Sudan University of Science and Technology

College of Graduate Studies

Determination of Sodium and Potassium in some Sudanese Vegetables and Fruits by Using Flame Photometry

تحديد الصوديوم و البوتاسيوم في بعض الخضروات و الفواكه السودانية بإستخدام مضوائية اللهب

A thesis submitted in partial fulfillment for the requirements of Master Degree in chemistry

By

Osman Abdelmunim Elbashir Mohamed [B.Sc. (Honors) scientific labs. Chemistry]

Supervisor

Dr. Mohamed El-Mukhtar Abdel Aziz

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الإستهلال

قال تعالي:

"وَقُل رَّبِّ زِدْنِي عِلْمًا"(114)-سورة طه

صدق الله العظيم

Dedication

I dedicate this work to my

Parents,

Brothers,

Sisters,

Wife and

My son.

Acknowledgment

Firstly, thanks go to Allah for giving me the power and strength to complete this work.

Then I wish to express my gratitude and thanks to Dr. Mohamed El Mukhtar for his guidance, suggestion, encouragement and support to complete this research.

I thank also Khartoum University-Central laboratory-Shambat for giving me an opportunity to use their facilities for sample preparation and analysis. Last, but not least, I am very much grateful to the academic staffs of the Sudan University of Science and Technology for guidance and support.

Abstract

In this study potassium and sodium have been determined in four Sudanese vegetables (watercress, tomato, potato and parsley) and four Sudanese fruits (banana, mango, date and orange). Dry ashing method was used to prepare samples after they were dried in the oven. Flame photometry was used to determine the concentration of the samples using standard curve method. The concentrations of potassium and sodium have been calculated in both dry and wet bases. Potassium concentrations (mg/100g) in watercress, tomato, potato, parsley, banana, mango, date and orange in dry bases are: 2825, 3463, 2088, 4563, 1388, 1050, 1075 and 1438 mg/100g, respectively, but potassium concentrations in wet bases for the previous vegetables and fruits are: 341.95, 181.54, 278.85, 912.68, 362.79, 215.16, 1022.84 and 201.09 mg/100g, respectively. Sodium concentrations (mg/100g) in watercress, tomato, potato, parsley, banana, mango, date and orange in dry bases are: 130, 135, 35, 512.5, 17.5, 22.5, 12.5 and 24.85 mg/100g, respectively, but sodium concentrations in wet bases for the previous vegetables and fruits are: 15.73, 7.08, 4.68, 102.52, 4.58, 4.61, 11.89 and 3.48 mg/100g, respectively.

المستخلص

في هذا البحث تم تقدير البوتاسيوم و الصوديم في اربعة انواع من الخضر السودانية(الجرجير، الطماطم، البطاطس و البقدونس) و اربعة انواع من الفواكه السودانية(الموز، المانجو، البلح و البرتقال). تم استخدام طريقة الحرق الجاف لتحضير العينات و ذلك بعد ان تم تجفيفها في الفرن. تم إستخدام جهاز الانبعاث اللهبي لتقدير تراكيز العينات و ذلك بإستخدام طريقة المنحنى القياسي. تم حساب تراكيز البوتاسيوم و الصوديوم للعينات الجافة و الرطبة أيضا. وجد أن تراكيز البوتاسيوم (بالملجرم/100جرام) في كل من: الجرجير، الطماطم، البطاطس، البقدونس، الموز، المانجو، البلح و البرتقال في العينات الجافة هي: 2825، 3463، 2088، 4563، 1388، 1050، 1075 و 1438 ملجرام/100جرام على التوالي ، أما تراكيز البوتاسيوم في العينات غير المجففة للخضروات و الفواكه السابقة هي: 341.95، 181.54، 278.85، 912.68، 362.79، 215.16، 1022.84 و 201.09 ملجرام/100جرام على التوالي. كما وجد أن تراكيز الصوديوم (بالملجرم/100جرام) في كل من: الجرجير، الطماطم، البطاطس، البقدونس، الموز، المانجو، البلح و البرتقال في العينات الجافة هي: 130، 135، 35، 512.5، 17.5، 22.5، 12.5 و 24.85 ملجرام/100جرام على التوالي ، أما تراكيز الصوديوم في العينات غير المجففة للخضروات و الفواكه السابقة هي: 15.73، 7.08، 4.68، 102.52، 4.58، 4.61، 11.89 و 3.48 ملجرام/100جرام على التوالي.

