An-Najah National University

Faculty of Graduate Studies

Determination and Assessment of Heavy Metals in Tobacco Sold and Smoked in Palestinian Market

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Dedication

To my parents who have given their love, encouragement, and sacrificed time and pleasure to teach me the great value of persistence in hard worthwhile work and study

To my brothers and sisters who have encouraged me all the time

To my dear husband ''God bless his soul'' **Shadi**

To my lovely son **Ameen**

To My Best Friend **Feryal** and her daughter **Ola**

To the committed teachers and good friends that have inspire me during my early years and throughout my life to seek for learning and greater education...

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Thanks and appreciation goes out to various people whose direct and indirect support has helped me to produce this thesis..

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إقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Determination and Assessment of Heavy Metals in Tobacco Sold and Smoked in Palestinian Market

أقر بأن ما اشتملت عليه هذه الرسالة إنما هي نتاج جهدي الخاص، باستثناء ما تم الإشارة إليه حيثما ورد، وأن هذه الرسالة ككل، أو أي جزء منها لم يقدم لنيل أي درجة أو لقب علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: **اسم الطالب:**

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Date: **التاريخ:**

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Abstract

Since there was no data about heavy metals contents in Palestinian cigarette brands, this study could provide a new data to be useful for health organizations in Palestine. Measured levels of heavy metals in cigarette tobacco brands show further information from a public health places.

Cadmium (Cd), lead (Pb), cobalt (Co), nickel (Ni), copper (Cu) and zinc (Zn) contents were determined in 25 brands of tobacco cigarette commonly available in Palestinian market by flam atomic absorption spectrophotometer. The concentration of heavy metals in the cigarettes ranged, Cd: from 0.85 to 2.11 μg/g with mean 1.20±0.15 μg/g, Pb: 2.21 to 5.06 μg/g with mean 3.12±1.33 μg/g, Co: 0.18 to 2.61 μg/g with mean 1.09±0.28 μg/g, Ni: 3.42 to 6.23 μg/g with mean 4.92±0.53 μg/g, Cu: 11.86 to 20.35 μg/g with mean 15.21±0.34 μg/g, and Zn: 30.55 to 114.43 μg/g with mean 51.15±0.14 μg/g.

Comparable results of heavy metals are obtained in both imported and Palestinian cigarettes. These results indicate that tobacco plant is a main source of many heavy metals pollutants and the levels of metals contents in cigarettes sold in Palestine are similar to other parts of the world, but the concentration of these metals in Palestinian cigarettes is slightly higher

than imported cigarettes. So it can extremely be increased by the effects of inhalation metals especially cadmium in places where smokers are present and it results in health problem more than what was assumed.

Thus, these data suggest smokers in Palestine could receive significantly higher exposures to various toxic and carcinogenic metals from cigarettes and have higher intake of heavy metals particularly Cd and Pb. 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 heavy metals.

Chapter One

Introduction

1. Introduction

1.1. General Introduction

Tobacco manufacture consuming increases all over the world, although tobacco smoking is one of the main problems that cause morbidity and mortality [1].

While the harmful effects on health of carbon monoxide, nicotine, tar, irritants and other noxious gases that are presented in tobacco smoke are well known, those due to heavy metals and other toxic mineral elements in tobacco smoke are not sufficiently emphasized. Tobacco smoking influences the concentrations of many elements in some organs [2].

Cigarette smoking may be a substantial source of intake of these hazardous elements not only to the smoker but also through passive smoking, to those who don't smoke. The adverse health effects of these toxic elements on the fetus through maternal smoking, and on infants through parent`s smoking, are with special concern [3].

Tobacco is a plant which grows fast and, like all the natural plants, it consumes heavy metals from the soil. Some of these metals can be naturally found in soils where tobacco plants are grown others were brought in to soils through fertilizer and various pesticides during the cultivation of tobacco crops [4, 5]. Tobacco plant is able to absorb and accumulate heavy metal species from the soil into its leaves [6].

Smoking of tobacco leaves is one of the main routes of exposure to heavy metals. Metals contain in tobacco leaves originate from root uptake and transfer to the shoots and also from deposition of aerosol particles on the leaves [7].

The exposure of plants to high concentrations of metals generally causes a stress, whose visible symptoms include an inhibition of root elongation, a decrease in shoot growth, leaf chlorosis, and necrosis of the tissues. This stress is generated by the perturbation of cell metabolism by metals, mostly because of the inactivation of proteins by adventitious binding. Plants have developed various mechanisms to tolerate heavy metals in their tissues [8].

Cigarette smoke contains particles and gases generated by the combustion of its various components at high temperature. The smoke can be inhaled directly by the smoker and non-smokers in cigarette-contaminated environment through passive smoking. In addition, smoking is connected with rising in heavy metals in human tissues [9,10].

Human population exposed heavy metals from many sources (air, water, soils, foodstuffs). Smoking is not the main reason of heavy metals exposure for humans, but cigarette smoking also influences heavy metals toxicity[11].

Tobacco is one of the most widely used commodities in the world. It has been studied extensively because of its scientific rareness, its important economically in society, the health results of tobacco use, the economic and political importance of the industry it produced, because of it, is able to generate massive revenues and because of governmental regulation [1].

A cigarette's shape features influence smoke particulate mass transport through the tobacco rod and filter, so cigarettes are characterized according to machine-smoked tar delivery categories which described as full flavour, light, and ultra light [12].

In addition to occupational exposure tobacco smoke is a potential source of some toxic trace elements including inorganic carcinogens. Just the tobacco companies know exactly what each cigarette contains, and only some of this information can be known [13].

Nicotine is the major material in cigarettes. However, that cigarette smoke contains in addition to this material on the 4000 material in the form of tar, carbon monoxide, ammonia, acetone, methanol, lead, cadmium, mercury [2].

Since 1950, the cigarette industry began in changing gradually, as rates have dropped from 38 mg tar to 12 mg, and the percentage of nicotine from 2.7 mg to 1.0 mg per cigarette by improving the filter type [1].

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 all over the world [14].

Cigarette production is a complicated 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 mixed according to time-honored formulas, or recipes, to produce tobaccos for different brands of cigarettes. This brand recipe contains ingredients and flavors which are added to the tobacco to give each brand its rare characteristics [15].

Cigarette production begins 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 combined 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. Next, The tobacco rod is wrapped in cigarette paper. After that, 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 metalized paper. Then they are packed in a cigarette pack [16, 17].

Several heavy metals found in tobacco smoke such as Cd, Pb, Co, Ni, Cu and Zn also accumulate in tissues and fluids through smoking [18].

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

1.2. Objectives

1.2.1. General Objective

The main objective of this project was to determine the levels of heavy metals in cigarettes sold in Palestine (locally and imported).

1.2.2. Specific Objectives

1. To determine the contents of some heavy metals (Cd, Pb, Co, Ni, Cu and Zn) using flame atomic absorption spectrometer .
2. To compare the levels of heavy metals in Palestinian cigarettes with the levels in the imported cigarettes.
3. To compare the levels of heavy metals in cigarettes according to country of origin.
4. To compare the levels of heavy metals in the Palestinian cigarettes with the levels reported in the literature on cigarettes sold or smoked around the world.

1.3. Significance of Thesis

The smoking of tobacco products and the number of smokers have been rising steadily throughout the world, and Palestine is not different in this. Tobacco in Palestine continued to display high growth in 2013, rising significantly in both volume and value terms.

It has been remarked recently the availability of so many farms of cigarettes and so many consumers diverts to use the local cigarettes without looking on one of very important factors on cigarettes selection which is the heavy metal content of cigarettes. This fact happened after the recent high increase of taxes by the Palestinian government on the imported cigarettes.

In Palestine 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 in cigarettes sold in Palestine quantitatively, since there is no study done on this.

Chapter Two

Literature Review

2. Literature Review

2.1. Definition of Tobacco

Family : *Solanaceae* (Nightshade family, the same as Potato and Tomato)

Genus : *Nicotiana Tabacum* (1 Year Plant)

Nicotiana Rustica (1 Year Plant)

Tobacco is an annual, with a long fibrous root, stem erect, round, hairy, and viscid, it branches near the top. Leaves are large, numerous, alternate, pointed, hairy, pale-green color, brittle, narcotic odor, with a nauseous, bitter acrid taste.

Many types of tobacco are grown in the world, with a variety of uses. These kinds vary according to tobacco classes in various countries and elements such as manipulation of nitrogen fertilization, plant density, time and height of topping, harvesting and curing are added to favorably influence the usability of the cured leaves for specific products [2, 19].

2.2. Tobacco Additives

"Additive" means any material, chemical or compound, other than tobacco, water or reconstituted tobacco sheet, that is introduced by a manufacturer into the tobacco, paper or filter of a cigarette or into cigarette tobacco during the processing, manufacturing or packing of the cigarette or cigarette tobacco [20].

Before the leaves are cut, a “dressing” is added to the tobacco. This contains a variety of ingredients, such as sugars, humectants (2.5-3.5%)

and aromatic substances. The addition of sugars to tobacco (4-6%) results in acidic smoke (pH 5.2-6.2) by neutralizing the alkalinity of the nitrogenous compounds.

Tobacco additives have been used in cigarettes throughout the history of cigarette industry. The majority of these ingredients (such as cocoa and sugars) are used to enhance aroma and flavour. Others are used to enhance sensory aspects, including taste, associated with the smoke (such as menthol), to facilitate tobacco processing and cigarette manufacturing (such as carbon dioxide and water), and to preserve moisture levels in the finished cigarette (such as water and glycerine) [21].

❖ **Aims of Additives**

- Humectants are added to keep the tobacco and smoke moist.
- Flavors are added to create a special brand flavor.
- Menthol, sweeteners and other additives are included to make the smoke easier to inhale.
- Some additives are designed to decrease objections to second-hand smoke.
- Various additives are used to promote the attraction of cigarettes to young people.
- Pharmacologically active additives are added to rise the speed and size of the nicotine "hit" and develop the opportunities of addicting a smoker [22].

❖ Nicotine-enhancing compounds added to tobacco

In the past, lawgivers felt that if tar levels were decreased, the health problems related to smoking would reduce. Cigarette manufacturers responded in the sixties by developing low-tar or light cigarettes.

They designed “Light” Cigarettes with filters and filter ventilation holes at the top of the cigarettes. The holes in the filter let pure air to be drawn into the smoker’s mouth which diluted the smoke, thus decreasing the quantity of nicotine and tar.

Tobacco companies were worried that these ventilation holes would result in a weaker taste because smoke would be diluted with air. Tobacco manufacturers introduced additives as taste enhancers so smokers would not have this weakened taste.

Tobacco manufacturers can control nicotine distribution by various design and manufacturing techniques:

- Using high-nicotine tobaccos and also higher nicotine-containing parts (i.e. stems) of the tobacco leaf to increase the nicotine focus in low tar cigarettes.
- Adding entirely extraneous nicotine.
- Using Ammonia compounds to rise the distribution of free nicotine to smokers.
- Genetically engineering tobacco plants so as to rise their nicotine content.
- Developing analogs that will have the same dependency-causing effect [23].

2.3. Pesticides in Tobacco

Tobacco is a sensitive plant prone to many illnesses. It therefore needs high chemical inputs: up to sixteen applications of pesticide are recommended during one -three month growing period. Some of these are absorbed by the plant and sediments remain in the final tobacco product. Residues of some pesticides used to grow tobacco remain on the tobacco leaf and can be present in cigarettes. Other pesticides that have not been used for years, such as DDT, may be found in tobacco due to the persistence of these chemicals in the soil where tobacco is planted [24].

Although the food chain has been recognised as a major source of human exposure to pesticides, tobacco and tobacco smoke are also considered as sources of exposure [25].

2.4. Heavy Metals

"Heavy metals" are chemical elements with a specific gravity that is at least 5 times the specific gravity of water. The specific gravity of water is 1 at 4°C (39°F). Simply stated, specific gravity is a measure of density of a given quantity of a solid material when it is compared to an equal quantity of water. Some well-known toxic metallic elements with a specific gravity that is 5 or more times that of water are Cadmium 8.65, Lead 11.34, Cobalt 8.746, Nickel 8.8, Copper, 8.930 and Zinc 7.135 [26].

Metals are vital for a large number of physiological processes in the human body, but can also destroy health when the concentration is not within the physiological appropriate range. Heavy metals are dangerous environmental pollutants and many of them are toxic even at very low concentrations [27].

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 [28].

In small amounts, certain heavy metals are nutritionally important for a healthy life. Some of these are referred to as the trace elements (e.g., iron, copper, manganese, and zinc). These elements, or some form of them, are commonly found naturally in foodstuffs, in fruits and vegetables, and in commercially available multivitamin products [29].

Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues. Heavy metals may enter the human body through food, water, air, or absorption through the skin when they come in contact with humans in farming and in manufacturing, pharmaceutical, industrial, or residential settings [30].

During smoking, the heavy metal content originally present in the tobacco filler partitions among the mainstream smoke, side stream smoke, ash, and cigarette butt. Heavy metals are present in tobacco smoke and have long been related to different illnesses. Inhalation transports heavy metals in mainstream smoke through the oral cavity to the lungs. From the lungs the heavy metals are carried to the peripheral circulation and other body organs along with other smoke constituents including addictive nicotine [31].

High exposure to heavy metals from smoking contributes to increased danger for lung disease, cancer [32], and other systemic diseases such as peripheral artery disease and complications of pregnancy. In addition, heavy metals have a long biological half life and accumulate in bones and teeth[33, 34].

Heavy metals can directly affect behaviour by damaging mental and neurological function, affecting neurotransmitter production and utilization, and altering numerous metabolic body processes [35, 36]. Systems in which toxic metal elements can induce damage 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). This was attributed to the increasing transfer rates of the added ingredients to smoke[37].

Heavy metals, through inhalation of smoking, easily get inserted into user`s body during smoking. Many previous data gives proof that metals exist in higher concentration in tissues of smokers than in nonsmoking persons [18, 38]. Thus, cigarette tobacco is very harmful, toxic and genotoxic for human health. so, the concentration of heavy metals in cigarette brands is of significance because of its toxicological effects [14,39].

2.4.1. Cadmium (Cd)

Cadmium is a chemical element with the symbol Cd and atomic number 48. This soft, bluish-white metal is chemically similar to the two other stable metals in group 12, zinc and mercury [40].

Cadmium is a lustrous, silver-white, ductile, very malleable metal. Its surface has a bluish color and the metal is smooth enough to be cut with a knife, but it tarnishes in air. It is soluble in acids but not in alkalis. It is similar in many respects to zinc but it forms more complicated compounds[41].

About three-fourths of cadmium is used in Ni-Cd batteries, most of the remaining one-fourth is used mainly for pigments, coatings and plating, and as stabilizers for plastics. Cadmium has been used particularly to electroplate steel where a film of cadmium only 0.05 mm thick will provide complete protection against the sea. Cadmium has the capacity to absorb neutrons, so it is used as a fence to control nuclear fission [42].

Cadmium can mainly be found in the earth's crust. It always occurs in combination with zinc. Cadmium also consists in the industries as an inevitable by-product of zinc, lead and copper extraction. After being applied it enters the environment mainly through the ground, because it is found in manures and pesticides [43].

Naturally a very large quantity of cadmium is released into the environment, about 25,000 tons a year. About half of this cadmium is released into rivers through weathering of rocks and some cadmium is released into air through forest fires and volcanoes. The rest of the cadmium is released through human activities, such as industry.

Human uptake of cadmium takes place mainly through food. Foodstuffs that are rich in cadmium can greatly increase the cadmium concentration in human bodies. Examples are liver, mushrooms, shellfish, mussels, cocoa powder and dried seaweed [44,45].

An exposure to significantly higher cadmium levels happens when people smoke. Tobacco smoke transports cadmium into the lungs. Blood will

transport it through the rest of the body where it can increase effects by potentiating cadmium that is already present from cadmium-rich food [46].
Other high exposures can occur with people who live near dangerous waste sites or factories that release cadmium into the air and people that work in the metal refinery industry. When people breathe in cadmium it can severely damage the lungs. This may even cause death.

Cadmium is first transported to the liver through the blood. There, it is bond to proteins to form complexes that are transported to the kidneys. Cadmium accumulates in kidneys, where it destroys refinement mechanisms. This causes the excretion of important proteins and sugars from the body and further kidney damage. It takes a very long time before cadmium that has accumulated in kidneys is excreted from a human body[31, 47].

Other health effects that can be caused by cadmium are:

- Diarrhoea, stomach pains and severe vomiting.
- Bone fracture.
- Sexual failure and may be even infertility.
- Damage to the fecal nervous system.
- Damage to the immune system.
- Psychological troubles.
- Possibly DNA damage or cancer development [48, 49].

2.4.2. Lead (Pb)

Lead is a chemical element in the carbon group with symbol Pb and atomic number 82. Lead is a soft and pliable metal, which is consider as a heavy metal and a poor metal [40] .

Lead is a bluish-white lustrous metal. It is very soft, highly pliable, flexible, and a relatively poor conductor of electricity. It is very resistant to corrosion but tarnishes upon exposure to air. Lead isotopes are the end products of each of the three series of naturally occurring radioactive elements [41].

Lead pipes bearing the badge of Roman emperors, used as outlets from the baths, are still in service. Alloys include pewter and solder. Tetraethyl lead is still used in some grades of petrol (gasoline) but is being phased out on environmental grounds. Lead is a main constituent of the lead-acid battery used extensively in car batteries. It is used as a coloring element in earthen glazes, as projectiles, in some candles to threat the fuse. It is the traditional base metal for organ pipes, and it is used as electrodes in the process of electrolysis. One of its main uses is in the glass of computer and television screens, where it protects the viewer from radiation. Other uses are in sheeting, cables, solders, lead crystal glassware, ammunitions, bearings and as weight in sport equipment [42].

