Comparative proximate and micro nutrient analysis between Home-Grown and Indigenous Mushrooms.

A dissertation submitted in partial fulfilment of the requirements for the Master of Science Degree in Food Security and Sustainable Agriculture (Production)

Bindura University of Science Education

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DECLARATION

I hereby declare that the research project entitled " **Comparative proximate and micro nutrient analysis between Home-Grown and Indigenous Mushrooms**" submitted to Bindura University of Science Education, Department of Agricultural Economics, Education and Extension is a record of an original work done by me under the guidance and supervision of **DR L Musemwa** and this work is submitted in partial fulfilment of the requirements for the award of a Master of Science Degree in Food Security and Sustainable Agriculture. The results embodied in this thesis have not been submitted to any University or Institute for the award of any degree of diploma.

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The undersigned certify that they have read the research project and have approved its submission for marking in relation to the department's guidelines and regulations.

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DEDICATION

This thesis is dedicated to my children Meghan Mazvita Remhunga and Lee Sbusiso Remhunga.

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ABSTRACT

Mushroom are known traditionally for their culinary and nutritional benefits, making them a widely and preferred choices in various cuisines worldwide. Mushrooms provide a source of essential nutrients such as proteins, vitamins and minerals hence serve as a valuable addition to human diets especially in regions where protein sources are limited. The study compared two distinct categories of mushrooms that are subject to different growing conditions. The grouping into wild and home-grown serves as a key independent variable. This quasi-experimental comparison helps to isolate the effect of growth conditions on the composition of the mushrooms. Protein content reveals a clear contrast: wild mushrooms such as Amanita zambiana (18.39 ± 0.15 g/100g dw) and Lactarius deliciosus (17.25 ± 0.05 g/100g dw) aim at moderate levels comparable to typical wild mushroom values. However, cultivated species like Pleurotus ostreatus (27.25 ± 0.88 g/100g dw) and especially Agaricus bisporus (34.05 ± 0.68 g/100g dw) exhibited significantly higher protein contents.The F statistic (0.033978) is much lower than its critical value (2.75871), and the p-value is almost 1.0. indicating that the overall proximate compositions (i.e., ash, carbohydrates, fiber, protein, fat, and moisture) do not differ significantly among the mushroom groups sampled.The p-value of 0.80796 is much higher than the conventional significance level of 0.05, and the F-value (0.061536) is well below the F-critical value (4.667193). This indicates that the difference in flavonoid content between wild mushrooms (mean ≈ 1.88) and home-grown mushrooms (mean ≈ 1.76) is not statistically significant. The carbohydrate content (expressed on a dry weight basis) is notably higher in wild mushrooms (63.76% dw) than in home-grown mushrooms (48.67% dw). This indicate that wild growing conditions trigger more lipid storage, possibly as an adaptive energy reserve under environmental stress. The ash, representing total mineral content, is higher in home-grown mushrooms (10.36% dw) compared to wild mushrooms (8.77% dw). This suggests that home-grown mushrooms may benefit from mineral supplementation or more controlled nutrient availability in the substrate. In conclusion, home-grown mushrooms and wild mushrooms have a potential to provide a reliable source of nutrients especially among the poor and marginalized groups.Adapting cultivation methods to maximize the desirable nutritional traits of mushrooms can significantly contribute to sustainable agricultural practices. By leveraging the inherent qualities of both wild and home-grown mushrooms, policy makers can design integrated food systems that improve local nutrition.

Key words: mushroom, wild, home-grown, proximate analysis

LIST OF ACRONYMS AND ABBREVIATIONS

FAO	Food Agriculture Organization
UNICEF	United Nations Children's Funds
WFP	World Food Program
W H O	World Health Organization
DW	Dry weight

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CHAPTER 1
INTRODUCTION

1.1 Background of the study

Non –Timber Forest Products have been recognized as essential components of rural and urban livelihoods contributing to food security, income generation and sustainable forest management (Hossan et al., 2019). NTFPs such as fruits, nuts, seeds, honey, mushrooms and medicinal plants are derived from forest woodlands and other natural ecosystems. Mushrooms have become a global cuisine leading to demand increasing due to their nutritional and culinary value. According to Fao (2024) global mushroom production, reached 14.2 million metric tonnes in 2020 valued at $52.7 billion.70 percent of the mushroom consumed are cultivated whilst 30% is wild harvested (Hanza et al., 2024).

Mushroom are known traditionally for their culinary and nutritional benefits, making them a widely and preferred choices in various cuisines worldwide. Mushrooms provide a source of essential nutrients such as proteins, vitamins and minerals hence serve as a valuable addition to human diets especially in regions where protein sources are limited (Grzywaez and Staisk, 2018). Recent studies have emphasized the nutritional richness of various edible species, revealing that mushrooms contain significant levels of bioactive compounds such as antioxidants and polysaccharides that are known to have numerous health benefits (Jaworska et al.,2015).

In Africa, over two thirds of the population rely on forest products either in form of cash derived from selling the NTFPs including mushrooms or consuming them directly (Fao., 2024). Africa constitute at least 25% of the total mushroom biodiversity in the world which contribute up to 0.4% of the total mushroom sales and new mushroom products on the global market (Fernandes et al.,2020). The contribution of mushrooms to food security is also evident in their potential to generate income and improve livelihoods (Fao, 2024). Furthermore, they can be preserved and stored for long periods making them a reliable source of nutrition during times of food scarcity.

Mushroom farming has experienced significant growth in Africa over the last 5 years. According to a report by the Food and Agriculture Organization (FAO), mushroom production in Africa increased by 25% between 2018 and 2022, with countries such as South Africa, Nigeria and Kenya leading the way (Fao, 2024). In terms of production volume, Africa produced over 1.3 million metric tons of mushrooms in 2022, up from 1.1 million

metric tons in 2018. This growth can be attributed to increasing demand for mushrooms as a nutritious and sustainable food source, as well as government initiatives to promote agricultural development and entrepreneurship (Hamza et al.,2024).

In Zimbabwe, mushroom farming has also seen a significant increase in recent years. According to the Zimbabwe Ministry of Agriculture, mushroom production in the country increased by 50% between 2019 and 2022, with over 1,000 metric tons of mushrooms produced in 2022 (FAO, 2024). This growth can be attributed to government initiatives to promote small-scale farming and entrepreneurship, as well as the establishment of mushroom farming cooperatives and training programs (FAO, 2024). The increase in mushroom farming in Zimbabwe has also created employment opportunities and contributed to the country's economic growth.

Despite the significant increase in mushroom farming in recent years, the consumption of mushrooms has remained surprisingly low as people still prefer foods like meat and beans and their source of nutrients. This research will look into micro- nutrients of mushrooms and proximate analysis to prove that mushroom is a potential source of essential nutrients. According to recent statistics, the global mushroom production has increased by over 20% in the past five years, with countries such as China, the United States and Poland leading the way (FAO, 2024). However, despite this increase in production, the average annual consumption of mushrooms per capita remains relatively low, ranging from 1-5 kg per person in most countries.

1.2 Problem statement

Approximately 800 million people are suffering from hunger, 160 million under the age of 5 years are malnourished and 12 million die per year where 50% of the deaths is related to malnutrition. Asia has more than two thirds of the world’s malnourished children compared to 25,6% in Africa and 2,3 in Latin America . Malnutrition affects all age groups however is more pronounced in poorer and less educated communities. The widespread prevalence of malnutrition and micronutrient deficiency is a cause of poor health in many developing countries like Zimbabwe. Inter-grating nutrient-rich foods such as vegetables, fruits and livestock products into diets is the most practical way to alleviate micronutrient deficiency. Edible wild mushrooms could be a potential source to solve the problem of malnutrition especially among the poor people who however have access to non-timber forest products like mushroom. The study aims to examine nutrient content of the five most consumed mushrooms in Zimbabwe and use the information to improve malnutrition.

Despite the rich biodiversity of non-timber forest products (NTFPs) in Zimbabwe, their potential to enhance nutrition and food security remains underutilized. NTFPs, which include a variety of edible plants, fruits, nuts, and mushrooms, play a crucial role in the livelihoods of rural communities, particularly in times of food scarcity. However, recent statistics indicate that approximately 49% of the Zimbabwean population faces food insecurity, with malnutrition rates among children under five standing at 23% in 2024 (FAO, 2024). This situation underscores the urgent need to assess the nutritional contributions of NTFPs, which could serve as a critical resource for improving dietary diversity and overall health.

Furthermore, there is a significant gap in knowledge regarding the nutritional value of various NTFPs available in Zimbabwe's forests. While these products have the potential to provide essential vitamins and minerals, their consumption is often overshadowed by reliance on staple crops. The lack of comprehensive data on the nutrient composition of NTFPs hinders efforts to promote their use in combating malnutrition and enhancing food security. Therefore, this study aims to investigate the nutritional benefits of selected NTFPs in Zimbabwe, emphasizing their role in addressing the pressing issues of malnutrition and food insecurity in the region.

The nutritional content of mushroom varies among species. For example, edible mushrooms like *Pheurotus ostreatus* contain approximately 17.06% crude protein while other species may have significantly lower protein levels affecting their viability as dietary protein source (Tullio and DeSantis 2021). The average protein content in various mushrooms can range from 6.60% to 36.87% depending on species and environmental conditions (Sanderland, 2022). This study will test nutrient content in five mainly consumed mushrooms in Zimbabwe.

1.3 Objectives

1.3.1 Main Objective

To determine proximate analysis and micro nutrient analysis of home-grown mushrooms versus wild mushrooms.

1.3.2 Specific objectives

- To determine proximate analysis (ash content , carbohydrates, , fiber, protein, fat and moisture content) of selected wild mushrooms versus home-grown mushrooms.

- To analyze micro- nutrient (vitamins, B-carotene and flavonoids) concentration of wild mushrooms versus home- grown mushrooms.
- To investigate the impact of environment that is wild versus home- grown (controlled) conditions on nutritional compositions in mushrooms.

1.4 Research questions

i) What is the proximate analysis (ash content, carbohydrates, fiber, protein, fat and moisture content) of selected wild mushrooms versus home-grown mushrooms?

ii) What is the micro- nutrient (vitamins, B-carotene and flavonoids) concentration of wild mushrooms versus home- grown mushrooms?

iii) What is the impact of the growing environment that is wild versus home- grown (controlled) on nutrient concentration of mushrooms?

1.5 Hypothesis

Null Hypothesis (H_{01}): There is no significant difference in the proximate composition (ash content, carbohydrates, fiber, protein, fat, and moisture content) between wild mushrooms and home- grown mushrooms.

Null Hypothesis (H_{02}): There is no significant difference in the concentrations of micronutrients (vitamins, β- carotene, and flavonoids) between wild mushrooms and home- grown mushrooms.

Null Hypothesis (H_{03}): The growing environment (wild versus home- grown conditions) does not significantly impact the nutrient composition of mushrooms.

1.6 Justification

Proximate analysis and micro- nutrient analysis will provide average nutrient quantities found in common mushrooms in Zimbabwe, this will educate consumers on the nutrients of food taken. The information can be used by nutrition specialists when preparing or prescribing complementary diets to individuals especially those suffering from malnutrition.

The findings will serve as an educational resource for both consumers and health professionals. Many individuals lack the knowledge the potential of local foods to provide essential nutrients. This study can provide guidelines and educational materials to enhance public awareness of nutrient status of non- timber forest products like mushroom.

The project meets the requirements of the masters in food security to carry out a research proposal in the final year; hence, this project will benefit the student to achieve educational goals.

1.7 Delimitations and limitations of the study

1.7.1 Limitations of the study

The research may be limited by the number of mushroom species selected for analysis. A small sample size might not adequately represent the diversity of mushrooms available.To avoid this limitation at least 500 grammes of mushroom sample were collected per mushroom type.

Nutritional content can vary significantly due to environmental factors such as soil type, climate and geographical location. This variability may impact the comparability of results.Samples were collected from three different farms ensuring that soil type and geographical location differs.Home grown mushrooms were collected from Harare farmers and Button mushroom was bought from TM supermarket which guaranteed different geographical locations.

Different methods of cultivating homegrown mushrooms (e.g., substrate, humidity, temperature) can lead to significant differences in nutritional profiles that may not be fully accounted for.To avoid this bias oyster mushroom was bought from mushroom farmers who use the same growing medium i.e wheat stalk.

The accuracy of proximate and micronutrient analysis depends on the methods employed. Variability in laboratory techniques or equipment may introduce discrepancies in the results.Experts form University of Zimbabwe were consulted who assisted in analysis ensuring that methods used produced minimum discrepancies.

The nutrient composition of wild mushrooms can fluctuate with seasonal changes. Collecting samples at different times may lead to inconsistent data.In Zimbabwe where data was collected mushrooms sprout during the rainy season only and collection was done at their peak of maturity that is March.

1.7.2 Delimitations

The study will concentrate on three commonly consumed wild mushrroms in Zimbabwe ie A*manita zambiana*, *Termitomyces* and *Lactarius Deliciosus* also known as *Lactarius Kabansus* commonly consumed homegrown and wild mushroom species, excluding rare or

less popular varieties.Oyester and button are the commonly grown species hence are the only home grown mushrooms covered in this research.

The analysis will prioritize proximate components (moisture, protein, fat, carbohydrates, fiber, ash) and select micronutrients (vitamins and minerals), without exploring other potential bioactive compounds.Micro-nutrient analysis looked at vitamins, B-caotene and flavonoids.

The research will focus solely on nutritional analysis and will not consider sensory attributes or culinary preferences related to mushroom consumption.

By clearly outlining these limitations and delimitations, the research aims to provide a focused and structured approach to understanding the nutritional differences between homegrown and wild mushrooms while acknowledging the constraints that may affect the findings.

1.8 Outline of thesis

Chapter 1 covers the introduction part of the thesis,background of the study, problem statement,mainobjective,specificobjectives,researchquestions,hypothesis,justification,limitations and delimitations of the study. Chapter two reviews the literature that is relevant to proximate and mirco- nutreient analsysis of mushrooms, previous work done on nutrient analysis between the two types of mushrooms i.e home-grown and wild, and lastsly conceptual framework that is the baseline in which the study is based on. Chapter three describes the methodology that was used including research design, data collection and data analysis. Chapter four covers the results for the all three specific objectives of the research. Chapter five summarises, concludes and makes recommendations on the research.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The fossil record has proven the long existence of fungi as far back in time as the Paleozoic era (408 – 438 million years ago) in the Silurian period. Mushrooms, have been a part of the fungal diversity for around 300 million years, might probably have been collected by prehistoric humans as food and possibly with medicinal aims (Oso and Omotso, 2020). As the civilization of mankind progressed, mushrooms have been valued as edible and medicinal resources based on the long existing history in some Asian countries like China and Japan (Hoissain *et al.,* 2020). Asian people collected, cultivated and consumed mushrooms for over two thousand years due to their pleasant flavour and texture. In the traditional knowledge, 'mushroom' has been defined as a fleshy, aerial umbrella-shaped, fruiting body of macrofungi (Oso and Omotso, 2020). The gathered edible mushrooms are commonly described as higher fungi or macrofungi.

