BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE EDUCATION

DEPARTMENT OF SCIENCE AND MATHEMATICS EDUCATION

COMPARING IRON CONTENT IN SELECTED MEDICINAL PLANTS

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A LABORATORY BASED DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE BACHELOR OF SCIENCE HONOURS DEGREE IN CHEMISTRY EDUCATION

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APPROVAL FORM

The undersigned certify that they have supervised, read and recommend to the Bindura University of Science Education for acceptance a research project entitled:

DETERMINATION OF IRON CONTENT IN SELECTED MEDICINAL PLANTS

Submitted by BANDA PATIENCE

In partial fulfilment of the requirements for the HONOURS IN BACHELOR OF SCIENCE EDUCATION: CHEMISTRY

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ACKNOWLEDGMENTS

Firstly, I would like to thank the Almighty for the spiritual guidance and inspiration throughout my studies at Bindura University of Science Education. I also give credit to my academic supervisor Prof Dzomba P. for his academic wisdom and unwavering guidance. I can not refrain from mentioning the members of my study group for their consistent, faithful support. In addition, I would like to thank the chemistry laboratory staff and encouragement, particularly Mrs Zhou R. for her advice and encouragement. Last but not least, I extend my sincere gratitude to my family for their constant love and consistent support.

DECLARATION

I BANDA PATIENCE declare that all the work in this project for the Honours Bachelor in Science Education degree of Bindura University of Science Education is my own work and has not been copied from other work without acknowledgement of the original source.

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Supervisor

I Prof P. Dzomba declare that I have supervised this research project and now hereby satisfy that it can be submitted to the faculty of Science Education of Bindura University of Science Education.

Signed

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BINDURA UNIVERSITY OF SCIENCE EDUCATION

RELEASE FORM

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DEGREE TITLE: HBScED

YEAR TO BE GRANTED: 2023

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ABSTRACT

Anaemia cases are on the rise in Zimbabwe. Due to tough economic situations, a number of individuals are failing to afford the required diet and medication. The study aimed at comparing iron content in selected traditional medicines, so that they could be recommended as an affordable remedy for anaemia. Plants were collected, dried, powdered and ashed. The ash was then filtered using sulphuric acid before being titrated against potassium permanganate. The results from the titrations were used to calculate the number of moles, and hence the mass of iron in each plant extract.

LIST OF TABLES

CONTENTS

CHAPTER ONE

This section focuses on the introduction, the background of the study, the statement of problem, the objectives, the significance and limitations.

1.0 *Introduction*

Medicinal plants have been a reliable source of succour in many countries and ethnic groups over the years. Anaemia has not been exempted from the diseases which have been cured by medicinal plants, especially in developing countries. This study intended to carry out a survey on medicinal plants used mainly in Zimbabwe for the treatment of anaemia. The researcher mostly centred her studies on the plants which are abundant in Kariba, in northwest Zimbabwe, Mashonaland west province. Iron content was determined for selected plants. The researcher used the titration method for comparing the iron content.

1.1 *Background of the study*

The number of people suffering from anaemia has been increasing recently in these past years. Some individuals usually fail to get medical attention because the doctors' fee and generic drugs are not affordable to them and are sometimes not readily available. In addition, there is an increase in the number of people who are advocating for natural products in favour of artificial/synthetic medicines. 'Going green' has become the trending norm, resulting in an increase in the use of natural medicines. Most of these have the advantage of being locally available at a low cost or at no cost at all. Medicinal plants are also becoming more and more popular because it is believed that their side effects are less severe than those of synthetic drugs.

1.2 *Statement of the problem*

Of late Zimbabwe has faced an economic nosedive. Most companies have been closing, leading to lots of people losing their jobs. Some have been retrenched and the COVID 19 pandemic has forced most employers to reduce the number of employees. This had led to most low income families failing in accessing medical attention. Some commercial drugs cost too much. In addition, medical doctors charge exorbitant fees. In the case of anaemic patients, if the condition is left unattended, it might lead to death. There also has been a notable increase in the number of teenage pregnancies in the previous few years, resulting in concealed pregnancies and lack of medical attention. A significant percentage of pregnant teenage girls have therefore ended up succumbing to iron deficiency and its complications. These could also be avoided if the girls could access cheap, readily available iron sources like medicinal plants.

1.3 *Objectives of the study*

The objectives of this research are:

- To identify local medicinal plants which contain iron.
- To identify the parts of the plant which are used for providing the iron.
- To select five of these plants and test for their iron content.

1.4 *Research questions*

The research aimed at answering the following questions:

- Which local plants are used for treating anaemia and anaemic symptoms?
- Which parts of these plants are used, and how?
- How much iron does each of the selected plants contain?

