ppm, as in Table (2).

Table (2): Traces of toxic elements in cigarette rolling papers (ppm)

Ni	**Pb**	**Co**	**Mn**	**Cr**	**Zn**	**Cu**	**Fe**	**Metallics / Type**
0.36	0.162	0.053	0.04	0.011	0.066	0.1	0.178	**Rothman**
0.18	0.154	0.018	0.08	Nd	0.166	0.02	0.47	**Marlboro**
0.298	0.074	0.017	0.11	Nd	0.06	0.62	0.089	**Karela**
0.001	0.11	0.035	0.03	0.002	0.09	0.03	0.214	**Riyadhi**
0.06	0.17	0.035	0.04	Nd	0.052	0.36	0.172	**L . M**
0.18	0.134	0.032	0.06	0.01	0.087	0.23	0.225	**General rates**

(Nd =element without device sensitivity)

The results show that there is a difference in the concentrations of toxic elements, and the reason for this may be attributed to the difference in the quality and composition of the soiled tissue in which the tobacco plant is grown, the degree of its contamination, and its proximity and distance from the various sources of pollution. The average concentration of toxic elements (Pb, Ni, Co, Cd) in agricultural soils was estimated to be (8, 25, 100, and 200) mg/kg, respectively. While the permissible concentrations of these elements in agricultural crops were estimated (1.0-10, 5.0, 0.05-0.5, and 0.5-10 mg/kg), respectively (Al-Saadi et al. 2019). In addition to the water quality used in plant irrigation, and air quality Whether it is contaminated or not, especially with fine dust particles loaded with toxic elements that are deposited on the surface of the leaves (Kazi et.al 2009). In addition to that, there is a difference in the manufacturing process and quality, as well as a difference in the method of preservation and storage. And the difference in the components of tobacco and additives such as flavorings and materials that help the combustion process, the packing density, the length of the cigarette, the characteristics of the filter and the paper that wraps the cigarette, and the temperature at which the tobacco burns (Afira 2010), and it was also shown through this study that the tobacco rolls It contains toxic elements and this is consistent with what was mentioned by Yebpella, 2001). (Robert et.al 2003) indicated that the reason why tobacco leaves remain lit even if left unused is the presence of some metallic elements that stimulate glow and combustion, which leads to the continuation of the combustion process of all chemical organic materials without extinguishing, either if the amount of these chemicals decreases in Tobacco is extinguished during smoking itself and the smoker is forced to light the coil several times. A study (Cevik et.al 2003) showed that there are substances and chemical elements that are added to tobacco in order to help convert nicotine molecules into a free base form, allowing the lungs to absorb the nicotine faster. Also, adding these substances and chemical compounds contributes to changing brain chemistry to make it more receptive to nicotine, as it works to improve the process of nicotine adhesion to brain cells. This helped turn some cigarettes from a lesser-selling brand into a global bestsellers. These materials differ in terms of their quality and quantity according to the type of tobacco rolling paper, which varies according to the properties of the tobacco. Tobacco ash, results from the combustion process of tobacco along with the rising smoke. The ash consists of carbonates, metal oxides, and organic salts present in tobacco, which were burned due to the glow. The researcher Guadagnini, (2000) pointed out To, the composition of tobacco smoke is related to the combustion conditions, the physical and chemical properties of the used tobacco leaves, the type of paper that the cigarettes are wrapped in (the puffer), and the type of filter that the cigarettes are supplied with. Chemical reactions and different physical transformations occur in cases of lack of oxygen and excess of hydrogen at the end. This is indicated by (Cevik et.al 2003) that the presence of toxic