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BIOPROSPECTING OF INDIGENOUS SPECIES *BERCHEMIA DISCOLOR* AND ITS SOCIO-ECONOMIC PROSPECTS IN VHEMBE DISTRICT MUNICIPALITY

By

MUGARI DZIVHULUWANI

Student number: 14003786

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SUPERVISOR: DR. T.M NELWAMONDO

CO-SUPERVISOR: DR. M.J MOKGOEBO

DECLARATION

I, **Mugari Dzivhuluwani**, declare that this research entitled “Bioprospecting of indigenous species *Berchemia discolor* and its socio-economic prospects in Vhembe District Municipality” for the Master in Environmental Sciences in Geography at the University of Venda is entirely my work and has not been previously submitted at any other university and all reference materials contained therein have been duly acknowledged.

Signature Date

28 / 04 / 2021

DEDICATION

I would like to dedicate this dissertation to my mom and my entire family.

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- ✓ I would like to thank God for the gift of life and for the blessing of my achievements. I would also like to thank the following people:
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Abstract

Bioprospecting is the successive process of finding new product from nature by extracting, exploring and screening biological resources (Harvey and Gericke 2011). The historical or traditional motive of bioprospecting has been to discover new valuable resources to enhance human health, through medicine and better nutrition level. The study focused on establishing *Berchemia discolor* species potentials and its utilization benefits which can be further commercialized.

The aim of the study was to determine the commercialization potentials of *Berchemia discolor* species. The objectives of the study were: to establish the bioprospecting opportunities that can arise from the utilization of *Berchemia discolor* using indigenous knowledge system, to investigate the benefits that can be derived from bioprospecting *Berchemia discolor,* to determine the challenges of utilizing *Berchemia discolor* species and to develop feasible strategies for improving the commercialization potential of *B. discolor.*

Two study areas were selected (Tshipise and Malamulele) to collect data because they have presence of *B. discolor* species. The primary data were collected using semi-structured interviews and field observations. Secondary data were collected through peer scientific journals and bioprospecting reports. The samples from the population sample were selected using a snowball sampling method.

Data were analyzed using inductive content analysis and SPSS-IBM 25 analytical tool. SPSS-IBM 25 was used to create graphs and tables that represent analyzed data. The study found that *B. discolor* is a good provider of medicine, timber materials, sweet edible fruits, and other useful materials. These factors influenced people to use the species for many purposes and gain income through commercialization. Thus, *Berchemia discolor* was found beneficial and there is a need for its recognition in local and national market

Keywords: Bioprospecting, *Berchemia discolor*, commercialization, snowball sampling

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

LIST OF ACRONYMS

ABS - Access and Benefits Sharing

CBD - Convention on Biological Diversity

CSR - Corporate Social Responsibility

DAFF - Department of Agriculture, forestry and fisheries

DAFOR - Dominant, Abundant, Frequent, Occasional, Rare

DEA - Department of Environmental Affairs

DEAT - Department of Environmental Affairs and Tourism

DST - Department of Science and Technology

i.e. - That is

IBM - International Business Machines

IDP - Integrated Development Planning

IKS - Indigenous Knowledge System

IPR - Intellectual Property Rights

IUCN - International Union for Conservation of Nature

LC - Least of Concern

NEMBA - National Environmental Management: Biodiversity Act

NRF - National Research Foundation

SAASTA - South Africa Agency for Science and Technology Advancement

SANBI - South African National Biodiversity Institute

SPSS - Statistical package for the social sciences

TK - Traditional Knowledge

UNDP - United Nations Development Programme

UNESCO - United Nations Educational, Scientific and Cultural Organization

VDM - Vhembe District Municipality

WEP - Wild Edible Plants

WTO - World Trade Organization

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

The concept “bioprospecting” has been used widely in the recent past. Different scholars tried to define the concept from different perspectives. Pimbert and Pretty (2007) defined bioprospecting as the exploration, extraction and screening of biological diversity and indigenous knowledge for commercially valuable genetic and biochemical resources. It is the exploration of biological materials for the commercially valuable genetic and biochemical property. This ensures that bioprospecting is the process that allows bio-prospectors a high chance of commercializing valuable products by actualizing biodiversity resources.

The historical or traditional purpose of bioprospecting has been to discover new valuable resources to enhance human health, through medicine and better nutrition level (Archaya, 2013). Even though bioprospecting can take place everywhere where there is biodiversity, it tends to focus where the biodiversity is at its richest because it raises the possibilities of discovering something useful (DST, 2014). Yet not all species in any area can be linked to bioprospecting.

Bioprospecting usually depends on the abundance and occurrence of the bio-resource that can be a successful target for utilization in a specific area. In some instances, the area can have rich biodiversity whereas the bio-resources that have potential opportunity to be explored are under threat of environmental conditions or extinction, which hinder the chances for bioprospecting target species to be utilized.

UNDP (2015) postulates that bioprospecting generates revenue that can be linked to the conservation of biodiversity and the benefits of local communities. In other words, bioprospecting can play a vital role in the financial state of the communities that can increase the rate of biodiversity conservation. For example, people who have *B. discolor* plant species in their areas might conserve the species if it becomes the target for bioprospecting because they can accumulate bioprospecting financial benefits.

Enujiugha (2017) stated that even though bioprospecting activities provide benefits to the occupancy of biological resources in specific areas, exploration of resources without

stewardship or the national government recognition from the host country has become a challenge. He went further to emphasize that, in spite of its positive effects, most of the bioprospecting practices are degraded into biopiracy of biological resources and patenting of processes based on traditional knowledge from indigenous communities.

Berchemia discolor tree is an indigenous tree species that falls under family Rhamnaceae and it is commonly known as Brown ivory. In South Africa, this species has respective tribal names, in Tshivenda is called “Munie”, in Xitsonga is called “Nyiyi or nyiri”, in Sepedi is named “Mogokgomo”, in Setswana is Motsintsila, nmumu / umadlozane / umhlungulo in Isizulu and in Afrikaans is called “Bruinivoor” or Voelpruim. It is a deciduous tree, up to 20m tall with a pale green stem covered with brown lenticels (Hutchings *et al.,* 2006). According to Raimondo (2009), *Berchemia discolor* has been Red Listed as LC (Least Concern) tree species as evaluated against the five IUCN (International Union for Conservation of Nature) criteria. This tree species is widely distributed in Southern Africa.

Berchemia discolor has special features that make it a special tree in the sense that it is edible, drought-resistant, attracts birds during flowering seasons and it is also recommended by traditional practitioners as a medicine and a useful plant for different alignments. This tree species can be grown by propagation of seed, and it is a rapidly growing species, at a rate of 600-800 mm per year (Van Wyk, and Van Wyk, 2007).

Apart from Indonesia and Brazil, South Africa is the third country with the biological diversity in the world with the great extent of native species (DEA, 2012). This means that biological resources occupy a huge contribution in the daily lives of individuals by gratifying their material needs (Rampedi, 2010). South Africans have a success of indigenous knowledge about the use of indigenous biological resources for medicinal, nutritional and personal care purposes (Venter, 2012). For instance, indigenous knowledge is crucial in bioprospecting as it gives chances of finding a target resource for commercialization which provides high rate of biological utilization and contribute to the economic growth and development.

Fernandes and Adams (2016) mentioned that the Department of Environmental Affairs, South Africa (DEA) through National Environmental Management: Biodiversity Act

(NEMBA) 10 of 2004 developed the access and benefits sharing regulation for bioprospecting. These regulations control the utilization of indigenous biological resources associated with the traditional knowledge targeted for bioprospecting with the intention to commercialize the end-product through a permitting system (DEA, 2008). Nevertheless, Rafi (2004) argued that in some countries where bioprospecting takes place, indigenous people are affected by biopiracy. Thus, bio-prospectors are not giving back to the community after a successful utilization of the indigenous biological resources.

According to Rampedi, (2010), in many countries, native plant species and the products that originate from them through bioprospecting have been commercialized with great success. For example, Tequila is one of a unique alcoholic beverages and a symbol of Mexican culture. The beverage is made from native plant species known as Blue Ave *(Agave tequiliana)* which is a succulent plant species with radiantly spreading body, nearly 1.5m tall and short thick stem at maturity. Rampedi (2010) further indicated that bioprospecting creates an economic value of the biological resources in a specific area which is important for the status of the host country. This means that the occurrence of the biological resource in the country is of great significance because it can be exposed for bioprospecting and explored to make a great utilization symbol in the country.

Wynberg (2017) identified two phases of bioprospecting namely: discovery phase and commercialization phase. In the discovery phase, the researcher attempts to find out if indigenous biological resource has the potential in a commercial market to be further developed. Commercialization phase is the phase where the commercialization potential of the indigenous biological resource has already been established and its associated traditional knowledge. It is referred to research, development or application of indigenous biological resources where the nature and extent of any actual or potential commercial exploration is sufficiently established (DEA, 2008). Therefore, the study focused on the discovery phase of bioprospecting as it attempts to find *B. discolor* potential in the commercial market with the use of indigenous knowledge system.

Crouch *et al*. (2008) showed that in discovery phase, bioprospecting starts with the project proposal and the idea on establishments of bioresources to be utilized. The basic research must also be conducted to get the target species for bioprospecting. Moreover, after all necessary procedures have been followed, products are being developed through screening and biological resource utilization. Yet, the commercialization / industrialization phase is where trade and exchange of valuable products utilized from nature takes place. This is called bioprospecting process. Figure 1.1 below summarized the process of bioprospecting according to its phases (Crouch *et al.,* 2008).

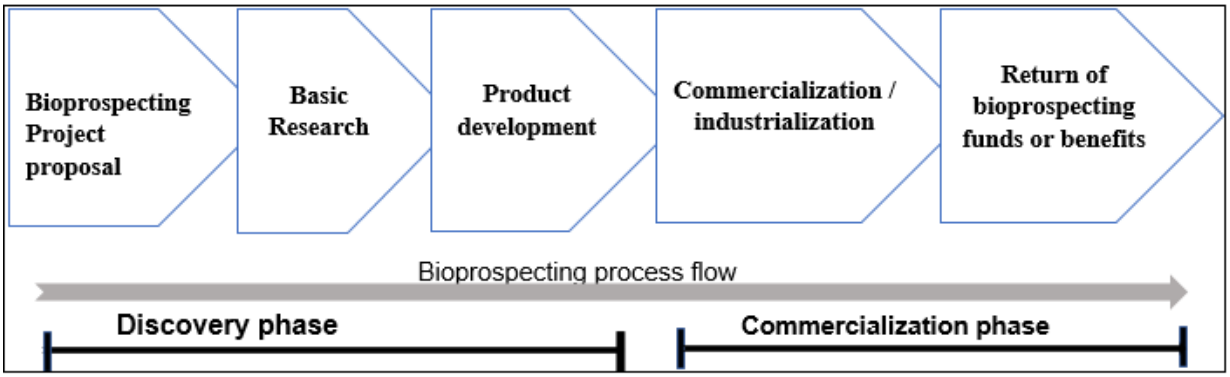

Figure 1.1 Bioprospecting process.

1.2 Problem statement

Berchemia discolor is one of the indigenous species that people utilize and produce products for local use. It is only through bioprospecting where biological resources such as *Berchemia discolor* can be extracted and explored for commercial purposes. In South Africa, bioprospecting is unevenly regulated activity wherein the different between "what is legal" and "what is right" is highly contested.

Geographically, *Berchemia discolor* is widely distributed and as such the prospect of bioprospecting the species are uneven and locationally diversified. Community members are already using their indigenous knowledge in the utilization of this valuable species. The incorporation of necessary biotechnology into indigenous knowledge system is a necessity yet not very compatible with value chain of indigenous practices.

1.3 Aim of the study

- ✓ The study aimed to determine the commercialization potentials of *Berchemia discolor* species.

1.4 Objectives

a) To establish the bioprospecting opportunities that can arise from the utilization of *Berchemia discolor* using indigenous knowledge system.
b) To investigate the benefits that can be derived from bioprospecting *Berchemia discolor.*
c) To determine the challenges that could arise from the utilization of *Berchemia discolor* species.
d) To develop feasible strategies for improving the commercialization potential of *Berchemia discolor*.

1.5 Research questions

a) What are the bioprospecting opportunities that can arise from utilization of *Berchemia discolor* with the use of indigenous communities?
b) What kind of benefits can be derived from bioprospecting *Berchemia discolor*?
c) Which challenges do *Berchemia discolor* utilization have in the society?
d) What are feasible strategies for improving commercialization potentials of *Berchemia discolor*?

1.6 Justification of the study

Despite the abundance of Munie (*B. discolor*) around Vhembe District villages, there have been no studies that have attempted to investigate the bioprospecting of Brown ivory and its socio-economic prospects within Vhembe district. Knowledge about bioprospecting opportunities of *Berchemia discolor* species and its characteristics will be essential for establishing effective ways of utilizing it sustainably. Biodiversity provides an important basis for socio-economic growth and development that underpins the well-being of the society (Tobin, 2002).

Bioprospecting is the concept that has not been fully developed in the developing countries around the world. Most of the developing countries have rich biodiversity of

indigenous and endemic species that can be explored and extracted for commercialization. Hence, commercialization of biological resources through bioprospecting is not given full attention.

Indigenous communities have preserved and experienced indigenous knowledge from generations to generations and they maintained it for health and care purposes. Therefore, most of the biological resources have potentials to be commercialized with the driven experience from the indigenous communities' knowledge.

1.7 Delimitation of the study

The study was based on the exploration and documentation of *Berchemia discolor* species at Vhembe District Municipality (VDM) with the contribution of indigenous knowledge system (IKS) while considering the plant's potentials for commercial output. *Berchemia discolor* tree species is abundant at Vhembe District Municipality local areas and can be utilized for bioprospecting opportunities with the use of indigenous knowledge system. Based on the phases of bioprospecting, the study focused on the discovery phase where the resource was explored to get commercialization potentials of the plant species.

The study focused on investigating characteristics of *Berchemia discolor species.* The species is most prominent in Vhembe District Municipality. However, special attention is given to conservation status of the tree species based on South African National Biodiversity Institute (SANBI) and International Union of Conservation of Nature (IUCN) criteria.

The researcher also entailed the necessity of knowledge of indigenous people within rural communities around Vhembe District Municipality where *B. discolor* species is widely distributed. The study is guided by national legislation on access and benefit sharing to avoid unauthorized access of biological resources. Thus, biopiracy mitigation strategies were taken into consideration to allow patenting of the species.

1.8 Description of the study area

Vhembe District Municipality is a C Category Municipality located in the Northern part of the Limpopo Province (Vhembe IDP, 2015). It shares borders with Zimbabwe and

Botswana in the North-West and Mozambique in the South-East through the Kruger National Park, which are areas that were previously under Venda and Gazankulu Bantustan's administration. Moreover, these countries contain the distribution of *Berchemia discolor* species which is an important useful plant in all the places where it occurs. *Berchemia discolor* species occurs naturally and grows plentifully at woodlands, rocky areas, bushvelds, and streams along Limpopo areas (Palgrave, 2008).

The district is comprised of four Municipalities: Musina, Collins Chabane, Thulamela and Makhado. Additionally, the district covers the geographical area that is predominantly rural, and it is a legendary cultural hub and a catalyst for agricultural and tourism development. The study focused on two different study areas within Vhembe District Municipality, which included a Venda-speaking area (Tshipise), Tsonga-speaking area (Malamulele).

The selected areas were mainly of focus with the high abundance of *Berchemia discolor* species. According to Palgrave (2008), this species has a high abundance at the Niyani (which means place of *berchemias*) in Limpopo and other neighboring villages including the selected study areas.

1.8.1 Geology and climate of the area

A significant part of Vhembe district lies within Soutpansberg Mountains. However, it has high biogeographical attributes and varied topography and landscape. Kabanda and Palamuleni (2013) state that Vhembe has geological compositions whose broad terrain patterns are characterized by intrusive igneous, sedimentary and metamorphic rocks, especially Soutpansberg region. It is comprised of gneiss minerals. The minerals that are found are flake granite, ironstone, marble, fire clay, limestone, magnesium and barite mineralization (Mulugisi, 2015). According to Raimondo (2009), *Berchemia discolor* species usually grow in the sandy and loamy soil. This means that the soil type within an area determines the significance of *Berchemia discolor* distribution.

The estimated mean annual rainfall of the selected areas ranges from 300mm to 500mm per year (Vhembe IDP, 2015). The area experiences a sub-humid climate. These areas experiences summer rainfall, with the northern and eastern areas

experiencing hot and humid summers and the mountain areas experiencing misty conditions. Winters are mild and generally frost free.

1.8.2 Vegetation cover

Vhembe District Municipality has rich plant biodiversity that is comprised of different vegetation species. It has biomes namely: savannah, grassland and forest which include shrubs, dense trees such as *Dischrostachys, Annona Senegalensis, Diopsyros Mesipiliformis, Berchemia discolor* and many other indigenous species and grasses (Mucina and Rutherford, 2006).

The most dominant trees amongst all are Acacia. However, the name Acacia has been retained to Australian Wattle, while in Africa, the name Acacia has been replaced in most cases by *Vachellia* and in others by *Senegalia.* To add, the most dominant trees species amongst all were *Senegalia* and *Vechellia* tree species. These species were mostly used for wood and have strong thorns for their own protection. Alien species are also found in the study area and have occupied huge space of fertile land and displaced indigenous species in the area.

Berchemia discolor is still one of the least of concern species and it is not prone to overutilization. Moreover, due to the lack of natural predators or competitors, other invasive species establishes easily, multiply rapidly and out-compete indigenous vegetation causing ecological disruption.

Around Musina municipality, *Berchemia discolor* species is dominant in areas such as Tshipise (one of the study areas), Muswodi, Mukovha, Shakadza, Thahale, Thengwe, Muledzhi, Tshilamba, Tshikundamalema, and Makuya and they are common. However, at Collins Chabane area, this species is most common at areas such as Malamulele, Matiane, Nghom-nghom, Nkavele, Bevula, Madonsi (Ndou, 2017). This area has abundant distribution of *B. discolor* species even though not all areas within the mentioned municipality contains it. Nevertheless, Ndou (2017) further revealed that there are areas where the species is not densely populated such as Nzhelele areas, Thohoyandou and other neighboring villages.

1.8.3 Socio-economic characteristics

In terms of human characteristics, Vhembe district has different cultural population of about 1 393 949 million people (StatsSA, 2016). This district is predominantly rural in nature with approximately 97% of its population residing in rural areas (Vhembe IDP, 2015). There is also a lack of provision of adequate basic services and the clear majority of the population resides in the rural areas and do not have access to potable water (Mabogo, 2013).

