

## **1. Introduction and literature review**

### **1.1 Introduction:**

*Adansonia digitata* (baobab) is the most widespread of the *Adnsonia* species, and is native to the African continent. The long-lived pachycauls are typically found in dry and hot savannahs of sub-Saharan Africa, where they dominate the landscape, and reveal the presence of a watercourse from afar. (Wickens, Gerald E 2008) Their growth rate is determined by ground water or rainfall, (Hankey & Andrew 2004) (Grove & Naas 2011) and their maximum age, which is subject to much conjecture, seems to be in the order of 1,500 years. (Woodborne & Stephan 2015) They have traditionally been valued as sources of food, water, health remedies or places of shelter, and are steeped in legend and superstition. (Hankey & Andrew 2004) Explorers of old were inclined to carve their names on baobabs, and many are defaced by modern graffiti. (Wickens& Gerald 2008)

Common names for the baobab include; dead-rat tree (from the appearance of the fruit), monkey-bread tree (the soft, dry fruit is edible), upside-down tree (the sparse branches resemble roots), cream of tartar tree (cream of tartar) and गोरख चिंच in Marathi (meaning monkey's tamarind).

### **1.2 Discovery and naming**

The vernacular name “baobab” is derived from Arabic (*Būhibāb*), which means "father of many seeds". The scientific name “*Adansonia*” refers to the French explorer and botanist, Michel Adanson (1727-1806), who discovered it in 1749 on the island of Sor, Senegal. (Michel Adanson 2015) On the nearby Îles des M adeleines Adanson found another baobab, 3.8 m in diameter, which bore the carvings of passing mariners on its trunk, including those of Henry the Navigator in 1444 and André Thevet in 1555. (Wickens&

Gerald 2008)

When Théodore Monod searched the island in the 20th century, the tree was not to be found however. Adanson concluded that the baobab, of all the trees he studied “is probably the most useful tree in all.” He consumed baobab juice twice a day, while in Africa. He remained convinced that it maintained his health for him.(The Baobab Tree, 2015 ) "Digitata" refers to the digits of the hand. The baobab's compound leaves with normally five (but up to seven) leaflets are akin to a hand.(du Plessis& Doep 2011)

### **1.3 Plant Profile**

Kingdom: Plantae

(unranked): Angiosperms

(unranked): Eudicots

(unranked): Rosids

Order: Malvales

Family: Malvaceae

Genus: Adansonia

Species: A. digitata

Common names: White Crossberry, Phalsa Cherry, Raisin bush, angara, Gangu, and kanger.

Hindi names: Gondni, and Gangeran

Synonyms: Chadara tenax Forssk, and G. populifolia Vahl.

### **1.4 Habit and physical description**

The trees usually grow as solitary individuals, and are large and distinctive elements of savannah or scrubland vegetation. Large individuals live to well over a thousand years of age. (Varmah J.C & Vaid K.M 1978)

All baobab trees are deciduous, losing their leaves in the dry seasons, and

remains leafless for nine months of the year.

They can grow to between 5–25 m (16–82 ft) in height. They are in fact known both for their height and trunk's girth. The trunk tends to be bottle-shaped and can reach a diameter of 10–14 m (33–46 ft). (Encyclopedia of life 2015) The span of the roots actually exceeds the tree's height, a factor that enables it to survive in a dry climate. Many consider the tree to be “upside-down” due to the trunk likeness to a taproot and the branches akin to finer capillary roots. The trunk is smooth and shiny and can range from being reddish brown to grey. The bark can feel cork-like. (The Baobab Tree, 2015) The branches are thick and wide and very stout compared to the trunk.

During the early summer (October to December in southern hemisphere) the tree bears very large, heavy, white flowers. These are 12 cm (4.7 in) across and open during the late afternoon to stay open for one night. (Hankey & Andrew 2004) (Encyclopedia of life 2015)

The pendulous, showy flowers have a very large number of stamens. They have a sweet scent but later emit a carrion smell, especially when they turn brown and fall after 24 hours. (Hankey & Andrew 2004) (Encyclopedia of life 2015) Researchers have shown that they appear to be primarily pollinated by fruit bats of the subfamily Pteropodinae. The flowers have 5 petals that are leathery and hairy on the inside. The sepals are cup-shaped and 5-cleft. The stamens are divided into multiple anthers and styles are 7-10 rayed.

The indehiscent fruit are large, egg-shaped capsules. (Hankey & Andrew 2004) They are filled with pulp that dries, hardens, and falls to pieces which look like chunks of powdery dry bread. (National Research Council 2008) The seeds are hard, black, and kidney-shaped. (Hankey & Andrew 2004)

### **1.5 Range:**

The northern limit of its distribution in Africa is associated with rainfall patterns; only on the Atlantic coast and in the Sudan does its occurrence venture naturally into the Sahel. On the Atlantic coast, this may be due to spreading after cultivation. Its occurrence is very limited in Central Africa, and it is found only in the very north of Southern Africa. In Eastern Africa, the trees grow also in Shrub lands and on the coast. In Angola and Namibia, the baobabs grow in woodlands, in coastal regions, and savannahs. It is also found in Dhofar region of Oman and Yemen in the Arabian Peninsula, Western Asia. This tree is also found in India, particularly in the dry regions of the country, (Plant Database of India 2011) and in Penang, and Malaysia, along certain streets.(Simon Gardner & Pindar Sidisunthorn 2011)

The baobab is native to most of Africa, especially in drier, less tropical climates. It is not found in areas where sand is deep. It is sensitive to water logging and frost.

