ETHNOBOTANICAL SURVEY AND PROFILING OF PHYTOCHEMICALS FROM MEDICINAL PLANTS USED TO TREAT CHILDHOOD DISEASES IN NYAMIRA COUNTY, KENYA

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DECLARATION

I declare that this thesis is my original work, and it has not been presented in this and any other university for examination purposes.

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DEDICATION

I am grateful to God for grace to carry out this research. I dedicate this work to my dear husband Cyrus Babu Ongòndo, Son Jemuel Ogana, Daughters Peace Tabitha Moraa and Praise Nyangweso for their immense support throughout the research period. May God richly bless you.

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ABBREVIATIONS AND ACRONYMS

BNH	Bangladesh National Herbarium
CBD	Convention on Biological Diversity
CITIES	Convention on International Trade of Endangered Species
FAO	Food Agriculture Organization
KNBS	Kenya National Bureau of Statistics
KWS	Kenya Wildlife Services
USAID	United States Agency for International Development
WHO	World Health Organization

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ABSTRACT

Medicinal plants have been in use for many years. Besides, the modern-day drugs can be traced to medicinal plants' origin. Herbalists utilize medicinal plants to treat various childhood diseases that are common in children below eighteen years in Nyamira County. However, these medicinal plants used remain largely undocumented as many herbalists use these plants using the knowledge acquired from their grandparents and other elderly people of their villages. Therefore, this study explored, documented plants used to treat childhood diseases and determined the presence of phytochemical compounds in the selected medicinal plants from Nyamira County, Kenya. The herbalists targeted were those registered as herbalists in the four Constituencies within Nyamira County while purposive and snowballing sampling techniques was utilized to select the participating herbalists. The information of interest in the questionnaires were on questions involved on the medicinal plants used, methods of harvesting, preparation and conservation. The most cited medicinal plants were sampled randomly and dried under the shade to prevent them from losing their phytochemical properties, and then carefully packed in small polythene bags which were labeled before packing for transportation to the laboratory. These samples were used for screening of phytochemical compounds in the medicinal plant extracts using methanol extraction. Similarly, specimens of the same samples were collected dried, mounted and deposited at Kenyatta University Herbarium for future reference. Data was collected from traditional healers in the four Constituencies randomly using semi-structured questionnaire. The data from the questionnaires was coded in excel and imported to SPSS software version 20 for analysis. The qualitative data was analyzed using descriptive and inferential statistics available in the SPSS software. The output was presented in form of figures and tables. The most cited plant part used as medicinal were the leaves (40.3%) followed by roots (29.6%), barks (13.3%) and fruits (10.3%). The most preferred method of herbal preparation was boiling cited by 36% of the interviewed herbalists, followed by soaking in cold water with 34% and pounding with 30% of the respondents. The selected medicinal plants were positive for phytochemicals; flavonoids, phenols, alkaloids, terpenoid, cardiac glycosides, saponins, tannins, anthraquinones and steroids. The findings from this study formed basis for documentation of other medicinal plants in Nyamira County. Besides, it presents phytochemicals which can be further purified and be used to treat not only childhood diseases but also other human diseases.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Medicinal plants have been a vital source of curative and preventive healthcare remedies since time immemorial (Mbuni *et al.*, 2020). According to Popović *et al.* (2016), 80% of the global population rely on herbal remedies for their primary health care. Besides, these plants used has led to increased and intensive research on these medicinal plants to identify the active compounds for use in development of new drug (Mutai *et al.*, 2021). According to Popović *et al.* (2016), research especially in plant resources in traditional medicine have been on the rise in the 20th and 21st century with the aim of finding new cures for a spectrum of human and animal diseases. Besides, the current researches in medicinal plants focus on understanding the relationship between the phototherapy, herbal medicine and discovery of drugs (Ouelbani *et al.*, 2016). The richness of floral in different continents can be associated with unique sources of potential medicines (Fakchich & Elachouri, 2021).

According to Fakchich and Elachouri (2021), more than 28,000 of earth's plant species have been investigated on the phytochemicals present and the pharmacological properties of these plants. In addition, approximately 50,000 higher plant species are believed to have medical importance. However, out of the 50,000 medicinal plants, only 5,000 have been studied for their medicinal use and evidence presented (Ouelbani et al., 2016).

Unlike in the past, the populations in the developing countries combine the conventional medicine and the herbal remedies (Schlittenlacher *et al.*, 2022). Increased use of herbal remedies in rural areas is because they are cheap, and available (Kipkore *et al.*, 2014). In Africa, use of these plants to treat diverse human and animal diseases has a long history (Nafiu *et al.*, 2017). The high use of medicinal plants in Africa is attributed to diversified flora in the African continent hence a high discovery of plants with significant medicinal value (Moyo *et al.*, 2015).

According to African Conservation center (2025), a total of 29,614 vascular plant species are known, this includes; 706 ferns, 44 gymnosperms and 28,864 angiosperms. Similarly, East Africa is one of the Sub-Saharan region rich in flora estimated at 12,317 plant species, being the highest plant diversity per unit area across mainland tropical Africa. Consequently, the availability of these plants is due to high numbers of these plants in the region (Mahomoodally, 2013). While in Kenya, 7,004 medicinal plants species have been recorded, of which 400 to 600 have been scientifically studied and documented with phytochemical compounds. Previously, it has been demonstrated that 70% of Kenyan population use home-made herbal remedies as the first source of therapy (Kipkore *et al.*, 2014). Similarly, 90% of Kenyan population use herbal remedies from plant-based sources (Sofowora *et al.*, 2013). In Kenyan communities, use of traditional medicine is highly valued and the indigenous knowledge was acquired through generations (Bussmann, 2006; Bussmann *et al.*, 2018). Despite its importance, knowledge on these plants is often transferred verbally. However, the information is less transferred due to the interference by industrialization which distorted the information and the adoption of western lifestyles

which disregard the traditional medicine knowledge (Kimondo *et al.*, 2015). Additionally, there is potential towards the environmental degradation and excessive harvesting of the medically important plants (Asner *et al.*, 2017). This results in depletion and threatening of the medicinal plants sustainability in different continents (Chi *et al.*, 2017) , unlike in developed countries, native knowledge on medicinal plants in Kenya remains largely undocumented (Mbuni *et al.*, 2020). This is because it is shared orally from one generation to another within a community. Consequently, this risks the loss of this information in future. Additionally, trade of plants with medicinal value, uncontrolled harvesting, overexploitation of the plant resources and climate change have been reported to threaten the availability of these plants (Mbuni *et al.*, 2020). Therefore, there is a need to record and preserve the ethnobotanical data on the diverse plants used in treatment of different human diseases.