In addition, the district economy has remarkably small production rate and large consumer population, whereas the means of income generation are limited. The level of employment is regarded poor with the literacy rate, which is relatively low and poor quality of education compounded by the dilapidated infrastructures in schools. Most of children under the age of 18 and adults above 60 years of age rely on social grants for financial stability. (Vhembe IDP, 2015).

1.8.4 Land-uses

Land use involves the classification of land according to what activities take place on it or how humans occupy it, for example, agricultural, industrial and terrestrial. The selected areas, Tshipise and Malamulele, occupy agriculture and livestock production as the most common land use. Agriculture and livestock production are the most effective enterprise within these areas. Bioprospecting can also be driven by the types of land use that takes place in an area. The areas also have dense forestry vegetation which contains big trees, shrubs and grasses and other species. The map below (figure 1.2) shows the two different locations of the chosen study areas in Vhembe District Municipality.

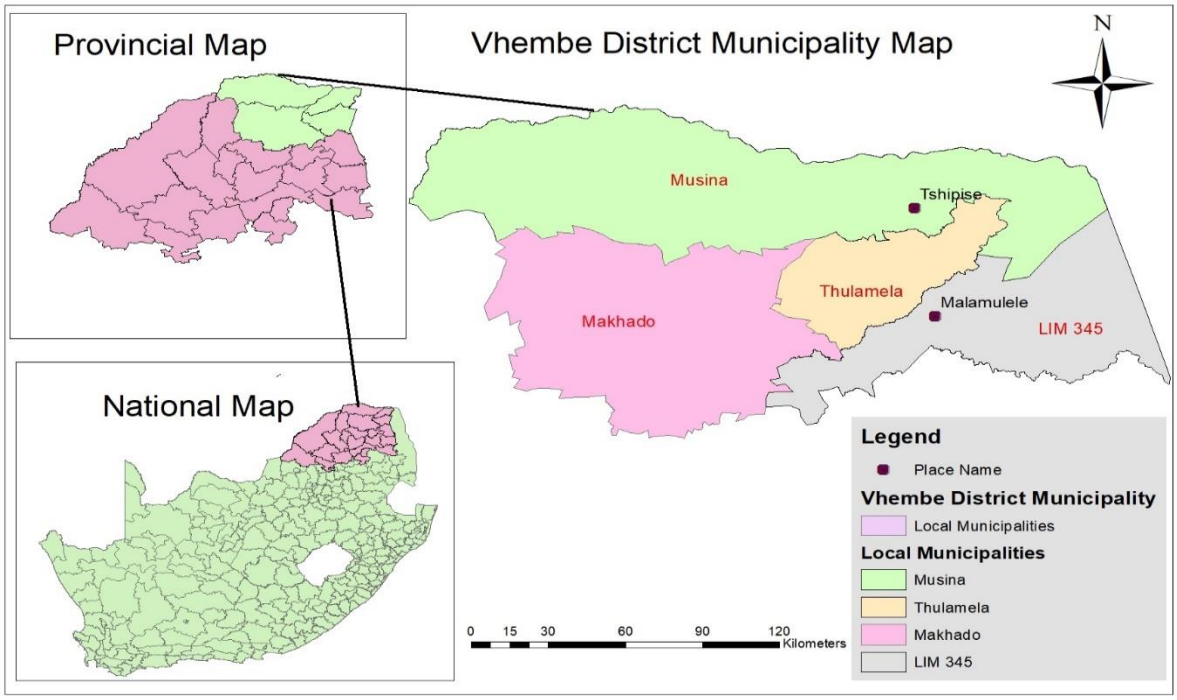

Figure 1.2 Map showing two study areas (Tshipise and Malamulele areas)

1.9 Description of key concepts

Bioprospecting - is the exploration, extraction and screening of biological diversity and indigenous knowledge for commercially valuable genetic and biochemical resources (Pimbert and Pretty, 2007: 24).

Biopiracy - Unlawful appropriation or commercial exploitation of biological materials, such as medicinal plants extract, usually without compensating indigenous people or country from which materials have been obtained (Robison, 2010: 164).

Berchemia discolor is a medium to large evergreen tree species, up to 20 meters tall (Raimondo, 2009: 7).

Commercialization is the process in which ideas, invention and knowledge are transformed into substantial wealth for business, individuals, or society at large (Australian Government, 2003).

Indigenous Knowledge System is a community-based system of knowledge that has been developed, preserved and maintained over generations by the local and indigenous communities through their continuous interactions, observations and experimentation with the surrounding environment (Pushpangadan and Nair, 2005: 10).

Endemic species are plants and animals that exist only in one geographic location (Brown and Gibson, 2015: 67).

Snowball sampling refers to a non- probability sampling technique in which a researcher begins with a small initial population of individuals and expands the sample by asking those initial participants to identify others that can participate in the study (Biernacki and Waldorf, 2007: 10).

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter aimed at reviewing related literature. The purpose of literature review is to lay the foundation or bases of the study on scholarly findings. This also enhanced the understanding on how the utilization and extraction of indigenous biological species benefit communities. The chapter started by historical background of bioprospecting and outlined perspectives and characteristics of bioprospecting and the related socio-economic prospects of *B. discolor*. The chapter also looks at how the available literature from other scholars propagates the opportunities of *B. discolor* extraction.

2.2 Historical background of bioprospecting

Bioprospecting is a systematic and organized search for useful product derived from bio-resources including plants, microorganism and animals. These products can be developed further for commercialization and overall benefits of the society (Harvey and Gericke, 2011).

According to Barrett and Lybbert (2006), bioprospecting is also explained as the proficient search for new marketable organisms, especially previously unstudied species. Thus, making bioresources commercially lucrative but at the same time inducing biodiversity conservation.

It is a process of biodiversity prospecting and a systematic search for biochemical and genetic information in nature to develop commercial valuable product for pharmaceutical, agricultural, cosmetic and other applications (Kharas *et al*., 2014). Bioprospecting, or the endeavor to discover active natural compounds and genetic material for pharmaceutical, agricultural, and industrial use, calls for multiple stakeholders such as drug companies, scientists, ethnobotanists, and producing-country governments and constitutions (Nwabueze, 2003).

This concept has multiple goals which include the conservation of biodiversity, the sustainable management of natural resources and economic development. Bioprospecting requires expertise from different disciplines, bringing together

government, academia, the business sector, indigenous people and cooperation (Lanjouw *et al*., 2015). Bioprospecting is the prototype of a cross-cultural, multi-national ethical controversy, and so far, it is a subject area of corporate social responsibility (CSR) that has not been deeply researched (Lukey *et al*., 2017).

Bioprospecting accepts the significance of natural product discovery based on traditional knowledge for the growth of new nutraceuticals, bioactive principles and medical specialties (Reed *et al*., 2006). This process has two major goals which are the sustainable use through biotechnology of biological resources and their conservation, and the second goal is the scientific and socioeconomic development of source nations and local communities (Kremen *et al*., 2004).

Megadiverse countries have a substantial picket in connecting the prospective of biotechnology and bioprospecting for realizing sustainable economic growth (Guérin-McManus *et al.,* 2008). A major concern in bioprospecting is benefit sharing, i.e., sharing of the benefit for biodiversity conservation and social development of the local ethnic populace. Bioprospecting may have a significant negative impact on the bioresources and environment if keystone species are removed or biodiversity extinctions triggered through overharvesting of the bioresources (Reed *et al*., 2006).

2.3 Characterization of bioprospecting

Bioprospecting is the process characterized by putting nature into work and it is a combination of resources, understanding indigenous knowledge use and commercialization (Harvey and Gericke, 2011). It comprehends the search for economically valuable genetic and biochemical resources from nature. Therefore, bioprospecting entails looking for new ways to commercialize biodiversity (Foden and Potter, 2005). The diverse environment provides an important abundant source for raw materials used in a range of products and processes such as medicine, cosmetics and agriculture (Davis, 2000).

It is the process that plays an important role in the development of many biodiversity economical useful products. This is what accelerates this process to be the best

recommended when it comes to successful development of pharmaceutical drugs, beverages and other useful products from nature (Sarma and Bhattacharya, 2008).

Folb (2012) emphasized that bioprospecting can be advantageous where there is high rate of biodiversity richness only if it is well managed. This process leads to the development of new products, but on the other hand can create several problems in the environment and society. Bioprospecting can also create environmental problems, including over exploitation and other socio-economic challenges related to the unfair sharing of benefits which shows disrespect of the rights, knowledge and dignity of local community (Sandhu, 2011).

According to Farnsworth and Soejarto (2011), most of the problems regarding the unfair benefits sharing occurs when the privately-owned organizations or individual prospectors start exploiting biological resource in areas which they are foreign. Moreover, these prospectors and organizations exploit indigenous biological resources without the equitable benefits sharing while neglecting the interest of local community which sometimes accountably being called “biopiracy”. Folb (2012) further explained that access to the biological resources need to be sought to acquire the use of the resources in the community for the purpose of research, bioprospecting, conservation and commercial use.

Van Wyk (2013) emphasizes that historically, a lack of bioprospecting policy framework and legislation, both at the national and international level, permitted an almost unconstrained access to South African indigenous biological resources. In addition, the unconstrained access was also permitted to the indigenous knowledge with biological and genetic resources being harvested, sometimes in destructively excessive quantities, and being exported for research and development at institutions abroad for innovative value addition, and offshore financial benefit (Van Overwalle, 2005). Consequently, traditional knowledge holders and providers of indigenous biological resources often lack their benefits from the use of indigenous biological resources and the associated indigenous knowledge.

Department of Science and Technology, South Africa (2014) reports that the bioprospecting’s main perspective is to produce new products from nature to be used by

human beings, improving their health through better nutrition and medicine. These are the key focal areas of bioprospecting. This is the process that plays an important role in discovering leads for medicine and drug development since existing compounds for developing medicines and drugs for human use are limited.

Wynberg (2017) postulates that bioprospecting includes exploration and research on indigenous knowledge in relation to the management and utilization of biological research. In other words, bioprospecting concept consists of conservation and sustainable use of biological resources, rights of indigenous and local community and different kinds of bioprospecting phases. These phases start with the collection of samples, isolation, characterization and move on to the product development and commercialization.

2.3.1 On-site collection of samples

Sampath (2005) argues that in each bioprospecting process, indigenous knowledge related to bioresource samples are collected and undergo systematic scientific investigation using a variety of different technologies. In history, such researches were time consuming and costly, however, recent techniques are significantly improving. Bioprospecting samples collection starts from an idea and elevates to the bioresource target to be utilized (Takeshita, 2008).

Collection of bioprospecting samples has made the screening of natural product molecules simple and fast which plays vital role in both the impact, and level of bioprospecting (Bhatia and Chugh, 2015). For example, novel and naturally occurring antibiotics are still being discovered from natural products' libraries that are decades old. These advances ultimately mean that the demand for new natural collections will decline as existing collections and local biodiversity are studied more comprehensively.

2.3.2 Screening of specific uses

According to Lock (2004), bioprospecting becomes an increasingly important concept used by the commercial sectors and commercial enterprises to identify regions of high biodiversity value. For bioprospecters to achieve a net gain of biodiversity to commercialize, there is a need for screening. Biological screening is a procedure

carried out to identify potentially active plants against validated therapeutic targets and this procedure is conducted through several stages.

According to Rausser and Small (2008), the only way to increase the success of bioprospecting in ecological and ethnobotanical knowledge is through direct biodiversity screening effort. Although it has been shown that ethnobotanical knowledge can be utilized to raise the success rate of screening natural products in some specific cases, the mismatch between the merchandise needs of rich and poor countries may leave much ethnobotanical knowledge under-exploited (Sheldon and Balick, 2005).

Many natural resources are still unknown throughout the world, and most resources have not been screened and tested for bioprospecting purposes (Strobel and Daisy, 2003). Screening of specific bioresources requires strong collaboration between indigenous communities and bioprospectors because stakeholders who collect specimens at specific areas might find new species for sciences. Nevertheless, at some point, local people in an area might have already known about that plant species and its uses (Mauro and Hardison, 2010; Posey, 2006). However, if a bioprospector works with local people in an area, they might be accustomed to using the local flora and fauna for different alignments. Thus, their knowledge would have acted as a filter to pinpoint plants that might be successfully bioprospected and their potential inputs for bioprospecting (Loether, 2002).

2.3.3 Bioprospecting product development

Product development and commercialization is the supply chain management process that provides structure for developing and bringing to market new products jointly with customers and suppliers. According to Pellikka and Virtanen (2009), the process of bioprospecting begins with an idea, proceeds with product development, and ends when the product creates wealth. Nonetheless, an increasingly popular non-linear product development approach emphasizes the interaction with stakeholders on product development and marketing or commercialization activities as the only good approach to put a product good sale (Aarikka-Stenroos and Sandberg, 2012).

Commercialization refers to the development of the product concept, its successful launch, and interaction with potential buyers (Jolly, 2007). Bringing a new product to market requires new activities and resources related to the creation of demand and markets. *Berchemia discolor* species raise an important demand in the local markets of rural communities thus gives good potential for it to be commercialized in a marketplace. Harrison and Waluszewski (2008) indicated that for *Berchemia discolor* to be profit-oriented, the innovating bioprospecters must create future demand and new markets by integrating their complementary resources, products, and channel relationships through networking. Succinctly, Ritter (2004) states that the success of *Berchemia discolor* commercialization requires resources such as technical competence, customer and market knowledge, the ability to identify the optimal functionality of the product, communication, distribution, and close relationships with key actors.

2.4 Perspectives of bioprospecting

Bioprospecting ensures that bio-prospectors' perception to the public is to make sure that biological materials are being collected from the field (forest, bushes, farms etc.) for screening to novel natural products (Brown and Gibson, 2015). However, people's perspective towards bioprospecting is to get benefits by utilizing indigenous species which are useful to them. Bioprospecting is the process in which its perspectives on the social cohesion and the environment depends on the actual discovery and potential use of biological resources, the amount of revenues generated, their use and benefits sharing clauses (Mateo, Nader and Tamayo, 2009).

Bioprospecting is mostly carried out by a wide variety of perspectives. Mentionable are the pharmaceutical industry, personal care and cosmetics industries, biological control and crop protection, the ethnobotanical industry, ecological restoration, ecotourism, biomimetic, biomonitoring, biodiversity-based industries and products, horticulture and agricultural seeds industry, bioremediation, etc. (Beattie *et al.,* 2011).

2.4.1 Pharmaceutical perspectives of bioprospecting

Bioprospecting, a vital step in the pharmaceutical production process, is also one of the most controversial and socially complex aspects in the pharmaceutical industry (Rose, Quave and Islam, 2012). Plants species represent a constant interest as sources of novel of medicines and pharmaceutical drugs. Plant derived medicines have been part of the traditional health care that people relied to, for many years (Cunningham, 2003). Pharmaceutical plants bioprospecting constitutes one of the important overlooked areas of South African health development standard. South African biodiversity is providing high rate of plants species that are sources of health remodifying agents (Gurib-Fakim, 2010).

Bioprospecting is the initiatory stride in a complex, long–term medicinal development process that can create various misunderstandings at different instants during the process (Shanley and Luz, 2003). In this regard, companies must gain legitimate access to resources that may have ambiguous legal standings due to their multiple roles (e.g., food, medicine) amongst different local communities across different legal jurisdictions (Rose *et al*., 2012).

According to Cunningham (2003), most of the regions in South Africa, depending on the development of the population, the community demands for pharmaceutical products are becoming excessively high. Moreover, there might be a large risk that many available medicinal products may run out. In so doing, bioprospecting of indigenous species for medicinal purposes is the crucial topic to be taken into consideration. Bioprospecting promotes innovation, helping countries to develop new pharmaceutical products (Nazarudeen, 2010).

- **Historical successes in pharmaceutical bioprospecting.**

Harvey and Gericke (2011) suggest that historical successes in medicinal discovery based on natural products can be a continued appetite for accessing natural products to use in medical or pharmaceutical discovery programmes. Historical successes of medicinal bioprospecting take place by seeking leads for new products from natural biological resources. According to Patwardhan (2005), two approaches can be followed to get bioprospecting leads from biological resources. The first approach can be the use

of historical leads from traditional medicinal practices which is simply called “ethnopharmacology”. This is the study of natural medicines from plants and other substances that have been traditionally used by groups of people to treat various human diseases. The second approach can be the use of natural products as a highly diverse set of chemicals for random bioprospecting screening (Rios and Recio, 2005).

There have also been medicinal leads from traditional medicines derived from traditional healers that have been used as the starting point for the development of analogues that become the active ingredients of the final medicinal products. However, accessing natural products used as traditional medicines can lead to many challenges, relating to ownership of intellectual property and benefit-sharing (Frisvold and Day-Rubenstein, 2008).

Grover *et al* (2007) argue that bioprospecting is currently performed on a small scale by numerous academic groups in South Africa. Meanwhile, Schowalter (2016) points out that bioprospecting network is needed to promote successful medicinal discovery from biodiversity through developing pharmacological screening methods. These methods can be readily transferred to groups in local communities of South Africa. Bioprospecting has been proposed as a potential means to encourage the conservation and sustainable use of biodiversity.

2.4.2 Food perspectives of bioprospecting

The use of wild edible plants species within local communities is widely documented. wild edible plants species are importantly and form part as a component of local remedy to increase food security (Wynberg, 2002). Food from different species plays major roles by giving people the coping mechanisms at times of famine and food shortage. Bioprospecting shows that indigenous fruits remain one of the major options for coping with hunger and nutritional deficiency in diets and with poverty in Southern Africa (Motlhanka and Makhabu, 2011). Most of the studies have shown that fruits harvesting from the wild and from the semi domesticated trees growing in different regions and in farmlands boost rural employment and generate substantial income in different communities around the country.

Bioprospecting accounts for dozens of tropical fruits that are suitable for small scale processing into jams, juices and dried food combinations. For example, in different areas around South Africa, fruits of *Sclerocarya birrea Sond* are bioprospected into an array of products such as cosmetic formulations (Marula soap, Marula oil), Marula jam, and sweets and also Marula alcohol (Motlhanka and Makhabu, 2011). *Mimosopus zeyheri* fruits are rich in vitamin C and are processed into a traditional dried pulp which has a long shelf life and serves as a delicious food during winter (Chen, 2009).

Bioprospecting is the process which have greater use in terms of food generation recently (Edward, 2012). The main perspective is that, in each food product generated through bioprospecting, nutritional value and income generation becomes the main considerable important factors. These factors are the main benefits of bioprospecting in different areas where the produce food and other useful products. Motlhanka and Makhabu (2011) state that bioprospecting indigenous wild fruits can have greater contribution in the socio-economic sector because it reduces the shortage of food security which is one of the challenges in most of African countries. However, in many parts of South Africa, bio-resources treasures remain untapped. Plants' prospecting plays an important role as sources of essential nutrients, vitamins and minerals necessary for the well-functioning of living things. Human beings obtain these when they consume plants as vegetable, fruits or prepared in any food formulation (Kucich and Wicht, 2016).