1.5 *Assumptions of the study*

The researcher assumed that medicinal plants used to treat anaemia contain a certain amount of iron in them. After this research people would be able to use the recommended medicinal plants as iron sources or remedies for anaemia.

1.6 *Significance of the study*

The results of the study may help people in Zimbabwe to use easily accessible resources as medicines for anaemia, almost at zero cost. It also leaves room for further research into these medicines so that they can be used as a natural source for making iron supplements.

1.7 *Limitations of the study*

The study was carried out while the researcher was carrying out all her teaching duties, which required a lot of attention in many ways such as lesson planning, assessment of learners' work, class teacher's including CALAs and related tasks which the researcher was assigned by the school. Twinned with her duties at home, the researcher was therefore presented with challenges in time management. The researcher also had very limited funds which would not allow her to travel to different regions in Zimbabwe to widen her study to other areas and collect samples from different areas.

1.8 *Delimitations of the study*

The study was limited to the plants found in Kariba only. It would also be interesting to find out how the percentage of the iron would vary with fruits and plants from different geographical environments.

1.9 *Definition of terms*

Nutrient

This is a source of nourishment such as food, that can be metabolised by an organism so that it gives energy and builds are important in metabolism and are found naturally in our body.

Micronutrient

It is a mineral ion, a vitamin or any other substance that is essential to rhe body but required in very small quantities for growth or metabolism.

Iron

Allison and Grant (2001) define iron as "an essential mineral necessary for the transport of oxygen (via haemoglobin or myoglobin in red blood cells) and for oxidation by cells (via cytochrome)."

Deficiency

A lack of, or a state of incompleteness of a certain component. It can also be defined as an insufficiency, especially of something essential to health.

Anaemia

This is a medical condition in which the capacity of the blood to transport oxygen to body tissues is reduced either because of too few red blood cells or too little haemoglobin.

Anaemia is defined as "haemoglobin concentration below established cut off levels". It is not a disease, but a state reflecting a nutritional deficit or sometimes an underlying disorder. As for the cut off levels, most studies carried out so far have used the values suggested by a WHO expert committee at the end of the 1960s: 13 g per decilitre for men, 12 g per decilitre for women.

Titration

Refers to a method in which known amounts of the titrant are added to the analyte until the reaction reaches the endpoint (also known as titrimetry). It is a common laboratory method of quantitative chemical analysis which is used to determine the concentration of an identified analyte.

Quantitative analysis

"It involves the use of computation, statistical and mathematical tools to derive results." (https://www.sisinternational.com/what is quantitative research).

1.10 Summary

This section gave a brief background to the study problem, spelt out the aims of the study, the objectives, significance, the limitations as well as the delimitations. The next chapter will be focusing on the literature related to iron, its structure, constituents and use.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The previous chapter gave a brief background to the study problem, spelt out the aims of the study, the objectives, significance, the limitations as well as the delimitations of this study. This chapter gives a brief overview of literature related to the study by focusing on the factors to consider when testing for iron as well as showing the amounts of iron in the different medicinal plants under study.

2.2 Medicinal plants

According to Gomez (1985), "traditional foods are said to be wholesome available, accessible, affordable, unrefined, unprocessed and natural." Consuming food directly from the source results in less nutrient loss. This increases the chances of obtaining more nutrients, including micronutrients like iron, even from medicinal plants because they require less processing. The advantage of medicinal plants is that they are drought resistant and therefore they do not require a lot of rain for them to survive. Harris and Mohammed (2003), stated that "these plants are resistant to diseases and droughts, and can be used as an alternative source of iron..." Lack of micronutrients in most foods has resulted in food scientists devising ways of fortifying processed foods with these nutrients." According to Welth and Graham (2004), more than three million people suffer from micronutrient mal-nutrition. This results in new bio-fortification initiative programmes being introduced in staple foods." Stangoulis (2010), asserts that this shows that most food consumed these days is fortified with micronutrients such as iron, zinc and vitamins. In this investigation, the following medicinal plants were gathered and analysed for their iron content:

TABLE 2.1: SOME MEDICINAL PLANTS USED FOR TREATING ANAEMIA

Common English name(s)	Some Shona names	Botanical name	Some Ndebele names
Beetroot		Beta vulgaris	
Pigweed/Wild beetroot	Mowa/bonongwe	Amaranthus retroflexus	Imbuya yabo babhemi
Sjambok pod/Long tail cassia	Murumanyama/Murembe rembe/Muvheneka	Cassia abbreviata	Ingwelala /Isihaqa
Black jack	Tsine/Mhuwu	Bidens pilosa	Umuhlabangubo/ Ucucuza
Tamarind	Utsiga/tsiga	Tamarindus indicus	Inkunkuzana enkulu

These plants were selected for two reasons. Firstly, they are naturally occurring plants. Secondly, they have no known side effects.

