REPUBLIC OF TURKEY
FIRAT UNIVERSITY
THE GRADUATE INSTITUTION OF NATURAL
AND APPLIED SCIENCES

DETERMINATION OF MINERAL AND TRACE ELEMENT IN SOME MEDICINAL PLANTS IN NORTH REGION OF IRAQ BY SPECTROSCOPIC METHOD

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Master Thesis
Department: Chemistry
First Supervisor: Prof. Dr. Ali ÖLÇÜCÜ
Second Supervisor: Assoc. Prof. Dr. Harun ÇIFTÇI

ELAZIĞ-2017

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May-2017

DECLARATION

I hereby declare that the titled “Determination of Mineral and Tace Element in Some Medicinal Plants in North Region of Iraq by Spectroscopic Method” thesis is my own research and prepared by myself. Except for the quoted lines, and single words that are quoted. It is being submitted for the Degree of Master of Science in (Analytical Chemistry) at the Firat University.

DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who raised and taught me that even the biggest task can be accomplished if it is done patiently and one step at a time. I would like to thank the of my friend’s members for their understanding, moral supports, encouragements, prayers, patience and all kind of support.

ACKNOWLEDGEMENTS

First of all, we would like to express thanks to almighty God. Second, we would also like to thank Firat University and faculty of the department of Chemistry Science.

I gratefully acknowledge the continuous and valuable guidance and input of my principal first supervisor Prof. Dr. Ali ÖLÇÜCÜ, who gave me the golden opportunity to do this wonderful project on the topic of industrial training, which also helped me in doing a lot of Research and came to know about so many new things.

My grateful acknowledgement is extended to my second supervisor Assoc. Prof. Dr. Harun ÇIFTÇI for her great guidance.

I would like to thanks all laboratory technical staff, especially Mrs. Ayşe ERDOĞAN and Emel.EKINCI who was always there to extend his hand in technical training and help for the instruments.

Secondly I would also like to thank my parents and friends who helped me a lot in finishing this project within the limited time.

I am making this project not only for marks but to also increase my knowledge.

Thanks again to all who helped me.

Mohammed RAMADHAN

ELAZIĞ-2017

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ABSTRACT

DETERMINATION OF MINERAL AND TRACE ELEMENT IN SOME MEDICINAL PLANTS IN NORTH REGION OF IRAQ BY SPECTROSCOPIC METHOD

The aim of this study, to determine the concentrations of some important minerals and trace elements, such as macro mineral; magnesium (Mg), calcium (Ca), trace elements; zinc (Zn), copper (Cu), iron (Fe), ultra-trace elements; manganese (Mn), lead (Pb), nickel (Ni), aluminum (Al), in some of medicinal plants such as dill *(Anethum graveolens L)*, clove *(Syzygium aromaticum)*, cardamom *(Elettaria cardamomum)*, black mulberry *(Morus nigra)*, oak galls *(Dyer's Oak) (Quercus infectoria)*, basil *(Ocimum basilicum L)*, chamomile *(Matricaria chamomilla L)*, thyme *(Thymus vulgaris L)*, peppermint *(Mentha x piperita L)*, ginger *(Zingiber officinale)*, purslane *(Portulaca oleracea L)*, coriander *(Coriandrum sativum L)*, cinnamon *(Cinnamomum zeylanicum)*, some of these plants which naturally grown in the Northern Region Iraq. For this purpose, during 2016 these plants were harvested from around Erbil.

Microwave digestion procedure was applied under optimized conditions for digesting sample of plants. Concentrations of minerals and trace elements in sample of plants were determined by using High Resolution Continuum Source Flame Atomic Absorption Spectrometry (HR CS-FAAS).

Calcium and magnesium observed with the highest concentration in all the medicinal plants studied as compared to other trace elements recorded. The studied medicinal plants were found calcium in basil (5.63 ± 0.36 mg/g) and magnesium in purslane (1.37 ± 0.12 mg/g) respectively, Also copper (0.38 ± 0.03 μg/g) in Cinnamon was found to be the lowest concentration in all the medicinal plants studied as compared to other trace elements recorded.

Decreasing sequence of the mean concentrations of the minerals and trace elements levels in medicinal plants studied were found in this orders: Ca > Mg > Zn > Fe > Al > Pb > Ni > Mn > Cu.

Keywords: HR CS-FAAS, medicinal plants, microwave digestion, mineral and trace elements.

ÖZET

IRAK'IN KUZEYİNDEKİ BAZI TIBBİ BİTKİLERDEKİ MİNERAL VE ESER ELEMENTLERİN SPEKTROSKOPİK YÖNTEMLE ILE TAYINI

Bu çalışmanın amacı, Irak'ın kuzey bölgesinde doğal olarak yetişen dereotu *(Anethum graveolens L),* karanfil *(Syzygium aromaticum),* kakule *(Elettaria cardamomum),* karadut *(Morus nigra)*, mazı *(Dyer's oak) (Quercus infectoria)*, fesleğen *(Ocimum basilicum L),* kekik *(Matricaria chamomilla L),* nane *(Thymus vulgaris L),* zencefil *(Mentha x piperita L),* semizotu *(Zingiber officinale)*, kişniş *(Portulaca oleracea L)*, tarçın *(Coriandrum sativum L),* papatya *(Cinnamomum zeylanicum)* gibi on üç tıbbi bitkideki makro mineral; magnezyum (Mg), kalsiyum (Ca), eser elementler; çinko (Zn), bakır (Cu), demir (Fe), ultra eser elementler; mangan (Mn), kurşun (Pb), nikel (Ni), alüminyum (Al) gibi bazı önemli mineral ve eser elementlerin konsantrosyonunu belirlemektir. Bu amaçla 2016 yılları arasında bu bitkiler Erbil ve çevresinden hasat edildi.

Bitki örneklerini parçalamak için optimize edilen şartlar altında mikrodalga parçalama yöntemi uygulandı. Bitki örneklerindeki mineral ve eser elementlerin konsantrasyonları Yüksek Çözünürlüklü Sürekli Işın Kaynaklı Alevli Atomik Absorpsiyon Spektrometresi (HR CS-FAAS) kullanılarak tayin edildi.

İncelenen tüm tıbbi bitkilerdeki kalsiyum ve magnezyumun konsantrasyonu tayin edilen diğer elementlerin konsantrasyonundan daha yüksek olduğu gözlendi. Çalışılan tıbbi bitkilerde kalsiyumun sırasıyla en yüksek fesleğen de (5.63 ± 0.36 mg/g) ve magnezyum semizotunda (1.37 ± 0.12 mg/g) olduğu, ayrıca bitkilerdeki konsantrasyonu en düşük olan eser elementin tarçınde bakırın (0.38 ± 0.03 µg/g) olduğu bulundu.

İncelenen tıbbi bitkilerdeki element seviyelerinin ortalama konsantrasyonlarının azalan sırası bu şekilde bulundu: Ca > Mg > Zn > Fe > Al > Pb > Ni > Mn > Cu.

Anahtar Kelimeler: HR CS-FAAS, tıbbi bitkiler, mikrodalga parçalama, mineral ve eser elementler.

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LIST OF SYMBOLS AND ABBREVIATIONS

General and Medical

RDA	: Recommended dietary allowance
UK	: United Kingdom
US	: United States
USA	: United States of America
USD	: United States dollar
WHO	: World health organization

Instrumental

AAS	: Atomic absorption spectroscopy
ETAAS	: Electrothermal atomic absorption spectroscopy
FAAS	: Flame atomic absorption spectroscopy
GFAAS	: Graphite furnace atomic absorption spectroscopy
ICP-AES	: Inductively coupled plasma atomic emission spectrometry
ICP-MS	: Inductively coupled plasma mass spectrometry
ICP-OES	: Inductively coupled plasma optical emission spectrometry
INAA	: Instrumental neutron activation analysis
HR-CS	: High Resolution-Continuum Source

Measurements

g	: Gram
kg	: Kilogram
L	: Litre
mg	: Milligram
min	: Minute
mL	: Millilitre
µg	: Microgram
°C	: Celsius
mΩ	: Milliohm
nm	: Nanometre
ppm	: Parts per million
SD	: Standard deviation

% : Percentage

Chemistry

Ag : Silver
Al : Aluminium
As : Arsenic
Au : Gold
B : Boron
Ba : Barium
Ca : Calcium
Cd : Cadmium
Cl : Chlorine
Cr : Chromium
Co : Cobalt
Cu : Copper
Fe : Iron
Hg : Mercury
K : Potassium
Mg : Magnesium
Mn : Manganese
Na : Sodium
Ni : Nickel
P : Phosphorous
Pb : Lead
S : Sulfur
Se : Selenium
Si : Silicon
Sr : Strontium
Ti : Titanium
U : Uranium
Zn : Zinc
C : Carbon
H : Hydrogen
N : Nitrogen
O : Oxygen

1. INTRODUCTION

Determination of trace elements and minerals in some medicinal plants from north region Iraq such as dill *(Anethum graveolens L)*, clove *(Syzygium aromaticum)*, cardamom *(Elettaria cardamomum)*, black mulberry *(Morus nigra)*, oak galls (Dyer's Oak) *(Quercus infectoria)*, basil *(Ocimum basilicum L)*, chamomile *(Matricaria chamomilla L)*, thyme *(Thymus vulgaris L)*, peppermint *(Mentha x piperita L)*, ginger *(Zingiber officinale)*, purslane *(Portulaca oleracea L)*, coriander *(Coriandrum sativum L)*, cinnamon *(Cinnamomum zeylanicum)*. The concentrations of some essential and non-essential heavy metals, namely; (Cu, Ca, Zn, Mn, Fe, Mg, Al, Pb, Ni), have been analyzed. The sampling was conducted from Ahi Evran University, Kirsehir, Turkey were analyzed by High Resolution-Continuum Source Flame Atomic Absorption Spectrometer (HR-CS FAAS). The method is rapid, accurate, precise and sensitive. The samples were digested with concentrated nitric acid in a microwave system provides a better, safer and cleaner method of sample preparation. Using a nitric acid (HNO3) digestion mixture in conjunction with microwave ovens in closed teflon vessels [1, 2, 3, 4]. Digest analyte concentrations can be determined by atomic absorption spectrometry (AAS) [5].

Medicinal herbs are widely used for treatment of diseases around the World. According to the World Health Organization (WHO) report about 80% of the world populations are taking interest in indigenous medicinal plants remedies. Herbal drugs or medicines have typically been used in the form of vegetables and fruit, drugs or their extract for the treatment of the diseases or protection and for maintenance health [6, 7]. Important minor or trace dietary minerals are required and essential nutrients for humans' health (Cu, Zn, Fe) and only become harmful at high concentrations, while others (Pb, Al) can present a health risk [8-9]. prepared from different parts of medicinal plants, i.e. herbs, flowers, fruits, leaves, seeds, barks and roots, medicinal plant formulation play an important preventive role in treating free radical mediated disorders and supporting medicinal therapy of different chronic diseases. Their consumption is recognized to exhibit numerous health benefits and therapeutic activities, including antioxidant, hepatoprotective, choleretic, diuretic, inflammatory and even anticancer properties, anti-anemic, hypoglycemic and neuroprotective effects. All this is associated with a relatively high content of a variety of biologically active organic constituents and phytochemicals such as vitamins, flavonoids, phenolic acids and coumarines, as well as minerals (macro, micro and trace elements) [10]. Determination of minerals and trace elements in medicinal herbs is a part of quality control to establish their purity, safety and efficacy according to the, (WHO) [11]. It is important not only to establish a method for determining the levels of some minerals or elements major; magnesium (Mg), calcium (Ca), trace elements; zinc (Zn), copper (Cu), iron (Fe), ultra-trace minerals; manganese (Mn), lead (Pb), nickel (Ni), aluminum (Al), in medicinal plants and their infusions that are widely and habitually consumed and used in Iraq for medical purposes, but also to found a reliable analytical procedure on mineral elements analysis for example, simply employing a closed pressurized digestion system without optimizing the type and amount of reagents or heating temperature and program will not provide accurate and precise results [13].

A number of techniques such as inductively coupled plasma-atomic emission spectrometry (ICP-AES), inductively coupled plasma-mass spectrometry (ICP-MS), atomic absorption spectrometry (AAS), electro-chemical methods, instrumental neutron activation analysis (INAA), and total reflection X-ray fluorescence, are widely used to determine mineral and trace elements [12,13,14].

2. LITERATURE OF REVIEW

2.1. Medicinal Plants

2.1.1. History of Medicinal Plants

Medicinal herbs have the ability to synthesize a variety of chemical compounds that are used to carry out important biological vital functions [15]. The use about therapeutic plants need been a vital part from human health care in many cultures for centuries. It was found in Iraq on the first cultural significance plant waste record of about 60,000 a year ago in 1960 at the Neanderthal human burial site [16]. Medicinal herbs have a promising future because there are about half a million herbs worldwide, and many of them have not investigate yet their medical activities, and their medical activities could be decisive in the treatment of current or future studies [17, 18].

2.1.2. Definition of Medicinal Plants

The plants or herbs having therapeutic or medicinal effects are called medicinal plants. The term “medicine” can be referred to a preparation or as compound containing one or more drugs or therapeutic agents which are used in the treatment, cure or mitigation of various diseases and external or internal injuries of man and other animals [19, 20].

Accordingly, the World Health Organization (WHO) advisory group on medicinal plants has developed a definition of medicinal herbs as follows: A medicinal herb or plant is any plant containing, in one or more of its organs, substances that can be used for medicinal purposes or which are precursors for chemo-pharmaceutical semisynthesis or which are a precursor for the synthesis of useful medicinal products or drugs [20].

Medicinal plants are different kinds of herbs that some believe to have medicinal or therapeutic properties, but some herbs or their ingredients phytochemical have been proven by rigorous science or approved by regulatory agencies such as the European food safety authority to have medical effects or drug administration and United States (US) food [21, 22].

2.1.3. Medicinal Plants as Drugs

Medicinal plants are herbs that have similar properties to traditional pharmaceutical medicines. It has been used by humans throughout history either to treat or reduce the symptoms of the disease. Pharmaceutical drugs are usually modeled after compounds found in medicinal herbs [23].

Useful plants that have healing and therapeutic properties or have positive effects pharmacological beneficial to the animal and human body are commonly defined as a medicinal plant [19]. Some of the important chemical intermediates needed for the production of modern drugs obtained from herbs or plants for example (diosgenin, solasodine, b-ionone). These drugs are derived from plants provides a stable worldwide market as well as plants remain a major source of new drugs [17, 24]. Medicinal herbs include a various kinds of herbs used in herbalism and some of these herbs have a medical treatment (medicinal activities). Also these medicinal herbs are derivatives consider as a rich source of active ingredients that can be used in the development and synthesis of "drugs in aspirin, and toothpaste. In addition, these herbs play an important role in the development of human culture all over the world. Besides, some herbs considered as an essential source of nutrition and therefore of the suggested herbs for their therapeutic values. These herbs include walnuts green tea, ginger, and some others herbs [17].

These days became the term "Alternative Medicine" is very common in culture western, it centers on the idea of using the plants for purpose medicinal. But the current belief that the drugs which come in capsules or tablets that medications we can trust and use. However, many of these tablets and capsules we make and use during our daily lives came from herbs or plants. Medicinal herbs are often used as raw materials for the extraction of active ingredients which are used in the synthesis of various drugs. Such as blood thinners, laxatives, antimalaria drugs and antibiotics, contain plant ingredients. In addition, the active ingredients of taxol, vincristine, and morphine isolated from foxglove, periwinkle, yew, and opium poppy, respectively [17].

The search for new herbs or plant derive medicinal products has accelerated in recent years. Botanists, ethno pharmacologists, microbiologists and natural products chemists work on the phytochemicals that lead to the evolution of new bioactive compounds in the treatment of infectious diseases [24].

The World Health Organization (WHO); definition medicinal plant or herb is any plant that contains in one or more of its organ a substance that can be used for purpose medicinal or as a precursor for drugs useful and synthesis [25]. Medicinal plants are widely used for healing or treatment of diseases around the world. According to the report of World Health Organization (WHO), about 80% of the world population are taking interest in indigenous the treatment of medicinal herbs remedies. Herbal medicines have generally been used in the form of vegetable and fruit, drugs or their extract for the healing of the maintain health and illness [6, 7].

2.1.3.1. Significances of Medicinal Plants to Human Being

1¬ Many of the modern drugs are produced indirectly from medicinal plants, for example aspirin comes from willow bark.