### **1.6 Food uses and nutrition**

The baobab is a traditional food plant in Africa, but is little-known elsewhere. The vegetable has been suggested to have the potential to improve nutrition, boost food security, foster rural development, and support sustainable land care. (National Academies Press 2008)

The African baobab fruit contains 50% more calcium than spinach, is high in antioxidants, and has three times the vitamin C of an orange. (The Tree of Life 2015). The dry pulp is either eaten fresh or dissolved in milk or water to make a drink. The leaves can be eaten as relish. Young fresh leaves are cooked in a sauce and sometimes are dried and powdered. The powder is called lalo in Mali and sold in many village markets in Western Africa. Oil extracted by pounding the seeds can be used for cooking but this is not

widespread. (Sidibe , M& Williams , J.T 2002 )

In Sudan, where the tree is called tabeldi, people make tabaldi juice by soaking and dissolving the dry pulp of the fruit, locally known as gunguleiz. (Gartenbauwissenschaft 2002) (Springer.com 2015)

In 2008, the European Union approved the use and consumption of baobab fruit as an ingredient in smoothies and cereal bars. (Novel Foods and Processes 2008) The United States Food and Drug Administration granted generally recognized as safe status to baobab dried fruit pulp as a food ingredient in 2009.(Laura M. Tarantino 2009)

Baobab leaves are sometimes used as forage for ruminants in dry season. The oilmeal, which is a byproduct of oil extraction, can also be used as animal feed. (Heuze ,V Tran & G Bastianelli 2013) In times of drought elephants consume the juicy wood below its bark. (Sheehan& Sean 2004)

### **1.7 Variation and dispersal**

In Africa, the different populations of baobabs have revealed significant genetic differences. It has consequently been suggested that the taxon contains more than one species. The shape of their fruit especially, varies considerably from region to region. (Van Wyk & Braam, 2011)

Baobab seed withstand drying and remain viable over long periods, as it has a hard seed coat. It can potentially be dispersed over long distances, and its germination potential is improved when it has passed through the digestive tract of an animal. Animals like elephants, black rhinos, and eland can potentially convey the seeds over long distances. Baboons likewise spread the seeds in their dung, but over shorter distances. (Van Wyk& Braam, 2011)

Pollination in the baobab is achieved primarily by fruit bats, but bush babies and several kinds of insect also assist. Some aspects of the baobab's

reproductive biology are not yet understood. It is still speculated whether fertile baobab seeds can result from pollination by the tree's own pollen. It would appear as if pollen from another tree is required for fertile seed, as isolated trees do form seed, only to abort them at a late stage. The existence of some very isolated trees may then be due to their self-incompatibility and inability to reproduce. (Van Wyk & Braam, Prof 2011)

Arab traders introduced it to northwestern Madagascar. There they were often planted at the center of villages, and sometimes outlived them. (Wickens & Gerald E 2008)

### **1.8 Legends and myths:**

Along the Zambezi, the tribes believe that baobabs were upright and too proud. The gods became angry and uprooted them and threw them back into the ground upside-down. Evil spirits now cause bad luck to anyone that picks up the sweet white flowers. More specifically, a lion will kill them.

In contrast some people think that if one drinks from water in which baobab seeds have soaked, you will be safe from crocodile attacks.

In Zambia, one baobab is said to be haunted by a ghostly python. A long time ago, the python lived in the hollow trunk and was worshipped by the natives. A white hunter shot him down, and led to bad consequences. Some nights, the natives still hear the hissing of the snake. (Krugerpark.co.za 2015)

In Kafue National Park, one of the largest baobabs is known as “Kondanamwali” or the “tree that eats maidens”.

The tree fell in love with four beautiful maidens. When they reached puberty, they made the tree jealous by finding husbands. So, one night, during a thunderstorm, the tree opened its trunk and took the maidens inside. Interestingly enough, a rest house has been built in the branches of the tree.

On stormy nights, the crying of the imprisoned maidens can still be heard.

Along the Limpopo River, it is thought that when a young boy is bathed in the water used to soak baobab bark, he will grow up into a big man.

Some natives believe that women living in kraals where baobabs are plenty have more children. This is scientifically accurate because those women have more access to filling in gaps in their diet with the tree's vitamins.

The African bushman legend states that Thora, the god, took a dislike to the Baobab growing in his garden, so he threw it over the wall of Paradise onto the Earth below. The tree landed upside down and continued to grow.

### **1.9 Conservation status and threats:**

As of April 2015 baobabs are not yet classified by the IUCN's Red List criteria, but they are a part of the "Catalogue of Life".(Catalogueoflife.org 2015) The species is extant over a wide range. (Encyclopedia of Life 2015) The baobab is a protected tree in South Africa.(Protected Trees 2013) In the Sahel, the effects of drought, desertification, and over-use of the fruit have been cited as causes for concern. (Osman & Siham M 2014)

A number of individual baobab trees attract sightseers due to either their age, size, specific history or isolated occurrence. Around Gweta, Botswana, some have been declared national monuments. Green's Baobab, 27 km south of Gweta was inscribed by the 19th-century hunters and traders Frederick Thomas Green and Hendrik Matthys van Zyl besides other ruthless characters. About 11 km south of Green's Baobab is the turn-off to Chapman's Baobab, which has a circumference of 25 m. It was historically used as a navigation beacon and as a post office by passing explorers, traders and travellers, many of whom left inscriptions on its trunk. The Ombalantu baobab in Namibia has a hollow trunk that can accommodate some 35 people. At times it has served as a chapel, post office, house, and a hiding

site. Some large specimens have been transplanted to new sites, like the one at Cresta Mowana lodge, Kasane. (Africageographic.com 2016)

### **1.10 Chemical Composition:**

The baobab seed and pulp were analyzed for proximate composition, mineral content, and amino acid composition. The seed oil and protein were evaluated for their fatty acid profile and protein solubility. The seed was found to be a good source of energy, protein, and fat. Both the kernel and the pulp contain substantial quantities of calcium, potassium, and magnesium. Amino acid analyses revealed high glutamic and aspartic acid contents and the sulfur-containing amino acids as being the most limited amino acid. The fatty acid profile showed that oleic and linoleic were the major unsaturated fatty acids, whereas palmitic was the major saturated acid. Of the several solvents tested to solubilize the seed protein, 0.1 M NaOH was found to be the most effective. The protein was more soluble at alkaline than acidic pH, with the lowest solubility at pH 4.0.

### **1.11 Calcium:**

Calcium is a chemical element with symbol (Ca) and atomic number 20. Calcium is a soft gray Group 2 alkaline earth metal, fifth-most-abundant element by mass in the Earth's crust. The ion  $\text{Ca}^{2+}$  is also the fifth-most-abundant dissolved ion in seawater by both molarity and mass, after sodium, chloride, magnesium, and sulfate. (Webb& D.A 1939)

Free calcium metal is too reactive to occur in nature. Calcium is produced in supernova nucleosynthesis.