In Kisii and Nyamira counties, use and conservation of medicinal plants face several challenges and opportunities. Traditional medicine remains a crucial component of healthcare especially in treating childhood diseases in rural areas where access to conventional medication may be limited (Omwenga et al., 2015a). Many local communities including those in Kisii and Nyamira Counties rely in indigenous knowledge passed down through generations to identify, prepare and administer herbal remedies. Therefore, the sustainability of this practice is compromised by various factors including modernization and changing lifestyles which occasion gradual erosion of valuable ethnobotanical knowledge.

Additionally, increasing population pressure in Kisii and Nyamira Counties has resulted to agricultural expansion, urbanization and deforestation hence reducing the availability of medicinal plants (Omwenga et al., 2015a). Moreover, some medicinal plants are overexploited due to high demand, leading to decline in their population and possible extinction of some species. Also, many of these medicinal plants largely remain undocumented making it challenging to validate their efficacy and integrate them into formal systems. Furthermore, there is regulatory and conservation challenges especially policies on sustainable use of medicinal plants and limited conservation efforts which in turn hinder the long-term preservation of these resources (Murigi, 2019).

According to Tanaka *et al*. (2002), plants with medicinal uses are utilized to treat different diseases including as diarrhea. Plants such as *Azadirachta indica, Asparagus racemosaus, Butea monosperma,* and *Cassina auriculata* are used as anti-diarrhea plants (Kumar et al., 2001). Secondary metabolites such as tannins, terpenoids, flavonoids, alkaloids, saponins, reducing sugars, sterols and triterpenes have been previously reported to have antidiarrheal or antimicrobial activity (Yu *et al*., 2000).

According to Omolo *et al*. (1997), the total and extractable bioactive metabolites from medicinal plants have been used in management of anemia while Kariuki *et al*. (2014), reported that *Erythrina abyssinica, Solanum aculeastrum, Carissa edulis, Croton megalocarpus* and *Myrica salicifolia* extracts used by the Maasai community in Kenya had

antibacterial activity. Therefore, the plants containing bioactive compounds can be used in treating and managing many children ailments that are caused when one eats contaminated food or drinks contaminated water or if exposed to an environment with bacteria. Ongu'en'e *et al.* (2003) reviewed antimalarial from African plants showed Africa as a rich source of plants with antimalaria abilities. However, majority of herbal products are unregulated thus raising safety concerns (Colenders *et al*., 2003; Mills *et al*., 2005). This requires scientists to screen and analyze these traditional plants more to prevent possible poisoning. *Biden pilosa* leaf extract of acetone, water and methanol are bioactive against bacteria such as *Bacillus cereus, Staphylococcus aureus* (Adedapo *et al.,* 2011; Kariuki *et al*., 2014).

Medicinal plants have crude drugs for example powder, tea, tincture, and poultice (Balick and Cox, 2020). There are more than 50% phytochemical compounds derived from plants found in the current clinical drugs. Higher plants give less than a half of the available drugs in the market (Farnworth *et al*., 1985; Newman and Cragg, 2007), while half of the flowering plants also support the modern clinical medicine. In North America pawpaw (*Carica spp)* and *Taxus brevifolia* are used to treat diseases such as ovarian cancer while *Podophyllum peltatum* is used to treat leukemia, lymphoma lung and testicle cancer (Gurib-Fakim, 2006). These plants have phytochemical compounds such as terpenoids used as flavoring agents while capsaicin compound obtained from plants such as chili pepper and some herbs are food spices used by humans. In addition, plants secrete rubber, waxes, dyes, sugar, amino acids and gums which are used to complement clinical drugs (Gulfraz, 2006). Plants contain natural products with different uses especially in human health (Galal

et al., 1991; Philip *et al.*, 2009). For instance, alkaloids are used as stimulants which substitute other stimulants such as caffeine and nicotine in cigarettes (Falodun, 2010).

Tannins are another important group of plant phytochemicals which have antifungal and antibacterial properties (Cowman, 1999). Besides, they have stringency properties hence used to treat sexually transmitted diseases such as gonorrhea, burns and piles (Argal and Pathak, 2006; Doss and Anand, 2012). In contrast, terpenoids contain farnesol, camphor, methanol and artemisia which is used as antimalaria agent (Vishwakarma, 1990). Some phytochemicals such as flavonoids have vital role in flowers, fruits, and leaves colors. Besides, flavonoids are used to treat microbial infections (Tanaka *et al*., 2002). Besides, they have antioxidant, anti-thrombic, ant-inflammatory and anticancer properties (Shirwalkar *et al*., 2003; Ahmad *et al*., 2006). According to Kazmi *et al*. (1994), quinones and anthraquinone from *Cassia italica* Mill are bacteriostatic against *Corynebacterium pseudodiphthericum* and *Psedomonas pseudomalliae*. Cardiac glycosides are of different types: Silicon is broken down to aspirin (Bolan & Steele, 1968).

Coumarin and glucosides have hemorrhagic, anti-fungicidal and antitumor activities (Abena *et al*., 2007). Cardiac glycosides such as digitalis, from foxglove (*Digitalis purpurea)* plant is an allopathic prescription (Maitai & Mungai, 2005). Cyanogenic glycosides are defense-related secondary metabolites, when broken down they give off volatile poison gas such as hydrogen cyanide that affects the respiratory system (Zeinali *et al.*, 2019).