Some metals are important in metabolism and are found naturally in plants. The human body contains 4g of iron, the majority of this occurring in haemoglobin, a red pigment in blood corpuscles (www.lenntech.com/recommended-daily-intake.htm). Iron can also be found in myoglobin, another protein molecule which also transports oxygen. Iron is an important mineral in our diets. Although considered as a trace mineral (one that is needed in relatively small quantities), a diet lacking iron can contribute to the deficiency condition known as anaemia. Certain foods, such as beef, liver, ground nuts, figs, milk, cereals and some vegetables, are natural sources of iron .According to Jorgenson (2012), the acceptable and recommended daily intake of iron in the diet is considered to be 15mg.

2.3 *Iron*

The human body contains 4g of iron, most of which is occurring in haemoglobin. Haemoglobin is a red pigment found in red blood corpuscles (www.lenntech.com/recommended-daily-intake.htm). Iron is an important mineral in our diets. Although it is considered as a trace mineral (one that is needed in relatively small quantities), a lack of iron can contribute to a deficiency condition known as anaemia. Naturally, iron occurs in certain foods, for example beef, liver, ground nuts, figs, milk, cereals and some vegetables. According to Jorgenson (2012), the acceptable and recommended daily intake of iron in the diet is considered to be 15mg. A lack iron can contribute to a deficiency condition known as anaemia

2.4 *Absorption of iron*

Only about 10% of the iron intake is absorbed in the human body. Waugh and Grand (2001) noted that, "the absorption of iron is poor due to the fact that most of the iron in the diet is ionic and non-haem." Non-haem iron (Fe^{3+}) cannot be absorbed directly by the body. This means that absorption will only take place when the iron (III) ions are converted to iron (II) ions which are then absorbed in the small intestines. Wood and Pickering (1982) further explained that iron is absorbed and passed directly into the mucosa cells where it binds with a protein as a prosthetic group and enters the bloodstream. According to Ancuceanu et al, (2015) factors like alkaloids, flavonoids, saponins, tannins, calcium zinc and vitamin C affect absorption of iron in the body. Vitamin C plays an important role in iron absorption as it causes the reduction of iron (III) ions to iron (II) ions. Wood and Pickering (1982) add that there are substances which prevent the absorption of iron (II) ions by the formation of precipitates. Examples of such substances include oxalates found in spinach, phosphates found in egg yolk and tannin in tea. Oxalates bind iron to form iron ferrous oxalate, making iron unavailable, Singh and Bhardwaj (2012).

2.5 *Functions of iron*

Iron is responsible for oxygen transportation in haemoglobin. Iron serves as an oxygen carrier. It transports oxygen to the tissues from the lungs. This is accomplished by red blood cells which have haemoglobin, which combines with iron to form oxyhaemoglobin (the compound which gives blood its bright red colour).The oxygen is used in the production of energy in the cells in a process called respiration. Myoglobin, a globular protein which also transports oxygen contains iron as a prosthetic group to help it function well. It holds iron in readiness for muscular activity. In cells, iron is also utilised by respiratory enzymes during respiration at cellular level. Wood and Pickering, (1982) also add that, "iron is absorbed and passed directly into the mucosa cells where it binds with a protein as a prosthetic group and enters the bloodstream." According to Ancuceanu et al, (2015) iron functions as a cofactor in many enzymes involved in the production of specific amino acids, neurotransmitters, hormones and collagen. Norris, Ryan and Acaster (2011) assert that, "iron (II) ions are involved in the function of cytochrome (cytochrome c), which is linked to ATP (energy) production in oxidative phosphorylation in the mitochondria found in living cells. Iron serves as a transport medium for electrons within the cells and as an integral part of important enzyme systems in various tissues. Iron is stored as Ferritin which is an iron complex with proteins. Ferritin is found in the bone marrow, liver and spleen. Iron is stored as ferritin and iron absorption is regulated by the quantity in the mucosal cells.

2.6 *Chemistry of iron*

Fe is the chemical symbol of iron. It has a molecular mass is 55.845g. Iron is a transitional metal element which has oxidation states ranging from -2 to +6, with the +2 and +3 being the most common oxidation states. They can be referred to as **Ferrous ion (Fe^{+2})** and **Ferric ion (Fe^{+3})**. The ferric ions are the most stable. Iron is the fourth most abundant element on earth, but iron deficiency in humans is one of the most widespread nutritional deficiency problems in the world. This is because the human intestine can not easily absorb most iron compounds.