Calcium is essential for living organisms, particularly in cell physiology where movement of the calcium ion into and out of the cytoplasm functions as a signal for many cellular processes. As a major material used in mineralization of bone, teeth and shells, calcium is the most abundant metal



by mass in many animals.

### **1.11.1 Occurrences:**

Calcium is not naturally found in its elemental state. Calcium occurs most commonly in sedimentary rocks in the minerals calcite, dolomite, and gypsum. It also occurs in igneous and metamorphic rocks chiefly in the silicate minerals: plagioclases, amphiboles, pyroxenes, and garnets.

### **1.11.2 Compound:**

Calcium chemistry is almost exclusively that of  $\text{Ca}^{2+}$  salts.  $\text{Ca}^{2+}$  is a hard cation, that is, it characteristically favors oxide ligands.

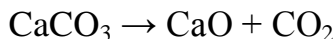
Hence the abundance of carbonates, nitrates, phosphates, and sulfates in the mineral kingdom. Many of these species crystallize with water. Because it is generally nontoxic and abundant, calcium is found in many foods and useful materials. Most calcium salts are colorless. As with magnesium salts and other alkaline earth metal salts, the halides are soluble in water.

Combined with phosphate, calcium forms hydroxylapatite [ $\text{Ca}_5(\text{PO}_4)_3(\text{OH})$ ], the mineral portion of animal bones, teeth, and some corals. (Hu& Russel 2001)

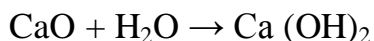
Large-scale chemical processes are involved in the conversion of calcium phosphate minerals into fertilizer.

Calcium is the main problematic ion in hard water; it forms insoluble deposits of calcium carbonate that are problematic in plumbing. It also reacts with soap to form soap scum. Calcium carbonate occurs naturally as limestone and chalk. When water percolates through limestone or other calcium-containing rocks, it partially dissolves the rock. The slow re-precipitation of minerals derived from dissolved calcium leads to formation of stalactites and stalagmites.

When heated above 825 °C, calcium carbonate converts calcium oxide (CaO), also known as quicklime:



When added to water, quicklime vigorously reacts (hence its name) to form calcium hydroxide:



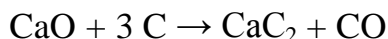
Also known as slaked lime, Ca(OH)<sub>2</sub> is an inexpensive base material used throughout the chemical industry. When mixed with sand, it hardens into a mortar and is turned into plaster by carbon dioxide uptake. Mixed with other compounds, lime forms an important part of Portland cement.

Combined with sulfate, calcium forms the mineral gypsum. When heated to about 300 °F (150 °C), it undergoes partial dehydration: (Franz Wirsching 2012)

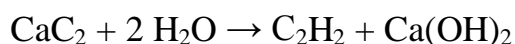


The resulting powder, when mixed with water, forms a stiff but workable paste that hardens to give Plaster of Paris.

Organocalcium compounds, those containing Ca-C bonds, are known, but generally of specialized interest in the research laboratory. One major exception is calcium carbide, which arises from heating calcium compounds with coal or other carbon-rich reducing agents.



It was historically important precursor to acetylene.



Other important calcium compounds are calcium nitrate (used in fertilizers), calcium chloride (used as for deicing roads), calcium cyanamide, and calcium hypochlorite (used for bleaching).

Focusing on chemical structure, Ca<sup>2+</sup> is a relatively large ion that tends to

adopt a high coordination number. In  $\text{CaF}_2$ , the mineral fluorite, each  $\text{Ca}^{2+}$  ion is surrounded by eight  $\text{F}^-$  ligands.

Structure of the polymeric  $[\text{Ca}(\text{H}_2\text{O})_6]^{2+}$  center in hydrated calcium chloride, illustrating the high coordination number typical for calcium complexes.

### **1.11.3 Method of calcium analysis:**

In a preferred embodiment, it relates to the volumetric determination of calcium in blood serum in which magnesium is also normally present. The calcium is directly titrated with ethylene glycol bis-(daminoethyl ether)-N,N'-tetraacetic acid and the end point is established by the color change from orange to green of a combined Eriochrome Blue Black R-methyl red indicator. The magnesium is converted to a non-interfering form by treating the serum with an alkaline borate solution in an amount sufficient to impart a pH from about 12 to 13 to the serum.

To the present time there is no reported method for directly titrating calcium in the presence of magnesium in a solution such as blood serum that provides sufficiently accurate results on a consistent basis, especially when working in micro quantities. The reason for this lack of a satisfactory method is due to the physiochemic-a-l obstacles presented in executing such a method. While other procedures for the quantitative direct titration of calcium in the presence of magnesium have been developed, the ones which might otherwise be suitable require costly apparatus and skilled personnel. Thus, the need and desirability of a direct titration method involving the consistently accurate visual determination of the end point is clear.

Some of the obstacles encountered in directly titrating calcium in the presence of magnesium using chelometric techniques include the inherent interferences which arise when dealing with mixed ion solutions. The closeness of the chelation constants of calcium and magnesium with the

heretofore commonly used chelating agent ethylene diaminetetraacetic acid and its sodium salt (10.70 and 8.69 being the  $\log K$  values of the respective chelates) makes a quantitatively selective titration for calcium difficult and introduces inaccuracies in the result.

In addition, the solution frequently under analysis is blood serum. Blood serum contains other ions such as phosphates which further complicate the selection of a suitable chelating agent as well as a metal indicator which functions properly in the presence of the various ions in solution. The metal indicator must indicate the presence or absence of calcium without interference from magnesium or other metals found in the serum and must be stable at room temperature in the working solution. It has been extremely difficult to find the right combination of chelating agent and indicator suitable for use under the complex conditions existing in solution.

Heretofore, direct titration methods have sought to avoid the interference of the magnesium in the calcium solution by conducting the titration in strongly alkaline solution. This was done in order to precipitate magnesium as the hydroxide so that it was no longer in a form capable of interfering with the chelation of the calcium and the operation of the calcium indicator. However, under the conditions employed, calcium co-precipitated and with the metal indicator was absorbed on the surface of the magnesium hydroxide to an extent that influenced the test results to an unsatisfactory degree. There have been attempts to overcome the source of error introduced by the absorption of calcium and the metal indicator on the surface of the magnesium hydroxide. Unfortunately, the attempts are not wholly satisfactory and usually require additional steps such as a back titration. In any case, none of the methods provide a satisfactory method for determining calcium in a simple direct titration with its obvious advantages.