1.2 Statement of the Problem

According to WHO (1978), complementary medicine from plants has been used to manage, prevent and treat human diseases. Medicinal plants use has been in existence for a long time and it is regarded as the oldest human health practice (Yogayata & Vijay, 2012). For instance, Nyamira County has approximately 137 health facilities with a population of 605,576 people which translates to a ratio of one doctor to 2,367 patients in a single day with an approximate of 12 km from one health center to the next (KNBS, 2019). This demonstrates that, most people seek their healthcare medication from medicine men and traditional healers whom they find easily available within the village and their residential areas. In addition, they find these treatments less costly. The demand of medicinal plants including those for treating childhood diseases is high hence the plants are likely to be overexploited and this jeopardizes their future availability (Shahidullah, 2007).

In addition, the medicinal plants are diminishing with time and the number of available medicinal plants is decreasing significantly. This implies there is need to document the medicinal plants and scientifically validate the different plants used by different communities. While the plants used to treat childhood diseases in Nyamira County are common, they remain largely undocumented. Secondly, phytochemicals associated with the medicinal properties of those plants has not been screened and documented. This study therefore aims at filling these gaps.

1.3 Study Justification

The natural medicinal plants in Nyamira County are decreasing due to excessive exploitation of these plants for medicinal and other purposes such as timber as well due to climate change. As a result, the availability of these plants is significantly reducing. Furthermore, the herbalists in this County rely on medicinal plants from natural sources such as forests. The harvesting methods are unplanned and indiscriminate resulting to overharvesting risks and extinct of these plants in the future. Often, the herbalists may not consider regeneration important. As such, this study is timely to address the need for conservation and sustainable use of medicinal plants. The documentation of information on traditionally used plants can lead to domestication of from wild to cultivated types.

1.4 Research Questions

i) What are the scientific names of the medicinal plant species used to treat childhood diseases in Nyamira County?
ii) How are the medicinal plants harvested, prepared and conserved by herbalists in Nyamira County?
iii) What are the phytochemical properties present in the identified medicinal plants for childhood herbal treatment?

1.5: Research Hypotheses

H0 -There are no known medicinal plants for treatment of childhood diseases in Nyamira County.

H0-There are no specific procedures for harvesting, preparing and conserving of medicinal plants used for childhood treatment in Nyamira County.

H0-There are no known phytochemicals derived from medicinal plants in Nyamira County.

1.6 Research Objective

The study is guided by the following objectives;

1.6.1: General Objective

To identify the harvesting, preparation methods, conservation and availability of medicinal plants used to treat childhood diseases in Nyamira County and characterize their phytochemical compounds.

1.6.2: Specific Objective

i. To document medicinal plants used to treat childhood diseases in Nyamira County
ii. To identify harvesting, preparation, conservation and availability of medicinal plant species used for treatment of childhood diseases in Nyamira County.
iii. To test the presence for phytochemical properties in the identified medicinal plants.

1.7 Significance of the Study and the Anticipated Output

The study findings promote understanding of different plants used by herbalists in Nyamira County. Secondly, it will guide the formulation of policies for utilization of medically important plants in treating childhood diseases to avoid overexploitation of the available medicinal plants. According to Shahidullah (2007), these plants are at risk of extinct due to overharvesting. Finally, information is used to identify medicinal plants with phytochemical properties that are of medical importance. This study output impacts on the

specific medicinal plant parts used by herbalists in treating childhood diseases. Besides, it has the impact on the documentation of ways of harvesting, preparing and conserving of medicinal plants and knowledge about their therapeutic properties. Moreover, it provides comprehensive data on the phytochemical compounds available in medicinal plants which further guides selection suitable plants for screening of active lead compounds for future use in drug development.

CHAPTER TWO: LITERATURE REVIEW

2.1. Medicinal Plants and Historical Uses

Childhood is a period in which a person's life when the person is below 18 years of age (Collins Dictionary, 2019). According to Susan (1999), childhood is a chronological age marking the boundary between childhood and adulthood which begins at zero (0) year and set at 18 years. Pelletier (1994) estimated that 55% of children deaths worldwide are attributable to common childhood diseases. However, some of the diseases are brought about by under-nutrition and poor healthcare given by the parents. According to Hamilton (1990), health becomes as important as wealth hence medicinal plants are valuable since they can be used to cure diseases.

Traditional medicine is referred to as summation of information that are based on different theories, beliefs and experiences. Traditional medicine is used by different indigenous cultures to maintain and improve their health and prevent those diseases (WHO, 2003). Since time immemorial, humans have been using herbal remedies for both curative and preventive healthcare. According to Akerele *et al*. (1998), medicinal plants that have medicinal history range from 35,000-70,000 different plant species. In the Caribbean since the time of slavery, and possibly before, they had a form of health care system in place they used in treating their children, mostly, these individuals used religion, knowledge of herbs and folk medicine to manage their health remedies (Handler & Jacoby, 1993). In South Africa, traditional medicine is well-established and well known for the healing, with the different communities using many different plants to treat various ailments in children (Samie *et al*., 2005).

Historical records show that human beings used whole plants or some parts of plants to treat different types of human diseases (Sindiga *et al*., 1995). Previously, it has been established that the ancient group of people such as the Assyrians, Babylonians, Hebrews and Egyptians used medicinal plants not only in treating early childhood diseases but also for the primary care of adults (Ghani, 1998). The medicinal plants use increased in the Greek civilization period where prominent persons such as Hippocrates (460) BC and Theophrastus becoming famous for practicing medicinal plants use. The '*Materia Medica'* which was documented by Hippocrates was comprised of 400 different medicinal plants. The document was later published under the encyclopedic work of Dioscordies, (*De Materia Medica)* in 78AD.

