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SCHOOL OF GRADUATE STUDIES

RESEARCH AND GRADUATE PROGRAMMES MASTER'S PROJECT

"Levels of trace metals in cigarettes commonly sold in Ethiopia"

A Graduate project Submitted in Partial Fulfillment of the

Requirements for the Degree of Master of Science in Chemistry

Adam Mekonnen Engida

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ADDIS ABABA UNIVERSITY

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By

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Advisor: Prof. B.S. Chandravanshi

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ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

STUDIES ON LEVELS OF TRACE METALS IN CIGARETTE SOLD IN ETHIOPIA

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Declaration

I, the undersigned, declared that this is my original work, has not been presented for a degree in any other university and that all sources of material used for the Project have been duly acknowledged.

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This project work has been submitted for examination with my approval as university advisor.

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ABSTRACT

A significant flux of heavy metals, among other toxins, reaches the lungs through smoking. This project reports the heavy metal concentrations in tobacco from samples of 11 cigarette products, sold in Ethiopia. Cadmium (Cd), lead (Pb), copper (Cu) and zinc (Zn) contents were determined in 11 brands of tobacco cigarette commonly available in Ethiopia by atomic absorption spectrophotometer. The concentration of trace metals in the cigarettes ranged, Cd, from 1.3 to 7.6 μg/g with mean 2.48 ± 0.32 μg/g, Pb, 0.50 to 12.50 μg/g with mean 6.24 ± 2.2 μg/g, Cu, 2.89 to 25.35 μg/g with mean 13.70 ± 4.12 μg/g, and Zn, 24.40 to 62.55 μg/g with mean 36.22 ± 7.50 μg/g. Comparable results of trace metals are obtained in both imported and Ethiopian cigarettes. The average trace metal contents of cigarettes available in Ethiopia are Cd, 1.82 ± 0.39, Pb, 4.23 ± 0.97, Cu, 10.22 ± 3.15 and Zn, 28.18 ± 7.81 μg/cigarette and a person who smokes 20 cigarettes per day is estimated to increase his/her daily Cd, Pb, Cu and Zn retention by approximately 0.036, 0.085, 0.204, 0.564 mg/day, respectively. The results indicate that smoking and exposure to cigarette smoke is a serious problem to be taken into account when carrying out epidemiological studies on human exposure to trace metals

Key words: Cigarette tobacco, Trace metals, Ethiopia, Wet digestion, Atomic absorption spectrometry

1. Introduction

The trace element contamination of plants has a major impact on both the environmental cycling of nutrients and the quality of foodstuffs. Plants can accumulate trace elements, especially heavy metals, from soils, waters or air, and in themselves become elemental sources for animals and human. Metals and their compounds have been used since ancient times for their therapeutic as well as cosmetic effects on the skin [1]. Metals are vital for a huge number of physiological processes in the human body, but can also destroy health when the concentration is not within the physiologically favorable range. Heavy metals are important environmental pollutants and many of them are toxic even at very low concentrations [2]. There are no toxic elements but only toxic concentrations. Even essential trace elements can cause damage to health or even death at increased concentrations. The form in which an element is ingested also plays a major role in its restorability or toxicity [3].

In addition to occupational exposure tobacco smoke is a potential source of some toxic trace elements including inorganic carcinogens [4]. Only the tobacco companies know exactly what goes into each cigarette, and only some of this information is available.

Usually, cigarette is made up of tobacco, paper and additives. As much as 600 – 1400 additives are used in cigarette manufacture, with many of these additives containing environmental contamination and exposure to heavy metals such as mercury, cadmium and lead is a serious growing problem throughout the world [5]. Heavy metals can directly influence behaviour by impairing mental and neurological function, influencing neurotransmitter production and utilization, and altering numerous metabolic body processes [6, 7]. Systems in which toxic metal elements can induce impairment and dysfunction include the blood and cardiovascular, eliminative pathways (colon, liver, kidneys, skin), endocrine (hormonal), energy production pathways, enzymatic, gastrointestinal, immune, nervous (central and peripheral) trace elements that include Ni, Pb, Cd, Cr, As, Se and Hg. This was attributed to the higher transfer rates of the added ingredients to smoke [8].

Cigarette production is a complex process. The tobacco undergoes a conditioning process where high temperatures and humidity restore moisture to suitable levels for cutting and blending. Then tobaccos are precisely cut and blended according to time-honored formulas, or recipes, to produce tobaccos for various brands of cigarettes. This brand recipe includes ingredients and favors that are added to the tobacco to give each brand its unique characteristics [9].