Recently some of the many problems have been solved by the use of ethylene glycol bis-( $\beta$ -amino ethyl ether)-N,N-tetra acetic acid as the complexing agent for calcium. For ease of discussion, the compound ethylene glycol bis-( $\beta$ -amino ethyl ether)-N,N-tetra acetic acid will hereinafter in the specification and claims be referred to as EDTA, an abbreviation that has found acceptance in the art. The use of EDTA as a chelating agent permits a more nearly selective titration of calcium in the presence of magnesium owing to the relatively large difference of the chelation constants. A difference the  $\log K$  of calcium and magnesium with EDTA has been found ( $\log K = 11.0$ ,  $\log K = 5.2$ ). While the use of EDTA in a direct titration of calcium greatly improves the accuracy of the result, it still is not sufficiently accurate for calcium determinations, particularly when working with a visual end point.

The present method improves upon the prior art use of EDTA for determining calcium and provides a method that yields consistently accurate results even when titrating to a visual end point. The present improvement comprises, broadly, selectively removing magnesium from the sample under analysis by treating the sample with an alkaline borate solution in an amount required to adjust the pH to between about 11 and 14. Preferably, the alkaline borate solution is added to adjust the pH to about 12 to 13.

The addition of the borate in strongly alkaline solution causes the magnesium to form a non-interfering product therewith. The product of magnesium and borate binds the magnesium and prevents it from complexing with the EDTA to thereby cause an erroneously high value for calcium.

Without intending to limit the present invention by theory herein advanced, it is believed that the magnesium forms an insoluble glass with the alkaline

borate while the calcium remains capable of being complexed at the indicated pH. It is believed that under the conditions created there is less tendency for the calcium to form the hydroxide and there is negligible absorption of the calcium hydroxide onto the surface of the precipitated magnesium glass. It is likely that the calcium undergoes the same reactions as the magnesium, forming a hydroxide and perhaps reacting with the borate, but in the case of calcium the product is sufficiently soluble so that the calcium is still available for reaction with the complexing or sequestering agent EDTA. On the other hand, it is believed that the magnesium in the strongly alkaline solution forms the hydroxide which in turn fuses with the borate to form a product that is sufficiently insoluble under the process conditions to prevent any magnesium from rebounding into solution and complexing with the EDTA as the calcium end point is reached.

Under the circumstances, it is essential to the proper execution of the present improved method that the operating solution be strongly alkaline, i.e. between a pH of about 11 and 14 so that magnesium will form a hydroxide which will then be available for fusion with the borate. The present method should not be confused with prior art methods which employed butler solutions such as ammonia buffers and borate buffers to maintain a pH of 10 and below throughout the course of the titration. The conditions existing in these prior art solutions were not suitable for achieving the present substantially complete deactivation and elimination of the magnesium as an interfering entity in the analysis for calcium.

As noted above, the present improvement enables the calcium determination to be carried out as a direct titration in which the end point may be visually determined. In such a determination, the EDTA is added to the sample to complex with the calcium in solution. When all of the calcium has been

complexed, an indicator previously added to the sample that is sensitive to the presence or absence of complexed calcium changes color to establish the end point.

The indicator itself is a complexing or sequestering agent much the same as the EDTA. Suitable indicators include chrome type dyes that form one color when complexed with a metal and another color when devoid of a metal. In addition, a suitable indicator must also have a dissociation constant between the metal-indicator less than that of the metal-EDTA constant. This is necessary so that when the EDTA is added as a titrant, it is able to sequester the metal (calcium) in the solution in competition with the indicator. If the indicator formed a stronger bond with the calcium than the calcium with the EDTA, the method would be wholly unsuitable.

Numerous metal indicators have been suggested for titration of calcium with ethylene di amine tetra acetic acid in alkaline solution. Generally, most of these indicators may be used in the present method and include the following indicators as typical examples: Acid Chrome lue K, Acid Chrome Dark Blue, Calcein, , Murexide, Phthaleincomplexone , Zincon. It has been found that Eriochrome Blue Black R is most satisfactory for present purposes this indicator has a red shade in the presence of calcium and is blue when the calcium is completely complexed with the EDTA. The performance of this indicator in mixed ion solutions in the presence of strong alkali improves with an increasing magnesium/calcium ratio. The pK values of the stability constants of the 1:1 calcium and magnesium complexes are 5.25 and 7.56 respectively. Because of these properties, it has been found to give superior results in the present method using EDTA.

Although the color change of the Eriochrome Blue Black R at the end point is reasonably distinct, the change from pink or red to blue presents a violet

transitional zone. With small quantities of samples such as serum being analyzed, this zone partly obscures the sharp end point required. The requisite sharpness of change may be obtained by adding a dye to the Eriochrome Blue Black R indicator that is yellow at the pH present in the solution during the entire course of the titration. When such a dye is added, there is a marked increase in the clarity of the end point which is then evidenced by a color change from a brilliant orange to brown at the transition zone to a clear green at the end point. The somewhat muddy brown color of the transitional zone is easily distinguished from the sharp green of the final end point.

As taught by the prior art, the calcium determination is not only influenced by magnesium but by other ions such as phosphate as well. The present method is not influenced by concentration of other ions such as phosphate in the sample except when present in unusually large concentrations. For example, the presence or absence of phosphate in the usual concentrations found in serum have been demonstrated not to influence the value of calcium obtained by the present method. However, substantially higher concentrations of phosphate may require consideration. When working with such a concentrated solution, the phosphate ion should preferably be removed by slurring a small amount of an anion exchange resin in the chloride form with the sample prior to the calcium determination to prevent any possible source of error. The phosphate will be absorbed onto the exchange resin and therefore not be actively present during the calcium determination.

The indicator selected for use in the present method is used in the same manner as indicators are normally used. Thus, a few drops of the indicator is added to the solution sufficient to impart enough color in solution for easy



detection of any change. The preferred indicator Eriochrome Blue Black R With methyl red is suitably combined in about equal weight ratios in a suitable diluent such as methyl alcohol. An anti-oxidant such as hydroxylamine hydrochloride may be added to the indicator solution to enhance its stability.