In the solid form, iron exists as a malleable metal, which readily oxidises in moist air. Iron is soluble in inorganic acids such as hydrochloric acid, sulphuric acid and nitric acid. Ferrous salt oxidises to the ferric form in the presence of moist air. It reacts with chromogenic agents to form complexes with coloured compounds. The colour of the complexes varies according to the oxidation state of iron in that complex. This is helpful for determining the presence of either ferrous or ferric iron, Wood and Pickering (1982).

2.7 *Iron analysis*

Background information

2.7.1 **Redox titration method**

In this method, iron (II) ions are titrated against potassium permanganate. The method is based on the following reaction:

$$5\,Fe^{2+}_{(aq)} + MnO_4^{-}{}_{(aq)} + 8\,H^{+}_{(aq)} \longrightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)} + 5Fe^{3+}_{(aq)}$$

Since potassium permanganate is an oxidising agent, it will oxidise Fe^{2+} ions in the test samples to Fe^{3+}. An acidic environment is necessary for reducing the $KMnO_4$ to Mn^{2+}.

Stoichiometry will then be used to determine the number of moles of iron present in the test sample. The volume will be multiplied by the concentration.

Iron (II) ions can also be titrated against thiocyanate ions (SCN^-).

$$Fe^{3+}{}_{(aq)} + SCN^{-}{}_{(aq)} \longrightarrow Fe(SCN)^{2+}{}_{(aq)}$$

The deep red colour of the iron (III) thiocyanate ion is directly related to the concentration of iron (III) originally present in the solution. Iron in foods is in the form of either iron (II) or iron (III). In this test, all iron in the original sample is either converted to iron (III) ions or is not determined through the thiocyanate test, Vogel (1978)

2.7.2 **Qualitative analysis**

The method is also referred to as the spot test. Hydrogen peroxide is used to oxidise the iron to iron (III) ions and a red spot is observed on the filter paper.

2.7.3 **Colorimetric**

This method is centred on the formation of coloured compounds as a result of the reaction between iron and colorimetric agents to form complex compounds. The colour of the complex compound formed varies depending on the oxidation state of iron in that complex. Sophisticated instruments which may be expensive are required for this method. The instruments may also be too complicated.

Conclusion

Iron is an essential micronutrient that is found in medicinal plants and vegetables. It is involved in a number of activities in metabolism and is also vital for oxygen transportation. It is an important component of the body for transportation of oxygen in the blood. The human body absorbs Fe^{2+} ions better than Fe^{3+}. There are chemicals which may either hinder or facilitate the absorption of iron in the body. Methods used to analyse iron include titration, qualitative and colorimetric.

Chapter 3

Research Methodology

3.1 *Introduction*

The previous chapter gave a brief summary of the literature related to this study. In addition, it also focused on the factors which are considered when testing for the presence of iron and on how to determine the amounts of iron in a given sample. This chapter explains how iron content investigations can be carried out. It explains how data can be collected and the reliability of the method used. The chapter also focuses on how the research was carried out. A description of the possible methods used to carry out the study is outlined, followed by a look into the research instruments, their advantages and disadvantages and the sampling methods used.

3.2 *Research design*

According to Ary (2007), a research design is a strategy, plan or structure of conducting a research. It can also be defined as a plan of study which provides the overall framework for collecting data. McMillan (2014), defined a research design as "the exposition or plan and structure of investigation which has the object of executing the research concerned in such a way that the validity of findings is maximised in answering specific research questions." The research design is a plan of the investigation used in order to obtain information and to answer the research questions for a study. Gay and Airasian (2003), defines a research design as a "strategy, plan or structure of conducting a research." It is a plan of study which provides the overall framework for collecting data. In this investigation the researcher used quantitative methods for her study.

3.3 ***Research instrument***

3.3.1 *The experiment method*

The researcher carried out investigations using the ash of the different samples. She first dried the leaves or bark (for beetroot the bulb was dried), powdered the samples and then ashed them.

Ashing was done in order to fee the iron from the biological molecules it might be bound to. It also enables an efficient reaction between the Fe^{3+} ions and the titrating reagents. After ashing, the samples were filtered using hydrochloric acid, which dissolves the iron compounds in the sample as well as supplies some H^{+} ions which are necessary for the reaction between manganate and ferrous ions. Distilled water was added to make up the volume and the samples were then titrated using potassium permanganate.

3.3.3 *Titration*

This is a technique in which a solution of known concentration and volume is used to determine the concentration of a solution whose concentration is unknown. Typically, the titrant is a solution whose concentration and volume is known. It is added from a burette to a known quantity of the analyte (the analyte is a solution which has unknown concentration) until the reaction is complete. The unknown concentration is determined using the known volume of the titrant added. An indicator is used to usually signal the end of the reaction, called the endpoint.