Figure 2.1. Willow bark

2 ¬ The use of plants as drugs directly by a majority of cultures worldwide for example, Indian medicine and Chinese medicine.

3 ¬ Some food crops have medicinal effects, such as garlic.

4¬ Studying medicinal herbs helps to understand plant toxicity and protect human and animals from natural poisons.

5¬ Medicinal herbs are resources of new drugs. It is estimated there are more than 250, 000 flower herbs species.

6¬ Cultivation and preservation of medicinal herbs protect biological diversity, for example metabolic engineering of herbs [26, 27, 28, 29].

2.1.3.2. Characteristics of Medicinal Plants

Medicinal plants have many characteristics when used as a treatment, as follows:

1. Synergic medicine — the ingredients of herbs all interact at the same time, so that their use can supplement or harm others or neutralize their possible negative effects.
2. Support of official medicine — these are used to deal with the complex cases such as cancer diseases.
3. Preventive medicine — it has been proven that the component of the plants is also characterized by their ability to prevent the appearance of some diseases. This will help to reduce the use of the chemical remedies which will be used when the disease is already present for example, reduce the side effect of synthetic treatment [17, 18, 19, 30, 31].

Table 2.1. List of the nomenclature of medicinal plants in northern region Iraq and therapeutic uses

No	English name	Scientific name	Part of the plant analyzed	Medicinal uses (Therapeutic uses)	Refe-rence
1	Dill	*Anethum graveolens L*	Leaves, seeds	Actions as an aromatic, carminative, mildly diuretic, galactagogue, stimulant, stomachic, appetite stimulant and digestive herb, stimulates milk flow in a lactating mother ,reduce blood cholesterol and lipid levels, menstrual bleeding and dysmenorrhea.	105
2	Clove	*Syzygium aromaticum*	Seed	Vomiting and diarrhea due to spleen and stomach coldness, skin disorders like acne, anti-oxidant, antiseptic for viral conditions, digestive aid.	106
3	Cardamom	*Elettaria cardamomum*	Seed	Against cramps, rheumatic pain, inflammations, stomach-aches, constipation, dysentery.	106, 107, 108
4	Black mulberry	*Morus nigra*	Seed	Anti-fever, as a laxative, anthelmetic, and expectorant, arthritis and anemia, treatment of liver hypertension, diabetes, treat oral and dental diseases, gall bladder and heart infections.	109
5	Oak galls, Dyer's oak	*Quercus infectoria*	Seed	Skin diseases, eczema, menorrhagia, asthma, intestinal hemorrhage , antidote, phthisis, hemorrhages, Coughs, dysentery, impetigo, spermatorrhea intertrigo, febrifuge, ophthalmic, ointments and suppositories, haemostatic agent, chronic diarrhea and tri-chomoniasis.	110
6	Chamomile	*Matricaria Chamomilla L*	Flowers	It is provided in conditions such as anger, mumps, pain, teething, neuralgia, irritability,	111

				night sweats, rheumatism, numbness, ulcers, whooping cough, hysteria, influenza, peritonitis, gout, miscarriage, mastitis, hernia, jaundice, headache, asthma (with a psychological basis), fever, diarrhea, convulsions, fainting, dyspepsia, colic, earache, dysmenorrhea, congestion, cramp, flatulence, pregnancy problems, over-sensitivity due to abuse of coffee and narcotics, sciatica, etc.	
7	Basil	*Ocimum basilicum L*	Leaves, seeds, flowers	Lowers cholesterol, protects against radiation, eliminates toxins, improves digestion and provides a rich supply of antioxidants prevents gastric ulcers, relieves inflammation, and lowers fevers.	106
8	Peppermint	*Mentha x piperita L*	Leaves	Antimicrobial, antibiotics, synthetic drugs, headache.	112
9	Ginger	*Zingiber officinale*	Dry (rhizomes) roots	Stomach, to avoid heat cramps, diabetic, cough, inflammation.	106
10	Purslane	*Portulaca oleracea L*	Seeds, leaves	Purslane source of omega-3 fatty acids treat stomachache and antioxidants. Such as arthritis, diabetes, heart disease, essential fatty acids may help prevent inflammatory conditions.	115
11	Coriander	*Coriandrum sativum L*	Seeds	Anti-diabetic, anti-inflammatory, chest pains, antispasmodic, appetizer and dyspeptic and to treat abdominal discomforts, cholesterol lowering effects, treat coughs, as an aphrodisiac and bladder complaints.	113, 114

12	Thyme	*Thymus vulgaris L*	Leaves	Anti-bacterial and anti-oxidant activities, whooping cough, diarrhea, and digestive disorders, improve respiratory function.	116
13	Cinnamon	*Cinnamomu-m zeylanicum*	Inner bark	Diarrhea and digestive disorders, diabetes, toothache and fight bad breath, oxidative stress related illness.	106

No	Medicinal plants of north region Iraq	Figure of some plants like (Fresh, dry, powder)
1	Dill	 
2	Clove	 

3	Cardamom		
4	Black Mulberry		
5	Oak Galls, (Dyers Oak)		
6	Chamomile		

7	Basil		
8	Peppermint		
9	Ginger		
10	Purslane		

11	Coriander		
12	Thyme		
13	Cinnamon		

Figure 2.2. Images of some medicinal plants of north region Iraq

Figure 2.3. Map of showing locality of Erbil in northern region Iraq

2.2. Minerals and Trace Elements

Minerals are inorganic a source of many important nutrients, usually in small quantities of less than (1 to 2500) mg per day are needed, depending on the mineral [32]. Minerals that also play a_vital role in ensuring healthiness and wellbeing. They include the trace elements Cu, I, Fe, Mn, Se and Zn together with the macro elements Ca, Mg, K and Na. Also minerals and vitamins they are obtained from a wide diversity of foods and usually found in small amounts within the body [33]. In biological activity, some macro minerals and trace minerals play an important role and essential in the early life growth and improvement of children. Early growth rates are rapid and highest also help and activity in the development of organ systems in period of infancy or childhood, when the concentrations of these minerals and trace elements are vital importance and require a balanced diet rich in minerals and nutrients. Trace elements are essential in many important bodily functions, such as bone mineralization, enzymatic reactions, and in biological membranes defense and protection of lipids and cells. Trace elements may lead to lack of decreased bioavailability, which may in turn reason weakness of body functions [34, 35]. Also some chemical elements, such as P, Ca, Mg, Na, K, P and Cl, are found in many foods and comparatively large quantities in human foods needed for normal body function and are necessary to maintain body electrolytes and tissue homeostatics. The body needs calcium and phosphorus to maintain strong bones and used in the formation of bones, teeth and also connective tissues in human. Other chemical elements, like include Mn, F, I, Cr, Co, Ni, Cd, Se, Si, As, V, Fe, Zn, and Cu, are needed in small quantities for suitable body development and for general mend of body tissues and are considered essential elements [36]. That locates green leaves plants as good sources of trace elements and minerals essential for our diet. In both animal and human, studies initially showed that optimum intake of chemical elements like, Na, K, Mn, Mg, Ca, Cu, Zn, I, to reduce individual hazard factors, including those associated to heart disease and blood vessels [37, 38, 39, 40, 41]. There is growing interest in the importance of dietetic elements in the prevention of various diseases of all over the world. Elements are of vital importance in the nutrition, although they only represent 4–6% of the human body. Major elements are those needed in large quantities more than 100 mg per day and they comprise 1% or less of body weight. These include phosphorus (P), magnesium (Mg), sodium (Na), calcium (Ca), potassium (K), chlorine (Cl), sulfur (S). Trace elements are necessary in much smaller quantities, less than 100 mg per day, and make up less than 0.01% of body weight. Essential trace elements are manganese (Mn), iron (Fe), zinc (Zn), fluoride (F), silicon (Si), chromium (Cr), copper (Cu), and iodine (I). The main major metals are used such as H_2O, acid–base balance and formation of bone and membrane or structural components of tissues, and function in cellular and basal metabolism [42, 43, 44].

2.2.1. Classification of Metals

2.2.1.1. Minerals can be Further Sub Divided into two Groups, Macro (Major) and Micro Minerals

- **Macro minerals:** are usually defined as minerals that are needed by adults in quantities generally more than 100 mg/day or are present in the body represent 1% or less of body weight. Major (macro) minerals include magnesium (Mg), calcium (Ca), sodium (Na), chloride (Cl), potassium (K) and phosphorus (P).

- **Micro minerals:**

- Trace elements (or trace minerals) are usually defined as minerals that are needed in quantities generally between 1 to 100 mg/day by adults or are present in the body in quantities less than 0.01% of body weight. Trace mineral group includes zinc (Zn), copper (Cu), and iron (Fe).

- Ultra-trace minerals are defined as minerals that are needed in quantities generally (≤1) mg/day. They include manganese (Mn), fluoride (F), chromium (Cr), selenium(Se), cobalt(Co), silicon (Si), iodide (I), boron (B), molybdenum (Mo), nickel (Ni), lithium (Li), cadmium (Cd), arsenic (As), lead (Pb), and vanadium (V) [45, 46, 47, 48, 49, 50, 51].

Nutritionally essential minerals, which are usually regarded as necessary for humans. Some minerals are having beneficial effects at low levels of exposure but some minerals have not known to be important to health of human. These include V, B, Ni, and Si; these elements are toxic at higher levels. Some elements, and their inorganic compounds, are probably the most potentially toxic elements in the environment. They have no known beneficial effects or nutritional on health of human but are ubiquitous in nature and present in soil, water, air, so that some level of exposure is not readily preventable. Table 2.2. Below, list the elements identified in the environmental chemistry paper as elements of concern; it also lists Mg and Fe, which are essential nutritionally [52].

Table 2.2. Classification of elements based on characteristics of health effects [52].

Nutritionally Essential Metals	Metals with Possible Beneficial Effects	Metals with No Known Beneficial Effects
Cu	Ni	Pb
Zn	B	Al
Fe	V	As
Cr	Si	Sb
Mn		Cd
Mo		Ba
Se		Be
Co		TI
		Ag
		Hg
		Sr

2.2.1.2. Definitions of Trace Elements

1- Trace elements bear different name and they can also be described by various definitions which can be determined by the mode of its study, also they are generally known as likely toxic elements, heavy metals, trace metals, minor elements, and micronutrients. The term “toxic elements’’ is a recent word use to explain that some of these elements are toxic to both plant and animals, and just a few are poisonous in a certain amount of concentrations. Iron are needed for survival in little quantity [53].

Definition of trace element depends on the disciplines and field of application. For example, in chemistry define transition metals or trace elements, as like periodic table between (Group IIIA) and (Group IIA) those elements which fall in the center and exhibit partial d-orbital filling. Also chemistry definitions of “trace elements” are have metallic properties and based on atomic weight (larger than that of sodium), density (larger than 5 g/cm^3). Soil fertility experts’ trace elements define as those minerals that are “toxic” to medicinal herbs at highest concentrations level, but essential to medicinal herb growth in little quantities. Toxicologists consider minerals those trace elements distributed into the environment by industrial processes that are harmful to the environment or human health [54].

Trace elements are very important for body of human to maintain normal yet complex physiological functions related to body’s development and growth. These elements are called trace owing to their concentration in the body which is few milligrams per kilogram or less [55].

Trace elements including heavy metals may be categorized into two classes depending on whether or not the biological processes keep them in the correct level in our bodies. They are called essential or non-essential based on their biological effect, diseases that occur because of their deficiency and toxicity due to overdose. Cu, Se, Fe, Cr, Mn, Zn, Co, F, I, Mo, are called essential trace elements. The border line or probably essential are Ni, Ti, V, Si and B. Elements such as Al, As, Ba, Bi, Br, Cd, Au, Pb, Li, Hg, Rb, Ag, Sr, Ti and Zr are called non-essential. An element is considered essential when its reduction below the required concentration affect the physiological state of an organism’s body. Non-essential elements show adverse health effects to organisms irrespective of their concentration level [56].

2-Heavy metals as likely arsenic (As), mercury (Hg), cadmium (Cd) and Lead (Pb) are widely dispersed in the environment. These elements have no useful property in humans, and there is no known homeostasis or equilibrium mechanism for them [57, 58]. They are commonly considered the most toxic to animals and humans; the influence or harmful effects on human health associated with exposure to them, even at low concentrations, are various and include, but are not limited to, actions carcinogenic and neurotoxic [24,25,26,27,28,29,30].

Heavy metals, as part of trace elements, are of great concern owing to their persistence and potential toxicity to human health. The long-term effect of heavy metals on human health is based upon their non-biodegradability and long biological half-lives for elimination. Although heavy metals occur naturally in various concentrations in the ecosystem, anthropogenic activities have contributed to their elevated concentrations beyond the required limit. Some of these heavy metals (e.g. Zn, Cu, Fe, Se, Co, Mo, I, Cr) are nutritionally essential and required in minute quantities for the normal functioning of the body, however, at elevated concentrations, they may be toxic [59,60] further substantiated that the large amounts of these metals may cause acute or chronic toxicity. A wide variety of toxic effects including neurological, hepatitic renal and hematopoietic ones may be exerted by heavy metals. Children and the elderly people are more susceptible to the direct effect of heavy metals [61, 62].

Table 2.3. Some commonly accepted functionally descriptive terms used to classify metals in bioenvironmental studies [63].

Description	Comments
Metal	Metals may be defined by the physical properties of the elemental state, but are better identified by consideration of their chemical properties. The term is used indiscriminately to refer to both the element and compounds.
Heavy Metal	A hopelessly imprecise and thoroughly objectionable term! It originates from a categorisation by density—hardly biologically significant. The term is now often used to mean any metal with atomic number >20, but there is no general concurrence.
Essential Metal	Broadly, one which is required for the complete life cycle of the organism and whose absence produces specific deficiency symptoms relieved only by that metal and whose effect is shown by a dose-response curve. The term is often used misleadingly since it should be accompanied by a statement of which organisms show a requirement for the element. New members. e.g. Ni, have recently been added to the group.
Beneficial Metal	An older term, now largely disused, this implied that a non-essential metal could improve vigour.
Toxic Metal	All metals are toxic, but the degree of toxicity varies greatly from metal to metal and from organism to organism. Toxicity, like essentiality, may be defined by a dose-response curve.
Abundant Metal	Usually refers to the proportion of the element in the earth's crust, though may be defined in terms of other regions, e.g. oceans, 'fresh water.
Available Metal	One which is found in a form which is easily assimilated by living organisms.
Trace Metal	A metal found in low concentration, perhaps ppm or less, in some specified source, e.g. soil, plant, tissue, ground water, etc. Sometimes this term has confining overtones of low nutritional requirement (by a specified organism).
Micro-nutrient	More recent term to describe the second of the meanings of trace metal, above.

2.2.2. Trace Elements and Minerals in Plant, Human and Animal Nutrition

1-Historically, soil scientists have studied trace elements and minerals for their effect on medicinal herb or plant nutrition and toxicity. A majority of this research was conducted in the 1950's and 1960's. In this case nutrients, the minerals and trace elements usually studied were those which are important for function and normal herb growth. Macronutrients (those nutrients required in large quantities by all herbs) group include Ca, C, S, H, K, Mg, N, O, and P, although O, H, C, are not typically considered mineral nutrients. Micronutrients (those nutrients required in relatively smaller quantities by all herbs) group include Zn, Cu, Mn, Mo, Cl, B and Fe. Additionally; a number of micronutrients are required by only certain herbs, including Ni, Si, V, Co, and Na. A lot of the research conducted by soil scientists for fertility purposes has been centered around deficiencies that limit herb growth and the essentiality of minerals and trace elements in the herb life cycle. A wide variation in soil content has been noted in soil fertility research. Certain minerals and trace elements at elevated concentrations are toxic to animals and humans. However, some minerals and trace elements are necessary by animals and humans for function of the body and healthy [54].

Essential trace elements and mineral are chemical elements which are necessary for the growth and reproduction of herbs. Synonyms for this term are nutrients, plant nutrients, mineral nutrients, or essential elements [64].

Macronutrients are nutrients that supply energy or calories. Nutrients are substances required for evolution, metabolism, and for other body functions. Because "macro" means large, macronutrients are nutrient necessary in large quantities.

There are macronutrients:

1. A type of food (e.g. fat, protein, carbohydrate) required in large amounts in the diet.
2. A chemical element (e.g. potassium, magnesium, calcium) required in large amounts for plant growth.

Micronutrients, as antonym or difference of macronutrients (fat, carbohydrates and protein), are include of minerals and vitamins which are needed in little amounts to guarantee normal metabolism, growth and physical wellbeing [33, 65].