2.4.3 Beverages perspectives of Bioprospecting.

Beverages have been used for centuries for all sorts of drinking, health, and nutritional reasons (Urso *et al.,* 2016). There are so many popular alcoholic beverages, teas and herbal tea blends coming into the marketplace due to bioprospecting. Herbal tea plants species and other plant species from which other beverages such as alcoholic beers can be harvested represent some of bioprospecting potential market opportunities (Heywood, 2009). With such development, the standard of living seemed to be improving in both rural and urban areas. Economic analysis has shown that bioprospecting of bio-resources that produce popular beverages considerably contribute to the economic welfare of people by generating a reasonable income (Edward, 2012).

2.4.4 Socio-economic perspectives of Bioprospecting

United Nations Development Programme (2015) shows that bioprospecting creates an inducement to monitor and maintain biodiversity in a way that avoid the possibility of losing economic opportunities from competitors or extinction. It is the process that promotes the growth of biotechnology and the way of transferring knowledge within the countries along with foreign direct investment from different places. Bioprospecting helps in social and economic development, especially in South Africa. Moreover, the discovery of genetic or biochemical information about the unknown natural species contribute to potential improvement of commodities especially medicine and intellectual nourishment (Heywood, 2011).

Different local populations, especially in South Africa are now becoming progressively aware of the possible economic value of natural habitat through biological exploration because of bioprospecting existence (Mbuvi and Boon, 2009). This shows that bioprospecting provides encouragement to the domestic population to protect biodiversity as it is one of the processes that keep people in terms of economic stability.

Additionally, bioprospecting favors socio-economic factors such as employment opportunities which are related to the discovery of natural products. In other words, people gain revenues from bioprospecting because it creates employment for both people, who own and utilize biological resources (Wynberg, 2002). It also helps to preserve traditional cultures and values by rediscovering ancient native practices of valuable products for people to use. Recently, South Africa has developed several notable bioprospecting industries that have already brought citizens' perspectives with direct and indirect benefits (UNDP, 2015).

2.5 Indigenous knowledge and bioprospecting

The wisdom that indigenous people have regarding bioprospecting is embedded in their belief system and their culture (Srivastava *et al.,* 2009). Indigenous knowledge is a community-based system of knowledge that has been developed, preserved and maintained over generations (Nair, 2005). This means that the development, preservation and maintenance are done at the local and indigenous communities

through people's continuous interactions, observations and experimentations with their surrounding environment. The accumulated wisdom, knowledge, belief and practices embodied in the traditional knowledge system were handed down to generation by an unbroken tradition and culture. Thus, promote the lead for bioprospecting of resources through indigenous knowledge that were in use for several years.

The indigenous knowledge associated with the biodiversity which was developed and held within the indigenous and local communities are thus found to be the most valuable lead for modern technological innovations (Pushpangadan *et al.*, 2017). Nevertheless, indigenous knowledge is viewed as additional information that eases the discovery of valuable natural resources. Yet, indigenous people are viewed as information providers as well as executors of biodiversity conservation. Biodiversity and indigenous knowledge are thus the most powerful resources in bioprospecting which the interventions of science and technology can generate wealth with (Nair, 2005).

Varughese and Manikantan (2017) also point out that the advent of new tools and techniques into bioprospecting, particularly biotechnology could convert biodiversity resources into industrially and commercially valuable products and processes. This creates an invention of having increased productivity and application in many crucial areas such as healthcare, medicines and vaccines.

Indigenous knowledge is enlisted as an imperative aspect to contribute to bioprospecting operation because it has high anticipation of finding a successful target from natural resources (Kumar and Tarui, 2004). In other words, bio-prospectors must express their intentions to provide equitable benefits of bioprospecting products obtained through the use of indigenous knowledge system. Moreover, economic and political powerful groups who normally manipulate an equitable compensation obtained from indigenous knowledge through people's overall collaboration in bioprospecting projects must also give back to the communities (Takeshita, 2008).

The Department of Environmental Affairs in South Africa (2008) once highlighted the irreplaceable and unique value of South African indigenous knowledge of biodiversity. However, the emphasis was that this knowledge can be more valuable to the modern biotechnological industries as well, not only to those who depend on it in their daily

lives. In the inaugural indigenous knowledge system Expo held by Department of Environmental Sciences in 2008, it has been pointed out that indigenous knowledge systems can make a significant contribution to sustainable development through conservation and sustainable use of biodiversity. Nevertheless, there is a clear need to strengthen indigenous knowledge practice and cultures by protecting and recognizing the value of such system and preventing their loss that has emerged (Department of Environmental Affairs, South Africa, 2008).

2.6 *Berchemia discolor* commodity prominence

According to Cheikhoyussef *et al*. (2010), *Berchemia discolor* is a wild edible plant species of multi-purpose which is distributed in many areas within African countries, and it is characterized by fruits which are edible, wood that can produce charcoal, building materials, furniture, crafts and various commodities for local use. It is a tree that can be planted as an ornamental, making an effective shade tree and it can be used as a windbreak. According to Coombe (2000), *Berchemia discolor*, like any indigenous biological species, have potentials that can be actualized if extracted with an idea to produce a biological product for any productive use.

Davis (2000) points out that indigenous people have developed a contiguous and distinct bond with the land and the environment in which they reside. These people have developed a unique system of perception, transformation and practices, which relate to the use and administration of biological diversity of their lands, species and their environments.

Davis (2000) further mentioned that many of these perceptions form a crucial input for research and advancement, particularly in areas like medicinal and cosmetic products. In the context of this use, indigenous people showed that bioprospecting potentials can be derived from this knowledge. However, the *Berchemia discolor* potentials can be segmented in various alignments.

Based on the South African's bioprospecting, access and benefits-sharing regulatory framework, bioprospecting potentials of a plant species can be segmented into various categories. These categories include medicinal/pharmaceutical, essential oils, food,

flavorings, fragrances, beverages, cosmetics, emulsifiers, oleoresins colours and extracts (DEA, 2012). This ensures that every target species for bioprospecting has its own important categories to pursue.

2.6.1 Medicinal viewpoint of *Berchemia discolor* in South Africa

The prediction of the age of indigenous medicine, especially in Africa, is entirely difficult to handle because there is a lack of historical written records (Reihling, 2008). The practice of utilizing biological species for medicinal purposes was established long time ago, meaning that it is as old as the culture, which has discovered it. The continuing survival and existence in most of the indigenous groups of cultures around Vhembe district have been seen to depend more on active and dependable roles of medicines extracted from their indigenous plants. Those plant species maintained good health and supply effective medicines and maintain peaceful living conditions (Maroyi, 2013).

A paper published by Kusar *et al.* (2006) clearly showed that nature is still a productive source of new medicines. The transformation of indigenous plant species has been recently seen as prerequisite for effective health promotion. This includes the reduction of medicinal production demand and poverty. Reihling (2008) emphasized that under colonialism, health and African tradition were rather contrary; however, today there is a revised interest in the way in which indigenous knowledge can be made applicable for public health.

World Health Organization (2008) defines bioprospecting as “problem solving strategy in the development of medicines” to achieve the long-term sustainable and productive development goals in South Africa. This ensures that bioprospecting also has effect to promote sustainable management of resources to enhance health care and fight most of the uncured diseases. Recently, bioprospecting is perceived as the successive procedure in which WHO has a particular interest in traditional medicine, the assessment of its safety, effectiveness and the integration into national health care system.

Maroyi (2013) indicates that indigenous plant species have been used for thousands of years by indigenous people to promote indigenous system of medicine. Despite South

Africa being remarkably biodiverse country with a large number of plants species that could potentially produce medicinal drugs opportunities, there are very few medicinal leads obtained from South African plants. This is despite the country having a large traditional medicine market, which potentially leaps products into the formal medicinal market.

South Africa is a country with a strong history of traditional healings, and host variety of indigenous medicinal plant species which includes *Berchemia discolor.* These species according to "African plants Checklist and Database project" has a variety of hidden potentials which can add on the 10% of the world's highest plant species if exploited. It is one of the medicinal plants species in South Africa which is locally recognized as the basis for number of critical human health, economic support and social benefits (Van Wyk and Gericke, 2000).

Recently, there is a growing interest in plant-based remedies as a source for commercial products. Prinsloo (2012) states that around 80% of the South African population use traditional medicines to meet their primary health care needs. However, only few South African medicinal plants are exploited to their full potential with regards to commercialization. This supports the fact that the pharmaceutical bioprospecting opportunity remains untapped (Street and Prinsloo, 2013).

The unique feature of most of *Berchemia discolor* plants species is that they are endemic to the region. Until recently, those species are not exposed to the organized sectors, which are involved in the production and commercial exploitation of medicines and drug-yielding plants*.* According to Gurib (2010), *Berchemia discolor* plants are associated with traditional practices used by the local herbal practitioners and as such are important component of indigenous knowledge system because such plant was in use for centuries. However, most of the plants which are medicinal related are now exposed to illegal trade and as such there has been large-scale depletion from their wilderness (Laird, 2013).

There has been a major renewal in the interest of traditionally used medicinal plants with a number of local initiatives actively exploring the botanical resources of southern Africa (Bousious, 2007). Moreover, the intention was to screen indigenous plants for

pharmacologically active compound. The diversity of this *Berchemia discolor* plant species in South Africa is the official mark of the vegetation types of Limpopo province. Of all the categories of plants, species with medicinal potential constitute the most important plant resource of the region (Farnsworth and Soejarto, 2011).

2.6.2 *Berchemia discolor* as food product

Plant species are currently major sources for food and non-food industry in South Africa. Recently, bioprospecting deals with two major technologies to develop new products from biological resources which are pharmaceutical and biotechnology. The most importance of wild edible plants like *B. discolor* is that they may be traced to antiquity to get the most important leads for food production through their historical period using biotechnology (Sava and Antofie, 2018).

According to Cheikhyoussef (2010), indigenous fruits are receiving special attention and interest because of the abundance and nutrition in South Africa. Fruits are the most important sources of food especially at times of food shortage and disasters. The main potential of indigenous fruits for utilization is the extent of health benefits such as vitamins, minerals and antioxidants. For bioprospecting purposes, indigenous trees become the target mostly in harvesting seasons. In addition, this is the season in which prospectors add value to the indigenous fruits by using biotechnology to convert fruits into processed food products (Bille *et al.,* 2013).

Bechemia discolor species contains the leaves which are dark green above and paler green below. According to Coombe (2000), the leaves of the tree are certainly browsed by animals such as elephants, kudus, impalas, duikers, nyalas, bushbucks and klipspringers.

The utilization of *Berchemia discolor* as a food plant, and for various other uses, forms the basis of the current demand of the plant species in Africa. This biological resource is apparently one of the most astounding looking trees and a true resource in the bushveld for humans being, birds and animals (Neuwinger, 2016). The tree produces sweet yellow fruit when ripe and rich in vitamin C and sugar. It is one of the most popular wild fruits in the Southern parts of the South Africa (Hailwa, 2002).

In South Africa, large quantity of the *B. discolor* fruits collected are dried and stored and later used by people in the Lowveld areas. Animals such as Baboons and Monkeys also utilize the fruit when ripen to feed themselves. Most of the fallen fruit from the tree are eaten by Bush pigs, Bushbucks, Duikers and Hyraxes (Musaba and Sheehama, 2009).

Adekunle and Oyerinde, (2004) stated that *B. discolor* plant species do stabilize the low level of food security where the species is widely distributed. Most of the indigenous tree species produce different kinds of fruits with different tastes. According to Robison (2010), most of the Rhamnacae family tree species with which *Bechemia discolor* is one of them, produces sweet edible fruit that contain adequate level of food nutrients required for normal body functioning of human being and other organisms.

Berchemia discolor fruits are normally called bird plums and they are not only crucial source of vitamins and nutrients for people in rural areas but sometimes are central to the survival of local communities in South Africa (Van Wyk and Gericke, 2000). Moreover, bird plums can contribute as important examples of trade since they can be dried and stored so that they can be sold in the local market areas of Southern Africa.

Holzhausen (2003) emphasized that several fruits have potentials, as current commercial crops and progress have already been pointed out with Marula fruits as an example. Native wild edible species that produce fruits constitute food to the society and plays a vital role in economic welfare, human health and nutritional value of the rural communities in developing countries. Nevertheless, indigenous wild edible plant species in researcher's point of view are not given enough attention, in both research and development, even though they are essential in people's diets.

2.6.3 *Berchemia discolor* and its prospects for traditional beverage

The most interesting potential source of new products from nature is the rich diversity of traditional alcoholic beverages, simply referred to as wine, beer or brandy (Van Wyk, 2011). This shows that the consumption of indigenous traditional beverages has a long history in Africa and South Africa as a whole. For example, Sorghum beer is one of the most important commercial beverages in South Africa and is produced using

standardized methods. Drinks made from the sugary juice of fruits from indigenous species are usually referred to as South African beer.

A diversity of indigenous fruits is used to produce wine, of which Marula is the best known. In addition, Marula wine has been sporadically available in South Africa, and it was with hope that entrepreneurs will grasp the opportunity to fully commercialize and brand this uniquely African drink (Van Wyk, 2011). Nonetheless, the flavour of *B. discolor* fruit is ideally suited for making liqueurs such as the world famous Amarula which is flavored with Amarula fruits (*sclerocarya birrea*) (Van Wyk and Van Wyk, 2007). Posey (2006) implies that a well-managed bioprospecting of biological resources can be advantageous, since it can generate income for the developing countries and create great opportunities of employment avenues. It can also provide incentives for the conservation of biological resources and biodiversity. Furthermore, it can lead to the development of new products which include medicines. Sandhu (2011) implies that bioprospecting collaborations between pharmaceutical companies and countries supplying the medicinal raw material and knowledge offer not only the revenue source for under-developed countries but also opportunities for society to better education.

2.7 The bioprospecting prospects of *Berchemia discolor* species

Every species utilization in the society has challenges if not well managed. Prospects of *Berchemia discolor* include biopiracy, the extent of the species abundance, herbivory destruction and most importantly overutilization of species. These are challenges which mostly hinder the utilization of resources for bioprospecting in most of the communities and restrict the sustainable ways of using biological resources. The major constraint perceived about *Berchemia discolor* utilization is the shortage of good regulations. These prospects are detailed below.

2.7.1 Biopiracy of biological resources

Biopiracy is the unfair sharing and disrespect of the knowledge, rights and dignity of local communities (Gadgil *et al.*, 2001). In history, Guérin-McManus *et al* (2008) argued that it has been evident that indigenous people conducted biological resources without creating major tension to the species. The biological resources were conducted in their

own communities only to accommodate people who were in need of help at a time by means of medicines and other uses.

According to Henrietta (2013), problems occurred once private organizations or individual prospectors started exploiting bioresources in areas to which they were foreign, without equitable benefit sharing and while neglecting the interests and wishes of local people. WTO (2005*)* states that through sustainable bioprospecting, there is a gigantic global population of beneficiaries beginning from business community to the biota rich. However, there has been poor income to the tropical communities who preserve and judiciously manage their natural resources.

Nevertheless, scientists and business people's points of view, providing local people with economic incentives to preserve their natural habitat is a sound investment and subsidizing the people who guard future resources is justifiable as fair and equitable (Gollin, 2002). Yet, in many countries, for instance, South Africa, lack of implementation of bioprospecting legislations and associated regulations by bioprospectors has been reported and permitted almost unconstrained access to bioresources. The lack of legislation implementation leads to materials being harvested without the legal consent of the host country and indigenous community owners (Medaglia and Silva, 2007).

Gadgil *et al*. (2001) state that biological resources are sometimes harvested in a destructive excessive quantity and exported to development and research unit of data structure abroad. This is normally practiced for innovative value addition, and offshore financial benefit. The result has been that the country, including traditional knowledge holding communities and bioresource providers, do not benefit equitably from this commercial and other gains derived from the use of this local bioresource commercialization. This is termed biopiracy.

Davis (2000) states that most of bioprospecting extractions recently from indigenous perspectives, are largely carried without prior consent from the custodians of knowledge and with petty or no contribution of economic benefits. This is a challenge because it is the commercial exploration of biological materials without contributing the indigenous people or land from which cloth is obtained. According to Blakeney (2009), indigenous communities are increasingly concerned that their knowledge of natural environment is

being explored. In due cases, the collection, screening, and patenting of plants and products by cosmetics, pharmaceutical and other research companies are being carried out without due regard for the rights of indigenous holders and custodians of knowledge about biological resources. Reid *et al.* (2016) also states challenges associated with biopiracy as access of biological resources to the communities and bioprospecting benefits sharing. These challenges have been explained below.

- **Access of biological resources**

South Africa, just like any other countries has legislated to be granted access for bioprospecting purposes to their biological resources (Pethiyagoda, 2004). It is one of the megadiverse countries that has introduced regulation of bioprospecting, biological access and benefits-sharing activities. The bioprospecting legislation and regulations introduced in South Africa have sought to redress disparities in benefits-sharing of products derived from bioprospecting. These regulation and legislation reflect access to bioresources through national sovereignty and a recognition of traditional knowledge (TK) and related intellectual property rights (IPR). Ideally, the access to biological resource may be sought for the purpose of the research, bioprospecting, conservation commercial use etc.

Blakeney (2009) emphasized that access to the resources can be divided into authorized and unauthorized access. Authorized access can be conducted through formal collaborations on research and utilization or through purchasing from recognized institutions. However, unauthorized access can be practiced through individual contacts, through unauthorized institutions. Unauthorized access often raises challenges towards biodiversity-rich countries, mostly those with weak law enforcement, which is further worsened by the fact that the practice usually takes place in remote locations (Srivastava *et al.,* 2009).

- **Bioprospecting benefits sharing**

Gadgil *et al.* (2001) emphasize that benefits sharing is the fair and equitable sharing of benefits arising from the use of genetic resources. This is the process of bioprospecting where bioprospectors compensate for indigenous bioproducts and people used for

screening efforts, commercially valuable genetic and biochemical resources. Benefits sharing agreement in South Africa recognises that bioprospecting relies on indigenous or traditional knowledge and that people who hold such knowledge are entitled to share benefits arising from its commercial utilization. In benefits sharing regulatory framework, consideration of biological resource property rights is of importance to indigenous people who entitle that their livelihoods and culture depends on such resources, and that their knowledge and practices relating to the natural environment constitute part of intellectual property rights (IPR).

The approach to developing access and benefit-sharing (ABS) legislation is supported increasingly by countries both rich and poor in bioresources (Medaglia and Silva, 2007). Department of Environmental Affairs and Tourism (1997) indicated that in May 1997, a white paper on the conservation and sustainable use of South Africa's biological diversity was gazetted. The paper was gazetted with subsequent minor modifications by Cabinet and adopted by parliament. The policy figured out the necessity for establishing legislation and institutional structures to control access to South Africa's indigenous genetic resources. In addition, the proposed legislation was to ensure that benefits arising from South African bioresources served the nation.