elements in cigarette ashes is of great importance in the study of toxicity, and these elements are partially or completely volatilized by the smoker and are inhaled again through reverse inhalation (passive smoking). In addition, the presence of ash inside the rooms for a period of time contributes to the effects of its fine particles in the air of the room, whose fungus reaches less than (2.5 microns). These tiny particles remain suspended in room air for long periods (days to several weeks) and have harmful effects on the respiratory system, especially because they have the ability to carry heavy metals with them. (Haroun, 2007) indicated that the combustion of cigarette smoke leads to the production of the primary smoke stream and the secondary smoke. The primary stream enters the mouth directly from the burning area and the heated area through the smoke column in the cigarette. As for the secondary stream, it spreads freely in the surrounding atmosphere. The combustion of the paper generates high heat that rushes into the smoker's respiratory system, and here the air entering the lungs is loaded with high concentrations of harmful chemicals, including toxic elements. And between (RlVM. 2012), when a cigarette is lit and smoke is drawn through the mouth, more than (19) chemicals are withdrawn, and these substances, due to heat, are associated with DNA and cause cancer and many genetic mutations. Heat and combustion increase the level of toxins in the blood. The increase in the number of smoking times per day and the duration of smoking helps in increasing the concentration of toxic elements. This increase is explained by the increase in combustion rates due to heat, as mentioned. Rubio et al. (2015). Either about the health effects of minerals that were detected through chemical analysis, and which do not enter into the physiology of the human body, such as lead, and its presence in the body, even in small concentrations, is considered dangerous, as it interferes with enzymes and leads to damage to the nerves and the respiratory system. For example, lead is considered one of the residues of phosphate and nitrogen fertilizers, and it has the property of moving between plant parts, and this depends on its chemical formula. (Cevik et.al 2003) (Kazi et.al 2009). Smokers are exposed to large amounts of chromium, which causes irritation in the nose, respiratory disorders, and a weakening of the immune system. (RlVM, 2012). High concentrations of copper irritate the nose, mouth, and eyes and cause smoke metal fever (WHO, 2011). Manganese, when it enters the body in high concentrations, is transmitted through the blood to the respiratory system and the brain, and causes tremors and bronchitis (Guadagnini, 2000). As for zinc, its danger is subject to the nature of the individual's body, his age, and the number of years of smoking. Among its dangers are severe infections in the digestive and respiratory systems (Yebpella, 200), while nickel causes lung and nose cancer in smokers (Yebpella, 2001). Most studies indicate a high rate of this. The element in the smoke until it reaches (50) micrograms/gram of tobacco, and it was found that there is a relationship between the amount of nickel in the liver, kidneys, and lungs and the number of years of smoking (Eisen, Hammond 2012), while cobalt enters the respiratory system and is absorbed by the capillaries spread on its inner surface and moves with Blood, where it is absorbed by the small intestine, and (85%) of the absorbed amount is excreted in the urine, and the rest is excreted with the feces or sweat (Zhang, Miura 2005), and its concentration in the body leads to an increase in red blood cells, an increase in hemoglobin, and thus leads to poisoning (Guadagnini, 2000). Iron if concentration increases in the body, it causes disorders in the blood circulation and in the liver. (Zhang, Miura, 2005).