In the encyclopedia, the work of Hippocrates comprised 600 different medicinal plants which was higher than the previous documentation. Since then, medicinal plants have been recognized as the baseline for most modern medicine that are available in the market today. Apart from Hippocrates, Galen (131-200 AD) contributed to ethnobotany field by writing 500 volumes on medicinal plants formulations and recipe preparations. Besides, Galen (131-200 AD) was the first person to develop procedures used in preparation of therapeutic recipes comprised of plant or animal ingredients (Claus & Tyler, 1965).Therefore, the information presented formed the foundation of allopathic and the homeopathic systems of medicine that is still in use up to today.

In 1122 BC, a Chinese named Shen Nung documented medicinal plants in a document known as Pen Tsao. Similarly, in the 13th and the 14th centuries, medicinal plants in Europe were based on doctrine of signatures. An example of the medicinal plant in the doctrine of signature was liverwort which was used to treat liver diseases by relating the structure of the plant with that of the organ. In this case, liverwort was used to treat liver due to its structure which is similar to the liver. In addition, Swiss physician Paracelsus (1490-41AD) indicated that the shape and physical features of a medicinal plant can be related to the illness, the disease symptoms and the organ that is affected by the disease. An example is the *Panax gingseng*.

Moreover, Al-Razi and Ibn Sina were among the few physicians from Arabia who contributed to medicinal plant history by developing drugs made from medicinal plant recipes for use to treat various human illnesses. Besides, the two contributed to advancing the Greek system of medicine by laying foundation for development and growth of the western medicine and the modern.

The Aborigines of Australia contributed long time ago on the medicinal plants such as in hunting where they used medicinal plants (Newman & Cragg, 2020). The South American counties have been instrumental in providing valuable medicinal plants in the natural forests and those domesticated in medicinal plant gardens. These plants have been vital in the provision of the herbal remedies especially with the newly reported illnesses and infections (Fabricant & Farnsworth, 2001; Gurib-Fakim, 2006). According to Buragohain (2011), Africa is one of the continents with more medicinal plants than other continents. As

a result, the World Health Organization is putting a lot of efforts in documentations of these in Africa and other continents.

Apart from WHO, Rig Veda and Ayurveda encyclopedia have documented many medicinal plants of Indian origin. The Ayurvedic encyclopedia is accredited to Chakara (WHO, 2003) while Rig Veda is known as one of the oldest mankind library with more than 8000 of South Asia medicinal plants of different species and their uses (Karki, 2000). On the other hand, the Ayurveda system, Unani, Sidha and the Tibetan provides information that is vital for primary health of more than 10 million persons relying on herbal remedies for their primary care (Karki, 2000). A few of medicinal plants documented in Ayurveda system include *Cinnamomum camphora* Camphor Laurel, *Centella asiatica* (L.), *Elettaria cardamomum* (L) Maton, *Rauwolfia serpentine (*L.) Benth ex Kurz, *Azadirachta indica* A. Juss, *Terminalia* species and *Santalum album* L. (Gurib-Fakim, 2006).

In Africa, these plants are used to aid cure diseases, and some are regarded to have value especially on religious ceremonies. The East African herbalists have often been referred to as 'medicine men' (Kokwaro, 2009). In addition, Kokwaro (2009) indicated that the art of native medicine has been in Kenya from time in memorial. In Nyamira County, medicinal plants are used by both literate and illiterate people with no clear documentation to various uses of those plants used to treat childhood diseases. In this community, information on the sources and use of each medicinal plant is passed from one person to another and from

generation to generation via oral methods. Oral sharing of information has negative impacts in that the information can be distorted hence not accurate in providing information on describing the plants, preparation of the plant and its uses (Ogbole *et al*. 2010; Ampitan, 2013).

2.2: Phytochemical Properties

Previously, plants parts have been utilized as medicine for many years (Artuso, 2013). The therapeutic value of the medicinal plants is associated with the phytochemicals and bioactive metabolites derivatives from these plants. According to Farnworth *et al.* (1985) and Newman and Cragg (2007), 50% drugs that are currently used in clinical medicine and in pharmaceutical market can be traced to medicinal plant origin. Despite the existence of many medicinal plants, only 1% have been investigated for pharmaceutical purposes (Newman & Cragg, 2007). This is lower than the number of plants in the tropical forest and the surrounding areas used as medicinal plants for children remedies. For example, anti-cancer drugs obtained from medicinal plants in North America such as *Carica spp*. and *Taxus brevifolia* Matthew H. have been demonstrated to be effective in treating ovarian cancer while *Podophyllum peltatum* (Linnaeus) Moench is used to treat different types of cancer such as lymphoma and leukemia (Gurib-Fakim, 2006). Despite the well-known usage of different medicinal plants for treating children diseases, there is also very little scientific information on phytochemical properties on indigenous medically used and recorded plants (Van, 2008). Plants have different phytochemical compounds such as rubber, waxes, flavonoids, flavors, dyes, sugars, amino acids and gums. Gulfraz (2006) indicates that such compounds are important for the treatment of various illnesses. It is also

noted that natural compounds obtained from medicinal plants have significant medical uses (Galal *et al*., 1991).

2.2.1. Alkaloids

Alkaloids are a group of compounds heterocyclic nitrogen compounds which are natural organic substances dominant in plants. It has one nitrogen atom in a negative oxidative state in their structure (Zeinali *et al.*, 2019). One of the medically important alkaloid (morphine) was obtained from *Papaver somnifera* (L.) in 1805 (Cowan, 1999). According Kutchan (1995), plant extracts with alkaloids are used as poisons and medicines. In the present world, alkaloids are used as stimulants just as other known stimulants such as caffeine and nicotine (Falodun, 2010). In addition, alkaloids with analgesic properties have pure compounds such as quinine, atropine and morphine which are medically applied, while others are illicit drugs that are abused such as cocaine. Previously alkaloids have been extracted from the leaves and fruits of *Berberis lyceum* Royle while in *Justica adhatoda* L. alkaloids were extracted from roots and leaves (Gulfraz, 2006).