Native lead is scarce in nature. Currently lead is usually found in ore with zinc, silver and copper and it is extracted together with these metals. The main lead metal in Galena (PbS) and there are also deposits of cerrussite and anglesite which are mined [43].

Lead happens naturally in the environment. However, most lead concentrations that are found in the environment are a result of human activities. Because the application of lead in gasoline an unnatural lead-cycle has consisted. In car engines lead is burned, so that lead salts (chlorines, bromines, oxides) will originate [50].

These lead salts enter the environment through the exhausts of cars. The larger particles will fall to the ground immediately and pollute soils or surface waters, the smaller particles will travel long distances through air and remain in the atmosphere. Part of this lead will fall back on earth when it is raining. This lead-cycle caused by human production is much more extended than the natural lead-cycle. It has caused lead pollution to be a worldwide problem [51].

Lead is a soft metal that has known many applications over the years. It has been used vastly since 5000 BC for application in metal products, cables and pipelines, but also in paints and pesticides. Lead is one out of four metals that have the most destructive effects on human health. It can enter the human body through uptake of food (65%), water (20%) and air (15%).

Foods such as fruit, vegetables, meats, grains, seafood, soft drinks and wine may contain big quantities of lead. Cigarette smoke also contains small quantities of lead [11].

Lead can enter (drinking) water through erosion of pipes. This is more possible to happen when the water is slightly acidic. That is why public water treatment systems are now required to carry out pH-adjustments in water that will serve drinking purposes.

For as far as we know, lead fulfils no important action in the human body, it can simply do harm after uptake from food, air or water. Lead is a highly toxic metal and is capable of causing dangerous effects, such as:

- Disruption of the biosynthesis of haemoglobin and anaemia.
- A rise in blood pressure.
- Kidney damage.
- Miscarriages and subtle abortions.
- Disruption of nervous systems.
- Brain damage.
- Declined fertility of men through sperm damage.
- Decreased learning abilities of children.
- Behavioural disruptions of children, such as aggression, impulsive behavior and hyperactivity.
- Lead can enter a foetus through the placenta of the mother. Because of this it can cause dangerous damage to the nervous system and the brains of unborn children [52, 53].

Table 2.1.The 2012 National Toxicology Program (NTP) literature-based monograph on health effects of low-level lead provides this information on health effects [54].

Blood Lead Level	Health Effects
Blood lead levels below 5 µg/dL	**Children** Reduced academic achievement, and decreases in specific cognitive measures, increased incidence of attention-related behaviors and problem behaviors **Adults** Reduced kidney function, maternal blood lead associated with reduced fetal growth
Blood lead levels below 10 µg/dL	**Children** Late puberty, decreased postnatal growth and decreased hearing **Adults** Increased blood pressure, increased danger of hypertension, and increased incidence of essential trembling

2.4.3. Cobalt (Co)

Cobalt is a chemical element with symbol Co and atomic number 27. Like nickel, cobalt in the Earth's crust is found only in chemically combined form, save for small deposits found in alloys of natural meteoric iron [40].

Cobalt is a hard ferromagnetic, silver-white, hard, lustrous, brittle element. It is a member of group VIII of the periodic table. Like iron, it can be magnetized. It is similar to iron and nickel in its physical properties. The element is active chemically, forming many compounds. Cobalt is stable in air and unaffected by water, but is slowly attacked by dilute acids [41].

Cobalt is used in many alloys (super alloys for parts in gas turbine aircraft engines, corrosion resistant alloys, high-speed steels, cemented carbides), in magnets and magnetic recording media, as catalysts for the petroleum and chemical industries, as drying tools for paints and inks. Cobalt blue is an significant part of artists' palette and is used by craft workers in porcelain, pottery, stained glass, tiles and enamel jewellery. The radioactive isotopes, cobalt-60, is used in medical treatment and also to irradiate food, in order to protect the food and look after the consumer [42].

Most of the Earth's cobalt is in its core. Cobalt is of relatively low abundance in the Earth's crust and in natural waters, from which it is precipitated as the highly insoluble cobalt sulfide .

Although the average level of cobalt in soils is 8 ppm, there are soils with as little as 0.1 ppm and others with as much as 70 ppm. In the marine environment cobalt is needed by blue-green algae (cyanobacteria) and other nitrogen fixing organisms. Cobalt is not found as a free metal and is usually found in the form of ores. Cobalt is usually not mined alone, and tends to be produced as a by-product of nickel and copper mining activities. The main ores of cobalt are cobaltite, erythrite, glaucodot, and skutterudite.

As cobalt is vastly dispersed in the environment humans may be exposed to it by breathing air, drinking water and eating food that includes cobalt. Skin contact with soil or water that contains cobalt may also enhance exposure.

Cobalt is not often freely obtainable in the environment, but when cobalt particles are not bound to soil or sediment particles the uptake by plants and animals is higher and accumulation in plants and animals may happen[55].

Cobalt is useful for humans because it is a part of vitamin B_{12}, which is important for human health. Cobalt is used to cure anaemia with pregnant women, because it activates the production of red blood cells. The total daily intake of cobalt is variable and may be as much as 1 mg, but almost all will pass through the body unadsorbed, except that in vitamin B_{12}[56].

However, too high concentrations of cobalt may destroy human health. When we breathe in too high concentrations of cobalt through air we suffer lung effects, such as asthma and pneumonia. This mainly happens with people who work with cobalt.

When plants grow on polluted soils they will accumulate very small particles of cobalt, particularly in the parts of the plant we eat, such as fruits and seeds. Soils near mining and melting facilities may include very high quantities of cobalt, so that the uptake by humans through eating plants can cause health effects. Health effects that are a result of the uptake of high concentrations of cobalt include vomiting, nausea, vision and heart problems and thyroid damage.

Health effects may also be caused by radiation of radioactive cobalt isotopes. This can cause futility, hair loss, vomiting, bleeding, diarrhea, coma and even death. This radiation is sometimes used with cancer-patients to damage tumors. These patients also suffer from hair loss, diarrhea and vomiting.

Cobalt dust may cause an asthma-like illness with symptoms ranging from cough, shortness of breath and dyspnea to decreased pulmonary function, nodular fibrosis, constant inability, and death. Exposure to cobalt may cause weight loss, dermatitis, and aerobic hypersensitivity [57, 58].

2.4.4. Nickel (Ni)

Nickel is a chemical element with the chemical symbol Ni and atomic number 28. It is a silvery-white lustrous metal with a slight golden tint. Nickel belongs to the transition metals and is hard and ductile [40].

Nickel is silvery-white, hard, malleable and ductile metal. It is of the iron group. It takes on a high polish. It is a fairly good conductor of heat and electricity. It forms a number of complex compounds which are blue or green. Nickel dissolves slowly in dilute acids and becomes passive when treated with nitric acid. The divided nickel adsorbs hydrogen [41].

Most nickel on Earth is inaccessible, it is locked away in the planet's iron-nickel molten core, which is 10 % nickel. The total amount of nickel dissolved in the is nearly 8 billion tons. Organic matter has a strong ability to absorb the metal which is coal and oil contain considerable amounts. Nickel occurs in some beans and it is an essential component of some enzymes. Tea is also rich of nickel [42].

Nickel is a compound that occurs in the environment only at very low levels. Humans use nickel for many different applications. The most common application of nickel is the use as an ingredient of steal and other metal products. It can be also found in jewelry [43].

Foodstuffs naturally contain small amounts of nickel. Such as chocolate and fats. Nickel uptake will boost eating large quantities of vegetables from polluted soils. Plants are known to accumulate nickel so the nickel uptake from vegetables will be eminent. Smokers have a higher nickel uptake through their lungs [59].

Humans may be exposed to nickel by breathing air, drinking water, eating food or smoking cigarettes. Nickel is essential, but when the uptake is too high it can be a dangerous.

An uptake of too large quantities of nickel has many results such as higher chances of lung cancer, nose cancer, larynx cancer and prostate cancer, sickness, lung embolism, respiratory failure, birth defects and heart disorders, asthma and chronic bronchitis, and allergic reactions such as skin rashes, mainly from jewelry.

Nickel fumes may cause pneumonitis. Exposure to nickel and its compounds may result "nickel itch". The first symptom is usually itching, which occurs up to 7 days before skin eruption occurs. The primary skin eruption is erythematous, or follicular, which may be followed by skin ulceration. Nickel sensitivity, once acquired, appears to persist indefinitely[60].

2.4.5. Copper (Cu)

Copper is a chemical element with the symbol Cu and atomic number 29. It is very high thermal and electrical conductivity. Pure copper is soft and malleable; a freshly exposed surface has a reddish-orange color [40].

Copper is a metal with a face-centered cubic crystalline structure. It absorbs other frequencies in the visible spectrum, due to its band structure, so it is a nice reddish color. It is malleable, ductile, and an extremely good conductor of both heat and electricity. It is softer than zinc and can be polished to a bright finish. It is found in group Ib of the periodic table, together with silver and gold. Copper has low chemical reactivity. In moist air it slowly forms a greenish surface film called patina, this coating protects the metal from further attack [41].

Most copper is used for electrical equipment (60%); construction, such as roofing and plumbing (20%); industrial machinery, such as heat exchangers (15%) and alloys (5%). The main long established copper alloys are bronze, brass (a copper-zinc alloy), copper-tin-zinc, which was strong enough to make guns and cannons, and was known as gun metal, copper and nickel, known as cupronickel, which was the preferred metal for low-denomination coins [42].

Copper is ideal for electrical wiring because it is easily worked, can be drawn into fine wire and has a high electrical conductivity. Copper is a very common material that happens naturally in the environment and spreads through the environment through natural phenomena. Humans use copper a lot . It is used in the industry and in agriculture. The production of copper has raised during last decades. Because to the quantities have raised.

The world's copper production is still rising. This means that more and more copper ends up in the environment. Rivers are depositing sludge on their banks that is contaminated with copper, due to the disposal of copper-containing wastewater. Copper enters the air, through the combustion of fossil fuels. It will remain there for an eminent period of time, and it settles when it starts to rain. Then it will end up in soils. So soils may also contain large quantities of copper after copper from the air has settled.

Copper can be released into the environment by both natural sources such as wind-blown dust, decaying vegetation, forest fires and sea spray. and human activities that contribute to copper release have already been named. and mining, metal production, wood production and phosphate fertilizer production.

As a result of this, copper is very widespread in the environment. It is often found near mines, industrial settings, landfills and waste disposals.

Most copper compounds will settle and be bound to either water sediment or soil particles. Soluble copper compounds form the largest threat to human health and occur in the environment after release through using it in agriculture [43].

Copper can be found in many kinds of food, in drinking water and in air. Thus, we absorb eminent quantities of copper every day. It is important to absorp the copper, because it is a trace element which is necessary for human health. Humans can handle proportionally large concentrations of copper, but too much copper can cause dangerous health problems [61].

Copper concentrations in air are usually quite low, so that exposure to copper through breathing is not clear. People who live near smelters that process copper into metal, know this kind of exposure.

People who live in houses which still have copper plumbing are exposed to higher levels of copper than others, because copper is in drinking water through corrosion of pipes.

Occupational exposure to copper often occurs. In work, copper contagion can lead to the metal fever. It is caused by over sensitivity and pass after two [62].

Long-term exposure to copper can cause irritation of the nose, mouth and eyes and it causes headaches, stomachaches, dizziness, vomiting and diarrhea. High uptakes of copper may cause liver and kidney damage until death.

There is a link between long-term exposure to high concentrations of copper and a decline in intelligence with young adolescents. In addition, industrial exposure to copper fumes, dusts, or mists may result in metal fume fever with atrophic changes in nasal mucous membranes. Chronic copper poisoning results in Wilson's Disease, characterized by a hepatic cirrhosis, brain damage, demyelization, renal disease, and copper deposition in the cornea [63].

2.4.6. Zinc (Zn)

Zinc is a lustrous bluish-white metal. Which is found in group IIb of the periodic table. It is brittle and crystalline at ordinary temperatures it becomes ductile and malleable when heated between 110°C and 150°C. It is a fairly reactive metal that will combine with oxygen and other non-metals, and will react with dilute acids to release hydrogen [40].

It is used principally for galvanizing iron, more than 50% of metallic zinc goes into galvanizing steel, but is also important to prepare certain alloys. It is used for the negative plates in some electric batteries and for roofing and gutters in building construction [41].

Zinc is the primary metal used in making American pennies and in die casting in the automobile industry. Zinc oxide is used as a white pigment in water colours or paints such as plastics, cosmetics, photocopier paper, wallpaper, printing inks etc, and in rubber production to act as a catalyst during manufacture and as a heat disperser in the final product. Zinc metal is included in most single tablet, it is believed to possess anti-oxidant properties, which protect against premature aging of the skin and muscles of the body [42].

Zinc is a very common substance that occurs naturally. Many foodstuffs contain certain concentrations of it. Drinking water also contains certain amounts of zinc, and may be higher when it is stored in metal tanks. Industrial sources or toxic waste sites may cause the zinc amounts in drinking water to reach levels that can cause health problems.

Zinc occurs naturally in air, water and soil. Its concentrations are rising unnaturally, during addition of zinc through human activities. Most zinc is added during industrial activities, such as mining, coal and waste combustion and steel processing. Some soils are heavily contaminated with zinc, that be found in areas where zinc has to be mined or refined, or were sewage sludge from industrial areas has been used as fertilizer [43].

Zinc is a trace element that is important for human health. When people take too little zinc, this can cause a loss of appetite, decreased sense of taste and smell, slow wound healing and skin sores, or it can even cause birth defects.

Too much zinc can still cause eminent health problems, such as stomach cramps, skin irritations, vomiting, nausea and anemia. Large quantities of zinc can damage the pancreas and disturb the protein metabolism, and cause arteriosclerosis, or respiratory disorders [64].

In the work place environment zinc can cause a flu-like condition which known as metal fever. It will pass after two days and is caused by over sensitivity.

Zinc can also be a danger to unborn and newborn children. If their mothers have absorbed high concentrations of zinc, the children may be exposed to it through blood or milk of their mothers [58].

The Food and Nutrition Board (FNB) has established Upper Intake Levels (ULs) for heavy metals (Table 2.2). Long-term intakes above the UL increase the risk of adverse health effects [65].

Table 2.2: The 2014 Tolerable Upper Intake Levels (ULs) for heavy metals

Heavy metal	Tolerable Daily Intake Levels UL (µg/day)
Cadmium	60-70
Lead	75
Cobalt	250
Nickel	200 – 1000
Copper	1000 – 10000
Zinc	4000 – 40000

Chapter Three

Methodology

3. Methodology

3.1. Chemicals

Chemicals used in this study are: Hydrochloric acid (HCl) (Merck, 1.00319, 35.5%). Nitric Acid (HNO_3) (Frutarom, 2355525100, 65%). Deionized Water. Standard solutions were prepared from chemically pure (CP) chemical solids: Cadmium nitrate-4-hydrate from Riedel-deHaen 11714, Lead(II) nitrate from Sigma-Aldrich-L6258, Cobalt(II) nitrate hexahydrate from Sigma-Aldrich-239267, Nickel(II) nitrate hexahydrate from Sigma-Aldrich-244074, Copper(II) nitrate trihydrate from Sigma-Aldrich-61194 and Zinc nitrate hexahydrate from Sigma-Aldrich-228737.

3.2. Apparatus

Universal ovens (Memmert UNB 100-500, U B 400-500).

Electric Muffle Furnace (J Lab Tech, LDO-060E Serial No 2011040402), Flame Atomic Absorption Spectrophotometer model icE-3000 SERIES, Serial number c113500021deigned in UK AA Spectrometer, with a hollow cathode lamp for cadmium, lead, cobalt, 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 Cd, Pb, Co, Ni, Cu and Zn. Linear range, detection limit and sensitivity of each metal are given in (Table 3.1).

Table 3.1. Detection limit, sensitivity and linear range of the heavy metals.

No	Elements	Wavelength (nm)	Linear range of metals mg/L	Detection limit of metals mg/L	Sensitivity mg/L
1	Cd	228.8	0.05 - 2	0.005	0.025
2	Pb	217.0	0.1 - 20	0.1	0.5
3	Co	240.7	0.05 - 5	0.05	0.2
4	Ni	232.0	0.3 - 5	0.04	0.15
5	Cu	324.8	0.2 - 5	0.02	0.1
6	Zn	213.9	0.05 - 1	0.005	0.02

3.3. Sample Collection

Twenty five brands of cigarettes available in Al Rashid Company in Jenin were purchased (given in table 3.2).

Table 3.2. Tobacco Sold In Palestinian Market.

NO.	Brand Name	Country of origin (manufacturer)	Information recorded on a pack of cigarettes	Source
1	Jamal/ red	Palestine	-	Local
2	Jamal	Palestine	-	
3	Imperial	Palestine	-	
4	Infinity	Palestine	-	
5	Victory	Palestine	-	
6	Lando	Palestine	-	
7	Arabic tobacco*	Palestine	-	
8	Rothmans	Britain	0.8 mg Nicotine 10 mg Tar	imported
9	Craven "A"	Turkey	1.1 mg Nicotine 12 mg Tar	
10	Viceroy	Turkey	-	
11	Next/ blue	Turkey	-	
12	Next/ light blue	Turkey	-	
13	Gold coast	Japan	0.8 mg Nicotine 12 mg Tar	
14	Winston/ red	Japan	0.9 mg Nicotine	

NO.	Brand Name	Country of origin (manufacturer)	Information recorded on a pack of cigarettes	Source
	(Classic)		12 mg Tar	
15	Winston / blue	Japan	0.6 mg Nicotine 8 mg Tar	
16	Parliament	Switzerland	0.8 mg Nicotine 10 mg Tar 10 carbon monoxide	
17	Marlboro/ red	Switzerland	0.6 mg Nicotine 12 mg Tar	
18	Marlboro/ white (gold original)	Switzerland	0.6 mg Nicotine 8 mg Tar	
19	LM/ red	Switzerland	0.8 mg Nicotine 12 mg carbon monoxide	
20	LM/ blue	Switzerland	0.6 mg Nicotine 8 mg carbon monoxide	
21	Davidoff classic	Germany	0.9 mg Nicotine 10 mg Tar	
22	Davidoff gold	Germany	0.6 mg Nicotine 7 mg Tar	
23	Gauloises/ blue	France	0.8 mg Nicotine 10 mg Tar	
24	Gauloises / red	France	0.6 mg Nicotine 8 mg Tar	
25	Gauloises/ orange	France	0.4 mg Nicotine 4 mg Tar	

***** not manufactured, but cigarettes are wrapped manually.

3.4. Sample Preparation

3.4.1. Precautions Against Contamination

It is important to keep the blank values as low as possible for analysis of trace level of analysts [66]. So glassware should be cleaned and dried to prevent contamination of solutions from glassware . All glassware and digestion vessels must be cleaned immediately prior to use with dilute HCl and then rinsed with deionized water.