The alkaline borate solution is preferably made from an alkali metal hydroxide and an alkali metal borate. The hydroxide is added to the sample in an amount sufficient to obtain the previously noted pH range. The alkali metal borate is added on a mole basis in an amount preferably at least equal to the moles of magnesium hydroxide that is formed upon addition of the alkali. An excess of the borate will not adversely affect the determination and since the precise quantity of magnesium present is generally not known, a substantial excess of the borate is generally added.

The calcium is determined by using a standard solution of EDTA and by observing the volume of EDTA necessary to reach the end point. The amount of calcium in the sample is readily calculated by the usual formula.

The present method is well suited for use in connection with the micro-titrator disclosed and claimed in copending patent application Serial No. 42,106, filed July 11, 1960, entitled Metering Device. The following experiments were conducted with said micro-titrator. It should be understood that these examples are offered for illustrative purposes only.

### **1.12 Potassium:**

Potassium is a chemical element with symbol K (derived from Neo-Latin, kalium) and atomic number 19. 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 the alkali metals have a single valence electron in the outer electron shell, which is easily removed to create an ion with a

positive charge –a cation, which combines with anions to form salts. Potassium in nature occurs only in ionic salts. Elemental potassium is a soft silvery-white alkali metal that oxidizes rapidly in air and 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 (Webb, D.A 2005) (Anthony &J 2006), and is part of many minerals.

Naturally occurring potassium is composed of three isotopes, of which  $^{40}\text{K}$  is radioactive. Traces of  $^{40}\text{K}$  are found in all potassium, and it is the most common radioisotope in the human body.

Potassium is chemically very similar to sodium, the previous element in Group 1 of the periodic table. They have a similar ionization energy, which allows for each atom to give up its sole outer electron. That they are different elements that combine with the same anions to make similar salts was suspected in 1702 (Margaret & Andreas Sigmund 1761), and was proven in 1807 using electrolysis.

Most industrial applications of potassium exploit the high solubility in water of potassium compounds, such as potassium soaps. Heavy crop production rapidly depletes the soil of potassium, and this depletion is prevented and remedied with agricultural fertilizers containing potassium, accounting for 95% of global potassium chemical production. (Greenwood)

Potassium ions are necessary for the function of all living cells. The transfer of potassium ions through nerve cell membranes is necessary for normal nerve transmission; potassium depletion in excess can result in numerous abnormalities, including an abnormal heart rhythm and various electrocardiographic (ECG) abnormalities. Fresh fruits and vegetables are good dietary sources of potassium. The body responds to the influx of

dietary potassium, which raises serum potassium levels, with a shift of potassium from outside to inside cells and an increase in potassium excretion by the kidney.

### **1.12.1 Occurrences:**

The element is widely distributed in Nature, being the seventh in abundance order. The ocean water contains about 0.07% of potassium chloride, and it is necessary to evaporate 98% of this to make potassium salts start to crystallize. Potassium can be found in many volcanic rocks, which by disintegration supply the element to the soils and the water. The silicate leucite and glauconite are the commercial sources of potassium. The clays can absorb potassium retaining it in the soil and allowing the plants to use it. The main potassium ores are: the sylvite (KCl), the carnalite (KCl.MgCl<sub>2</sub>.6H<sub>2</sub>O), the langbeinite (K<sub>2</sub>SO<sub>4</sub>.2MgSO<sub>4</sub>), and the polyhalite (K<sub>2</sub>SO<sub>4</sub>.MgSO<sub>4</sub>.2CaSO<sub>4</sub>.2H<sub>2</sub>O) that can be found in Germany, USA, Canada, Russia, Palestine, Congo, Ethiopia, Brazil and Bolivia.

### **1.12.2 Compound:**

The principal ores of iron are hematite (ferric oxide, The only common oxidation state for potassium is +1.

Potassium metal is a powerful reducing agent that is easily oxidized to the monovalent cation, K<sup>+</sup>. Once oxidized, it is very stable and difficult to reduce back to the metal. (Dye & J.L 1979)

Potassium hydroxide reacts readily with carbon dioxide to produce potassium carbonate, and is used to remove traces of the gas from air. In general, potassium compounds have excellent water solubility, owing to the high hydration energy of the K<sup>+</sup> ion. The potassium ion is colorless in water and is very difficult to precipitate; possible precipitation methods include

reactions with sodium tetraphenylborate, hexachloroplatinic acid, and sodium cobaltinitrite. (Hollemon & Arnoldf 1985)

Potassium oxidizes faster than most metals and forms oxides with oxygen-oxygen bonds, as do all alkali metals except lithium. Three species are formed during the reaction: potassium oxide, potassium peroxide, and potassium superoxide (Lide&David R 1998) formed of three different oxygen-based ions: oxide ( $O^{2-}$ ), peroxide ( $O^{2-}_2$ ), and superoxide ( $O^{2-}$ ). The last two species, especially the superoxide, are rare and are formed only in reaction with very electropositive metals; these species contain oxygen-oxygen bonds. (Bukhardt ,P) All potassium-oxygen binary compounds are known to react with water violently, forming potassium hydroxide. This compound is a very strong alkali, and 1.21 kg of it can dissolve in as little as a liter of water.(Lide & D.R 2005) (Schultz ,P)

Potassium compounds are typically highly ionic and thus most of them are soluble in water. The main species in water solution are the aquated complexes  $[K(H_2O)_n]^+$  where  $n = 6$  and  $7$ . (Lincoln ,S.F 1972)

Some of the few poorly soluble potassium salts include potassium tetraphenylborate, potassium hexa chloro platinate, and potassium cobaltinitrite. (Hollemon & Arnoldf 1985)

### **1.12.3 Method of Potassium analysis:**

Determination of potassium by a simple flow injection flame photometric system a simple flow injection with flame photometric detection has been developed for potassium and total alkalies in Portland cement, fly ash, admixture and water of concrete. A liquid sample or a digest of solid sample was injected into a water carrier stream which flowed to a flame photometer .A change in emission intensity at a selected wavelength was recorded as a

peak.

Determination of potassium by tetra phenyl borate method; and also determination of potassium by atomic absorption spectrophotometry .