2- The trace elements and minerals in medicinal plants get into the plants or herbs by absorption from soils or nutrient solutions through roots, foliar or translocation [66]. Mg, Mn, Ca, Fe, Zn, and other trace elements or mineral are necessary components for human health. The lack of any one of these elements can lead to harmful health problems. Dietary iron (Fe), zinc (Zn), calcium (Ca), and other elements are taken from both plant and meats or herb foods. Due to a variety of reasons, element deficiencies, mainly iron (Fe), zinc (Zn), calcium (Ca), deficiencies, are the big problems health in the human and developing countries, especially for children and infants. iron (Fe), zinc (Zn), deficiency causes delayed mental development, impaired immune function, and poor growth. Although numerous mineral supplements or mineral-containing nutraceuticals are available on the market, poor absorption of iron (Fe), zinc (Zn), calcium (Ca), by the humans significantly limits effectiveness of these supplements. Many reasons, mineral-mineral interactions during absorption, can influence their absorption, as well as health status of individual, or such as dietary vitamin, lipids and habits cofactors. Nevertheless, increasing dietary iron (Fe), zinc (Zn), calcium (Ca), in plant or herb foods is a vital significant strategy to enhance element nutrition [67].

2.2.2.1. Minerals Elements Needed for Good Health

Minerals or trace elements play important functions of humans and animals in physiological functions and the normal metabolism:

1. Bone and membrane formation: fluoride (F), calcium (Ca), magnesium (Mg), phosphorus (P).
2. Some elements are needed for the maintenance of H_2O and electrolyte balance in cells: Na, K, and Cl.
3. Metabolic catalysis: selenium (Se), copper (Cu), molybdenum (Mo), zinc (Zn), magnesium (Mg).
4. Oxygen binding: iron (Fe).
5. Impacts of hormone: I, Cr [68].

2.2.2.2. Essential Chemical Elements in Adult Diet

Recommended Dietary Allowances (RDA) for minerals and trace elements (mg) [69, 70, 71, 72, 73, 74].

Minerals	(RDA), (mg/day)
Cu	1.5 - 3.0
Mg	300 - 350
Fe	10 - 20
Ca	800 - 1200
Zn	15
Mn	2.0 - 5.0

2.2.2.3. Recommended Daily Intake Values as well as Toxic Values

The World Health Organization (WHO) report of the Food Drug Administration (FDA), and a variety of other governmental and private agencies in the UK and the USA have come up with recommended daily intake values of some metals as well as their toxic values are shown in table 2.4 and table 2.5 [75,76].

Table 2.4. Intake of some metals and their effects [75].

Metal	Recommended Daily Dose (U.S.)	Result of Deficiency	Toxic Level	Toxic Effects
Ca	1 g	Bone deterioration	> 2.5 g day^{-1}	Magnesium deficiency
Fe	10-15mg	Anemia	>60 mg kg^{-1}	Liver cirrhosis, vascular congestion

Cu	2 mg	Brain disease, anemia, heart disease	7.5 g (death)	Hemolytic anemia
Zn	15 mg	Growth retardation, skin changes	> 500 mg day^{-1}	Heavy vomiting

Table 2.5. Recommended daily intake values of some metals and their toxic values [76].

Metal	Recommended Daily Intake (mg)	Toxic Intake
Mn	5	>5
Mg	350	400mg
Pb	1	10g
Ni	< 1	>1mg

2.2.3. General Function of Trace Elements and Minerals

The general function of trace elements and minerals in human health can be summarized as follows:

- Some elements such as Ca, P, are necessary components of skeletal structures like builds teeth and bones or maintaining bone strength.
- Some minerals such as Na, K, Cl, play a key role in the maintenance of osmotic pressure, and regulates bodily fluids and exchange of solutes and H_2O within the animal body.
- Elements serve as structural constituents of soft tissues.
- Elements are necessary for the communication and contraction of muscle and nerve function.
- Elements play a critical function in the maintenance of H_2O and electrolyte balance in cells and acid-base equilibrium of the body, and thus pH regulate of the blood and other body fluids.
- Elements serve as necessary components or mechanism in some enzymes that assist biochemical reactions, hormones, vitamins, and as cofactors in metabolism, or

respiratory pigments and minerals are required for the catalytic activity of enzymes [77].

2.2.4. Roles of Heavy Metals in Human Health and Toxicity

Environmental pollution by heavy metals has led to numerous adverse influences on human health [78]. Heavy metals are problematic due to their non-degradability and persistence in the environment [79]. They are also harmful because they tend to bioaccumulate. Bioaccumulation implies a greater amount of a chemical in a biological organism with time, compared to the amount of chemical in the environment. Interests in metals like copper, zinc, manganese and iron that are essential for metabolic functions in organisms rely on their nutritional value as well as their toxicity. Metals such as lead and chromium may exhibit extreme toxicity even at low concentrations under certain conditions [78].

The minerals as likely nickel, lead are supposed to be "toxic" in nature and their presence in little quantity in assorted medicinal herb sample analyzed is due to the pollution arising from industrial activities and automobile [79].

Nickel; no biochemical function for nickel has been clearly defined for higher animals or humans. Nickel may, however, function as a cofactor or structural component in specific metalloenzymes in higher organisms, because such enzymes have been identified in invertebrates, plants, bacteria, and fungi. These nickel-containing enzymes include carbon monoxide dehydrogenase, hydrogenase, methyl coenzyme M reductase, and urease [80, 81].

Lead; is not an essential mineral for human and it is very "toxic" for the kidneys and for the nervous system, Pb has no physiological or biochemical importance and is considered as a "toxic" pollutant. It may be causes a rise in blood pressure, decline fertility of men through sperm damage, brain damage, kidney damage, subtle abortion and miscarriages, disruption of nervous systems and diminishing abilities of children [82].

2.2.5. Deficiencies and Toxicity of Minerals

A well-balanced diet is very important for healthy human generally guarantees an adequate supply with all essential minerals. Imbalanced diets (dietetic) and consumption of a high degree of processed food can cause deficiencies of essential elements with subsequent development of diseases. Excessive load with essential elements causing symptoms of toxicity can occur, if food plants grow on the soil containing high concentrations of such minerals, either naturally or by contamination [83, 84]. Deficiencies of elements, particularly of Ca, Zn Fe, are a major public problem in developing countries and influence or harmful effects on animals and human health. Wheat or Grain crops and legumes are of worldwide importance in nutrition and provide high quantities of a variety of elements [85, 86]. Food of herb source is mainly important for supply with trace metals and minerals; though, it can also be an origin of toxic minerals, such as As, Tl, Th, U, Hg, Pb, Po, or Cd. These minerals have no known biological functions, but can harmfully interfere with biological reactions. Organisms generally have defense mechanisms against the toxicity of such minerals, and tolerate certain quantities in the diet [87]. The fact that an herb grows on volcanic soil does hence not guarantee high concentrations of essential elements and minerals. Tobacco herbs are known to accumulate cadmium and other toxic minerals in the leaves [88]. The heavy metal content of medicinal plant products is generally studied from the point of view of bioavailability and toxicity. Heavy metals such as As, Pb, Hg, Cd, Could be introduced into herbs in a variety of ways, including such as pollution during cultivation or contamination during cultivation, processing, and storage [89]. The analysis of heavy elements in herbal products is widely interested in many countries around the world (Australia, India, China, Turkey, Germany, Poland ...), where the herbal products have been used as (drugs scientific). The inorganic accompanied and compositions organic, minerals in many herbal products have been well identified using various advanced techniques of analytical chemistry [90, 91].

Table 2.6. Functions, deficiency and toxicity of some minerals in human [92, 75, 93].

Minerals	Functions	Deficiency Diseases	Toxicity
Ca	Bone formation, nervous system	Bone deformities, tetany	Cataract; gall stones; atherosclerosis
Mg	Bone formation, Metabolic catalysis, electrochemical regulation	Convulsions	Anaesthesia
Zn	Metabolic catalysis, protein formation	Decreased immune function, skin rashes, development and Poor growth.	Depressed immune function, decreased copper absorption.
Cu	Metabolic catalysis	Anemia, poor growth, bone abnormalities	Vomiting
Fe	Transportation of oxygen with blood	anemia: fatigue, weakness, small pale red blood cells, low hemoglobin	Gastrointestinal upset, liver damage
Mn	Metabolic catalysis	Impaired growth, skeletal abnormalities	Nerve damage
Al	Non-essential, non-beneficial elements	Depressed growth, incoordination, weakness in hind legs	Encephalopathy
Pb	Non-essential, non-beneficial elements	Non	Coma, renal failure, anaemia, gastrointestinal disturbances, peripheral neuropathy, encephalopathy, decrease in learning ability in children.
Ni	Redox regulation, antioxidant protection, enzyme catalysis, anti-tumorigenic metabolites	Depressed growth, dermatitis	Non

2.3. Microwave Decompositions

The use of microwave ovens for the decomposition of both inorganic and organic samples was first proposed in the mid-1970s and by now has become an important method for sample preparation. Microwave digestions can be carried out in either closed or open vessels, but closed vessels are more popular because of the higher pressures and higher temperatures that can be achieved [94].

One of the main advantages of microwave decompositions compared with conventional methods using a hot plate or flame (regardless of whether an open or a closed container is used) is speed. Typically, microwave decompositions of even difficult samples can be accomplished in five to ten minutes. In contrast, the same results require several hours when carried out by heating over a flame or hot plate. The difference is due to the different mechanism by which energy is transferred to the molecules of the solution [95].

2.4. Analytical Instruments for Determination of Elements in Plant

1. Atomic Absorption Spectrometry (AAS)
2. Inductively Coupled Plasma Mass Spectrometry (ICP-MS)
3. Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)
4. Neutron Activation Analysis (NAA)
5. X-ray fluorescence (XRF) [117].

2.4.1. Atomic Absorption Spectroscopy (AAS)

Atomic absorption spectroscopy (AAS) determines the presence of metals in liquid and solid samples. Allen Walsh has introduced it in 1950. Flame technique first described by Bunsen and Kirchhoff in (1806) for quantitative and qualitative analysis of metals [96, 97,100]. AAS is now one of the most versatile and popular methods for the trace elements researches. In atomic absorption there are two methods of adding thermal energy to the sample. A graphite furnace AAS uses graphite tube with strong electric current to heat the sample. In flame AAS we use the air acetyl flame or nitrous oxide - acetylene. The atoms vaporized in a flame, which absorb electronic energy levels (excitation). Spraying a solution of the substance into flame and the concentration of the element is determined from the intensity of the special design as a fine uniform spray. An atomizer using air or oxygen forms the drops. Then the analyte concentration is determined by the amount of absorption. Concentration measurements are made from working curve after calibrating the instrument with standards of known concentration. Air acetylene is the preferred flame for the determination of 35 elements by AAS, the temperature of the air acetylene flame is about the 2300 ℃.

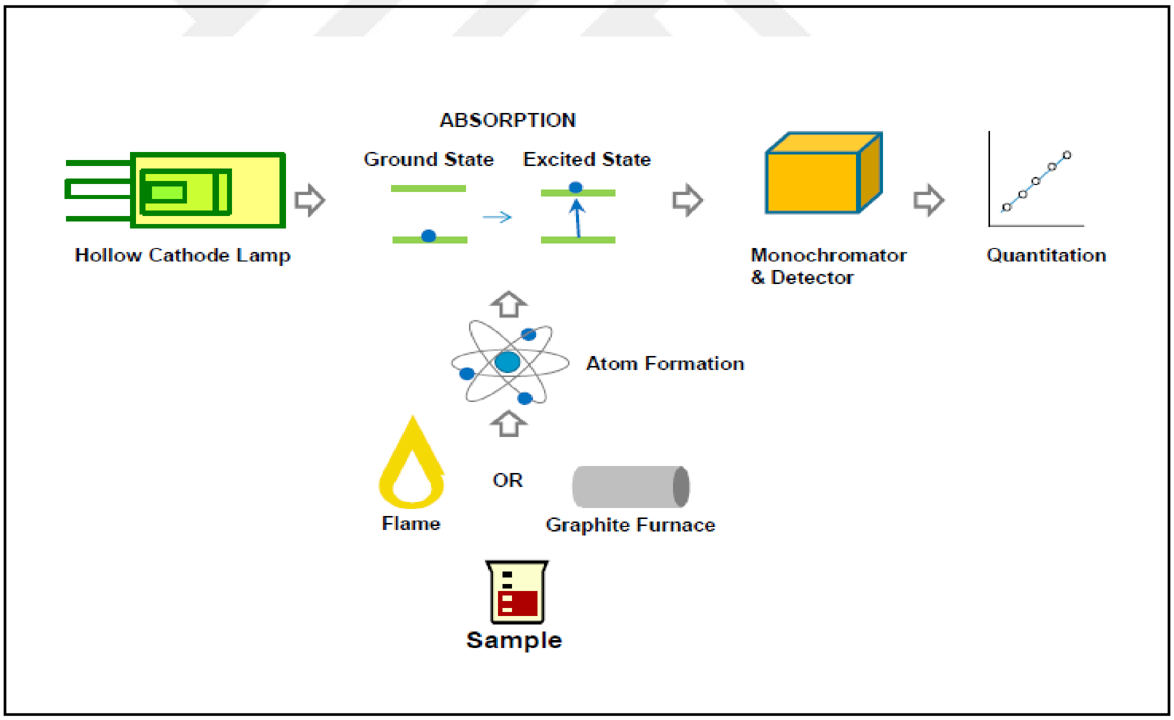
The main components of an (AAS) instrument are:

(1) Radiant energy detector system.

(2) Nebulizer and burner system.

(3) Hollow cathode or electrodeless discharge lamps containing the element of interest.

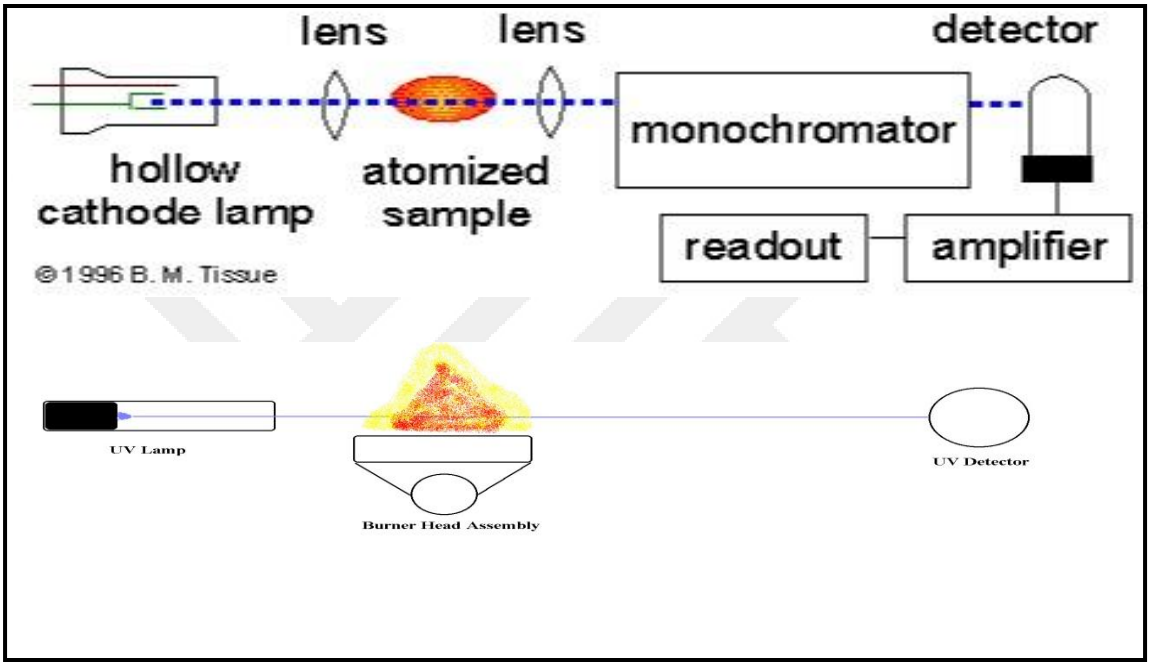
The two types of hollow cathode lamps are the multielement and the single element [98].



Appendix 2.1: Schematic diagram of GFAAS, FAAS [98].

2.4.1.1. Instrumentation

Schematic diagram of atomic absorption spectrometry system is shown in appendix 2.2. It consists of light source, an atomizer, detection device and data processor [99,100,101].



Appendix 2.2: Schematic diagram of atomic absorption spectrometry system. [99,100,101].