Significantly, the white paper of the conservation and sustainable use of South Africa's biological diversity (1997) recognized that it was in the country's best interest to ensure that access to biodiversity was not unnecessarily restrictive, and further recommended that legislative conditions should stimulate economic activity. The appraisal considers whether the key policy considerations have been successfully achieved, given that both legislations NEMBA Act 10 of 2004, hereafter referred to as the Act and regulations have subsequently been ratified. Relatively few parties to the Convention on Biological Diversity (CBD) have reached the commendable goal, with fewer than 10% of the CBD parties having adopted access and benefit sharing legislation, ten years after the emergence of the convention. The below Figure 2.1 showed how the process, the context of key legislative developments and access and benefits sharing legislations in South Africa has been introduced (Alcorn, 2010).

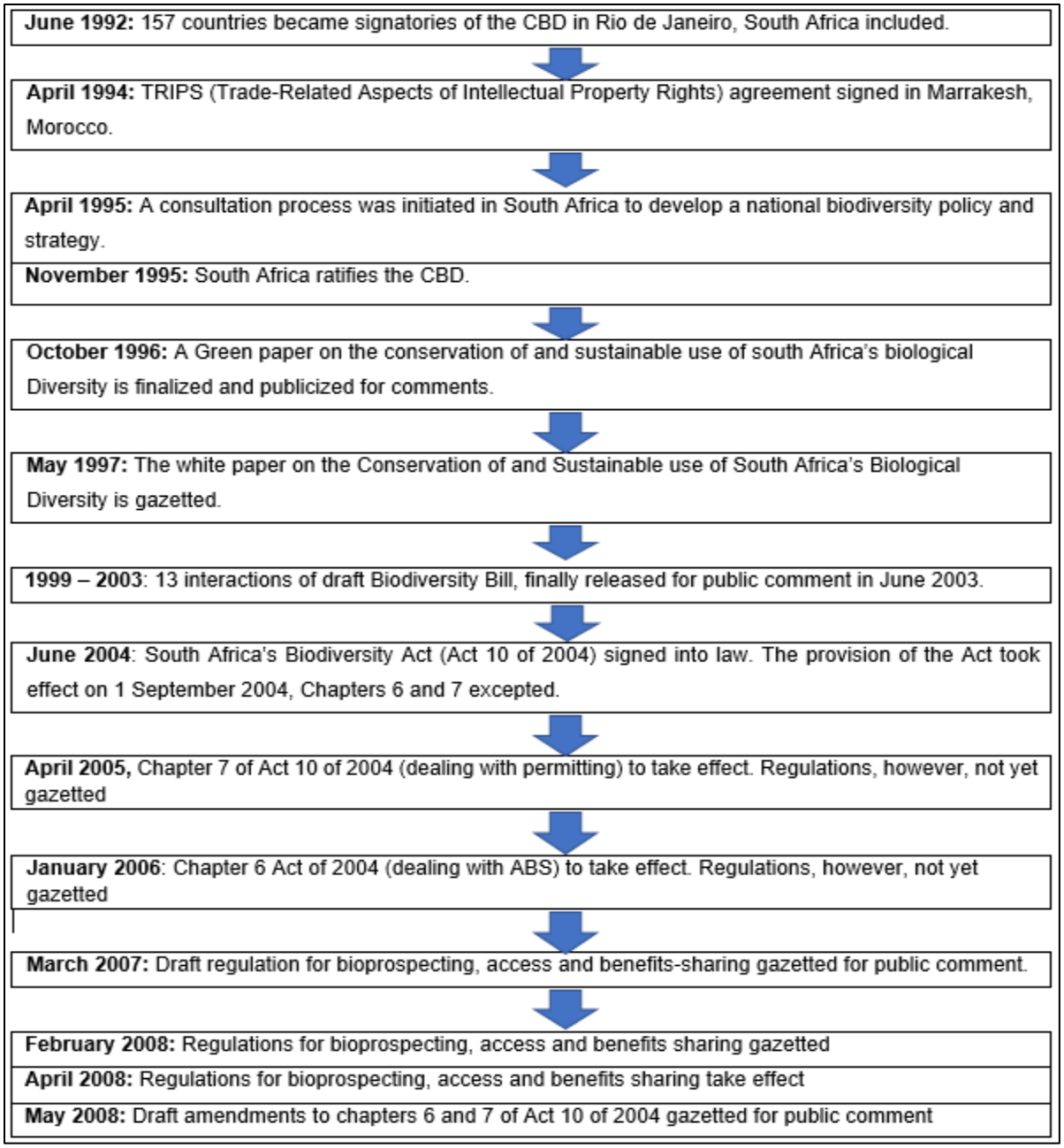

Figure 2.1 Bioprospecting regulation (Source: DEAT, 1997)

2.7.2 Species abundance

Species abundance is a component of biodiversity and refers to how rare or common a species is in the community or a location in which it is found (Vázquez, 2007). The species' richness of biological resource is important in a specific area if a resource is a target for utilization. Venter (2012) states that communities which has a greater number

of species targeted for bioprospecting utilization tends to have stable ecosystem which is an important aspect for biodiversity conservation.

Berchemia discolor species present relative abundance and more evenly distribution in many areas around Limpopo. According to Ramavhale (2018), *B. discolour* species diversity responds differently to various environmental factors. There are regions where this species is widely distributed and where it is not. The species is also influenced by different landscape characteristics such as surrounding vegetations and mountains. The abundance of these species attracts people and animals to utilize its resources and use them for different reasons.

In most of the regions around Limpopo province, the biodiversity is undergoing global threats, more especially loss of species through utilization. For example, Ndou (2017) shows that *Brackenridgea Zanguebarica oliv* species, commonly known as yellow peeling plane is one of the species which has least of abundance and endangered because of utilization. The tree is predominantly found at Limpopo Thengwe village, and it is exploited mostly by traditional healers for medicinal purposes and bioprospecting. *Berchemia discolor* species is found in these regions where most of indigenous species are being utilized for commercial and personal uses. This affects the development and abundance of the species in the area mostly if it is a target for bioprospecting and hinders the production of valuable new products for humanity, including medicines and industrial processes (Lead, 2005).

Department of Agriculture, Forestry and Fisheries (DAFF), South Africa (2017) points out that the current global decline that is being experienced by biodiversity may affect bioprospecting in various ways. Serious undervaluation of such losses for bioprospecting result by lack of recognition that a high proportion of commercially important species are either small or microscopic, and so losses go undetected. Other threats include loss of traditional knowledge, the impacts of some kinds of modern agricultural technologies, and depletion of natural resources (Lead, 2005).

2.7.3 Over-utilization

Over-utilization is the harvesting of species from the wild at the rates faster than natural population can recover (Michaels, 2018). Over-exploitation is a growing problem for many indigenous species in South Africa. According to Purkayastha (2016), bioprospecting has a significant negative challenge on the bioresources and environment if the keystone species is overharvested or totally eliminated. So far bioprospecting has also added some environmental impacts which need a worth consideration of proper utilization of natural resources.

Although *Berchemia discolor* species is rated as Least of Concern (LC) according to International Union for Conservation of Nature, improper bioprospecting can lead to over-exploitation possibility if the species is a keystone target of bioprospecting (Doust and Doust, 2004). In most utilization scenarios, prospectors target unplanned and fast depletion of bioprospecting because it leads to the increase in the economic value and market of these resources. Unfortunately, bioresources utilizers do this without considering the future propagation of the same species which is the target of exploration. However, it is also important to ensure that bioprospecting is done in a justifiable manner and the outcomes are used for benefits of the country and local people from where the genetic resources are obtained (Guérin-McManus *et al.*, 2008).

The most significant concern is the impact of threats to biodiversity and species loss on bioprospecting (Johns and Eyzaguirre, 2006). This involves the growth of valuable bioactive molecules, medicines, new crop varieties. Purkayastha (2016) also noticed that the threats go unnoticed as the global decline of biodiversity and loss of a particular species of commercial importance is not discovered at once. Bioprospecting is also affected by the passing of traditional knowledge, which constitutes the backbone of exploring new organisms for their commercial/industrial importance (Posey, 2006).

2.7.4 Herbivory Destruction

Schowalter (2016) postulates that herbivory is the act where organisms, primarily get food by consuming plant species. Species herbivory destruction has the impact to every aspect and stages of the plant's life. Thus, it influences where the plant species can grow and the abundance of its distribution. Spotswood (2002) implies that herbivorous

animals have different impacts on the biological plant species and plants get attacks from different consumers.

Traditionally, herbivory destruction is considered as a key ecosystem process that has widely recognized effects on primary production and on vegetation structure and composition. Schowalter (2016) emphasized that trees such as *Bechemia discolor* also experience the destruction of its seeds, flowers, and fruits by both vertebrates and invertebrate species and have a huge effect of reducing the reproductive output.

In other words, herbivory destruction reduces resource availability and has subsequent indirect impacts on plant reproduction. For example, some of the herbivores such as dusky monkeys, turaco unicolor birds feed themselves through plants leaves, some eat fruits and some also feed from flowers (Woldetensay *et al.,* 2014). This means that if the target for bioprospecting in a certain species is a fruit, then herbivores can limit the production of such product that a species can produce. Herbivory destruction still lies as a challenge to many prospectors because if there is unlimited carrying capacity where the target for bioprospecting is located, the production to such a species will be low (Rios and Recio, 2005).

However, the impact of herbivory on indigenous species in South Africa depends on herbivore feeding type and intensity. For example, Doust and Doust (2004) found that flower feeding herbivores significantly reduce seed production of *Berchemia discolor* during flowering season because they depend on flower as a source of food. Likewise, birds, rodents and deer can also destroy a large proportion of reproductive output of trees and shrubs in deciduous and coniferous forests by eating fruits, seeds and leaves of species such as *Berchemia discolor,* or catch them for later use (Sava and Antofie, 2018).

Huntly (2006) contends that herbivores may feed selectively on immature plant species, which can lead to slower growth rates or totally elimination of such damaged individual plant species. However, Erneberg (2009) states that herbivorous insect such as armyworms, locusts and bees also have directly limit on the seed production and lifetime fitness by feeding on inflorescences of *Berchemia discolor.* These herbivores significantly limit the abundance of a plant species where they are densely populated. In

this regard, herbivory destruction gives highlight which negatively impact components of plant fitness such as its survival, flower and fruit production. This prohibits the bioprospecting processes as it limits the life span of the plant species if it is a key species to be bioprospected in a certain area (Davidson, 2003).

2.8 Conclusion

This chapter reviewed related literature about bioprospecting where bioprospecting perspectives were outlined. The characteristics of bioprospecting process were also highlighted. The study also reviewed the importance of indigenous knowledge in bioprospecting of indigenous tree species like *B. discolor.* This chapter highlighted the expected commercialization potential of *Berchemia discolor* and outlines its use in the communities of South Africa where the species is distributed. This chapter revealed that several scholars have reviewed the literature related to bioprospecting and *Berchemia discolor* species. Nevertheless, there is limited literature review about the core focus of the study. Additionally, the study also concluded by giving the challenges that can be faced when utilizing *B. discolor* which is an indigenous species. In this regard, the chapter emphasized that for prospectors need to consider indigenous people since bioprospecting was seen the main challenge of utilizing indigenous species.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter is aimed at documenting the research methodology. The purpose of documenting research methodology was to know the types of methods that were used to collect data and how data were presented, analyzed and interpreted. According to Creswell and Clark (2016), research methodology is the systematic, theoretical analysis of the methods applied to the field of study. Thus, the types of data collection methods, data sampling methods and data analysis techniques that were used in the study were outlined.

The data was collected from two study areas, which fall under Vhembe District Municipality in Musina and Collins Chabane Local municipalities. Two areas were selected and had different total number of population and households: Tshipise area, which falls under Musina Local Municipality with 306 households, and Malamulele area, which falls, under Collins Chabane Municipality with 3205 households (StatsSA, 2011).

3.2 Research design

Research design is the set of methods and procedures used in collecting and analyzing measures of variables specified in the research problem (Leedy and Ormrod, 2016). The study employed case study research design in order to focus on the in-depth, and detailed examination of *Berchemia discolor* species utilization at Tshipise and Malamulele areas. Thus, the study followed a descriptive survey design through questionnaires and an instrumental case study design in the form of structured interviews.

The case study design allowed the exploration and understanding of in-depth investigation of this study. Data was gathered through primary and secondary data collection methods. Validity and reliability were used in the study to validate the data that was collected during fieldwork. Again, the study underwent all ethic procedures and were approved (appendix C) before interacting with the respondents.

3.3 Data collection methods

The study adopted both qualitative and quantitative methods for data collection. Qualitative data included data collected by field observations, structured face-to-face interviews, and questionnaires in the study whereas quantitative data included data collected by peer-reviewed scientific journals. The data that was collected included both primary data and secondary data. Primary data is the data that is collected firsthand by the researcher for a specific project or purpose. It is time consuming and can be collected in many ways (Glass, 2006). Primary data sources included field observations, structured face-to-face interviews and questionnaires.

Secondary data refers to the data that is already collected from other sources. This data can be readily accessible than primary data. Examples include textbooks and journals. Secondary data sources in the study included bioprospecting reports and documented materials. Data collection methods and procedures on how data were collected, sampled and analyzed have been outlined below.

3.3.1 Primary data collection

The data was collected at Tshipise area and Malamulele area. Interviews were conducted in each selected household in the study areas. These data were collected using different primary data methods such as field observation, interviews, focus group and questionnaires. Questionnaires were also self-distributed in each household selected. These were outlined as follows.

- **Field observation**

The researcher undertook the field observation at Tshipise and Malamulele areas to assess the availability of tree species (*Berchemia discolor)* and its occurrence. The field observation was also undertaken to check the environmental challenges that occurred at the study areas. Field survey was undertaken using checklist (to-do list) to check the presence of *B. discolor* within two areas. This is a list of items required, things to be done, or points to be considered, used as a reminder which helps to ensure consistency and completeness in carrying out research.

The checklist was used to assess the level of species' presence per area. The checklist also appraised organisms that interact and feed themselves with the *B. discolor* fruits and leaves which were found during field observation. The checklist contained information about observed challenges in the study areas which can hinder utilization of *Berchemia discolor*.

- **Interviews**

Primary data was collected using semi-structured face-to-face interview with respondents. Interviews were used to collect data about bioprospecting opportunities and benefits that *B. discolor* species has on the society. Interviews were done by physically going to the respondents' households. The researcher undertook semi-structured face–to-face interview while taking into consideration the use of language of communication with the respondents. The consideration was taken by allowing respondents to participate in their own language and by being cautious from using vulgar and jargon words. This was done to validate the information provided by respondents to make sure that the respondents were the right participants for the study.

The interviewees were selected using purposive sampling, starting by selecting target respondents which were traditional healers in both study areas. The researcher used causal effect to accumulate more respondents from the target respondents until the specific size of sampling was reached. Thus, 41 respondents were sampled at Malamulele area and 40 participants at Tshipise area. The total of 81 respondents were interviewed in both study areas.

During the interview, the researcher was probing to the respondents' questions (that is to examine thoroughly or to question respondents closely), mostly to the illiterate people (people who cannot read and write) so that they can get a clear understanding of the research questions. Interviews were conducted during the day to cover unemployed and illiterate participants and then between 16 and 18 hours for people who have knocked off at work.

To verify the reliability of the data collected, the researcher used test-retest reliability. Through test-retest reliability, the researcher conducted the same interviews with the

same group of people more than once (two times). After the first interview session, the researcher undertook the second interview session after 15 days in every household. This helped the researcher to verify the validity of information provided by respondents even though some were not found for the second time.

- **Focus group**

The study also used focus group as a way of collecting data at two different study areas. This was done for the researcher to explore different perceptions, ideas, attitudes and feelings from participants about bioprospecting of an indigenous species, "*Berchemia discolor"*. The focus group interview was done in both study areas to gather data about the challenges of utilizing *Berchemia discolor* and people's perspective about bioprospecting. When conducting the focus group interview, the researcher used referral sampling method to sample the groups of participants to voluntarily participate in the study.

The researcher developed two (2) focus groups from two different study areas and all people who participated were from the age of 15 and above. The participants in all groups were chosen using referral sampling method because the researcher believed that they have more knowledge about the historical biodiversity exploration of *Berchemia discolor* and they can provide appropriate information about the study.

Focus groups were created by using referral sampling method, thus the first respondent nominated others until specific sample needed is reached. In the first group from Malamulele area, there were 11 participants including two traditional healers and a group leader. The other group from Tshipise area was having 8 participants including 3 traditional healers and one group leader who was coordinating the group.

The researcher interviewed traditional leaders who participated and answered some question because they have more knowledge regarding the use of medicines. However, group leaders were also there to make sure that each member is participating under ethics without any harm. For focus group to take place, the researcher was fully involved in the groups and facilitated the questions, then allow the groups to interact on

the questions. During the focus group, the researcher recorded the information from the participants using voice recorder and data was gathered using open-ended questions.

For data to be reliable and being fair to anyone, the researcher created a thoughtful, permissive atmosphere for anyone to participate. Moreover, the tone of the discussion was also taken into consideration so that anyone can comment peacefully without any offence. The researcher developed open environments for all participants to take part of the study by making sure that the questions were non-threatening or embarrassing. For, confidential purpose, the researcher informed the participants about the recording and make sure that they do not mention their names when answering the question.

- **Questionnaires**

Questionnaires were distributed purposively as a primary method of collecting data in the study. This was done by selecting initial target respondents based on their availability on the study. Questionnaires were distributed by physically going to each participants' households to gather information about the bioprospecting opportunities that can arise from the utilization of *Berchemia discolor*. Only a total of 100 questionnaires was distributed at both selected study areas. At the end, 38 (12%) out 306 households at Tshipise area were selected whereas 56 (2%) out of 3205 households at Malamulele area were also selected. The households' percentages vary because the areas have different number of households. Furthermore, this means that only people who were available were selected to answer the questionnaires.

Questionnaires were also used to gather information about feasible strategies that can be adopted for full utilization of *Berchemia discolor*. This was gathered from research participants, community stakeholders, landowners and traditional healers because they had relevant information on this issue. About 6 questionnaires were also distributed to the department and institutional personnel (Department of Environmental Affairs and South African National Biodiversity Institute) to give ideas on feasible strategies that can be adopted for further commercialization of *Berchemia discolor* species.

Questionnaires were comprised of both close-ended and open-ended questions. Closed-ended questions were used to gather demographic data and open-ended

questions were used to gather the general information from research participants and departmental personnel. The researcher used equivalent forms reliability to verify the reliability of data collected using a questionnaire. On the equivalent forms reliability, the researcher administered the same questionnaire in two different periods while yielding the same questions to check if the respondents will provide the same results. This helped to validate the data that was collected by the researcher using a questionnaire.