The fruiting body (carpophore, mycocarp) in higher fungi is found mostly above ground. A fruiting body grows from spacious underground mycelia (hyphae) by the process of fructification (Hoissain *et al.,* 2020). The bulk of fruiting bodies have a short lifetime only about 10-14 days. Most types of mushrooms are commonly found in the shape of umbrella with pileus (cap) and stipe (stem). Nonetheless, some species additionally possess an annulus (ring), or a volva (cup), or have both (Oso and Omotso, 2020). The forms of some unusual mushrooms look like pliable cups, golf balls, or small clubs.

Unlike green plants, mushrooms lack chlorophyll and so they cannot manufacture their own food from simple inorganic materials, such as water, carbon dioxide, and nitrates. They exploit foods from complex organic materials stored in dead or live tissues of plants and animals (Rizzo et al.,2021). Generally, they can be divided into three types of fungi according to their ecology. Those growing on dead organic material are termed saprophytic fungi. Those obtaining substances from living plants and animals and causing harm to the hosts are

referred to as parasitic fungi. Those living with their hosts by symbiosis to gain vital benefits from each other are called mutualistic symbiotic fungi. Mycelia of ectomycorrhizal species grow within roots of plants, such as trees (Raman et al.,2021). Terrestrial saprobic species snatch nutrients mainly from organic compounds of the plant and animal debris (Lallawmsanga and Passari, 2022). Here is the review of commonly mushroom species both wild and home grown in Zimbabwe.

2.2 Types of mushrooms grown in Zimbabwe

Zimbabwe is home to diverse mushroom species,including edible and non edible varieties.Edible mushrooms are divided into home-grown cultivated by farmers and wild mushrooms found in natural forests.

2.2.1. Wild mushroom

2.2.1.1 *Amanita zambiana* -Nhedzi

Amanita Zambiana is a species of mushrooms in the genus Amanita that is commonly known as the false morel or destroying angel. Found in Miombo woodlands, especially under Brachystegia and Julbernadia trees (Jaworska et al.,2015). Highly sought –after wild mushroom often known for its thick stem and cap. The cap of Zambiana is typically 3-6cmin diameter and is hemispherical to convex in shape. The gills of Amanita zambiana are free, crowded and white(Jaworska et al.,2015). They are typically 3-5 mm wide. Amanita Zambiana is as shown in figure 2.1* below.

*Figure 2. 1 Amanita Zambiana source :*Resource gate, *2025*

2.2.1.2 Lactarius kabansus - nzeve

Lactarius kabansus is also known as the Safron Milk Cap is a species edible in the genus Lactarius.Commonly called *Lactarius delicious* due to its delicious tatste. A milky cap mushroom that exudes a white latex when cut. The cap of Lactarius is typically 4-8 cm in diameter and convex to flat in shape. The cape is orange –red to reddish brown in color with a smooth and dry surface (Jaworska et al.,2015). Lactarius deliciosus typically found in association with pine trees often in sandy or acidic soils. Commonly used in traditional dishes.

Figure 2. 2 Lactarius kabansus/Lactarius deliciosus Research gate, *2025*

2.2.1.3 Termitomyces-huvhe

Termitomyces is a genus of fungi that forms a symbiotic relationship with termites commonly known as “termites mushrooms”. They have a distinctive morphology, with a cap that is often small and rounded and are rich in protein , fiber vitamins and carbohydrates(Jaworska et al.,2015). Termitomyces are as shown in Figure 2.3 below.

*Figure 2. 3 Termitomyces source :*Research gate, *2025*

2.2.2 Home-grown mushrooms

Mushroom cultivation has evolved into a significant agricultural practice worldwide, providing nutritional, economic, and ecological benefits. This literature review examines the origins of mushroom cultivation, its migration to Africa and Zimbabwe and highlights common species cultivated in these regions.

Mushroom cultivation dates back thousands of years, with evidence suggesting that it began in ancient Egypt and China. The earliest records of cultivated mushrooms, particularly the button mushroom (**Agaricus bisporus**), can be traced to France in the 17th century, where they were grown in underground caves (Kumar et al.,2023). In Asia, particularly in China and Japan, species like shiitake (**Lentinula edodes**) and oyster mushrooms (**Pleurotus ostreatus**) were cultivated for their culinary and medicinal properties. The practice of mushroom farming expanded significantly in the 20th century, driven by advancements in agricultural techniques and a growing global market for edible fungi (Thakur, 2020).

Mushroom cultivation began to spread to Africa Figure 2, 1 in the late 20th century. Initially, efforts focused on promoting the cultivation of species like the button mushroom and oyster

mushroom, primarily as part of food security initiatives. Countries such as South Africa and Nigeria led early adoption, with various agricultural programs aimed at enhancing nutrition and income for smallholder farmers (FAO, 2021). In the past two decades, interest in mushroom farming has surged across the continent. The African mushroom market has expanded, driven by increasing urban populations and a growing awareness of the health benefits of mushrooms. This trend has encouraged research into indigenous species and their potential for cultivation, further diversifying the mushroom industry in Africa (Ariyo, 2023).

Mushroom cultivation in Zimbabwe began gaining traction in the early 2000s, coinciding with initiatives aimed at enhancing food security and providing alternative livelihoods. Various non-governmental organizations and agricultural extension services have played a crucial role in promoting mushroom farming among smallholder farmers (Chai et al., 2021). Mushroom farming has become a vital source of income for many households in Zimbabwe, contributing to improved food security. Mushrooms are rich in essential nutrients, including proteins, vitamins, and minerals, which help address malnutrition in vulnerable communities (Chikowe et al., 2022). Mushroom cultivation has a rich history that spans various cultures and regions. Its migration to Africa and Zimbabwe has opened new avenues for sustainable agriculture and food security. The cultivation of common species like button, oyster, and shiitake mushrooms is transforming local economies and improving nutrition. Continued research and support for mushroom farming practices will be crucial for maximizing these benefits.

Two commonly grown mushrooms in Zimbabwe are button and oyster. Button Mushroom (**Agaricus bisporus* is one of the most widely cultivated in Zimbabwe, appreciated for its versatility and ease of cultivation. It is commonly grown in controlled environments, such as mushroom houses, using substrates like straw and compost. Oyster mushrooms have gained popularity due to their rapid growth and adaptability to various substrates, including agricultural waste. They are particularly favored by smallholder farmers for their nutritional value and potential for income generation. Although less common than button and oyster mushrooms, shiitake cultivation is emerging in Zimbabwe. Its popularity is growing, mainly due to its culinary uses and health benefits (Muposhi et al., 2021).

2.2.2.1 Oyster Mushroom (**Pleurotus ostreatus**)

The oyster mushroom, scientifically known as **Pleurotus ostreatus*, is one of the most widely cultivated and consumed mushrooms globally. This literature review explores the

origin of the oyster mushroom, its introduction to Zimbabwe, and recent studies highlighting its nutritional and economic significance. The oyster mushroom is believed to have originated in temperate and subtropical regions of Asia and Europe. Historical evidence suggests that it has been consumed for thousands of years, with early cultivation practices documented in Japan and China, where it was valued for both its culinary qualities and medicinal properties (Raman et al., 2020). The modern commercial cultivation of oyster mushrooms began in the early 20th century, particularly in Japan, where advancements in cultivation techniques significantly increased production (Raman et al., 2021).

By the mid-20th century, the cultivation of oyster mushrooms had expanded to various parts of the world, including North America and Europe. The species' adaptability to a wide range of substrates, such as straw and agricultural waste, made it a popular choice for smallholder farmers and commercial producers alike (Adedokun, 2022).

Oyster mushrooms were introduced to Zimbabwe in the early 2000s as part of agricultural initiatives aimed at improving food security and providing alternative livelihoods for small-scale farmers. The Zimbabwean government, along with various non-governmental organizations, recognized the potential of oyster mushrooms to contribute to nutrition and income generation in rural communities (Muposhi et al., 2021). Since their introduction, oyster mushrooms have become increasingly popular in Zimbabwe due to their ease of cultivation and rapid growth cycle. Farmers are encouraged to utilize locally available substrates, such as maize stalks and sugarcane bagasse, making oyster mushroom farming accessible and cost-effective (Chikowe et al., 2022). The establishment of training programs has further facilitated the spread of knowledge about mushroom cultivation techniques.

Recent research has focused on the nutritional profile of oyster mushrooms. A study by Chikowe et al., (2022) highlighted that oyster mushrooms are rich in essential nutrients, including proteins, vitamins (especially B vitamins), and minerals such as potassium and iron. These findings emphasize the importance of oyster mushrooms in addressing malnutrition in vulnerable populations. Research by Muposhi et al., (2021) assessed the economic impact of oyster mushroom farming in Zimbabwe. The study found that cultivating oyster mushrooms has provided a viable source of income for many households, contributing to local economies. The market for oyster mushrooms continues to grow, driven by increasing consumer demand for healthy and organic food options.

A study by Kumar et al., (2023) explored the ecological benefits of oyster mushrooms in Zimbabwean agriculture. The research indicated that oyster mushrooms can effectively decompose organic waste, contributing to soil health and nutrient cycling. This ecological role underscores the potential of oyster mushrooms in sustainable agricultural practices. The oyster mushroom (**Pleurotus ostreatus**) has a rich history and significant potential for enhancing nutrition and providing economic opportunities in Zimbabwe. Its introduction in the early 2000s marked a turning point for smallholder farmers, with recent studies highlighting its nutritional, economic, and ecological benefits. Continued research on proximate analysis and micro –nutrient analysis support oyster mushroom cultivation will be vital for maximizing these benefits in the region.

Oyester mushroom*:Source:* Research gate , 2025

2.2.2.2 Button Mushroom *(*Agaricus bisporus*)*

The button mushroom, scientifically known as **Agaricus bisporus**, is one of the most widely cultivated and consumed mushrooms globally. This literature review explores the origin of the button mushroom, its introduction to Zimbabwe, and recent studies highlighting its cultivation, nutritional benefits, and economic significance.

The button mushroom is believed to have originated in Europe, with early cultivation practices documented in France during the 17th century. Initially, these mushrooms were

foraged from the wild before cultivation techniques were developed to enhance their availability (Ritota and Manzi,2019). The species gained popularity due to its mild flavor and versatility in various culinary application. The commercial cultivation of button mushrooms expanded significantly in the 20th century, particularly in the United States and Europe. Advances in agricultural technology and production methods allowed for increased yields and improved quality (Lallawmsanga and Passari,2022). Today, button mushrooms are cultivated worldwide, making them a staple in many diets.

The introduction of button mushrooms to Zimbabwe began in the late 1990s and early 2000s. As part of agricultural development initiatives, the Zimbabwean government and various NGOs promoted mushroom farming as a means to enhance food security and provide alternative livelihoods for smallholder farmers (Muposhi et al., 2021). Since their introduction, button mushrooms have become increasingly popular among Zimbabwean farmers. The ease of cultivation in controlled environments, such as mushroom houses, has facilitated their adoption. Farmers are trained to utilize local substrates, such as composted agricultural waste, which contributes to sustainable farming practices (Chikowe et al., 2022). Recent research has focused on the nutritional profile of button mushrooms. A study by Chikowe et al., (2022) highlighted that button mushrooms are rich in essential nutrients, including proteins, B vitamins, and minerals like selenium and potassium. These findings emphasize the role of button mushrooms in improving nutrition among local populations.

Muposhi et al., (2021) assessed the economic viability of button mushroom farming in Zimbabwe. Their study found that cultivating button mushrooms provides a significant source of income for many households, contributing to local economies and enhancing food security. The growing demand for mushrooms in urban markets has further driven interest in cultivation. Despite their benefits, challenges remain in button mushroom cultivation. Research by Fernandes et al., (2020) identified issues such as pest management, substrate quality and market access as significant barriers for smallholder farmers. Addressing these challenges is crucial for maximizing the potential of button mushroom farming in Zimbabwe. The button mushroom (**Agaricus bisporus**) has a rich history and significant potential for contributing to nutrition and economic development in Zimbabwe. Its introduction in the late 1990s marked an important step for sustainable agriculture, with recent studies highlighting its nutritional benefits and economic impact.

Figure 2.2 Button mushroom *source :*Research gate 2025

2.3 Nutrient content of mushrooms

Mushrooms are a nutrient dense food offering a wide range of nutrients while being low in calories. Their unique composition makes mushroom a valuable addition to a balanced diet promoting overall health and improving nutrition in communities.

2.3.1 Carbohydrates

The composition of mushroom fruiting bodies, the predominating component is carbohydrate. The majority of carbohydrates are found in the polymeric form, glucan and hemicellulose types (D'Amici and Sampo, 2017). In general, glucose, mannitol and trehalose represent the major forms of monosaccharide, their derivatives and oligosaccharide groups, respectively. In their research, D'Amici and Sampo (2017) found out that glucose and trehalose contents are low and mushrooms contain higher levels of insoluble dietary fiber (2.28-8.99 g/100 g edible weight) than soluble dietary fiber (0.32-2.20 g/100 g edible weight). Mannitol that participates in volume growth and firmness of fruiting bodies shows different amounts in different species (Hoisssan et al., 2020).

The reserve polysaccharide found in some mushrooms is glycogen, not starch as in plants. The common content is about 5-10% of dry matter.Chitin, a water-insoluble structural polysaccharide, is up to 80% of dry matter in mushroom cell walls and restricts the availability of other mushroom components and is indigestible for humans(Hoisssan et al.,

2020). In addition to chitin, mushrooms contains considerable amount of dietary fiber. Guillamón showed that the dietary fiber supply among mushroom species exhibited a great variability. In the examinations on Boletus group, *Agrocybe aegerita*, *A. bisporus*, *Pleurotus eryngii* and ostreatus, total fiber was reported from 5.5-42.6% of dry matter, in which β-glucans were the main fiber polysaccharides together with chitin, where β-glucans account for 4-13% of the total fiber with a variability of the dietary fiber fractions depending on mushrooms species (Gaitan et al., 2020). β-glucans have been regarded as functional compounds as they exhibit the abilities of stimulating the immunomodulatory response, modulating humoral and cellular immunity.

2.3.2 Proteins and amino acids

Protein is the major component next to carbohydrates in mushrooms. Wide variations occur in the content of crude protein because not only the species of mushroom differ largely but also different converting factors are used based on the determination by Kjeldahl method. Although many researchers widely used the Nitrogen converting factor of 6.25 to calculate crude protein in mushrooms, Kumar and Sajar (2023) and El-Ramady et al., (2022), used a factor of 4.38 by considering the high proportion of non-protein nitrogen, mainly in chitin and discovered that albumins and globulins are the prevailing proteins of *Boletus edulis* and *Cantbaraellus cibarius* whilst proteins in mushrooms are composed of most of the essential amino acids. During research content of protein represented as a percentage in dry matter virtually did not change during air-drying of mushrooms at 40ºC or on freezing to -20ºC, however there was a significant drop was caused by boiling of fresh mushrooms (Hoissan et al., 2020). To avoid overestimating the content of crude protein, Hamza et al., (2024) recommended a specific converting factor of 4.16. Nonetheless, some essential sulfur-containing and aromatic amino acids are scarce. The free amino acids account for nearly 20% of the total nitrogen. Even though their contents are low, they play an important role in the taste of mushrooms. Glutamic acid and alanine were found as the dominant free amino acids in *T. portentosum* and *T. terreum* (Hoissan et al., 2020).

