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An Analysis of the Iron Content of Prince's Feather, *(Amaranthus Hypochondriacus)*. Implications for the treatment and dietary supplementation for anaemic conditions.

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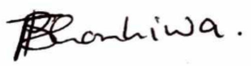

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Abstract

This research aimed to investigate the iron content of Prince's Feather, a plant commonly known as Amaranthus hypochondriacus with potential to address iron deficiencies particularly in developing countries such as Zimbabwe. Iron is an essential mineral required for various physiological functions in the human body. The samples were collected from different sources, ensuring representation and minimizing variation. Plant samples were dried, powdered and ashed. The ash was then filtered using sulphuric acid before being titrated against potassium permanganate. The findings revealed the presence of a significant iron content, indicating the potential of Prince's Feather as a dietary source of iron. The study also explored factors that may influence the iron content of Prince's Feather, such as soil composition. The implications of the iron content in Prince's Feather are significant, as it represents a natural and potentially accessible source of dietary iron. Iron deficiency is a prevalent nutritional concern, particularly in populations with limited access to diverse food sources. The availability of iron-rich plant-based alternatives, such as Prince's Feather, can contribute to addressing iron deficiency and improving overall nutritional status. The findings highlight the potential of Prince's Feather as a source of dietary iron. Further research is warranted to explore the bioavailability and absorption of iron from Prince's Feather, as well as the impact of processing and cooking methods on its iron content. The results of this study contribute to the understanding of plant-based iron sources and their potential role in addressing iron deficiency.

Dedications

This research id dedicated to my family, Bindura staff and entire nutritionists teams within schools in the country.

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I would like to thank my family, fellow chemistry teachers, chemistry tutors and laboratory technicians for their advice which helped me to make this project a success.

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CHAPTER ONE

This chapter outlines the rationale, significance, methodology, limitations, and delimitations of an investigation into the iron content of selected medicinal plants, with a focus on understanding their potential contribution to addressing iron deficiency and related health issues.

1.0 Introduction

In recent years, there has been a growing interest in the use of medicinal plants as natural sources of iron due to their potential nutritional and therapeutic benefits. Iron is an essential mineral for human health, playing a crucial role in various physiological processes such as oxygen transport, energy metabolism, and deoxyribonucleic acid (DNA) synthesis. Medicinal plants have been a reliable source of succour in many countries and ethnic groups over the years and have been widely used in the treatment of anaemia especially in developing countries. The results of the study are expected to contribute to the existing knowledge by analyzing the iron content of specific medicinal plants and investigating their potential as natural sources of iron supplementation. The iron content will be determined for selected plants collected from Nyamakate area in Mashonaland West Province.

1.1 Background of the study

The world Health Organization (WHO) reports in its 2002 report that an estimated 350 million women and children in Africa suffer from deficiencies in iron, vitamin A and folic acid. The WHO estimates that deficiencies in iron, vitamin A and zinc each rank among the top ten leading causes of death in developing countries through disease. However, the World Food Program (WFP), (2006) reports that the majority of the people affected by micronutrient deficiencies do not show overt clinical symptoms, nor are they themselves aware of the deficiency, a phenomenon called “hidden hunger”. Iron deficiency is a significant global health issue, affecting a large portion of the population, especially in developing countries and medicinal plants have been used for centuries in traditional medicine systems due to their diverse therapeutic properties. Besides their well-known nutritional use, these plants also contain various minerals, including iron that could potentially contribute to addressing iron deficiency. Understanding the iron content of medicinal plants is crucial for determining their nutritional value and assessing their suitability as natural sources of iron for dietary purposes. The number of people suffering from anaemia has been increasing recently in these past years. While iron supplements are commonly used to address this problem, there is a growing interest in exploring natural sources of iron, as alternative or complementary strategies for iron supplementation. Some individuals usually fail to get medical attention because of prohibitive doctors’ fees and expensive generic drugs that are either unaffordable or 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. However, the iron content of medicinal plants can vary significantly depending on factors such as species, growing conditions, and plant parts used. A detailed analysis of the iron levels in selected medicinal plants is therefore essential so as to identify plants with high iron content that could be beneficial for combating iron deficiency with better health outcomes. This study seeks to fill this gap in knowledge by providing valuable information for further research and potential integration of these plants into dietary strategies for managing iron deficiency.