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Mt	Metering ton
ppm	part per million
mg	milligram
ml	milliliter
g	gram
nm	nanometer

Chapter One

Introduction and Literature Review

1. Introduction and literature review

1-1.Potassium

Potassium is a chemical element with the symbol K (from Neo-Latin *kalium*) and atomic number 19. Potassium is a silvery-white metal that is soft enough to be cut with a knife with little force. Potassium metal reacts rapidly with atmospheric oxygen to form flaky white potassium peroxide in only seconds of exposure. It was first isolated from potash, the ashes of plants, from which its name derives. In the periodic table, potassium is one of the alkali metals, all of which have a single valence electron in the outer electron shell, that is easily removed to create an ion with a positive charge a cation, that combines with anions to form salts. Potassium in nature occurs only in ionic salts. Elemental potassium reacts vigorously with water, generating sufficient heat to ignite hydrogen emitted in the reaction, and burning with a lilac-colored flame. It is found dissolved in sea water (which is 0.04% potassium by weight, and occurs in many minerals such as orthoclase, a common constituent of granites and other igneous rocks.

Potassium is chemically very similar to sodium, the previous element in group 1 of the periodic table. They have a similar first ionization energy, which allows for each atom to give up its sole outer electron. It was suspected in 1702 that they were distinct elements that combine with the same anions to make similar salts, and was proven in 1807 using electrolysis. Naturally occurring potassium is composed of three isotopes, of which ^{40}K is radioactive. Traces of ^{40}K are found in all potassium, and it is the most common radioisotope in the human body (Potassium - Wikipedia, 2021).

1-2.Sodium

Sodium is a chemical element with the symbol Na (from Latin *natrium*) and atomic number 11. It is a soft, silvery-white, highly reactive metal. Sodium is an alkali metal, being in group 1 of the periodic table, because it has a single electron in its outer shell, which it readily donates, creating a positively charged ion the Na^+ cation. Its only stable isotope is ^{23}Na. The free metal does not occur in nature, and must be prepared from compounds. Sodium is the sixth most abundant element in the Earth's crust and exists in numerous minerals such as feldspars, sodalite, and rock salt (NaCl). Many salts of sodium are highly water-soluble: sodium ions have been leached by the action of water from the earth's minerals over eons, and thus sodium and chlorine are the most common dissolved elements by weight in the oceans.

Sodium was first isolated by Humphry Davy in 1807 by the electrolysis of sodium hydroxide. Among many other useful sodium compounds, sodium hydroxide (lye) is used in soap manufacture, and sodium chloride (edible salt) is a de-icing agent and a nutrient for animals including humans (Potassium - Wikipedia, 2021).

1-3.Uses of the potassium and sodium and their compounds

Sodium, potassium and their compounds have many uses of which selected examples are given here. Sodium–potassium alloy is used as a heat-exchange coolant in nuclear reactors. A major use of Na–Pb alloy was in the production of the anti-knock agent PbEt4, but the increasing demand for unleaded fuels renders this of decreasing importance. The varied applications of compounds of Na include those in the paper, glass, detergent, chemical and metal industries. In 2000, the world production of NaCl was 210 Mt; of this, 51.6 Mt was used in the US. The major consumption of NaCl is in the manufacture of NaOH, Cl_2 and Na_2CO_3, A large fraction of salt is used for winter road de-icing. Both Na and K are involved in various electrophysiological functions in higher animals. The [Na]:[K] ratio is different in intra- and extra-cellular fluids, and the concentration gradients of these ions across cell membranes are the origin of the trans-membrane potential difference that, in nerve and muscle cells, is responsible for the transmission of nerve impulses. A balanced diet therefore includes both Na and K salts. Potassium is also an essential plant nutrient, and K salts are widely used as fertilizers (Housecroft and Sharpe, 2012).