### **1.13 Ferrous:**

Ferrous ( $\text{Fe}^{2+}$ ), in chemistry, indicates a divalent iron compound (+2 oxidation state), as opposed to ferric, which indicates a trivalent iron compound (+3 oxidation state). (Merriam-webster 2008) This usage has mostly been deprecated, with current IUPAC nomenclature having names containing the oxidation state in bracketed Roman numerals instead, such as iron(II) oxide for ferrous oxide ( $\text{FeO}$ ), and iron(III) oxide for ferric oxide ( $\text{Fe}_2\text{O}_3$ ). Iron is an abundant element in the universe; it is found in many stars, including the sun Pourbaix diagram of aqueous iron Outside chemistry, ferrous is an adjective used to indicate the presence of iron. (Merriam-Webster 2008) The word is derived from the Latin word ferrum (iron). (Etymology 2008)

Ferrous metals include steel and pig iron (with a carbon content of a few percent) and alloys of iron with other metals (such as stainless steel). Manipulation of atom-to-atom relationships between iron, carbon, and various alloying elements establishes the specific properties of ferrous metals. (Ferrous Alloys Properties 2013 )

The term non-ferrous is used to indicate metals other than iron and alloys that do not contain an appreciable amount of iron.(Merriam-Webster 2008)

#### **1.13.1 Occurrence:**

Iron is the fourth most abundant element in the earth's crust, of which it constitutes about 5% by weight, and is believed to be the major component of the earth's core. Iron is found distributed in the soil in low concentrations and is found dissolved in groundwaters and the ocean to a limited extent. It

is rarely found uncombined in nature except in meteorites, but iron ores and minerals are abundant and widely distributed.

$\text{Fe}_2\text{O}_3$  and limonite (ferric oxide trihydrate,  $\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ ). Other ores include siderite (ferrous carbonate,  $\text{FeCO}_3$ ), taconite (an iron silicate), and magnetite (ferrous-ferric oxide,  $\text{Fe}_3\text{O}_4$ ), which often occurs as a white sand. Iron pyrite (iron disulfide,  $\text{FeS}_2$ ) is a crystalline gold-colored mineral known as fool's gold. Chromite is a chromium ore that contains iron. Lodestone is a form of magnetite that exhibits natural magnetic properties.

### **1.13.2 Compound:**

Iron forms such compounds as oxides, hydroxides, halides, acetates, carbonates, sulfides, nitrates, sulfates, and a number of complex ions. It is chemically active and forms two major series of chemical compounds, the bivalent iron (II), or ferrous, compounds and the trivalent iron (III), or ferric, compounds. Ferrous sulfate heptahydrate ( $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ ) sometimes called green vitriol, is a compound formed by the reaction of dilute sulfuric acid (formerly called oil of vitriol) with metallic iron; it is used in the manufacture of ink, in dyeing, and as a disinfectant. Ferric chloride hexahydrate,  $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ , is a yellow-brown crystalline compound used as a mordant in dyeing and as an etching compound. Ferric oxide,  $\text{Fe}_2\text{O}_3$ , is a reddish-brown powder used as a paint pigment and in abrasive rouges. Prussian blue,  $\text{K}_4[\text{Fe}_2(\text{CN})_6]$ , is a pigment containing the ferrocyanide complex ion. Iron rusts readily in moist air, forming a complex mixture of compounds that is mostly a ferrous-ferric oxide with the composition  $\text{Fe}_3\text{O}_4$ .

### **1.13.3 Method of analysis:**

Iron can be determined by direct titration; when iron (III) solution titrated with standard EDTA by using colored indicator, the initial color of indicator

will change to yellow at the end point.

Determination of iron as 8-hydroxyquinolate; Iron (III) can be extracted from aqueous solution with a 1 per cent solution of 8-hydroxyquinolate in chloroform by double extraction when the PH of the aqueous solution is between 2 and 10, iron (III) oxinate is dark –colored in chloroform and absorbs at 470 nm.

Determination of iron as iron (III) oxide by initial formation of basic iron (III) formate.

### **1.12 Objective of this work:**

#### **The objectives of this work are:**

- To analyze the baobab pulp and seeds, in order to determine the nutritional contents of some elements such as calcium, potassium and Iron.
- Getting through the methods of analysis using modern instruments such as spectrophotometer and flame photometer.

## **2. Materials and methods**

### **2.1 Materials and equipments:**

#### **2.1.1 Materials**

Hydrochloric acid (HCL)

Ammonium ferrous sulfate ( $(\text{NH}_4)_2\text{SO}_4 \cdot \text{FeSO}_4 \cdot 6\text{H}_2\text{O}$ )

Sulfuric acid ( $\text{H}_2\text{SO}_4$ )

Potassium Permanganate ( $\text{KMnO}_4$ )

Nitric acid ( $\text{HNO}_3$ )

Potassium cyanide (KCN)

Distilled water (D.W)

Sodium hydroxide (NaOH)

### **2.2 Methods:**

#### **2.2.1 Sample preparation:**

Preparation of raw materials: *Adansonia digitata* were collected from a valley local market in Khartoum. The experiment was carried out during the year 2016.

#### **2.2.2 Chemical analysis of the sample:**

##### **2.2.2.1 Ash content:**

20.0 g of the sample was burned in oven at  $600^\circ\text{C}$ , until removed all carbon from organic matter in form of carbon dioxide, water which produced from this heat and remaining of burning were weighted of ash. The percent of ash was found to be as shown below:



**Table 2.1**

| Weight of crucible/g | Weight of crucible and ash/g | Weight of ash/g |
|----------------------|------------------------------|-----------------|
| 62.3057 g            | 63.8657 g                    | 1.56 g          |

$$ash = \frac{\text{w of g of ash}}{\text{w of g of sample}} \times 100 \quad ash = \frac{1.56}{20.00} \times 100 = 7.85\%$$

### **2.2.2.2 Determination of protein;**

#### **i) Preparation of sample:**

Sample was grinded or blended until homogenous then kept in screw-cap bottle in a freezer.

#### **ii) Analysis:**

Blank; include two reagent blanks, in every batch of analysis to subtract reagent nitrogen from sample nitrogen.