1.2 Statement of the problem

Zimbabwe has, of late, faced an economic nose dive due to a number of factors. Most companies have been closing down, leading to lots of people losing their jobs. Some have been retrenched and a few years ago the COVID 19 pandemic forced many employers to scale down operations. According to research by Merx, Lofti, van den Heuvel and Mannar (1996) and a report by the World Food Programme (WFP), (2006), iron deficiency is one of the most widely prevalent micronutrient deficiencies in the world and is affecting at least half of all pregnant women and young children in the developing world. According to Mason, Lotfi, Dalmiya, Sethuraman and Deitchle (2001), children under the age of 2 years are especially at risk and iron deficiency results in stunted growth and a compromised or reduced ability to resist common childhood illnesses with older children failing to concentrate or perform well in school. Anaemia is a serious risk to mothers and there are many women who die in childbirth because of severe anaemia. Iron deficiency due to anaemia in pregnant women reduces the oxygen supply to the fetus, causing intrauterine growth retardation and increased risk of premature delivery as well as reduced birth weight. This has led to most low-income families failing to access medical attention as most commercial drugs are costly over and above the exorbitant fees charged by medical doctors. 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 related complications. These could have been 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 analyze the iron content of a selected commonly used medicinal plant namely Prince’s Feather.
- To assess the potential nutritional value and implications of the iron content in the selected plants.

1.4 Research questions

The research will aim to answer the following questions:

- How much iron does the selected plant contain?
- Can this plant be used for treating anaemia and anaemic symptoms?
- Is the selected plant suitable for containing iron deficiency?

1.5 Significance of the study

Basing on the results from the 1999 Zimbabwe Demographic Health Surveys, (ZDHS), Mishra, Thapa, Retherford and Dai (2005) observed that supplementation of pregnant mothers with iron has a positive effect on a child's birth weight. Iron deficiency together with vitamin and mineral deficiencies makes the problem worse, yet iron can be obtained from animal products such as red meat and in vegetables, grains, legumes as well as the medicinal plants which are the subject of this research. The analysis of the iron content of medicinal plants holds is therefore of significant importance for various stakeholders, including researchers, healthcare professionals, policymakers, and the general public. The following points highlight the significance of this study.

1.5.1 Nutritional Value:

The study will contribute to the understanding of the nutritional value of the selected medicinal plant and the results will contribute to the body of knowledge on natural sources of iron particularly in terms of their iron content. This information will be useful for individuals seeking natural sources of iron supplementation, especially those with iron-deficiency, anaemia or other related conditions as well as healthcare practitioners seeking alternative and complementary approaches to addressing nutritional deficiencies.

1.5.2 Traditional and Cultural Relevance:

Many communities rely on traditional medicinal plants for their healthcare needs. By assessing the iron content of selected plant, the results of this study can help preserve and promote the use of culturally significant plants in addressing nutritional deficiencies, thus maintaining the cultural relevance and importance of traditional healing practices. The research will also bridge the gap between traditional medicine and modern scientific knowledge by providing empirical evidence regarding the iron content and potential medicinal applications of plants used in traditional medicine.

1.5.3 Sustainable Management of Resources:

The identification of high-iron medicinal plants may contribute to sustainable nutritional practices and improve access to essential nutrients, increased cultivation and conservation efforts, promoting sustainable resource management practices and potentially reducing dependence on synthetic iron supplements. Identifying iron-rich medicinal plants, particularly in regions where conventional healthcare resources are scarce. Utilizing locally available medicinal plants as a source of iron can enhance food security and nutritional diversity in communities with limited access to commercial supplements.

1.5.4 Health Implications:

The findings of the study are expected to provide valuable insights into the potential therapeutic value of medicinal plants in addressing iron deficiency, thereby contributing to the development of alternative natural remedies for related health conditions.