Cigarette production starts with manufacturing the filters. They are made as long filter rods that measure 120 mm and consist of fine gauze-like acetate fiber. Each filter rod is cut into four or six filters depending on how long the filter is on the individual cigarette. Cigarette and packing machines are usually linked together in one machine unit. The cigarette machine is supplied with tobacco and filters through pipes by means of a pneumatic conveying system. Three other materials are used: cigarette paper - which comes in six km long rolls wound on large bobbins - tipping paper and glue (for gluing the cigarette rod and filter together). The cigarette is assembled in a three-step process. First a tobacco rod is made of tobacco supplied from the feed table. The tobacco rod is then wrapped in cigarette paper. The rod is glued in transit and a rotating knife cuts the cigarette to the right length. The filter and cigarette rod are then glued together by attaching tipping paper, and the finished cigarettes are conveyed to the packing machine. In the packing machine the cigarettes are packed in aluminium foil or metallized paper. Then they are packed in a cigarette pack [10, 11].

A wide range of toxic metals is found in tobacco, depending largely on the soil content where the tobacco was grown. The use of fertilizers has been blamed for high concentrations of arsenic, mercury, lead, cadmium, chromium, nickel, and selenium in tobacco. Tobacco plant is amenable to absorb and accumulate heavy metal species from the soil into its leaves [12]. Cigarette smoke contains particles and gases generated by the combustion of its various components at high temperature. More than 4000 compounds have been identified in environmental tobacco smoke. The cigarette smoke can be inhaled directly by the smoker and non-smokers in cigarette-contaminated environment through passive smoking [13]. .

This research work reports the levels of trace metals (Cd, Pb, Ni, Zn, and Cu) in cigarette tobaccos sold in Ethiopia. Determination of these trace metals in cigarette material is very important because of biological significance.

Copper is a familiar metal that, in minute amounts, are necessary for proper metabolism to occur. It normally occurs at low concentration and is known as trace metal. Zinc is a cofactor in over 100 enzyme reactions. High levels of zinc can result in a deficiency of copper. Heavy or toxic metals are trace metals that are at least five times denser than water. As such they are stable elements (meaning they cannot be metabolized by the body) and bio-accumulative (passed up the food chain to humans). These include: nickel, lead, cadmium and others. Heavy metals have no function in the body and can be highly toxic [14].

In Ethiopia there are imported and manufactured cigarettes with unleveled (unknown) metal contents. As mentioned above heavy metals have dangerous health effects on smokers and also on non-smokers. Hence it is worth to analyze the contents of these dangerous toxic trace metals from cigarettes sold in Ethiopia quantitatively; since there is no study done on this. There are many cigarettes: Nyala and Gisela and Marlboro light (local), and Rothmans, Marlboro Red, Benson, Winston, Kents, London, Gold seal, Ronson, Ghamdan (imported), sold in Ethiopia. These cigarettes will be analyzed with the selected method for contents of metals. The result of this study will give some figure about each cigarette quality with respect to the content of metals.

2. OBJECTIVES

2.1 General Objective

The main objective of this project was to determine the levels of toxic metals in cigarettes sold in Ethiopia.

2.2 Specific Objectives

1. To collect samples of selected cigarettes (both imported and locally manufactured) which are most commonly sold in Addis Ababa, Ethiopia.
2. To determine the composition of some trace metals both: essential (Zn, Cu) and toxic metals (Pb, Cd,) using flame atomic absorption spectrometer (FAAS).

3. To compare the levels of metals in the Ethiopian cigarettes with that of imported cigarettes sold in Ethiopia.
4. To compare the levels of metals in the Ethiopian cigarettes with literature reports on cigarettes sold or smoked around the world.

3. Experimental

3.1 Apparatus

An atomic absorption spectrometer (Buck model 210 VGP, U.S.A.) equipped with air/acetylene flame, with a hollow cathode lamp for cadmium, lead, nickel, copper and zinc. The wavelength, slit width and lamp current of each metal was adjusted according to the description given in the manufacturer manual for the determination of Pb, Cd, Cu and Zn. Linear range, detection limit and sensitivity of each metal are given in Table 1.

Table1. Detection limit, sensitivity and linear range of the trace metals.

No	Elements	Wavelength (nm)	Linear range of trace metals mg/L	Detection limit of metals mg/L	Sensitivity mg/L
1	Cd	228.80	0.01 – 2	0.01	0.75
2	Pb	217.00	0.08 – 20	0.08	10.00
3	Cu	217.89	0.005 – 50	0.005	2.00
4	Zn	213.86	0.005 – 250	0.005	0.50

Standards and Reage

Lead standard, [Lot #A207X], 999 µg/mL, in 2% HNO_3, copper standard, [Lot #A207N], 1004 µg/mL, in 2% HNO_3, cadmium standard, [Lot #A207W], 1002 µg/mL, in 2% HNO_3, and zinc standard [Lot #A207A], 997 µg/mL, in 2% HNO_3 Buck Scientific, Inc. were used. Nitric acid pure 69-72% (Loba Chemie, India) and hydrogen peroxide (ADWIC, Egypt) about (30%) w/v of pure reagent for analysis were used for digestion. Hydrochloric acid pure 35-38 (Loba Chemie, India) was used for decontamination purpose. De-ionized water obtained from Purelab option-S 7/15-version 2- 1001 purification system (Elga, U.K.) was used.