3.4.2. Physical Properties of Samples

The average weigh of each cigarette brand was measured by weighing 5 sticks of each brand before and after removing the filters and papers. The samples were dried in an oven at a temperature of 90 °C for 1 h and then cooled in desiccators. The mean weight of each cigarette tobacco was calculated.

3.4.3. Grinding of Samples

The whole sample preparation procedures are the principles of Campbell and Plank [67]. The dried tobacco was grounded by a mortar and with a pestle until be powder finely as much as possible for homogenization, to simplify weighing and to facilitate organic matter digestion. The remaining tobacco particles were wiped off from the mortar and pestle before proceeding to the next sample to avoid contamination.

3.5. Sample Digestion

Digestion was carried out using two methods. One by using dry ashing method [68,69] and the wet ashing method, in order to select the most suitable of them.

3.5.1. Wet Ashing Method

1- One gram of Arabic dry tobacco sample was treated with a mixture of concentrated HNO_3 and HCl acid in a ratio of 3:1 and heated to near dryness.

2- The digest was filtered through Whitman filter paper into a 100 ml volumetric flask and the volume was completed with deionized water.

3- The solution was analyzed for heavy metals (Cd, Pb, Co, Ni, Cu and Zn) using an atomic absorption spectrophotometer.

3.5.2. Dry Ashing Method

1- One gram of Arabic dry tobacco sample was ashed in muffle furnace at 500°C.

2- The ash was treated with a mixture of concentrated HNO_3 and HCl acid in a ratio of 3:1 and heated to near dryness.

4- The digest was filtered through Whitman filter paper into a 100 ml volumetric flask and the volume was completed with deionized water.

The solution was analyzed for heavy metals (Cd, Pb, Co, Ni, Cu and Zn) using Atomic Absorption Spectrophotometer.

Chapter Four

Results and Discussion

4. Results and Discussion

The results of this work are represented in tabular and graphical form. Results were devoted to determine the heavy metals (Cadmium, Lead, Cobalt, Nickel, Copper and Zinc) in tobacco sold and smoked in Palestinian market.

4.1. Test Method

The purpose of this test is to select the appropriate method of digestion of tobacco. Results from the Flame Atomic Absorption spectrophotometric analysis showed that the second method (dry ashing) is more accurate, as showen in Table 4.1(less Rsd), so it was used in this study.

Table 4.1. Results from the flame atomic absorption spectrophotometric analysis determination of heavy metal contents in Arabic tobacco (mg/L)

Method	**Cd**		**Pb**		**Co**		**Ni**		**Cu**		**Zn**	
	Conc (mg/L)	Rsd %	Conc (mg/L)	Rsd %	Conc (mg/L)	Rsd %	Conc (mg/L)	Rsd %	Conc (mg/L)	Rsd %	Conc (mg/L)	Rsd %
Wet ashing	0.065	4.3	0.173	32	0.075	23	0.303	47	0.769	2	0.541	0.3
	0.078	19	0.132	56	0.061	11	0.306	6.7	0.731	2.5	0.556	0.3
	0.067	6.4	0.120	43	0.050	38	0.319	8.1	0.771	4.2	0.562	0.4
dry ashing	0.083	15	0.121	5.6	0.068	15	0.313	9	0.824	2.4	0.544	0.3
	0.077	7.5	0.169	7.1	0.077	2.9	0.306	7.9	0.798	2.4	0.536	0.3
	0.079	6	0.157	1.4	0.075	4	0.309	4.8	0.808	0.9	0.544	0.5

4.2. Calibration Curves

Stock solution was used to prepare different concentrations 0, 0.2, 0.8, 1, 1.2 and 1.5 mg/L of heavy metals Cd, Pb,Co, Ni, Cu and Zn, and then the samples were scanned by Flame Atomic Absorption Spectrophotometer. The calibration curves were constructed by plotting values of absorbance versus concentration, as shown in the following figures.

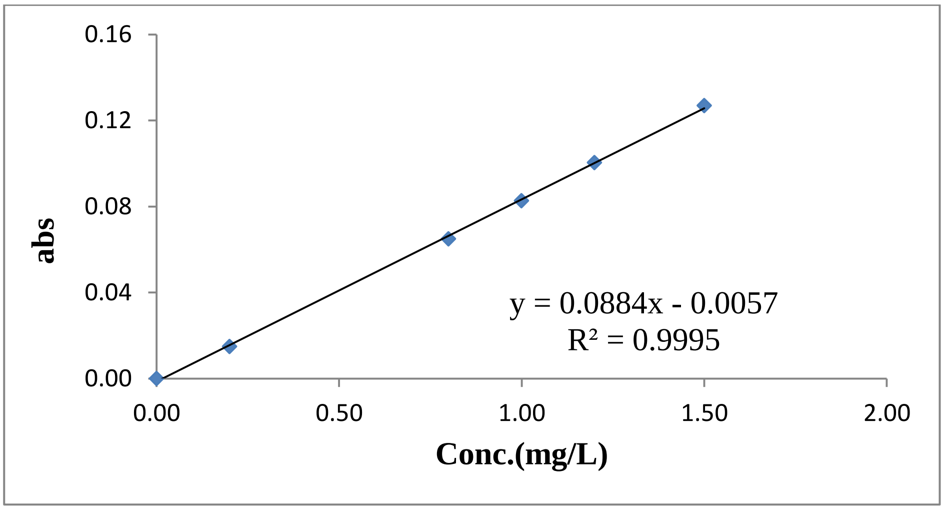


Figure 4.1. Calibration curve of Cadmium at 228.8 nm

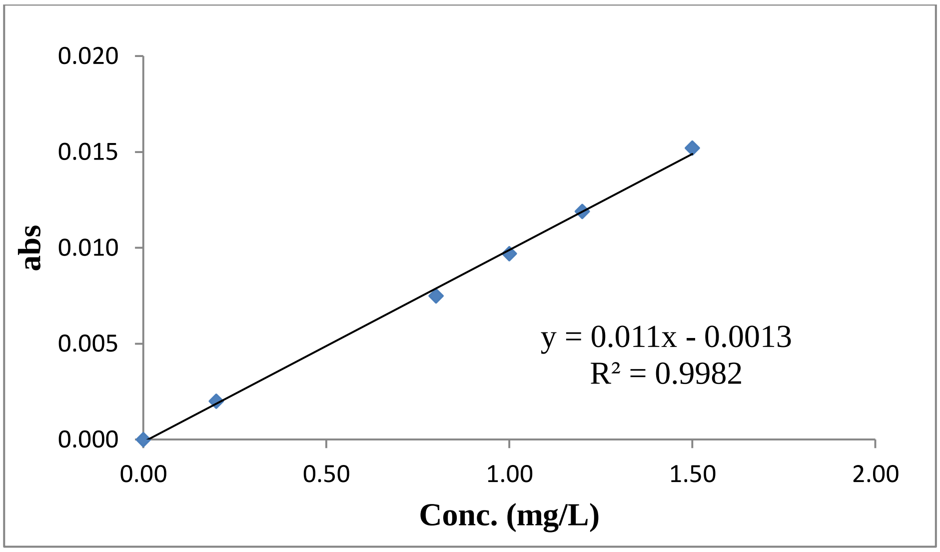


Figure 4.2. Calibration curve of lead at 217.0 nm

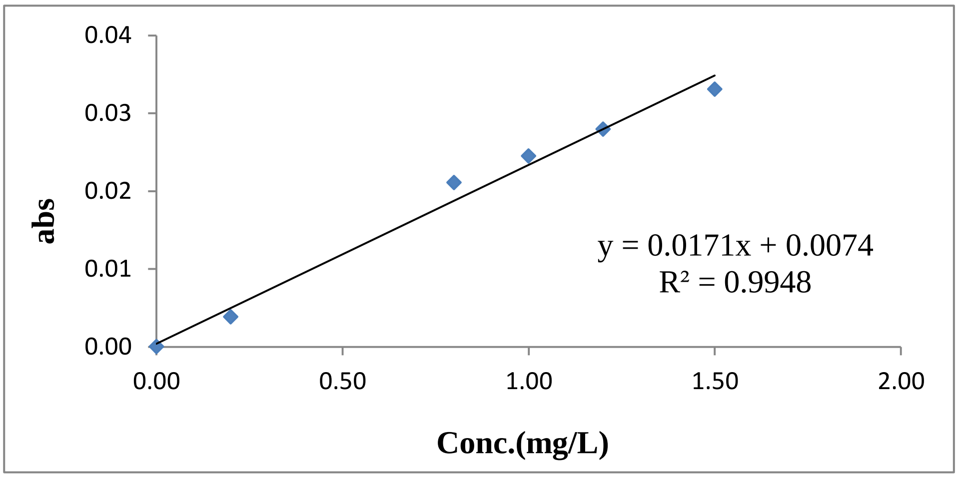


Figure 4.3. Calibration curve of Cobalt at 240.7 nm

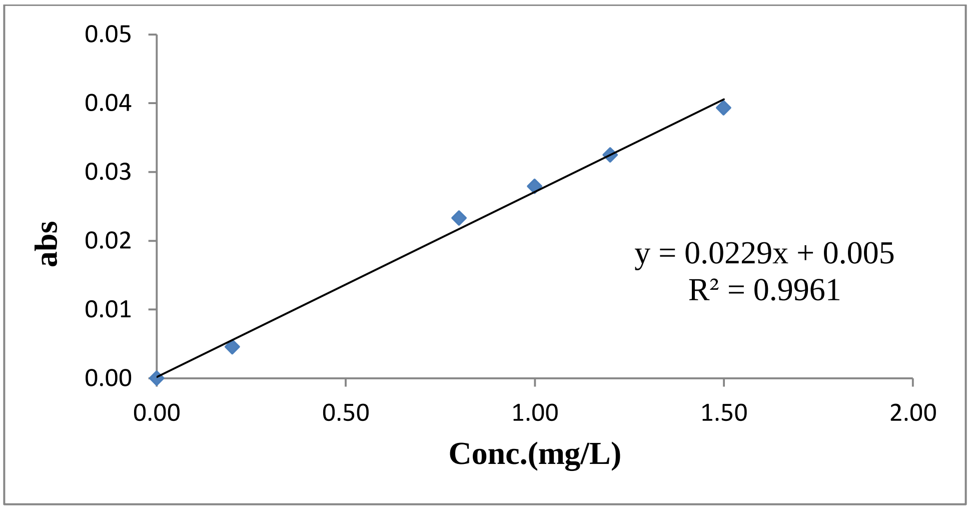


Figure 4.4. Calibration curve of Nickel at 232.0 nm

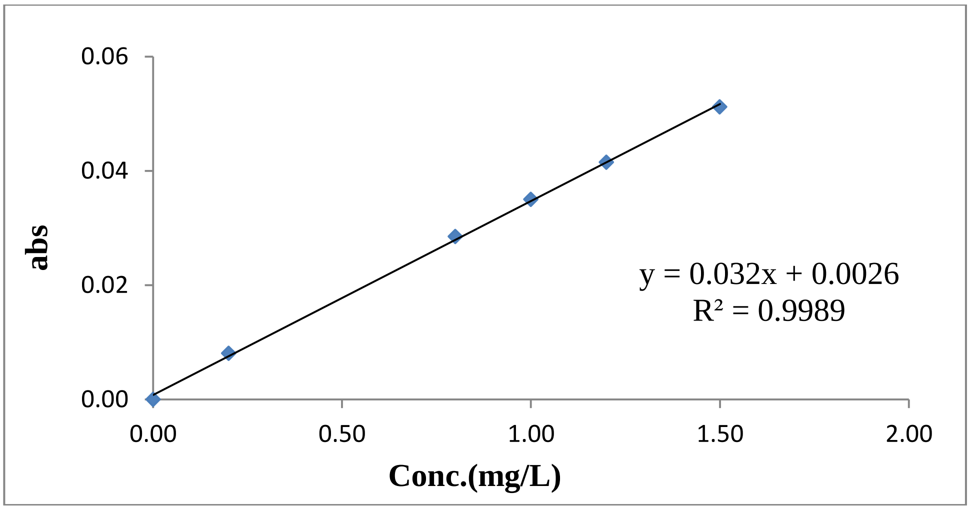


Figure 4.5. Calibration curve of copper at 324.8 nm

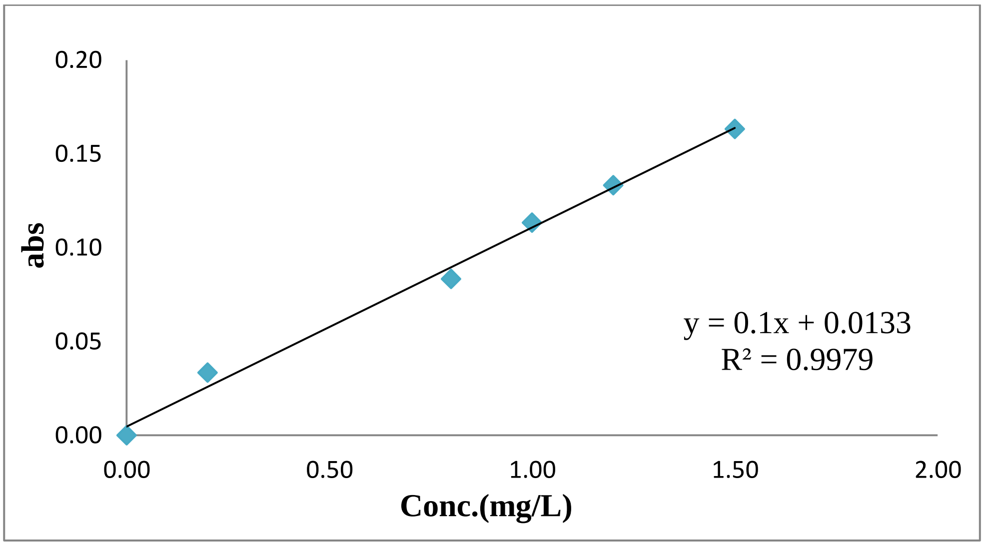


Figure 4.6. Calibration curve of Zinc at 213.9 nm

4.3. The Percentage of Organic Matter in Cigarettes

The weight of the tobacco in a cigarette varies depending on the length of the cigarette and other factors. From the (Table 4.2) it was noticed that the average weight of the cigarettes with paper and filter is 0.899 g with a range (0.788-1.188) g the max for Arabic tobacco . The average weight of the cigarettes without the filter and paper is 0.658 g with a range (0.545-0.988) g. The average weight of dry tobacco in one cigarette is 0.596 g with a range (0.478- 0.852)g. The average proportion of organic matter is 73% range (69%-74%). It is noticed that Arabic tobacco has the largest dry weight and the lowest proportion of organic matter, this is because of the absence of any additions where Arabic tobacco is not manufactured, but cigarettes are wrapped manually. Thus it has high proportion of ash (minerals).