3.3.2 Secondary data collection

Secondary data refers to the data that is already collected from other sources. This data can be readily accessible than primary data (Glass, 2006). Examples include textbooks and journals.

- **Documents review and internet sources**

Secondary data was collected as an additional data in some of the objectives. Data associated with the opportunities of bioprospecting, challenges of *Berchemia discolor* utilization and data about feasible strategies for further commercialization were also conducted from previous research journals and Internet sources. This was done by using google scholar data source. Moreover, keywords such as bioprospecting and commercialization were used. Only sources, which have information containing bioprospecting of biological sources and other related materials for the study were outlined, whereas information conducted from such sources were duly acknowledged.

3.4 Sampling methods

The study adopted purposive sampling method and the main advantage of using purposive was to establish the contact with target respondents from the sampling frame. The additional respondents were added using causal effect from the information provided by the initial person. In other words, the first respondents on sampling frame recommended the next and the next recommended the other and so on until the pre-specific sample size has been completed. This sampling method was used for the selection of the respondents to be interviewed in both study areas.

Furthermore, the researcher was not familiar with the study areas and this sampling established connection between the researcher and respondents. This sampling

focused on the characteristics of population of interest due to their availability and accessibility on their households. Within the sampling frame, purposive sampling method was used to select traditional healers as the initial targets within the study areas. This was done because the researcher wanted them to participate in the study and give their bioprospecting perspectives about *Berchemia discolor*.

Snowball sampling method was used to select respondents who participated in the focus groups in both study areas. The main aim of using snowball sampling was to focus on the characteristics of the population of interest that were able to answer the research questions. Questionnaires were also distributed using purposive sampling method because all participants selected were having relevant knowledge towards bioprospecting. Additionally, the Department of Environmental Affairs (DEA) and South African National Biodiversity Institute (SANBI) personnel were also selected using a purposive sampling method. The reason was for the researcher to gather information from person who can provide information about conservation of biodiversity and bioprospecting processes.

3.5 Data analysis methods

The data was analyzed using different analysis methods. According to Clemence (2014), data analysis is a process of inspecting, transforming, and modeling data with the aim of discovering useful information, suggesting conclusions, and supporting decision-making. The data analysis methods used in the study included inductive content analysis, SPSS-IBM 25 descriptive statistics and Microsoft Excel together with factor analysis.

3.5.1 Inductive / thematic content analysis

According to Thomas (2006), inductive content analysis is the qualitative method of analysis that the researcher used to develop a theory and identify themes by studying documents, recording and other printed verbal materials. In the study, qualitative data was analyzed using inductive content analysis. This included data collected by structured interviews which were about bioprospecting opportunities and benefits that *B. discolor* species has on the society.

Furthermore, to conduct inductive content analysis, the researcher read all data transcripts that were conducted during interviews continuously and familiarized himself with the responses of the participants. Then, the notes about the first impression of the study from the participants' results were made. When first impressions were made, the researcher reread the transcripts again one by one for validation. The researcher then labelled relevant pieces of the transcript such as sentences, phrases, section and words which is called coding. The researcher then created themes or categories by bringing several codes together. The researcher then labeled raw themes or categories and decided the most relevant and how they connect with each other in every theme from the data collected and draw conclusion on the study. Data was presented using tables, bar graphs and pie charts.

Inductive content analysis was also used to analyze data from the focus group interviews. Data was conducted by research transcript during focus group to avoid missing important statements and comments. The researcher reread the transcripts several times whilst developing coding scheme of the data. Then after coding, categories were made, and the researcher created theory about the data that participants shared during focus group. Data was then presented in graphs and tables.

3.5.2 Factor analysis

The study used factor analysis to analyze the data about the challenges that occurs when utilizing *Berchemia discolor* species within two study areas. Factor analysis is the data analysis technique that is used to reduce large number of variables into fewer numbers of factors. The factor analysis method was used to determine the types of challenges to be broken down into subcategories or factors in both study areas. This helped the researcher to determine the challenges that were in the study areas, that affected the utilization of *Berchemia discolor.*

3.5.3 SPSS -IBM 25

Data collected using a questionnaire, such as data for feasible strategies to improve the commercialization potential of *B. discolor* and challenges that *B. discolor* species utilization has in the areas was analyzed through SPSS-IBM 25 descriptive statistics. In

addition, data was analyzed using descriptive statistic through frequencies within SPSS-IBM 25 in order to get the results. The gathered data was entered in the variable view in SPSS-IBM 25, until all variables are done. The analyzed variable was grouped and presented. The entered data was summarized into percentages.

3.6 Ethical considerations

The researcher followed ethical guidelines. This means that the researcher sought informed consent, which is the process of getting permission to the study area before conducting any participation. The researcher respected the confidentiality and anonymity of the respondents by not stating the respondent's name on the questionnaire and ensured that the respondents participate voluntarily and are protected from any harm.

3.7 Conclusion

Several methods were used to analyze data collected at the study areas. The sampling method used was snowball sampling because it assisted the researcher to establish the contact with the first respondents from the sampling frame and add other participants from the information provided by the initial person. In this chapter, data was collected through observation using a checklist, interviews, focus group and questionnaires. Then qualitative data collected was analyzed using inductive content analysis. SPSS-IBM statistical software and Excel were also used for qualitative analysis. The analyzed data was then presented in the form of tables, charts, bar graphs and plates.

CHAPTER 4: RESULTS, DATA INTERPRETATION AND DISCUSSION

4.1. Introduction

This chapter presents the findings, the scientific interpretation of data and the discussions. The interpretation of data was scientifically compiled by physically going to study areas to distribute questionnaires, interview respondents and conduct field observation. Different approaches which include questionnaires, focus group interviews and field observation were used to collect data while the discussions re factually based on both deductive and inductive approaches.

4.2. Demographic data

Demographic data is the measures of the characteristics or changes to the population, records of birth, death and other regular census of population. It also refers to the data that is statistically socioeconomic in nature such as education, income and employment which shows certain geographic information associated with time (Himes and Clogg, 2011).

4.2.1. Gender of respondents at Malamulele and Tshipise

The results showed that male and female respondents from Malamulele and Tshipise area participated in the study. The importance of establishing the gender of the respondent was to assess different perspectives of using *Berchemia discolor* species within males and females of the areas and how they utilize the species for their own use. The study indicated that males and females from the study areas use *Berchemia discolor* in various ways and for different purposes. The data presented in Table 4.1 indicated the gender of participants that were sampled at Tshipise and Malamulele area.

Table 4.1 Gender of respondents. (Source, field work, 2020)

		Frequency (%)		Tshipise		Malamulele	
Valid	Male	75	(37.5)	37	(18.5)	38	(19)
	Female	125	(62.5)	51	(25.5)	74	(37)
	Total (N)	200	(100)	88	(44)	112	(56)

The data presented in Table 4.1 indicated the gender of participants that were sampled. Two hundred (200) respondents were sampled. Out of 200 respondents, 75 (37.5%) were males and 125 (62.5%) respondents were females. The findings indicated high proportion of female respondents than male respondents within both study areas. These means that high number of female respondents has been interviewed. The finding also indicated that high number of females concluded that they use *Berchemia discolor* than males and this was evident according to their responses on the use of the *Berchemia discolor* products.

The proportion of female respondents who used the species for many purposes reasons within both study area was 122 females. Thus, only 3 female respondents at Tshipise said they do not use the species for anything. However, the proportion of male respondents who use *Berchemia discolor* within the study area was 75, meaning that all male respondents showed that they use the species for several purposes.

The findings indicated the difference in gender of participants according to the study areas. Thus, Tshipise area had 88 respondents altogether, meaning that there were 37 (18.5%) male respondents and 51 (25.5%) female respondents. Tshipise area had high number of female respondents who participated and points out that they benefit from *Berchemia discolor* by accessing part of species for medicine which they use to treat wounds, for cooking food and for timber. About (35%) 18 female respondents at Tshipise area indicated that during fruits bearing seasons, they harvest the fruits of *the Berchemia discolor* species. These respondents harvest those fruits to sell and to eat at their homes. Nevertheless, Malamulele area had 112 respondents and 38 (19%) were males 74 (37%) were females.

Female respondents at Malamulele area were familiar with the use of the species and access it more than males for fruits to feed their family members, and healthy benefits to treat wounds problem. This area showed high number of unemployed and self-employed females in the area which made them to be available to participate in the study. The findings showed that from 37% (74) of female respondents, 28 were self-employed at the area and 21 were unemployed. These respondents indicated that their other means of gaining money was through utilizing *Berchemia discolor* and sell product

in local markets. This leads to the commercialization potential *Berchemia discolor* species.

4.2.2 Age group of Respondents within Malamulele and Tshipise

The different age groups determine different point of view of utilizing *B. discolor* species within Malamulele and Tshipise areas. People with different age groups observed changes and prospects of the *B. discolor* species in the study areas. The results in Figure 4.1 indicate the age group of respondents. The age groups ranged from below 20 years to 60 years and above.

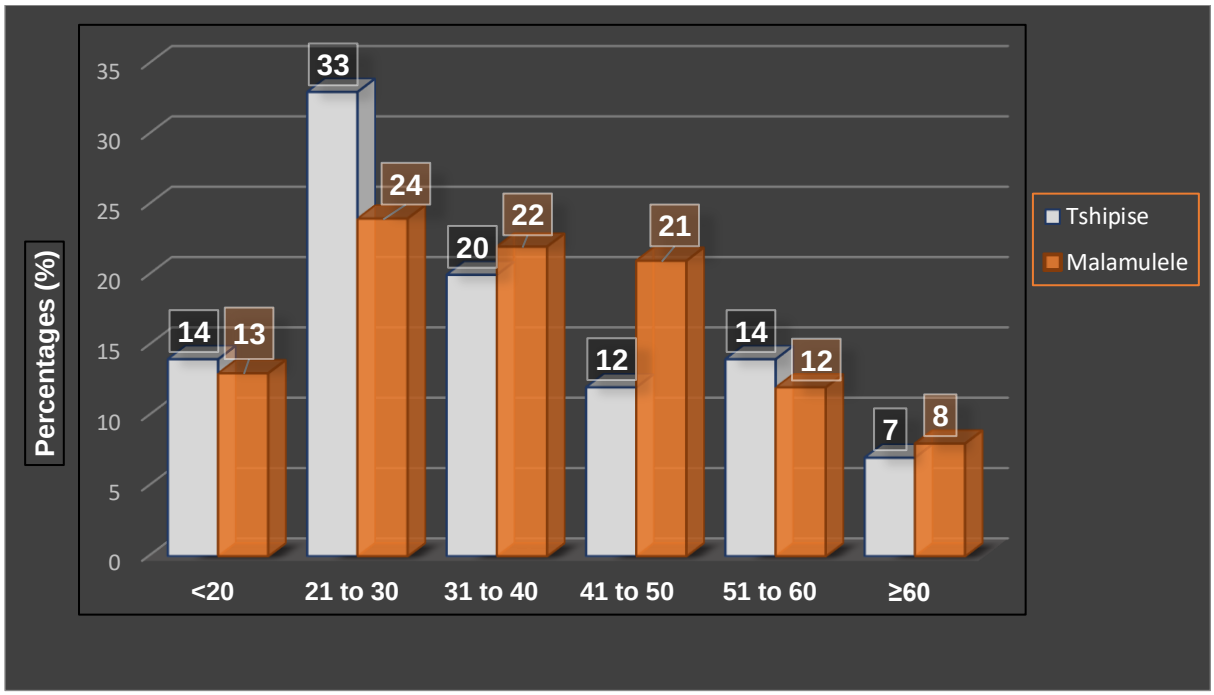

Figure 4.1 The age respondents at Tshipise and Malamulele area

The study revealed that participants aged below 20 from Tshipise area were 14% (12) and 13% (14) at Malamulele area. In this age group, 10 of the participants at Tshipise area and 11 at Malamulele area were school learners whereas 2 respondents from Tshipise and 3 respondents from Malamulele area were still young parents aged 15 to 17 years. These respondents knew about *Berchemia discolor* species and they utilized it to generate income by selling products such as wooden spoons to the local market after school. This age group showed that the species can be commercialized in local markets successfully.

The study showed huge commercialization potential because young participants were interested in harvesting and selling of products for financial stability. This was an active age group because during fruits harvesting time, they collect fruits in bulk and dry them so that they can be preserved. This age group revealed high proportionality of bioprospecting *B. discolor* species and its importance in the local market sales because it was enabling the development of new product markets and economic value of indigenous species.

The study showed the high rate of *Berchemia discolor* users between the age of 21 to 40 within Malamulele and Tshipise area. This age group had high number of people who contributed to the study. Malamulele area had 46% (52) of this age group whereas Tshipise had 53% (47) of participants in this age group. The findings showed that youth within the study areas had high chances of accessing the species where it was dominantly present. The findings showed that number of this age group uses the species to create self-employment opportunities by selling the fruits and other commercialized materials within the area and in other places.

The results revealed that participants in the area consider species utilization as a means for many profitable bioresources which are timber products and sales of fruits and a good approach of corporate social responsibilities in the local markets. This gives good commercialization opportunity towards *B. discolor* species. The results showed that this age group utilizes *B. discolor* species and shares its knowledge and benefits with others which they find more useful for further successful utilization.

Within the age group of 21- 40, the results also showed that respondents between the age of 31 to 40 contributed 20% (18) participation at Tshipise area and 22% (25) at Malamulele area. This was the age group that had most of the working-class people in both areas. These respondents were available between 16h00 and 18h00 after work. This emphasized that this age group does not have enough time for utilizing *B. discolor* species, yet they find the species more useful because they were benefiting from its fruits, and other products. Participants showed that they make extra income to boost

their financial sustainability and support their families due to *Berchemia discolor* sales of the products.

4.2.3 Educational qualifications of respondents in Tshipise and Malamulele areas

The level of education brought about the various proportions in the way people think about utilization of *Berchemia discolor* species. The study showed various understanding of bioprospecting of the species from people with formal education and those with no formal education. As presented Figure 4.2 showed the educational levels of the respondents.

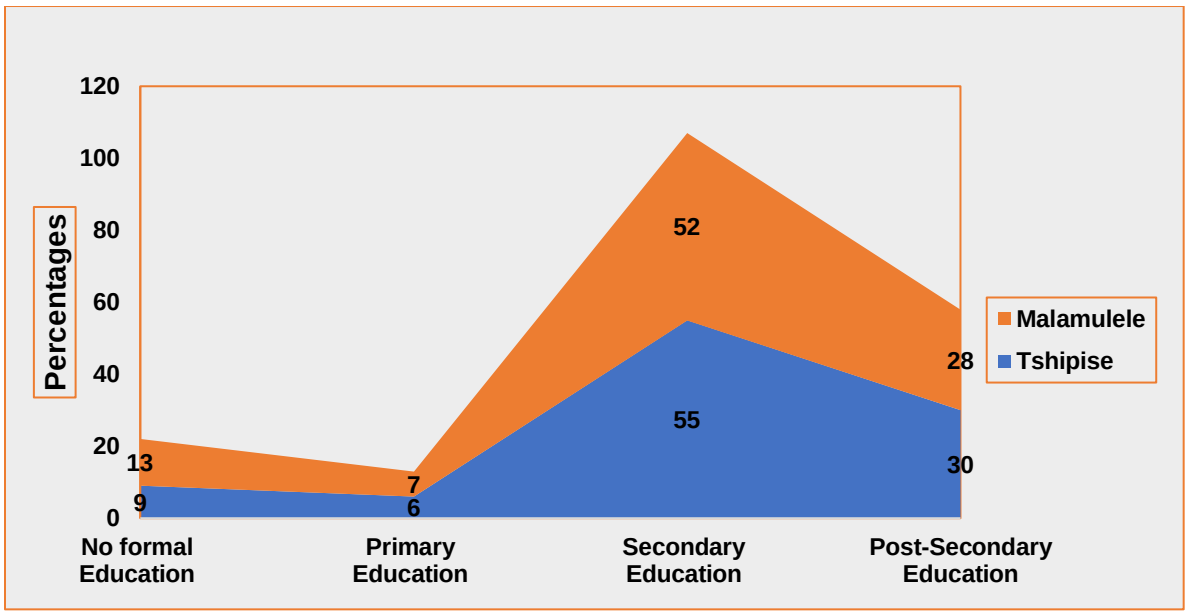

Figure 4.2 Highest educational qualification achieved.

The study found that 9% (8) of respondents at Tshipise and 13% (15) at Malamulele had no formal education. This age group had extensive knowledge about *B. discolor* species and its importance to the livelihood of the communities. These respondents revealed that *B. discolor* is useful by providing them with medicinal needs and provide them with timber to make useful wooden products from the species. This showed that these respondents were familiar with the use of *Berchemia discolor*.

The results indicated that there was a high number of people with secondary education within the study areas. The results showed that Tshipise area had 55% (48) of people with secondary education whereas Malamulele area had 52% (59) of people who had

secondary education. This concludes that the study had 53,5% (107) people with secondary education. Respondents with secondary education that gives good contribution to the society. These respondents showed *Berchemia discolor* as asset species by assessing its provision of benefits in the study area. Respondents showed they benefits more financially by making useful materials from the tree. They further alluded that they even research about the potentials that the species have so that they can exercise them at their homes. Those potentials included domestic and medicinal potentials of *B. discolor*.

Tshipise area was also having 24% (21) and Malamulele area was having 23% (26) of people who had grade 8 to 11 as their highest qualification. These people were still at school whereas 37 of them were school dropouts without pursuing grade 12. These respondents showed that they sell the fruits after schools and on holidays and weekends to make extra income.

The findings further indicated that Tshipise and Malamulele area had 30% (60) of participants who had grade 12 as their highest qualifications. These respondents showed that education enhanced their understanding that the potential utilization of *B. discolor* species contribute to the wide range of commercial activities that are useful in different households in the communities. At Tshipise area, about 31% (27) of respondents had grade 12 as their highest qualifications whereas at Malamulele, it was only 29% (33) of participants. The findings showed that major educational transformation towards rural areas because the study areas had good standard of education. Respondents who had Grade 12 at Tshipise and Malamulele area showed innovation through the potential of *B. discolor* utilization and engaged themselves in the selling and utilization of *B. discolor* products.

The findings revealed that Malamulele and Tshipise area were having 28.5% of respondents who had post-secondary education. This included people who have diplomas, higher certificates, degrees and postgraduates' students in different universities. Therefore, the study showed that 10% (9) of respondents at Tshipise and 12% (13) at Malamulele area have diplomas as their highest qualifications. Furthermore, another 10% (9) at Tshipise and 12% (13) at Malamulele were people

having degrees as their highest qualifications. These respondents stated that education helps them to identify new use, improve production and promote welfare of their local communities through research and reading of the bioprospecting regulations. The study also indicated that 10% (9) of people at Tshipise area and 4% (4) of people at Malamulele area who participated were postgraduates. Postgraduates in the study areas were having insight about bioprospecting and *Berchemia discolor,* and they provided valid information about the study according to what they understood because they read and know more about it and its potential benefits.