Advantages of titration

(1) Cost effective

(2) Does not need great expertise except for some skill and practice

(3) It is one of the oldest and commonly used methods

(4) Instruments are easily available in school laboratories

(5) Is a simple method

Disadvantages:

(1) If done manually it is time consuming

(2) It needs instruments which are properly calibrated and the calibrations must be visible

(3) Needs skill and practice for effective results

(4) There is need to carry out a thorough research on the reactivity of the elements because this might affect the end point

3.4 *Determination of iron*

The method recommended by the 39th International Chemistry Olympiad of 2007 is the basis on which the method used to determine iron content was selected (in this research). Fe^{2+} ions are fairly strong reducing agents. They can be readily oxidised to Fe^{3+} ions, thus this can be determined separately or as total iron content. The iron was determined as total iron in medicinal plants using titration with permanganate (VII) in this research.

$$MnO_4^-{}_{(aq)} + 8H^+{}_{(aq)} + 5e^- \longrightarrow Mn^{2+}{}_{(aq)} + 4H_2O_{(l)} \qquad (1)$$

This equation shows the reduction of manganate (VII) to manganite (II)

$$Fe^{2+}{}_{(aq)} \longrightarrow Fe^{3+}{}_{(aq)} + e^- \qquad (2)$$

This equation shows the oxidation of ferrous iron (Fe^{2+}) to ferric iron (Fe^{3+})

$$MnO_4^-{}_{(aq)} + 8H^+{}_{(aq)} + 5Fe^{2+}{}_{(aq)} \longrightarrow Mn^{2+}{}_{(aq)} + 5Fe^{3+}{}_{(aq)} + 4H_20_{(l)} \quad \text{(equation 1+ equation 2)}$$

This is the overall reaction in which manganite ions oxidise ferrous iron. The end point of the titration procedure will mark the complete oxidation of iron, hence the percentage composition of iron can be determined by stoichiometric calculations.

The following equation was used for determining the number of moles:

number of moles = concentration x volume

According to the overall reaction, 1 mole of manganate ions reacts with 5 moles of ferrous ions. Number of moles of MnO_4^- is multiplied by 5 in order to obtain the number of moles of iron. Number of moles of iron is then divided by the volume so as to get the concentration. Mass in grams is obtained by multiplying the moles by the molecular mass (Mr).

3.5 *Sample preparation*

- For pigweed and blackjack, remove leaves and dry in a shed. Using mortar and pestle, pound the dry leaves into a powder. Measure 2.5 g of the powder and put into a crucible. Use a burner to heat the powder until it has all been ashed. Remove the burner and allow the ash to cool. Transfer the ash into a small beaker.

To avoid iron contamination, pluck the leaves by hand and clean the crucible, pestle and mortar with hydrochloric acid and double distilled water before use.

- For sjambok pod first dry the bark and then powder it. Treat 2.5g of the powder in the same way as the powder of the pigweed and blackjack powders.

- Cut the beetroot bulb using a glass blade to avoid iron contamination, and then dry in a shed and powder. Measure 2.5g and ash.

- Dry Tamarind pulp before measuring 2.5g of the powder and ashing it).

Procedure

1. Weigh 5 empty small beakers using an electronic digital balance and record their masses.

2. Place an ash sample in the small beaker and weigh. Each sample must be weighed in its own beaker until all the 5 samples are of the same mass.

Record your results in table 1.1

Table 3.1

Mass of small beaker + sample (g)	
Mass of empty small beaker (g)	
Mass of sample used (g)	

3. Add $10cm^3$ of 2M hydrochloric acid to the ash and thoroughly stir the mixture for 1 minute.

4. Add 10cm^3 distilled water to the mixture, stir and then filter. Collect the filtrate.

5. Transfer the filtrate into a 250ml volumetric flask. Make up to the mark with distilled water.

6. Pipette 25cm3 of the filtered solution into a conical flask. Add a rice grain of zinc powder (this would reduce any Fe^{3+} ions in the sample to Fe^{2+}).

7. Add 25.0cm^3 of sulphuric acid into the conical flask (an acidic environment is necessary for the redox reaction to occur)

8. Titrate the contents of the conical flask with 0.1M $KMnO_4$ until a bright pink colour is observed in the flask. Repeat the titrations for as many times as you may see necessary.

8. Record your results in a table as the one below:

Table 3.2

Final burette reading (cm^3)				
Initial burette reading (cm^3)				
Volume of $KMnO_4$ used (cm^3)				

Preparation of chemicals

Sulphuric acid was used as the solvent. 100ml of 32% Sulphuric acid was separately diluted into a volumetric flask and made up to 1000ml to give a concentration of 1.0 moldm^{-3}. 4g of Potassium permanganate was dissolved in 250ml of distilled water giving 0.1moldm^{-3}.