The commonly known class of bioactive compounds inhibiting bacteria are alkaloids isolated from medicinal plants including *Chelidonium majus* L. (Zielińska *et al*., 2019). Alkaloids intercalates with the bacteria DNA and inhibit important enzymes involved in DNA processes such as replication, transcription and translation (Mickymaray, 2019). Similarly, bioactive compounds chrysin, tangeritin, nobiletin, apigenin and quercetin from medicinal plants have been reported to inhibit DNA replication in different bacteria such as *Bacillus subtilis, Mycobacterium tuberculosis* and *Escherichia coli* (Vijayakumar *et al*.,

2018). These compounds inhibit DNA gyrase enzyme which aids in DNA replication. Similarly, some of these bioactive compounds bind to the beta subunit of gyrase and block the ATP binding pocket thus inhibit the bacterial replication and growth (Zielińska *et al*., 2019).

Helicase aids in unwinding of the DNA strands during replication process. Compounds such as luteolin, myricetin and morin inhibit the activity of the helicase enzyme thus inhibiting the DNA replication (Shadrick *et al*., 2012). Also, myricetin inhibit DNA and RNA polymerase which are important enzymes in DNA replication (Bhosle and Chandra, 2016). Besides, this compound inhibits the reverse transcriptase enzyme in viruses hence inhibit survival of viruses. Moreover, the myricetin bioactive compound extracted from *Prunus domestica* L. inhibits the dihydrofolate reductase enzyme which inhibits the synthesis of purine and the pyrimidine rings in the nucleic acids (Huang *et al*., 2018). Consequently, the inhibition of the purine and pyrimidines results to reduced DNA, RNA, protein synthesis and cell death.

2.2.2 Tannins

The phytochemicals grouped as tannins are polymeric phenolic substances (Cowan, 1999). Tannins are heterogenous group of phenolic compounds which occur naturally in plants within the plant kingdom. Previously, it has been established that tannins have antifungal and antibacterial properties. The tannins mode of action is through binding to microorganism cell walls while some have protease activity. These modes of actions inhibit the growth and activity of the microorganism (Jones *et al*., 1994). According to Álvarez

and Ramírez (2007), tannins can be extracted from various plant parts such as barks, leaves, fruits, stem and roots. Apart from high molecular weight structures, the tannin group of phytochemicals are soluble in water. Besides, tannins have the ability to bind on protein complexes. The tannin compounds have been previously reported to be used to treat gonorrhea (Argal & Pathak, 2006; Doss & Anand, (2012). Similarly, tannins are used to convert animal hides to leather through the process of putrefaction. In a previous study by Doss and Anand (2012), high tannin levels are used to treat wounds because they support formation of layers on the injured mucosal surface.

According to Huang *et al*. (2018), tannins are found in the vulnerable parts of the plants such as the leaves and flowers. The chemical structures and the concentration of tannins in plants are influenced by the temperatures, light intensity, exposure to herbivory and nutrient stress. Tannins are further grouped into three groups; hydrolysable tannins (HT), condensed tannins (CT) and phlorotannin (PT) (Huang *et al*., 2018). In plants, tannins serve as the plants chemical defense system against invasion of pathogens or attack by insects.

According to Liu *et al*. (2013), tannins have antimicrobial properties against bacteria, fungi and yeasts. The modes of action of the tannins against bacteria are diverse. These includes formation of complexes in cell membrane hence causing morphological changes which in turn increase the membrane permeability (Aye *et al*., 2019). In addition, the tannins inhibit bacteria through inhibition of important biological processes such as oxidative phosphorylation and disruptions of the cell membrane and cell functions. Previously, 12

tannins in the condensed tannins (CT) have been isolated from *Dalea purpurea* Vent. In contrast, tannins in subgroup phlorotannins (PT) have been isolated from *Ascophyllum nodosum* L. Le Jolis.

According to Ganesan *et al*. (2018), tannins inhibit microbial activities by deactivating the microbial adhesins, enzymes and membrane transport systems. In infectious pathogenic microbes, coumarins one of the compounds in the tannin group prevent infections due to its ability to stimulate macrophages (Srikrishna *et al*., 2016).

2.2.3. Terpenoids

Terpenes bioactive compounds are characterized by oxygen containing hydrocarbons (Masyita *et al.*, 2022). According to Aye *et al*. (2019), the terpenoids are divided into different subgroups such as the esters, ethers, aldehydes, alcohol, ketones, epoxidases and phenols. Terpenoids commonly also known as terpenes are compounds which have extensive branching than the acids. Despite having more branching and crystalized, terpenoids and the acids have the same family origin. Examples of the terpenoids include methanol, farnesol and camphor. Besides, terpenoids have biological activities. Artemisia which is used as antimalaria agent is characterized by terpenoid group of compounds (Vishwakarma, 1990).

In addition, terpenoids are lipophilic compounds with antibacterial properties where the mode of action is disruption of cell membranes. However, increasing the hydrophilicity of the terpenoid compounds such as kaurene diterpenoids through the addition of methyl group reduces the antibacterial activity of these compounds (Kumar *et al*., 2001).

Bioactive compounds with significant biological activities in the terpenoid class and have history of extraction from medicinal plants included menthol, thymol, geraniol, citronellal, carvacrol, and linalool (Masyita *et al*., 2022). Previously, terpenoids have been reported to have antimicrobial properties against antibiotic susceptible and resistant bacteria. Terpenoids inhibit bacteria through two mechanisms; promote cell rapture and inhibition of the DNA synthesis. Examples of the terpenoids with history of affecting microbial growth are the monoterpenoids subgroup.

2.2.4 Flavonoids

Flavonoids constitute a highly diverse class of bioactive compounds. According to Liu *et al*. (2013), flavonoids have approximately 9000 known structures. Flavonoids from plants have been further grouped into flavanones, flavones, flavanols, paranthocyanidins, anthocyanins and isoflavonoids (Yang *et al*., 2016). The flavonoids have been isolated from different plants including all vascular plants and a few mosses. Flavonones, flavones and their derivatives were first isolated from medicinal plant *Petroselinum crispum* (Mill.) Nym and *Antirrhinum majus* (L.).