Wild mushrooms typically have a higher protein content compared to cultivated varieties. Study carried out by Sobieralski and Szponaski in 2018 showed that wild mushrooms can contain protein levels ranging from 11.56% to 27.42% on a dry weight basis, which is considerably higher than the 3-4% protein found in button mushrooms. This higher protein content in wild mushrooms can be beneficial for dietary supplementation, especially in regions with limited protein sources.

2.3.3 Vitamins

Mushrooms have been considered as a good source of vitamins because of the high levels of riboflavin (vitamin B2), niacin, folic acid and traces of vitamin C, vitamin B1, vitamin D, βcarotene (precursor of vitamin A), vitamin E and vitamin B12 (Hoissan et al., 2020) Mushrooms are notable for their B-complex vitamins (niacin, thiamin and B12) and folic acid. Their ability to accumulate these vitamins eventually substantiates their biosynthetic capacities even when they are grown on lignocellulosic wastes and the fact is that folate synthetase and B12 synthetase enzyme systems have been proven in mushroom cells (Tullio et al., 2021). Compared to plants, mushrooms appear to have a limited occurrence of carotenoids including those which can act as precursors of retinol and mushrooms are the only natural food source that can provide vitamin D to vegetarians since they are the only non-animal-based food containing vitamin D (Tullio et al., 2021). There is a remarkable amount of vitamin D2 (ergocalciferol) in numerous wild mushroom species, but is almost absent in cultivated species due to lacking exposure to sunshine (Grzywacz and Stasiak 2018). It has been well known that vitamin D2 is originated by photoirradiation from its precursor ergosterol. When exposed to UV light, ergosterol undergoes photolysis to generate various photoirradiation products, mainly previtamin D2, tachysterol and lumisterol. The previtamin D2 then undergoes spontaneous thermal rearrangement to vitamin D2. Jaworska et al., (2015) reported that the conversion of ergosterol in mushrooms to vitamin D2 was affected by many factors, such as the irradiation time and temperature, moisture content of mushrooms, the type and intensity of the UV irradiation. A variety of minor sterols present in fungi have been identified, such as fungisterol, ergosta-5,7dienol, 24-methyl cholesterol and methylene cholesterol (Grzywacz and Stasiak 2018). Although fungal and plant sterols are produced through similar biosynthesis reactions, the sequence of postsqualene reactions and the stereochemistry of the main products are distinct and different.

2.3.4 Lipids

The fat comprises representatives of all types of lipid compounds, such as free fatty acids, mono-, di-, and triglycerides, sterols, sterol ester, and phospholipids (Grzywacz and Stasiak 2018). Overall, unsaturated fatty acids prevail over saturated fatty acids, especially nutritionally undesirable saturated palmitic acid (C16:0), monounsaturated oleic acid (C18:1) and polyunsaturated linoleic acid (C18:2), while the remaining fatty acids are only found in small amounts whilst exceptional case is seen in *Lactarius kabansus* which contains an abundant amount of stearic acid (C18:0) (Grzywacz and Stasiak 2018). Linolenic acid (18:3)

is the precursor of 1-octen-3-ol, known as the mushroom alcohol. It is the principal aromatic compound in most fungi, which contributes characteristically and distinctively to mushroom flavour (Tullio et al., 2021).

The growth temperatures of cultivated oyster mushroom below 17oC led to a rise of unsaturated fatty acid proportion as compared to mushrooms produced at temperatures above 17oC. Manzi et al (1999) reported that ash content of mushroom was around 6-10.5% of dry matter, this result was supported by Hoisan et al., (2019) who showed it to be about 5-12%. The principle constituents in the ash are potassium, phosphorus, magnesium, calcium, copper, iron and zinc (Tullio et al., 2021). In fruiting body, the distribution of potassium is not even, its concentration indicates a decreasing trend in the order: cap > stipe > spore-forming part > spores (Tullio et al., 2021). This property can be ambivalent, for it is not only useful in providing desired minerals in good quantities but also is dangerous for consumption when toxic elements are accumulated (Grzywacz and Stasiak, 2018). Mushrooms are able to accumulate potassium and phosphorus in their fruiting bodies. The concentrations of potassium and phosphorus are respectively 20-40 folds and 10-50 folds higher than those in the underlying substrates.

2.4 Nutrient content of wild mushrooms versus home grown

Home-grown mushrooms such as **Agaricus bisporus** (button mushrooms) and **Pleurotus ostreatus** (oyster mushrooms), are cultivated in controlled environments, which often results in consistent nutrient profiles for example, a typical serving (100 grams) of *Agaricus bisporus* contains approximately 3.1 grams of protein, 0.3 grams of fat and 3.3 grams of carbohydrates, along with essential vitamins and minerals such as potassium (318 mg), phosphorus (86 mg) and selenium (9.3 µg) (D'Amici and Sampo, 2017). These mushrooms are low in calories, making them a popular choice for health-conscious consumers.

In contrast, wild mushrooms exhibit greater variability in their nutrient content due to the diverse environments in which they grow. For instance, wild chanterelles (**Cantharellus cibarius**) can provide significantly higher levels of certain nutrients. A 100-gram serving of chanterelles contains about 1.5 grams of protein, 0.5 grams of fat, and 6.5 grams of carbohydrates, along with higher levels of vitamin D (up to 1200 IU when exposed to sunlight) and potassium (400 mg) (D'Amici and Sampo, 2017). This variability highlights the potential for wild mushrooms to offer enhanced nutritional benefits compared to their cultivated counterparts.

Wild mushrooms generally offer superior nutritional benefits compared to home-grown varieties like button mushrooms, particularly in terms of protein, minerals, vitamins and antioxidant content (Hoissan et al., 2020). The nutrient content of mushrooms is significantly influenced by environmental factors such as soil quality, climate and the substrates used for cultivation (Sokot et al., 2018). Wild mushrooms absorb nutrients from their natural habitats, leading to a more diverse nutrient profile. In contrast, home-grown mushrooms, including button mushrooms, are cultivated in controlled environments, which may limit their nutrient uptake and diversity (Hoissan et al., 2020). However, the choice between wild and cultivated mushrooms may depend on factors such as availability, safety and personal preference. Further research is warranted to explore the full potential of both wild and cultivated mushrooms in human nutrition.

In conclusion, both home-grown and wild mushrooms provide unique nutritional benefits, with wild mushrooms often exhibiting higher levels of specific nutrients and bioactive compounds.

2.5 Conceptual framework

The conceptual framework for the study of micro and macronutrient analysis of homegrown and wild mushrooms emphasizes the relationship between nutritional composition and food security. By examining the proximate (such as protein, fat, carbohydrates, and fiber) and micronutrient (including vitamins,flavonoids and minerals) profiles of both homegrown and wild mushrooms, the framework aims to identify the potential of these fungi as nutrient-dense food sources. This analysis is grounded in the understanding that mushrooms can serve as a sustainable and accessible dietary option, particularly in regions facing food insecurity. By leveraging the nutritional benefits of mushrooms, the study seeks to inform strategies that enhance food and nutrition security, thereby addressing malnutrition and promoting healthier diets.

Additionally, the framework incorporates the impact of cultivation practices and environmental factors on the nutrient composition of mushrooms. Homegrown mushrooms are influenced by cultivation methods, substrate quality, and growing conditions, whereas wild mushrooms are shaped by their natural habitats and ecological environments. By comparing these two sources, the framework aims to highlight best practices for mushroom cultivation that optimize their nutritional value. Ultimately, this research seeks to contribute to food security initiatives by providing evidence-based recommendations for integrating

mushroom consumption into local diets, promoting sustainable agricultural practices, and enhancing overall nutritional outcomes in communities at risk of food insecurity as shown in Figure 1.1 below.

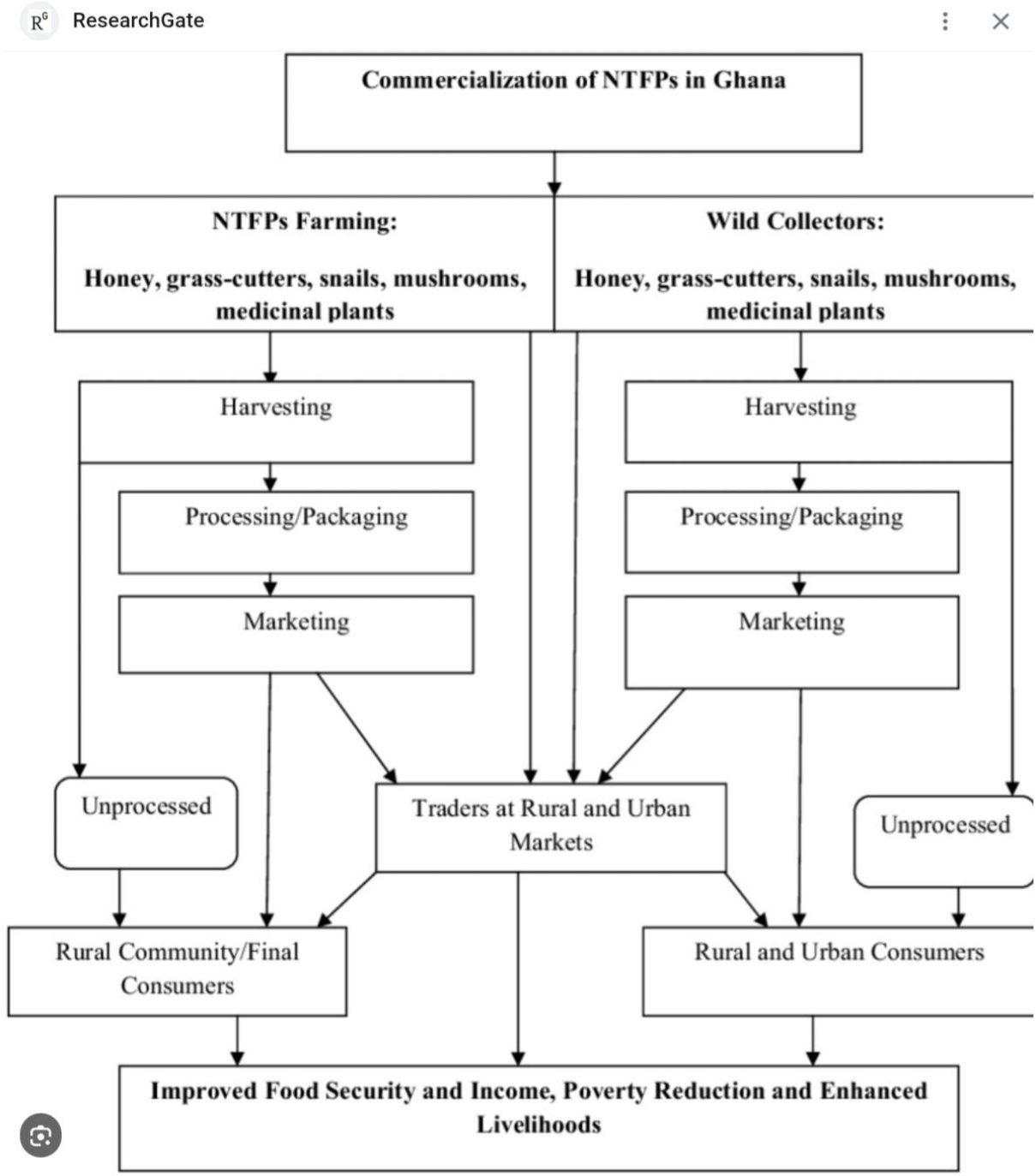

Figure 1.1 Conceptual framework *source :*Research gate

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter gives an outline of research methods that were followed in the study. The instrument that was used for data collection is also described and procedures that were followed to carry out the study included. Methods used to analyze data are also discussed.

3.2 Brief description of study site

Wild mushroom samples were collected from Chivhu due to proximity under Furtherstone district. Chivhu is located in Natural Farming Region IV characterized by dry forest biome climate. The region is also known as the Highveld region with an average rainfall of around 600-800mm, well- drained soils including loams and clay loams. Wild mushroom were collected from Adelina farm: coordinates (X 30.96156 ,Y18.61162, Dorasdale farm (X 30.91400,Y 18.68461)and Nieuwejaarsfontein farm (X30.95516, Y18.64933). Home grown mushrooms were collected from mushroom farmers based in Harare.

3.3 Research design

This study utilized an experimental approach to examine differences in both proximate and micronutrient composition between selected wild and home-grown mushrooms. In this design, the independent variable is the type of mushroom (wild vs. home-grown), while the dependent variables include the proximate parameters moisture content, protein, fat, fiber, ash content, and carbohydrates as well as the micronutrient composition (vitamins and flavonoids).

3.3.1 Manipulation of the Independent Variable: The study compares two distinct categories of mushrooms that are subject to different growing conditions. Although the researcher did not “manipulate” the environment in a classic laboratory sense (since the wild samples naturally grow in their environment and the home-grown ones are cultivated), the grouping into wild and home-grown serves as a key independent variable. This quasi-experimental comparison helps to isolate the effect of growth conditions on the composition of the mushrooms(Jaworska et al.,2015).

3.3.2 Control of Extraneous Variables: By employing standardized protocols for sample collection, preparation, and analysis (e.g., oven drying for moisture determination, the Kjeldahl method for protein, Soxhlet extraction for fats), the design minimizes potential confounding factors. Using triplicate samples for each measurement ensures that the data are reliable and any observed differences between the groups are more likely due to the mushroom type rather than methodological inconsistencies (Gaitan and Esquenda,2018).

3.3.3 Measurement of Multiple Dependent Variables: The experimental design allows for a comprehensive examination of nutritional attributes by measuring a range of proximate components and micronutrients. Such a multidimensional approach provides a full profile of the nutritional content, highlighting, for instance, that home-grown mushrooms consistently have higher protein levels while wild mushrooms tend to have greater carbohydrate and fiber content. This detailed data collection supports nuanced comparisons between the two growth conditions (Jaworska et al.,2015).

3.3.4 Statistical Analysis and Inference: The application of statistical tests such as ANOVA on the data collected from triplicate samples enables the researcher to compare the means of the two groups for each nutritional parameter. Even though the composite proximate analysis did not show significant differences due to high within-group variability, individual nutrient trends could be clearly identified. This method of analysis supports drawing valid conclusions regarding the effects of the independent variable on each of the dependent variables (Dias and Brito,2017).

3.3.5 Validity and Reliability: Conducting the analysis using careful experimental controls and replicates not only enhances the internal validity of the study but also ensures that the findings are reliably linked to the mushroom type. This design facilitates the drawing of conclusions about how cultivation conditions may be optimized to enhance specific nutritional traits, such as protein content in home-grown mushrooms, while recognizing the inherent strengths of wild mushrooms in terms of fiber and carbohydrate content.

3.3.6 Implications for Practice and Policy: Through this experimental design, the study provides robust data that can inform sustainable agricultural practices and local nutritional strategies. For instance, the significant increase in protein content in home-grown mushrooms highlights the potential for controlled cultivation practices to improve key nutritional

attributes. Likewise, conservation of wild mushrooms may be emphasized where high fiber content is valued, supporting integrated food security programs (FAO, 2024).