1-4.Importance of sodium and potassium

Sodium and potassium are essential for human health. They are important ions in the body and are associated with many physiologic and pathophysiologic processes. Sodium ions are the major cations of extracellular fluid, whereas, potassium ions are the major cations of the intracellular fluid. To maintain internal fluid and electrolyte balance, water, sodium, and potassium are in constant movement between the intracellular and extracellular body compartments. Potassium and sodium ions are particularly important in the renal regulation of acid-base balance because hydrogen ions are substituted for sodium and potassium ions in the renal tubule. Potassium plays a key role in that potassium bicarbonate is the primary intracellular inorganic buffer. Potassium enters the cell more readily than sodium and initiates the brief sodium-potassium exchange across the cell membranes.

Potassium is essential for the proper function of all cells, tissues, and organs in the human body. It is also crucial to heart function and plays a key role in skeletal and smooth muscle contraction, making it important for normal digestive and muscular function (Pohl, Wheeler and Murray, 2013).

Potassium is an essential nutrient needed for maintenance of total body fluid volume, acid and electrolyte balance, and normal cell function. Reduced potassium consumption has been associated with hypertension and cardiovascular diseases, and appropriate consumption levels could be protective against these conditions. A recent meta-analysis including 11 cohort studies reported an inverse association between potassium intake and risk of stroke, also another study found that increased potassium intake lowers blood pressure (World Health Organization, 2012).

1-5.Sources of potassium in the diet

- Potassium occurs in all living cells. Therefore it is present in all plants. (crops) and animals.
- Meat and meat products.
- Dairy and dairy products.
- Green leafy vegetables and non leafy vegetables, mushrooms.
- Legumes.
- Roots and tubers (potatoes and sweet potatoes).
- Fruits - bananas, kiwi, citrus fruits, avocado.
- Nuts. (Kinabo and SALAM, 2015).

1-6.The destruction of organic matter

Fruits and vegetables, and their products like any other foods contain organic matter which must be destroyed prior to the estimation of minerals.

Dry ashing or wet digestion is generally used for the destruction of organic matter. The choice of the procedure depends on the nature of the organic materials, the nature of any inorganic constituent present, the metal to be determined and the sensitivity of the method used for determination.

Dry ashing is applicable to most common minerals with the exception of mercury and arsenic. It requires less attention and large amount of material can be handled more conveniently than by wet digestion. The procedure is particularly suitable when the use of sulfuric acid is objectionable. Calcium, phosphorus and iron generally estimated in fruits and vegetables may safely be ashed by this procedure. The loss of potassium may occur if the temperature is too high, and it is usual to avoid a temperature of over 480˚C if all the potassium is to be retained. A temperature of 450˚C should not be exceeded if zinc is to be determined.

The wet digestion method offers certain advantages. The temperature cannot exceed the boiling point of the mixture and generally carbon is destroyed more quickly than in dry ashing. The wet digestion procedure depends primarily on the use of nitric acid for the destruction of organic matter at a fairly low temperature to avoid loss by evaporation, and in the later stages of digestion, the process is sometimes considerably speeded up by the action of perchloric acid or hydrogen peroxide. The wet digestion method is generally employed when it is required to estimate arsenic, copper, lead, tin and zinc (Ranganna, 2007).

In preparing plant materials for elemental analysis, organic matter in plant tissue is destroyed using combustion at high temperature. This process is termed dry ashing or wet ashing when acid mixtures are used to digest the materials (Sahrawat, Ravi Kumar and Rao, 2002).

The preparation of plant materials for elemental analysis requires that the plant tissues be destroyed and the elements extracted in a solution suitable for analysis, this process is routinely carried out by analytical laboratories, using either dry or wet ashing techniques. Dry ashing usually consists of the combustion of plant tissues at relatively low temperatures (450-550'C), often followed by dissolution in hot acid (HCl, HNO_3, or a combination of both. Wet ashing consists of digesting the plant tissue in acid ($HClO_4$ and HNO_3 or HNO_3).

Dry ashing is more commonly used, as it is simpler, safer and more economical than wet ashing where potentially carcinogenic or explosive substances are used (Ali, Zoltai and Radford, 1988).