Sample collection

Eleven (11) cigarette samples, which are sold in Ethiopia, were bought from the retailers' shops of different places in September and October 2006. Three packs of a particular cigarette (available cigarettes) were bought from three different places for the purpose of random sampling. The cigarettes were: Nyala and Gisela and Marlboro light (local), and Rothmans, Marlboro Red, Benson, Winston, Kents, Gold seal, Ronson, Ghamdan (imported).

Table2. Sample description.

N o	Samples (cigarettes)	Place of sample collection	Country of origin (manufacturer)	Remark
1	Nyala	Addis Ababa and Bahir Dar	Ethiopia	Some cigarettes are bought in a single place due to their inavailability
2	Gisela	Shewarobit	Ethiopia	
3	Ghamdane	Addis Ababa	Yemen	
4	Benson	Addis Ababa and Bahir Dar	England	
5	Rothmans	Addis Ababa and Bahir Dar	U.K.	
6	Kent	Addis Ababa and Bahir Dar	U.S.A.	
7	Gold Seal	Addis Ababa	U.K.	
8	Marlboro Light	Addis Ababa and Bahir Dar	U.S.A	
9	Marlboro Red	Addis Ababa and Bahir Dar	U.S.A.	
10	Ronson	Addis Ababa	U.K.	
11	Winston	Addis Ababa	U.S.A.	

3.4 Sample preparation

3.5 Precautions against contamination

For analysis of trace level of analytes, it is necessary to keep the blank values as low as possible [15]. Hence glassware should be cleaned and dried in such a manner to ensure that contamination from glassware does not occur. The cleaning of glassware and the cleanliness of the environment in which the analysis is performed, has a direct effect on the accuracy and precision of the method. In order to achieve accurate results, all glassware and digestion vessels must be cleaned immediately prior to use with dilute HCl (1+1) and then rinsed with deionized water [16].

3.6 Physical properties of samples

The average weight of each cigarette tobacco was determined by weighing 5 sticks of each brand after removing the filter and paper. The mean weight of each cigarette tobacco was calculated. Composites of each brand were prepared by removing the papers and filters from 60 cigarettes of 3 packs. The moisture content of each cigarette was different. The samples were dried in an oven at a temperature of 80°C for 6 hours and allowed to cool in a desiccator [5, 17].

3.7 Grinding of samples

The dried tobacco was grounded in a mortar and with a pestle until powdered finely as much as possible for homogenization, to simplify weighing and to facilitate organic matter destruction (digestion). The whole sample preparation procedures are the principles of Campbell and Plank [17]. After macerating the tobacco, the remaining tobacco particles were wiped off from the mortar and pestle before proceeding to the next sample to avoid cross contamination.

3.8 Sample digestion

3.8.1 Organic matter destruction

Plant tissues samples previously dried, ground, and weighed are prepared for elemental analysis through decomposition or destruction of organic matter. Two commonly used methods of organic matter destruction include dry ashing (high temperature combustion) and wet ashing [17]. Both methods are based on the oxidation of organic matter through the use of heat and/or acids [18].

3.8.1.1 Dry ashing

Dry ashing is conducted in a muffle furnance at temperatures of 500 to 550 ^{o}C [19]. For tissue high in carbohydrate and oils, ashing aids may be required to achieve complete decomposition of organic matter. After ashing, the vessel is removed, cooled, and the ash is dissolved in nitric (HNO_3) and/or hydrochloric (HCl) acid and diluted as needed to meet range requirements of the analytical instrument.

3.8.1.2 Wet ashing

Wet ashing involves the destruction of organic matter through the use of both heat and acids. Acids that have been used in these procedures include H_2SO_4, HNO_3, and $HClO_4$ [20, 21], either alone or in combination [22]. Hydrogen peroxide H_2O_2 [23] is also used to enhance reaction speed and complete digestion [24]. Most laboratories have eliminated the use of $HClO_4$ due to risk of explosion. Hot plates or digestion blocks are utilized to maintain temperatures of 80 to 125 ^{o}C [25, 26]. After digestion is complete and the sample is cooled, the vessel is filled to volume and dilutions are made to meet analytical requirements. The digestion procedure depends on the elements under consideration, on the method used for the determination, and on the volatility of elements.

Both methods have their own advantages and disadvantages. In this work wet ashing is preferred to dry ashing. Wet ashing, especially conventional, decreases analyte lose since it is carried out at low temperature.