3.4 Sampling procedure

Convenience sampling was used, were mushroom was collected from the 3 farms where mushrooms grow. Oyster mushroom was bought from a mushroom farmer in Kuwadzana 5. The mushroom was harvested the previous night and refrigerated overnight. Button Mushroom was bought from TM Joina city, as it was not available from local mushroom farmers.

Convenience sampling involves selecting research subjects that are easy to access and willing to participate. This method is widely used when time, budget, or logistical constraints limit the ability to conduct probability-based sampling (Dhar,2017). While it does not guarantee that the sample is representative of the entire population, it often provides a quick and cost-effective means to gather preliminary data, especially in exploratory studies.

The study was conducted in a setting where multiple mushroom sources were readily identified, making convenience sampling an expedient choice. Wild mushrooms were collected from three farms with documented coordinates, ensuring that the samples came from specific, accessible locations. Meanwhile, home- grown mushrooms were systematically obtained from local suppliers one directly from a mushroom farmer in Kuwadzana 5 and another from a retail outlet (TM Joina City) where Button mushrooms were available. This approach allowed the researcher to gather diverse samples within the constraints of available resources and time.

The primary aim was to compare proximate analysis and micronutrient composition between wild and cultivated mushrooms. By focusing on readily available sources in the local area, the study could efficiently assess the nutritional differences attributable to growth environments. Although this method may introduce some sample biases, stringent collection and handling protocols (e.g., using sterile tools, proper labeling, and standardized drying and extraction methods) helped maintain data quality and reliability.

Because convenience sampling does not involve random selection, caution must be taken when generalizing the results to all mushroom populations. The insights gained are most applicable to the particular environments sampled in this study. Future research could employ

probability sampling or stratified sampling techniques to validate these findings and extend their applicability across different regions and cultivation practices.

Overall, convenience sampling, as applied in this study, provided a practical and effective means of collecting mushroom samples from accessible, well-defined local sources. While it offers significant advantages in terms of efficiency and resource management, researchers must also recognize its inherent limitations regarding representativeness. In this context, the approach was justified by the specific objectives of comparing wild and home- grown mushrooms and the logistical constraints faced during data collection. These findings lay a solid foundation for further research, which may incorporate more rigorous sampling methods to broaden the generalizability of the results (Hoissa et al.,2020; Saglam and Ozgunler,2022; FAO, 2024).

3.5 Data collection procedure

3.5.1 Sample collection

- Clean, sterilized tools (knives, gloves) were used to minimize contamination during the collection process.

- mushrooms were collected at their peak maturity in march 2025, as this was when they were most likely to contain optimal nutritional content. Specimens that showed signs of decay or contamination were avoided.

- A minimum of 500 grams were harvested of each selected species to ensure sufficient material for nutritional analysis.

3.5.2 Sample Handling and Storage

- Collected mushrooms were be placed in breathable containers (baskets) to prevent moisture build-up, which can lead to spoilage.Own transport was used to transport the mushroom to Harare as public transport would prolong transportation time.

- Each sample was be labelled with relevant information, including species name, collection date and location.

3.5.3 Preparation for Analysis

- Samples were transported to Harare, sun dried under with no additives for 2 weeks and stored in breathable baskets.

- The dried mushrooms was grinded into a fine powder using a clean grinder to ensure uniformity for subsequent analyses.

3.5.4 Sample Preparation

3.5.4.1 Extraction

-Suitable solvent was used (methanol, acetone, or ethanol) to extract different nutrients. The extraction was performed using cold extraction where powdered mushroom was soaked in the solvent at room temperature for a specified time.

3.5.4.2 Filtration:

- The extract was filtered using filter paper to separate the solid residue from the liquid extract

3.5.5 HPLC Setup

High-Performance Liquid Chromatography (HPLC) is a powerful analytical technique used to separate, identify, and quantify compounds in various samples, including mushrooms. This method is particularly useful for testing nutritional composition of mushrooms. Here is a detailed description of the procedure involved in using HPLC for testing mushroom toxicity.

3.5.5.1 Equipment Preparation

- Set up the HPLC system, which includes a pump, injector, column, detector (often UV/Vis or fluorescence), and data acquisition system.

3.5.5.2 Column Selection:

- Choose an appropriate HPLC column based on the target compounds. Common column types include C18 reversed-phase columns for non-polar compounds and ion-exchange columns for charged species.

3.5.5.3 Mobile Phase Preparation:

- Prepare the mobile phase, which consists of solvents that will carry the sample through the column. The composition will vary depending on the nature of the compounds being analysed (e.g., water and acetonitrile for polar compounds).

3.5.6 HPLC Analysis

3.5.6.1 Injection:

- a known volume of the prepared mushroom extract was injected into the HPLC system using an auto sampler.

3.5.6.2 Separation:

- The mobile phase carried the sample through the column, where different compounds were separated based on their interaction with the stationary phase.

3.5.6.3 Detection:

- As compounds exited the column, they passed through the detector. The detector generated a signal for each compound, which was recorded as a chromatogram.

3.5.6.4 Retention Time:

- the retention times of known standards were monitored to identify the compounds present in the mushroom extract.

3.5.6.5 Quality Control

3.5.6.5.1 Calibration:

-the HPLC system was regularly calibrated using standard solutions to ensure accuracy and precision in measurements.

3.5.6.5.2 Replicates:

-each sample was replicated 3 times to validate results and account for variability in measurements.

3.6 Data Analysis

Microsoft Excel was the primary tool for data analysis. Excel is widely used in food science and many other fields for its capability to perform a range of statistical procedures ranging from descriptive statistics and regression analysis to hypothesis testing and visualization (Robinson et al.,2019).

For the proximate analysis which includes measurements of moisture, protein, fat, fiber, ash, and carbohydrate content Excel was used to calculate key statistical parameters such as the mean, median, mode, standard deviation, and correlation coefficients. These descriptive statistics provided an initial understanding of the distribution and variability within the data. In addition, hypothesis testing was performed within Excel to determine whether significant differences exist between the means of the wild versus home-grown mushroom groups. All experiments were run in triplicate to ensure reproducibility and to minimize random error, thereby ensuring that any differences in nutritional content were robust and statistically sound.

For the analysis of micronutrients (including vitamins and flavonoids), a one-way analysis of variance (ANOVA) was performed using Excel. ANOVA is a powerful inferential statistical method used to compare the means of two or more groups. In this study, it helped determine if the differences in micronutrient levels between different mushroom groups (wild versus home- grown) were statistically significant. Once again, triplicate measurements were used to capture within-sample variability and to enhance the reliability of the comparisons.

Excel was also used to analyze sensory evaluation scores. The mean, median, and mode of these scores were computed, and appropriate statistical tests were performed to discern any significant differences between sensory ratings of the different mushroom samples, further supporting the overall analysis of nutritional quality. Excel's graphing capabilities were leveraged to create visual representations (e.g., bar charts) of the data, allowing for easier interpretation of the patterns and differences across the studied groups.

O

3.7 Ethical considerations

According to Kaliyaperumal et al., (2018) ethics are defined as the norms or standards of behaviour that guide moral choices about our behaviour and our relationships with others. The researcher adhered to high ethical standards to promote trust, accountability and mutual respect. In carrying out the research the researcher firstly sought for the permission from the relevant authorities that is Bindura University where support of a research conformation letter was obtained and University of Zimbabwe where experiments were carried out.

3.8 Challeges and solutions encountered during data collection

3.8.1 Variability in Wild Samples:

Wild mushrooms are subject to naturally variable growing conditions, including differences in humidity, temperature, soil composition and light exposure. Such variability can lead to inconsistent nutrient profiles and makes it challenging to ensure that samples are directly comparable (Kaliyaperumal et al.,2018). To avoid this mushrooms were colleceted from three different farms with different growing conditions to find the mean nutrient profiles.

The availability and quality of wild mushrooms can vary seasonally. Collecting samples from different sites at different times may result in significant fluctuations in proximate and micronutrient content, thereby compromising the uniformity of the dataset. In Zimbabwe wild mushroom only sprout after the rainy season in moist conditions and mushrooms were collected in March 2025 at their peak of maturity.

3.8.2 Standardization of Sampling

There is an inherent variability in the maturity, size and morphology of mushroom specimens. Even within the same species, differences in developmental stage can influence nutrient concentration, making it difficult to obtain truly representative samples (Sánchez, 2010). At least 500 grammes of mushroom was colleceted per sample and all sizes of mushroom were collected

3.8.3 Cultivation and Handling of Home- Grown Samples

Even within controlled environments, home- grown mushrooms may experience slight differences in substrate composition, watering schedules, or microclimatic conditions. These subtle variations can contribute to inconsistency in nutrient levels across replicates (Sharma et al.,2023).To avoid this bias oyster mushroom was collected from three different mushroom farmers.Button mushroom was bought from TM supermarkets hence they only purchase from farmers who meet standard growing procedures.

Ensuring uniformity in sample preparation such as cleaning, drying and pulverizing is critical for accurate proximate analysis. Variations in these steps may introduce errors in measurements and increase the within-group variability. To minimize this, similar treatment was given to all samples to ensure uniformity.

3.8.4 Instrumentation and Measurement Limitations

The reliability of proximate and micronutrient analysis depends on the precision of the instruments. Calibration issues or limits in detection sensitivity can introduce measurement errors, further complicating comparisons between samples. To minimize bias expert personnel from University of Zimbabwe were consulted and assisted in labarotory analysis to minimize errors.

Although triplicate measurements enhance reliability, any inconsistencies in lab procedures (such as inconsistent drying times for moisture content or incomplete extraction of fats) can lead to higher variability in the data (Kumar and Sagar,2023).

3.8.5 Logistical Constraints:

The time and method of transporting wild mushroom samples from the field to the laboratory may affect their chemical composition. Delays or suboptimal storage conditions can lead to nutrient degradation, particularly for sensitive compounds like vitamins. To reduce this , own transport was used to avoid public transport delays and the collected mushrooms were transported in breathable baskets.

3.9 Summary

This chapter explained how the researcher collected the data. Data collection methods, data collection tools, sampling procedures and sample size determination are also explained in this

Chapter. Apart from the above it also express the data collection application and data analysis application that the researcher intent to use. Lastly it also showed the skeleton on how data is going to be analysed. This chapter has explained on how the researcher collected the data. It has shown all data collection methods, data collection tools, sampling procedures and sample size. Apart from the above it also express the data collection application and data analysis application that the researcher intent to use. Lastly it also showed the skeleton on how data is going to be analysed.

CHAPTER 4

RESULTS AND DISCUSSION

4.1. INTRODUCTION

This study focused on proximate analysis and micro-nutrient composition of wild and home-grown mushrooms chapter the researcher identified and presented the nutrient composition of mushrooms sourced by accessibility. As data was analysed a comprehensive guide of the proximate analysis and micro-nutrients was laid out supported by statistical analysis. Recommendation and discussions were made axing with a chapter summary

4.2 Results

4.2.1 Proximate analysis of wild mushrooms versus home grown mushrooms

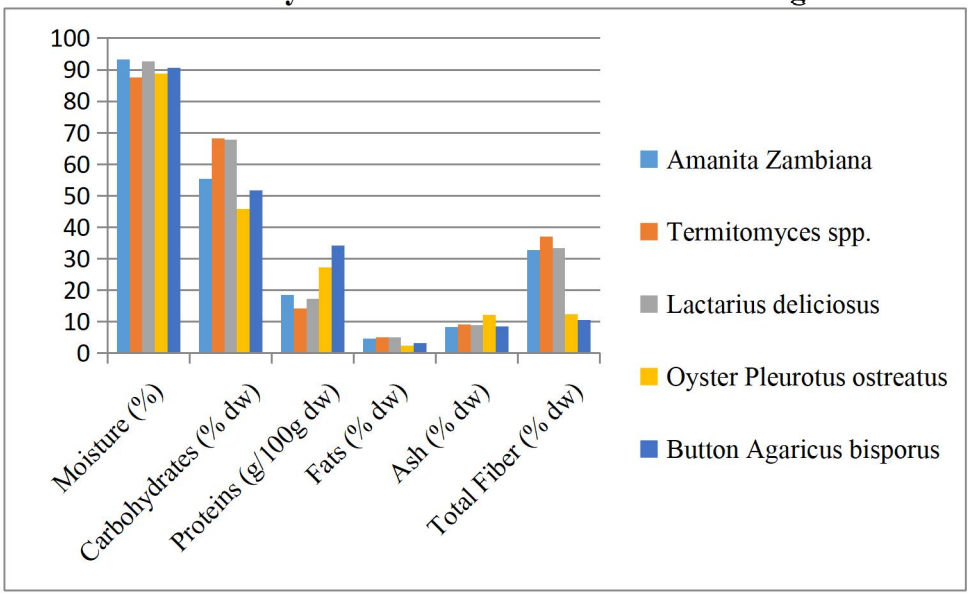

Figure 4. 1 Proximate analysis of the sampled mushrooms

4.2.1.1 Moisture Content: Fresh mushrooms generally exhibit high moisture content. In our data, Amanita zambiana registers the highest moisture at 93.31 ± 0.4%, while Termitomyces spp. show a somewhat lower value at 87.46 ± 1.04%. These values fall within the commonly reported range of 85–90% moisture for fresh mushrooms (Kumar et al., 2023). The slightly higher moisture in Amanita zambiana reflect species-specific water-retention capabilities or differences in the habitat microclimate during collection. Such variations are expected given that environmental factors, such as humidity and temperature at the time of harvest, can influence water content (Kalač, 2010).

4.2.1.2 Carbohydrates: On a dry-weight basis, carbohydrate values varied notably among the species. Wild mushrooms, such as Termitomyces spp. (68.26 ± 0.21%) and Lactarius deliciosus (67.68 ± 0.75%), showed higher carbohydrate levels compared to Amanita zambiana (55.35 ± 0.94%). In contrast, the cultivated mushrooms Pleurotus ostreatus (45.76 ± 2.36%) and Agaricus bisporus (51.57 ± 1.68%) displayed relatively lower carbohydrate levels. The observed higher carbohydrate content in certain wild species is attributed to the natural storage of energy reserves in response to nutrient variability in their natural habitat. Similar findings were reported by Kalač, (2010) who noted that wild mushrooms often accumulate higher storage carbohydrates compared to their cultivated counterparts, which are often managed under more nutrient-stable conditions.

4.2.1.3 Proteins: Protein content reveals a clear contrast: wild mushrooms such as Amanita zambiana (18.39 ± 0.15 g/100g dw) and Lactarius deliciosus (17.25 ± 0.05 g/100g dw) aim at moderate levels comparable to typical wild mushroom values. However, cultivated species like *Pleurotus ostreatus* (27.25 ± 0.88 g/100g dw) and especially *Agaricus bisporus* (34.05 ± 0.68 g/100g dw) exhibited significantly higher protein contents. This trend is supported by previous work (Kumar et al., 2023), which suggests that cultivation practices often involving enriched substrates and controlled environmental conditions can enhance protein synthesis in these species. The differences could also be driven by selective breeding or by the specific nutrient composition of the growth media utilized in commercial cultivation.