The results with sorghum plant materials show that while both triacid and dry ashing procedures are equally effective for determining K, Mg, Mn, and Zn, the dry ashing technique may be preferred for determining Ca, Fe, and Cu in plant materials. Results with rice plant samples gave similar results for all nutrient elements tested except Ca for which dry ashing provided more reliable results (Sahrawat, Ravi Kumar and Rao, 2002).

1-7.Previous studies

Jose, Antonio and Renata determined potassium and sodium in five vegetables (lettuce, spinach, parsley, watercress, turnip leaf and turnip sprouts) by flame emission spectrometry. First they dried samples of vegetables in oven at (80-100 C□); then the digests of the vegetables were prepared by wet acid digestion. They found out the concentrations of potassium and sodium expressed in milligrams of analyte per gram of dried samples (mg/g), after that the concentrations were converted to be expressed in mg/100g, the results were shown in table (1-1) (Lima, Rangel and Souto, 1996).

Table (1-1): The potassium and sodium concentrations (mg/g and mg/100g) in the dried samples

Sample	Potassium mg/g	Potassium mg/100g	Sodium mg/g	Sodium mg/100g
Watercress	33.76	3376	10.47	1047
Parsley	39.1	3910	6.27	627
Lettuce	51.16	5116	3.15	315
Spinach	28.92	2892	29.3	2930
Turnip sprout	34.56	3456	2.55	255
Turnip leaf	50.38	5038	8.7	870

1-8.Research objective

The main objective of this research is to determine potassium and sodium quantitatively using flame photometer, in the most common fruits and vegetables in Sudan, specifically at Khartoum city. The targeted fruits and vegetables are as follow:

Fruits: Banana, mango, dry date and orange.

Vegetables: Watercress, tomato, potato and parsley.

Chapter Two

Materials and Methods

2-Materials and methods

2-1. Reagents

Potassium chloride (KCI) stock solution: Dissolve 1.909 g of AR potassium chloride in distilled water and make up to 1 liter in a volumetric flask (1.0 mg K per ml or 1000 ppm).

Sodium chloride stock solution: Dissolve 2.5418 g of AR sodium chloride in 1 liter of glass distilled water in a volumetric flask (1 ml = 1.0mg Na or 1000 ppm).

2-2. Apparatus and equipments

- Analytical balance, HANGPING, model no JA2003, Max 200g, Min 1mg
- Electric oven, Chongqing Yinhe Experimental Equipment Co.,Ltd China, model no CS202-A, 300 C□
- Digital flame photometer, Shamghavi Impex, India, model no 381.
- Porcelain crucibles
- Beakers
- Volumetric flasks, 100ml, 500ml

2-3.Methods

2-3-1.Sample preparation

2-3-1-1.Drying

First of all fresh fruits and vegetables were washed with tap water very well then washed with distilled water, then for banana, mango, orange and potato the peels were removed and only fleshy part was taken. Seeds were removed from orange, date and tomato. For watercress and parsley only leaves were taken for drying. Then they were cut into small pieces using stainless steel knife, after that a certain weight from each was taken and spread on a silica dish, they were dried in a hot air oven at atmospheric pressure. Both vegetables and fruits were dried at 55C□ for 4 days. After drying is finished the dried samples weights were recorded in Table (3-1).

2-3-1-2.Dry ashing

2g of the well mixed samples were weighed in porcelain crucibles. First they were heated over a low Bunsen flame to volatilize as much of the organic matter (until no more of smoke is given out by the material) as possible. The crucibles were transferred to a temperature controlled muffle furnace. The muffle was kept at about 300 C□ until all the carbon has ceased to glow and then the temperature was raised to 450 C□, the crucibles remained in the muffle for 7hours , then they were taken out and were put in desiccator and left to cool. The ash was dissolved using dilute HCl(25ml) then the volume was made up to 50ml volumetric flask with distilled water. (Ranganna, 2007).

2-3-2. Flame photometric method

Sodium and potassium in solution are atomized into an oxyhydrogen or oxyacetylene flame. The flame excites atoms of sodium and potassium causing them to emit radiations at specific wavelengths. The amount of radiation emitted is measured on a spectrophotometer. Under standard conditions, it is proportional to the concentration of sodium or potassium in the solution (Ranganna, 2007).