3.8.1.3 Procedure

The digestion procedure of Campbell and Plank [17] was used. 1) Weighed 0.50 ± 0.01 g cigarette tobacco that has been dried and ground thoroughly homogenized was placed in a 100 mL flat bottom flask [27]. 2) 5.0 mL of concentrated HNO_3 acid was added and the flask was covered with watch glass and allowed to stand over night. The covered flask was placed on a Phillip Home: Model No. 1100 hot plate with temperature controller and heated at 200 ^{o}C for 30 min. 3) The flask was removed and allowed to cool and 2 mL of 30% H_2O_2 was added and digested at the same temperature and time in the same way. 4) Step 3 was repeated for complete digestion. 5) The digest was allowed to dry to 1 to 2 mL at 150 ^oC. Then 5.0 mL of 1% HNO_3 was added to digest residue and filtered quantitatively through Whatman filter paper (31 low ash) into a 25 mL volumetric flask and made up to volume with deionized water. This was subsequently analyzed for Cd, Pb, Ni, Zn and Cu using flame atomic absorption spectrophotometer (Buck, Model 210 VGP, USA). Internal quality control with retests of cadmium, lead, nickel, copper and zinc standards prepared in 2% HNO_3 was undertaken. Digestion blanks were also prepared and results reported are average of triplicates.

4.0 Results and Discussion

4.1 **Limits of detection**

The detection limit is the lowest concentration at which an analyte can be detected in a sample that does not cause matrix interferences (typically determined using spiked reagent water). Method detection limits (MDLs) of each metal were determined. Limits of detection of the analysed metals were determined as thrice the standard deviation (3σ) of the blank determinations by FAAS from the mean of six replicate analyses. The detection limits of each element were expressed as the amount of analyte in μg/mL. The method detection limits of elements Cd, Pb, Cu and Zn were calculated from the blank and found as 0.02, 0.03, 0.03 and 0.08 μg/mL. Good linearity with r = 0.999, 0.987, 0.950 and 0.999 for Pb, Cd, Cu and Zn respectively was obtained from the calibration curves prepared from about 1000 μg/mL of each metal standard.

4.2 Method validation

The validation of the method was evaluated by spiking the standard stock solution of different volume of (Zn) in blank samples. From these determinations the precision and accuracy of the procedure were determined. The results of determinations show good recoveries (89.00 – 93.10 %) as shown in Table 3.

Table3. Recovery of Zn from spiked blank samples.

No	Spiked			Determined		RSD (%)	Recovery (%)
	Volume (mL)	Conc. (μg/mL)	Mass (μg)	Conc. (mean ± SD) (μg/mL)	Mass (μg) (mean ± SD)		
1	0.10	10	1.0	0.036 ± 0.002	0.90 ± 0.05	5.50	90.0
2	0.25	10	2.5	0.092 ± 0.005	2.30 ± 0.125	5.40	92.0
3	0.30	10	3.0	0.107 ± 0.006	2.68 ± 0.15	5.60	89.0
4	0.40	10	4.0	0.149 ± 0.009	3.725 ± 0.25	6.20	93.1