4.2.1.4 Fats: All species analyzed exhibited low fat contents, with values ranging from 2.4 ± 0.15% in *Pleurotus ostreatus* to approximately 4.98 ± 0.1% in Lactarius deliciosus and *Termitomyces* spp. These low values are typical of mushrooms and are consistent with the general observation that mushrooms are low in lipids (Kumar et al.,2023). The minor variations in fat content across species reflect inherent biosynthetic differences or slight disparities in substrate composition. Although *Amanita zambiana* showed a marginally elevated fat content (4.62 ± 0.47% dw), this remains within an acceptable range when compared to the broader literature.

4.2.1.5 Ash Content: Ash, representing the total mineral content, was lowest in wild species 8.31 ± 0.14% for *Amanita zambiana*, 8.88 ± 0.17% for Lactarius deliciosus, and 9.12 ± 0.19% for Termitomyces spp.—but was notably higher in Pleurotus ostreatus (12.19 ± 0.83% dw). In *Agaricus bisporus*, the value was intermediate at 8.52 ± 0.34% dw. The elevated ash

content in *Pleurotus ostreatus* suggests that the substrate used for its cultivation is rich in minerals, or that this species inherently accumulates more inorganic material, a phenomenon reported in some studies (Kalač, 2010). Such high mineral contents have implications for the nutritional value and functional use of mushrooms in human diets.

4.2.1.6 Total Fibre: A striking observation is the substantial difference in fibre content between wild and cultivated mushrooms. Wild species possess notably higher fibre levels *Termitomyces* spp. at 36.91 ± 0.93% and *Lactarius deliciosus* at 33.39 ± 1.03% while cultivated mushrooms, *Pleurotus ostreatus* and *Agaricus bisporus*, have much lower fibre contents (12.34 ± 1.26% and 10.52 ± 0.34%, respectively). This trend aligns with previous findings by Kumar et al., (2015), suggesting that wild mushrooms, which grow in more fibrous substrates, tend to accumulate higher levels of dietary fibre. However, some studies have reported even lower values for certain wild species, indicating that environmental and methodological differences are influential. The elevated fibre levels in wild mushrooms could offer additional health benefits, particularly for digestive health, and also affect their energy density.

4.2.2 Proximate composition

Table 4. 1 Anova output for proximate composition as displayed on EXCEL

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Amanita zambiana	6	231,6	38,6	5955,8
Termitomyces spp.	6	265,52	44,2533	6789,36
Lactarius deliciosus	6	201,55	33,5917	3923,02
Button Agaricus bisporus	6	24,48	4,08	22,2621
Oyster Pleurotus ostreatus	6	353,11	58,8517	5171,04

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	9730,11	4	2432,53	0,55635	0,6963	2,75871
Within Groups	109307	25	4372,3			
Total	119038	29				

The above table is a display from Microsoft Excel Plus 2010 (version 14.0.4734.1000) for the ANOVA of proximate composition. This was done on original values from the triplicates of the sampled home grown and wild mushrooms. The extremely high p-value (0.997633) indicates that there is no statistically significant difference among the proximate means of the five mushroom groups. In other words, the variability within each group is so high that the modest differences in group averages are statistically indistinguishable.

The F statistic (0.033978) is much lower than its critical value (2.75871), and the p-value is almost 1.0. This leads us **to accept the null hypothesis**, indicating that the overall proximate

compositions (i.e., ash, carbohydrates, fiber, protein, fat, and moisture) do not differ significantly among the mushroom groups sampled. The high within-group mean square (1143.087) relative to the between-group mean square (38.83961) suggests that natural biological variability, measurement error, or sample heterogeneity obscured any potential differences between wild and home-grown mushrooms.

4.2.3 Micro-nutrient concentration of wild mushrooms versus home-grown mushrooms

4.2.3.1 Vitamin A

Table 4. 2 Output of One-way ANOVA for vitamin A from EXCEL

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Wild mushrooms	9	1700	188,889	547,406
home grown mushrooms	6	607,72	101,287	9565,32

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	27626,9	1	27626,9	6,8795	0,02107	4,66719
Within Groups	52205,9	13	4015,84			
Total	79832,8	14				

Since the p-value (0.02107) is less than the common significance level of 0.05 and the calculated F statistic (6.88) exceeds the F critical value (4.667), we **reject the null**

hypothesis. This indicates that there is a statistically significant difference in vitamin A levels between wild and home-grown mushrooms. The data shows that wild mushrooms have a significantly higher average vitamin A content (188.89) compared to home-grown mushrooms (101.29). This suggests that the environment in which these mushrooms are naturally grown contribute to higher vitamin A accumulation. Factors such as natural sunlight exposure, soil composition, and interactions with other organisms in the wild enhance the synthesis or accumulation of vitamin A precursors. Noticeably, the home-grown mushrooms exhibit a much higher variance (9565.33) relative to the wild ones (547.41). Such high variability in the home-grown group suggests that external factors in the cultivation environment (e.g., substrate differences, varying microclimates, or inconsistency in controlled conditions) influence vitamin A levels widely. This variability obscure more consistent trends unless further controlled studies are undertaken.

In an envelope, the ANOVA analysis, conducted using Microsoft Excel Plus 2010, shows a statistically significant difference in vitamin A content between wild and home-grown mushrooms, with wild mushrooms possessing higher levels. This suggests that environmental factors inherent to wild habitats favour vitamin A accumulation, while higher variability in home-grown samples indicates a need for more controlled cultivation practices. These findings are in line with previous literature that discusses how cultivation conditions impact nutritional composition and offer critical insights for optimizing mushroom farming to support sustainable agriculture and local food systems.

4.2.3.2 Vitamin C

Table 4. 3 Output of One-way ANOVA for vitamin C from EXCEL

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Wild mushrooms	9	119,76	13,3067	4,28262		
home grown mushrooms	6	50,95	8,49167	86,5767		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	83,4632	1	83,4632	2,32267	0,15145	4,66719
Within Groups	467,144	13	35,9342			
Total	550,607	14				

Since the p-value (0.151453) is greater than the standard significance level of 0.05 and the F-value (2.322669) is below the critical value (4.667193), we **fail to reject the null hypothesis**. This finding indicates that, at the current sample sizes and conditions, the difference in vitamin C content between wild and home-grown mushrooms is not statistically significant. The wild mushrooms have a higher average vitamin C content (13.31) compared to the home-grown mushrooms (8.49). Although this difference is notable, the ANOVA suggests that it is not statistically significant given the existing variability in the data. A striking observation is that the variance in vitamin C content for home-grown mushrooms (86.58) is much higher than that for wild mushrooms (4.28). This suggests that home-grown mushrooms exhibit considerable heterogeneity in vitamin C levels, which could be due to inconsistent cultivation practices, variable substrate quality, or environmental fluctuations even within controlled settings. High variance mask true differences between groups when using statistical tests like ANOVA.

Previous studies have demonstrated that environmental factors play a crucial role in the biosynthesis and accumulation of micronutrients such as vitamin C. For example, Chang and Miles (2004) highlighted that wild mushrooms, benefiting from diverse ecological conditions including natural sunlight and a varied nutrient base can sometimes accumulate higher

micronutrient levels. Although the data show a higher mean vitamin C content in wild mushrooms, the high variability in the home-grown group reduced the overall statistical power to detect a significant difference. Sánchez, (2010) also noted that while controlled cultivation can optimize many nutritional parameters, achieving consistency in micronutrient content can be challenging. The high variance observed here among home-grown mushrooms aligns with these challenges and underscores the need for improved standardization in cultivation practices.

In short, the ANOVA for vitamin C content reveals that wild mushrooms have a higher average than home-grown ones, the difference is not statistically significant at an alpha level of 0.05 (F = 2.3227, p = 0.1515). The high variability within the home-grown group likely contributes to this outcome. These results underscore the importance of standardizing cultivation conditions and increasing sample sizes in future research to better capture differences. In terms of policy, enhancing cultivation protocols and supporting research into the environmental factors that influence micronutrient accumulation help in developing more nutritionally consistent mushroom production systems, contributing to sustainable agriculture and local food security.

4.2.3.3 Vitamin E

Table 4. 4 Output of One-way ANOVA for vitamin E from EXCEL

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Wild mushrooms	9	10,57	1,17444	0,73988		
home grown mushrooms	6	66,4	11,0667	144,105		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	352,282	1	352,282	6,30423	0,02605	4,66719
Within Groups	726,443	13	55,8803			
Total	1078,73	14				

Since the p-value (0.026051) is below the standard significance level of 0.05 and the F-value (6.304227) exceeds the critical value (4.667193), **the null hypothesis is rejected**. This result indicates a statistically significant difference in vitamin E content between wild and home-

grown mushrooms. The statistically significant difference means that home-grown mushrooms have a considerably higher average vitamin E content (11.07 units) compared to wild mushrooms (1.17 units). This suggests that controlled cultivation practices enhance the vitamin E accumulation, possibly due to optimized substrate quality, controlled light exposure, or other cultivation parameters (Chang & Miles, 2004). Although the wild group shows low variability (variance = 0.739878), the home-grown group exhibits remarkably high variability (variance = 144.1049). This high variance in home-grown mushrooms are linked to inconsistencies in cultivation conditions such as differences in substrate nutrient availability or microclimatic fluctuations which can lead to a range in vitamin E contents. Despite this variability, the marked increase in the average indicates that, on balance, home-grown mushrooms tend to accumulate more vitamin E.

Research by Kliyaperumal et al., (2018) suggests that optimized cultivation techniques enhance specific micronutrients. The higher vitamin E content in home-grown mushrooms aligns with this observation in that controlled environments allow for targeted nutrient supplementation or stress conditions that favor vitamin E synthesis. As noted by Sánchez, (2010) maintaining consistency in micronutrient content during controlled cultivation can be challenging. The high variability in the home-grown group underscores this challenge, indicating that while enhancing vitamin E is achievable, standardization of cultivation protocols is necessary to minimize inconsistencies. Wild mushrooms, growing in varied and naturally stable conditions, exhibit a more consistent (albeit lower) vitamin E content. This difference further supports the concept that environmental and cultivation factors critically influence nutrient accumulation (Hoissain et al., 2020).

All in all, the ANOVA analysis for vitamin E content indicates a statistically significant difference between wild and home-grown mushrooms, with home-grown mushrooms exhibiting substantially higher vitamin E levels ($F = 6.304227$, $p = 0.026051$). Despite the high variability in the home-grown group, the overall evidence suggests that optimized cultivation conditions can enhance vitamin E accumulation. These findings support the need for further research to refine cultivation practices and underscore policy opportunities to standardize mushroom farming techniques, thereby contributing to sustainable agriculture and improved local food security.

4.2.3.4 Vitamin B2

Table 4. 5 Output of One-way ANOVA for vitamin B2 from EXCEL

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Wild mushrooms	9	28,96	3,21778	0,04577
home grown mushrooms	6	297,68	49,6133	2366,18

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	7749,17	1	7749,17	8,51466	0,01199	4,66719
Within Groups	11831,3	13	910,098			
Total	19580,4	14				

The ANOVA conducted using Microsoft Excel Plus 2010 (version 14.0.4734.1000) compares vitamin B2 levels between wild and home-grown mushrooms. Because the p-value (0.011987) is less than 0.05 and the F-value (8.51466) exceeds the critical value (4.667193), we reject the null hypothesis. This indicates that there is a statistically significant difference in vitamin B2 content between wild and home-grown mushrooms. The average vitamin B2 content in home-grown mushrooms (49.61333) is markedly higher than that in wild mushrooms (3.21778). This substantial difference suggests that the controlled cultivation practices employed in the home-grown samples lead to enhanced riboflavin accumulation relative to natural growth conditions. The wild mushrooms exhibit extremely low variability in vitamin B2 (variance = 0.04577), indicating a consistent, stable level of this nutrient in their natural environment. In contrast, home-grown mushrooms display a very high variance (2366.181), implying that while the average vitamin B2 content is high, there is significant heterogeneity among samples. This heterogeneity is due to fluctuations in cultivation conditions such as substrate composition, temperature, light exposure, or nutrient supplementation.

Prior research has demonstrated that controlled cultivation environments can be optimized to enhance specific micronutrients, including vitamin B2. For example, Grzywaez and Stasiak, (2018) noted that adjustments in substrate composition and controlled environmental

parameters can lead to improved nutrient profiles in cultivated mushrooms. The high average B2 content in the home-grown samples supports this finding. Conversely, wild mushrooms tend to show stable yet lower micronutrient levels due to the natural equilibrium in their habitats (Sánchez, 2010). In the case of vitamin B2, the wild mushrooms' low variability reflects a consistent ecological baseline, though they may not reach the nutrient levels achieved through optimization in cultivated settings. Riboflavin is essential for energy metabolism and antioxidant protection. The substantial increase in vitamin B2 in home-grown mushrooms, if consistently replicated, imply that optimized cultivation contribute to enhanced dietary intake of this vitamin an important consideration for enhancing local food quality and nutritional security (FAO, 2024).

To sum up, the ANOVA results for vitamin B2 reveal a statistically significant difference between wild and home-grown mushrooms ($F = 8.51466$, $p = 0.011987$). Home-grown mushrooms exhibit substantially higher average vitamin B2 content despite high variability, likely reflecting the effects of controlled cultivation conditions.

4.2.3.5 Flavonoids

Table 4. 6 Output of One-way ANOVA for flavonoids from EXCEL

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Wild mushrooms	9	16,88	1,87556	0,87675		
home grown mushrooms	6	10,55	1,75833	0,6873		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0,04947	1	0,04947	0,06154	0,80796	4,66719
Within Groups	10,4505	13	0,80389			
Total	10,5	14				

The p-value of 0.80796 is much higher than the conventional significance level of 0.05, and the F-value (0.061536) is well below the F-critical value (4.667193). Hence, we **fail to reject the null hypothesis**. This indicates that the difference in flavonoid content between wild mushrooms (mean ≈ 1.88) and home-grown mushrooms (mean ≈ 1.76) is not statistically significant. The low between-group sum of squares (0.049468) compared with the relatively high within-group mean square (0.803885) shows that most of the variability in flavonoid content is due to differences within each group rather than differences between the two groups. This suggests that the production conditions or genetic variability within each group are a more critical factor in determining flavonoid content than whether the mushrooms are wild or cultivated.

Several studies have shown that while certain nutrients differ between wild and cultivated mushrooms, other bioactive compounds such as flavonoids can sometimes be quite stable

across different growing conditions. This result is consistent with previous findings that indicate the environmental factors affecting flavonoid biosynthesis are similar in both wild habitats and controlled cultivation environments, thereby leading to comparable average levels (Hoissain et al., 2020; Sánchez, 2010).

The ANOVA for flavonoid content reveals no statistically significant difference between wild and home-grown mushrooms ($F = 0.061536$, $p = 0.80796$). This suggests that regardless of whether mushrooms are harvested from the wild or is cultivated under controlled conditions; their average flavonoid levels remain comparable. From a policy perspective, this indicates that controlled mushroom cultivation is a reliable method for producing antioxidant-rich food, thereby supporting sustainable agricultural practices and local food systems without compromising the beneficial bioactive compounds.