Beam sources used in atomic absorption measuring;

1. Hollow Cathode Lamps (HCL)
2. Electrodeless discharge lambs (EDL)
3. Steam discharge lambs
4. Flame
5. Continuum Sources

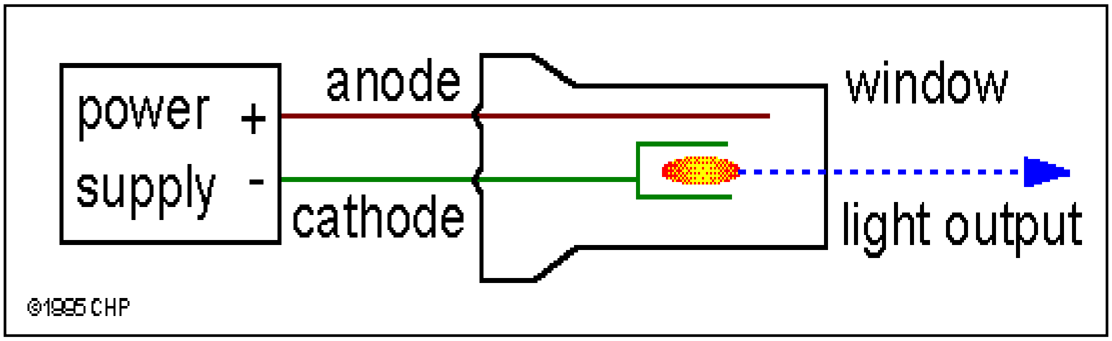
Since the device used in this study is High Resolution Continuum Source Flame AAS (HR-CS FAAS) where single lamb is used, detail information is given only on continuum source [138].

2.4.1.2. Continuum Sources or High Resolution Continuum Source Flame AAS (HR-CS FAAS)

In recent years, High Resolution Continuum Source Flame AAS (HR-CS FAAS) devices, as an option to AAS (LS FAAS) with hollow cathode lamp (Line Source), have been developed. All wavelengths required for all possible analytical determinations are provided by a single lamp, thus reducing lamp cost. As a continuum source, a xenon arc lamp emitting a strong beam between 185-900 nm is used. With this device, single lamp, it is possible to analyze multiple elements in a flammable and hydride system. With the detector system it has, periphery of analytical line within 0.3nm area in absorbance spectrum against wavelength/pixel is monitored and thus spectral interferences can be detected during method developing [137]. Since hollow cathode lamps of some radioactive elements that are formed and decomposed in a very short time cannot be produced, such elements can also be identified with HR-CS FAAS. It is also possible to analyze isotope elements at characteristic wavelengths. Using some equipment, the non-metallic molecules such as phosphorus, sulfur and halogens can be identified from molecular absorption spectra between 185 and 900 nm. The most important problem for element identification in continuum sources is that the emission line coming from the source is wider than the absorption line of analyte, resulting in absorption of only a fraction of the incoming light of the analyte ions. Today, this problem is solved with the development of high-resolution double-echelle monochromators. Since this monochromator has a resolution of 2 picometers at 200 nm, it can clearly distinguish the absorption line of the analyte and transfer it to a high UV sensitive CCD (charge coupled device) detector with a photodiode series. In HR-CS FAAS, by acquiring less floor signal and more high analyte signal comapred to LS-FAAS, identification limit for elements to be identified are decreased by 5-7 times [138].

2.4.1.3. Light Source

The light source is typically a hollow cathode lamp of the element that being measured lasers is also used in research instrument. The disadvantage of these narrow- band sources is that only one element is measurable at a time. The structure of hollow cathode lamp is schematically shown in appendix 2.2. [104].



Appendix 2.3: Schematic diagram of hollow cathode lamp [104].

2.4.1.4. Atomizer

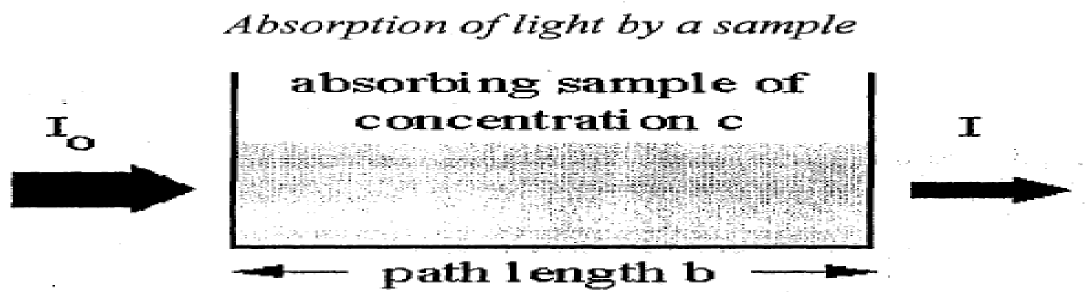
AAS require that the analyte atoms be in the gas phase. Atoms or ion in a Sample must undergo desolation and vaporization in a high temperature source such as flame or graphite furnace. Flame AAS can only analyze Solution, while graphite furnace AAS can analyze solutions, slurries and solid samples. Sample solution is aspirated with the gas flow into a nebulizing mixing chamber to form small droplets before entering the flame [104].

2.4.1.5. Light Detection

AAS uses monochromator and detectors for visible light and UV, the main purpose of the monochromator is to isolate the absorption line from background light due to interference. Simple detected AAS instruments often replace the monochromator with a band pass interference filter. Photomultiplier tubes are the most common detectors for AAS [100,102].

2.4.1.6. Principle Underlining AAS

In their elemental forms, minerals absorb ultraviolet light when they are excited by heat; each mineral has a characteristic wavelength that will be absorbed. Through a flame and into a detector, the sample of interest is aspirated into the flame; if that mineral is present in the sample it will absorb some of the light, thus reducing its intensity. The instrument measures the change in intensity. A computer data system converts the change in intensity into absorbency. The intensity of the transmitted radiation can be represented by Beer- Lambert's law (fundamental equation for calorimetry and spectroscopy) as follows [102].



$$I = I_o e^{-kcb}$$

Where

I: Light intensity after passing through the sample.

I_o: The initial light intensity.

c: concentration of absorbing atoms.

b: The length of the optical path in cm.

The basic mathematical relationship between change in intensity or energy of the radiation passing through absorbing medium, the length of the optical path, and the concentration of the absorbing molecular species is commonly quoted Bear- Lambert law or the Bouguer- beer law, formulated as an exponential absorption law in which concentration and length appear as symmetrical variables. Beer's law may be expressed simply as the absorption of a medium is directly proportional to the number of absorption centers. It would be in place to recall that the Lambert's law is a credit for investigating the change of absorption of light with the thickness of the medium; whereas the Beer's law is applied similar experiment to solutions of different concentrations. In the combined form they referred to as the Beer - Lambert's law as written above [103].

The combined formula holds rigorously only when:

(i) The incident radiation is monochromatic or homogenous that is the radiant energy of a single frequency.

(ii) Absorbing centers (molecules and ions) act independently of one another regardless the medium is homogeneous, isotropic or nonmetallic.

(iii) The absorption is limited to a volume of uniform cross-section that is to rectilinear transmission through a medium having smooth, parallel surface.

(iv) The colored substances or pigments do not react with the solvent or undergo disassociation or other change on dilution or do not exhibit dichorism and don't absorb light differentially [102, 70,100].

3. EXPERIMENTAL WORK

3.1. Sample Collection

Thirteen medicinal plants were collected from local market in Erbil North Region Iraq. The parts of the plants were collected Such as stem barks, Seeds, root barks, inner bark, flowers and leaves. some medicinal plants were collected from local market such as dill *(Anethum graveolens L)*, clove *(Syzygium aromaticum)*, cardamom *(Elettaria cardamomum)*, black mulberry *(Morus nigra)*, oak galls (Dyer's Oak) *(Quercus infectoria)*, basil *(Ocimum basilicum L)*, chamomile *(Matricaria chamomilla L)*, thyme *(Thymus vulgaris L)*, peppermint *(Mentha x piperita L)*, ginger *(Zingiber officinale)*, purslane *(Portulaca oleracea L)*, coriander *(Coriandrum sativum L)*, cinnamon *(Cinnamomum zeylanicum)* after washing by water while still fresh and cut into small pieces and then dried at shade temperature between (32 °C - 40 °C) for one week and powdered for different periods of time depending on the succulence of the plant materials. The powdered plant materials were kept at room temperature away from direct sunlight in closed dry plastic bags. And we brought samples in Turkey to directly subject to analysis [118].

3.2. Reagents and Standards

All solutions were prepared using ultra-pure water (specific resistance 18 MΩ cm) from a Milli-Q purification system (Millipore Corporation, Massachusetts, USA). Standard solutions of analytes were prepared from their 1000 mg L^{-1} stock solutions (Merck). All glassware was cleaned using ultra-pure water, kept in nitric acid for 24 h, and washed again with ultra-pure water.

3.3. Sample preparation

3.3.1. Digestion and Analysis Procedure

The sampling was conducted from Ahi Evran University, Kirsehir of Turkey in December of 2016. The medicinal plants were transferred to the laboratory. The method prepared for sample plants for the quantitative determination of the concentration of magnesium (Mg), copper (Cu), calcium (Ca), iron (Fe), manganese (Mn), lead (Pb), aluminum (Al), nickle (Ni) and zinc (Zn), using a nitric acid (HNO_3) digestion mixture in conjunction with microwave heating in closed Teflon vessels [47,48,49,50]. The thirteen medicinal plants samples were brought in to solution by digestion in Teflon (PTFE). For this purpose, a 5 mL of concentrated 60% HNO_3 nitric acid was added to each of the 0.2 g medicinal plants samples in polytetrafluoroethylene (PTFE) bombs. The mixtures were agitated well and kept standing overnight at room temperature for pre-digestion. Then, the PTFE-bombs with the mixtures were tightly closed and put in a microwave oven.

In a tightly closed system, the five-step microwave digestion program (200 W, 5 min; 0 W, 5 min; 400 W, 5 min; 0 W, 5 min and 800 W, 5 min) was applied. PTFE bomb was left to cool for an hour and then carefully opened. Colorless solution was transferred into a beaker and evaporated to dryness with a hot plate. Afterwards final volume was diluted to 10 mL with 1 % HNO3 solutions. The clear solutions were analyzed by High Resolution-Continuum Source Flame Atomic Absorption Spectrometer (HR-CS FAAS) for the determination of minerals and trace elements. In addition, blank samples were prepared and analyzed using same method. Results of medicinal plants analysis were given in table 4.1, table 4.2.

3.4. Instrumentation

The analysis was performed by ContrAA 300 a High Resolution-Continuum Source Flame Atomic Absorption Spectrometer (HR-CS AAS) (Germany, Berlin, GLE) equipped with a 50 mm burner head. All absorption lines of an element in the spectral range of 185-900 nm can be analytically evaluated by using a Xe short-arc lamp as a continuum lamp source. The spectral background of the sample in the HR-CS FAAS is always corrected directly on the analysis line simultaneously and independently. All measurements were carried out under optimum conditions in three replicates.

Figure (3.1 to 3.9) shows the calibration curves for (Cu, Pb, Zn, Al, Mn, Ni, Fe, Ca, Mg) respectively and (table 3.1) show the characteristics data of the calibration curves of elements using **(**HR-CS FAAS).