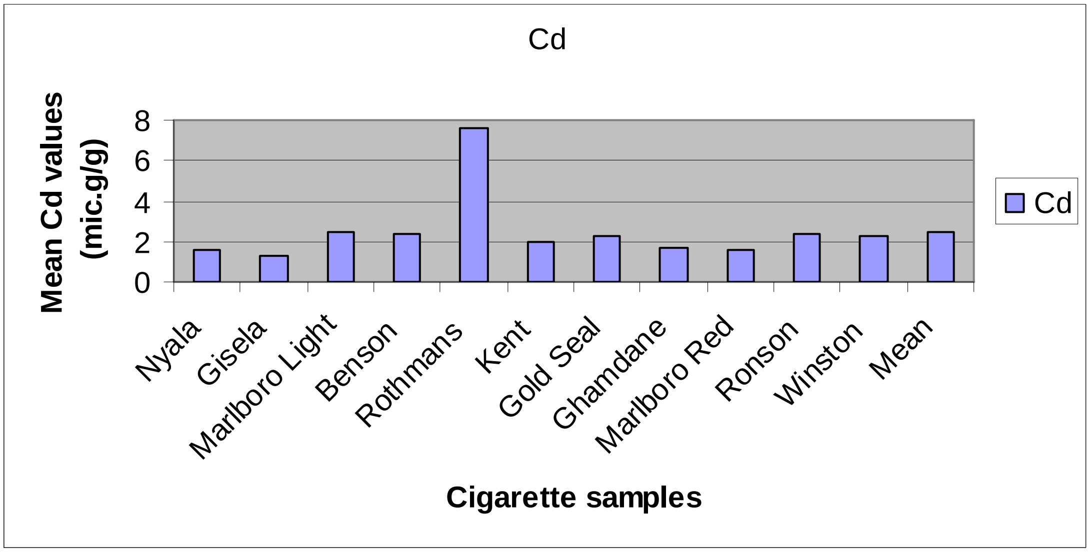
4.3 Data interpretation

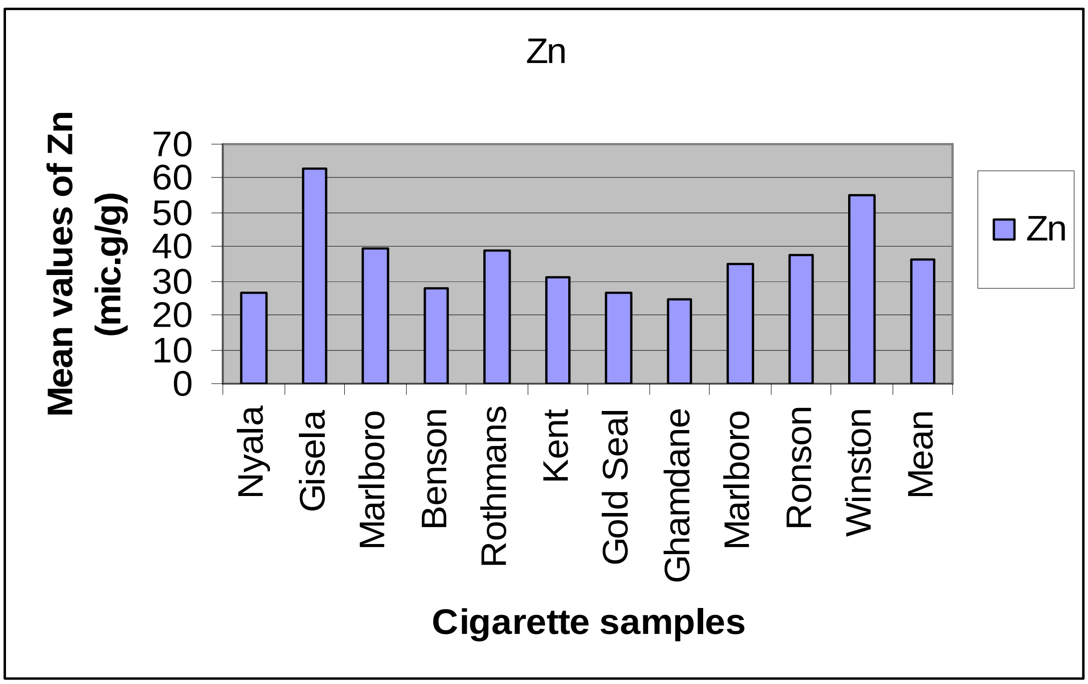
The weight of the cigarette tobaccos (removing the papers and filters) varies depending on the length of the cigarette and other factors. The average weight of the cigarettes without the filter and paper is (0.75 ± 0.86) g (range 0.66 ± 0.01 (Ronson and Marlboro light) to 0.98 ± 0.05 g (Gissla).

The determined concentrations of 4 representatives “trace metals” in 11 cigarette samples are presented in Table 4. The combined data are displayed as histograms (Figure 1) where the overall trends are immediately obvious.

Table 4. Results for the atomic absorption spectrophotometric determination of trace metal contents (mean ± SD) (μg/g, dry weight) of Ethiopian and some overseas brands of cigarette tobacco. Mean values of triplicate analyses (n = 3) are given.

No	Samples	Cd	Pb	Zn	Cu
1	Nyala	1.55 ± 0.15	5.52 ± 0.50	26.30 ± 1.75	19.75 ± 1.04
2	Gisela	1.30 ± 0.00	5.10 ± 0.50	62.55 ± 4.50	2.80 ± 0.55
3	Marlboro Light	2.43 ± 0.10	10.78 ± 0.98	39.50 ± 3.35	16.75 ± 1.25
4	Benson	2.40 ± 0.01	6.10 ± 0.51	27.75 ± 2.70	13.30 ± 0.20
5	Rothmans	7.60 ± 0.05	5.96 ± 0.91	38.70 ± 0.60	6.45 ± 0.01
6	Kent	2.00 ± 0.20	Trace	31.15 ± 0.55	10.35 ± 2.50
7	Gold Seal	2.30 ± 0.00	12.50 ± 0.60	26.60 ± 1.70	25.35 ± 0.55
8	Ghamdane	1.65 ± 0.05	0.50 ± 0.00	24.40 ± 2.50	12.55 ± 2.10
9	Marlboro Red	1.54 ± 0.05	6.00 ± 1.00	34.95 ± 3.20	21.15 ± 1.75
10	Ronson	2.38 ± 0.15	7.50 ± 1.00	37.90 ± 0.95	7.50 ± 0.05
11	Winston	2.28 ± 0.05	2.40 ± 0.50	55.40 ± 3.55	14.70 ± 0.01
	Mean	2.49 ± 0.32	6.24 ± 2.20	36.22 ± 7.50	13.70 ± 4.12


Cd
Mean Cd values (mic.g/g)
8
6
4
2
0
Cd
Nyala
Gisela
Marlboro Light
Benson
Rothmans
Kent
Gold Seal
Ghamdane
Marlboro Red
Ronson
Winston
Mean
Cigarette samples