1.5.5 Research and Development:

The study is tipped to offer a critical foundation for further research, thereby contributing to the broader scientific understanding of medicinal plants' nutritional value and their potential integration into public health initiatives. 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 development of iron supplements or therapeutic interventions derived from medicinal plants that they can be used as a natural source for making iron supplements. The findings of this study can support further research on the role of medicinal plants in addressing iron deficiency and inform the development of evidence-based dietary recommendations and policies related to iron supplementation. In conclusion, the outcomes of this study have the potential to impact public health strategies, foster cultural preservation, and promote sustainable approaches to iron supplementation, ultimately benefiting individuals and communities seeking natural solutions to nutritional challenges.

1.5.6 Relevance to the Chemistry Curriculum

This research has great relevance to the teaching and learning of chemistry at Ordinary and Advanced level in various ways as explained below.

1.5.6.1 The link between theory and practice

Studying the iron content of medicinal plants relates to fundamental concepts in chemistry in that elements like iron are essential for plant growth and metabolism and are subsequently passed on to humans when these plants are consumed. Iron is the element present in haemoglobin which is responsible for carrying oxygen to the body tissues where it is used for respiration therefore determining the iron content in medicinal plants establishes the link between theory and practice as well as giving relevance to what the students study in class.

1.5.6.2 Experimental Design

The conduct of the study will enable the detailing of the experimental procedures used to analyse the iron content of the selected plants by highlighting the specific chemical techniques employed. Analytical techniques that may be used to quantify the iron levels include spectrophotometry, atomic absorption spectroscopy, complexometric, colorimetric and redox titrations which will help in connecting to key principles in analytical chemistry and instrumental analysis that are commonly taught in chemistry courses.

1.5.6.3 Data Analysis

This will involve the presentation of the results obtained from the investigation and explaining how these findings are interpreted in terms of the medicinal value of the plants. This will possibly involve discussing the bioavailability of iron from plant sources and a comparison of the results with recommended daily intake values. The analysis will also emphasize the role of stoichiometry and calculations in converting experimental data into meaningful insights which helps the learners apply concepts taught in class thereby establishing the relevance of chemistry in everyday life.

1.5.6.4 Interdisciplinary Connections

The study will enable the exploration of the interdisciplinary nature of science through the connection of this Chemistry based research with other scientific disciplines. It will show how knowledge from fields such as biology, botany, and nutrition complement the chemistry aspect of the investigation. This in turn highlights the importance of a holistic approach to scientific inquiry.

1.5.6.5 Educational Implications

A reflection on how this investigation is done can enhance chemistry pedagogy in that chemistry educators can propose classroom activities or laboratory experiments that simulate aspects of the study to engage students in hands-on learning. This will encourage critical thinking in that it prompts students to consider the impact of iron deficiency on human health and the role of medicinal plants in addressing nutritional needs. By integrating the investigation into the iron content of medicinal plants with chemistry pedagogy, educators can provide students with a practical context to apply their theoretical knowledge and foster a deeper appreciation for the relevance of chemistry in real-world applications.

1.6 Rationale of the Study

This study is motivated by the desire to explore and document the iron content in selected medicinal plants. Given the prevalence of iron deficiency and the potential side effects of synthetic iron supplements, there is growing interest in natural alternatives, and medicinal plants present a promising avenue. By systematically analysing the iron content of this medicinal plant, this investigation aims to contribute to the existing knowledge on traditional medicine, natural remedies, and the potential use of medicinal plants in addressing iron deficiency and related health issues.

Medicinal plants are known to contain a wide range of nutrients, including iron, which can contribute to the daily iron intake required for optimal health. By analyzing the iron content of this plant, we can identify specific species that have high levels of bioavailable iron, making them valuable additions to the diet to combat iron deficiency. A number of cultures around the world have long relied on medicinal plants for their healing properties. Incorporating iron-rich medicinal plants into traditional diets can not only help address iron deficiency but also preserve cultural heritage and promote the use of natural, locally sourced remedies.

Iron is essential for various physiological processes in the body, and a deficiency may lead to a range of health problems. By identifying medicinal plants with significant iron content, their potential therapeutic benefits in preventing and managing conditions related to iron deficiency such as anaemia can be explored. In comparison with synthetic iron supplements, medicinal plants offer a sustainable and environmentally friendly source of iron. By promoting the use of locally grown medicinal plants rich in iron, we can enhance accessibility to this essential nutrient, particularly in regions where access to conventional iron supplements is limited.