3.8 *Conclusion*

The titration method was used to analyse the iron content because of various reasons, some of which are the ease of implementation and no need for expertise. The samples were titrated with the procedure in the ZIMSEC November 2015 A level paper. The results from all measurements were recorded in tables.

Chapter 4

Data presentation, analysis and interpretation

4.1 *Introduction*

The method used to analyse iron content in the five medicinal plants was focused on in the previous chapter. It also described how the samples and chemicals were prepared. This chapter focuses on how data was collected and data analysis. The methods and procedures outlined in chapter three were used for interpretation of data. Tables, graphs and calculations were used for presenting the data collected. The data collected will also be interpreted in this chapter.

Presentation of Results

Table 4:1 shows the masses of samples used for titration

Table 4:

Calculation of mass of Beetroot used

Mass of small beaker + sample (g)	9.73
Mass of empty small beaker (g)	7.23
Mass of sample used (g)	2.50

Table 4:2 shows the mass of dried tamarind pulp used for titration

Table 4:2

Calculation of mass of Tamarind used

Mass of small beaker + sample (g)	9.75
Mass of empty small beaker (g)	7.25
Mass of sample used (g)	2.50

Table 4:3 shows the mass of black jack used for titration

Table 4:3

Calculation of mass of black jack used

Mass of small beaker + sample (g)	9.72
Mass of empty small beaker (g)	7.22
Mass of sample used (g)	2.50

Table 4:4 shows the mass of wing pod used for titration

Table 4:4

Calculation of mass of Sjambok pod used

Mass of small beaker + sample (g)	9.73
Mass of empty small beaker (g)	7.23
Mass of sample used (g)	2.50

Table 4:5 shows the mass of pig weed used for titration

Table 4:5

Calculation of mass of Pigweed used

Mass of small beaker + sample (g)	9.73
Mass of empty small beaker (g)	7.23
Mass of sample used (g)	2.50

4:3 *Calculations*

Titration with the first sample of beetroot gave the following endpoints.

Table 4.6 shows results of the titration of KMnO4 with a sample of beetroot.

Table 4.6

Titration with Beetroot (Beta vulgaris)

	Rough titre	**First titre**	**Second titre**
Initial burette reading (cm^3)	0.0	3.6	7.0
Final burette reading (cm^3)	3.6	7.1	10.6
Volume of $KMnO_4$ used (cm^3)	3.6 √	3.5	3.6 √

$3.6cm^3$ of $KMnO_4$ reacted with $50cm^3$ of sample solution.

Number of moles of $KMnO_4$ = concentration of $KMnO_4$ x volume

= $0.1moldm^{-3}$ x $0.0036dm^{-3}$

= 0.00036mol

Number of moles of iron = 5 x 0.00036

= 0.0018 mol

50ml of sample contained 0.0018mol of iron

Concentration of iron = (1000 ÷ 50) x 0.0018

= $0.036moldm^{-3}$

Molar mass of Fe = 56g

Therefore 0.036 moles weigh 0.036 x 56

= 2.016g

Beetroot has 2.016g of iron per dm^{-3} or a concentration of $0.036 moldm^{-3}$ of iron

Table 4.7 shows results of the titration of KMnO4 with a sample of tamarind.

Table 4.7

Titration with Tamarind (Tamarindus indicus)

	Rough titre	**First titre**	**Second titre**
Initial burette reading (cm^3)	0.0	3.0	6.0
Final burette reading (cm^3)	2.3	5.3	8.3
Volume of $KMnO_4$ used (cm^3)	2.3 √	2.3 √	2.3 √

$2.3cm^3$ of $KMnO_4$ reacted with $50cm^3$ of sample solution.

Number of moles of $KMnO_4$ = concentration of $KMnO_4$ x volume

= $0.1moldm^{-3}$ x $0.0023dm^{-3}$

= 0.00023mol

Number of moles of iron = 5 x 0.00023

= 0.00115 mol

50ml of sample contained 0.00115mol of iron

Concentration of iron = (1000 ÷ 50) x 0.00115

= 0.023moldm^{-3}

Molar mass of Fe = 56g

Therefore 0.023 moles weigh 0.023 x 56

= 1.288g

Tamarind has 1.288gdm^{-3} of iron or a concentration of 0.023moldm^{-3} of iron

Table 4.8 shows results of the titration of $KMnO_4$ with a sample of black jack.

Table 4.8

Blackjack (Bidens pilosa)

	Rough titre	**First titre**	**Second titre**
Initial burette reading (cm^3)	0.0	0.013	0.026
Final burette reading (cm^3)	0.013	0.026	0.038
Volume of $KMnO_4$ used (cm^3)	0.013 √	0.013 √	0.012

0.013cm^3 of $KMnO_4$ reacted with 50cm^3 of sample solution.