Flavonoids is a group of compounds with one carboxyl group. According to (Tanaka *et al*., (2002), approximately 2,000 flavonoids have been extracted from plant sources. More than 2,000 have been identified from plants. Flavonoid compounds are known to be responsible for the different colors in plant leaves, fruits and flowers. Plants synthesize flavonoid compounds in response to microbial infections hence these compounds are vital in inhibiting potential pathogenic microbes (Tanaka *et al*., 2002). The activity of flavonoid compounds especially those with lipophilic properties is through disruption of the microbe

cell membranes (Tanaka *et al*., 2002). Other properties of flavonoids include anticancer, antioxidant, anti-inflammatory, antiviral, antiallergic and anti-thrombotic (Venkatesh *et al*., 2011).

Medicinal plant *Glycyrrhiza uralensis* Fisch which is widely known source of food flavoring agent (Ng *et al*., 2021). In addition, flavanones and flavones have been isolated from this plant. These includes compounds liquiritigenin, isoliquiritigenin and 7,4'-dihydroxyflavone (Zhu *et al*., 2018). Additionally, phenylpropanoids form a large part of bioactive compounds from medicinal plants. According to (Yang *et al*., 2016), the most important phenylpropanoid and their derivatives include the monolignols, lignans, phenolic acids, stilbenes and flavonoids. In plants, the phenylpropanoids is a basic component of floral pigments, scents compounds and signaling molecules. According to (Thabet *et al*., 2022), phenylpropanoids have been isolated in medicinal plants in the family Lamiaceae.

Medicinal plant *Pueraria lobata (Willd.) Ohwi* in the family Fabaceae has had medicinal value against cardiovascular diseases. The hydroxylated phenolics in this group form complexes with the cell walls of the microorganism thus disrupting the microbial membranes. Some of the highly active flavonoids from medicinal plants include quercetin, naringenin, tiliroside and sophoraflavanone (Sanver *et al*., 2016). According to Martens and Mithöfer (2005), the highly active flavonoids inhibit microbes by decreasing the lipid bilayer thickness, reduce the fluidity levels and increase membrane permeability hence promoting leakage of the ions and the intracellular proteins in the microorganisms.

Flavonoids with antibiotics such as ampicillin and tetracycline inhibit microbes through synergistic effects (Mickymaray, 2019).

Additionally, flavonoid compounds known to have antimicrobial activity include acacetin, morin, apigenin and rhamnetin (Mickymaray, 2019). The mode of action of these group of flavonoids is disrupting the cell wall by disarranging the lipid bilayer which leads to leakage of the vesicle leakage. Similarly, other bioactive compounds in the flavonoid class such as lipophilic 3-arylidene isolated from medicinal plant *Eriosema chinense* Vogel inhibit pathogenic microorganism by causing cell clump through influencing the integrity of the cell wall thus causing biofilm disruption and death of the pathogenic microbes (Sutthivaiyakit *et al*., 2009).

Flavonoid compounds from medicinal plants such as *Ficus sansibarica* Warb inhibit bacteria through biofilm formation (Awolola *et al*., 2014). This is because the flavonoids cause accumulation of multicellular composites of bacteria which inhibit the growth of bacteria growth after the accumulation. Examples of flavonoid derivates from medicinal plants known to inhibit bacteria growth through biofilm formation include galanin, isovitexin, and 3-0-octanoyl-epicatechin (Mickymaray, 2019). Additionally, bioactive compound apigenin and naringenin extracted from medicinal plant *Kalanchoe pinnata* (Lam) Perse inhibit bacteria through cell signaling and prevention of biofilm formation by bacteria such as *E. coli* (Thiago *et al*., 2016).

Often, active compounds in the flavonoids are associated with inhibition of energy production in bacteria (Martens & Mithöfer, 2005). Examples of flavonoids with ability to inhibit ATP production in bacteria are morin, silymarin, quercetin, silybin and baicalein isolated from medicinal plant *Artocarpus communis* Forst (Kuete *et al.*, 2011). These compounds inhibit the FIFO ATPase system thus inhibiting this enzyme activity and cause cell death. *Pseudomonas aeruginosa, Staphylococcus aureus* and *Staphylococcus mutans* are example of microbes whose activity has been demonstrated to be affected by inhibiting the enzymatic activity of the FIFO ATPase enzyme (Elmasri *et al*., 2017).

2.2.5 Cardiac Glycosides

The bioactive glycoside compounds have mono or oligosaccharides bound to the uronic acid. The glycosides have diverse main constituents, including cardiac glycosides, saponins, anthraquinone glycosides, glucosinolates and cyanogenic glycosides (Singh & Juneja, 2019). Glycosides consist of glucose sugars. Tannins are glycosides of gallic with astringent property hence with medicinal value, others like silicon transformed to salicylic acid are synthesized to other compounds such as aspirin (Bolan & Steele, 1968). In plants, flavonoid glycosides are responsible for the yellow pigments in flowers. Besides, the flavonoid glycosides have demonstrated to have coumarin and glucosides with hemorrhagic, anti-fungicidal and antitumor activities (Abena *et al*., 2007). Cardiac glycosides such as digitalis obtained from foxgloves plant are commonly preferred for allopathic prescription. According to Maitai and Mungai (2005), plants such as cassava (*Manihot escaluta* Crantz have cyanogenic glycosides. Cyanogenic glycosides are known as defense-related secondary metabolite (Bennett & Wallsgrove, 1994).