Despite the long history of using medicinal plants in healthcare, there is limited comprehensive research on the iron content of specific medicinal plant species especially in Zimbabwe. This study aims to bridge this gap by analyzing and documenting the iron levels in selected medicinal plants, thereby contributing valuable data to the existing body of knowledge on nutritional plant resources. In conclusion, the analysis of the iron content of selected medicinal plants is crucial for exploring their potential role in addressing iron deficiency and promoting better health outcomes.

1.7 Limitations

Despite careful planning and execution, every research study has inherent limitations that should be recognized and acknowledged to understand the boundaries and potential constraints of the research. The thesis will be subject to the following limitations:

1.7.1 Sample Size and Representativeness:

The study's findings and conclusions will be based on the analysis of a single medicinal plants. The single plant may not be fully representative of the diverse range of medicinal plants available globally. Therefore, the generalizability of the results to other medicinal plants or different geographical regions may be limited.

1.7.2 Variations in Iron Content:

The iron content of the medicinal plant can vary significantly due to various factors, including plant species, geographic location, cultivation practices, and environmental conditions. The study may not account for all potential sources of variability, leading to variations in the observed iron content within and between different samples of the same plant species.

1.7.3 Plant Part Analysis:

Medicinal plants consist of various plant parts, such as leaves, roots, stems, and fruits, each potentially containing different iron concentrations. The thesis may focus on specific plant part or use composite samples, which may not accurately represent the iron content of individual plant parts. Consequently, the study's results may not reflect the iron content variations across different plant parts within the selected medicinal plant. However, the use of leaves is mostly encouraged as it preserves the tree population in our environments.

1.7.4 Method of Analysis:

The accuracy and precision of the analytical methods used to determine the iron content can influence the study's results. Variations in sample preparation, extraction techniques, and measurement methods may introduce potential sources of error or bias.

1.7.5 Seasonal and Environmental Factors:

The iron content of medicinal plants can be influenced by seasonal variations, soil composition, climate, and other environmental factors. The study may not incorporate the comprehensive assessment of these factors, which may lead to incomplete understanding or potential confounding effects on the observed iron content.

1.7.6 Effects of the Long-Term use of the plants:

The thesis may not explore the long-term effects of consuming medicinal plants with high iron content. The study's scope may be limited to analyzing the iron content alone, without considering potential interactions, side effects, or cumulative effects that may arise from prolonged use of these plants as iron supplements. An acknowledging these limitations, researchers can identify areas for further investigation and interpretation. It is important for readers and researchers to consider these limitations when interpreting the study's results and applying them to real-world scenarios.

1.8 Delimitations of the study

Delimitations outline the boundaries and constraints within which the research will operate. The following delimitations are established to clarify the scope and limitations of the study. The study will focus on a specific medicinal plant known for its traditional medicinal uses and potential nutritional value. The analysis will be limited to the selected plant and will not encompass the entire spectrum of medicinal plants with varying iron content. The research will be limited to a specific geographical location where the selected medicinal plants are commonly found. The iron content of this plant may vary based on environmental factors and growing conditions specific to the region. The analysis will consider the iron content of specific parts of the selected medicinal plant, such as leaves, roots, fruits, or seeds. Different plant parts may contain varying levels of iron, and the study focuses on a particular part or parts as deemed relevant for nutritional analysis.

The determination of iron content will be conducted using a specific analytical method depending on the availability of resources and equipment. The study's findings may be influenced by the chosen analytical techniques and their limitations. The research will involve a predetermined sample of selected medicinal plant for iron content analysis. The sample size might be limited by logistical constraints, time considerations, or availability of plant specimens, which could impact the generalizability of the results. The study will be conducted within a defined time frame, analysis and reporting will be constrained by this timeframe. Long-term changes in iron content due to seasonal variations or plant growth cycles may not be fully captured within the study's duration.

The findings of the study will be interpreted within the context of the specific medicinal plants and analytical methods employed. Extrapolation of the results to other plants or generalization beyond the selected species will be limited by the study's focus on a defined medicinal plant. External factors, such as soil composition, climate variations, and cultivation practices, may influence the iron content of medicinal plants. The study acknowledges the potential impact of these external factors on the results but will not delve deeply into analyzing or controlling for all possible external variables.