Number of moles of $KMnO_4$ = concentration of $KMnO_4$ x volume

= 0.1moldm^{-3} x 0.000013dm^{-3}

= 0.000001339mol

Number of moles of iron = 5 x 0.000001339

= 0.000006696mol

50ml of sample contained 0.000006696 mol of iron

Concentration of iron = (1000 ÷ 50) x 0.000006696

= 0.000134moldm^{-3}

Molar mass of Fe = 56g

Therefore 0.036 moles weigh 0.000134 x 56

= 0.0075g

Black jack has 0.0075g dm^{-3} of iron or a concentration of 0.000134moldm^{-3} of iron

Table 4.9 shows results of the titration of $KMnO_4$ with a sample of wing pod.

Table 4.9

Sjambok pod (Cassia abbreviata)

	Rough titre	**First titre**	**Second titre**
Final burette reading (cm^3)	5.8	5.8	6.1
Initial burette reading (cm^3)	5.4	6.1	6.7
Volume of $KMnO_4$ used (cm^3)	0.4	0.3 √	0.3 √

0.3cm^3 of $KMnO_4$ reacted with 50cm^3 of sample solution.

Number of moles of $KMnO_4$ = concentration of $KMnO_4$ x volume

= $0.1moldm^{-3}$ x $0.003dm^{-3}$

= 0.0003mol

Number of moles of iron = 5 x 0.0003

= 0.0015mol

50ml of sample contained 0.0015 mol of iron

Concentration of iron = (1000 ÷ 50) x 0.0015

= $0.03moldm^{-3}$

Molar mass of Fe = 56g

Therefore 3 moles weigh 0.03 x 56

= 1.68g

Sjambok pod has 1.68g dm^{-3} of iron or a concentration of 0.03moldm^{-3} of iron

Table 4

Pigweed (Amaranthus retroflexus)

	Rough titre	**First titre**	**Second titre**
Initial burette reading (cm^3)	26.0	30.0	34.0
Final burette reading (cm^3)	30.0	33.6	37.6
Volume of $KMnO_4$ used (cm^3)	3.7	3.6 √	3.6 √

3.6cm^3 of $KMnO_4$ reacted with 50cm^3 of sample solution.

Number of moles of $KMnO_4$ = concentration of $KMnO_4$ x volume

= 0.1$moldm^{-3}$ x 0.003572dm^{-3}

= 0.00036mol

Number of moles of iron = 5 x 0.00036

= 0.0018 mol

50ml of sample contained 0.0018mol of iron

Concentration of iron = (1000 ÷ 50) x 0.0018

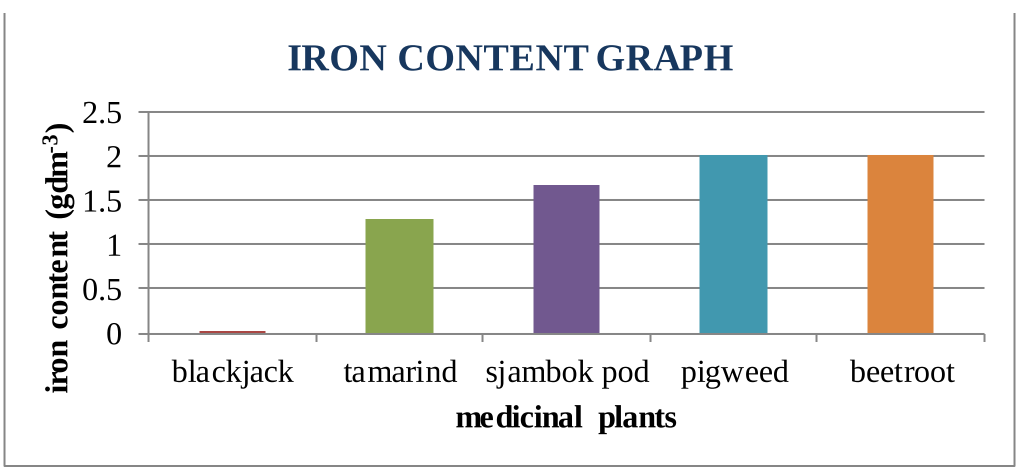
= 0.036$moldm^{-3}$

Molar mass of Fe = 56g

Therefore 0.036 moles weigh 0.036 x 56

= 2.016g

Pigweed has 2.016gdm^{-3} of iron or a concentration of 0.036$moldm^{-3}$ of iron