Table 4.2. The weight of the cigarette tobacco (g) and the proportion of organic matter (%). Mean values of 5 cigarettes are given

No.	Brand Name	Weight of cigarette (g)			Proportion of organic matter (%)
		With paper and filter	After removing the paper and filter	Dry (After removing the paper and filter)	
1	Jamal/ red	0.986	0.769	0.664	73
2	Jamal	0.98	0.831	0.726	74
3	Imperial	0.935	0.776	0.676	74
4	Infinity	0.911	0.705	0.615	73
5	Victory	0.908	0.707	0.617	73
6	Lando	0.995	0.802	0.704	70
7	Arabic tobacco	1.188	0.988	0.852	69
8	Rothmans	0.832	0.611	0.53	73
9	Craven "A"	0.857	0.658	0.572	74
10	Viceroy	0.871	0.639	0.558	73
11	Next/ blue	0.849	0.651	0.562	73
12	Next/ light blue	0.834	0.573	0.498	74
13	Gold coast	0.887	0.676	0.588	73
14	Winston/ red (Classic)	0.828	0.631	0.55	74
15	Winston / blue	0.788	0.554	0.478	73
16	Parliament	1.057	0.812	0.702	74
17	Marlboro/ red	0.927	0.72	0.632	74
18	Marlboro/ white (gold original)	0.881	0.636	0.557	74
19	LM/ red	0.851	0.645	0.564	74
20	LM/ blue	0.864	0.614	0.535	73
21	Davidoff classic	0.895	0.67	0.578	73
22	Davidoff gold	0.867	0.644	0.558	73
23	Gauloises/ blue	0.848	0.645	0.563	74
24	Gauloises / red	0.842	0.617	0.54	74
25	Gauloises/ orange	0.791	0.545	0.48	74
	Mean	**0.899**	**0.685**	**0.596**	**73**
	Min	**0.788**	**0.545**	**0.478**	**69**
	Max	**1.188**	**0.988**	**0.852**	**74**

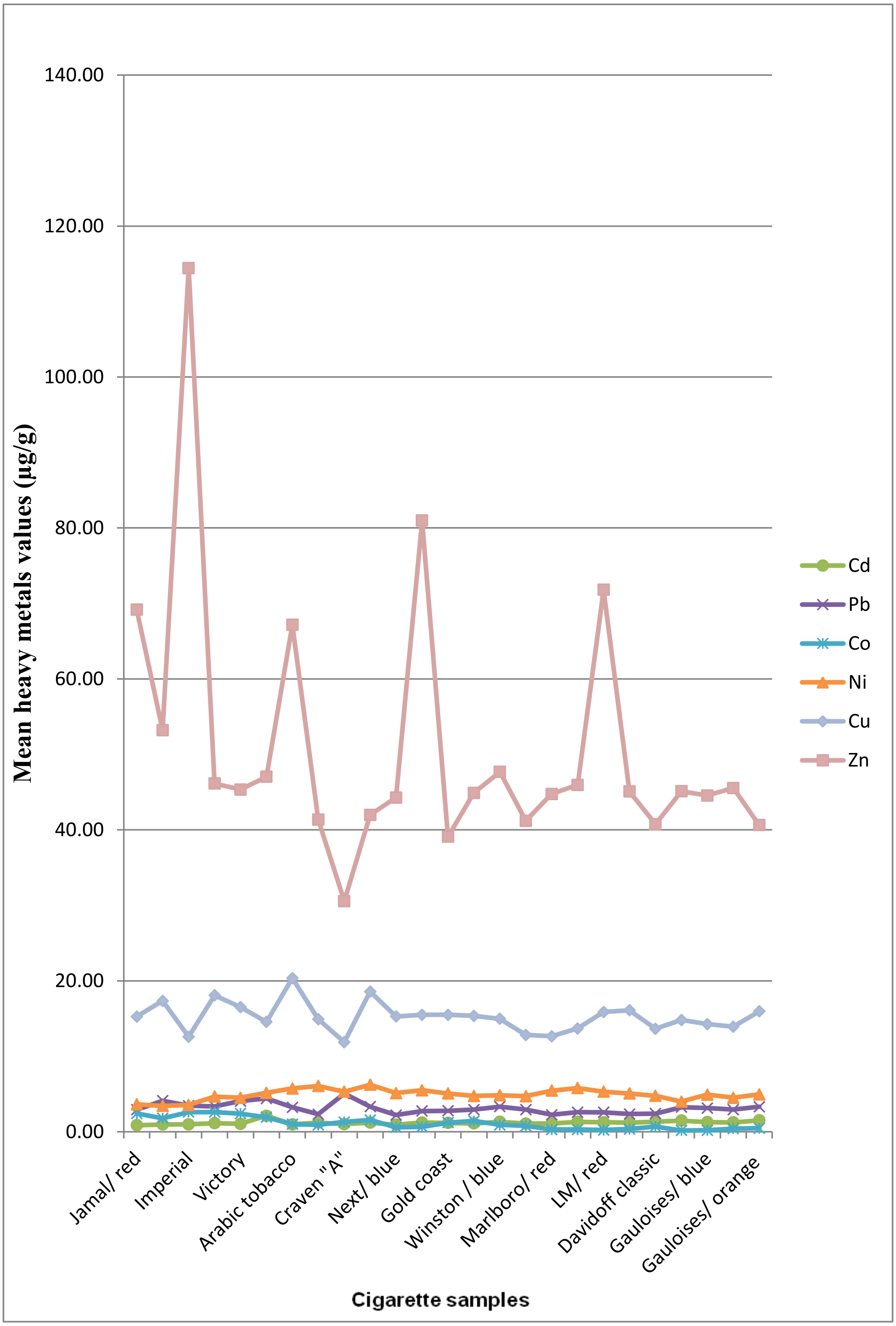
4.4. Determination of the Contents for Some Heavy Metals

The determined concentrations of 6 heavy metals (Cd, Pb, Co, Ni, Cu and Zn) in 25 cigarette brands are presented in (Table 4.3) The combined data are displayed as histograms (Figures 4.7(a), 4.7(b), 4.7(c), 4.7(d), 4.7(e), 4.7(f) and 4.7(g)) where the overall trends are immediately obvious.

The concentration of heavy metals in the cigarettes ranged, Cd: from 0.85 to 2.11 μg/g with mean 1.20±0.15 μg/g, Pb: 2.21 to 5.06 μg/g with mean 3.12±1.33 μg/g, Co: 0.18 to 2.61 μg/g with mean 1.09±0.28 μg/g, Ni: 3.42 to 6.23 μg/g with mean 4.92±0.53 μg/g, Cu: 11.86 to 20.35 μg/g with mean 15.21±0.34 μg/g, and Zn: 30.55 to 114.43 μg/g with mean 51.15±0.14 μg/g. Such inner brand variations in trace element concentration of tobacco products have been observed by others as well [38] . However, these variations could possibly be related to agriculture soil contents of trace metals on which tobacco leaves were cultivated [70,71] , farming fields close to roads and residential areas [39] , the chemistry of tobacco leaves and finally to its processing [70].

Table 4.3. Results for the flame atomic absorption spectrophotometric determination of heavy metals contents (mean ± SD) (µg/g, dry weight) of 25 brands of cigarette tobacco sold in Palestine. Mean values of triplicate analyses (n = 3) are given

Brands	Cd	Pb	Co	Ni	Cu	Zn
Jamal/ red	0.85±0.20	2.91±0.67	2.41±0.84	3.64±0.84	15.25±0.41	69.17±0.28
Jamal	0.96±0.44	4.10±0.94	1.79±0.30	3.42±0.79	17.34±0.16	53.21±0.05
Imperial	0.99±0.18	3.44±0.79	2.60±0.49	3.55±0.82	12.58±0.42	114.43±0.23
Infinity	1.13±0.42	3.35±0.77	2.61±0.48	4.67±0.63	18.07±0.07	46.14±0.05
Victory	1.04±0.26	4.06±3.97	2.41±0.08	4.50±0.75	16.52±0.31	45.34±0.14
Lando	2.11±0.09	4.41±1.01	1.92±0.71	5.15±2.43	14.55±0.29	47.03±0.14
Arabic tobacco	0.98±0.22	3.24±1.87	1.00±0.47	5.73±0.38	20.35±0.51	67.18±0.20
Rothmans	1.21±0.08	2.31±1.00	0.91±0.34	6.06±0.49	14.91±0.63	41.36±0.17
Craven "A"	1.01±0.15	5.06±2.85	1.29±0.19	5.30±0.48	11.86±0.64	30.55±0.09
Viceroy	1.21±0.09	3.32±0.76	1.56±0.46	6.23±0.49	18.57±0.45	41.98±0.13
Next/ blue	0.93±0.16	2.21±1.79	0.58±0.20	5.11±0.25	15.27±0.14	44.27±0.22
Next/ light blue	1.21±0.04	2.74±2.70	0.65±0.22	5.49±0.56	15.49±0.36	80.99±0.24
Gold coast	1.17±0.15	2.79±1.43	1.21±0.19	5.07±0.70	15.50±0.54	39.09±0.04
Winston/ red	1.10±0.21	2.93±0.67	1.42±0.09	4.74±0.08	15.35±0.40	44.89±0.04
Winston / blue	1.30±0.08	3.32±0.76	0.90±0.11	4.83±0.26	14.96±0.13	47.68±0.29
Parliament	1.09±0.10	2.92±0.67	0.77±0.31	4.71±0.37	12.83±0.17	41.20±0.16
Marlboro/ red	1.10±0.07	2.24±0.71	0.30±0.12	5.44±0.13	12.66±0.41	44.76±0.09
Marlboro/ white	1.31±0.08	2.58±2.34	0.30±0.11	5.79±0.14	13.68±0.67	45.95±0.05
LM/ red	1.25±0.15	2.58±1.38	0.22±0.05	5.31±0.22	15.87±0.05	71.80±0.14
LM/ blue	1.19±0.11	2.34±1.61	0.37±0.24	5.08±0.70	16.09±0.03	45.08±0.23
Davidoff classic	1.32±0.10	2.40±1.64	0.69±0.52	4.76±0.37	13.65±0.40	40.76±0.04
Davidoff gold	1.48±0.02	3.26±0.75	0.18±0.04	3.98±0.18	14.81±0.61	45.11±0.05
Gauloises/ blue	1.26±0.04	3.14±0.72	0.19±0.04	4.91±0.28	14.26±0.40	44.55±0.27
Gauloises / red	1.24±0.15	2.93±0.67	0.41±0.17	4.50±0.57	13.92±0.14	45.55±0.09
Gauloises/orange	1.51±0.16	3.30±0.76	0.47±0.29	4.95±0.30	15.96±0.10	40.63±0.04
Mean	**1.20±0.15**	**3.12±1.33**	**1.09±0.28**	**4.92±0.53**	**15.21±0.34**	**51.15±0.14**
Min	**0.85**	**2.21**	**0.18**	**3.42**	**11.86**	**30.55**
Max	**2.11**	**5.06**	**2.61**	**6.23**	**20.35**	**114.43**



Figures 4.7(a). Histograms of comparison of the heavy metal contents of different brands of cigarette samples for the elements: Cd, Pb, Co, Ni, Cu and Zn.

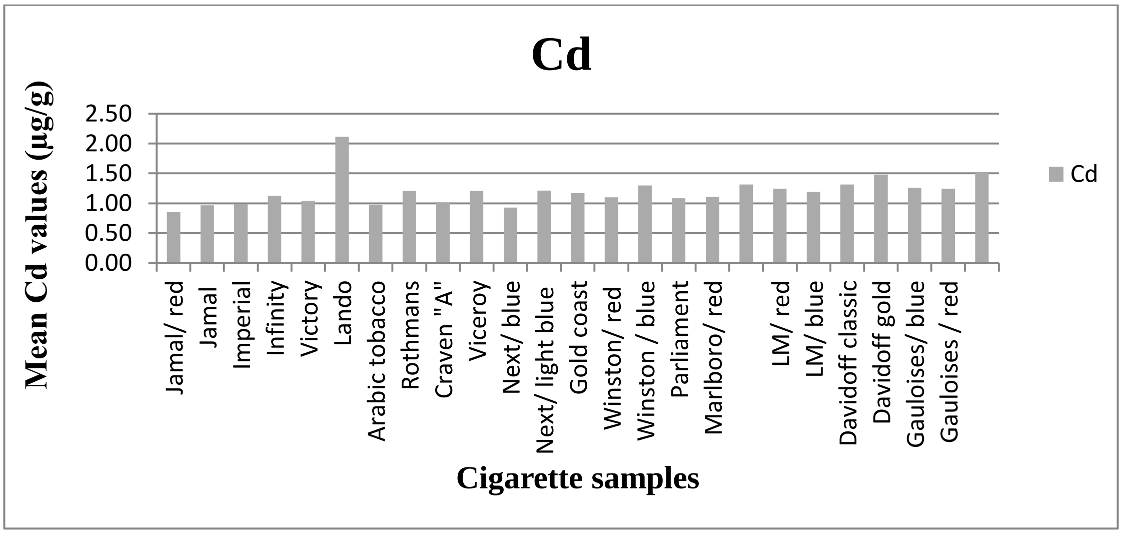


Figure 4.7(b): Cadmium content in different brands of cigarette samples.

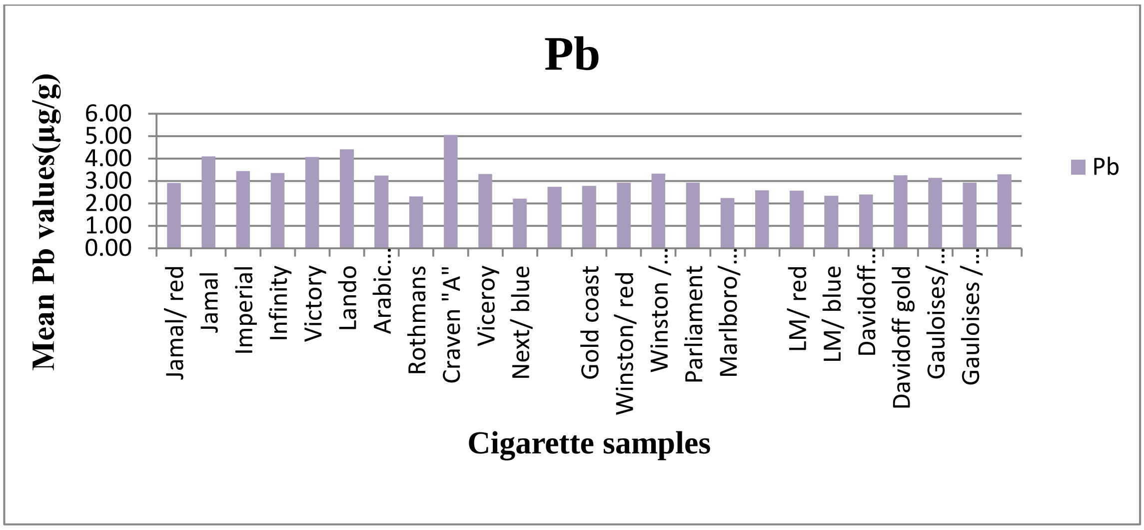


Figure 4.7(c): lead content in different brands of cigarette samples.

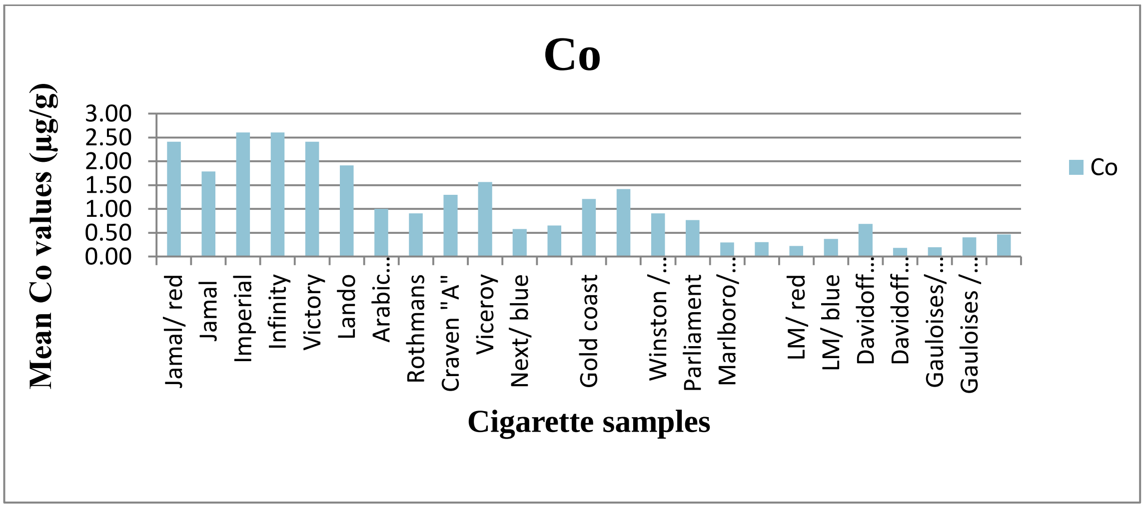


Figure 4.7(d): Cobalt content in different brands of cigarette samples.

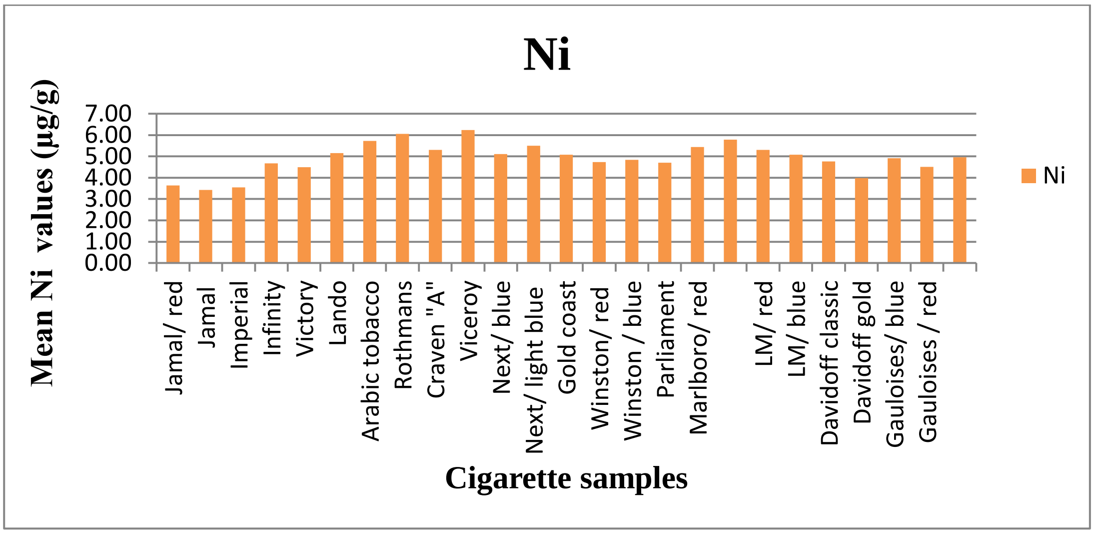


Figure 4.7(e): Nickel content in different brands of cigarette samples.