1.9 Chapter 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

2.0 Introduction

A literature review provides an overview of the current state of knowledge in a particular field, identifies gaps, debates, or inconsistencies in the existing literature, and synthesizes the findings to support the development of new research, theories, or methodologies. It also aims to contextualize the research by demonstrating how it fits within the broader scholarly conversation and contributes to the understanding of the subject area. This chapter will focus on literature related to the function of iron in the body and the determination of iron in a specific medicinal plant, namely, Prince's Feather *(Amaranthus hypochondriacus).*

2.1 Iron

Iron is an essential mineral required for various physiological processes in the human body, including oxygen transport, energy production, and immune function. Medicinal plants have long been recognized for their potential therapeutic properties and are often used in traditional medicine systems. This literature review aims to provide an overview of existing research on the iron content of selected medicinal plants. By examining the available literature, this review will contribute to the understanding of the iron composition of these plants and their potential as a source of dietary iron.

2.1.1 Chemistry of iron

Iron is a transition metal which has oxidation states ranging from -2 to +6, with the +2 and +3 being the most common. 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 cannot 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).

2.2 Impact of Iron in Medicinal Plants on Human Health

Iron plays a crucial role in human health, as it is involved in various physiological processes. Iron deficiency can lead to anaemia, fatigue, impaired cognitive function, and compromised immune function. Therefore, identifying natural sources of iron, such as medicinal plants, can be valuable for promoting adequate iron intake and addressing iron deficiency. The processing and preparation methods of medicinal plants can also impact their iron content. Traditional practices such as drying, grinding, and decoction may affect the stability and availability of iron. For example, excessive heat or prolonged cooking can cause iron loss or degradation. It is essential to consider the impact of processing and preparation methods on the iron content of medicinal plants to optimize their nutritional value. 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.

2.3 Medicinal plants

Traditional medicine systems, such as Ayurveda, Traditional Chinese Medicine, and Indigenous healing practices, provide a theoretical framework for understanding the historical and cultural context of medicinal plants. These systems recognize the therapeutic properties of various plant species and their potential role in addressing health conditions, including nutritional deficiencies. The theoretical underpinnings of traditional medicine systems contribute to the exploration of medicinal plants as a natural source of iron in the context of traditional healing practices.

Gomez (1985), posits that traditional foods are 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.

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.the following table shows some medicinal plants used in the treatment of anaemia. Environmental conditions, such as soil composition, pH levels, and mineral availability, can significantly impact the iron uptake and accumulation in plants. Additionally, the plant species, growth stage, and plant parts (leaves, roots, or stems) can also affect iron content.

Table 1.1: Examples of Medicinal Plants used in the treatment of Anaemia

Common English name(s)	**Some Shona names**	**Botanical name**	**Ndebele names**
Beetroot	---------------------	*Beta vulgaris*	-------------------------
Prince's Feather	*Mowa/bonongwe*	*Amaranthus hypochondriacus*	*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*

The above are examples of plants that are used in the treatment of anaemia but the study is going to focused on one plant only, Prince's Feather, *(Amaranthus hypochondriacus).*

Fig 1.1: Prince's Feather, *(Amaranthus hypochondriacus)*

Amaranthus hypochondriacus is an herbaceous annual or short-lived perennial plant with showy feathery and is commonly viewed as a weed on wasteland as well as on agricultural land. The plant is monoecious (which means that individual flowers are either male or female, but both sexes can be found on the same plant). The plant's agent of pollination is the wind. The plant grows well in well-drained fertile soil in full sun. It is often cultivated, especially in tropical areas, for its edible leaves and seeds, though it is less often seen in northern climates because it is late maturing.

2.4 Role of Medicinal Plants in Addressing Iron Deficiency

Iron deficiency is a prevalent nutritional deficiency worldwide, affecting a significant portion of the population, particularly in developing countries. Incorporating iron-rich medicinal plants into the diet could offer a natural and accessible means to address iron deficiency. However, it is important to consider the overall diet and potential interactions with other dietary components to ensure optimal iron absorption and utilization.