Zn
Mean values of Zn (mic.g/g)
70
60
50
40
30
20
10
0
Zn
Nyala
Gisela
Marlboro
Benson
Rothmans
Kent
Gold Seal
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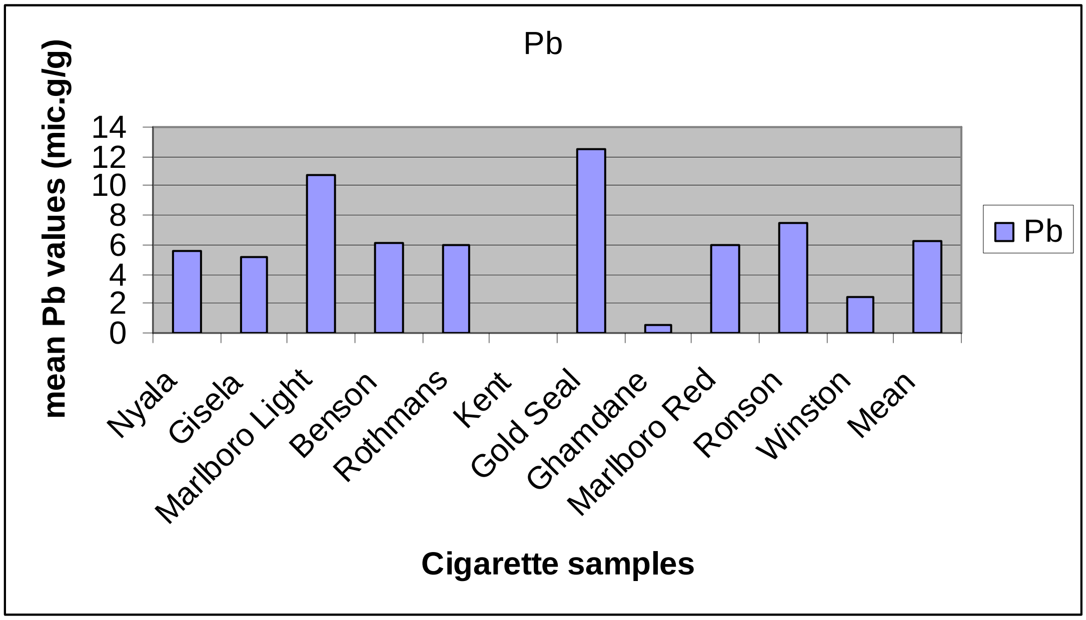
Ronson
Winston
Mean
Cigarette samples



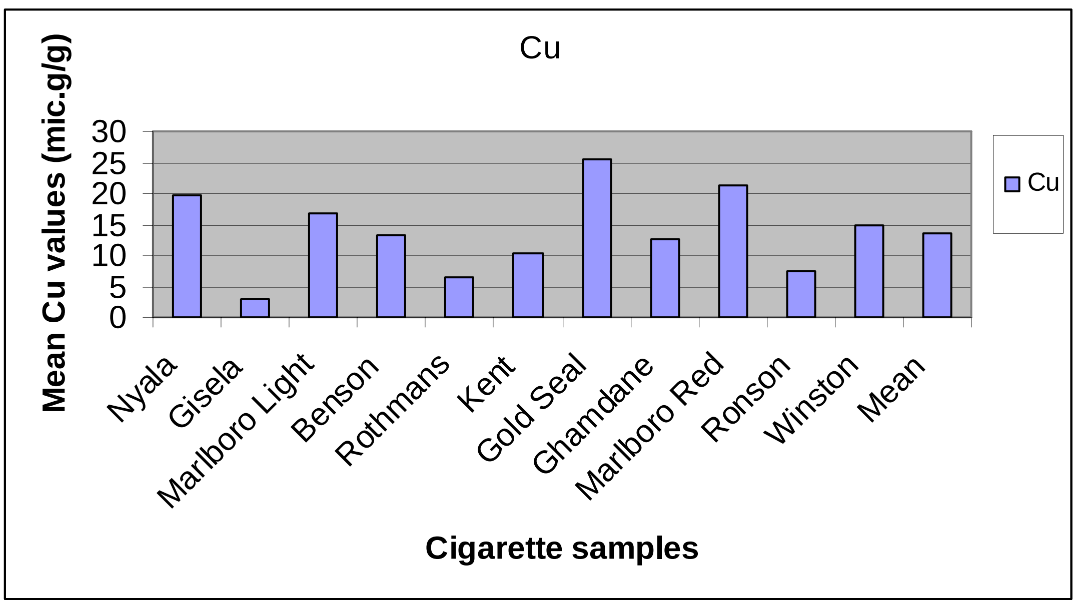


Figure 1. Histograms comparing the heavy metal contents of different brands of cigarette samples for the elements: Cu, Zn, Cd and Pb.

Table 5. Trace metal contents (mean ± SD) (µg/g, dry weight) of Ethiopian brands of cigarette tobacco.

No	Samples	Cd	Pb	Zn	Cu
1	Nyala	1.55 ± 0.15	5.52 ± 0.50	26.30 ± 1.75	19.75 ± 1.04
2	Gisela	1.30 ± 0.00	5.10 ± 0.50	62.55 ± 4.50	2.80 ± 0.55
	mean	1.43 ± 0.15	5.31 ± 0.71	44.43 ± 4.83	11.28 ± 1.8

Table 6. Trace metal contents (mean ± SD) (µg/g, dry weight) of some imported brands of cigarette tobacco.