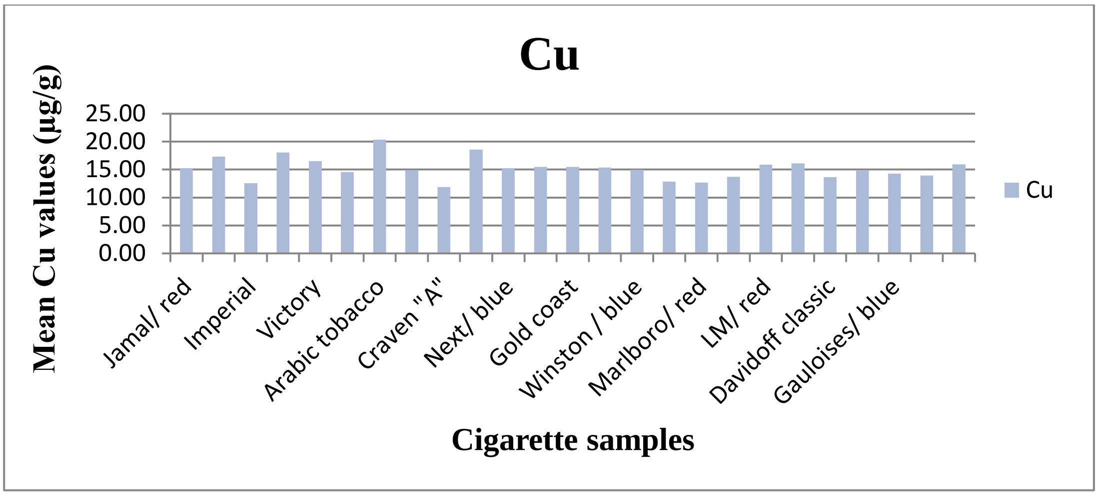


Figure 4.7(f): Copper content in different brands of cigarette samples.

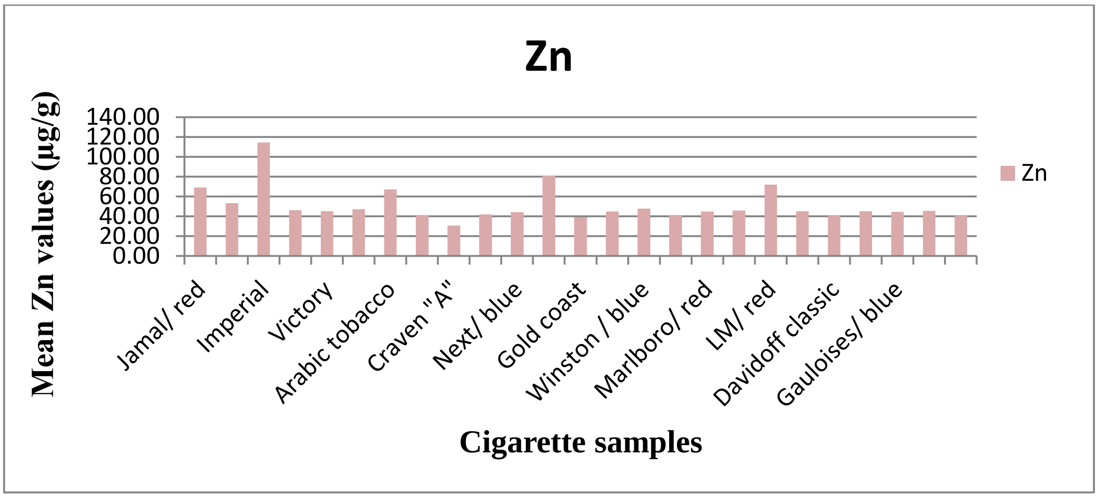


Figure 4.7(g): Zinc content in different brands of cigarette samples.

4.5. Comparison of the Levels of Heavy Metals in the Palestinian Cigarettes With That Imported Cigarettes Sold in Palestine

The mean Pb, Co, Cu and Zn contents of Palestinian cigarettes, are bit higher than imported brands. Imported cigarettes show a bit higher Cd and Ni contents than Palestinian cigarettes, as shown in (Figure 4.8) and (Tables 4.4 and 4.5).

On other hand, among cigarette brands, the highest concentration of cadmium element were found in Lando with 2.11±0.09μg/g (local brand), Gauloises/ orange with 1.51±0.16 μg/g and Davidoff gold with 1.48±0.02 μg/g (imported brand), whereas lowest cadmium content was in Jamal/ red (local brand) and Next/ blue (imported brand) with 0.85±0.20 and 0.93±0.16 μg/g, respectively. It is likely that the major source cadmium in tobacco probably occurs from the widespread use of chemical fertilizers [14,72]. The concentration of other elements including: Lead, Cobalt, Nickel, Copper and Zinc elements are also indicated in (Tables 4.4 and 4.5).

Table 4.4. Heavy metal contents (mean ± SD) (μg/g, dry weight) of Palestinian brands of cigarette tobacco

Brands	Cd	Pb	Co	Ni	Cu	Zn
Jamal/ red	0.85±0.20	2.91±0.67	2.41±0.84	3.64±0.84	15.25±0.41	69.17±0.28
Jamal	0.96±0.44	4.10±0.94	1.79±0.30	3.42±0.79	17.34±0.16	53.21±0.05
Imperial	0.99±0.18	3.44±0.79	2.60±0.49	3.55±0.82	12.58±0.42	114.43±0.23
Infinity	1.13±0.42	3.35±0.77	2.61±0.48	4.67±0.63	18.07±0.07	46.14±0.05
Victory	1.04±0.26	4.06±3.97	2.41±0.08	4.50±0.75	16.52±0.31	45.34±0.14
Lando	2.11±0.09	4.41±1.01	1.92±0.71	5.15±2.43	14.55±0.29	47.03±0.14
Arabic tobacco	0.98±0.22	3.24±1.87	1.00±0.47	5.73±0.38	20.35±0.51	67.18±0.20
Mean	**1.15±0.26**	**3.65±1.43**	**2.10±0.48**	**4.38±0.95**	**16.38±0.31**	**63.21±0.15**
Min	**0.85**	**2.91**	**1.00**	**3.42**	**12.58**	**45.34**
Max	**2.11**	**4.41**	**2.61**	**5.73**	**20.35**	**114.43**

Table 4.5. Heavy metal contents (mean ± SD) (µg/g, dry weight) of imported brands of cigarette tobacco

Brands	Cd	Pb	Co	Ni	Cu	Zn
Rothmans	1.21±0.08	2.31±1.00	0.91±0.34	6.06±0.49	14.91±0.63	41.36±0.17
Craven "A"	1.01±0.15	5.06±2.85	1.29±0.19	5.30±0.48	11.86±0.64	30.55±0.09
Viceroy	1.21±0.09	3.32±0.76	1.56±0.46	6.23±0.49	18.57±0.45	41.98±0.13
Next/ blue	0.93±0.16	2.21±1.79	0.58±0.20	5.11±0.25	15.27±0.14	44.27±0.22
Next/ light blue	1.21±0.04	2.74±2.70	0.65±0.22	5.49±0.56	15.49±0.36	80.99±0.24
Gold coast	1.17±0.15	2.79±1.43	1.21±0.19	5.07±0.70	15.50±0.54	39.09±0.04
Winston/ red	1.10±0.21	2.93±0.67	1.42±0.09	4.74±0.08	15.35±0.40	44.89±0.04
Winston / blue	1.30±0.08	3.32±0.76	0.90±0.11	4.83±0.26	14.96±0.13	47.68±0.29
Parliament	1.09±0.10	2.92±0.67	0.77±0.31	4.71±0.37	12.83±0.17	41.20±0.16
Marlboro/ red	1.10±0.07	2.24±0.71	0.30±0.12	5.44±0.13	12.66±0.41	44.76±0.09
Marlboro/ white	1.31±0.08	2.58±2.34	0.30±0.11	5.79±0.14	13.68±0.67	45.95±0.05
LM/ red	1.25±0.15	2.58±1.38	0.22±0.05	5.31±0.22	15.87±0.05	71.80±0.14
LM/ blue	1.19±0.11	2.34±1.61	0.37±0.24	5.08±0.70	16.09±0.03	45.08±0.23
Davidoff classic	1.32±0.10	2.40±1.64	0.69±0.52	4.76±0.37	13.65±0.40	40.76±0.04
Davidoff gold	1.48±0.02	3.26±0.75	0.18±0.04	3.98±0.18	14.81±0.61	45.11±0.05
Gauloises/ blue	1.26±0.04	3.14±0.72	0.19±0.04	4.91±0.28	14.26±0.40	44.55±0.27
Gauloises / red	1.24±0.15	2.93±0.67	0.41±0.17	4.50±0.57	13.92±0.14	45.55±0.09
Gauloises/ orange	1.51±0.16	3.30±0.76	0.47±0.29	4.95±0.30	15.96±0.10	40.63±0.04
Mean	**1.22±0.11**	**2.91±1.29**	**0.69±0.21**	**5.13±0.36**	**14.76±0.35**	**46.46±0.13**
Min	**0.93**	**2.21**	**0.18**	**3.98**	**11.86**	**30.55**
Max	**1.51**	**5.06**	**1.56**	**6.23**	**18.57**	**80.99**

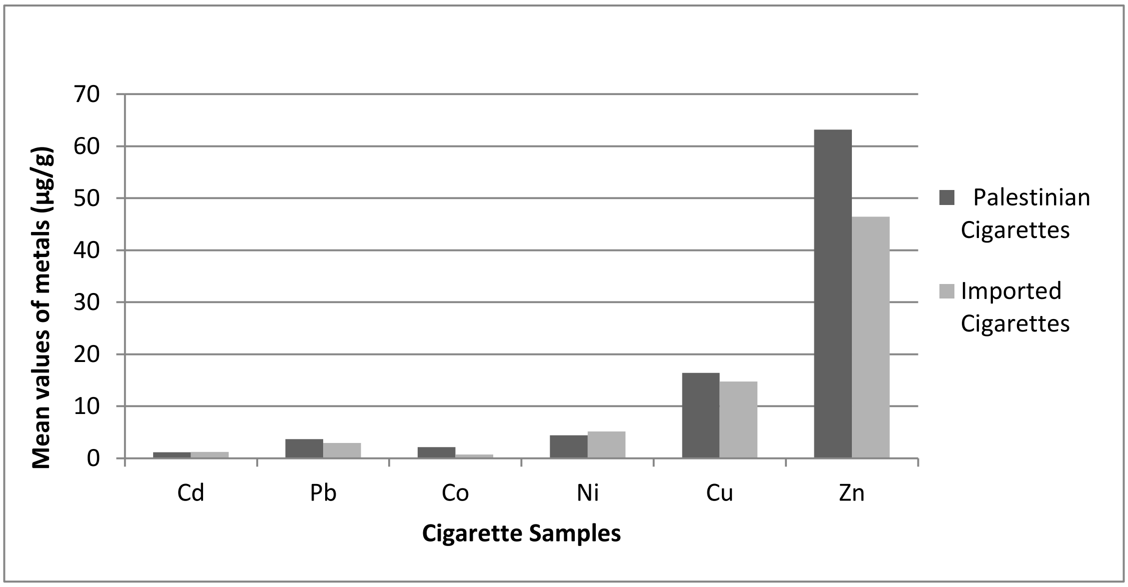


Figure 4.8. Histogram of comparison of the heavy metal contents of imported and local cigarettes for the elements: Cd, Pb, Co, Ni, Cu and Zn

4.6. Comparison of the Levels of Heavy Metals by according to country of origin

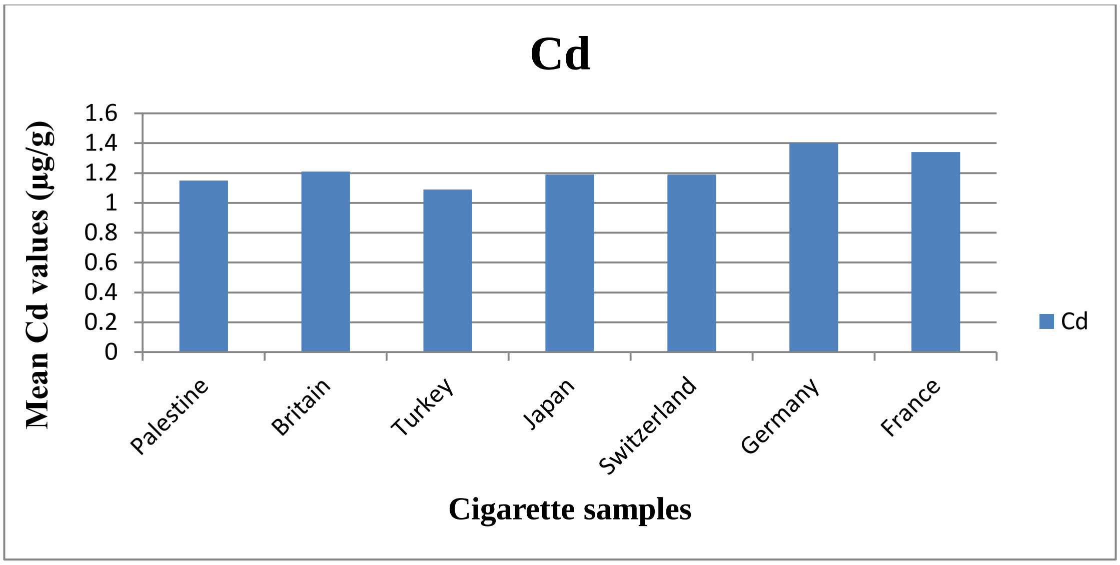
In (Table 4.6) and (Figures 4.9(a), 4.9(b), 4.9(c), 4.9(e), 4.9(f) and 4.9(g)), the results showed that Cd content in Germany tobacco is much higher than other countries. Palestinian tobacco has the highest concentration of heavy metals Pb, Co, Cu and Zn.

The British tobacco has the highest mean content of Ni and the lowest mean content of Pb and Zn. Swiss and Germany tobacco has the lowest mean content of Cu. The lowest Co tobacco content is from Swiss, Germany and France.

According to Nnorom *et al* [14], the mean metal contents of cigarettes varied clearly depending on the geographical area of production. However, it is not 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. It is also reported that it has been observed that some species of plant accumulate high concentrations of some metals, most especially Cd, in the leaf tissue rather than in the roots[14]. 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 [72]. For this reason, there are large variations in the content of metals in tobacco between countries.

Table 4.6. Comparison of heavy metals contents (mean ± SD) (µg/g, dry weight) of cigarettes sold in Palestine according to country of origin (manufacturer).

Country of origin	Cd	Pb	Co	Ni	Cu	Zn
Palestine	1.15±0.26	3.65±1.43	2.10±0.48	4.38±0.95	16.38±0.31	63.21±0.15
Britain	1.21±0.08	2.31±1.00	0.91±0.34	6.06±0.49	14.91±0.63	41.36±0.17
Turkey	1.09±0.11	3.33±2.02	1.02±0.27	5.54±0.44	15.30±0.39	49.45±0.17
Japan	1.19±0.14	3.01±0.96	1.18±0.13	4.88±0.35	15.27±0.36	43.89±0.12
Switzerland	1.19±0.10	2.53±1.34	0.39±0.17	5.26±0.31	14.23±0.26	49.76±0.13
Germany	1.40±0.06	2.83±1.19	0.44±0.28	4.37±0.27	14.23±0.50	42.93±0.04
France	1.34±0.12	3.12±0.72	0.36±0.17	4.79±0.38	14.71±0.21	43.58±0.13



Figures 4.9(a): Cadmium content in cigarette samples according to country of origin.

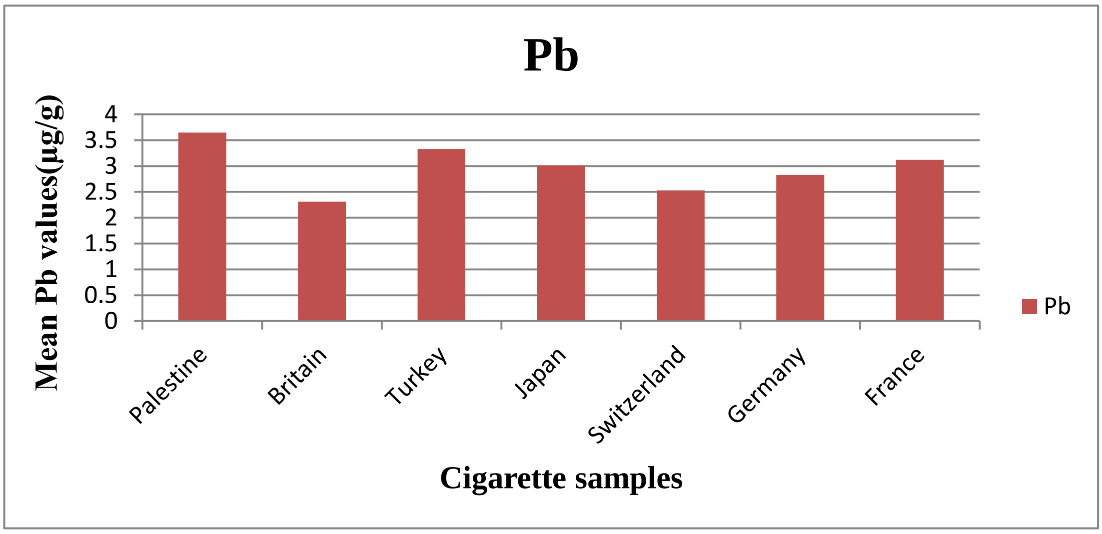


Figure 4.9(b): lead content in cigarette samples according to country of origin.