4.2.4. Respondents' positions within their respective families

The importance of showing family positions was to give an indication of people who utilize *B. discolor* within different households. The results showed that there are different points of view for utilizing the species as a breadwinner, parent and as a dependent. The findings showed that 41% (37) of people at Tshipise and 39% (44) at Malamulele who contributed to the study were dependents. The results showed that dependents contribute more and utilized *B. discolor* because they are mostly available in their households. The findings show that these people have potential to commercialize the species in local market and other nearby areas because they can access the species more than their parents and breadwinners in their families.

Nevertheless, the results showed that commercialization requires resources exploration, customers and ability to identify optical functionality of product. The results indicated that dependents in the study areas showed close relationship and interconnectedness among other people because high proportion of dependents utilized the species. Thus, increase the potential of *B. discolor* utilization and commercialization.

Furthermore, about 31% (27) of respondents at Tshipise households and 36% (40) of respondents at Malamulele area were parents. This means that they were also available during the study because they are taking care of their families everyday as they were unemployed. The findings highlighted that these participants create their own jobs by utilizing species and sell the products. The study postulates that the species act as an imperative asset during fruits bearing time.

About 28% (24) of the respondents at Tshipise area and 25% (28) of respondents at Malamulele were breadwinners. Breadwinners showed interest in *Berchemia discolor* species as one of the crucial species when it comes to financial generation during summer times by selling dried and raw fruits. These respondents were available between 16 and 18 hours after work. Respondents showed that there is a great potential in the utilization *B. discolor* for a commercialization purpose because the species has lot of benefits that many people can access and actualize to make a living. Breadwinners point out that during fruits harvest time, they reserved places where they can store dried fruits to commercialize when many people ran out of *Berchemia discolor* fruits.

4.3. Knowledge about *Berchemia discolor* species

The study comprised of *Berchemia discolor* species and in so doing, the results indicated that 97% of people at Tshipise were familiar with the species. This shows that the study took place in areas where people understand species to be bioprospected. Even though 97% people at Tshipise area seemed to know *B. discolor* species, there were 3% of respondents which were not familiar with the species. These people indicated that the species is not helpful to them since they do not use it. However, at Malamulele area all participants knew about *Berchemia discolor*.

About 86 out of 88 respondents at Tshipise area and 112 respondents at Malamulele area showed that overall, 99% of them were familiar with *Berchemia discolor* species because they were using it for years. Participants who were familiar with the species highlighted the advantages of being associated with it as a wild edible plant. The findings showed that 13 households out of 86 households at Tshipise area and 9 households out of 112 at Malamulele area were having the species within their yards.

Participants indicated that they have access to *Berchemia discolor* species even though some of the species were not matured. However, there were people who accessed the species easy in the forests and in the roadsides of the villages. These respondents concluded that the species has high opportunity to be actualized for commercialization since they enjoy its benefits throughout the years.

4.4. People's experiences in the utilization of *Berchemia discolor* species

The number of years that people spent with the biological resources within their areas determines the experience they have about the species or biological resource. The importance of including number of years that people have been using this species was to get different exposures of respondents towards *B. discolor*. Respondents gave their perceptions about the species according to the number of years they have been associated with it. Figure 4.4 shows the number of years that people have been using *Berchemia discolor* species.

The below figure shows that in age category 15-20, 41% (46) of participants at Malamulele and 40% (36) of participants at Tshipise areas have been knowing the species for less than 20 years. These are people who understand the *B. discolor* species and utilize it for its benefits. This proportion showed that these people has limited historical background of the species, yet they utilize the species using common knowledge they have. The high number of people associated with the species within both study areas showed greater importance of *B. discolor* since they utilized it with the knowledge they acquired during their years of association with the species. Respondents showed the value of utilizing the *B. discolor* species because they utilized it even though they were associated with it for few years.

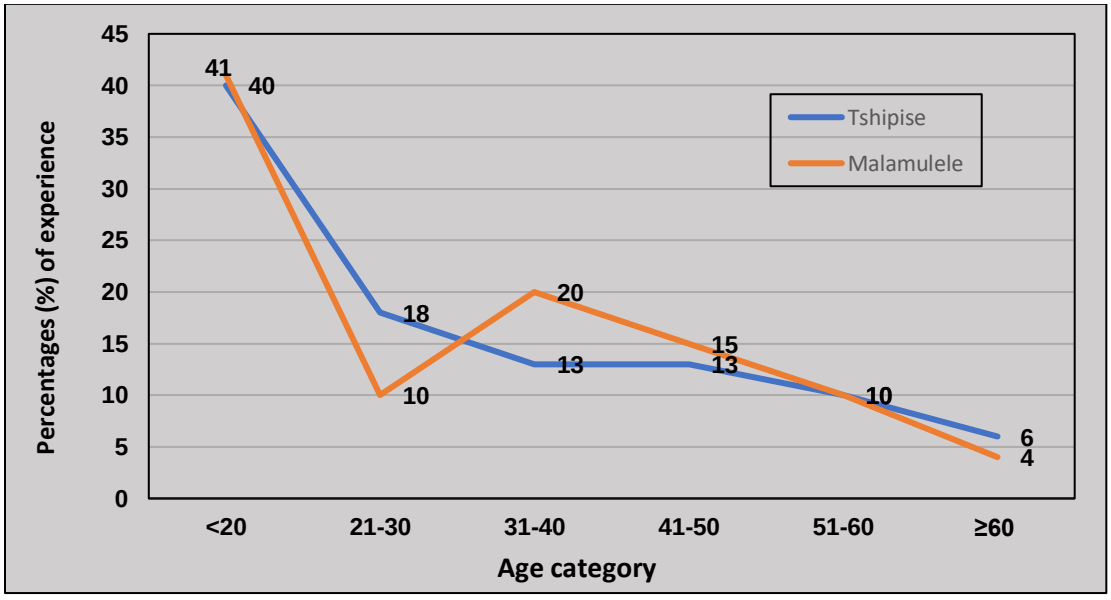

Figure 4.3 People's experiences in the utilization of *Berchemia discolor* species

In age category 21-30 18% (16) of people at Tshipise area and 10% (12) at Malamulele area who were familiar with *B. discolor* species for more than 20 years. Respondents within Tshipise experienced that the species is useful to treat stomach aches and to be eaten by people and animals. Respondents showed that using *B. discolor* species as a medicine depends on the experience they have over the years and knowledge of knowing species better.

The study revealed that 13% (11) of people at Tshipise area and 20% (22) at Malamulele area were using *Berchemia discolor,* and they were associated with it for 31 to 40 years. Respondents showed that the level of association with the species is important on how it is used. These respondents showed that species has some of the useful parts that develop over years which is used to treat people with birth problems. Respondents who were familiar with the species for 31 to 40 years revealed that they are part of those people experienced different parts of the species being used differently for many years.

The findings point out in age category 41 to 50 13% (11) of participants at Tshipise area and 15% (17) at Malamulele area were using the species for about 40 years and more. Moreover, 10% (9) of participants at Tshipise and 10% (11) at Malamulele area were associated with and using *B. discolor* for about 51 to 60 years. These were people who knew *Berchemia discolor* species from young age and witnessed it growing for a long time. The study also showed that only 6% (5) of respondents at Tshipise area and 4% (4) at Malamulele area have been associated with *B. discolor* species for 60 years and above. These respondents were old people and were associated with *B. discolor* since they were born.

The study showed that the respondents' level of association with *B. discolor* species played an important role in the provision of results of the study. People participated in the study because they knew the tree *Berchemia discolor* species and they were interested. Respondents also implied that being associated with the species for many years showed the usefulness of the species as food, timber, wound treatment and other uses.

4.5. Observed *Berchemia discolor* species

The observation was taken to assess the presence of *Berchemia discolor* species within the study areas. The presence of *Berchemia discolor* species was observed using DAFOR (Dominant, Abundant, Frequent, Occasional, Rare) scale to assess its relative abundance within study areas. The study used checklist to observe the presence of the *Berchemia discolor* species within the area. The total number of *Berchemia discolor* species found in both study areas were 70, thus, 26 *Berchemia discolor* species at Malamulele and 44 *Berchemia discolor* species at Tshipise area. The species were mostly found in the village not in the riverine areas.

At Malamulele area, the results indicated that *Berchemia discolor* species was dominantly present compared to other tree species in the area, mostly Acacia tree species. Species were dominantly distributed in the forest and near the rivers. However, in the households, the species were rarely distributed. These showed that *Berchemia discolor* species was dominant in the bushes than in the households.

Tshipise area showed high proportion of *Berchemia species* occurrence because there were 44 species observed. This showed that there was dominant distribution of *B. discolor* than Malamulele area. The level of species distribution between the two study areas was also influenced by the development which was occurring within. At Malamulele area, lot of developments took place and people cut down trees to build infrastructures. The researcher conducted the study during late summer, beginning of autumn when the species had fruits. About 58 *Berchemia discolor* (41) at Tshipise and 17 at Malamulele) out of 70 that were found during field work were matured, tall with fruits, brown- like stem and green leaves.

The findings showed that *Berchemia discolor* species is probably most spectacular looking tree species in the bushveld and in some households in different communities for humans, animals and birds. Plate 4.1 showed one of the species that was found at Tshipise area next to the road where people pass most of the time. It is one of the most well-known wild edible plant (WEP) species in the area that provides nearby citizens with variety of benefits and use. Plate 4.2 also showed *B. discolor* species that have

been located at Malamulele area, and it is one the species that are based within the respondents' household.

Plate 4.1 *B. discolor* species at Tshipise area

Plate 4.2. *B. discolor* species at Malamulele area.

Bioprospecting potential in terms of the *B. discolor* species at Tshipise area is in the bush (plate 4.1) while another one (Plate 4.2) is within the household yard. The colour of the leaves on the species at Tshipise area was greenish to yellow which shows the fruit bearing potential (Mmbengeni, 2017). This was fruit harvesting season because the species was having fruits which were ripen during field work. Yet, people with *B. discolor* within their households use to feed their animals with the leaves of the species and it also provided them with shade.

The study showed *B. discolor* potential in medicine as the species is useful for epilepsy, stomach aches, wounds and infertility problems which brings about its healthy values. The study also showed *B. discolor* potentials in food because respondents eat species fruits for nutritional values and commercialize them for finance benefits. The findings indicated that the species is one of the wild edible plants (WEP) that provides major livelihood strategies in indigenous local rural communities of Vhembe District Municipality. Thus, the species assist in food provision which regulate food insecurity in communities.

4.6. Uses and Benefits of *Berchemia discolor*

The findings in Table 4.2 showed the variety of *B. discolor* use in the communities of Tshipise and Malamulele area which were socio-economic, domestic and medicinal. The findings indicated that respondents from different locations, tribes, and the age group have provided how they use the species. *Berchemia discolor* species showed lot of different benefits that many respondents articulated at the study. The species seemed to maintain the livelihood standards of participants and gave them different benefits in different alignments.

During field work, 50% (44) of people at Tshipise area and 48% (54) participants at Malamulele area use the species to eat its fruits as food and as snacks. This means that 98 people out of 200 respondents of the whole study indicated that they use *B. discolor* for food and to snack fruits when they are dried. To add, 41 respondents out of 98 eat the fruits at their homes whereas 57 respondents out of 98 commercialize the fruits in the local market. This implies that the species has high opportunity rate of commercialization within local and nearby marketplaces in the area because of high demand of *Berchemia discolor* fruits. The number of people using these fruits showed the high demand within the communities and how useful it is to them.

Moreover, 10% (9) of participants at Tshipise area and 14% (16) of participants at Malamulele indicated that they use the species for timber. The results showed that the species has the potential of being used for wooden / timber products within different areas. To add, about 9% (8) of participants at Tshipise and 8% (9) of people at Malamulele area points out that the species is useful to treat woman with birth / infertility problems. Moreover, 8% (7) of respondents at Tshipise and another 8% (9) of respondents at Malamulele area used the species to feed livestock in their households. Furthermore, the species showed its demand in pharmaceutical point of view which determines another potential for medicine specifically for female people in this regard.

The findings showed that 7% (6) of people at Tshipise area and 8% (9) of participants at Malamulele area point out *Berchemia discolor* is also used to treat body wounds. However, 6% (5) of the participants at Tshipise area and 1% (1) at Malamulele area

indicated that they use the species to treat epilepsy disease. Yet 8% (7) of participants at Tshipise and 9% (10) of participants at Malamulele use it to treat stomach problems.

The study showed that there were people who use the tree only to gain shadow and only 4% (5) of them participated and they were found at Malamulele area. These were people who participated at the study and indicated that they do not use the species for anything, and they contributed only 2% of the study. All those people were found at Tshipise area. 2% of respondents showed that the bioprospecting opportunities at Tshipise are sometimes compromised because not all people believe in indigenous way of utilizing indigenous species. The use of *B. discolor* as indicated by the respondents were discussed as follows.

Table 4.2 Uses and Benefits of *Berchemia discolor*

Uses and benefits of *Berchemia discolor*	**Tshipise area (%)**	**Malamulele area (%)**
Provide fruits	50	48
Timber	10	14
Treat birth problems	9	8
Food for animals	8	8
Wounds treatment	7	8
Epilepsy treatment	6	1
Stomach aches	8	9
Shade	0	4
Nothing	2	0

4.6.1. *Berchemia discolor* provide sweet edible fruits

The study showed that out of 200 respondents, 50% (44) of respondents at Tshipise and 48% (54) of respondents at Malamulele indicated that *B. discolor* species provide them with sweet, flavoured fruits that they eat when they have ripened. Participants postulate that this species is one of the wild edible plant species which bear sweet flavoured fruits that the community members are aware of. About 98 people from both study areas who participated in the study ensured that *B. discolor* plant species

provides life-sustaining fruits during summer season and provides food with nutritional security. *Berchemia discolor* fruits are small drupes and tend to become yellow when ripened.

Berchemia discolor is one of the wild edible species that provide people with food benefits which helps them to maintain their basic living standard. Respondents indicated that the fruits of the species can maintain people from food insecurity. Many people contend that *B. discolor* species has high socio-economic livelihood sustainability when it comes to food provision. Thus, this species provides welfare benefits towards respondents.

The findings indicated that the *B. discolor* fruits are always in demand because they are pleasant and sweet which attract people and animals. Just like many wild edible plants species, the findings showed that *B. discolor* plant plays a vital role in most rural communities. People within rural areas benefit from *Berchemia discolor* by collecting its fruits for sales and eating. Findings indicated that about 49% of respondents of the study benefited from *Berchemia discolor* species.

Respondents also state that the plants provide enough fruits which influence them to have commercial ideas and sell in the local markets. The results showed that people from both study areas do sell *B. discolor* fruits in their local markets to gain income. These fruits are used or available for income that alleviates poverty. At Malamulele area, respondents argued that the fruits of the species have lot of money mostly when they are dried whereas in Tshipise area most people indicated that selling raw fruits generate faster income than dried ones. Moreover, in both study areas, young people were interested in the commercialization of the fruits since they gain income to sustain them at schools.

The findings showed that *B. discolor* species produce fruits which also support their livestock and other wild animals within the area. Thus, it entails that people compete with herbivorous animals, birds and other animals that feed with *B. discolor* fruits during fruits bearing season. However, most people showed that they consume and preserve

fruits by drying them and store for later use. This showed that the fruits have high edible prospect for human beings because they can preserve it for a long time than animals.

In addition, participants from Malamulele area showed to have the experience of drying the fruits and they further mentioned that dried fruits become sweeter than undried raw fruits. Participants explained that dried fruits of *B. discolor* can also be eaten as snacks. Moreover, the findings showed that the same dried fruits can also be smashed to make what is called smooth snack (Mugume) in Tshivenda and Mahlahla in Xitsonga. These findings indicate that the species has high potential gains through fruits only that can be benefited through commercialization. The fruits of *B. discolor* has high opportunity for utilization because people know how to use it for different purposes. In addition, this species also produces flowers during fruits bearing season, that contain much pollen, which is eagerly collected by bees during the flowering season and provides an excellent honey.

The study also showed the species' nutritional potentials through the use of the *Berchemia discolor* species. Respondents' states that *B. discolor* are nutritionally important to the people. Respondent within different study areas showed that they get nutritional benefits from *Berchemia discolor* species through eating of fruits. Nevertheless, respondents showed that bioprospecting of *B. discolor* plant resources can be a potential way of ensuring nutritional security to many people in the near future. This ensures that *B. discolor* species have a good potential to be commercialized for the provision of Nutritional value and also income generation to the respective bioprospectors.

Plate 4.3 presents bird plum fruits that were taken at Tshipise area during field work when the fruits have ripened and changed colour from green to yellow. In addition, plate 4.4 shows *B. discolor* plant species that has fruits which has ripened and dried. The picture was taken at Malamulele area during field work.

Plate 4.3. Bird plum fruits (Tshipise)

Plate 4.4. Bird plum fruits (Malamulele)

4.6.2 Medicinal uses and healthy benefits

The study showed that the development of indigenous medicinal plant species has been seen as a necessity for effective health promotions. The results indicated that out of 200 respondents in both study areas, the overall of 30% (26) at Tshipise and 26% (29) at Malamulele indicated that they get medicinal and health benefits from *B. discolor* species. The findings showed that *B. discolor* as a WEPs is rich in vitamins which ensures good health in human beings and animals.

The findings showed that the species is a good provider of food, and medicinal product which makes it important for the health care needs of participants in the study areas. Respondents ensured that the species treat different diseases and heal different conditions that affect people's health. One of the traditional healers at Tshipise indicated that he receives different cases for people who come for treatment. Moreover, in many cases, the species seems to be useful which shows that they benefit from pharmaceutical perspectives. Thus, the use of *B. discolor* species as a medicinal plant species is becoming a commodity with value. Traditional healers indicated that there is a demand for *B. discolor* species wherein they even go out to look for important part of *B. discolor* that they use to heal people. Respondents from both study areas showed to

have some special indigenous knowledge for the use of medicinal plants for the treatment of diseases.

Nevertheless, participants who attested more about medicinal benefits were traditional healers who had experience in using the parts of the species to heal people. They were skilled persons and have knowledge about the importance of different plant herbs used for the treatment of diseases. They argued that *B. discolor* species have slow growth rate, causing high demand and makes them to travel long distances to access matured tree species. However, these people also showed that the species are not prone to extinction, but the limited number of existing matured tree species limit the rate of utilization and the use of their indigenous knowledge in the communities.