No	Samples	Cd	Pb	Zn	Cu
1	Marlboro Light	2.43 ± 0.10	10.78 ± 0.98	39.50 ± 3.35	16.75 ± 1.25
2	Benson	2.40 ± 0.01	6.10 ± 0.51	27.75 ± 2.70	13.30 ± 0.20
3	Rothmans	7.60 ± 0.05	5.96 ± 0.91	38.70 ± 0.60	6.45 ± 0.01
4	Kent	2.00 ± 0.20	Trace	31.15 ± 0.55	10.35 ± 2.50
5	Gold Seal	2.30 ± 0.00	12.50 ± 0.60	26.60 ± 1.70	25.35 ± 0.55
6	Ghamdane	1.65 ± 0.05	0.50 ± 0.00	24.40 ± 2.50	12.55 ± 2.10
7	Marlboro Red	1.54 ± 0.05	6.00 ± 1.00	34.95 ± 3.20	21.15 ± 1.75
8	Ronson	2.38 ± 0.15	7.50 ± 1.00	37.90 ± 0.95	7.50 ± 0.05
9	Winston	2.28 ± 0.05	2.40 ± 0.50	55.40 ± 3.55	14.70 ± 0.01
	Mean	2.73 ± 0.29	5.75 ± 2.16	35.15 ± 7.22	14.23 ± 3.95

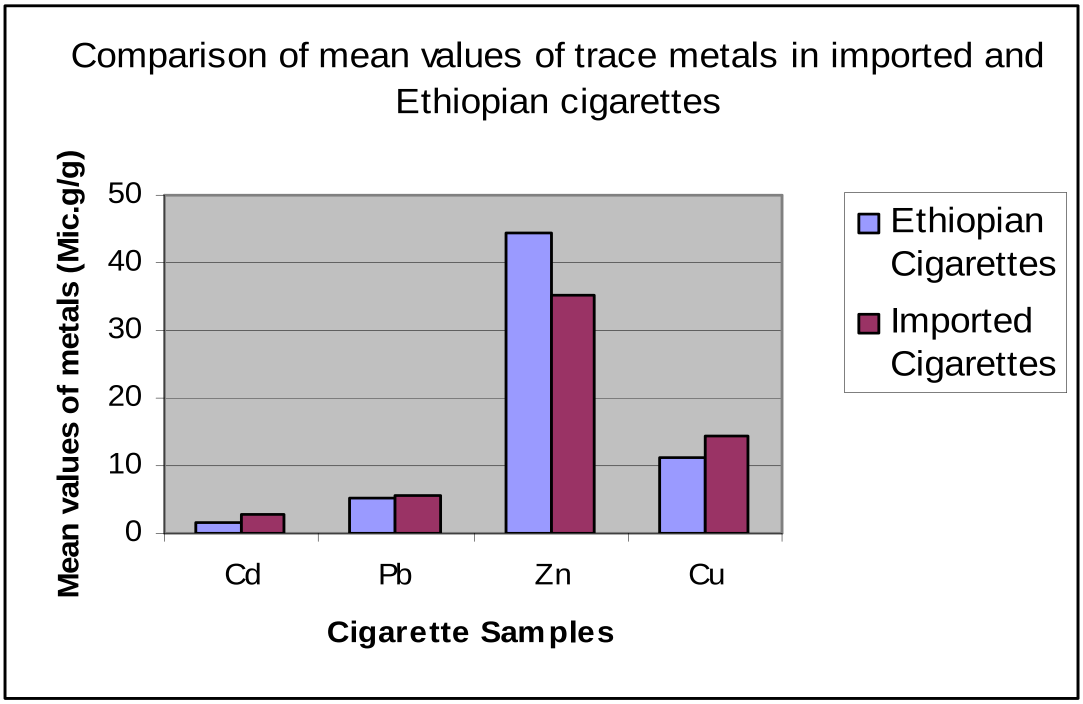


Figure 2. Histogram comparing the heavy metal contents of imported and local cigarettes for the elements: Cu, Zn, Cd and Pb.

Table7. Comparison between the results of present study and available reported levels of Cd, Pb, Zn and Cu in cigarette tobaccos in the literature.