2-3-3.Potassium

2-3-3-1.Standard curve

Standard solution (containing 100ppm of potassium) was prepared by measuring 100ml from stock standard solution and 5 ml of conc. HCI into a volumetric flask and the solution was made up to 1 liter. Aliquots of the standard solution were diluted with 0.5% HCI to produce a series of solutions containing: 2, 4, 6, 8, and 10 ppm of potassium.

The solutions were atomized in flame photometer with the wavelength dial set at 768 nm, setting the top standard at 100% transmittance. The Emitted Optical Density for each concentration was reported. A standard curve was drawn by plotting concentration on abscissa and the emitted optical density on the ordinate (Ranganna, 2007).

2-3-3-2.Procedure

The samples solutions were diluted by taking 10ml of each ash solutions and the volume was made up to 100ml in a volumetric flask then 10ml was taken from this solution and the volume was made up to 500ml in a volumetric flask.

The diluted solutions were atomized in a calibrated flame photometer with the wavelength dial set at 768 nm and the transmittance set at 100% for the top standard solution of potassium. Check the instrument periodically with the top standard solution. From the standard curve note the concentration (Ranganna, 2007).

2-3-4.Sodium

2-3-4-1.Standard curve

Standard solution (containing 100ppm of sodium) was prepared by measuring 100ml of stock standard solution and 5 ml of conc. HCI into a volumetric flask and the solution was made up to 1 liter. Aliquots of the standard solution were diluted with 0.5% HCI to produce a series of solutions containing: 2, 4, 6, 8, and 10 ppm of sodium.

The solutions were atomized in flame photometer with the wavelength dial set at 589 nm, setting the top standard at 100% transmittance. The Emitted Optical Density for each concentration was noted. A standard curve was drawn by plotting concentration on abscissa and the emitted optical density on the ordinate (Ranganna, 2007).

2-3-4-2.Procedure

The ash solutions were atomized in a calibrated flame photometer with the wavelength dial set at 589 nm and the transmittance set at 100% for the top standard solution of sodium.

For watercress, tomato and potato (sample No 1, 2 and 3 respectively) solutions were diluted by taking 10ml of ash solution and the volume was made up to 100ml in a volumetric flask. But for parsley (sample No4) solution was diluted by taking 10ml of ash solution and the volume was made up to 100ml in a volumetric flask then 10ml was taken from this solution and the volume was made up to 100ml in a volumetric flask.

The instrument was checked periodically with the top standard solution. From the standard curve note the concentration (Ranganna, 2007).

Chapter Three

Results and discussion

3. Results and discussion

3-1.Drying

The results of samples drying were shown in table (3-1)

Table (3-1): Weights of samples before and after drying

No	Name	Weight before drying/g	Weight after drying/g
1	Watercress	098.716	11.949
2	Tomato	103.307	05.416
3	Potato	036.203	07.008
4	Parsley	045.171	09.036
5	Mango	036.110	07.399
6	Banana	039.719	10.385
7	Dry date	024.700	23.505
8	Orange	045.280	06.334

3-2.Standard potassium solutions

The instrument reading of potassium standard solutions was recorded in table (3-2).

Then the emission was plotted against concentration using Microsoft office excel (figure (3-1)).

Table (3-2): The emissions of potassium standard solutions in flame photometry

No	**K** Standard solution concentration (ppm)	Emitted Optical Density
1	2	13.4
2	4	38
3	6	56
4	8	78
5	10	100