Test sample:

0.20 g of sample was weighted in duplicate into the digestion tube and 5-7 g of catalyst and 1 glass bead to prevent solution from bumping, 10-20 ml sulfuric acid were added. The digestion tube was placed in digester and digest mixture initially at low temperature to prevent frothing and boil briskly until the solution is clear and is free of carbon or until the oxidation is completed. The digestion was continued until the digest is obtained, the liquid was heated to another hour after became clear to completed breakdown of all organic matter, 250-500ml Erlenmeyer flask containing 50ml of 4% boric acid with indicator was placed as receiver on the

distillation unit ,100ml of water and 70ml of 50% sodium hydroxide were added to the digests and start distillation , the solution was distilled until all ammonia has been released or approximately >150ml distillate is obtained , the receiver flask was lowered so that the delivery tube is above the liquid surface and the distillation was continued for 1-2 minutes. (Hurwitz W ,2000)

The distillate was titrated with the standardized 0.1 N hydrochloric acid until the first appearance of the pink color, and then the volume of acid used to the nearest 0.05 ml was recorded.

$$N (g\%) = \frac{\text{ml } 0.1N \text{ HCl sample} - \text{mL } 0.1N \text{ HCl BLANK} ) * NHCl * 100}{\text{weight of sample}}$$

$$= 0.56 \%$$

$$\text{Protein ( g per 100g)} = \% \text{ total nitrogen} * \text{appropriate conversion Factor}$$

$$= 3.50\%$$

### **2.2.2.3 Determination of metals:**

#### **2.2.2.3.1 Sample preparation for metals analysis:**

The ash obtained from step 2.2.2.1 was dissolved with hydrochloric acid, converted to 100ml volumetric flask and completed up to mark with distilled water.

#### **1) Determination of iron:**

0.707 g of ammonium ferrous sulphate was weighted into 100ml beaker, dissolved with small portion of water and sulfuric acid and oxidized to  $Fe^{+3}$  using potassium permanganate(0.02M) converted to 100ml volumetric flask and completed to mark with distilled water. The solving solutions were

prepared using Solution of sample KSCN and HNO<sub>3</sub> then completed up to the mark with distilled water as shown in table 2.2:

**Table (2.2)**

| <b>C/Ppm</b>           | <b>0</b> | <b>2</b> | <b>4</b> | <b>6</b> | <b>8</b> | <b>10</b> |
|------------------------|----------|----------|----------|----------|----------|-----------|
| <b>Fe<sup>+3</sup></b> | 0        | 1        | 2        | 3        | 4        | 5         |
| <b>HNO<sub>3</sub></b> | 2.5      | 2.5      | 2.5      | 2.5      | 2.5      | 2.5       |
| <b>SCN</b>             | 3\2      | 3\2      | 3\2      | 3\2      | 3\2      | 3\2       |
| <b>Sample</b>          | 0.5      | 0.5      | 0.5      | 0.5      | 0.5      | 0.5       |

And the adsorption was measured at 480 nm. The results was recorded at Table 2.3

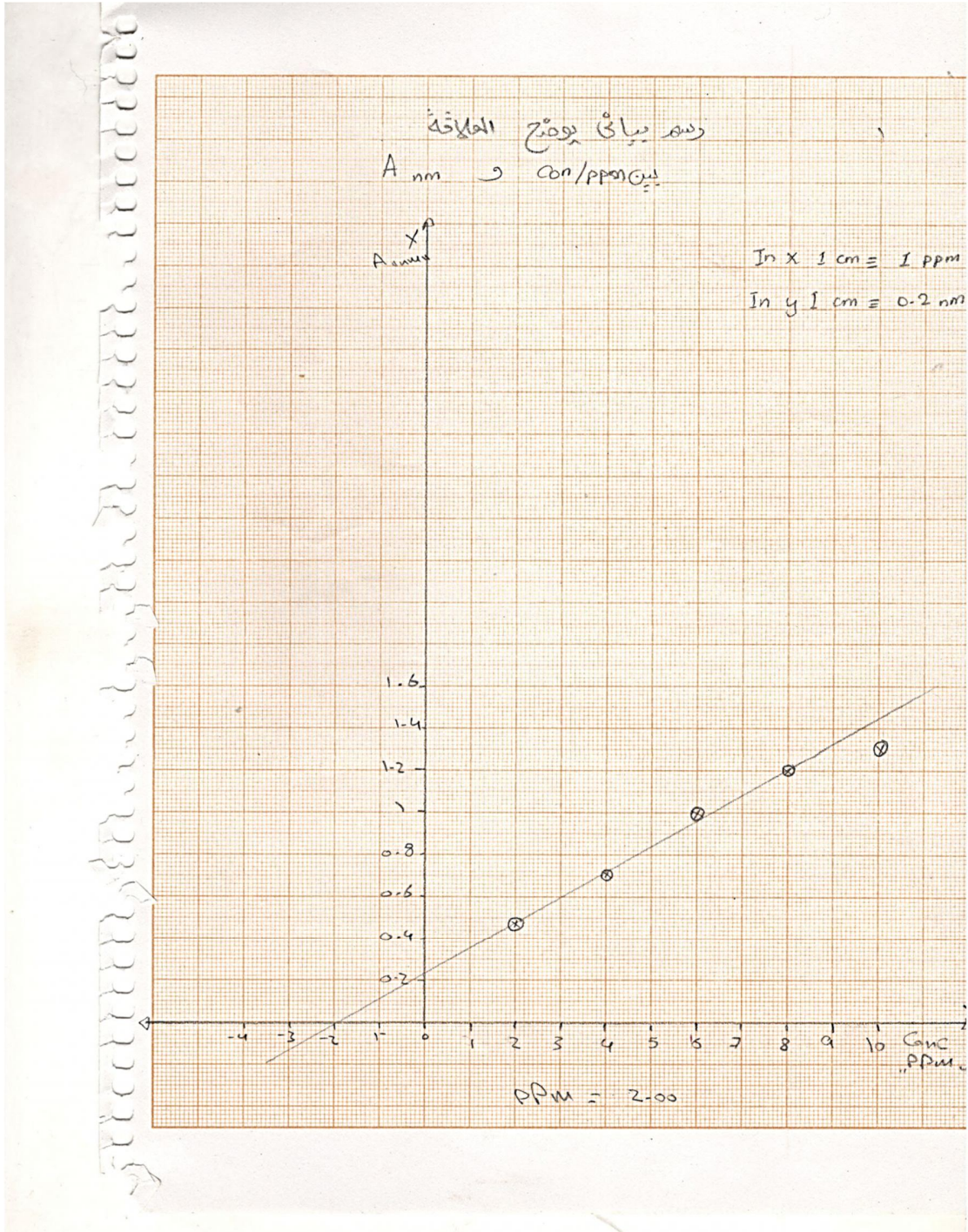
**Table (2.3)**

| <b>Concentration ppm</b> | <b>Absorption</b> |
|--------------------------|-------------------|
| <b>0</b>                 | 0.0               |
| <b>2</b>                 | 0.478             |
| <b>4</b>                 | 0.727             |
| <b>6</b>                 | 1.052             |
| <b>8</b>                 | 1.244             |
| <b>10</b>                | 1.353             |