4.2.3.6 Beta-carotene

Table 4. 7 Output of One-way ANOVA for Beta-carotene from EXCEL

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Wild mushrooms	9	216,57	24,0633	37,7528		
Home grown mushrooms	6	99,43	16,5717	133,868		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	202,05	1	202,05	2,70409	0,12404	4,66719
Within Groups	971,362	13	74,7202			
Total	1173,41	14				

Since the p-value (0.124043) is greater than the conventional significance level (0.05) and the calculated F-value (2.704093) is below the F critical value (4.667193), we **fail to reject the null hypothesis**. This result indicates that, based on the current data, the difference in

beta-carotene content between wild and home-grown mushrooms are not statistically significant. While the average beta-carotene content for wild mushrooms (24.06) is higher than that of home-grown mushrooms (16.57), the higher variability observed in the home-grown samples (variance = 133.87) compared to those from the wild (variance = 37.75) can mask potential differences. High within-group variability, especially in the home-grown group,is due to inconsistent cultivation practices or environmental fluctuations during growth.

Previous studies have shown that bioactive compounds like beta-carotene can be influenced by environmental stress and substrate diversity. Wild mushrooms, growing under naturally variable conditions, sometimes accumulate higher concentrations of certain pigments and antioxidants due to stress responses (Hamza et al., 2024). Although the wild mushrooms here show a higher average beta-carotene level, the statistical analysis indicates this difference is not significant, due to high variability among cultivated specimens (Sánchez, 2010). Beta-carotene is an important precursor to vitamin A and contributes to antioxidant defence. Even though the difference is not statistically significant in this analysis, the trend toward higher beta-carotene in wild mushrooms could be of nutritional interest.

All in all, the ANOVA for beta-carotene content shows that, although wild mushrooms exhibit a higher average beta-carotene level (24.06) compared to home-grown mushrooms (16.57), the difference is not statistically significant ($F = 2.704093$, $p = 0.124043$). The high variability within the home-grown group likely contributes to this lack of significance. These findings suggest that, under the current conditions, cultivation methods do not significantly alter beta-carotene levels compared to wild mushrooms. However, further research employing larger samples and enhanced standardization reveal actionable insights to optimize the nutraceutical quality of cultivated mushrooms.

4.2.3.7 Overall comparative analysis of micro-nutrients

The ANOVA was performed using Microsoft Excel Plus 2010 (version 14.0.4734.1000) for the micro-nutrients establishing statistical significance of the differences. Data for micro-nutrient composition and for mineral constituents were reported as the mean ± SD for three determinations per sample. The results were given as mean ± SD.

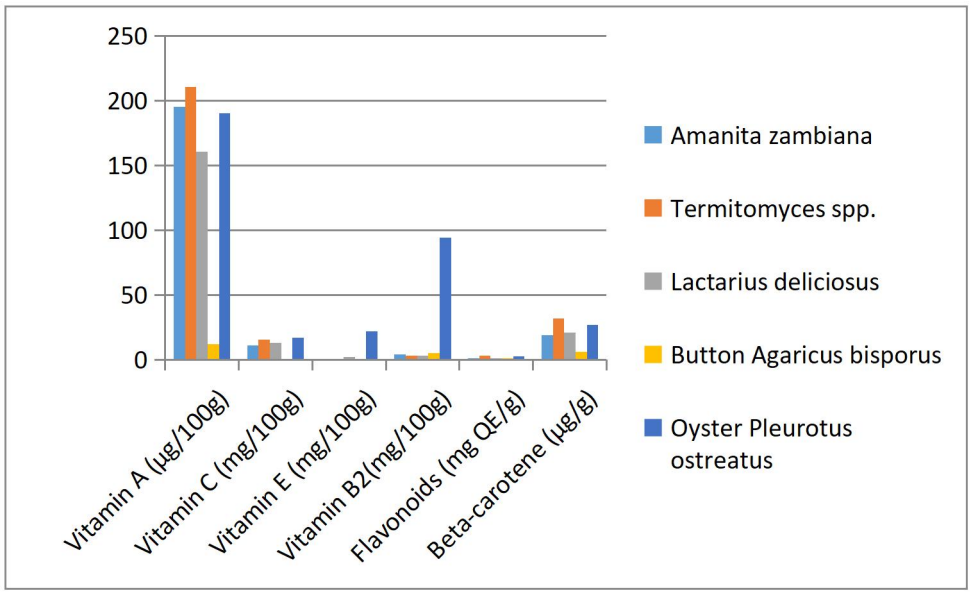

Figure 4. 2 Comparative schedule of micro-nutrients for sampled mushroom species

∗ Note: The units for flavonoids are expressed as mg of quercetin equivalents per gram, and all standard deviations indicate the reproducibility among triplicate samples.

4.2.3.7.1 Vitamin A

Wild species like Termito myces spp. and Amanita zambiana show high values (≈210.71 and 195.48 µg/100g, respectively), whereas Button Agaricus bisporus has a very low content (≈12.10 µg/100g). These differences suggest that certain wild mushrooms naturally accumulate more vitamin A, which can be critical for addressing deficiencies in local diets.

The associated standard deviations (≈11–17 µg/100g) indicate moderate consistency among replicates in most species.

4.2.3.7.2 Vitamin C

Ranging between 0 and 16.98 mg/100g, *Pleurotus ostreatus* and Termito myces spp. tend to have higher contents compared to *Agaricus bisporus* (which registered 0). High variability (standard deviations around 10 mg/100g) suggests natural fluctuations or sensitivity to environmental conditions during growth. The absence of vitamin C in Button mushrooms might be significant for nutritional planning.

4.2.3.7.3 Vitamin E

While most species (e.g., Amanita and Termito myces spp.) show low values (<1 mg/100g), Pleurotus ostreatus stands out dramatically with 22.02 mg/100g. This high vitamin E level in the Oyster mushroom underscores the potential of controlled cultivation to enhance specific micronutrients. The standard deviation for Oyster is also high (±10.34 mg/100g), suggesting some inconsistency that could benefit from optimized protocols.

4.2.3.7.4 Vitamin B2 (Riboflavin)

Most species exhibit modest levels (≈3–5 mg/100g), except Pleurotus ostreatus, which reports a very high value (≈94.02 mg/100g). The enormous value in Oyster mushrooms could be due to targeted nutrient supplementation or more efficient biosynthesis under controlled conditions. The relatively low variability in Oyster (±0.68 mg/100g) implies high reproducibility and reliability of this measurement.

4.2.3.7.4 Flavonoids

Average flavonoid contents are similar across species (≈1.07 to 3.11 mg QE/g), with Termito myces spp. having the highest average (≈3.11 mg QE/g). The comparable levels indicate that, despite differing environments, the antioxidant potential (in terms of flavonoid content) remains somewhat stable across species. Standard deviations are low (≈0.07–0.21), supporting the consistency of these measurements.

4.2.3.7.4 Beta-carotene

Values range from about 6.05 µg/g (Button) to 32.10 µg/g (Termito myces spp.).

Higher beta-carotene levels in wild species like Termito myces spp. may imply a greater capacity to serve as a natural precursor for vitamin A. The standard deviations vary; some species show relatively high dispersion (±10.68 µg/g), which might reflect environmental influences or intrinsic variability.

The micronutrient data with values expressed as means ± standard deviations demonstrates significant differences in nutrient content among mushroom species. These results not only highlight the nutritional potential of specific mushrooms for dietary enhancement but also underscore the value of precise, replicable measurements obtained from triplicate analyses. Optimizing cultivation protocols based on these findings can help sustainably boost the nutritional quality of mushrooms and inform targeted food security and agricultural policies.

4.2.4 The impact of environment that is wild versus home-grown (controlled) conditions on nutritional compositions in mushrooms

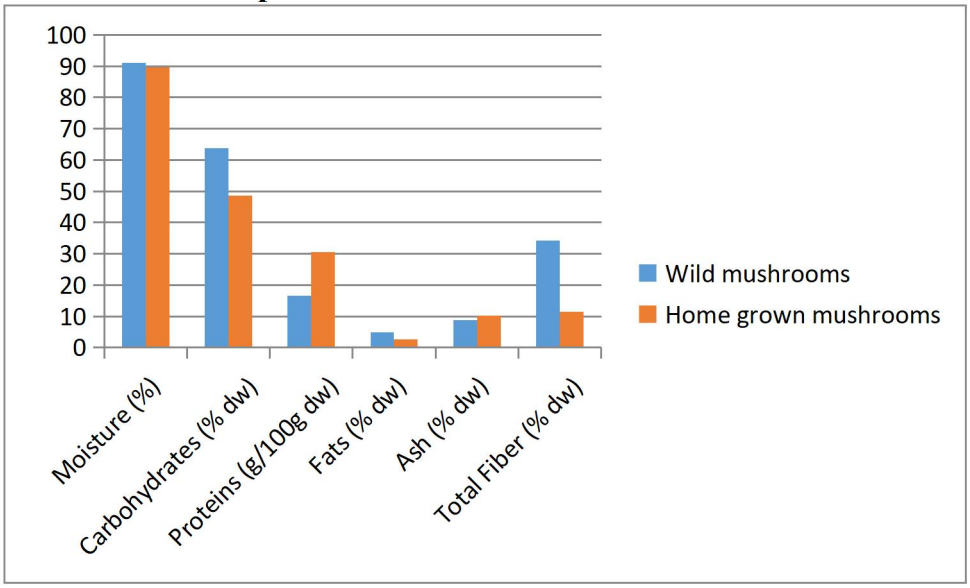

Figure 4. 3 Proximate analysis of wild and home-grown mushrooms

4.2.4.1 Moisture Content: Wild mushrooms show a slightly higher moisture content at 91.15% compared to 89.66% in home-grown mushrooms. This small difference reflect natural water retention in wild conditions versus the more controlled drying and storage of cultivated samples.

4.2.4.2 Carbohydrates: The carbohydrate content (expressed on a dry weight basis) is notably higher in wild mushrooms (63.76% dw) than in home-grown mushrooms (48.67% dw). Higher carbohydrate levels in wild mushrooms suggest that the varied, nutrient-rich natural substrates may promote greater polysaccharide accumulation.

4.2.4.3 Protein: A stark difference is observed in protein content, with home-grown mushrooms containing 30.65 g/100 g dw nearly double the 16.59 g/100 g dw found in wild mushrooms. This boost in protein content under controlled cultivation likely results from optimized substrate formulations and environmental conditions tailored to encourage amino acid and protein synthesis (Hamze et al.,2024).

4.2.4.4 Fats: Wild mushrooms contain 4.86% fat on a dry weight basis, while home-grown mushrooms have a lower fat content of 2.76% dw. This may indicate that wild growing

conditions trigger more lipid storage, possibly as an adaptive energy reserve under environmental stress.

4.2.4.5 Ash Content: The ash, representing total mineral content, is higher in home-grown mushrooms (10.36% dw) compared to wild mushrooms (8.77% dw). This suggests that home-grown mushrooms may benefit from mineral supplementation or more controlled nutrient availability in the substrate.

4.2.4.6 Total Dietary Fiber: Wild mushrooms have a remarkably high fiber content at 34.34% dw, whereas home-grown mushrooms show only 11.43% dw. Elevated fiber levels in wild specimens could be attributed to the natural development of structural components required for survival in competitive, variable environments (Sánchez, 2010).

The data clearly demonstrate that the growing environment substantively influences the nutritional composition of mushrooms.Wild mushrooms are characterized by higher carbohydrates and fiber, along with higher fat content. These attributes are reflections of a more variable nutrient supply and the development of adaptive structural features in response to environmental stresses. In contrast, the controlled environment of home- grown mushrooms results in markedly higher protein and slightly higher ash content. The enhanced protein concentration is indicative of optimized cultivation practices such as careful substrate management that favor amino acid accumulation and protein synthesis(Hamze et al.,2024).

The contrasting profiles mean that both wild and home-grown mushrooms offer unique nutritional benefits. For instance, if a dietary program is aimed at boosting protein intake, home-grown mushrooms would be the more suitable option. Conversely, wild mushrooms' high fiber and carbohydrate contents may be advantageous for consumers seeking greater dietary bulk and sustained energy release. This differentiation supports the concept of integrated nutritional strategies and sustainable food production models, where the selection of mushroom type can be aligned with specific dietary needs (FAO, 2024).

These quantitative comparisons satisfy the objective by demonstrating that environmental conditions (wild vs. controlled) significantly affect proximate composition. The data not only offer measurable differences across key nutritional parameters but also provide actionable insights for optimizing cultivation practices based on desired nutritional outcomes.

4.3 DISCUSSION

4.3.1 Proximate analysis of wild mushrooms versus home grown mushrooms

Overall, these findings largely align with the established literature. Wild mushrooms often show higher carbohydrate and total fiber contents compared to their cultivated counterparts (Kalač, 2010; Hamza et al.,2024). The protein content reported for wild species falls within the expected range, although the significantly higher protein levels in cultivated mushrooms underscore the impact of controlled growth conditions. The ash values support the view that mineral uptake is influenced both by the species and the cultivation substrate, with variations noted particularly in *Pleurotus ostreatus*. Discrepancies, such as the slightly lower protein content in Termitomyces spp relative to some earlier reports and the elevated ash in *Pleurotus ostreatus*, may be attributed to differences in geographical locations, substrate compositions, and specific analytical methodologies used across studies. These deviations stress the importance of standardized analytical methods to facilitate more consistent comparisons across different studies.

According to Kalač, (2010), wild mushrooms generally exhibit carbohydrate contents around 60–65% on a dry-weight basis, and our data for Lactarius deliciosus and Termitomyces spp. are in close agreement. Hamze et al.,2024 noted that wild mushrooms tend to have higher dietary fiber content, which is evident in the fiber values for Termitomyces spp. and *Lactarius deliciosus* compared to the cultivated varieties. The findings also illustrate the broader environmental benefits of mushroom cultivation. Wild mushrooms, with their robust fiber and carbohydrate makeup, are not only of nutritional importance but also of ecological interest because of their role in nutrient cycling and maintaining biodiversity in natural ecosystems (Sánchez, 2010). This ecological role makes them a natural ally in preserving forest health and ecosystem balance. Integrating these insights into agricultural policy could help balance productivity with ecological stewardship, ensuring that local food production systems are both sustainable and environmentally responsible (FAO, 2024).

4.3.2 Proximate composition

Previous studies such as Dias and de Brito, (2017) observed that cultivated mushrooms often have higher protein content due to optimized substrates, whereas wild mushrooms sometimes exhibit higher fiber and carbohydrate levels due to environmental stressors (Sánchez, 2010).

However, in the employed composite ANOVA, these individual differences may become diluted when aggregated into an overall proximate measure.

Limited sample sizes and high measurement variability can reduce the statistical power of an ANOVA test. This challenge is commonly noted in biological studies where natural variations are high, suggesting that a larger or more stratified sample might reveal significant differences that the current analysis could not detect (; Sánchez, 2010). Dias and de Brito, 2017)

While some studies point to stark differences between wild and cultivated mushrooms, the ANOVA executed with a widely available tool like Microsoft Excel Plus 2010 reveals a more complex picture, where variability within groups masks the differences between them.

4.3.3 Micro-nutrient concentration of wild mushrooms versus home-grown mushrooms

4.3.3.1 Vitamin A

The analysis revealed a statistically significant difference in vitamin A content, where wild mushrooms had an average of approximately 188.89 µg/100 g compared to 101.29 µg/100 g in home-grown mushrooms ($p \approx 0.021$). This suggests that the natural conditions encountered in the wild such as diverse substrate composition, more direct exposure to sunlight, and varying microclimates may stimulate biosynthetic pathways that enhance the accumulation of vitamin A or its precursors. In contrast, the controlled environment of home-grown mushrooms, despite offering stability, may not activate the same level of natural metabolic stressors that lead to higher vitamin A levels. It is also notable that the home-grown group showed high variability, which could be due to variations in substrate quality or subtle differences in controlled conditions.