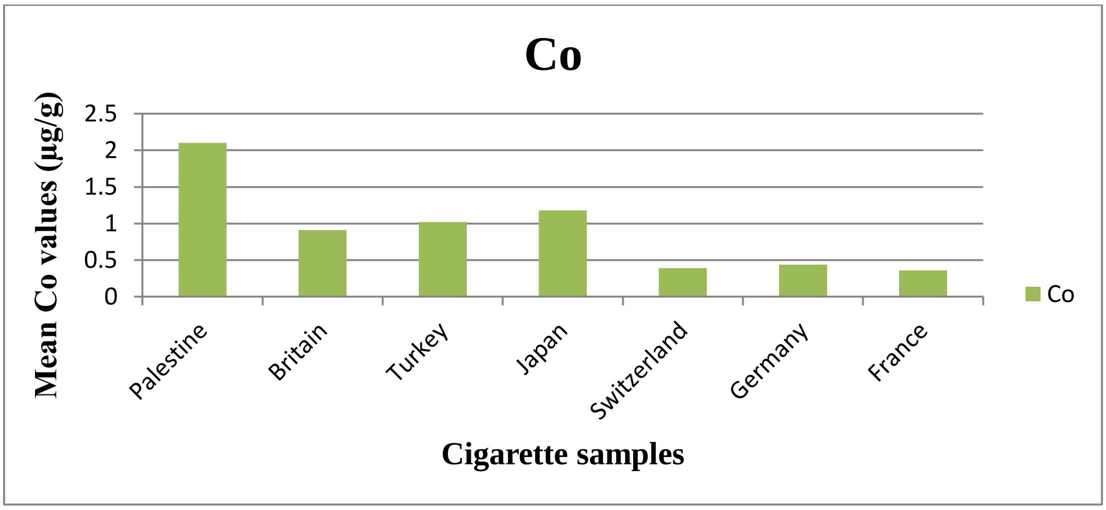


Figure 4.9(c): Cobalt content in cigarette samples according to country of origin.

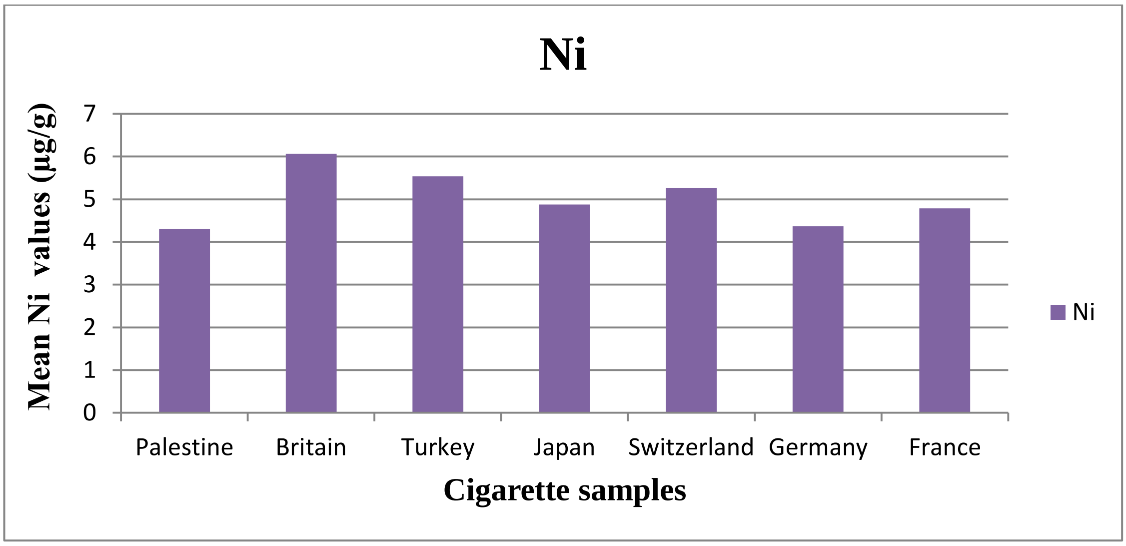


Figure 4.9(e): Nickel content in cigarette samples according to country of origin.

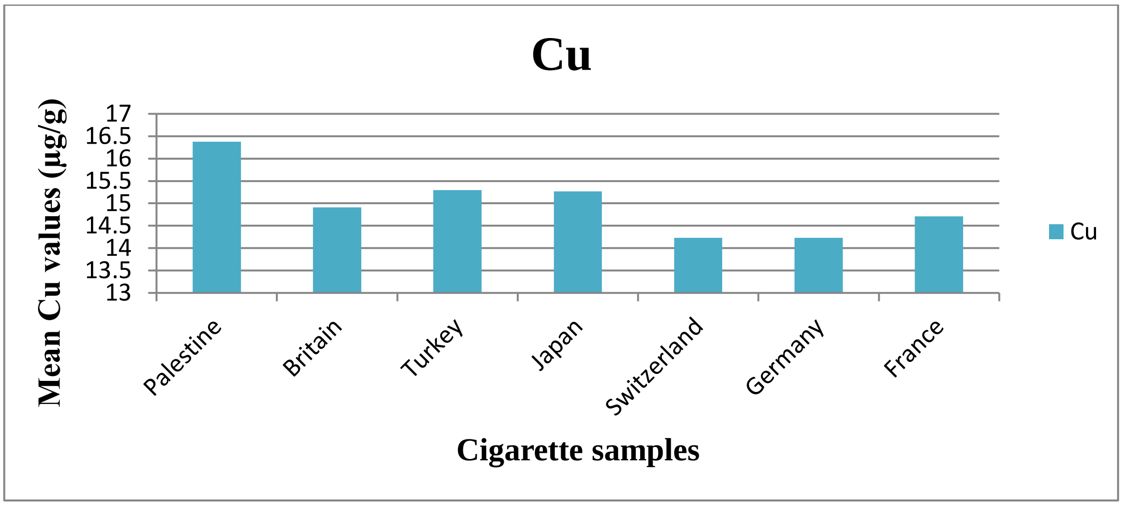


Figure 4.9(f): Copper content in cigarette samples according to country of origin.

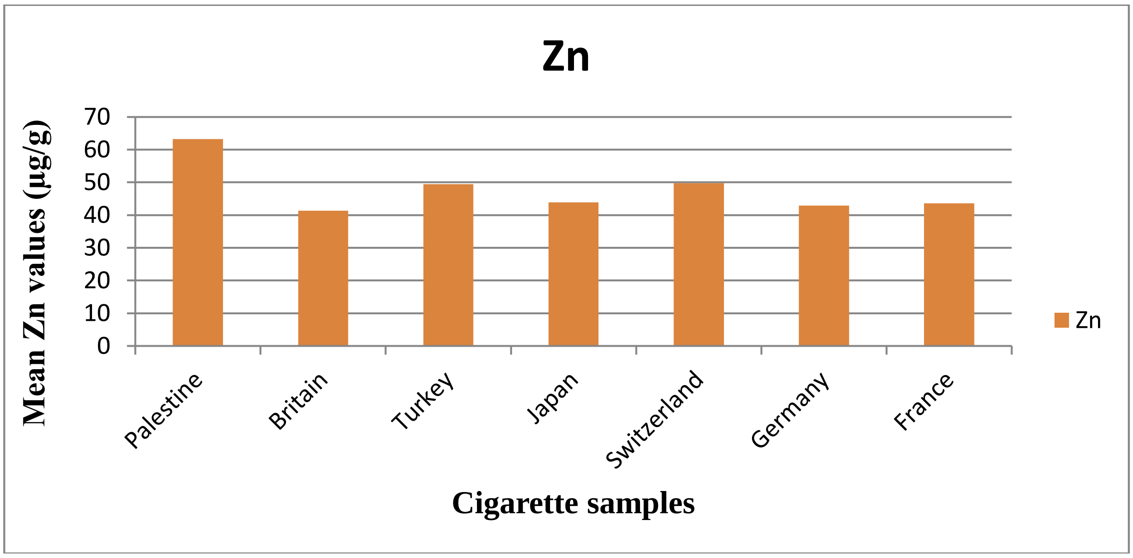


Figure 4.9(g): Zinc content in cigarette samples according to country of origin.

4.7. Comparison of Heavy Metals Contents in the Palestinian Cigarettes With Literature Reported results on Cigarettes Sold or Smoked Around the World

The mean concentration of Cd in the tobacco in this study was 1.20 µg/g. This metal content was higher than its concentration in China 0.18 µg/g, India 0.4 µg/g, Pakistan 0.5 µg/g, and some reported investigation in (Table 4.7), but comparable with cigarette tobaccos of Nigeria and Turkey. Mussalo - Rauhama *et al* [10] investigated in different cigarettes and found the cadmium content ranging between 0.8 to 3.4 µg/g.

The mean concentration of Pb in tobacco samples 3.12 µg/g, have significantly lower concentration than Pakistan cigarette 14.4 µg/g , Nigeria cigarette 10.8 µg/g [73, 74] and Ethiopia 6.07 µg/g [75] but almost agree with Andrade *et al* [76], Watanabe *et al* [77], Massadeh *et al* [78], and more published data in (Table 4.7).

Table 4.7. Comparison of the results from studies of heavy metals contents in cigarettes (µg/g, dry weight) in various countries and results of the present study

Cd	Pb	Co	Ni	Cu	Zn	References
1.20	3.12	1.09	4.92	15.21	51.15	This study
2.71	2.07	4.42	17.93	9.7	27.02	Iran [75]
0.4	1.6	0.91	3.6	18	29	India [79]
0.9	4.3		3	39	39.5	India [80]
0.45	1.94		8.79	14	27	India [38]
2.49	6.24			13.7	36.22	Ethiopia [75]
0.5	14.53			7.89	8.57	Pakistan [73]
2.64	2.67			12.6	55.62	Jordan [77]
1.95	1.2		2.4	9.4	49.8	Germany [81]
1.7	1.02		0.22	2.45		Turkey [82]
0.18	0.64		2.23	4.13		China [83]
1.02	1.35			7.73	38.5	Korea [83]
0.9	0.74			13	31.9	Uk [83]
					51.4	Ohaio [84]
1.27	10.8					Nigeria [14]
2.3						France [14]
1.9						Switzerland [14]

4.8. The Amount of Heavy Metals Arising from Smoking a Pack of Cigarettes

Due to differences in the rate of weight packaged tobacco per cigarette from one type to another, the concentration of heavy metals was calculated in each pack (20 cigarettes) as shown in the (Table 4.8) and (Figures 4.10(a), 4.10(b), 4.10(c), 4.10(d), 4.10(e) and 4.10(f)).

The mean of heavy metal contents of cigarettes available and sold in Palestine are Cd: 16.31 µg/packet with range (12.09– 33.92) µg/packet, Pb: 42.67 µg/packet with range (28.29 – 70.74) µg/packet, Co:14.87 µg/packet with range (2.36– 40.38) µg/packet, Ni: 67.34 µg/packet with range

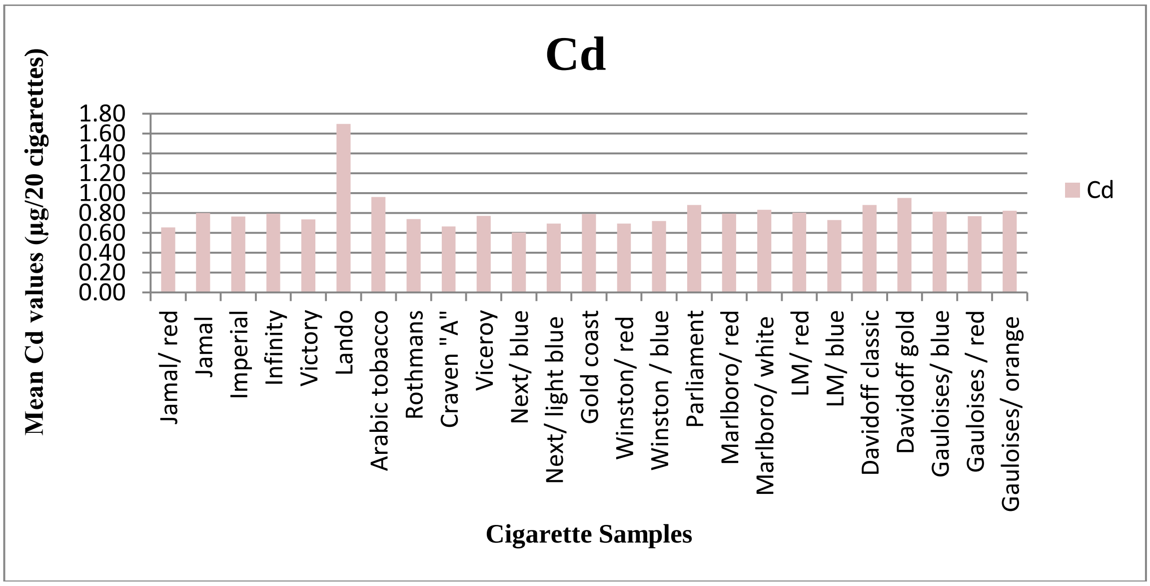
(51.31– 113.24) μg/packet Cu: 208.34 μg/packet with range (156.08– 402.13) μg/packet, Zn: 700.47 μg/packet with range (402.02– 1775.93) μg/packet.

It has been observed that Lando cigarette brand has high mean Cd and Pb values with 33.92 and 70.74 μg/packet, respectively. Imperial cigarette brand has high mean Co and Zn values with 40.38 and 1775.93 μg/packet, respectively . Arabic tobacco brand has high mean Ni and Cu values with 113.24 and 402.13 μg/packet, respectively. It is very important to point out that heavy metals Cd and Pb content in local cigarettes was high concentration than in imported brands.

In the report of an International World Health Organization (WHO) and United Nations Environment Programme (UNEP) for assessment of human exposure to heavy metals has reported higher levels of Cd in kidney cortex samples of smokers compared to non-smokers [74, 12]. According to this project work the recommended cigarette with low mean trace metal contents are Jamal/ red and Next/ blue.

Table 4.8. Heavy metal contents in one packet (20 cigarettes) (µg/packet) of brands of cigarette tobacco sold in Palestinian market

Brands	Cd	Pb	Co	Ni	Cu	Zn
Jamal/ red	13.14	44.78	37.10	55.92	234.51	1063.79
Jamal	16.03	68.21	29.69	56.83	288.17	884.27
Imperial	15.34	53.34	40.38	55.07	195.22	1775.93
Infinity	15.87	47.27	36.74	65.80	254.84	650.55
Victory	14.74	57.47	34.05	63.62	233.66	641.06
Lando	33.92	70.74	30.72	82.56	233.44	754.36
Arabic tobacco	19.27	64.00	19.75	113.24	402.13	1327.42
Rothmans	14.77	28.29	11.08	74.07	182.26	505.39
Craven "A"	13.34	66.55	17.04	69.78	156.08	402.02
Viceroy	15.45	42.41	19.96	79.67	237.34	536.50
Next/ blue	12.09	28.75	7.53	66.58	198.82	576.37
Next/ light blue	13.90	31.35	7.48	62.96	177.51	928.13
Gold coast	15.84	37.65	16.34	68.59	209.55	528.53
Winston/ red	13.88	36.98	17.90	59.77	193.75	566.47
Winston / blue	14.39	36.83	10.02	53.55	165.72	528.31
Parliament	17.63	47.48	12.48	76.46	208.32	669.12
Marlboro/ red	15.91	32.24	4.30	78.35	182.26	644.47
Marlboro/ white	16.69	32.86	3.85	73.66	174.02	584.46
LM/ red	16.08	33.22	2.85	68.45	204.72	926.27
LM/ blue	14.61	28.77	4.52	62.35	197.64	553.63
Davidoff classic	17.62	32.18	9.23	63.78	182.92	546.15
Davidoff gold	19.06	42.01	2.36	51.31	190.79	581.01
Gauloises/ blue	16.30	40.49	2.49	63.32	183.97	574.76
Gauloises / red	15.34	36.11	5.02	55.55	171.76	562.07
Gauloises/ orange	16.46	35.96	5.09	53.97	173.93	442.83
Mean	**16.31**	**42.67**	**14.87**	**67.34**	**208.34**	**700.47**
Min	**12.09**	**28.29**	**2.36**	**51.31**	**156.08**	**402.02**
Max	**33.92**	**70.74**	**40.38**	**113.24**	**402.13**	**1775.93**



Figures 4.10(a): Cadmium content in one packet of brands of cigarette tobacco sold in Palestinian market.

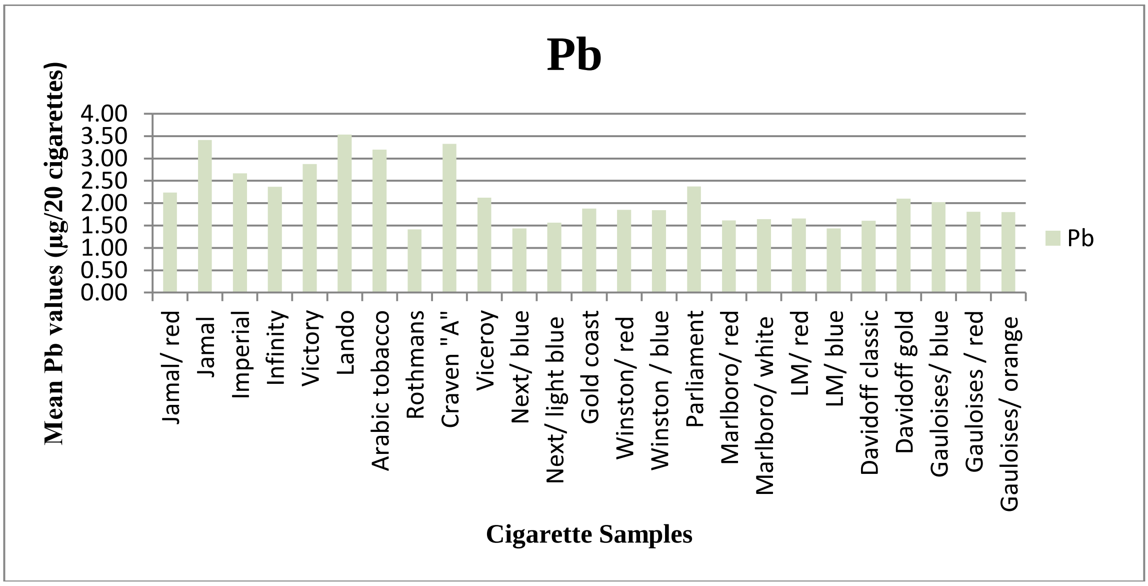


Figure 4.10(b): lead content in one packet of brands of cigarette tobacco sold in Palestinian market.