4:4 ***Analysis and interpretation of the results***

The collected data shows that pig weed, beetroot, tamarind, black jack as well as sjambok pod all contain iron in different concentrations, with black jack containing the least amount, an almost negligible value of 0.0075gdm^{-3}.interestingly, beetroot and pigweed have equal amounts of iron concentrations which are 2.016gdm^{-3}. Pigweed grows on its own during the rainy season, in fields, gardens and cow sheds. So does black jack. Tamarind and sjambok pod are naturally occurring trees which grow freely all over Zimbabwe. No need is there to seasonally plant these. Only beetroot needs to be propagated since it is not native to Zimbabwe, and neither does it naturally grow on its own. Blackjack shows that it has very little iron content compared with the other plants.

https://www.livescience.com states that beetroot has about 1mg of iron per 100g. This value differs from that which was obtained experimentally in this research. https://www.webmed.comwhat to know about blackjack postulates that blackjack has 15mg of iron per 100g. The percentage iron content of tamarind is said to be 2.61% and that of pigweed is said to be around 2.3mg per 100g.The difference in experimental values from that of other writers may be attributed to different experimental methods, conditions and tools.

The plants were obtained from different soils and environments, a probable cause for different results. The availability of iron in the soil affects iron availability in the plant. According to Chisowa and Kambalami (2017) the iron content of soils depends on the parent rock of that soil, and this links directly to the availability of iron to plants growing in that environment. They also explain that the ability of a plant to absorb and store iron is highly related to the genetic composition of the plant. Another major contributing facto may be the difference in parts of the plant which were tested for iron content. Some may test for iron content in bark/ stems, roots or leaves. These parts vary in their iron content since the percentage content is not uniform throughout the whole plant

Chapter 5

Summary, recommendations and conclusion

5.1 *Introduction*

The previous chapter focused on the method used to analyse the quantity of iron in the medicinal plants under investigation. The whole research will be summarised in this chapter and the major findings will be highlighted. In order to help researchers interested in carrying out similar or further studies, there are explanations on recommendations.

5.2 *Summary*

The results obtained from the research were presented in the form of a bar graph. Black jack proved to contain a negligible amount of iron, while both pigweed and beetroot contain the highest amount of iron. The iron in tamarind is slightly less than that in sjambok pod. The research was based on the assumption that certain medicinal plants used for treating iron contain anaemia. This was in an attempt to recommend locally available and cheap resources for the treatment of iron deficient anaemia. The amount of iron in each of these medicinal plants is what the researcher was mainly concerned with. The main research method used was the titration method. Potassium permanganate ($KMnO_4$), which oxidises ferrous ions (Fe II) to ferric ions (Fe III), was titrated against the samples. Stoichiometry was then used to determine the amount of inn the plant samples. Beet root and pigweed were found to contain the highest amount of iron while blackjack contained the least amount. The selected plants were among the most commonly used treatments for anaemia.

Pigweed appears to be the most common traditional remedy, followed by blackjack, but since tamarind is abundant in Kariba, it is also a common treatment, though it is seasonal. Beetroot has the advantage of growing all year round where it is propagated.

5.3 *Recommendations*

Instead of struggling to source iron from expensive and sometimes unaffordable meat products (which may eve lead to complications like cancers), the researcher recommends the propagation of plant sources of iron such as beetroot, pigweed and tamarind. The plants do not take long to mature (particularly beetroot and pigweed) and they can be grown all year round. Communities can even consider coming up with community gardens in which such plants are propagated al year round. Beetroot can be used to prepare fresh juice, as a salad or eaten raw. The leaves can also be prepared as a relish. Tamarind pulp can be used to make juice, to prepare porridge or eaten as a fruit. Although the amount of iron in blackjack is negligible, it has a significantly high amount of vitamin C, which is necessary for the absorption of iron. This might be the reason why it is used for treating anaemia.

Likewise, the researcher recommends the intake of foods high in vitamin C to facilitate the iron intake from these medicinal plants. Related to this, the researcher recommends reduced intake of tannin and caffeine, which hinder iron absorption in the body. Pregnant women should refrain from eating soil in an attempt to find iron because this might lead to conditions such as constipation and ***irritable bowel movement.***

The researcher encourages further research into the side effects of these medicinal plants as well as the daily amounts per specific age group or body mass. There is need to find out which parts of the plants are the best sources of iron as well as how best they can be taken. Some are better off eaten raw while others are best eaten cooked. There can also be further research into other trace minerals in these plants, because there are high chances that there may also be other mineral ions in these plants.

In this research the titration method was used, but there can be other methods like the **flame absorption spectroscopy (FAAS) or the Prussian blue method.** These may come up with slightly different or even more accurate results.

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APPENDICES

beetroot

pigweed

tamarind

sjambok pod

set up for a titration

stages in ashing sjambok pod