2.4.1 Bioavailability of Iron in Medicinal Plants

While the iron content of medicinal plants is important, it is equally crucial to consider the bioavailability of iron from these plant sources. Iron bioavailability refers to the extent to which the human body can absorb and utilize iron from a particular food source. Factors such as the presence of iron-binding compounds (e.g., phytates and polyphenols) and the plant matrix can influence the bioavailability of iron in medicinal plants. Future studies should explore the bioavailability of iron from selected medicinal plants to better understand their potential impact on human iron status.

2.5 Integration of Medicinal Plants into Dietary Strategies

Considering the iron content of medicinal plants, they can be integrated into dietary strategies to address iron deficiency. This integration can be done through the promotion of traditional medicine practices, inclusion of medicinal plants in community gardens, or development of functional food products enriched with plant-based iron sources. Such approaches can provide accessible and culturally appropriate solutions for improving iron status in populations at risk of deficiency.

2.6 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 was 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).

2.7 Functions of iron

Iron is responsible for oxygen transportation in haemoglobin. This is accomplished by red blood cells which have haemoglobin, which combines with iron to form oxy-haemoglobin (the compound which gives blood its bright red colour). 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) 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 co-factor 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 adenosine tri-phosphate, (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.

Medicinal plants rich in iron can potentially provide nutritional support and aid in the prevention and treatment of iron deficiency-related disorders and hence further research is needed to explore the bioavailability of iron from medicinal plants and their role in addressing iron deficiency. The findings of such studies can contribute to promoting the utilization of medicinal plants as a dietary strategy to improve iron status and overall human health

2.8 Summary

This literature review provided an overview of the existing research and methodologies employed for the determination of iron content in medicinal plants. The review emphasizes the importance of accurate iron content determination for assessing the nutritional value and therapeutic potential of medicinal plants. It highlighted the various factors influencing iron content, and the observed variability among different plant species. The findings of this review underscore the need for standardized methodologies and careful consideration of influencing factors when determining iron content in medicinal plants. The next chapter will look at the methodology.

Chapter 3: Research Methodology

3.0 Introduction

The previous chapter gave a brief summary of the literature related to this study. It also focused on the factors which are considered when testing for the presence of iron as well as how to determine the amount of iron in a given sample. This chapter explains how the iron content investigations can be carried out. It explains how data can be collected as well as 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.

3.1 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), define 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 carrying out the research.

3.2 Preparation of chemicals

Sulphuric acid: 100ml of 32% Sulphuric acid was separately diluted into a volumetric flask and made up to 1000ml to give a concentration of 1.0 $moldm^{-3}$.

Potassium permanganate (VII): 4g were dissolved in 250ml of distilled water giving 0.1$moldm^{-3}$.

3.3 Research instrument

An experimental method is used to determine the amount of iron in the medicinal plant under investigation. The procedure includes sample collection, sample preparation and the experimental determination of iron content in the plant sample.

3.3.1 Sample Collection

Samples of the selected medicinal plant were collected from reliable sources, using proper plant identification techniques, ensuring the accuracy of the species and plant parts used. Adequate precautions were taken to avoid contamination during collection and handling of the samples.

3.3.2 Sample Preparation

The collected plant sample was cleaned to remove any extraneous material, such as dirt or debris. Different plant parts, such as leaves, roots, or stems, were separated and the leaves were chosen basing on the traditional use of the plant. The leaves were air dried in a shed in order to preserve the iron content. The dried leaves were then ground to a fine powder (to facilitate uniform analysis) and stored in a sealed dry container. To avoid iron contamination, the leaves were plucked by hand and the pestle and mortar used for grinding as well as the crucible, were cleaned with hydrochloric acid and double distilled water before use.

3.4 The experiment method

The fine powder will be ashed in order to free the iron from any biological molecules it might be bound to. This also enables an efficient reaction between the Fe^{2+} ions and the reagents used during the titration process. After ashing, the sample is filtered using hydrochloric acid, which dissolves the iron compounds in the sample as well as supply some H^+ ions which are necessary for the reaction between manganate and ferrous ions. Distilled water will be added to make up the volume and drawn samples will then be titrated using potassium permanganate (VII) under acidic conditions.