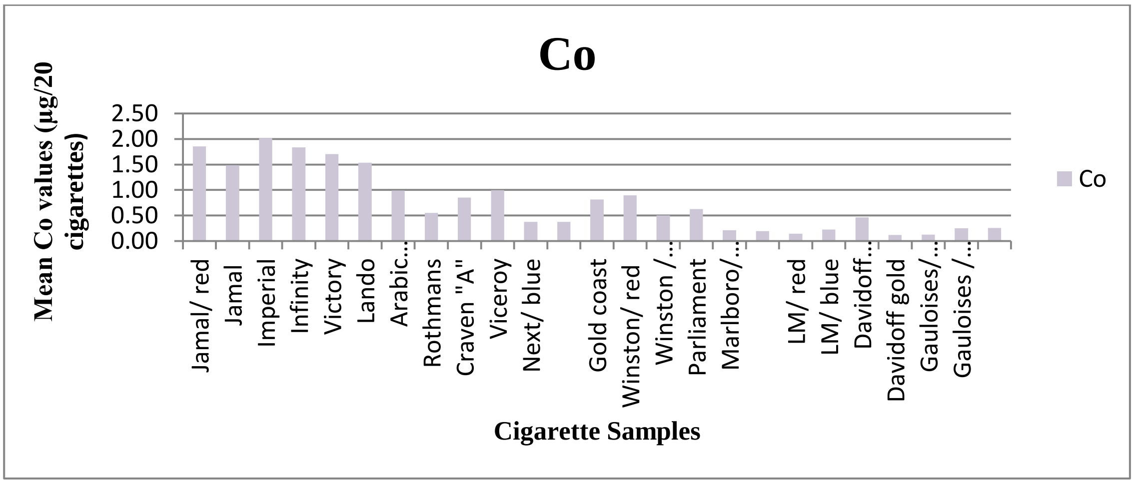


Figure 4.10(c): Cobalt content in one packet of brands of cigarette tobacco sold in Palestinian market.

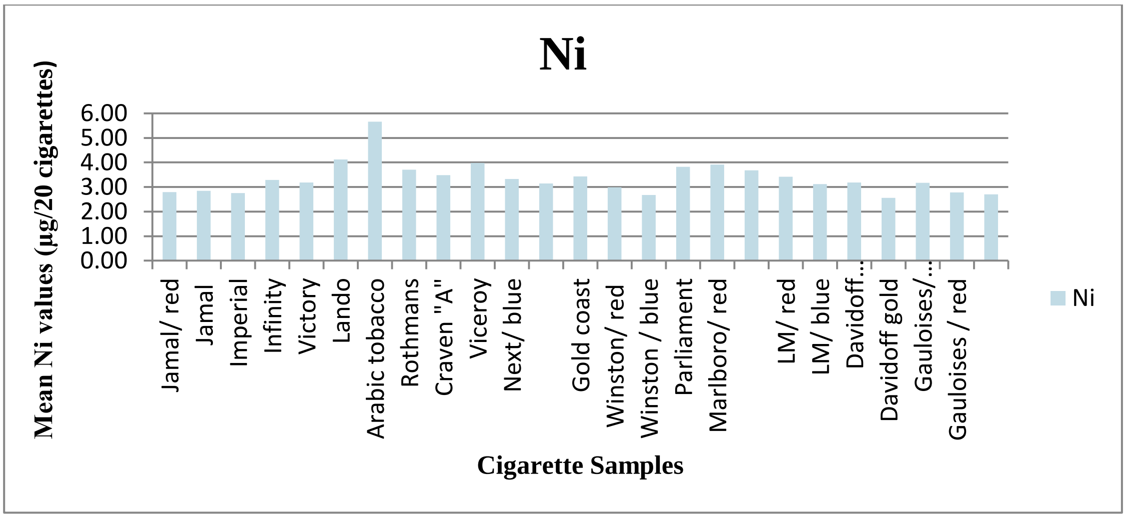


Figure 4.10(d): Nickel content in one packet of brands of cigarette tobacco sold in Palestinian market.

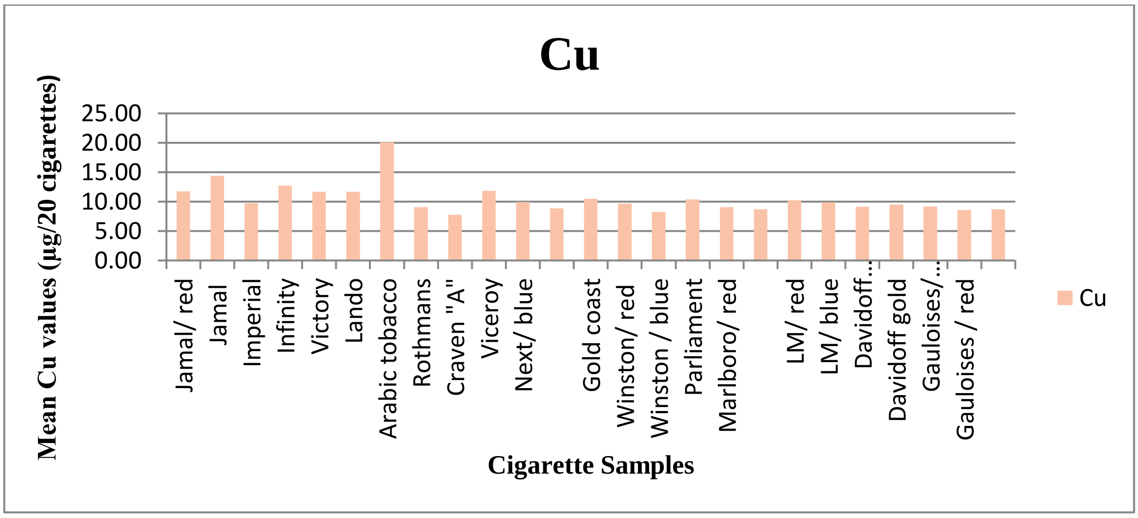


Figure 4.10(e): Nickel content in one packet of brands of cigarette tobacco sold in Palestinian market.

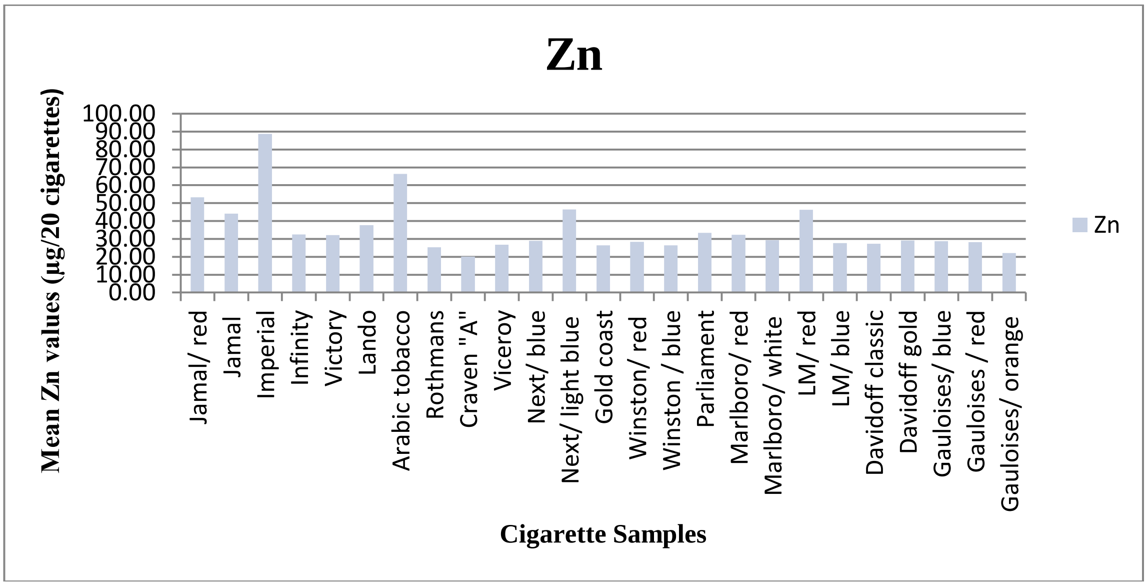


Figure 4.10(f): Copper content in one packet of brands of cigarette tobacco sold in Palestinian market.

4.9. Comparison of Heavy Metals Contents Between Heavy and Light Brands of Cigarettes

The results in (Tables 4.9 and 4.10) and (Figure 4.11). indicate that the mean Cd content of heavy brands cigarette are near to the light brands of cigarette. showed a lower Pb, Co, Ni, Cu, and Zn content than heavy cigarettes. As the light cigarettes have a low weight average than heavy cigarettes.

Table 4.9. Heavy metal contents in one packet (µg/ packet) of heavy brands of cigarette tobacco sold in Palestinian market

Brands	Cd	Pb	Co	Ni	Cu	Zn
Jamal/ red	13.14	44.78	37.10	55.92	234.51	1063.79
Imperial	15.34	53.34	40.38	55.07	195.22	1775.93
Infinity	15.87	47.27	36.74	65.80	254.84	650.55
Victory	14.74	57.47	34.05	63.62	233.66	641.06
Lando	33.92	70.74	30.72	82.56	233.44	754.36
Arabic tobacco	19.27	64.00	19.75	113.24	402.13	1327.42
Rothmans	14.77	28.29	11.08	74.07	182.26	505.39
Craven "A"	13.34	66.55	17.04	69.78	156.08	402.02
Viceroy	15.45	42.41	19.96	79.67	237.34	536.50
Next/ blue	12.09	28.75	7.53	66.58	198.82	576.37
Gold coast	15.84	37.65	16.34	68.59	209.55	528.53
Winston/ red	13.88	36.98	17.90	59.77	193.75	566.47
Parliament	17.63	47.48	12.48	76.46	208.32	669.12
Marlboro/ red	15.91	32.24	4.30	78.35	182.26	644.47
LM/ red	16.08	33.22	2.85	68.45	204.72	926.27
Davidoff classic	17.62	32.18	9.23	63.78	182.92	546.15
Gauloises/ blue	16.30	40.49	2.49	63.32	183.97	574.76
Mean	**16.54**	**44.93**	**18.82**	**70.88**	**217.28**	**746.42**
Min	**12.09**	**28.29**	**2.49**	**55.07**	**156.08**	**402.02**
Max	**33.92**	**70.74**	**40.38**	**113.24**	**402.13**	**1775.93**

Table 4.10. Heavy metal contents in one packet (µg/ packet) of Light brands of cigarette tobacco sold in Palestinian market

Brands	Cd	Pb	Co	Ni	Cu	Zn
Jamal	16.03	68.21	29.69	56.83	288.17	884.27
Next/ light blue	13.90	31.35	7.48	62.96	177.51	928.13
Winston / blue	14.39	36.83	10.02	53.55	165.72	528.31
Marlboro/ white	16.69	32.86	3.85	73.66	174.02	584.46
LM/ blue	14.61	28.77	4.52	62.35	197.64	553.63
Davidoff gold	19.06	42.01	2.36	51.31	190.79	581.01
Gauloises / red	15.34	36.11	5.02	55.55	171.76	562.07
Gauloises/ orange	16.46	35.96	5.09	53.97	173.93	442.83
Mean	**15.81**	**39.01**	**8.50**	**58.77**	**192.44**	**633.09**
Min	**13.90**	**28.77**	**2.36**	**51.31**	**165.72**	**442.83**
Max	**19.06**	**68.21**	**29.69**	**73.66**	**288.17**	**928.13**

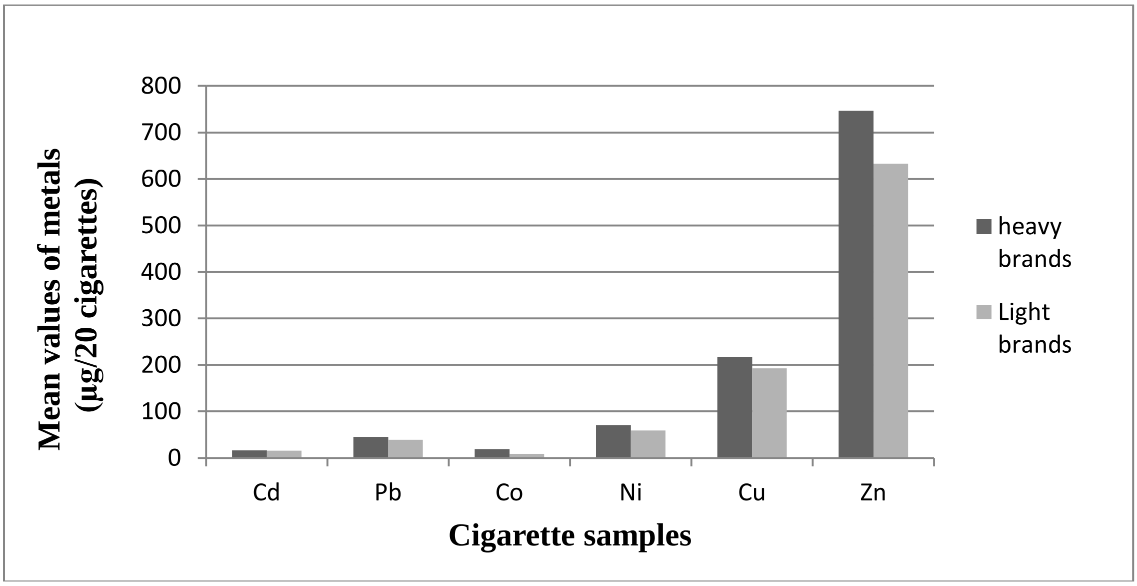


Figure 4.11. Histogram comparing the heavy metal contents of heavy and light brands cigarettes for the elements: Cd, Pb, Co, Ni, Cu and Zn

4.10. Estimation of Heavy Metals Contents in Mainstream Smoke

The amount of heavy metals in mainstream smoke was estimated and shown in (Table 4.11) and (Figures 4.12(a), 4.12(b), 4.12(c), 4.12(d) and 4.12(e)). It has been documented in the literature that the average of 2.0 % for Cd, 5.8% of Pb, 2.0% for Cu, 1.0 % for Zn contained in cigarettes are passed to mainstream smoke [10]. There was no studies for Co and Ni. The results showed that the concentration of heavy metals in the mainstream smoke for one packet ranged Cd: 0.24 to 0.68 µg with mean 0.33 µg. Pb: 1.64 to 4.1 µg with mean 2.47 µg. Cu: 0.31 to 0.8 µg with mean 0.42 µg. Zn: 4.02 to 17.76 µg with mean 7 µg.

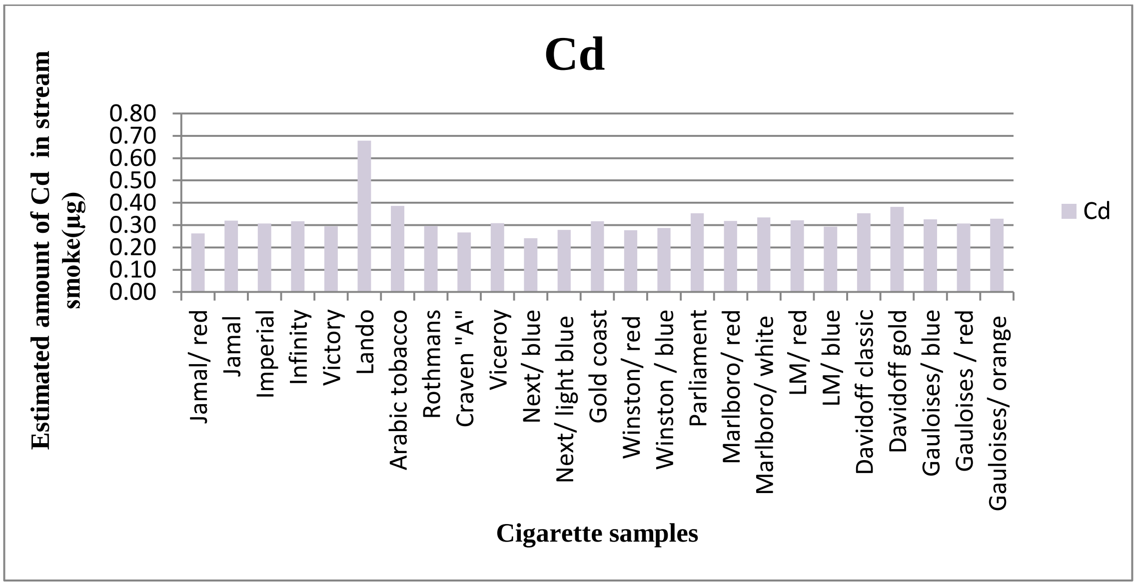
When smoking , about 6 % and 11 % of lead in tobacco moves to mainstream smoke [51,18] (WHO and Galażyn-Sidorczuk et al), it is thought that half of this quantity reaches to smokers' lungs. Most of the rest can be found in the ash . That causes increasing in the levels of lead in the house's dust, and this can cause the air pollution. So the use of cigarette products damage the smokers and also affects the health of non smokers, especially children, pregnant women and adults that result in high metals content in blood stream.

An average of 40-60% of cadmium inhaled via smoking can directly affect the blood stream of the smoker easily. Smoking more than 20 cigarettes daily (one packet) can increase Cd contents in body by 10 folds and impair the body organs. On the other hand, the reports [71] proved that excess zinc can prevent cadmium toxicology .The ratio of zinc-cadmium is very important because cadmium toxicity causes greater activity in tissue function with zinc deficiency, so cadmium may displace zinc from binding sites like enzymatic and organ functions. Because of that, the competition between Cd and Zn is proved by the fact that extra Zn is able to prevent Cd toxicity.