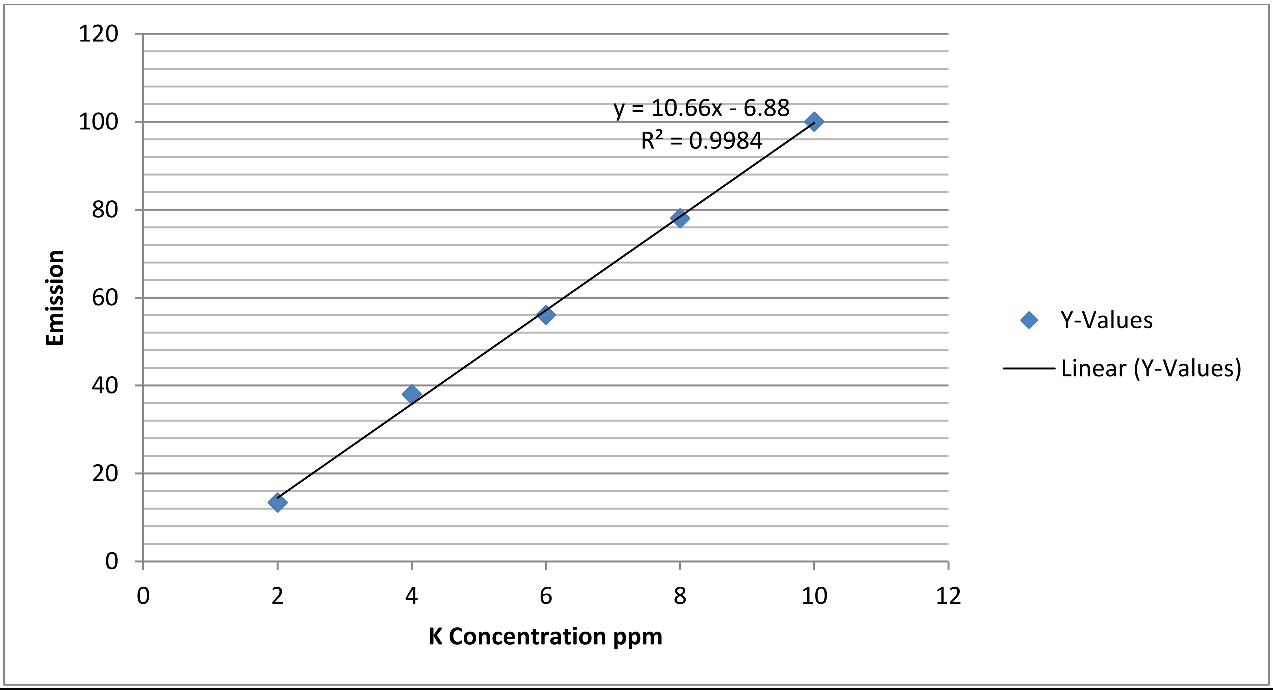

Figure (3-1): graph of emission against potassium concentration /ppm

3-3.Standard sodium solutions

The instrument reading of sodium standard solutions was recorded in table (3-3).

Then the emission was plotted against concentration using Microsoft office excel (figure no (3-2).

Table (3-3): The emissions of sodium standard solutions in flame photometry

No	**Na** Standard solution concentration (ppm)	Emitted Optical Density
1	2	21.6
2	4	40.9
3	6	63.6
4	8	79.9
5	10	100