The findings showed the healthy and medicinal benefits of *Berchemia discolor* benefited people by helping them to treat birth problems, wounds treatment, epilepsy treatment and stomach aches.

- ***Berchemia discolor* used to treat infertility problems**

The findings indicated that it is possible to use *B. discolor* to treat women with infertility or birth problems. About 9% (8) of respondents at Tshipise area and 8% (9) at Malamulele showed that birth problems can be treated by using the water which comes from the little part of the branch of the species (Plate 5). Based on respondents' perspectives, the part of tree produces water that assists women who always miscarry their unborn child. This emphasizes that *B. discolor* plants species plays a central role in the treatment of existing diseases by providing raw material to the traditional herbal healers. This indicates that the plant has a high potential to provide pharmaceutical industries with medicinal opportunity.

One of the traditional healers further contends that this part of the tree must be boiled until the colour of the water changes. In addition, any woman who has infertility problem only drinks the boiled water and be healed. Respondents who participated stated that they do commercialize such medication but only to the people who need it and not in local markets.

The study showed that the development of indigenous medicinal plant species has been seen as a necessity for effective health promotions. The results indicated that respondents in both study areas get health benefits from *B. discolor* species. Even though not many people showed to gain healthy benefits from this species, WEPs are rich in vitamins which ensure good health in a human being and animals.

The findings showed that the species is a good provider of medicinal product which makes it important for the health care needs of participants in the study areas. Respondents showed that the species treats different diseases and heals different conditions that affect people's health. One of the traditional healers at Tshipise point outs that he receives different cases of people who come for treatment and the species seems to be useful to many. Plate 5 showed the last part of the *Berchemia discolor* species branches which is used to treat infertility problem.

Plate 4.5: Part of *Berchemia discolor* species that is used for infertility treatment

- **Wound treatments**

The study showed that 7% (6) of people at Tshipise area and 8% (9) of people at Malamulele area use *B. discolor* species as a medicine to treat wounds in human body. It has been revealed that this species is important for wounds treatment. Respondents at Tshipise and Malamulele areas showed that water that comes from the roots of *B. discolor* species act as a medicine to treat wound of cancer disease called Tshipfula in Tshivenda and also known as Xifula in Xitsonga. Scientific medicinal term for this

disease is called wet gangrene. This is one of the diseases that occur in many parts of the body such as hands and legs and if not treated in time, it can lead to death. In some instances, some of the people who have this disease also lose parts of their bodies in hospitals and clinics.

The results showed that for such medication to work, the roots of the species are dug and boiled to get its water. The water acts as a mechanism to absorb all pus in the wound which makes it less painful. Moreover, the wound of the cancer described is known to be painful and it oozes brown pus which is so smelly. Findings implied that most people who provided such medicinal knowledge were traditional healers and elderly people who were familiar with the tree species for a long time. The study postulates that most of the *B. discolor* bioprospecting opportunities arise from the knowledge of traditional people and utilization of indigenous species. However, this showed that the initial success for bioprospecting process is the interaction between traditional knowledge holders and bioprospectors.

Respondents at Tshipise area and Malamulele area state that the species benefit them from pharmaceutical perspectives. Thus, the use of *B. discolor* species as a medicinal plant species is becoming a valuable asset to them. Respondents from both study areas showed to have special indigenous knowledge for the use of medicinal plants and their use for the treatment of diseases.

- ***Berchemia discolor* used for Epilepsy treatment and Stomach problem**

The results indicated that the barks of *B. discolor* are used to treat people with epilepsy. Only 6% (5) of respondents at Tshipise area and 1% (1) of people at Malamulele who participated indicated that epilepsy is dangerous, and it happens anytime. However, people also indicated that they use barks of *B. discolor* and mix it with some of their indigenous medicinal species to produce epilepsy treatment. The findings showed that the species is a main source of the traditional epilepsy medicine because it cannot work without *B. discolor* barks.

The study showed that the barks of *B. discolor* species is regarded as one of the best parts of the tree which helps and promote certain uses in rural communities. About 8%

(7) of people at Tshipise area and 9% (10) at Malamulele area in the study, indicated that the barks of the species are used as to produce laxative like medicine which is very helpful to treat stomach problems such as constipations and stomach aches. Most people in rural areas prefer using this type of traditional methods to treat stomach aches because they provided that there is a huge demand of healthy facilities in their communities. The results showed that people who suffer from Peptic ulcer also use the barks of *B. discolor*. However, only 1% of participants at Malamulele showed that they also use the barks of the tree for stomach problems. Plate 6 presents the barks of *B. discolor* species that were taken at Malamulele area.

The findings indicated that conditions such as epilepsy and stomach problems which requires the use of tree bark, put the tree species in danger because people chop it to get barks. Respondents' states that some of the trees mostly those that are not yet matured are prone to die after being chopped. This reduces the distribution of *B discolor* in other areas. Plate 6 showed the barks of *B. discolor* species.

Plate 4.6. The barks of *B. discolor* species

Traditional healers also indicated that they sometimes work with health facilities to share their experiences even though they do not get paid because it is a voluntary sharing of knowledge. The study indicated that the long-term sustainability of medicinal plants is an essential commodity for health care, it remains important to regulate the medicinal plant stock. Nevertheless, the need is to explore different tools for

strengthening the plant sectors including biotechnology, community conservation, bioprospecting, and ways to preserve biopiracy.

4.6.3 Domestic uses and financial benefits

The study indicated that *Berchemia discolor* species is one of the important potential contributors to the respondents' cash economy within the areas. The findings showed that the species is one of their financial contribution sources especially to unemployed people.

The results showed that people from both study areas do sell the fruits of *B. discolor* in their local markets to gain income. Respondents showed that *Berchemia discolor* WEPs are used or available for income smoothing that determines vulnerability to poverty. At Malamulele area, respondents argued that the fruits of the species have lot of money mostly when they are dried whereas in Tshipise area, respondents indicated that selling raw fruits is faster and more profitable than dried ones. Moreover, in both study areas, even young people were interested in the commercialization of the fruits since they gain income to use in their schools. The other income generators from *Berchemia discolor* are timber products and fuelwood.

- ***Berchemia discolor* timber uses and benefits**

The study shows that 10% (9) of respondents at Tshipise area and 14% (16) at Malamulele area use *B. discolor* species for timber. They showed that the species provide them with timber benefits which they use to produce valuable product that they sell within their areas. Those products include wooden spoons, hoe handles, wooden tables, and *B. discolor* fruits that can make a living for almost a month. This promotes more efficient economical potential development that boosts the lives of people who utilize *B. discolor* in rural areas. This indicated that *B. discolor* species has potential to be commercialized by utilizing it for timber purposes.

Respondents in this area showed that the branch stems of the trees are very hard which makes their products reliable and being bought by many people. The findings showed that products are being sold to their respective local markets. However, product such as hoe handles are always in demand in time of summer seasons when people want to plough. The findings showed that most people who focus on making money through

indigenous species are unemployed, elderly and self-employed people and the contribution from these self-made product makes a huge difference in their livelihoods.

- **Fuelwood benefits and uses**

Berchemia discolor species is a tree that has hard stem which makes good firewood in the rural communities. The results indicated that 9% (8) of people who participated at Tshipise area and 14% (16) of participants at Malamulele showed that *Berchemia discolor* species has hard stem which makes good firewood. Respondents indicated that they use wood to cook because they have limited access of electricity whereas some have low-income budgets which do not allow them to buy electricity to cook but only to use for lights due to expensive electricity tariffs.

Respondents indicated that electricity do not last longer if they use it for cooking. This means that the species maintain the livelihood of the citizens and provide everyday needs to the rural communities where it is widely distributed. Participants showed that *B. discolor* wood are used in braais and some people chop them in a nice way and place them in the plastics to sell them on the side of the main roads for income generation. The study revealed that respondents gather wood daily in the forests because they have to cook food for their families. However, respondents showed that they gather wood for *B. discolor* and other species' so that their families can get fuels to cook whereas some do so to get financial benefits by selling firewood.

4.6.4 Berchemia discolor provide food for animals

Most of the herbivorous wild and domestic animals in rural communities feed from grass and tree species that are found in the area. The study showed that 8% (7) of the people at Tshipise area and 8% (9) of the people at Malamulele indicated that *Berchemia discolor* is one of the species that feed most of herbivorous animals. Results showed that animals such as goats and sheep feed from fruits and leaves of the species. This means that the ability to maintain the sustainability of *B. discolor* at the area is limited because it is used by human beings and animals for different purposes. This limits the chances of people and domestic animals to get enough fruits and other useful parts of the *B. discolor* species.

Respondents showed that the yellow fruits of the species act as a source of food to feed Louries, Hornbills, and other different birds in the bushes. Kudus, impalas, nyalas, bushbucks and klipspringers eat and enjoy the leaves of *Berchemia discolor* species. However, baboons and monkeys feed by eating the fruits of the tree whereas the fallen fruits are eaten by bush pigs, duikers and hyraxes. These create competition of *Berchemia discolor* resources between people and animals. Thus, the species has high potential of being utilized and used by animals and human beings.

The study found that the species' nutritional potentials in the communities is now recognized. People showed that *B. discolor* species have nutritionally importance in indigenous people as a contributor of food in the areas. Respondent within different study areas showed that they get nutritional benefits from *Berchemia discolor* species through eating of fruits. Nevertheless, the results showed that bioprospecting of *B. discolor* plant resources can be a potential way of ensuring nutritional security to many people in the near future.

4.6.5 *B. discolor* species to provide shade

The findings revealed that only 4% (5) of people at Malamulele area use *B. discolor* species only to provide them with shade during the day when the sun rises. The results showed that the species that were used for shade were matured, yet some were still young to bare fruits.

4.7 Commercialization of *Berchemia discolor* within study areas

Commercialization of *Berchemia discolor* products is most essential steps in any many rural indigenous people in the study areas. Respondents showed that when the species produces good wooden products, medicine and food. Respondents entailed that when the species product is available, it should reach to desire market fulfilling the demands of the customers. The findings support the point of view that commercialization demand the ability to identify and access the required resources to gain market profit.

The study showed that about 64% (56) of people at Tshipise and 66% (74) of participants at Malamulele area indicated that they commercialize *B. discolor* species in their local markets. The main reason is for them to gain money out of the products that

they produce from the tree and by selling fruits. This ensures that only people who can access the tree species in the communities since most of them are in the bushes can have a good commercialization access. This limits the market value of the respondents who depend on indigenous species for to get money and those who used it such as traditional healers.

The findings showed that for respondents to bring a new product to market requires the demand of that product, market value and time to accumulate enough product for the threshold. Although *B. discolor* production of product is not that feasible, high number of available products in the local market are commercialized.

About 36% (32) of them at Tshipise area and 34% (38) at Malamulele area indicated that they do not sell or commercialize any part of the tree species. They state that they have never seen people selling the fruits around the communities and they believe that the species cannot be commercialized anyhow.

4.8 Bioprospecting of *Berchemia discolor* species

The contribution of bioprospecting to the development of traditional communities is significant and continues to grow progressively. The study showed that bioprospecting helps in social and economic development of rural communities, however, 74% (148) of respondents do not understand this process. The study found that 29% (26) of people at Tshipise area understand the process of bioprospecting and how it is put in place. At Malamulele, only 23% (26) of people understand the process of bioprospecting and how it can be taken into consideration.

Bioprospecting is simply the exploration, conservation and sustainable utilization of bio-resources. However, some respondents showed that bioprospecting denotes the competent search for new marketable organisms, especially previously unstudied species. About 71% (62) of the respondents at Tshipise area showed that they do not know about bioprospecting process and its socio-economic perspectives. Yet, at Malamulele area, 77% (86) of the respondents showed that they do not understand bioprospecting process. However, the findings showed that bioprospecting is the most

asset to nature that ensures sustainable exploration of species which benefit humankind even though many rural people are not practicing it.

The findings revealed that 26% (52) of participants understood the process of bioprospecting in both study areas. This showed that bioprospecting-based processes offer new possibilities for sustainable exploration and commercialization of bio-resources from rural areas to the big cities and some countries. Moreover, respondents further state that for people to understand bioprospecting, there must be good development of bioprospecting industries that can be practiced.

4.9. Potential challenges of utilizing *Berchemia discolor* species

The utilization of *Berchemia discolor*, just like any other species has severe challenges that hinder its sustainability if not well utilized. The findings showed that the challenges hinder the respondents to have good commercialization opportunity of the species. The findings revealed that challenges include competition between human and wild animals towards fruits benefits, deforestation for wood and timber purposes, species accessibility and the height of the tree species. Figure 4.5 showed the challenges of utilizing *B. discolor* species.

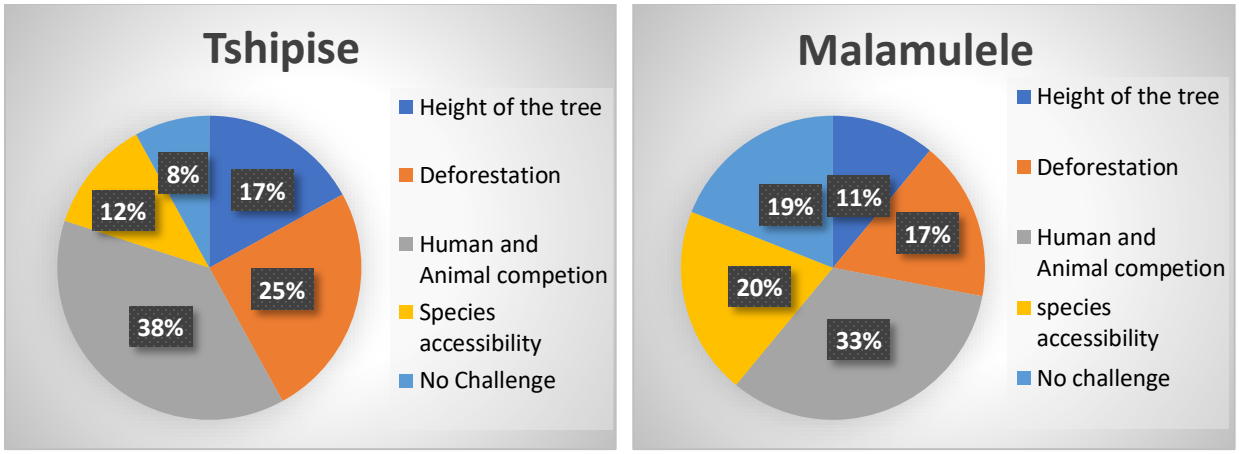

Figure 4.4 Potential challenges of utilizing *B. discolor* species.

4.9.1 Height of the tree

The findings show that 17% of people at Tshipise and 11% of people at Malamulele area state that the height of the species becomes a challenge during fruits bearing seasons. These respondents emphasized that they have a challenge of accessing fruits

which are on the top branches of the tree except if they have someone who can climb the tree for them. The height of the tree was emphasized as one of the challenges that hinder the process of utilizing *B. discolor.* This means that the potential of utilizing *B. discolor* species is compromised because respondents will have limited fruits of the species. However, animals like monkeys and other wild animals benefit from the fruits on the top branches of the tree since they do not have high competition with human beings in the area.

4.9.2 Deforestation

People at different areas deforest tree species for many reasons. About 25% of respondents at Tshipise area and 17% of participants at Malamulele area showed that deforestation is the other challenges that restrict potential utilization of *B. discolor* utilization. Findings showed that people practice deforestation for different reasons such as firewood for cooking. The study revealed that people deforest this species for medicinal purposes and for timber materials that other produce to gain money. The results showed that many species are being deforested, the less the accessibility of its product. This means that people who deforest *B. discolor* species contribute to the reduction of its potential benefits.

4.9.3 Human and animal competition

Berchemia discolor species produces fruits that are eaten by both herbivorous wild animals, human being and other animals such as bird etc. The study indicated that 38% of respondents at Tshipise area and 33% of respondents at Malamulele area indicated that there is a high competition between human beings and wild animals in times of fruits harvesting in their areas. Most of the times, wild animals eat the fruits before human beings can harvest them which poses a challenge because people lack enough products to utilize from the species. They further indicated that wild animals have easy access to the species than human beings and it reduces the chances of actualizing the species.

4.9.4 Species accessibility

The findings postulate that most of the species within the study area are at the forest and are not that easy to access whereas some are at the roadside and at people's households. The results showed that 12% of respondents at Tshipise area and 20% of respondent at Malamulele area have a challenge of accessing the species because of the distance that they must travel. They indicated that most of the species are at the bushes, and it is not easy to access them, thus the potential for this species to be actualized becomes limited to some people. However, even though people face this challenge, they indicated that the species is much useful to them, and they travel to get where they are widely distributed within their areas.

4.9.5 No challenges

Even though some people in the area showed that they have challenges regarding *B. discolor* utilization, about 8% of the respondents at Tshipise and 19% of respondents at Malamulele area showed that they do not encounter challenges towards the utilization of these species. These respondents indicated that they utilize the species without travelling long distances and they enjoy its benefits because they are associated with it in an accessible area.

4.10 Strategies for enhancing commercialization of *B. discolor*

The study showed that the utilization of a *Berchemia discolor* tree species has tremendous importance within Tshipise and Malamulele areas. Respondents showed that the utilization of *B. discolor* can have negative impact in its distribution. This means that if people utilize the species without conserving it, there will be a high demand because it takes long for it to grow. Figure 4.6 showed the feasible strategies that can improve commercialization potentials of *B. discolor.*

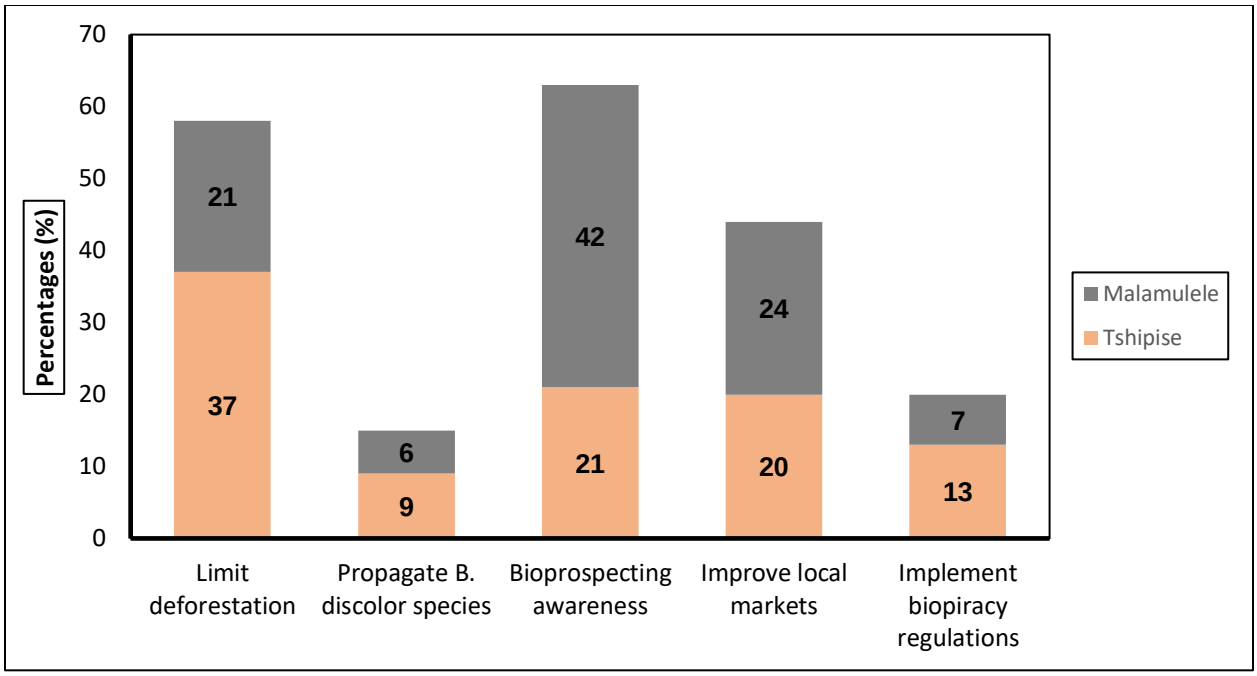

Figure 4.5 Feasible strategies to improve *B. discolor* commercialization.