From the plot the concentration of the iron was found to be 1.7ppm

$$\% = \frac{ppm * Vml * df * 10^{-4}}{W_s}$$

$$Fe\% = \frac{2 * 100 * 100 * 10^{-4}}{20} = 0.1\%$$



**Figure (2.1) absorbance of  $Fe^{+3}$  against concentration:**

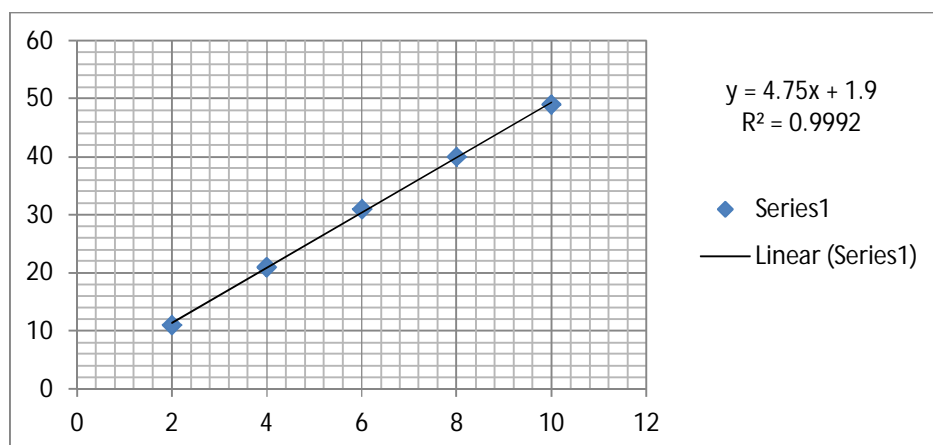
## 2) Determination of potassium:

1000 ppm of solution of potassium was prepared, from which 0, 2,4,6,8 and 10 ppm were prepared in 50 ml volumetric flask, the emission was measured, 2 ml of the sample was transferred to 10 ml volumetric flask filled up to the mark with D.W, 1 ml of this solution was diluted to 100 ml, the emission was measured and the results were recorded at Table 2.5

**Table (2.4)**

| C/ppm  | Emission |
|--------|----------|
| 0      | 0        |
| 2      | 11       |
| 4      | 21       |
| 6      | 31       |
| 8      | 40       |
| 10     | 49       |
| Sample | 37       |

$$\% K = \left( \frac{7.32 \times 100 \times 10^{-4}}{20.00} \right) \times 100 = 0.00366\%$$



**Figure (2.2) Emission against concentration**

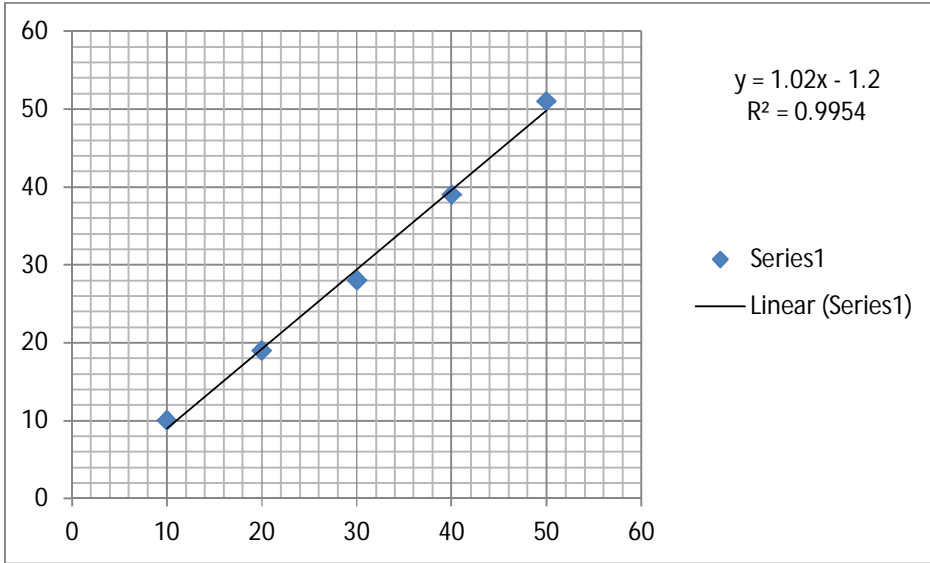
### 3) Determination of calcium:

1000 ppm of solution of Calcium was prepared, from which 0,2,4,6,8 and 10 ppm were prepared in 50 ml volumetric flask, the emission was measured, 5ml of the sample was transferred to 10 ml volumetric flask filled up to the mark with D.W , the emission was measured and the results were recorded at Table 2.6 .

**Table (2.5)**

| C/ppm  | Emission |
|--------|----------|
| 0      | 0        |
| 10     | 10       |
| 20     | 19       |
| 30     | 28       |
| 40     | 39       |
| 50     | 51       |
| Sample | 18       |

$$\% \text{ Ca} = \left( \frac{92.588 \times 100 \times 10^{-4}}{15.083} \right) \times 100 = 0.046\%$$



**Figure (2.3) Emission against concentration**

### **3. Discussion**

The baobab seed and pulp were analyzed for proximate composition, mineral content; also protein was evaluated .pulp contain substantial quantities of calcium, potassium, and magnesium. So The percentage of Iron was estimated using atomic spectrophotometry method the percentage was found to be 0.1%. Calcium and potassium were estimated using spectrophotometric method. The percentage was found to be 0.00366 and 0.046 % respectively. Also Protein was estimated using digestion method and the percentage was found to be 3.50%.



### **Recommendations**

We recommended that baobab fruit may be used as mineral supplier for the deficient of some minerals for human as food or drinking juice, that's due to the potential to improve nutrition, boost food security, foster rural development, and support sustainable land care.

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