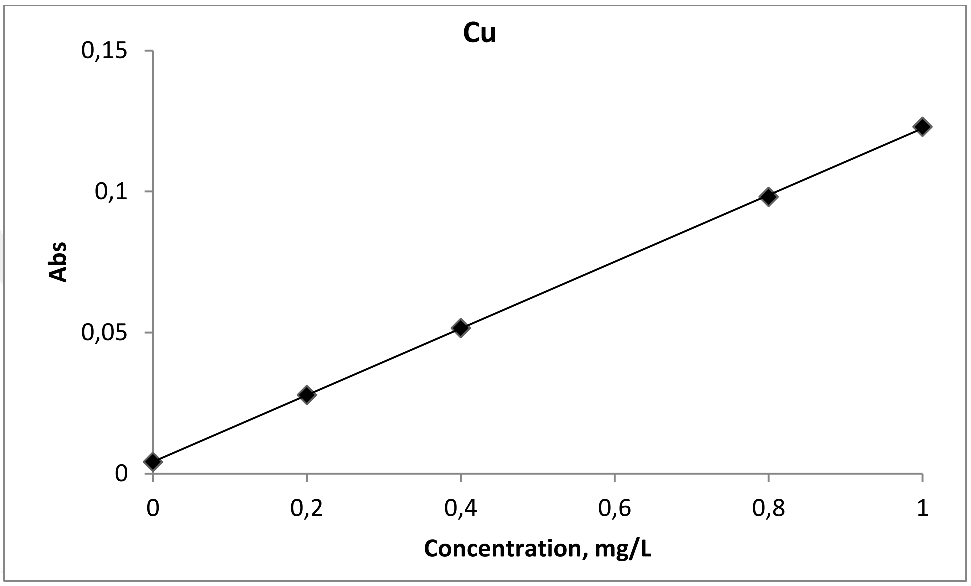


Figure 3.1. Calibration graph of Copper

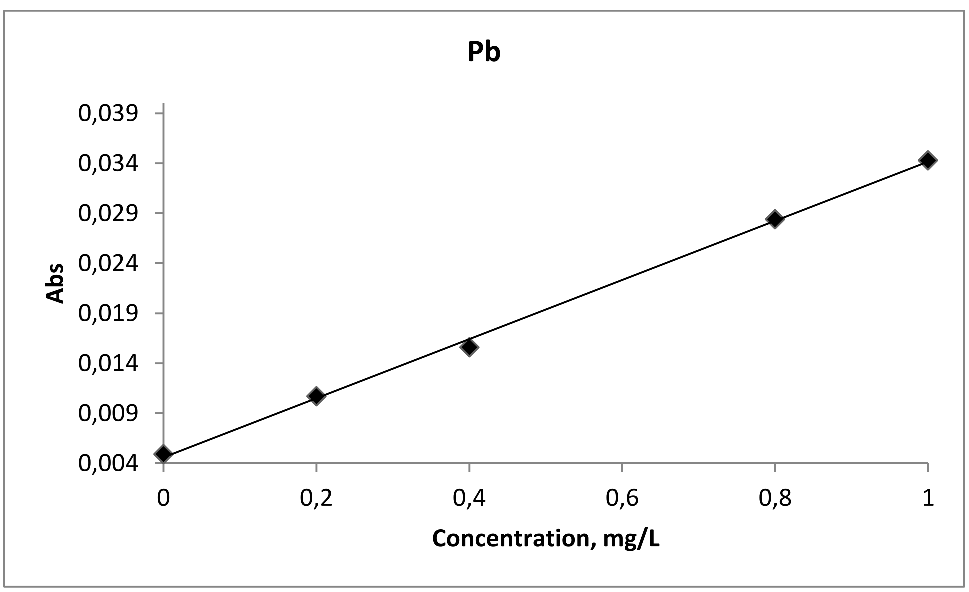


Figure 3.2. Calibration graph of Lead

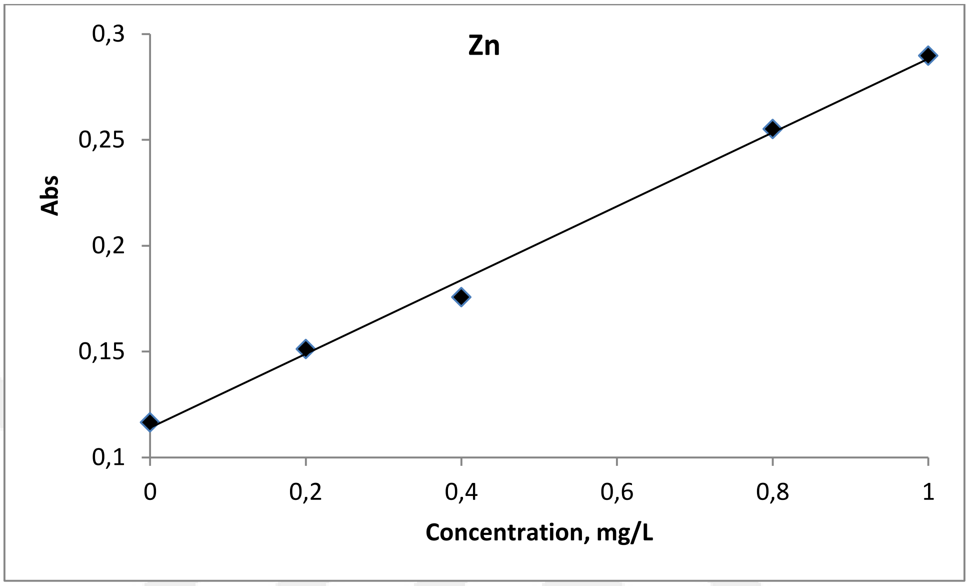


Figure 3.3. Calibration graph of Zinc

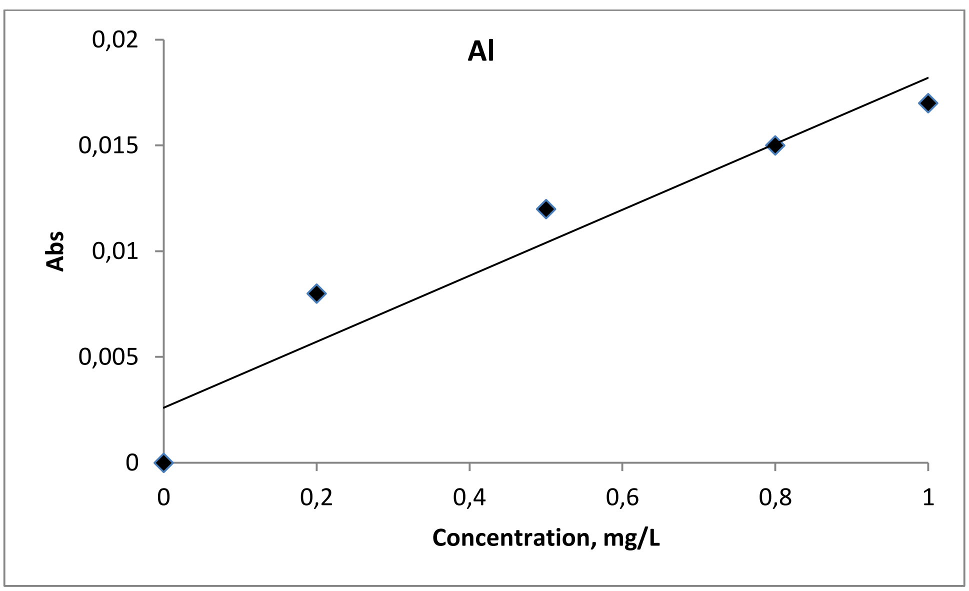


Figure 3.4 Calibration graph of Aluminum

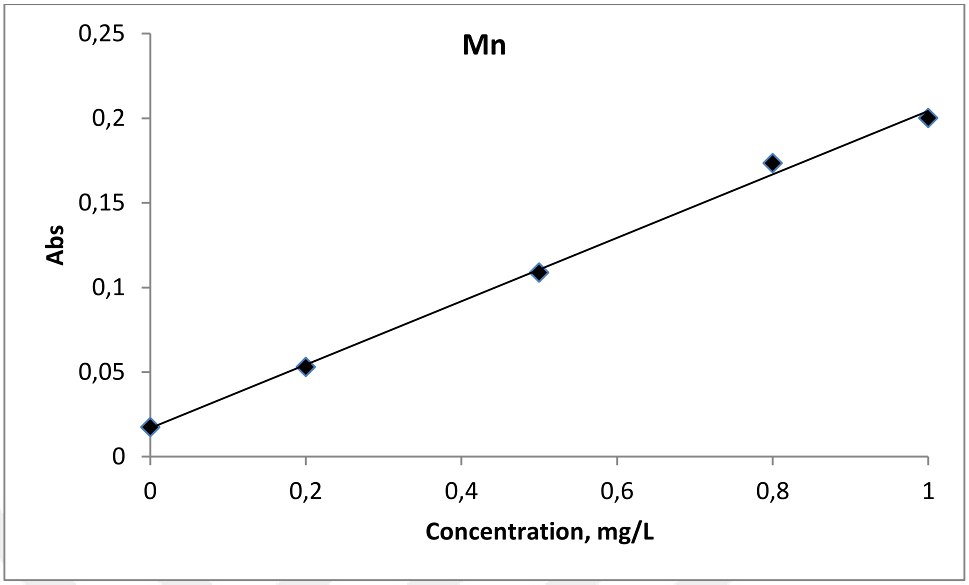


Figure 3.5. Calibration graph of Manganese

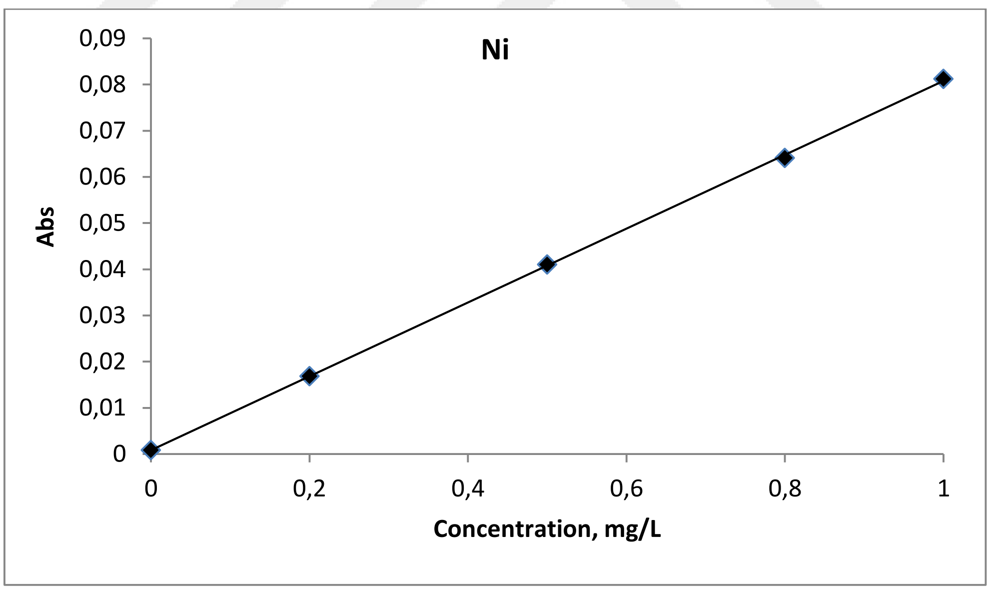


Figure 3.6. Calibration graph of Nickel

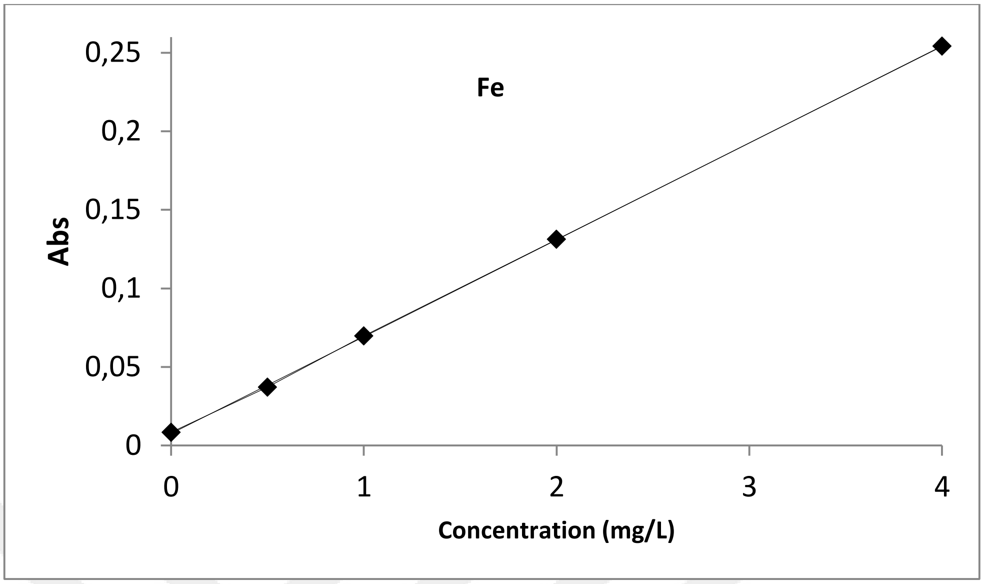


Figure 3.7. Calibration graph of Iron

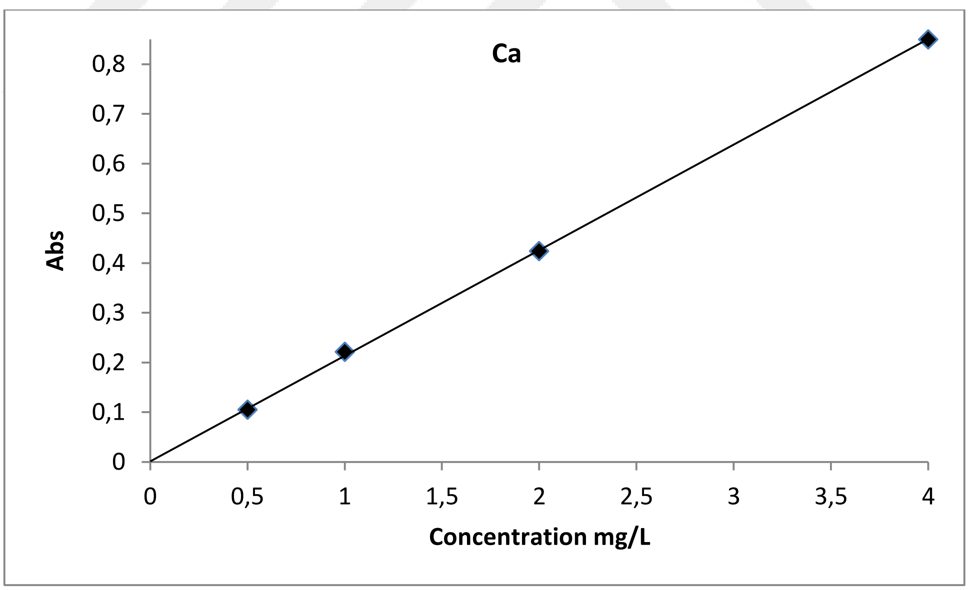


Figure 3.8. Calibration graph of Calcium

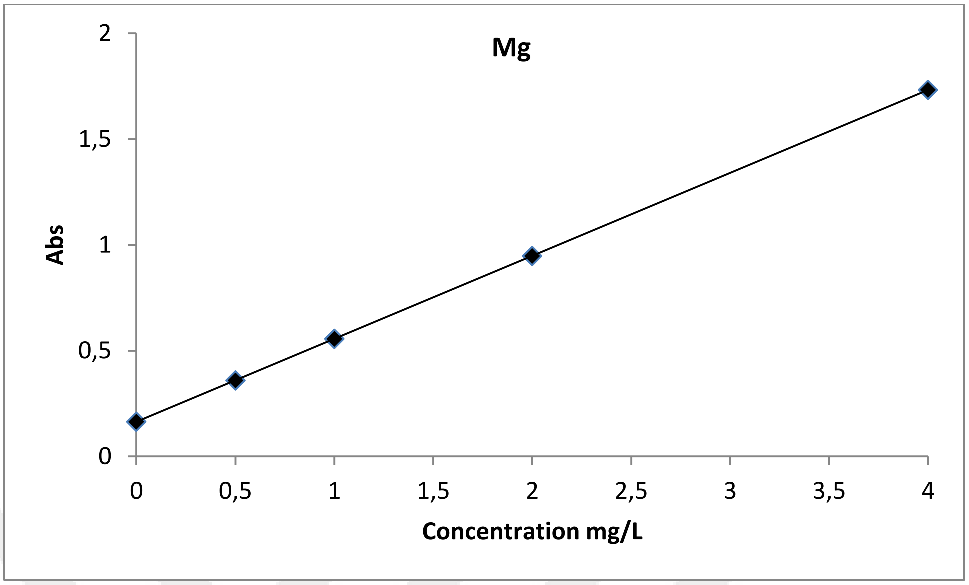


Figure 3.9. Calibration graph of Magnesium

Table 3.1. Characteristics data of the calibration curves of elements using **(**HR-CS FAAS)

Metal	Calibration equation (mg L^{-1})	Correlation coefficient (R^2)	Dynamic range (mg L^{-1})	Wave length (nm)
Cu	y = 0.1187x + 0.0042	0.9999	0.2- 2	324.754
Pb	y = 0.0294x + 0.0049	0.9971	0.2-10	217.0005
Zn	y = 0.1782x + 0.1166	0.9916	0.2- 1	213.856
Al	y = 0.01x + 0.0007	0.9979	0.2- 10	396.152
Mn	y = 0.1826x + 0.0175	0.9999	0.2- 1	257.611
Ni	y = 0.0804x + 0.0008	0.9999	0.2- 2	231.604
Fe	y = 0.0614x + 0.0084	0.9974	0.2 – 20	259.941
Ca	y = 0.2128x – 0.0013	0.9999	0.2 – 5	422.673
Mg	y = 0.3922x + 0.1635	0.9972	0.2 – 2	279.079

4. DISCUSSION AND RESULTS

Thirteen medicinal plants were determined by ContrAA 300 a High Resolution-Continuum Source Flame Atomic Absorption Spectrometer (HR-CS AAS), the different concentrations of elements in the thirteen medical herbs are shown in table 4.1, table 4.2.

The variation in elemental concentration is mainly attributed to the differences in botanical structure, as well as in the mineral composition of the soil in which the plants are cultivated. Other factors responsible for a variation in elemental content is preferential absorbability of the plant use of fertilizers, irrigation water and climatologica conditions [119].

The trace elements and minerals in medicinal plants get into the plant or herb by absorption from soils or nutrient solutions through roots, foliar or translocation [120].

Trace elements are both non-essential and essential in an organism. Essential trace elements are those elements that are necessary for the correct functioning and equilibrium of the organism. Non-essential trace elements are elements that may be toxic to the organism. They occur in little quantities in terrestrial and aquatic ecosystems [66]. Both non-essential and essential trace elements become toxic when the levels are elevated. However, some of the elements are beneficial to humans at low levels as they can boost the human immune system. Knowledge of trace element content in crops is significant for the identification of adequate, sub adequate and marginal intake levels for humans, so that diseases related to trace element deficiency can be overcome. The trace elements considered in this study and their roles in the human body are briefly discussed in the following subsections [121].

The levels of trace elements and minerals in the medicinal plants studies were determined and the results shown in table 4.1 and table 4.2.

Analysis of the present data revealed that calcium (Ca) and magnesium (Mg) content were observed in table 4.2 observed with the highest concentration in all the medicinal plants studied as compared to other trace elements recorded. The highest concentration of the calcium (Ca) and magnesium (Mg) among the studied medicinal plants were found calcium (Ca) in basil *(Ocimum basilicum L)* and magnesium (Mg) in purslane *(Portulaca oleracea L)* (5.63, 1.37 mg g^{-1}) respectively, but smallest concentrations of calcium (Ca) and magnesium (Mg) in oak galls (0.18, 0.06 mg g^{-1}) respectively.

Also (0.01 μg/g) Cu in clove was found to be the lowest concentration in all the medicinal plants studied as compared to other trace elements recorded.

Table 4.1 lists the concentrations of (μg/g) and table 4.2 (mg/g) (mean ± standard deviation) of levels of mineral and trace elements in the medicinal plants. Table 4.3 shows a comparison of results concentrations of elements in literature published reports of medicinal plants.

As can be seen from table 4.1 and table 4.2 the levels value of mineral and trace elements in the medicinal plants samples obtained:

Calcium:

The concentrations of Ca in samples studied that range between (0.18 – 5.63 mg/g). The higher quantity of Ca in all samples was determined in basil (5.63 mg/g), but small concentration of calcium (Ca) in oak galls (0.18 mg/g).

The plants of purslane, dill, thyme, basil are rich in Ca (3.64, 4.09, 4.14, 5.63 mg/g) respectively and are recommended for use in ayurvedic medicine in calcium deficient cases.

The concentration of Ca in samples studied that thyme, cinnamon, peppermint, chamomile, (4.14, 1.64, 2.33, 1.85 mg/g) (table 4.2). These values were comparable to (table 4.3) those reported for thyme, cinnamon, peppermint, (13.81, 9.60, 11.94 mg/g) respectively from Turkey, while Ca in thyme the highest concentrations in all the medicinal plants [124], also Ca in chamomile the smallest concentrations (0.189 mg/g) from Poland (table 4.3) [130].

Magnesium:

Magnesium is important to all the cells in humans. It is present in many enzymes involved in proteins, lipids, and carbohydrate metabolism. In plants, Magnesium is present in chlorophylls [132].