Another point is that other heavy metals like Ni, Co and Cu may also enter the lungs and bloodstream, and the results may be additional or even synergistic with Cd, but experimental transfer coefficients between tobacco and smoke are not presently well determined for many heavy metals. If any of these low-dose effects proves to cause significant harm, then the role of enhanced levels of Cd and other heavy metals in cigarette smoke becomes rather more important than currently appreciated [71].

Table 4.11. Estimated amount of heavy metals contents in mainstream smoke (µg) for one packet (20 cigarettes) of brands of cigarette tobacco sold in Palestinian market

Brands	Cd	Pb	Cu	Zn
Jamal/ red	0.26	2.60	0.47	10.64
Jamal	0.32	3.96	0.58	8.84
Imperial	0.31	3.09	0.39	17.76
Infinity	0.32	2.74	0.51	6.51
Victory	0.29	3.33	0.47	6.41
Lando	0.68	4.10	0.47	7.54
Arabic tobacco	0.39	3.71	0.80	13.27
Rothmans	0.30	1.64	0.36	5.05
Craven "A"	0.27	3.86	0.31	4.02
Viceroy	0.31	2.46	0.47	5.36
Next/ blue	0.24	1.67	0.40	5.76
Next/ light blue	0.28	1.82	0.36	9.28
Gold coast	0.32	2.18	0.42	5.29
Winston/ red	0.28	2.14	0.39	5.66
Winston / blue	0.29	2.14	0.33	5.28
Parliament	0.35	2.75	0.42	6.69
Marlboro/ red	0.32	1.87	0.36	6.44
Marlboro/ white	0.33	1.91	0.35	5.84
LM/ red	0.32	1.93	0.41	9.26
LM/ blue	0.29	1.67	0.40	5.54
Davidoff classic	0.35	1.87	0.37	5.46
Davidoff gold	0.38	2.44	0.38	5.81
Gauloises/ blue	0.33	2.35	0.37	5.75
Gauloises / red	0.31	2.09	0.34	5.62
Gauloises/ orange	0.33	2.09	0.35	4.43
Mean	**0.33**	**2.47**	**0.42**	**7.00**
Min	**0.24**	**1.64**	**0.31**	**4.02**
Max	**0.68**	**4.10**	**0.80**	**17.76**



Figures 4.12(a): Estimated Cadmium content in one packet in mainstream smoke of different brands of cigarette samples.

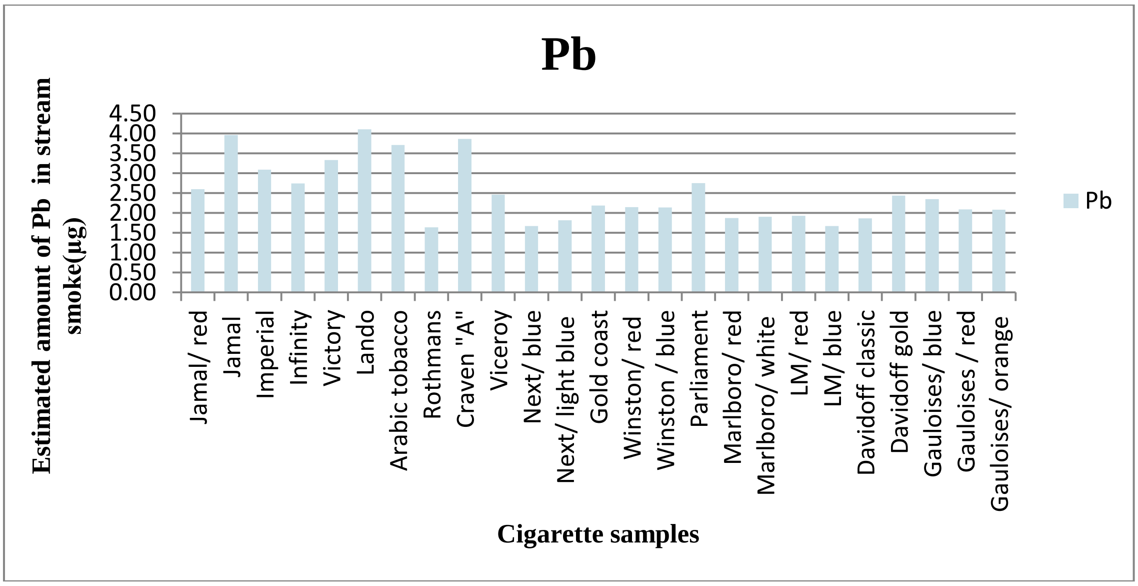


Figure 4.12(b): Estimated lead content in one packet in mainstream smoke of different brands of cigarette samples.

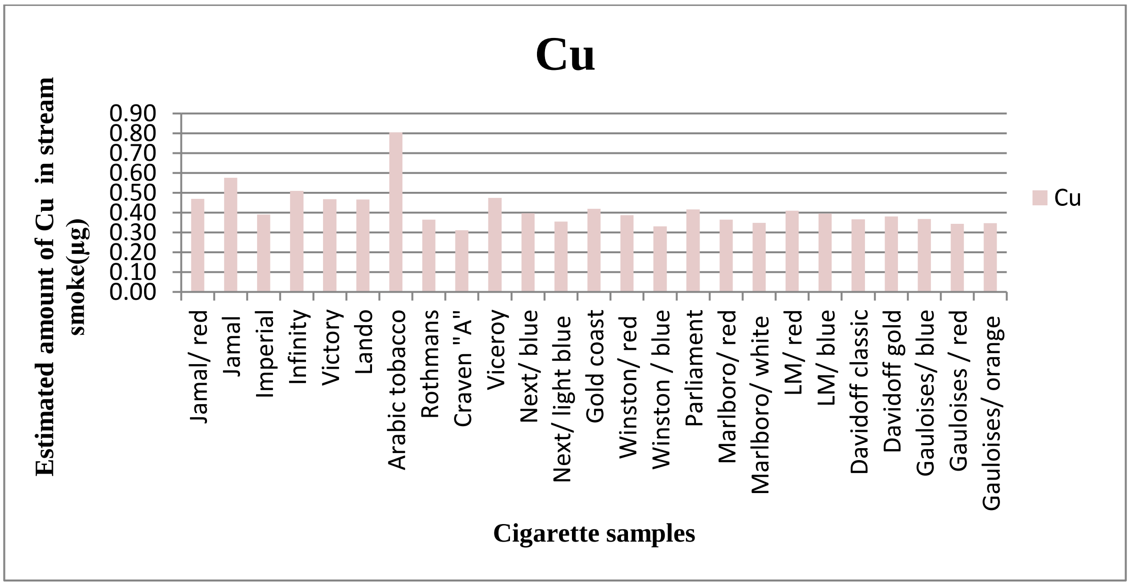


Figure 4.12(c): Estimated Copper content in one packet in mainstream smoke of different brands of cigarette samples.

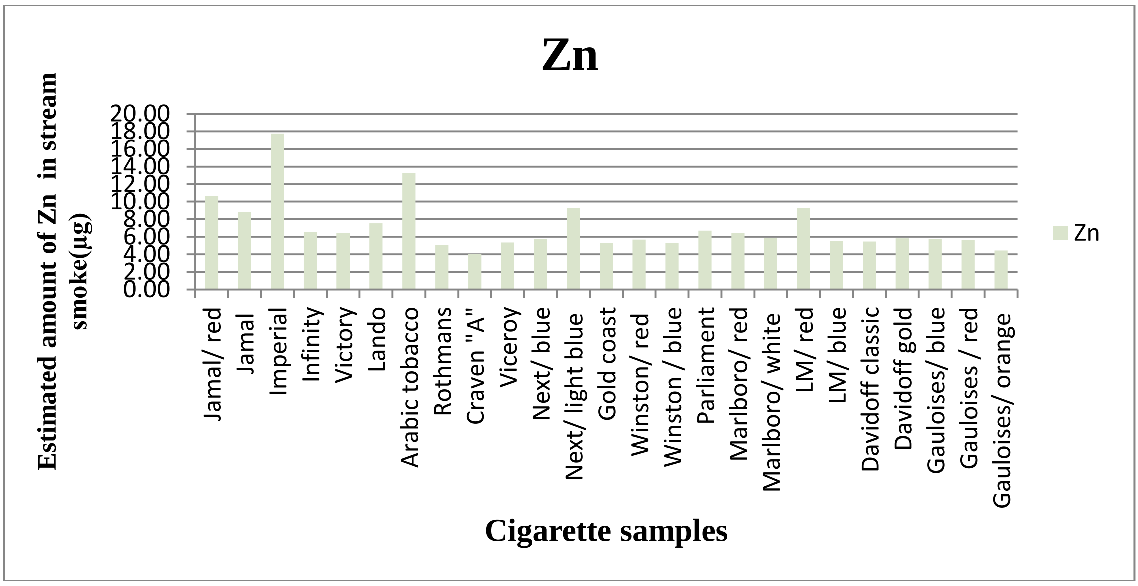


Figure 4.12(d): Estimated Zinc content in one packet in mainstream smoke of different brands of cigarette samples.

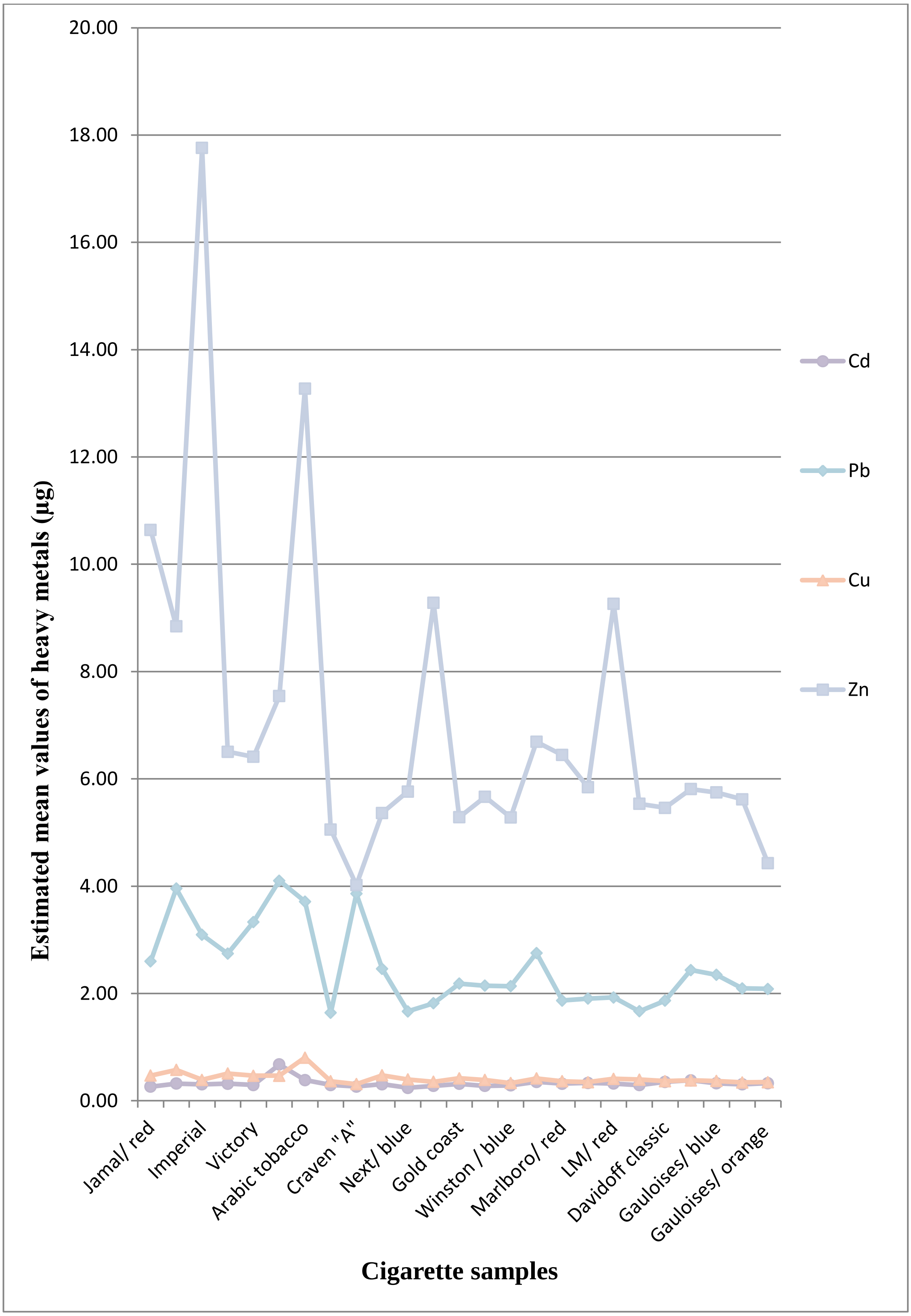


Figure 4.12(e): Histogram comparing the estimated heavy metal contents for one packet (20 cigarettes) in mainstream smoke of different brands of cigarette samples for the elements: Cd, Pb, Cu and Zn.

Chapter Five

Conclusion and Recommendation

Conclusion:

The conclusion obtained from this study are:

1. The levels of Cd, Pb, Co, Ni, Cu and Zn in cigarettes sold in Palestine are nearly similar to levels in cigarettes sold in other parts of the world.
2. The level of Pb, Co, Cu and Zn are slightly higher in local cigarettes than in imported cigarettes.
3. The level of Cd and Ni are slightly lower in local cigarettes than in imported cigarettes.
4. The British tobacco has the highest level of Ni and the lowest levels of Pb and Zn. While Swiss and Germany tobacco has the lowest level of Cu.
5. The lowest Co level is in Swiss, Germany and France cigarettes.
6. Arabic tobacco has the heaviest dry weight and the lowest proportion of organic matter, this is due to the absence of any additions where Arabic tobacco is not manufactured, but cigarettes are wrapped manually. Thus it has high proportion of ash(minerals).
7. Lando cigarette brand has high Cd and Pb levels.
8. Imperial cigarette brand has high Co and Zn levels.
9. Arabic tobacco brand has high Ni and Cu values.
10. The concentration of the heavy metals Cd and Pb in local cigarettes are high than in imported brands.

11. Light cigarettes show lower Pb, Co, Ni, Cu, and Zn content than heavy cigarettes.
12. Presence of significant amounts of two toxic heavy metals Cd and Pb in the cigarette sold in Palestine. Thus the smokers in Palestine might have have higher intake of Cd and Pb than the non-smokers.

Recommendation

1. Efforts should be made by the concerned organization and government to discourage consumption of cigarettes.
2. In this study the amount of Hg, As and Se which are commonly found in tobacco are not determined. Because determination of these elements requires other procedure, i.e. hydride generation for As and Se and cold vapor generation for Hg [85]. Thus, future studies should focus on the determination of Hg, As and Se in a cigarettes.
3. The obtained results data here obtained will be valuable in complimenting available data on Cd exposure from cigarette consumption, and in estimating dietary intake of heavy metals in Palestine.
4. There was no studies for estimating Co and Ni content in mainstream smoke, therefore we recommend further studies.
5. Further work should be done to show the level of emergency of heavy metals on human.

Chapter Six

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جامعة النجاح الوطنية

كلية الدراسات العليا

تحديد وتقدير المعادن الثقيلة في التبغ المباع ويدخن في السوق الفلسطينية

إعداد

علا أحمد محمد

إشراف

د. أحمد أبو عبيد

د.شحدة جودة

قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في العلوم البيئية بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين.

2014

تحديد وتقدير المعادن الثقيلة في التبغ المباع ويدخن في السوق الفلسطينية

إعداد

علا أحمد محمد

إشراف

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د.شحدة جودة

الملخص

حيث أنه لا يوجد أي بيانات حول محتوى العناصر الثقيلة في أنواع السجائر الفلسطينية، هذه الدراسة تزود بيانات جديدة يمكن استخدامها من قبل وزارة الصحة الفلسطينية. تم تحديد محتوى الكادميوم والرصاص والكوبلت والنيكل والنحاس والزنك في 25 نوع من السجائر المباعة في السوق الفلسطينية باستخدام جهاز الامتصاص الذري اللهبي. تراكيز العناصر الثقيلة في السجائر تراوحت في الكادميوم من 0.85 إلى 2.11 مايكرو غم/غم بمتوسط (0.15±1.20) مايكرو غم/غم، الرصاص من 2.21 إلى 5.06 مايكرو غم /غم بمتوسط (1.33±3.12) مايكرو غم/غم. الكوبلت من 0.18 إلى 2.61 مايكرو غم/غم بمتوسط (0.28±1.09) مايكروغم/غم، النيكل من 3.42 إلى 6.23 مايكرو غم/غم بمتوسط (0.53±4.92) مايكرو غم/غم، النحاس من 11.86 إلى 20.35 مايكرو غم /غم بمتوسط (0.34±15.21) مايكرو غم/غم، الزنك من 30.55 إلى 114.43 مايكرو غم/غم، بمتوسط (0.14±51.15) مايكرو غم/غم.

تم الحصول على نتائج قابلة للمقارنة للعناصر الثقيلة في كل من السجائر المستوردة والسجائر الفلسطينية. أشارت هذه النتائج إلى أن نبات التبغ هو مصدر رئيس للعديد من العناصر الثقيلة الملوِّثة، وأظهرت أن محتواها في السجائر المباعة في فلسطين مشابه للسجائر في أنحاء العالم، لكن تراكيز بعض هذه العناصر أعلى قليلا في السجائر الفلسطينية من السجائر المستوردة.

تشير النتائج أن التعرض لمختلف العناصر الثقيلة السامة منها والمسببة للسرطان عن طريق الاستنشاق أعلى بكثير في الأماكن التي يتواجد فيها المدخنون وبالتالي نسبة حدوث مشاكل صحية تكون أكبر. التدخين والتعرض للدخان من قبل غير المدخنين مشكلة خطيرة يجب أن تؤخذ في الإعتبار عند إجراء دراسات عن تعرض الإنسان للمعادن الثقيلة.