3.4.1 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 (a solution whose concentration and volume is known) is added from a burette to a known quantity of the analyte (the solution whose concentration is unknown) until the reaction is complete (signified by a colour change). 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

- Cost effective
- Does not need great expertise except for some skill and practice
- It is one of the oldest and commonly used methods
- Instruments are easily available in school laboratories
- It is a simple method

Disadvantages

- If done manually it is time consuming
- It needs instruments which are properly calibrated and the calibrations must be visible
- Requires skill and practice for effective results
- There is need to carry out a thorough research on the reactivity of the elements because this might affect the end point

3.5 Determination of iron content

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 the medicinal plant 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 (Fe2+) to ferric iron (Fe3+)

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

This is the overall reaction in which manganate (VII) 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.

Experimental Procedure

1. Weigh an empty small beaker using an electronic digital balance and record its mass.
2. Place an ash sample in the small beaker and weigh. Tabulate the results.
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 $25cm^3$ 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 $10.0cm^3$ 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 KMnO4 until a bright pink colour is observed in the flask. Repeat the titrations for as many times as you may see necessary.
8. Tabulate the results in an appropriate table:

3.6 Conclusion

The methodology outlined above provides a framework for conducting an analysis of the iron content of the selected medicinal plant ensuring a systematic sample collection, appropriate sample preparation and accurate iron content analysis, leading to reliable and meaningful results. The titration method was used to analyse the iron content mainly because of the ease of implementation and non-requirement of sophisticated laboratory equipment.

Chapter 4: Data Presentation and Analysis

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.

4.2. **Presentation of Results**

Table 4:1 shows the mass of sample used to prepare the solution used for titration whilst Table 4:2 shows the titration results.

Table 4.1: Calculation of the mass of *Amaranthus hypochondriacus* 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: Titration results for *Amaranthus hypochondriacus*

	Rough titration	**1st titration**	**2nd titration**
Final burette reading /cm^3	34.8	33.6	37.6
Initial burette reading /cm^3	31.1	30.0	34.0
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

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

= **<u>0.00036 mol</u>**

Number of moles of iron = 5 x 0.00036

= **<u>0.0018 mol</u>**

50ml of sample contained 0.0018mol of iron

Concentration of iron = $(1000 \div 50) \times 0.0018$

= **$0.036\ moldm^{-3}$**

Molar mass of Fe = 56g

Therefore 0.036 moles weigh (0.036×56) g

= **2.016 g**

Prince's Feather has $2.016gdm^{-3}$ of iron or a concentration of $0.036moldm^{-3}$ of iron

4:3 Analysis and interpretation of the results

The collected data shows that Prince's Feather has amounts of iron concentrations which are around $2.016gdm^{-3}$. Prince's Feather grows on its own during the rainy season, in fields, gardens and cow sheds therefore there is no need to plant it on a seasonal basis.

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 factor 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.

4.4 Chapter summary

The results presented show that prince's feather (*Amaranthus hypochondriacus*) contains an appreciable amount of iron which affirms its possible use as a dietary supplement for anaemic or iron deficient patients. The next chapter will look at the recommendations and a summary of the study.

Chapter 5. Summary, conclusion and recommendations

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 research was based on the assumption that certain medicinal plants used for treating anaemia contain iron. This was in an attempt to recommend locally available and cheap resources for the treatment of iron deficient anaemia. Chapter one introduced the study with an overview of the use of natural remedies in the treatment of anaemia. In the second chapter, a review of related literature was given in which all aspects related to the use of natural remedies, their advantages as well as the characterisation of iron was given. The third chapter described the methodology and as well as outlining how the determination of the iron content would be done. In chapter four the results were presented. Chapter five concludes the study with a summary as well as outlining recommendations for the use of natural remedies and further research on iron supplements. The research showed that prince's feather contains an appreciable amount of iron and it can therefore be used as an alternative source of iron for anaemic patients. The main research method used was the titration method. Potassium permanganate ($KMnO_4$), which oxidises ferrous ions (Fe^{2+}) to ferric ions (Fe^{3+}), was titrated against the sample amount of iron in the plant sample was determined through stoichiometric calculations.