CONCLUSION AND RECOMMENDATIONS

1- Organizing scientific activities such as seminars and conferences and issuing scientific publications related to smoking and its health, social and environmental harms to educate and rationalize citizens.

2- Preparing an indicative program to define the dangers of smoking and the chemical toxins contained in cigarettes, especially toxic elements, and their harmful effect on the health and safety of the consumer.

3- Issuing strict laws on the authorities concerned with importing tobacco of poor quality, and imposing a tax that exceeds the purchasing power of the importer and consumer.

4- Educating all age groups in society about the dangers of smoking and its health and environmental harms

5- Conducting future research to estimate the toxic elements in all brands of tobacco and all synthetic components of a cigarette, and compare them with international standards, and the effect of combustion and heat factors on increasing chemical reactions and the formation of other compounds that may be more dangerous, including toxic substances included in the composition of tobacco, in addition to determining the proportions These pollutants are in the materials used in packaging and their validity, such as cigarette rolling papers, and the study of the relationship between the proportions of toxic elements in cigarettes and their increase due to manufacturing, packaging, and preservation processes.

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APPENDAGES:

Appendix (1): The results of the (T) test to find out the differences in the heavy elements studied for the type of cigarette (Rothman)

Type of cigarette	The group	Statistics	Nickel	Lead	Cobalt	Chrome	Manganese	Zinc	Copper	Iron
Rutman	Ash	$\overline{X}_1$	0.113	Nd	0.042	0.005	0.060	0.059	0.073	1,240
		$S.D_1$	0.123	0.081	0.008	0.004	0.014	0.007	0.019	0.531
	Leaves Roll a cigarette	$\overline{X}_2$	0.353	0.161	0.053	0.011	0.040	0.065	0.100	0.178
		$S.D_2$	0.014	Nd	0.001	Nd	Nd	0.001	Nd	0.001
	T test	T-test	32.19	484-	1.94-	1.98-	1.88	1.19-	1.93-	183.69
	probability value	P-value	0.00	0.000	0.12	0.11	0.13	0.29	0.12	0.00

Appendix 2: Results of the (T) test to find out the differences in the studied heavy elements for the type of cigarette (Marlboro)

Type of cigarette	The group	Statistics	Nickel	Lead	Cobalt	Chrome	Manganese	Zinc	Copper	Iron
Marlboro	Ash	$\overline{X}_1$	0.247	0.110	0.053	0.006	0.033	0.004	0.043	0.057
		$S.D_1$	0.006	Nd	0.001	0.001	0.006	0.001	0.006	0.015
	Leaves Roll a cigarette	$\overline{X}_2$	0.177	0.153	0.018	Nd	0.077	0.166	0.017	0.460
		$S.D_2$	***0.006***	0.001	0.001	Nd	0.006	0.001	0.006	0.010
	T test	T-test	**14.84**	**134-**	**72.24**	**17**	**9.19-**	**343.65-**	**5.65**	**38.26-**
	probability value	P-value	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**

Appendix 3: Results of the (T) test to find out the differences in the studied heavy elements for the type of cigarette (Carela)

Type of cigarette	The group	Statistics	Nickel	Lead	Cobalt	Chrome	Manganese	Zinc	Copper	Iron
Carela	Ash	$\overline{X}_1$	0.089	0.179	0.068	0.057	0.057	0.050	0.067	0.089
		$S.D_1$	0.002	0.002	0.050	0.006	0.006	Nd	0.006	0.002
	Leaves Roll a cigarette	$\overline{X}_2$	0.089	0.298	0.073	0.017	0.110	0.057	0.617	0.089
		$S.D_2$	0.002	0.001	0.001	0.001	Nd	0.006	0.006	0.002

	T test	T-test	0.22-	112.6-	0.174-	11.94	16-	2-	116.67-	0.22-
	probability value	P-value	0.83	0.00	0.87	0.00	0.00	0.11	0.00	0.83

Appendix (4): Results of the T-test to find out the differences in the studied heavy elements for the type of cigarette (mathematical***)***

Type of cigarette	The group	Statistics	Nickel	Lead	Cobalt	Chrome	Manganese	Zinc	Copper	Iron
mathematical	Ash	$\bar{X}_1$	0.069	0.002	0.008	0.002	0.027	0.018	0.033	0.069
		$S.D_1$	0.002	Nd	0.006	0.001	0.006	0.002	0.006	0.002
	Leaves Roll a cigarette	$\bar{X}_2$	0.213	***0.001***	0.035	0.002	0.027	0.087	0.027	0.213
		$S.D_2$	0.001	Nd	0.001	Nd	0.006	0.006	0.006	0.001
	T test	T-test	115.99-	25-	8.06-	1	***Nd***	19.47-	1.41	115.99-
	probability value	P-value	0.00	0.00	0.001	0.37	1	0.00	0.23	0.00

Appendix 5: Results of the (T) test to find out the differences in the heavy elements studied for the type of cigarette (LM***)***

Type of cigarette	The group	Statistics	Nickel	Lead	Cobalt	Chrome	Manganese	Zinc	Copper	Iron
LM	Ash	$\bar{X}_1$	0.080	0.273	0.142	0.011	0.057	0.034	0.033	0.080
		$S.D_1$	0.002	0.006	0.001	Nd	0.006	0.001	0.006	0.002
	Leaves Roll a cigarette	$\bar{X}_2$	0.175	0.053	0.163	0.034	0.037	0.045	0.357	0.175
		$S.D_2$	0.005	0.012	0.006	0.001	0.006	0.012	0.006	0.005
	T test	T-test	29.49-	29.51	6.46-	35-	4.24	1.62-	68.58-	29.49-
	probability value	P-value	0.00	0.00	0.00	0.00	0.01	0.18	0.00	0.00

(Nd = element without the sensitivity of the device, not calculated statistically)***.***