Table 4.2 shows the concentration of magnesium was found to be highest in purslane *(Portulaca oleracea L)* (1.37 mg/g). The concentration of magnesium was found to be lowest concentrations of magnesium (Mg) in oak galls dyer's oak *(Quercus infectoria)* (0.06 mg/g).

Purslanes, dill, basil, thyme, were the richest sources of magnesium with concentration values of 1.37 mg/g, 0.98 mg/g, 0.94 mg/g, and 0.64 mg/g, respectively. The concentration of Mg in samples studied that clove, cinnamon, cardamom, coriander, chamomile (0.63, 0.28, 0.55, 0.36, 0.35 mg/g) respectively (table 4.2). These values were comparable to those reported for clove, cinnamon, cardamom, coriander, (2.483, 0.4292, 3.87, 2.67 mg/g) from Pakistan, while Mg in cardamom the highest concentrations in all the medicinal plants [127], also Mg in chamomile the smallest concentrations (0.218 mg/g) from Poland (table 4.3) [130].

Zinc:

The element as Zn necessary minerals (micro nutrients) for living organisms. Zn is relatively non-toxic. Zn, deficiency is a public health problem associated with pregnancy complications and birth results, severity of diarrhea in children and increased duration, and impaired immune function [133].

Table 4.1 shows the concentrations of zinc in all the medicinal plants samples studies that range between (2.84–79.48 μg/g). The smaller quantity was determined in black mulberry (2.84 μg/g) and the maximum in dill (79.48 μg/g).

The concentration of Zn in samples studied that chamomile, cinnamon, peppermint, (8.39, 3.33, 5.84 μg/g) respectively (table 4.1). These values were comparable to those reported for chamomile, Peppermint, (88.8, 75.3 μg/g) from Poland, while Zn in chamomile the highest concentrations [130], also Zn in cinnamon the smallest concentrations (0.216 μg/g) from Iraq (table 4.3) [131].

Iron:

Fe is an important trace element for animals and human beings and is an essential component of haemoglobin [134].

In various medicinal herbs samples analyzed, the iron content was observed in (table 4.1) that the maximum in ginger (74.38 μg/g), and minimum in oak galls shows the values

(2.77 μg/g). Hence the use of ginger in general tonic preparation may be advised to compensate for (Fe) deficiency.

The concentration of Fe in samples studied that peppermint, cinnamon, basil, ginger, chamomile, dill (27.65, 6.01, 31.81, 74.38, 13.61, 49.76 μg/g) respectively (table 4.1). These values were comparable to those reported for peppermint, cinnamon, basil, ginger, chamomile, dill, (546, 108, 769, 345, 716, 220 μg/g) respectively from Turkey, while Fe in basil the highest concentrations [125], also Fe in cinnamon, basil the smallest concentrations (0.470 μg/g) from Iraq (table 4.3) [131].

Copper:

Cu is one of many elements that are essential to life, despite being as inherently toxic as nonessential heavy metals [135].

Table 4.1 for analyzed samples copper in oak galls has the highest content concentration (5.97 μg/g), but (0.01 μg/g) Cu in clove was found to be the lowest concentration in all the medicinal plants studied as compared to other trace elements recorded.

The concentration of Cu in samples studied that chamomile, cinnamon, dill, basil, coriander, (1.41, 0.38, 1.76, 2.30, 0.96 μg/g) respectively (table 4.2). These values were comparable to those reported for chamomile, cinnamon, dill, basil, (0.140, 0.068, 0.051, 0.077 μg/g) respectively from Iraq, while Cu in dill the smallest concentrations [131], also Cu in coriander, the highest concentrations (74.41 μg/g) from India (table 4.3) [129].

Manganese:

Table 4.1 shows the concentrations of manganese in samples studies that range between (0.04 -50.51 μg/g). The smaller quantity was determined for oak galls (0.04 μg/g) and the higher for ginger (50.51 μg/g).

The concentration of Mn in samples studied that cinnamon, coriander, clove, cardamom, (37.22, 3.13, 32.12, 16.30, μg/g) respectively (table 4.1). These values were comparable to those reported for cinnamon, coriander, clove, cardamom, (879.8, 48.74, 649.9, 758.1, μg/g) from Pakistan, while Mn in cinnamon the highest concentrations [123], also Mn in coriander, the smallest concentrations (11.9 μg/g) from Saudi Arabia (table 4.3) [128].

Nickel:

No biochemical function for nickel has been clearly defined for higher animals or humans. Nickel may, however, function as a cofactor or structural component in specific metalloenzymes in higher organisms [80, 81].

Table 4.1 for analyzed samples, cardamom has the highest content in nickel (0.54 μg/g), followed by cinnamon shows values has the smallest concentration (0.13 μg/g).

Dill, purslane, shows the similar values of Ni (0.52 μg/g), also ginger, black mulberry content (0.32 μg/g).

The concentration of Ni in samples studied that dill; (0.52mg/g) (table 4.1). These values were comparable to those reported for Dill, (7.59 μg/g) from Turkey, while Ni in Dill the highest concentrations [125], also Ni in dill, the smallest concentrations (0.023μg/g) from Iraq (table 4.3) [131].

Lead:

Lead, is not an essential mineral for human and it is very “toxic” for the kidneys and for the nervous system, and Pb has no physiological or biochemical importance and is considered as a “toxic” pollutant [82].

Table 4.1 dill has the great content in Lead (113. 01 μg/g). Thyme has the smallest content in Lead (0.41 μg/g).

The concentration of Pb in samples studied that cinnamon (0.61 mg/g) (table 4.1). These (level values) were comparable to those reported for cinnamon, (27μg/g) from Saudi Arabia, while Pb in cinnamon the highest concentrations [128], also Pb in cinnamon the smallest concentrations (0.042 μg/g) from Iraq (table 4.3) [131].

Aluminum:

Dill, ginger, thyme, have the similar values of Al (0.03 μg/g) this the highest values of Al, while the clove, cardamom, oak galls, peppermint, chamomile, coriander, cinnamon, black mulberry, shows the similar values of Al (0.01 μg/g) this the smallest values of Al, and basil, purslane, have the same concentration content in Al (0.02 mg/g) (table 4.2).

The concentration of Al in samples studied that chamomile (0.01 mg/g) (table 4.2). These (level values) were comparable to those reported for chamomile (0.356 μg/g) from Turkey, while Al in chamomile the highest concentrations [90], also Al in chamomile the smallest concentrations (0.122 μg/g) from Poland (table 4.3) [130].

In this study, we can observe that the minerals and trace elements contents in the medicinal plants were found at different levels. Therefore, these medicinal plants are rich in some essential elements, particularly Ca, Mg and Fe which are important for human health.

Medicinal plants also contain toxic elements; if not taken care of or consumed in wrong dosages may cause serious problems.

Some minerals are essential for a healthy diet (*e.g.*, Ca, Mg, Zn, Fe, Al, Pb, Ni, Mn, Cu.) whereas, others can be toxic (*e.g.*, Al, Pb, Ni). It is often important to know the mineral content of product during processing because this affects the physicochemical properties of the product.

Basil *(Ocimum basilicum L)* shows the high concentration of Ca macro mineral recorded in all samples. The plants of purslane, dill, thyme, basil are rich in Ca and Mg, are recommended for use in ayurvedic medicine in calcium and magnesium deficient cases.

The plants are rich of ginger in Fe, Mn, Al (74.38 μg/g), (50.51 μg/g), (0.03 mg/g) respectively and also dill in Zn, Pb, Al (79.48 μg/g), (113.01 μg/g), (0.03 mg/g) respectively, basil in Ca (5.63) oak galls in Cu (5.97 μg/g). While the oak galls show recorded the low concentrations of Ca, Al, Mg, Mn and Fe.

The concentrations of analyzed minerals were found to be dependent on the identity of the medicinal plants. This trend has been in the table 4.1, table 4.2 concentrations that range of Ca (0.18- 5.63 mg/g) and Mg (0.06–1.37 mg/g) were the highest, followed by Pb (0.41 – 113.01 μg/g), Zn (2.84–79.48 μg/g), Fe (2.77–74.38μg/g), and Mn (0.04 –50.51 μg/g), Al (0.01 – 0.03 mg/g), Cu (0.01–5.97 μg/g), Ni (0.13 –0.54μg/g), Ca >Mg >Pb >Zn >Fe >Mn >Al >Cu >Ni.

Table 4.1. Concentrations (μg/g) of elements in medicinal plants samples analyzed by (HR CS-FAAS)

Name of the herbs	Cu	Zn	Fe	Pb	Mn	Ni
Dill	1.76±0.09	79.48±3.65	49.76±2.82	113.01±4.55	0.39±0.04	0.52±0.05
Clove	0.01±0.001	3.41±0.03	18.80±3.78	4.39±0.38	32.12±2.30	0.30±0.02
Cardamom	0.28±0.05	5.75±0.45	2.81±0.24	4.23±0.36	16.30±2.15	0.54±0.09
Black mulberry	0.49±0.03	2.84±0.26	9.65±0.97	2.63±0.02	1.89±0.17	0.32±0.02
Oak Galls	5.97±0.56	12.92±1.18	2.77±0.21	2.31±0.22	0.04±0.01	0.29±0.02
Chamomile	1.41±0.12	8.39±0.75	13.61±1.12	3.22±0.31	6.90±0.53	0.35±0.03
Basil	2.30±0.21	8.84±0.78	31.81±3.52	3.01±0.22	7.57±0.64	0.48±0.04
Peppermint	0.81±0.07	5.84±0.42	27.65±2.45	1.12±0.10	8.15±0.73	0.37±0.02
Ginger	0.20±0.01	5.47±0.52	74.38±5.33	0.87±0.07	50.51±4.25	0.32±0.03
Purslane	0.18±0.01	4.62±0.33	42.85±2.92	1.08±0.12	12.72±1.91	0.52±0.04
Coriander	0.96±0.08	5.43±0.51	4.66±0.42	1.00±0.09	3.13±0.32	0.21±0.15
Thyme	0.61±0.05	5.44±0.52	57.57±3.83	0.41±0.03	6.33±0.55	0.34±0.28
Cinnamon	0.38±0.03	3.33±0.32	6.01±0.45	0.61±0.05	37.22±3.12	0.13±0.01

* (Means ± SD).

Table 4.2. Concentrations (mg/g) of elements in medicinal plants samples analyzed by (HR CS-FAAS)

Name of the herbs	Mg	Ca	Al
Dill	0.98±0.08	4.09±0.45	0.03±0.01
Clove	0.63±0.05	1.23±0.11	0.01±0.001
Cardamom	0.55±0.04	0.94±0.08	0.01±0.002
Black mulberry	0.27±0.01	1.38±0.12	0.01±0.01
Oak Galls	0.06±0.01	0.18±0.01	0.01±0.001
Chamomile	0.35±0.03	1.85±0.16	0.01±0.005
Basil	0.94±0.01	5.63±0.36	0.02±0.001
Peppermint	0.48±0.03	2.33±0.21	0.01±0.001
Ginger	0.35±0.02	0.31±0.03	0.03±0.01
Purslane	1.37±0.12	3.64±0.31	0.02±0.01

Coriander	0.36±0.03	0.69±0.06	0.01±0.001
Thyme	0.64±0.05	4.14±0.37	0.03±0.01
Cinnamon	0.28±0.02	1.64±0.13	0.01±0.002

* (Means ± SD).

Table 4.3. Investigation Compared of mineral concentrations (Cu, Zn, Fe, Pb, Mn, Ni, µg/g), and (Mg, Ca, Al, mg/g) of medicinal plants in different countries and the method of analysis in present study published reports in the literature

Name of the plants	countries	Samples analyze by	Refer-ence	Cu	Zn	Fe	Pb	Mn	Ni	Mg	Ca	Al
Chamomile	Turkey	FAAS, ICP-AES.	[90]	8.34±0.05	30.6±2.1	502.7±3.0	0.72±0.08	60.2±3.3	1.8±0.4	1.643±0.07	12.72±0.2	0.356±0.023
Cinnamon	Turkey	ICP-OES, ICP-MS	[122]	3.3	17.9	56.7		104	0.6	0.852	10.978	
Thyme	Turkey	ICP-OES, ICP-MS	[122]	6.1	22.4	440		116	1.5	2.115	7.759	
Ginger	Turkey	ICP-OES, ICP-MS	[122]	4.0	13.5	86.8		127	1.9	2.006	0.944	
Chamomile	Turkey	ICP-OES, ICP-MS	[122]	8.2	24.4	521		96.4	1.5	2.319	6.959	
Peppermint	Turkey	ICP-OES, ICP-MS	[122]	17.7	17.9	975		112	1.0	2.929	11.749	
Cinnamon	Pakistan	ICP-MS	[123]	2.83± 0.01	13.75±0.06		0.1627± 0.00158	879.8± 0.55	0.94±0.01			
Coriander	Pakistan	ICP-MS	[123]	7.82± 0.04	37.85±0.02		0.2134± 0.00045	48.74±0.05	1.35±0.02			
Clove	Pakistan	ICP-MS	[123]	2.35± 0.03	14.00±0.01		0.3661±0.29	649.9±0.46	1.08±0.01			
Cardamom	Pakistan	ICP-MS	[123]	6.18± 0.04	61.18±0.03		0.4511±0.00054	758.1± 0.54	1.99±0.02			
Thyme	Turkey	ICP-AES, ICP-MS	[124]	12.17±0.52	20.4 ± 1.7	301 ± 26		44.5 ± 1.6	2.34 ± 0.09	1.67 ± 0.06	13.81 ± 0.60	
Cinnamon	Turkey	ICP-AES, ICP-MS	[124]	2.78 ±0.20	38.3 ± 3.2	53 ± 4.9		156.2 ±12.6	0.32±0.05	0.40 ± 0.02	9.60 ± 0.53	
Peppermint	Turkey	ICP-AES, ICP-MS	[124]	10.04±0.79	23.6±2.2	281 ± 19		98.0 ± 0.9	2.40 ± 0.27	3.63 ± 0.02.57	11.94 ± 0	
Peppermint	Turkey	ICP-MS	[125]	11.1 ± 0.7	24.3 ± 1.4	546 ± 23	0.36 ± 0.03	140 ± 2	4.40 ± 0.00			
Cinnamon	Turkey	ICP-MS	[125]	4.68 ±0.29	13.0 ± 1.9	108 ± 7	0.31 ± 0.06	264 ± 31	0.72± 0.06			
Basil	Turkey	ICP-MS	[125]	30.2 ± 4.3	34.7 ± 2.8	769 ± 68	0.49 ± 0.02	102 ± 7	1.53±0.0			

									4			
Ginger	Turkey	ICP-MS	[125]	17.6 ± 2.7	26.6 ± 0.9	345 ± 18	3.01 ± 0.60	255 ± 9	2.26±0.12			
Chamomile	Turkey	ICP-MS	[125]	13.9 ± 0.5	22.2 ± 0.8	716 ± 65	0.06 ± 0.00	41.6 ± 3.0	3.68±0.04			
Dill	Turkey	ICP-MS	[125]	14.7 ± 0.5	22.8 ± 0.6	220 ± 1	0.46 ± 0.02	62.0 ± 0.9	7.59±0.43			
Coriander	Sudan	ICP-OES, ICP-MS	[126]	11.3 ± 0.2	39.3 ± 0.4	107 ± 10		22.8 ± 1.6		3.455±0.0073		
Clove	Pakistan	ICP-OES	[127]			623.2±9.5				2.483±0.02	6.778±0.038	
Cinnamon	Pakistan	ICP-OES	[127]			46.12±1.01				0.4292±0.00683	8.323±0.044	
Cardamom	Pakistan	ICP-OES	[127]			57.99±1.12				3.87±0.023	4.177±0.02	
Coriander	Pakistan	ICP-OES	[127]			71.31±1.04				2.67±0.003	6.577±0.034	
Clove	Saudi Arabia	AAS	[128]	3.2±0.1	6.3±0.9	90.4±6.0	0.7±0.01	490±14	1.8±0.1			
Cinnamon	Saudi Arabia	AAS	[128]	3.9±0.1	5.2±0.3	65.6±1.4	27±0.09	309±18	1.6±0.1			
Ginger	Saudi Arabia	AAS	[128]	2.5±0.3	7.9±0.7	231±41	0.8±0.06	97.9±9.7	1.0±0.03			
Coriander	Saudi Arabia	AAS	[128]	8.4±0.1	16.9±0.3	48.8±3.3	1.4±0.3	11.9±3.1	2.1±0.05			
Coriander	India	AAS	[129]	74.41±3.65	16.99±0.58	223.79±4.04	2.87±0.26	101.50±0.90		0.22235±0.00014		
Peppermint	Poland	ICP-OES	[130]	1.75±0.02	75.3±0.1	37.9±0.5		12.0±0.1		0.422±0.002	0.489±0.003	0.238±0.002
Chamomile	Poland	ICP-OES	[130]	1.38±0.01	88.8±0.5	15.7±0.2		13.8±0.1		0.218±0.001	0.189± 0.002	0.122±0.001
Chamomile	Iraq	FAAS	[131]	0.140	1.250	6.870	0.046		0.450			
Cinnamon	Iraq	FAAS	[131]	0.068	0.216	0.470	0.042		0.110			
Dill	Iraq	FAAS	[131]	0.051	0.990	1.280	0.110		0.023			
Basil	Iraq	FAAS	[131]	0.077	29.090	0.470	0.10		0.030			

* (Means ± SD).