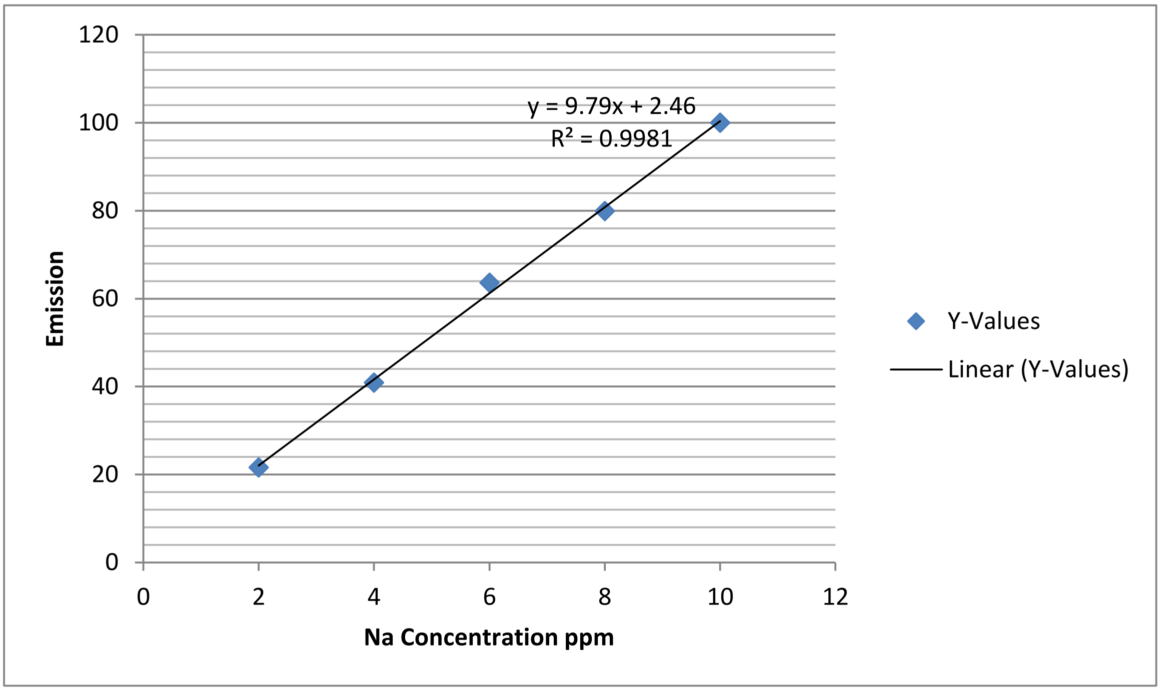

Figure (3-2): graph of emission against potassium concentration /ppm

3-4.Samples

3-4-1.potassium

The results of emission of the sample solutions for potassium in flame photometer were shown in table (3-4).

Table (3-4): The emissions of samples solutions in flame photometry for potassium

No	Sample Name	Emitted Optical Density
1	Watercress	17.2
2	Tomato	22.7
3	Potato	10.9
4	Parsley	32
5	Mango	2.1
6	Banana	4.9
7	Dry date	2.3
8	Orange	5.4

3-4-2.Sodium

The results of emission of the sample solutions for Sodium in flame photometer are shown in table (3-5).

Table (3-5): The results of emissions of samples solutions in flame photometry for sodium

No	Sample Name	Emitted Optical Density
1	Watercress	53.4
2	Tomato	55.3
3	Potato	16.2
4	Parsley	22.5
5	Mango	90.6
6	Banana	71
7	Dry date	51.4
8	Orange	99.8

3-5.calculations

3-5-1.Water content

Based on table (3-1) the moisture content of all samples has been calculated and the results were recorded in table (3-6).

$$\text{Moisture content} = \frac{wet\ weight - dry\ weight}{wet\ weight} \times 100$$

Table (3-6): Illustrates the moisture percentage of all samples

No	Name	Weight before drying/g	Weight after drying/g	Water content % (w/w)
1	Watercress	098.716	11.949	87.896
2	Tomato	103.307	05.416	94.757
3	Potato	036.203	07.008	86.642
4	Parsley	045.171	09.036	79.996
5	Mango	036.110	07.399	79.510
6	Banana	039.719	10.385	73.854
7	Dry date	024.700	23.505	04.838
8	Orange	045.280	06.334	86.011

3-5-2.Potassium

From graph No (3-1) and using the equation $\boldsymbol{y = 10.66x - 6.88}$ the concentration x (in ppm) was calculated when the emission y is known from table No (3-4), the calculated results were recorded in table No (3-7). After that Potassium concentration in the dried samples (mg/100g) was calculated using the formula:

$$\boldsymbol{potassium}(\textbf{mg/100g}) = \frac{\begin{matrix} ppm\ found\ from \\ standard\ curve \end{matrix} \times volume\ made\ up \times dilutions \times 100}{weight\ of\ sample\ \times 1000}$$

The calculated results was recorded in table (3-8)

Then the Potassium concentration in wet sample was calculated as follows:

- First the wet weight (dry weight + water) was calculated for every sample using the formula: $\boldsymbol{wet\ weight} = \frac{dry\ weight}{1 - water\ content\ fraction}$

  The results were recorded in table No (3-9)

- Then potassium concentration in wet sample was calculated using the formula:

$$\boldsymbol{Potassium}(\mathbf{mg/100g}) = \frac{\genfrac{}{}{0pt}{}{ppm\ found\ from}{standard\ curve} \times volume\ made\ up \times dilutions \times 100}{weight\ of\ wet\ sample \times 1000}$$

The calculated results were recorded in the table (3-10)