4.3.3.2 Vitamin C

Although wild mushrooms exhibited a higher average vitamin C concentration (13.31 mg/100 g) relative to home-grown ones (8.49 mg/100 g), the difference was not statistically significant ($p \approx 0.151$). The high within-group variance for the home-grown samples—possibly related to subtle fluctuations in cultivation practices or postharvest handling—appears to have obscured any clear trend. This outcome suggests that while some natural environmental factors might lean toward an increased accumulation of ascorbic acid in wild species, the controlled conditions do not consistently enhance vitamin C production, leaving its levels more dependent on other, perhaps transient, factors.

4.3.3.3 Vitamin E

Differences in vitamin E were pronounced: home-grown mushrooms had a mean value of 11.07 mg/100 g compared to only 1.17 mg/100 g for wild varieties ($p \approx 0.026$). This significant elevation in cultivated mushrooms likely reflects the advantages of controlled practices. In optimized cultivation systems, substrate formulations and regulated exposure to light and temperature can boost the biosynthesis of vitamin E—a potent antioxidant. Despite the high variance within the home-grown group (which might stem from minor differences in environmental controls from batch to batch), the overall trend is clear: controlled conditions favor vitamin E accumulation.

4.3.3.4 Vitamin B2

The study found an even more striking difference for vitamin B2. Home-grown mushrooms averaged approximately 49.61 mg/100 g versus only about 3.22 mg/100 g in wild mushrooms, with a statistically significant result ($p \approx 0.012$). Controlled conditions in mushroom farming—by standardizing factors like substrate nutrient composition and microclimate—appear to drive the pathways responsible for riboflavin production. Although the cultivated samples showed high within-group variability, the overall enhancement in vitamin B2 indicates that targeted nutrient supplementation and environmental stability can markedly boost this micronutrient.

4.3.3.5 Flavonoids

When comparing flavonoid content, the results were very similar between the two groups (wild mushrooms averaged 1.88 mg QE/g versus 1.76 mg QE/g in home-grown). The ANOVA produced a p-value of approximately 0.808, well above the significance threshold. This suggests that, irrespective of the growing environment, the biosynthetic mechanisms for flavonoid production in mushrooms are relatively robust. In other words, the natural genetic programming that controls the synthesis of these antioxidant compounds might be less sensitive to variations in external conditions or, alternatively, both wild and cultivated environments provide the necessary cues for flavonoid synthesis in a similar fashion.

4.3.3.6 Beta-carotene

For beta-carotene, wild mushrooms showed a trend toward higher average levels (24.06 µg/g) compared to home-grown mushrooms (16.57 µg/g), but this difference did not reach statistical significance ($p \approx 0.124$). The elevated variability in the home-grown samples—evidenced by a greater variance compared to the wild group—hints that beta-carotene

accumulation in cultivated mushrooms might be more susceptible to inconsistent factors (such as fluctuating light exposure or slight differences in substrate constituents). This variability can mask true differences and suggests that further standardization in cultivation practices might be needed to reliably enhance beta- carotene accumulation.

4.3.3.7 Overall comparative analysis of micro-nutrients

4.3.4 The impact of environment that is wild versus home-grown (controlled) conditions on nutritional compositions in mushrooms

Mushrooms have a unique ability to convert organic waste into valuable biomass. The controlled cultivation of home-grown mushrooms often utilizes agricultural residues or spent grains as substrates. This process not only diverts waste from landfills but also recycles nutrients back into the food system (Dias and de Brito, 2017). In this way, mushroom cultivation can be integrated into circular economy models, where waste streams become inputs for food production, thereby reducing the need for synthetic fertilizers and lowering the environmental footprint of agriculture (Smith et al., 2018). The study goes beyond isolated micronutrient measurements by comparing the overall influence of growth conditions on the nutritional profile. Below are the key environmental impacts.

Wild mushrooms are exposed to a diverse and dynamic range of nutrients present in forest soils, decaying organic matter, and unregulated microclimates. These conditions lead to a higher accumulation of storage carbohydrates and dietary fiber as demonstrated by higher carbohydrate and fiber levels. Natural environmental stressors may trigger adaptive responses, such as the synthesis of vitamin A precursors, contributing to the higher vitamin A content observed. The consistent, albeit lower, production of flavonoids suggests that wild fungi maintain baseline antioxidant protection despite environmental fluctuations.

Controlled cultivation allows for the fine-tuning of environmental factors such as temperature, humidity, light exposure, and nutrient supplementation. These optimized conditions have led to significantly higher protein levels and markedly enhanced levels of vitamins E and B2. This indicates that home- grown mushrooms can be tailored to yield higher concentrations of certain nutrients by providing conditions that favor metabolic processes like protein synthesis and coenzyme production. The slightly higher ash content in home- grown mushrooms suggests that controlled environments are better at providing and regulating mineral nutrients, possibly due to deliberate substrate supplementation.

Additionally, by thriving on organic waste, mushrooms enhance soil health when their spent substrates are returned to the fields, bolstering the nutrient cycling process. Such recycling is foundational to regenerative agriculture practices that aim to restore ecosystem balance and improve long-term soil fertility (FAO, 2024).

The ability of wild mushrooms to accumulate higher vitamin A levels has implications for local food systems. If wild types provide enhanced micronutrient content, then sustainable harvesting and conservation of these populations could be important for regions facing micronutrient deficiencies. On the other hand, optimizing cultivation practices to mimic or improve upon the natural conditions could help home-grown mushrooms achieve similar nutritional quality, aligning with sustainable agricultural policies that aim to increase local nutrient-dense food production.

In summary, adapting cultivation methods to maximize the desirable nutritional traits of mushrooms can significantly contribute to sustainable agricultural practices. By leveraging the inherent qualities of both wild and home-grown mushrooms, policy makers can design integrated food systems that improve local nutrition, reduce waste, empower communities, and promote environmental sustainability (Dias and de Brito, 2017)

4.4 SUMMARY

This chapter presented, analysed and discussed the data collected from the wet, cleaned mushrooms just after picking and the dried and crushed sample that were analysed in the laboratory. The descriptive statistics (mean and standard deviation) and inferential statistics (one-way ANOVA) were employed as statistical techniques with the help of the use of Microsoft Excel software to analyse the data. As a result of the analysis, the study found a comparative steady nutrient composition between both mushrooms with a possibility of it being influenced by outside factors such as sunlight exposure, substrate compositions and cultivation practices.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This study was motivated by the desire to search for an organic answer to poor relish diversity through mushroom. This study created an opportunity for the researcher to investigate the proximate and micro-nutrient composition of mushroom. In this chapter the researcher will postulate summary of findings from chapter 4 and hence stress out recommendations, implications for policy making and point out research gaps which can be taken in future. The chapter concludes with the researcher's views and thoughts regarding the findings of the current study.

5.2 RESEARCH SUMMARY

This study was undertaken to compare the nutritional compositions of wild versus home-grown mushrooms, emphasizing both proximate parameters (such as moisture, carbohydrate, protein, fat, ash, and fiber content) and micronutrient profiles (including vitamins A, C, E, B2, β-carotene, and flavonoids). Against the backdrop of food security and sustainable agriculture, the research aims to assess whether differences in natural and controlled cultivation environments result in measurable changes in the nutrient profiles of mushrooms. By doing so, the study seeks to inform strategies that could improve nutritional outcomes and enhance sustainable food production among local communities.

The research employed a quasi-experimental design to compare wild and home-grown mushrooms. Wild mushrooms were collected from specific farms in natural settings (in Zimbabwe's highveld regions) while home-grown specimens were sourced from local mushroom farmers and retailers. Samples underwent standard analytical procedures to quantify moisture, protein, fat, ash, carbohydrate, and fiber contents. Methods such as oven drying, the Kjeldahl method, and Soxhlet extraction were employed. High-Performance Liquid Chromatography (HPLC) was used to determine levels of vitamins (A, C, E, B2) along with β-carotene and flavonoids. Titration techniques supported the analysis of vitamin

C. Triplicate measurements and one-way ANOVA tests (conducted using Microsoft Excel) were applied to assess the significance of differences between the two groups.

Samples were harvested using sterilized tools at peak maturity to ensure optimal nutritional representation. Wild mushrooms were collected from forested farm locations with known coordinates, while cultivated mushrooms were gathered from urban and peri-urban farms. Careful labeling and proper storage methods (including refrigeration and controlled drying) were ensured to maintain sample integrity. Post-collection, samples were sun dried, ground into a fine powder, and prepared using solvent extractions for the micronutrient assays. Standardized protocols were strictly followed to minimize measurement errors and ensure reliable repeatability. The proximate and micronutrient data were statistically analyzed using Microsoft Excel. Descriptive statistics (mean, standard deviation) were calculated, and one-way ANOVA tests were employed to identify significant differences between wild and home-grown mushrooms. The analysis examined both overall proximate composition and individual micronutrient variations.

The composite measurements did not indicate a statistically significant difference between the two groups overall, largely due to high within-group variability. Displayed higher carbohydrate and fiber contents. The elevated fiber levels may relate to their adaptation to variable, nutrient-rich natural substrates. Consistently showed significantly higher protein content attributed to the optimized substrates and controlled cultivation conditions that favor amino acid synthesis. Small differences in fat and ash content were observed, with wild mushrooms revealing a slightly higher fat content while home-grown ones had marginally increased ash (mineral) levels.

Wild mushrooms had significantly higher vitamin A levels compared to home-grown ones, suggesting that natural conditions (including exposure to sunlight and diverse substrates) boost the biosynthesis or accumulation of vitamin A precursors. Although wild specimens recorded higher average vitamin C content than cultivated ones, the difference was not statistically significant due to high variability in the home-grown group. Home-grown mushrooms exhibited markedly higher vitamin E content. The controlled environment appears to enhance antioxidant synthesis, likely through regulated light exposure and substrate optimization. A dramatic increase was noted in home-grown mushrooms, which showed significantly higher vitamin B2 levels. This finding underscores the potential of controlled, nutrient-rich environments to boost this vitamin. Flavonoid levels were very

similar between wild and home- grown groups, indicating that these compounds are produced at relatively consistent levels regardless of the environment. Although wild mushrooms trended towards higher β- carotene levels, the difference did not reach statistical significance, likely due to variability within the cultivated samples.

It was also noted that wild environment favors the accumulation of structural components such as carbohydrates and fibers, along with higher vitamin A levels, likely due to the variability and natural stresses present in their habitats. Controlled cultivation (Home-grown) supports higher protein synthesis and enhanced levels of certain micronutrients (notably vitamins E and B2) due to consistent environmental parameters and optimized substrate management.

Based on the findings, several recommendations are being proposed to enhance mushroom cultivation strategies and inform local food security policies. These recommendations include increasing funding and support for controlled trials aimed at optimizing substrate composition and cultivation parameters, conducting larger multi-location studies to reduce variability, and developing standardized protocols for consistent micronutrient production. Encouraging the use of organic waste as substrates is promoting both the nutritional quality of mushrooms and the recycling of agricultural by-products. Providing incentives and technical training helps local farmers adopt these practices, while supporting initiatives to protect wild mushroom habitats promotes controlled cultivation. Formulating integrated strategies that combine wild harvesting with home-grown production is enhancing dietary diversity and nutritional security, and developing policies that grant micro-enterprises and local communities access to low-cost cultivation technologies strengthens local food systems and addresses regional nutrient deficiencies.

This comprehensive summary unifies the introductory rationale, methodological rigor, detailed data analysis, and targeted findings with strategic recommendations to enhance both mushroom-based nutrition and sustainable agricultural practices. Furthermore both oyster and button mushroom are an excellent source of protein providing 88 g/100g dw and ± 0.68 g/100g dw of protein respectively.

5.3 CONCLUSION

5.3.1 Proximate analysis

Although the overall proximate composition does not yield statistically significant differences between wild and home-grown mushrooms, the detailed analysis shows meaningful distinctions. Wild mushrooms tend to be richer in carbohydrates and fiber, whereas home-grown mushrooms offer higher protein content. These distinctions point toward the complementary nutritional strengths of each growing method.

The enhanced protein content in home-grown mushrooms demonstrates that controlled cultivation practices can be optimized to boost specific nutritional traits. This is particularly valuable for developing nutrient-dense foods in local food systems and for addressing protein deficiencies in diets. Maintaining wild mushroom populations remains important because their higher fiber and carbohydrate levels contribute to a balanced nutritional profile and offer health benefits such as improved digestive health and sustained energy release. Integrating both wild and cultivated mushrooms into food security initiatives could leverage the complementary advantages of each.

In conclusion, the proximate analysis of selected wild and home- grown mushrooms reveals that while overall proximate composition differences are not statistically significant, specific nutritional components vary in meaningful ways. Home- grown mushrooms exhibit significantly higher protein content, likely due to optimized cultivation conditions, whereas wild mushrooms offer greater carbohydrate and fibre content. These findings highlight the potential for tailored agricultural practices to maximize desired nutritional traits and support the integration of both wild and cultivated mushrooms into sustainable, local food systems. Further research with standardized protocols is recommended to refine our understanding of these variations and to guide future nutritional and agricultural policies.

5.3.2 Micro-nutrients (vitamins, B-carotene and flavonoids) concentration of wild mushrooms versus home-grown mushrooms

The most notable outcomes from the study indicate that certain micronutrients specifically vitamin E and vitamin B2 are significantly enhanced under controlled (home- grown) cultivation conditions. This suggests that technical refinements (e.g., in substrate formulation and environmental control) can be exploited to produce mushrooms with superior micronutrient profiles.

The findings provide essential insights for sustainable agricultural practices. Controlled cultivation can be optimized to consistently produce mushrooms with enhanced levels of vitamins E and B2 nutrients crucial for antioxidant defence and energy metabolism. In parallel, maintaining the biodiversity of wild mushrooms remains important for ensuring a stable supply of naturally grown varieties that possess a nutritionally balanced profile. These results support the integration of optimized mushroom farming into local food security and public health programs by ensuring the production of nutrient-rich, sustainable and environmentally friendly food sources.

In summary, the analysis of micronutrient concentrations including vitamins, β- carotene, and flavonoids demonstrates that while certain micronutrients (vitamin E and vitamin B2) are significantly enhanced in home- grown mushrooms through controlled cultivation, others (vitamin C, β- carotene, and flavonoids) do not differ significantly from wild mushrooms. These results highlight the potential of optimized cultivation methods to improve nutritional quality while reinforcing the importance of preserving wild varieties for their consistent bioactive properties. Together, these insights form a solid basis for developing sustainable agricultural policies and targeted nutritional interventions.

5.3.3 The impact of environment that is wild versus home-grown (controlled) conditions on nutritional compositions in mushrooms

The data made it possible to relate specific environmental conditions to differential nutrient accumulation. For example, stable and controlled conditions in home- grown settings may reduce stress, thereby enabling enhanced protein synthesis and higher concentrations of certain micronutrients like vitamin E and B2. In contrast, the naturally fluctuating conditions in wild environments can trigger stress responses that lead to increased fiber and carbohydrate accumulation. These observations help clarify how the physical and biological conditions of the growing environment affect metabolic pathways and ultimately the nutritional profile.