In this (table 4.3) analysis of the present data revealed that calcium (Ca) and magnesium (Mg) content were observed the highest concentrations in all the medicinal plants, studied as compared to other trace elements recorded. The highest concentrations of the calcium (Ca) and magnesium (Mg) among the studied medicinal plants were found calcium (Ca) in thyme from Turkey (13.81) [124], and magnesium (Mg) in cardamom from Pakistan (3.87 mg g^{-1}) [127], but smallest concentrations of calcium (Ca) and magnesium (Mg) in chamomile (0.189-0.218 mg g^{-1}) respectively from Poland [130].

Also Ni (0.023 μg/g) in dill from Iraq the lowest concentration in all the medicinal plants studied as compared to other trace elements recorded [131].

5. CONCLUSION

1-To determine the concentrations of minerals and trace elements in some medicinal plants in north region Iraq were found at different levels. Therefore, these medicinal plants are rich in some essential minerals, especially Ca, Mg and Fe which are essential for human health.

The concentration of some essential and non-essential heavy metals, namely; Cu, Ca, Zn, Mn, Fe, Mg, Al, Pb and Ni, have been analyzed.

In this work, minerals and trace elements in some medicinal plants samples from Ahi Evran University, Kirsehir, Turkey were determined by using ContrAA 300 a High Resolution-Continuum Source Flame Atomic Absorption Spectrometer (HR-CS AAS) after microwave digestion. The method is rapid, accurate, precise and sensitive. The use of microwave digestion system in plant samples provides a better, safer and cleaner method of sample preparation.

2- Determination of minerals and trace elements in plants is very important because the quality of many medicines and foods depends upon the content and type of elements [136]. The minerals and trace elements content present in medicinal plants studied are a source of biologically important elements, which may play part in the observed therapeutic properties of these plants. Medicinal plants useful for healing as well as for curing of human diseases and preparation of various drugs singly or in combination or even are used as the source of raw material for the other medicines.

Concentrations of the minerals and trace elements levels in medicinal plants studied were found in this order: Ca >Mg >Pb >Zn >Fe >Mn >Al >Cu >Ni.

Their concentrations were mostly within the range of the published literature and in accordance to the critical guideline limits of RDA. The levels of Cu were relatively low in all medicinal plants. In general, the concentrations of minerals confirmed a positive present in all medicinal plants contribution.

The results of table 4.1, table 4.2 and table 4.3 comparative studied on elemental analysis of medicinal plants:

- Table 4.1, table 4.2 calcium (Ca) and magnesium (Mg) observed with the highest concentration in all the medicinal plants studied as compared to other trace elements recorded. The highest concentration of calcium (Ca) and magnesium (Mg) among the studied medicinal plants were found calcium (Ca) in basil (Ocimum basilicum) and magnesium (Mg) in purslane (Portulaca oleracea L) (5.63, 1.37 mg/g) respectively, but low concentrations of calcium (Ca) and magnesium (Mg) in oak galls (0.18, 0.06 mg/g) respectively.

Also Cu (0.01 µg/g) in Cinnamon was found to be the lowest concentration in all the medicinal plants studied as compared to other trace elements recorded.

Increasing sequence of the mean concentrations of the minerals and trace elements levels in medicinal plants studied were found in this order: Ca >Mg >Pb >Zn >Fe >Mn >Al >Cu >Ni.

- Table 4.3 observed with the highest concentrations in all the medicinal plants and countries, studied as compared to other trace elements recorded. The highest concentrations of the calcium (Ca) and magnesium (Mg) among the studied medicinal plants were found calcium (Ca) in thyme from Turkey (13.81 mg/g) [124], and magnesium (Mg) in cardamom from Pakistan (3.87 mg/g) [127], but smallest concentrations of calcium (Ca) and magnesium (Mg) in chamomile (0.189-0.218 mg/g) respectively from Poland [130].

  Also Ni (0.023 µg/g) in dill from Iraq the lowest concentration in all the medicinal plants studied as compared to other trace elements recorded [131].

  Increasing sequence of the mean concentrations of the minerals and trace elements levels in medicinal plants studied were found in this order: Ca > Mg > Mn> Fe> Al > Zn > Cu>Pb> Ni.

6. REFERENCES

[1] White, Jr., R.T. and G.E. Douthit. 1985. Use of microwave oven and nitric acid hydrogen peroxide digestion to prepare botanical materials for elemental analysis by inductively coupled argon plasma emission spectroscopy. *Journal-Association of official analytical chemists*, **68(4)**, 766-769.

[2] Anderson, D. L., & Henderson, L. J. (1986). Sealed chamber digestion for plant nutrient analyses. *Agronomy Journal*, **78(5),** 937-939.

[3] Kalra, Y. P., Maynard, D. G., & Radford, F. G. (1989). Microwave digestion of tree foliage for multi-element analysis. *Canadian Journal of Forest Research, **19***(8)**,** 981-985.

[4] Stripp, R. A., & Bogen, D. C. (1989). The rapid decomposition of biological materials by using a microwave acid digestion bomb. *Journal of analytical toxicology, **13***(1)**,** 57-59.

[5] Watson, M.E. and R.A. Isaac. 1990. Analytical instruments for soil and plant analysis, pp. 691-740. In: R.L. Westerman (Ed.), Soil Testing and Plant Analysis. Third edition. SSSA Book Series 3. Soil Science Society of America, Madison, WI.

[6] Sahito, S. R., Memon, M. A., Kazi, T. G., Kazi, G. H., Jakhrani, M. A., Haque, Q. U., & Shar, G. Q. (2003). Evaluation of mineral contents in medicinal plant Azadirachta indica (Neem). *Journal of the Chemical Society of Pakistan, **25***(2)**,** 139-143.

[7] Kiran, B., Lalitha, V., & Raveesha, K. A. (2011). In vitro evaluation of antifungal activity of Psoralea corylifolia L.(seeds) and its different fractions on seed borne fungi of maize. *Journal of Chemical and Pharmaceutical Research, **3***(4)**,** 542-550.

[8] Gupta, U. C., & Gupta, S. C. (2014). Sources and deficiency diseases of mineral nutrients in human health and nutrition: a review. *Pedosphere, **24***(1)**,** 13-38.

[9] Rao, R. N., & Talluri, M. K. (2007). An overview of recent applications of inductively coupled plasma-mass spectrometry (ICP-MS) in determination of inorganic impurities in drugs and pharmaceuticals. *Journal of pharmaceutical and biomedical analysis*, ***43*(1),** 1-13.

[10] Pohl, P., Dzimitrowicz, A., Jedryczko, D., Szymczycha-Madeja, A., Welna, M., & Jamroz, P. (2016). The determination of elements in herbal teas and medicinal plant formulations and their tisanes. Journal of pharmaceutical and biomedical analysis, **130,** 326-335.

[11] Jabeen, S., Shah, M. T., Khan, S., & Hayat, M. Q. (2010). Determination of major and trace elements in ten important folk therapeutic plants of Haripur basin, Pakistan. *Journal of Medicinal Plants Research*, ***4*(7),** 559-566.

[12] Xuqi, D., Zhiguang, Z., Chonghua, L., Bailing, H., Pinyan, K., Guangtao, Z., ... & Song, P. (2002). Determination of Trace Rare Earth Elements in Pig's Liver and Pork by ICP-AES. *Chinese Journal of Spectroscopy Laborator*, ***19*(1),** 60-64.

[13] Yan, Q., Yang, L., Zhang, H., & Niu, L. (2012). Determination of Mineral Elements in Fifteen Medicinal Herbs and Their Infusions by Inductively Coupled Plasma Atomic Emission Spectrometry. *Asian Journal of Chemistry*, ***24* (2),** 899.

[14] Niamat, R., Khan, M. A., Khan, K. Y., Ahmad, M., Ali, B., Mazari, P., ... & Ahmad, H. (2012). Element content of some ethnomedicinal Ziziphus Linn. species using atomic absorption spectroscopy technique. *Journal of applied pharmaceutical Science*, ***2*(3),** 96.

[15] Tapsell, L. C., Hemphill, I., Cobiac, L., Sullivan, D. R., Fenech, M., Patch, C. S., ... & Fazio, V. A. (2006). Supplement-Health benefits of herbs and spices: The past, the present, the future. *Medical Journal of Australia*, ***185*(4)**, S1.

[16] Solecki, R. and I. V. Shanidar. 1975. A Neanderthal flower burial in northern Iraq. Science. **190:** 880-881.

[17] Rasool Hassan, B. A. (2012). Medicinal plants (importance and uses). *Pharmaceut Anal Acta*, ***3*,** e139.

[18] Kumar, S., Shukla, Y. N., Lavania, U. C., Sharma, A., & Singh, A. K. (1997). Medicinal and aromatic plants: prospects for India. *J. Med. Arom. Pl. Sc*, ***19*(2),** 361-365.

[19] Ghani, A. (1998). Medicinal plants of Bangladesh: chemical constituents and uses. Asiatic society of Bangladesh.

[20] Sofowora, A. (1982). Medicinal Plants and Traditional Medicine in Africa, Africa: John Wiley & Sons Ltd., pp. 6,10,11,74,114,256.

[21] Voumik, S. (2014). In Vitro Pharmacological Investigations of Petroleum Ether Fraction of Ficus racemosa Leaves Extract (Doctoral dissertation, East West University).

[22] Newman, D. J., Cragg, G. M., & Snader, K. M. (2003). Natural products as sources of new drugs over the period 1981− 2002. *Journal of natural products*, ***66*****(7),** 1022-1037.

[23] Alam, M. (2015). Cytotoxic and antioxidant activity in aqueous fraction of Opuntia elatior extract (Doctoral dissertation, East West University).

[24] Cowan, M. M. (1999). Plant products as antimicrobial agents. *Clinical microbiology reviews*, *12*(4), 564-582.

[25] Goldstein, A., Aronow, L. and Kalman, S.M., (1974) Principles of drug action-the basis of pharmacology. 2nd edition. New York: John Wiley & Sons Ltd. P. 729-755.

[26] Akhter, S. (2012). Phytochemical and pharmacological evaluation of different fractions of Lannea grandis Engl (Family: Anacardiaceae).

[27] Hafiz, M. (2016). Phytochemical and Pharmacological study of the extract of the roots of Bombax ceiba (Doctoral dissertation, East West University).

[28] Shayed, N. M. (2014). Cytotoxic, antimicrobial and antioxidant activity of crude fraction of Ficus resemosa leaves extract (Doctoral dissertation, East West University).

[29] AKANDA, M.(2013). Phytochemical and Pharmacological Investigations of Genoderma Lucidum (Doctoral dissertation, East West University).

[30] Prakash, P., & Gupta, N. (2005). Therapeutic uses of Ocimum sanctum Linn (Tulsi) with a note on eugenol and its pharmacological actions: a short review. *Indian journal of physiology and pharmacology*, ***49*****(2)**, 125.

[31] Janes ME, Nannapaneni R, Johnson MG, 1999. Identification and characterization of two bacteriocin-producing bacteria isolated from garlic and ginger root. J Food Prot.**62:**899-904.

[32] Soetan, K. O., Olaiya, C. O., & Oyewole, O. E. (2010). The importance of mineral elements for humans, domestic animals and plants-A review. *African Journal of Food Science*, ***4*(5),** 200-222.

[33] HARDT, ROBERT S., and NUTRI-EPIGENETIC BIOCHEMICAL ANALYST. "“Let your food be thy medicine!” …. Hippocrates." Codex **7:** 19-**2013**.

[34] Brätter, P., de Brätter, V. E. N., Raab, A., & Blasco, I. N. (1998). Speciation as an analytical aid in trace element research in infant nutrition. *Analyst*, ***123*(5),** 821-826.

[35] Schlenker, E., & Roth, S. L. (2013). Williams' Essentials of Nutrition and Diet Therapy-Revised Reprint. Elsevier Health Sciences.

[36] Bourne, G. H. (Ed.). (1985). Minerals in food and nutritional topics. Karger.

[37] Anke, M., Groppel, B., & Kronemann, H. (1984). Significance of newer essential trace elements (like Si, Ni, As, Li, V,) for the nutrition of man and animals. *In: Trace elements-analytical chemistry in medicine and biology*, **3,** 424-464.

[38] Sanchez-Castillo, C. P., Dewey, P. J., Aguirre, A., Lara, J. J., Vaca, R., de la Barra, P. L., ... & James, W. P. T. (1998). The mineral content of Mexican fruits and vegetables. *Journal of food composition and analysis*, ***11*(4),** 340-356.

[39] Rahmatollah, R., & Mahbobeh, R. (2010). Mineral contents of some plants used in Iran. *Pharmacognosy research*, ***2*(4),** 267.

[40] Thomas, A. O., & Oyediran, O. E. (2008). Nutritional importance and micronutrient potentials of two non-conventional indigenous green leafy vegetables from Nigeria. *Agric. J*, ***3*(5),** 362-365.

[41] Mertz, W. (1982). Trace minerals and atherosclerosis [Chromium, iron, copper, zinc, selenium, iodine]. *Federation Proceedings Fed of Am Societies for Experimental Biology*.

[42] Macrae, R., Robinson, R. K., & Sadler, M. J. (1993). Encyclopaedia of food science, food technology and nutrition.

[43] Nielsen,F.H. 1984. Ultratrace elements in nutrition. Annual Review of Nutrition **4,** 21-41.

[44] Smith, K. T. 1988. Trace minerals in foods. New York: Marcel Dekker.

[45] DiSilvestro, R. A., O'Dell, B., & Sunde, R. A. (1998). Handbook of nutritionally essential mineral elements. *Free Radical Biology and Medicine*, ***24*(4),** 684-684.

[46] Dutta, T. K., & Mukta, V. (2012). Trace elements. MEDICINE, 22.

[47] Pathak, M. U., Shetty, V., & Kalra, D. (2016). Trace Elements and Oral Health: A Systematic Review. *Journal of Advanced Oral Research*, ***7*(2)**.

[48] Gonzalvez, A., Armenta, S., Cervera, M. L., & De La Guardia, M. (2008). Elemental composition of seasoning products. *Talanta*, *74*(5), 1085-1095.

[49] Nielsen FH, Hunt CD. Uthus EO. Ann NY Acad Sci **1980; 355:152**-64.

[50] Miller, K. (1959). Nutrition and Reproduction. *NUTRITION*.

[51] Nielsen, F. H. (2008). Essential and toxic trace elements in human health and disease. *Current Topics in Nutrition and Disease*, ***18,*** 277-292.

[52] Goyer, R., Golub, M., Choudhury, H., Hughes, M., Kenyon, E., & Stifelman, M. (2004, August). Issue paper on the human health effects of metals. In *US Environmental Protection Agency Risk Assessment Forum* (Vol. 1200).

[53] Alloway, B. J. (1995). Heavy metals in soils Blackie Academic and Professional. *London, UK*.

[54] Albright, E. I. (2004). Background concentrations of trace elements in soils and rocks of the Georgia piedmont. Published M. Sc Thesis submitted to the Graduate Faculty of the University of Georgia, Athens, Georgia, 175.

[55] Trace Elements, (2015). http://chaudhary.kau.edu.sa/Files/0030235/files/19029_TRACE%20ELEMENTS_Clinical%2 0Chem%20Lect%203rd%20yr%20MT1st%20semester.pdf [Accessed: 23/09/2015].

[56] World Health Organization. (2002). The world health report 2002: reducing risks, promoting healthy life. World Health Organization.