Table (3-7): The potassium concentration in ppm of sample solutions

No	**Sample Name**	**Concentration /ppm**
1	Watercress	2.26
2	Tomato	2.77
3	Potato	1.67
4	Parsley	3.65
5	Mango	0.84
6	Banana	1.11
7	Dry date	0.86
8	Orange	1.15

Table (3-8): The potassium concentration (mg/100g) in the dried samples

No	Sample Name	Potassium (mg/100g)
1	Watercress	2825
2	Tomato	3463
3	Potato	2088
4	Parsley	4563
5	Mango	1050
6	Banana	1388
7	Dry date	1075
8	Orange	1438

Table (3-9): The wet weight of samples

No	Sample Name	Non-dried weight/g
1	Watercress	16.523
2	Tomato	38.146
3	Potato	14.972
4	Parsley	9.998
5	Mango	9.760
6	Banana	7.649
7	Dry date	2.102
8	Orange	14.297

Table (3-10): The potassium concentration (mg/100g) in the wet samples

No	Sample Name	Potassium (mg/100g)
1	Watercress	0341.95
2	Tomato	0181.54
3	Potato	0278.85
4	Parsley	0912.68
5	Mango	0215.16
6	Banana	0362.79
7	Dry date	1022.84
8	Orange	0201.09

3-5-3.Sodium

From figure (3-2) and using the equation $\boldsymbol{y = 9.79x + 2.46}$ the concentration x (in ppm) was calculated when the emission y is known from table (3-5), the calculated results were recorded in table (3-11). After that Sodium concentration in the dried samples (mg/100g) was calculated using the formula:

$$\boldsymbol{Sodium}(\mathbf{mg/100g}) = \frac{\begin{matrix} ppm\ found\ from \\ standard\ curve \end{matrix} \times volume\ made\ up \times dilutions \times 100}{weight\ of\ sample\ \times 1000}$$

The calculated results was recorded in table (3-12).

Then Sodium concentration in wet sample was calculated as follows:

- First the wet weight (dry weight + water) was calculated for every sample and the results were recorded in table No (3-9)
- Then Sodium concentration in wet sample was calculated using the formula:

$$\textbf{Sodium}(\text{mg}/100\text{g}) = \frac{\frac{ppm\ found\ from}{standard\ curve} \times volume\ made\ up \times dilutions \times 100}{weight\ of\ wet\ sample \times 1000}$$

The calculated results were recorded in the table (3-13).

Table (3-11): The sodium concentration (ppm) of samples solutions

No	**Sample Name**	**Concentration /ppm**
1	Watercress	5.2
2	Tomato	5.4
3	Potato	1.4
4	Parsley	2.05
5	Mango	9.0
6	Banana	7.0
7	Dry date	5.0
8	Orange	9.94

Table (3-12): The sodium concentration (mg/100g) in the dried samples

No	**Sample Name**	**Sodium (mg/100g)**
1	Watercress	130
2	Tomato	135
3	Potato	35
4	Parsley	512.5
5	Mango	22.5
6	Banana	17.5
7	Dry date	12.5
8	Orange	24.85

Table (3-13): The sodium concentration (mg/100g) in the wet samples

No	Sample Name	Sodium (mg/100g)
1	Watercress	015.73
2	Tomato	007.08
3	Potato	004.68
4	Parsley	102.52
5	Mango	004.61
6	Banana	004.58
7	Dry date	011.89
8	Orange	003.48

3-5.Conclusion

In this research potassium and sodium were determined in the selected fruits and vegetables in mg/100g both in dried and wet samples.

Parsley which is vegetable showed the highest potassium and sodium content: 4563mg/100g and 512.5 mg/100g, respectively, in dry samples.

Mango and dry date have the lowest potassium content (1050mg/100g and 1075mg/100g respectively) in dried sample.

Dry date had the lowest sodium content: 12.5mg/100g, in dried samples.

Dry date had the highest potassium content in wet samples: 1022.84mg/100g.

Tomato had the lowest potassium content in wet sample: 181.54mg/100g, as well as had the highest water content.

Parsley had the highest sodium content in wet sample: 102.52mg/100g.

Orange had the lowest sodium content in wet sample: 3.48mg/100g.

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