By relating the data back to the objective, we see that the findings are not merely descriptive; they provide insight into how environmental manipulation a shift between wild and controlled cultivation can be strategically used to optimize mushroom nutrient profiles for specific dietary needs. For instance, if the goal is to produce mushrooms with higher protein and vitamin contents, the data suggest that controlled cultivation is preferable. Conversely, if a diet requires higher fiber and carbohydrate content, wild-harvested mushrooms might be

more beneficial. This clear linkage helps in developing targeted strategies for sustainable agriculture and local food security.

In summary, the data relate to the objective by offering detailed, statistically analyzed measurements that illustrate how different environmental conditions affect the nutritional composition of mushrooms. This relationship helps in understanding and optimizing cultivation practices to achieve desired nutritional outcomes while acknowledging the roles of natural environmental stressors in shaping nutrient profiles.

5.4 POLICY IMPLICATION AND RECOMMENDATIONS

5.4.1 RECOMMENDATIONS

5.4.1.1 Support Research and Development

Encourage public and private research initiatives focused on identifying and replicating the specific environmental factors that lead to higher micro-nutrient levels and optimal nutrient profiles in wild mushrooms. Funding for controlled trials and field studies can assist in fine-tuning substrate composition, light exposure, and microclimate conditions to improve the nutritional profile of home-grown mushrooms (Teke et al., 2021; Sánchez, 2010). Given the high within-group variability observed in part due to limited sample sizes policies should support larger, multi-location studies. This could enhance the statistical power of future analyses and guide more nuanced recommendations for cultivation practices.

5.4.1.2 Develop and Promote Sustainable Cultivation Practices

Formulate incentives such as tax credits or grants for farmers and small enterprises that integrate organic waste recycling into mushroom production. Mushrooms can efficiently convert agricultural by-products into high-value nutritional food, reducing waste and closing nutrient cycles (Smith et al., 2018). Develop guidelines and best practices for mushroom cultivation that aim to harmonize techniques across the industry. This strategy would help reduce variability, ensuring that home-grown mushrooms meet or exceed the micronutrient benchmarks found in wild populations. Extension services and training programs should be part of this initiative.

5.4.1.3 Strengthen Local Food Systems and Community Empowerment

Implement policies that facilitate access to low-cost technology and technical training for local mushroom farming. Given their low input requirements and high nutritional yields, mushroom cultivation can be a viable micro-enterprise that boosts local economies, particularly in resource-limited settings (Thakur 2020). Integrate mushroom production into broader food security programs at local and national levels. Wild mushrooms' high micronutrient suggests that sustainable harvesting of these natural resources alongside improved home-grown varieties can diversify the local food basket and enhance dietary diversity. Given that both wild and home-grown mushrooms deliver similar levels of flavonoids and vitamin B2(antioxidant properties), initiatives can promote mushroom farming as a feasible, nutrient-dense food production method. Integrating these practices into local food systems can help diversify diets and provide consistent sources of antioxidants, which are essential for public health.

5.4.1.2 Conservation and Sustainable Harvesting of Wild Mushrooms

Develop and enforce policies that protect wild mushroom habitats. Given their higher vitamin A content and unique nutritional profiles, wild mushrooms should be conserved to maintain biodiversity and serve as nutritional resources. Sustainable harvesting practices, along with educational programs on the importance of these fungi, are key (Sánchez, 2010). Establish monitoring systems to track and manage the wild mushroom populations effectively. This approach ensures that wild harvesting remains sustainable, preventing over-exploitation and preserving environmental integrity.

5.4.2 IMPLICATIONS FOR POLICY MAKING

The distinct nutritional characteristics of wild and home-grown mushrooms underscore the potential for integrating mushroom cultivation into local and sustainable food systems:

5.4.2.1 Nutrient-Rich Local Production: Policies could support small-scale and urban mushroom farming initiatives that enhance local food security by providing an affordable, high-protein food source.

5.4.2.2 Waste Management and Environmental Benefits: Encouraging the use of organic waste as a substrate for mushroom cultivation promotes a win-win scenario: reducing waste, supporting sustainable agriculture, and decreasing the reliance on chemical inputs.

5.4.2.3 Economic and Social Empowerment: Given their low capital requirement and efficient use of resources, mushrooms can spur micro-enterprises within local communities. Subsidies, technical assistance, and research grants could be directed toward optimizing substrate composition and cultivation practices, thereby fostering resilient, community-based food systems that align with sustainable development goals.

5.4.2.4 Nutrient Security and Public Health: The significant differences in vitamin A content, combined with the overall nutritional consistency between wild and home-grown mushrooms, indicate that promoting mushroom cultivation can positively impact public health, especially in regions facing micronutrient deficiencies. Policy initiatives could incorporate strategic food supplementation programs that leverage these nutritional resources.

5.4.2.5 Environmental Sustainability: Encouraging the use of organic waste for mushroom cultivation and integrating mushrooms into local food systems align with broader environmental policies aimed at reducing agricultural waste, lowering greenhouse gas emissions, and enhancing soil fertility through nutrient recycling.

5.4.2.5 Economic Development: By bolstering local food production through diversified mushroom farming practices, policies can stimulate rural and urban economic development. Support measures including access to low-cost inputs and technical assistance enable communities to create sustainable livelihoods while contributing to food security.

5.4.2.6 Integrated Policy Framework: These recommendations underscore the need for an integrated policy framework that bridges agricultural research, environmental conservation, and economic development. The framework should facilitate collaboration between government agencies, research institutions, and local communities to optimize mushroom cultivation practices and ensure environmental sustainability.

5.5 AREAS FOR FURTHER RESEARCH

Based on the current findings comparing micronutrient concentrations in wild versus home-grown mushrooms, several areas warrant further investigation:

5.5.1 Increasing Sample Size and Diversity

Future studies should include a larger number of samples and more diverse collection sites. A more extensive dataset can reduce the influence of outliers and provide a clearer picture of inherent nutrient variability. Examining how micronutrient levels fluctuate across different seasons in both wild and cultivated mushrooms would help identify optimal harvesting periods.

5.5.2 Standardizing Cultivation Conditions

Research should focus on systematically varying cultivation parameters such as substrate formulation, light exposure, humidity, and temperature to determine which factors most strongly influence nutrient accumulation. Controlled experiments can minimize within-group variability, especially for nutrients like vitamin E and B2 that showed promising enhancements under controlled conditions. Given the potential of organic waste to serve as a cost-effective substrate, further studies should evaluate how different types of organic waste influence the profile of micronutrients.

5.5.3 Mechanistic Studies

Investigating the underlying biochemical and genetic mechanisms that control micronutrient biosynthesis in mushrooms can provide insights into why certain nutrients (e.g., vitamin E and B2) are enhanced in home-grown varieties. Such studies might involve gene expression analyses under varying environmental stresses or substrate conditions. Since environmental factors (e.g., sunlight and nutrient availability) appear to influence the accumulation of bioactive compounds like beta- carotene and vitamin C, research into the stress-response pathways in mushrooms could elucidate how wild conditions drive these nutrient levels.

5.5.4 Longitudinal and Post-Harvest Studies

Long-term studies tracking micronutrient stability over multiple crop cycles or growth phases could help determine whether observed differences persist over time or are transient phenomena. Additional research on the effects of processing, storage, and preservation methods on micronutrient retention can assist in developing best practices that ensure maximum nutritional value reaches consumers.

5.5.5 Expansion of Nutrient Profile Analysis:

While this study focused on vitamins, β- carotene, and flavonoids, further research could include a broader spectrum of micronutrients (e.g., minerals, other antioxidant compounds) to develop a more comprehensive nutritional profile. Including more edible mushroom species can help determine if the observed nutrient trends are specific to the species studied or are common across a wider range of fungi.

5.5.6 Antioxidant Capacity and Mechanistic Studies

The researcher noted presence of bioactive compounds and antioxidant properties of mushrooms and exploring these is a promising avenue that could pave the way for developing natural, organic nutritional supplements and potential adjuncts in cancer prevention and therapy. Mushrooms produce a wide array of secondary metabolites including flavonoids, and Beta-carotene that contribute to their antioxidant and anticancer properties. Advanced analytical techniques such as high-performance liquid chromatography (HPLC), mass spectrometry (MS), and nuclear magnetic resonance (NMR) should be employed to comprehensively identify and quantify the various bioactive compounds in both wild and cultivated mushrooms (Sharma et al.,2021). Establishing standardized methods for extracting these compounds is essential to ensure consistency and reproducibility. This standardization is critical when developing organic nutritional supplements, ensuring that each batch contains the intended potent mix of bioactives (Saglam and Ozgunler,2022).

Research should utilize in vitro assays like DPPH, ABTS, and FRAP to measure the antioxidant capacity of mushroom extracts. These assays will provide quantitative data on the ability of these extracts to scavenge free radicals, a key indicator of their potential therapeutic effects (Sánchez, 2010). Detailed mechanistic studies on cancer cell lines can help elucidate how specific e such as flavonoids and β- glucans regulate cell signaling pathways, induce apoptosis, or inhibit tumor proliferation. Such studies could involve gene expression analyses to determine the impact of mushroom extracts on pathways associated with carcinogenesis.

Future studies might also explore the synergistic effects of combining multiple bioactive compounds from mushrooms or even combining mushroom extracts with other natural antioxidants. Synergistic formulations could potentially offer enhanced benefits over individual compounds alone.

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Appendice 2:Request for laboratory analysis at University of Zimbabwe.

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BINDURA UNIVERSITY OF SCIENCE EDUCATION

16 April 2025

The Chairperson
Department of Nutrition Dietetics and Food Sciences
University of Zimbabwe
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Zimbabwe

Dear Sir/Madam,

RE: REQUEST FOR FUNCTIONAL ANALYSIS OF MUSHROOM SAMPLES FOR ARETAH ALICE MURISI (REG NO. B1233841)

I am writing to request your assistance in analysing mushroom samples for our student, Aretah Alice Murisi. The student is pursuing an MSc programme in Food Security and Sustainable Agricultural Production in the Department of Agricultural Economics, Education and Extension at Bindura University of Science Education. During her final year of study she is supposed to do a research project in her area of specialisation. She is undertaking a research project titled 'Comparative analysis of Mushroom Toxicity and Nutrient Composition in Home-Grown and Indigenous Mushrooms.' The project requires the student to do functional analysis of mushroom and she is in need of facilities for conducting functional analysis. Based on your institution's experience in Nutrition Dietetics and Food Science, I believe that your Department would be an excellent resource for Ms Murisi. Attached below is protocol that the student adopted.

Your assistance to Ms. Murisi with the functional analysis of mushroom samples would be greatly appreciated. The student has already collected the necessary samples and is prepared to proceed to the analysis phase.

Thank you for your consideration of this request. We look forward to hearing from you soon.

If you need any further information, please do not hesitate to contact me.

Yours Faithfully

Dr. L. Musemwa
Coordinator: MSc in Food Security and Sustainable Agriculture

Appendice 3: Formulas for nutrient concentration

Protein Content

Protein content was measured using the AOAC (2016) standard form. Approximately 1 gram of sample was placed in a digestion flask. About 200 mL of H2SO4 concentrate and 5 g of Kjedahl catalyst were added to the sample. Approximately 5 g of Kjedahl catalyst and a concentration of 200 mL H2SO4 were used to prepare a blank flask and no sample was added. The two flasks were tilted and gently heated until foaming ceased. The contents of the two flasks were brought to a boil before the solution became transparent. After the flasks had cooled, 60 mL of water was carefully added. The flask was rotated to thoroughly mix the contents before heating until all the NH3 had distilled off

Calculation:

$$\text{Protein (\%)} = \frac{(A - B) \times N \times 1.4007 \times 6.25}{W}$$

Where: A = Volume (ml) of 0.2N HCl used sample titration

B = Volume (ml) of 0.2N HCl used in blank titration

N = Normality of HCl

W = Weight (g) of sample

14.007 = atomic weight of nitrogen

Moisture Content

Moisture content was measured according to AOAC (2016). 5 g of the prepared sample was accurately weighed in a moisture tray previously dried in an oven at 105°C. The dish was placed in the oven maintained at 105°C for 4 hours. The dish was cooled in a desiccator and weighed. The process of heating, cooling and weighing was repeated until the difference between two consecutive samples was less than 1 mg. The moisture content was calculated from the mass loss.

Calculation:

$$\text{Moisture \% by weight} = \frac{100 \times (W1-W2)}{(W1-W)}$$

W1 = weight (g) of a dish with the material before drying.

W2 = weight (g) of a dish with the material after drying to constant weight.

W = weight (g) of empty dish

Total Ash content

The ash mineral content was determined by the AOAC (2016). The dried material remaining in the dish after moisture determination was ignited with the flame of a burner until it charred. The shell was transferred to a muffle furnace with a temperature of 550-600 °C and further ignited until gray ash was formed. The dish was cooled in a desiccator and weighed. The process of heating, cooling and weighing was repeated at half hour intervals until the weight difference in two consecutive weighings was less than 1 mg.

Calculation:

$$\text{Total ash on dry basis (\% by weight)} = \frac{(W2 - W) \times 100}{W1 - W}$$

W2 = Weight (g) of the dish with the ash

W = Weight (g) of empty dish

W1 = Weight (g) of the dish with the dried material taken for a test

Fat content

Fat content was determined using the Soxhlet extraction method (AOAC, 2016). Samples of 3 g were weighed into an extraction thimble and defatted with petroleum ether (40-60°C) for 1 hour. The petroleum ether extract was dried in an oven at 103°C for 30 minutes. Total fat content was determined by calculating the extract weight as a percentage of the original sample weight.

Calculation:

$$\text{Fat (\%)} = \frac{\text{Weight of fat} \times 100}{\text{Weight of sample}}$$

Carbohydrates content

The percentage of carbohydrate was calculated by subtraction, adding the weight in grams of the determined protein, fat, ash and moisture values in grams to the total weight of the sample (FAO, 2004).

Flavonoids

Flavonoids were tested using High-Performance Liquid Chromatography (HPLC).

Calculation: Absorbance X Dilution Factor X Volume of Extract /(Weight of sample X Standard Curve Slope).

Beta - carotene

High-Performance Liquid Chromatography (HPLC) was used to separate and quantify beta-carotene.

Calculation: (Absorbance X Dilution Factor X Volume of Extract) / (Weight of Sample X Extinction Coefficient)

Vitamin A (retinol)

High-Performance Liquid Chromatography (HPLC) was used to separate and quantify vitamin A.

Calculation: (Absorbance (at 325nm) X Dilution Factor X Volume of Extract) / (Weight of Sample X Extinction Coefficient).

Vitamin E (tocopherol)

High-Performance Liquid Chromatography (Absorbance at 292nm) (HPLC) was used to separate and quantify vitamin E .

Calculation: (Peak area X Concentration of Standard) / (Weight of sample X Peak Area of Sample).

Vitamin C (Ascorbic Acid)

Titration was used to calculate and separate Vitamin C.

Calculation: (Titre Value X Normality of Titrant X Volume of Extract)/ (Weight of Sample).