[57] Draghici, C., Coman, G., Jelescu, C., Dima, C. & Chirila, E. (2010). Heavy metals determination in environmental and biological samples, In: Environmental Heavy Metal Pollution and Effects on Child Mental Development- Risk Assessment and Prevention Strategies, NATO Advanced Research Workshop, Sofia, Bulgaria, **28 April**-1 May 2010.

[58] Vieira, C., Morais, S., Ramos, S., Delerue-Matos, C. & Oliveira, M.B.P.P. (2011). Mercury, cadmium, lead and arsenic levels in three pelagic fish species from the Atlantic Ocean: intra- and inter-specific variability and human health risks for consumption. Food & Chemical Toxicology, **49,** 923-932.

[59] Vernet, J. P. (1992). Impact of Heavy Metals on the Environment. New York: American Elsevier Publishing Company, Inc.

[60] Coen, N., Mothersill, C., Kadhim, M., and Wright, E. G. (2001). Heavy metals of relevance to human health induce genomic instability. *Journal of Pathology*, **195(3),** 293–299.

[61] Olowoyo, J.O., van Heerden, E. & Fischer, J. (2013). Trace metals concentrations in soil from different sites in Pretoria, South Africa. Sustain. Environ. Res., **23(2)**, 93-99.0.

[62] HARVEY, D. (1947). Trace elements in plant and animal nutrition. The British veterinary journal, 103(8), 278-289.

[63] Phipps, D. A. (1981). Chemistry and biochemistry of trace metals in biological systems. In Effect of heavy metal pollution on plants (pp. 1-54). Springer Netherlands.

[64] Karr, M. (2003). Mineral Nutrient Depletion in US Farm and Range Soils. Youngevity Canada.

[65] Otitoju, G. T. O., Ene-Obong, H. N., & Otitoju, O. (2014). Macro and micro nutrient composition of some indigenous green leafy vegetables in south-east zone nigeria. J. Food Process. Technol, **5**, 389.

[66] Kabata, P. A. and Henryk, P. (1984). Trace elements in soils and plants. CRC Press. Pp 51-56.

[67] Zhao, J. (2007). Nutraceuticals, nutritional therapy, phytonutrients, and phytotherapy for improvement of human health: a perspective on plant biotechnology application. Recent Patents on Biotechnology, **1(1),** 75-97.

[68] Combs Jr, G. F. (2013). Geological impacts on nutrition. In Essentials of Medical Geology (pp. 179-194). Springer Netherlands.

[69] Cakmak, I., Graham, R. D., & Welch, R. M. (2004). Agricultural and molecular genetic approaches to improving nutrition and preventing micronutrient malnutrition globally. Eolss Publishers.

[70] Hoffman, F. A. (1985). Micronutrient requirements of cancer patients. Cancer, **55(S1),** 295-300.

[71] Chernoff, R. (2005). Micronutrient requirements in older women. The American journal of clinical nutrition, **81(5),** 1240S-1245S.

[72] National Research Council (US). Food, & Nutrition Board. (1968). Recommended Dietary Allowances: A Report of the Food and Nutrition Board (Vol. 1146). National Academies.

[73] National Research council. (1989). Recommended dietary allowances. National Academies Press.

[74] Fosmire, G. J. (1990). Zinc toxicity. *The American journal of clinical nutrition*, 51(2), 225-227.

[75] Bertini, I. (2007). Biological inorganic chemistry: structure and reactivity. University Science Books.

[76] Lenntech, B.V (2012), Culled from http://www.lenntech.com/recommended-daily-intake.htm.

[77] Tacon, A. G. J. (1987). The nutrition and feeding of farmed fish and shrimp; a training manual. 1: The essential nutrients.

[78] Okoro, H. K., Fatoki, O. S., Adekola, F. A., Ximba, B. J., & Snyman, R. G. (2012). A review of sequential extraction procedures for heavy metals speciation in soil and sediments.

[79] Lokhande, R. S., Andhale, M. L., & Singare, P. U. (2011). Analysis of essential trace elements in some traditional Indian medicinal plants using instrumental neutron activation analysis and atomic absorption spectroscopy techniques. International Journal of Immunological Studies, **1(3),** 285-296.

[80] Sigel H. Sigel A. eds. 1988. Metal ions in biological systems, vol 23. Nickel and its role in biology. New York: Marcel Dekker, 1-188.

[81] Lancaster, J. R. (1988). The bioinorganic chemistry of nickel. Vch Pub.

[82] Khan, K. Y., Khan, M. A., Niamat, R., Munir, M., Mazari, H. F. P., Seema, N., ... & Ahmed, S. N. (2011). Element content analysis of plants of genus Ficus using atomic absorption spectrometer. *African journal of pharmacy and pharmacology*, ***5*(3),** 317-321.

[83] Mudgal, V., Madaan, N., Mudgal, A., Singh, R., & Mishra, S. (2010). Effect of toxic metals on human health. *Open Nutraceut J*, **3,** 94-99.

[84] Ljung, K., Palm, B., Grandér, M., & Vahter, M. (2011). High concentrations of essential and toxic elements in infant formula and infant foods–a matter of concern. *Food chemistry*, ***127*(3),** 943-951.

[85] Cauvain, S. P. (2004, December). How much more bread research do we need? In *Using Cereal Science and Technology for the Benefit of Consumers: Proceedings of the 12th International ICC Cereal and Bread Congress 24-26 May, 2004* (Vol. 109, p. 127). CRC Press.

[86] Sandberg, A. S. (2002). Bioavailability of minerals in legumes. *British Journal of Nutrition*, ***88*(S3),** 281-285.

[87] Fraga, C. G. (2005). Relevance, essentiality and toxicity of trace elements in human health. *Molecular aspects of medicine*, ***26*(4),** 235-244.

[88] Clarke, B. B., & Brennan, E. (1989). Differential cadmium accumulation and phytotoxicity in sixteen tobacco cultivars. *JAPCA*, ***39*(10),** 1319-1322.

[89] Bober, U., & Chen, D. (2005). A powerful tool for analysis of heavy metals in traditional Chinese medicines. *Agilent ePharmaceut. Anal*, **15**.

[90] Başgel, S., & Erdemoğlu, S. B. (2006). Determination of mineral and trace elements in some medicinal herbs and their infusions consumed in Turkey. *Science of the Total Environment*, **359(1),** 82-89.

[91] Divrikli, U., Horzum, N., Soylak, M., & Elci, L. (2006). Trace heavy metal contents of some spices and herbal plants from western Anatolia, Turkey. *International journal of food science & technology*, ***41*(6),** 712-716.

[92] Taylor, D. M., & Williams, D. R. (1995). Trace element medicine and chelation therapy. Royal society of chemistry.

[93] Nielsen, F. H. (1991). Ultratrace minerals mythical elixirs or nutrients of concern? Boletin de la Asociacion Medica de Puerto Rico, **83(3),** 131-133.

[94] Matusiewicz, H. and Sturgeon, R.E. (1989), Prog. Anal. Spectrosc. 12, 21. Mitchell, J.W. (1982), J. Radioanal. Chem. 69, 47.

[95] Alfassi, Z. B. (Ed.). (2012). Instrumental multi-element chemical analysis. Springer Science & Business Media.

[96] Chaturvedi, R. K., Das, S., Animesh, K., & Pathak, M. (2009). Recent analytical techniques in detection of poisons in lab. *Medico-Legal Update*, ***9*(1),** 9-11.

[97] Robert, H. and Pinta, M. Trace elements in soils. PP99 Development of soil science, Elsevier (**1977**).

[98] Kalra, Y. (Ed.). (1997). Handbook of reference methods for plant analysis. CRC press.

[99] Linberg, P. and Bingerfors, S. Trace elements in plants. Journal Ada Agricultural Sciences, 20, 133(**1970**).

[100] Basset, B.and Jeffiy, M.5 Denney, R., Jeffery.G.,Mendham, JTVogel's Textbook of Quantitative Analysis. (4th edition), E1BS, Longman, pp. 695 (**1978**).

[101] Chapman, H. D., & Pratt, P. F. (1961). Methods of Analysis for Soils, Plants and Waters. Priced Publication 4034. Division of Agriculture Sciences. *University of California, Berkeley*.

[102] Len, M. Minerals and your health, PP.4-13. **Allen and Unwin, NewYork(1986).**

[103] Pearson, D. Chemical analysis of food (5th edition), pp. 123-131. Churchill ltd. (**1962**).

[104] Mohamed, A. A. (2001). Determination of some Trace Elements in Edible Crops Grown in Jebel Merra area.

[105] Jana, S., & Shekhawat, G. S. (2010). Anethum graveolens: An Indian traditional medicinal herb and spice. Pharmacognosy reviews, **4(8),** 179.

[106] Kokab, S., & Ahmad, S. (2011). Developing Herbal Pharmaceutics in Pakistan–II: Distinctiveness of Selected Medicinal Herbs and Uses.

[107] Nagashree, S., Archana, K. K., Srinivas, P., Srinivasan, K., & Sowbhagya, H. B. (2016). Anti-hypercholesterolemic influence of the spice cardamom (Elettaria cardamomum) in experimental rats. Journal of the Science of Food and Agriculture.

[108] Ravindran, P. N., & Madhusoodanan, K. J. (Eds.). (2003). *Cardamom: the genus Elettaria*. CRC Press.

[109] Ahlawat, T. R., Patel, N. L., Agnihotri, R., Patel, C. R., & Tandel, Y. N. Black mulberry (Morus nigra).

[110] Shrestha, S., Kaushik, V. S., Eshwarappa, R. S. B., Subaramaihha, S. R., Ramanna, L. M., & Lakkappa, D. B. (2014). Pharmacognostic studies of insect gall of Quercus infectoria Olivier (Fagaceae). Asian Pacific journal of tropical biomedicine, **4(1),** 35-39.

[111] Chandrashekhar, V. M., Halagali, K. S., Nidavani, R. B., Shalavadi, M. H., Biradar, B. S., Biswas, D., & Muchchandi, I. S. (2011). Anti-allergic activity of German chamomile (Matricaria recutita L.) in mast cell mediated allergy model. *Journal of ethnopharmacology*, ***137*(1),** 336-340.

[112] **Sasidharan, I., Menon, A.N. (2010).** Comparative chemical composition and antimicrobial activity of berry and leaf essential oils of Piper nigrum L. Int J Biol Med Res, **1(4)**: 215-218.

[113] **Sahib, N. G., Anwar, F., Gilani, A. H., Hamid, A. A., Saari, N., & Alkharfy, K. M. (2013).** Coriander (Coriandrum sativum L.): A Potential Source of High-Value Components for Functional Foods and Nutraceuticals-A Review. Phytotherapy Research, **27(10),** 1439-1456.

[114] **Rajeshwari, U., & Andallu, B. (2011).** Medicinal benefits of coriander (Coriandrum Sativum L). Spatula DD, **1(1),** 51-58.

[115] **Meuninck, J. (2013).** Basic Illustrated Edible Wild Plants and Useful Herbs. Rowman & Littlefield.

[116] **Basch, E., Ulbricht, C., Hammerness, P., Bevins, A., & Sollars, D. (2004).** Thyme (Thymus vulgaris L.), thymol. *Journal of herbal pharmacotherapy*, *4*(1), 49-67.

[117] **De Gennaro, G., Daresta, B. E., Ielpo, P., & Placentino, M. (1999).** Analytical Methods for Determination of Metals in Environmental Sampes.

[118] **Piero, N. M., Murugi, N. J., Kibiti, C. M., Ngeranwa, J. J. N., Njue, W. M., Maina, D., & Gathumbi, K. P. (2011).** Hypoglycemic activity of some kenyan plants traditionally used to manage diabetes mellitus in Eastern Province.

[119] **Rajurkor, N.S. and pardeshi,B.M.(1997).** “Analysis of some herbal plants from India used in the control of diabetes mellitus by NAA and AAS techniques”. Appl. Radiat. Isot.**48:**1059.

[120] **Davis, G. K. and Mertz, W. (1987).** Trace elements in human and animal nutrition. Academic press, New York. P 301.

[121] **KIPYEGON, N. (2012).** Analysis of essential trace elements in soils, amaranthus cruentus and amaranthus hypochondriacus grains, leaves and stems from selected parts of Kenya (Doctoral dissertation, KENYATTA UNIVERSITY).

[122] **Kara, D. (2009).** Evaluation of trace metal concentrations in some herbs and herbal teas by principal component analysis. Food Chemistry, **114(1),** 347-354.

[123] **Khan, N., Choi, J. Y., Nho, E. Y., Jamila, N., Habte, G., Hong, J. H., ... & Kim, K. S. (2014).** Determination of minor and trace elements in aromatic spices by micro-wave assisted digestion and inductively coupled plasma-mass spectrometry. Food chemistry, **158,** 200-206.

[124] Karadaş, C., & Kara, D. (2012). Chemometric approach to evaluate trace metal concentrations in some spices and herbs. Food chemistry, 130(1), 196-202.

[125] Tokalıoğlu, Ş. (2012). Determination of trace elements in commonly consumed medicinal herbs by ICP-MS and multivariate analysis. Food Chemistry, **134(4),** 2504-2508.

[126] Ebrahim, A. M., Eltayeb, M. H., Khalid, H., Mohamed, H., Abdalla, W., Grill, P., & Michalke, B. (2012). Study on selected trace elements and heavy metals in some popular medicinal plants from Sudan. Journal of natural medicines, **66(4),** 671-679.

[127] Ebrahim, A. M., Etayeb, M. A., Khalid, H., Noun, M., Roumie, M., & Michalke, B. (2014). PIXE as a complement to ICP-OES trace metal analysis in Sudanese medicinal plants. Applied Radiation and Isotopes, **90,** 218-224.

[128] Seddigi, Z. S., Kandhro, G. A., Shah, F., Danish, E., & Soylak, M. (2016). Assessment of metal contents in spices and herbs from Saudi Arabia. Toxicology and industrial health, **32(2),** 260-269.

[129] Subramanian, R., Gayathri, S., Rathnavel, C., & Raj, V. (2012). Analysis of mineral and heavy metals in some medicinal plants collected from local market. Asian Pacific Journal of Tropical Biomedicine, 2(1), S74-S78.

[130] Pytlakowska, K., Kita, A., Janoska, P., Połowniak, M., & Kozik, V. (2012). Multi-element analysis of mineral and trace elements in medicinal herbs and their infusions. Food chemistry, **135(2),** 494-501.

[131] Intidhar, D. S., Rafea, K. A., & Jasem, D. S. (2013). Determination of some essential elements in Iraqi medicinal herbs. Chemistry, 26(1), 234-240.

[132] Prasad, A. S. (1981). Symposia from the XIII International Congress on Nutrition. Prog. Clin. Biol. Res.; **77**:172–177.

[133] Walingo, M. K. (2009). Indigenous food processing methods that improve zinc absorption and bioavailability of plant diets consumed by the Kenyan population.

[134] Critchley, M. (1986). (Editor-in-Chief), In Butterworths Medical Dictionary, ELBS, UK, 1035.

[135] Merian, E., & Clarkson, T. W. (1991). Metals and their compounds in the environment: occurrence, analysis, and biological relevance.

[136] Yagi, S., AbdRahman, A. E., ELhassan, G. O., & Mohammed, M. A. (2013). Elemental analysis of ten sudanese medicinal plants using X-ray fluorescence. Journal of Applied and Industrial Sciences, **1(1),** 49-53.

[137] Welz, B.; Borges, D. L.G.; Leprib, F. G.; Vale, M. G. R.; Heitmannd, U. *Atomic Spectroscopy* **2007, 62,** 873–883.

[138] Welz, B.; Morés, S.; Carasek E.; Vale, M. G. R.; Okruss, M.; Becker-Ross, H. *Applied Spectroscopy Reviews* **2010**, **45,** 327–354.

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A personal Profile

My name is Mohammed Sadeeq. I am from Iraq / Dohuk / Akre, and i graduated science of chemistry at University of Dohuk. And graduated master of analytical chemistry at Firat University in Turkey. I got enough information about my major so i can adaptable with job now. As we know the science of chemistry has contain huge information in different things and i can work in many sector in Hospital or Oil Company and so on.

Qualification and training

I have bachelor degree in term of the science of chemistry in the top university of Iraq. In the third year of my studied, i went to Akre Emergency Hospital during the summer and i worked 6 hours per day training.

Achievement

1-I am graduated from University of Dohuk at department of the science of chemistry.
2-And graduated master of analytical chemistry at Firat University in Turkey.

Interest

I like working with Oil Company which is one part of my job and studied it at college. I always read the books and research about oil and how chemise can be successful in oil field.