The glycosides and their derivatives have been associated with the inhibition of pathogenic microbes through the inhibition of Na+/K+ ATPase pumps which is important to transport of materials across bacterial cell membranes. Medicinal plants in family Scrophulariaceae such as *Digitalis purpura* L., *Digital lanata* Ehrh and family Convallariaceae, such as *Convallaria majalis* Var. rosea have been reported to produce cardiac glycosides with significant antimicrobial activities (Thabet *et al*., 2022). Similarly, *Nerium oleander* L., *Thevetia peruviana* (Pers.) K. Schum and *Strophanthus gratus* (Wall & Hook.) Baill are medicinal plants that produce cardiac glycosides (Singh & Juneja, 2019). Apart from antimicrobial properties, cardiac glycosides have inhibitory activities against rhinovirus (Johnson *et al*., 2021).

2.2.6 Phenols

According to Ganesan *et al*. (2018), phenolic compounds with the hydroxyl functional group are known to be toxic to microorganisms. This is because the phenolics cause increased reactions of the hydroxylation process thus causing cell lysis in microorganisms (Sanver *et al*., 2016). Similarly, the quinones with aromatic rings and ketone molecules have been reported to have significant antimicrobial properties (Ganesan *et al*., 2018). The antimicrobial properties of this group of compounds are due to the irreversible complex that with nucleophilic amino acids in the microorganisms. According to Matijašević *et al*. (2016), the aromatic compounds from medicinal plants such as *Coriolus versicolor* (L.) Quel target the cell membrane adhesins, membrane bund polypeptides and the enzymes in the cell membrane and consequently, it results to cell lysis.

2.2.7 Saponins

There are phytochemical compounds composed of hydrophobic aglycone which can be either triterpenoid or steroids linked via glycosidic bond to various sugars such a glucose, arabinose, xylose, rhamnose among others (Baky *et al*., 2022). Saponins are not only produced by plant but also in marine organisms, animals, and bacteria. These compounds are characterized with properties such as soap-like form in aqueous media hence have unique applications in various fields.

According to Badukale *et al*. (2021), saponin obtained from *Madhuca indica* flower and leaf used in traditional Indian medicine is mainly used as a cooling agent, and tonic for treatment of diseases such as bronchitis and chronic tonsilitis. Similarly, *Mimusas elengi* stems were used in Indian medicine to treat diarrhea and dysentery (Baliga *et al*., 2011). *Chrysophyllum albidum* leaf were used as an emollient in treatment of stomachache and diarrhea (Angone *et al*., 2013). In South Africa, medicinal plant *Manikara bidentata* fruit are used to treat constipation while *Manikara hexandara* stem is used in South Asia to treat diarrhea fever and stomach infections. According to Baky *et al*. (2022), dietary saponins from plant material are important to children because they are therapeutic to control obesity pathogenicity.

2.2.8 Anthraquinones

Anthraquinones are group of compounds reported with over 700 chemicals. Majority of these compounds are produced by plants with approximately 200 chemicals while the remaining are produced ether by lichens or fungus (Watroly *et al.*, 2021). In plants,

anthraquinones are found in all plant parts including roots, rhizomes, fruits, flowers, and fruits (Duval *et al.*, 2016). Besides, anthraquinones have many applications especially in food and pharmaceutical industries. Anthraquinones have significant importance to human because of its diverse therapeutic properties including antioxidant, anticancer, anti-inflammatory, antarthritic , antibacterial and antifungal (Watroly *et al.*, 2021). According to Lombardi *et al*. (2022), anthraquinones are produced by various medicinal plants including *Cassia acutifolia* Senna syn. *Rhamnus frangula* Frangula, *Aloe spp* syn, among others.

2.3 Description of the Selected Medicinal Plants

2.3.1 *Solanum nigrum* Linn.

Solanum nigrum is a plant in the genus *Solanum* and family Solanaceae. The genus *Solanum* is comprised of more than 2,000 plant species distributed in tropical and subtropical region (Chen *et al*., 2022). The plant has tap root system and lignified, well developed main root. In addition, the stem has no conspicuous edges and can either be green or purple. The *Solanum nigrum* leaf is ovulate and measures 2.5-10 cm long and 1.5-5.5 cm wide. The leaf apex is shortly pointed and measures 1-2cm long. The flowers are inflorescence composed of 3-6 flowers (Ling *et al.*, 2019). Traditionally, *Solanum nigrum* is used to treat sore throats, cancer, acute nephritis, eczema, furuncles, dermatitis, leucorrhea, toothache among others (Chen *et al*., 2022). In Libya and Italy, *Solanum nigrum* is used as antispasmodic, sedative, diuretic, and analgesic drug while in Jordan, *Solanum nigrum* fruit is used antispasmodic drug (Aburjai *et al*., 2014). In Indian traditional medicine, *Solanum nigrum* is used to treat dysentery, fever, and stomach complaints (Aburjai *et al*., 2014).

In South Africa, the Zulus use infusions from *Solanum nigrum* Linn are used as enema to infants with abdominal upsets (Potawale, 2008). In addition, the infusions from the leave are rubbed into children's gums with crooked teeth. In Kenya, the unripe fruits of this plants used to relieve pain in children who are teething. The leaves and fruits are pounded to make in infusion which is used against tonsillitis in children. Moreover, it is used to treat the urinary tract infections in children (Arun, 2017).

Plate 2.1: *Solanum nigrum* Linn in Kenya

Source: *Agwata, The Herbarium Specimen Collector, Specimen. 1. *Solanum nigrum* L. 22 April 2023. Kenya. Nyamira County. Kenyetta University Herbarium (KUN), Accession No. 1.

2.3.2 *Carissa edulis* Valh

Carissa edulis Valh is a plant in the family Apocynaceae. *Carissa edulis* is an evergreen shrub and is native in tropical and subtropical regions of Africa, Asia and Oceania. The shrub has a height of 1-5 m. The stem is branched, globuluours leaves and it is rich in white latex. The leaves arrangement of this plant is opposite decussate. Besides, it has a small,

fragrant, white inside and pink to red on the outside. Traditionally, *Carissa edulis* is used to treat diseases such as arthritis, malaria, headache, syphilis and gonorrhoea. The commonly parts used includes leaves, barks, stems, fruits and the roots.