Trace metals	**Mean ± SD (n = 3)**	**Range (from literature)**	**Remark**
Cd	**2.49** ± 0.32 (mean) 1.30 to 7.60 (Range)	1.27 (Nigerian cigarettes)– 2.3 (France cigarettes) 0.5 – 0.8 (0.6 ± 0.1) μg/g (real) (U.K.) 1.1 – 6.1 (3 ± 1.6) (counterfeit) = forged or simulated (U.K.)	[5] [28]
Pb	**6.07** ± 2.2 (mean) 0.50 to 12.50 (Range)	0.3 _ 0.5 (0.4 ± 0.1) μg/g (Genuine)= real (U.K.) 1.3 – 10.3 (4.1 ± 2.6) (counterfeit) = forged (U.K.) 0. 5 – 10 (range)	[28] [29]

		(Indian)	
Cu	**12.70** ± 4.12 (mean) 2.80 to 25.35 (Range)	11.7 – 16.2 (13.0 ± 1.7) μg/g (Genuine)= real (U.K.) 11.8 – 42.2 (16.7± 5.2) (counterfeit) = forged (U.K.) 20 – 50 [range] (Indian)	[28] [29]
Zn	**36.22** ± 7.50 (mean) 24.40 to 62.55 (Range)	26 – 40 (32 ± 4) μg/g (Genuine) (U.K.) 33 – 100 (49 ± 15) (counterfeit)= Forged (U.K.) 5.0 – 100 (Range) (Indian)	[28] [29]

A comparison of the result of studies of the Cd, Pb, Cu and Zn contents of cigarettes in various countries and results of the present study are given in Table 7.

Most results of this work are in good agreement with the literature results. The concentration of trace metals in the cigarettes ranged, Cd: from 1.3 to 7.6 μg/g with mean 2.49 ± 0.32 μg/g, Pb: 0.50 to 12.50 μg/g with mean 6.24 ± 2.20 μg/g, Cu: 2.80 to 25.35 μg/g with mean 13.70 ± 4.12 μg/g, and Zn: 24.40 to 62.55 μg/g with mean 36.22 ± 7.50 μg/g. There is no significant difference between the determined values and literature values as it is seen in Table 7. There is a bit significant variation of Cd in Rothmans and mean values of Pb from literature values. The average trace metal contents of cigarettes available in Ethiopia are Cd: 1.82 ± 0.39 μg/cigarette (range 1.27 – 5.4 μg/cigarette, Pb: 4.23 ± 2.34 μg/cigarette (range trace – 10.21 μg/cigarette), Cu.: 10.22 ± 3.15 μg/cigarette (range 2.74 – 20.50 μg/cigarette) Zn: 28.18 ± 7.81 μg/cigarette (range 18.79 - 61.30 μg/cigarette).

The mean Pb content of Ethiopian cigarettes, as shown in Figure 2, are comparable with imported brands. Ethiopian cigarettes show a bit higher Zn content than imported cigarettes. Imported cigarettes show a bit higher Cd and Cu contents than Ethiopian cigarettes. It is likely that the major source of trace metals in tobacco leaves and cigarettes probably result from the widespread use of chemical fertilizers [5, 30]. According to Nnorom *et al* [5], the mean metal contents of cigarettes varied markedly depending on the area of production. However it has not been possible to obtain any evidence to suggest that the differences are related to the area of production or the extent of industrial development of the area. Nnorom *et al.* [5] has reported that some species of plant have been observed to accumulate high concentrations of some metals, most especially Cd, in leaf tissue rather than in roots. The processing, packaging and other technological processes (including the use of additives) used to bring raw food items to the consumer can significantly increase heavy metal contents in cigarette tobacco [30].

In the report of an International (WHO/UNEP) program for assessment of human exposure to heavy metals has reported higher levels of Cd in kidney cortex samples of smokers compared to non-smokers [5, 30]. According to this project work the recommended cigarette with low mean trace metal contents are Ghamdane and Kent.

In this study the amount of Hg, As, Se and Ni which are commonly found in tobacco are not determined. Because to determine these elements, another procedure is required, i.e. hydride generation for As and Se and cold vapor generation for Hg and a different digestion procedure for Ni which are different methods from direct analysis of elements in single aliquots using FAAS. For this reason, as Guler SOMER, Arzu Nakısı ÜLU, mentioned instead of a HNO_3 – $HClO_4$ acid mixture, different acids and acid combinations should be used for Ni determination. As mentioned that either H_2SO_4 or $HClO_4$ alone or H_2SO_4 – $HClO_4$ mixture can be used. Guler SOMER, Arzu Nakısı ÜLU [27], concluded that for nickel determinations in biological materials HNO_3 can not be used for digestion. Thus, future studies should focus on the determination of Ni, Hg As and Se in a different method.

5. Conclusions

This study shows that the levels of Cd, Pb, Cu and Zn in cigarettes available in Ethiopia compares well with levels in cigarettes from other parts of the world. However, the level of Pb and Zn are slightly higher in cigarettes available in Ethiopia than in cigarettes from other parts of the world. Nickel was not detected in any of the eleven brands of the cigarette consumed in Ethiopia. The results also showed the presence of significant amounts of the two toxic heavy metals Cd and Pb in the cigarette sold in Ethiopia. Thus the smokers in Ethiopia have higher intake of Cd and Pb than the non-smokers. Hence efforts should be made by the concerned organization at discouraging consumption of cigarettes. According to this project work the recommended cigarette with low mean trace metal contents are Ghamdane and Kent.

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