4.10.1 Limit deforestation

The findings showed that 37% (32) of respondents at Tshipise and 21% (23) of participants at Malamulele reveals that the best strategy is to limit *B. discolor* deforestation. These respondents showed that they deforest the species for timber purposes and in the process of deforestation some of the species die. Deforestation of indigenous species is very high in rural areas because people use them for many timber purposes, cooking and building infrastructures. Respondents showed that some timber products manufacturing need part of the species to be cut out whereas some need the whole trees to be cut down. For example, hoe handles, and wooden spoons can be manufactured without cutting down the whole tree whereas products like tables like cutting down of *Berchemia discolor* species decreases the chance of it to be utilized for further commercialization because it takes time to grow and be matured.

4.10.2 Propagate *Berchemia discolor* species

The findings showed that propagation of *B. discolor* species in both areas is another feasible strategy to sustain commercial utilization of the species. The study showed that people must adopt afforestation as a process of improving the species distribution so that it cannot extinct. About 9% (8) of respondents at Tshipise area and 6% (7) of

participants at Malamulele area indicated that propagation of species is the best strategy because it increases the rate of *B. discolor* distribution. At Malamulele area, the rate at which people use the species for timber seemed to be high and that influenced people to see the need to propagate the species.

4.10.3 Promotion of bioprospecting awareness

The study indicated that most the people do not understand the process of bioprospecting and how it works. In so doing, 21% (19) of respondents at Tshipise area and 42% (47) of participants at Malamulele area indicated that giving awareness and bioprospecting knowledge to the community can be the best strategy to increase the rate of *B. discolor* commercialization. Thus, people from all study areas can be familiar with the process of utilizing species for commercialization.

To add, when people understand bioprospecting, it becomes easy for them to practice it and increase the rate of commercializing the species. The findings showed that respondents need to be familiar with bioprospecting process for sustainable utilization of species to produce market value product that can be commercialized successfully.

4.10.4 Establishment and improvement of local markets

The study showed that local markets produce and sell most of the indigenous species' products. About 20% (18) of respondents at Tshipise area and 24% (27) of people at Malamulele area indicated that the improvement of local markets sales is another strategy to improve commercialization of the species. The findings showed that the improvement of local market sales increases the rate of employment in the areas as the species is dominantly distributed and commercialized in high rate.

Thus, when local market improves the rate at which *B. discolor* is sold, many people become aware of the species and popularize it into different marketplaces. Within the two study areas, local markets have potential to commercialize the species because respondents have easy access of *Berchemia discolor*. This encourages them to harvest more fruits and other part of the species to produce products for commercialization.

4.10.5 Implement biopiracy regulations

The findings showed that people in rural areas are not familiar with access and benefits sharing regulations which leads to biopiracy. About 13% (11) of respondents at Tshipise area and 7% (8) of participants at Malamulele area state that implementation of biopiracy regulations at rural areas can improve the rate of commercialization. The results showed that people must be aware of the protocols to follow when accessing bioresources and benefits in rural communities. However, respondents state that bioprospectors must clearly state their biopiracy policies for the successful utilization of the species. This improves the rate of commercialization of that species.

4.11 Conclusion

This subsection of chapter 4 presented the key findings of *Berchemia discolor* utilization and its socio-economic prospects within the two study areas. The findings from face-to-face interviews, questionnaires and the data observed through field observations were presented in this chapter. *Berchemia discolor* species was found to be the most useful species at Tshipise and Malamulele area which is used for different purposes. The study provided results about the bioprospecting potentials that can be utilized for future commercial bioprospecting. Different uses and benefits of *B. discolor* species were also provided. Feasible improvement for commercialization potentials of *B. discolor* species was outlined.

Berchemia discolor plant species was viewed as tapped or utilized resources that is playing a significant role in rural development, poverty alleviation, livelihood and nutritional security of local communities. Moreover, with the applications of suitable science and technological interventions, this species can be utilized for bioprospecting purposes.

CHAPTER 5: RECOMMENDATIONS AND CONCLUSION

5.1 Introduction

This chapter provides the general conclusion and recommendation of the study and highlights the answers to some questions that were constructed in the initial stage of the research. The study recommended the feasible strategies for improving the commercialization potentials of *Berchemia discolor* at Tshipise and Malamulele area.

5.2 Synthesis of the findings

The study achieved the first objective which is "to establish the bioprospecting opportunities that can arise from the utilization of *Berchemia discolor* using indigenous knowledge system". The study established bioprospecting opportunities from utilizing *Berchemia discolor* using indigenous knowledge system. Opportunities were identified through several potentials of utilizing *Berchemia discolor* species within Malamulele and Tshipise area. The species was found useful in the study areas regardless of the season in which the data were conducted and was very helpful to indigenous people in both study areas.

The study explored the perception and understanding of *B. discolor* utilization and its bioprospecting potential from respondents since they utilized the species for important uses. The species was found useful in treating different diseases that affect human beings. *Berchemia discolor* showed its potential in pharmaceutical perspectives by treating body wound of human beings, infertility problems and stomach problems.

The study established opportunities from *Berchemia discolor* utilization because the species is useful to provide strong timber materials, sweet edible fruits and food for animals. Timber materials provided lots of financial gains by selling products like wooden spoons, home-made tables and hoe handles to the local market. The species showed its potential in the provision of fruits which are sweet. The species provided fruits for respondents, and they use raw and dry them to eat as snacks. This has showed huge opportunity for the species to be bioprospected since the fruit can be dried and preserved for a long time. Animals also gained food by enjoying leaves and fruits of the species.

The second objective which is to investigate the benefits that can be derived from bioprospecting *Berchemia discolor* was also achieved*. Berchemia discolor* species was evident to provide lot of benefits that were derived from bioprospecting at Tshipise and Malamulele area. Health benefits, financial benefits, social welfare benefits, nutritional and fuelwood benefits were the most common benefits that people gained from *Berchemia discolor* species. The species was found beneficial by providing healthy fruits with nutritional benefits from its utilization. The results showed the species as a valuable asset in the study areas because it was providing high commercial gains through its bioproducts. Respondents utilized the species to generate fuelwood for cooking which helps them to manage the use of electricity since electricity tariffs were meant to be expensive in the study areas.

The third objective which is to determine the challenges that could arise from the utilization of *Berchemia discolor* species was achieved. The study determined the challenges that hinder the utilization of the species in the study areas. The challenges included the distance between the household and the species location, the height of the tree, deforestation and herbivory destruction. Moreover, the study showed that many respondents do not understand biopiracy regulations and bioprospecting and their implementation. This poses a challenge because bioprospectors can exploit the resources without giving back to the community.

The study also achieved the fourth objective which is to develop feasible strategies for improving the commercialization potential of *Berchemia discolor*. The strategies were developed, and they have a good approach in improving commercialization opportunities of *Berchemia discolor*. The strategies were to limit deforestation, propagate *B. discolor* species, implement bioprospecting awareness, improve local markets and to implement biopiracy regulations. The study showed that for a successful utilization of the species, people must limit cutting down of trees and practice propagation of the species in different parts of the area. The study indicated that bioprospecting awareness must be implemented so that people must understand the rationale behind commercial utilization of indigenous species. In addition, the implementation of biopiracy regulations was more prone to be discussed as a good

strategy because it is important for bioprospectors to give share benefits by giving back to the community. This also improves the market value of the species because when respondents benefit from the species, they preserve and utilize it in a sustainable way.

5.3 Recommendations

The study recommends the following feasible strategies to improve the commercialization of *Berchemia discolor* species.

5.3.1 Bioprospecting awareness

The study recommends bioprospecting awareness to improve the commercialization of *Berchemia discolor*. The study indicated that respondents should be aware about the importance of bioprospecting indigenous species through community meetings, awareness campaigns and articles. It is recommended that people need to be educated about the sustainable utilization and risks of overutilizing species for bioprospecting purposes. The awareness must also be implemented through school programmes or environmental and bioprospecting non-governmental organizations (NGOs). The study recommends the need to implement bioprospecting biopiracy, access and benefit sharing (ABS) regulations. However, ABS regulations need to be simple and easy to comprehend and not discourage bioprospectors by being too stringent and time-consuming.

5.3.2 Indigenous knowledge transfer from generations to generations

The study recommends transfer of knowledge from one generation to the other as another strategy that can improve the commercial utilization of *B. discolor* in the future. The study showed that adults in most of the rural areas do not share all indigenous knowledge to the younger generations. Indigenous elderly people call it a taboo to speak sensitive information to their younger siblings. However, the study recommends that elderly people share indigenous information which is related to *Berchemia discolor* utilization because it will improve successful bioprospecting of the species.

5.3.3 Market orientation approach

The study recommends market orientation approach as another strategy that people must adopt for the improvement of *B. discolor* utilization and commercialization. There is a need for broader conceptualization of sustainable market perspectives so that the utilization of the species can be successful for commercialization. Respondents must produce the commercialization flow of *Berchemia discolor* utilization in their areas so that they can improve local markets.

5.3.4 Propagate *B. discolor* in accessible areas

The study recommends propagation of *B. discolor* in an easily accessed areas for people to utilize without lack of access to the species. This will simply improve chances of the species sustainable utilization in future for bioprospecting. *Berchemia discolor* species can be propagated by NGOs during World Environmental Day (WED), Abour week and also as an afforestation habit to the community.

5.3.5. Conduct more scientific research on *Berchemia discolor* production

The study recommends for further scientific research to be conducted about *Berchemia discolor* production. The issue of marketing and pricing of *Berchemia discolor* products should be addressed. There is a need to recognize this species and its value-added products in the local, national or international markets.

5.4. General conclusion

The study concluded that *Berchemia discolor* species has several potentials of producing valuable bioproducts for commercialization. The findings showed that there are many factors influencing people from using the species for many purposes. These factors showed that the species is useful in terms of medicinal purposes, food purposes and timber productions. The findings also showed species sustainability in terms of food security. Thus, the fruits of the species can be dried and preserved for a long time for future use which ensures good bioprospecting potentials.

There are lot of knowledgeable information which were shared by respondents to ensure smooth commercialization of the species. Thus, respondents suggested that the bioprospecting awareness must be promoted, biopiracy regulation must be

implemented and local markets need to be established and improved. *Berchemia discolor* was found beneficial and there is a need for its recognition in local and national market. Thus, more research is needed for the enhancement of *Berchemia discolor* bioprospecting.

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APPENDICES

Appendix A: Research Questionnaire

Researcher's Name: Mugari D

Respondent number ☐

Topic: Bioprospecting of indigenous species *Berchemia discolor* and its socio-economic prospects at Vhembe District Municipality

Summary of the questionnaire

This questionnaire is meant for academic purpose only. The information contained will not be used for any other purpose. The intended participants are the residents of Tshipise area and Malamulele area, which fall under Musina and Collins Chabane local Municipalities. Confidentiality and anonymity will be respected and guaranteed. Respondents will participate voluntarily and will be protected from any harm. The information you give will be kept securely and not revealed to anyone else.

*N.B. Please mark your answer with an **X** where applicable*

Demographic information

1. *What is your gender?*

Male	
Female	

2. *Which age group do you belong to?*

< 20	
21 to 30	
31 to 40	
41 to 50	
51 to 60	
≤ 60	

3. *What is your highest academic qualifications?*

None	
Grade 1 to 7	
Grade 8 to 11	
Grade 12	
Diploma	
Degree	

Postgraduate	

4. *What is your position in the family?*

Breadwinner	
Parent	
Child	
Other	

If other, specify

_____

5. *Under which tribal group do you belong?*

Venda	
Tsonga	
Pedi	
Other	

If other specify

_____

General information

6. Do you know *Berchemia discolor* species?

Yes	
No	

7. What do you use this species for?

_____
_____
_____
_____

8. What are the benefits of using this species?

_____
_____
_____
_____

9. What are the challenges of utilizing *Berchemia discolor* species?

_____
_____
_____

10. For how long have you been using *B. discolor* from traditional knowledge point of view?

_____
_____
_____
_____

10. Is *Berchemia discolor* species ever being commercialized somehow?

_____
_____
_____
_____

11. What do you know about bioprospecting?

_____
_____
_____

_____

12. What do you know about Biopiracy?

_____
_____

_____

13. What are your recommendation regarding the use of bioprospecting in *B. discolor species*?

_____
_____
_____

14. What are feasible strategies that can improve commercialization potentials of *Berchemia discolor*?

_____
_____
_____

Appendix B: Approval of Master research proposal

UNIVERSITY OF VENDA

OFFICE OF THE DEPUTY VICE-CHANCELLOR: ACADEMIC

TO : MR/MS D. MUGARI

SCHOOL OF ENVIRONMENTAL SCIENCES

FROM: PROF J.E CRAFFORD

DEPUTY VICE-CHANCELLOR: ACADEMIC

DATE : 20 MARCH 2019

DECISIONS TAKEN BY UHDC OF 20th MARCH 2019

Application for approval of Masters research proposal in Environmental Sciences: **D. Mugari (14003786)**

Topic: "Bioprospecting of indigenous Species Berchemia Discolour and its Social-Economic Prospects at Vhembe District Municipality."

Supervisor	UNIVEN	Dr. T.M Nelwamondo
Co-supervisor	UNIVEN	Mr. M.J Mokgoebo

UHDC approved Masters proposal

PROF J.E CRAFFORD
DEPUTY VICE-CHANCELLOR: ACADEMIC

Appendix C: Ethic approval certificate

ETHICS APPROVAL CERTIFICATE

RESEARCH AND INNOVATION
OFFICE OF THE DIRECTOR

NAME OF RESEARCHER/INVESTIGATOR:
Mr D Mugari

STUDENT NO:
14003786

PROJECT TITLE: Bioprospecting of indigenous species Berchemia discolor and its social-economic prospects at Vhembe District Municipality.

PROJECT NO: SES/19/GGIS/07/3006

SUPERVISORS/ CO-RESEARCHERS/ CO-INVESTIGATORS

NAME	INSTITUTION & DEPARTMENT	ROLE
Dr TM Nelwamondo	University of Venda	Supervisor
Mr MJ Mokgebo	University of Venda	Co - Supervisor
Mr D Mugari	University of Venda	Investigator - Student

Type: **Masters Research**
Risk: **Minimal risk to humans, animals or environment**
Approval Period: **June 2020 – June 2022**

The Animal, Environment and Biosafety Research Ethics Committee (AEBREC) hereby approves your project as indicated above.

General Conditions

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following.

- The project leader (principle investigator) must report in the prescribed format to the REC:
  - Annually (or as otherwise requested) on the progress of the project, and upon completion of the project
  - Within 48hrs in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.
  - Annually a number of projects may be randomly selected for an external audit.
- The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project. The project leader must apply for approval of these changes at the REC. Would there be deviated from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date; a new application must be made to the REC and new approval received before or on the expiry date.
- In the interest of ethical responsibility, the RECs retains the right to:
  - Request access to any information or data at any time during the course or after completion of the project,
  - To ask further questions; Seek additional information; Require further modification or monitor the conduct of your research or the informed consent process.
  - withdraw or postpone approval if:
  - Any unethical principles or practices of the project are revealed or suspected.
  - It becomes apparent that any relevant information was withheld from the REC or that information has been false or misrepresented.
  - The required annual report and reporting of adverse events was not done timely and accurately,
  - New institutional rules, national legislation or international conventions deem it necessary

UNIVERSITY OF VENDA
OFFICE OF THE DIRECTOR
RESEARCH AND INNOVATION
2020 -07- 07
Private Bag X5050
Thohoyandou 0950

ISSUED BY:
UNIVERSITY OF VENDA, RESEARCH ETHICS COMMITTEE
Date Considered: June 2020

Name of the AEBREC Chairperson of the Committee: Prof IEJ Barnhoorn.....

Signature _____..... Date: 30 June 2020.....

Director Research and Innovation

Signature: ... GIEEkosse.... Date: 07 July 2020 .....

University of Venda
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Appendix D: Proofreading letter

P.O BOX 663
THOLONGWE
0734
27 April 2021

Dear Sir/Madam

This is to certify that the dissertation entitled “Bioprospecting of Indigenous Species *Berchemia discolor* and its socio-economic prospects in Vhembe District Municipality” by Mugari Dzivhuluwani (student number 14003786) has been edited and proofread for grammar, spelling, punctuation, overall style and logical flow. The edits were carried out using the “Track changes” feature in MS Word, giving the author final control over whether to accept or reject effected changes prior to submission, provided the changes I recommended are effected to the text, the language is of an acceptable standard.

Please don’t hesitate to contact me for any enquiry.

Kind regards

Dr. Hlaviso Motlhaka (BEDSPF-UL, BA Hons-UL, MA-IUP: USA, PhD-WITS, PGDiP-SUN)

Cell number: 079-721-0620/078-196-4459
Email address: hlavisomhlanga@yahoo.com

Appendix E: Turnitin report

BIOPROSPECTING OF INDIGENOUS SPECIES BERCHEMIA DISCOLOR AND ITS SOCIO-ECONOMIC PROSPECTS IN VHEMBE DISTRICT MUNICIPALITY"

ORIGINALITY REPORT

10%	2%	1%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of Venda Student Paper	7%
2	docplayer.net Internet Source	1%
3	www.researchgate.net Internet Source	1%
4	"Bioprospecting of Indigenous Bioresources of North-East India", Springer Science and Business Media LLC, 2016 Publication	1%
5	etnobotanica.us Internet Source	1%

Exclude quotes	On
Exclude bibliography	On