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 Prince's Feather and many others. The plants do not take long to mature and they usually grow on their own. Communities can even consider coming up with community gardens in which such plants are propagated all year round.
- However the researcher recommends the intake of foods high in vitamin C to facilitate the iron intake from medicinal plants. The researcher also recommends a reduced intake of foodstuff that contains 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 by body mass. There is need for further research 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.

- It is crucial to consider the long-term effects of consuming medicinal plants with high iron content to ensure the safety and effectiveness of iron supplementation. Healthcare professionals, including herbalists, nutritionists, and physicians, play a vital role in providing guidance, monitoring, and assessing the long-term implications of using medicinal plants as iron supplements.

References

Ancuceanu, R. Dinu, M. and Negres, S. (2015) A Survey Of Plant Iron Content- A Semi-Systematic Review, Bucharest, Romania, Carol Davila University of Medicine and Pharmacy

Ary, D. (2007) Introduction to research in education (4th ed) Orlando, FL, Harcourt Brace

Gomez, M.I. (2017) A Resource Inventory of Indigenous foods in Zimbabwe, UZ, Zimbabwe

Jorgenson, R. (2012) scientific opinion on Dietary Reference Values for Iron in EFSA Journal; 13 (10)

Guo, H., Barnard, A.S., (2013). Naturally occurring iron oxide nanoparticles: morphology, surface chemistry and environmental stability. Journal of Materials Chemistry A. 1 (1), 27-42.

Hem, J.D., Cropper, W.H. (1962). Chemistry of iron in natural water. Report US Geological Survey. 1-31

Mason, J. B.; Lotfi, M.; Dalmiya, N.; Sethuraman, K., and Deitchler, M. (2001). The Micronutrient Report-Current Progress and Trends in the Control of Vitamin A, Iron, and Iodine Deficiencies. Micronutrient Initiative: p240.

Merx, R. J. H. M., Lofti, M., van den Heuvel, P. N. and Mannar, V. M. G. (1996). Micronutrient fortification of food: Current practices, research and opportunities, International Agricultural Centre/The Micronutrient Initiative, Wageningen, the Netherlands.

Mishra, V., Thapa, S., Retherford, R. D. and Dai, X. (2005). Effect of iron supplementation during pregnancy on birth weight: Evidence from Zimbabwe. Food and Nutrition Bulletin; 26: 338-347.

Norris, Ryan and Acaster (2011) Cambridge International AS and A Level Chemistry Coursebook, London, UK, Cambridge University Press

PerkinElmer. Atomic Spectroscopy. (2011). A Guide to Selecting the Appropriate Technique and System. 16

Rout, G.R., Sahoo, S. (2011). Role of iron in plant growth and metabolism. Reviews in Agricultural Science. 3, 1-24 (2015).

Singh, M. K. and Bhardwaj, N. (2012) Determination of iron content in spinach-a titrimetric study

Stangoulis, J. (2011) Teaching aspects of Zinc and Iron Analysis, London, UK, Cambridge University Press

Vogel, A. (2013) A book of qualitative Inorganic Analysis, London, Longman group

Wachasunder, S.D., Nafade, A. (2001). Precision and accuracy control in the determination of heavy metals by atomic absorption spectrometry. Science (80-). 58, 517-528.

Waugh, N. and Grand A. (2001) crops that feed the world 4.Strengths and weaknesses in the in the context of food security, Food security, Springer.

Wood, E. and Pickering, W. (1982) Introduction to Biochemistry, London.

Woods, J.T., Mellon, M.G. Thiocyanate method for iron. A spectrophotometric study. Industrial & Engineering Chemistry Analytical Edition. 13 (8), 551-554 (1941).

World Food Program (WFP). (2006). Micronutrient fortification: WFP experiences and ways forward. Food and Nutrition Bulletin; 27: 67-75.

World Health Organisation: (2002). The World Health Report: Reducing Risks, Promoting Healthy Life, Geneva.

World Health Organisation and United Nations Children's Fund (UNICEF). Focusing on anaemia: Towards an Integrated Approach for Effective Anaemia Control.