According to a study done by Kigen *et al*. (2016) in Nandi County, concoction of the *Carissa edulis* Valh roots is used to treat skin rashes, abdominal pains and skin infections in children. Additionally, this plant is used by the Luo community to manage hyperactive disorders in children which includes abdominal colic and diarrhoea (Linus *et al*., 2019). Kamau (2021) noted that in Narok County, *Carissa edulis* Valh roots were used to neutralize the toxicity of other medicinal plants while preparing concoctions for treating colic pain and stomach ache in children.

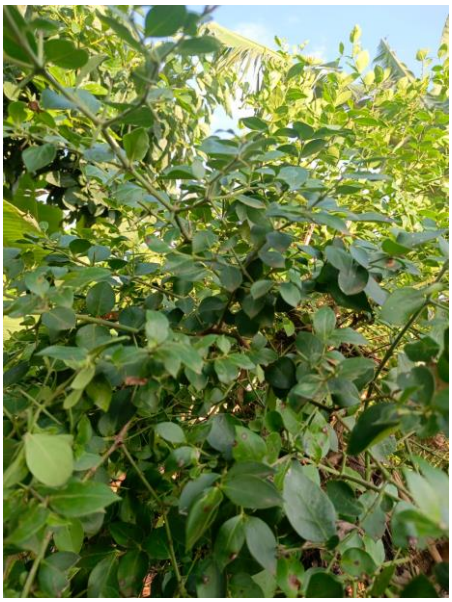

Plate 2.2: *Carissa edulis* Valh
Source : *Agwata, The Herbarium Specimen Collector, Specimen. 2. *Carissa edulis* Valh. 22 April 2023. Kenya. Nyamira County. Kenyatta University Herbarium (KUN), Accession No. 2.

2.3.3 *Croton macrostachyus* Hochst. Ex Delile

Croton macrostachyus is a plant commonly referred as broad-leaved croton, is a tree in the family Euphorbiaceae. *Croton macrostachyus* is deciduous tree with and height of between 25-30 m tall. The tree has alternate leaves which are simple and turn orange before falling (Degu *et al*., 2016). The bark is grey to grey-brown while its flowers are unisexual and yellowish to white in colour. The fruits are globular capsule and measure between 8-12 mm in diameter (Wakjira & Negash, 2013). The fruits are stellate hairy, apex centrally depressed and pale greyish brown. *Croton macrostachyus* are three seeded and seedlings have the epigeal germination.

The tree is mostly found in West Africa regions and the flowering starts during the rainy season in East African countries such as Kenya. Flowering of *Croton macrostachyus* occurs throughout the year with peaks in March to June (Maroyi, 2017). Fruit development in *Croton macrostachyus* takes 4-5 months (Wakjira & Negash, 2013). On the other hand, pollination is mainly done by insects. The maximum growth for *Croton macrostachyus* is 1.5 m per year (Wakjira & Negash, 2013). Based on ecology, *Croton macrostachyus* thrive in secondary forests especially in forest edges and along the rivers or lakes. Besides, it grows in dry green upland forest, woodland, wooded grassland and in bushlands (Rascovan *et al*., 2016). Moreover, the tree grows in soils with volcanic origin, rainfall of 150-200mm annually and in altitude of 200-3400 m (Maroyi, 2017).

In East Africa, concoction of *Croton macrostachyus* Hochst. Ex Delile plant roots and leaves are used to treat fever in children. It is also used to treat gastrointestinal challenges such as digestive problems and stomachaches among children (Maroyi, 2015). The extracts from the leaves are used to treat respiratory conditions such as coughs in children. Similarly, the leaves are used to treat wounds and skin rashes by applying it topically (Maroyi, 2017). Previously, *Croton macrostachyus* Hochst. Ex Delile has been reported to have antihelminthic properties hence used traditionally to kill intestinal worms in children (Ayza *et al.*, 2020).

Plate 2.3: *Croton macrostachyus* Hochst. Ex Delile in Kenya
Source: *Agwata, the Herbarium Specimen Collector, Specimen 3. *Croton macrostschyus* Hochst. Ex Delile. 22 April 2023. Kenya: Nyamira County. Kenyatta University Herbarium (KUN), Accession No. 3.

2.3.4 *Lantana camara* L.

Lantana camara is a plant in the family Verbenaceae. *Lantana camara* is a shrub which can grow up to two meters when matured. Besides, it has flowers which may vary in colour

ranging from pink, red, yellow, violet and white. This shrub posse a strong root system while the stems are covered with bristly hairs when green. The roots produce new shoots even after several cuttings. *Lantana camara* leaves are simple, opposite with long petioles and has oval blades. This shrub leaves are known for their strong aroma.

Lantana camara flowers are small, multicoloured and have fur short spreading lobes. *Lantana camara* flowers change after anthesis. Often, the *Lantana camara* flowers occur in clusters. Traditionally, extracts from this plant are of use in treatment of various human ailments including measles, ulcers, high blood pressure, tetanus, skin itches, asthma and cancer (Shankar Mane *et al.*, 2019). In Children, it is applied topically for skin conditions such as wounds, insect bites and skin rashes. It is also used in management of inflammation and diseases such as Kwashiorkor in children (Mahwasane *et al*., 2013). The leaves and extracts are used in management of respiratory conditions and fever. Also, it is used to treat stomach-aches among children and adults.

Plate 2.4: *Lantana camara* L. in Kenya

Source : *Agwata, The Herbarium Specimen Collector, Specimen. 4. *Lantana camara* L. 22 April 2023. Kenya : Nyamira County. Kenyatta University Herbarium (KUN), Accession No. 4.

2.3.5 *Asparagus africanus* Lam.

Additionally, *Asparagus africanus* Lam. is a plant in the family Asparagaceae. *Asparagus africanus* is a perennial climber which is widely distributed in Africa. The plant stem grows upto 6 m high and thrives well in altitude ranging from 700-3800 m above sea level (Kebede *et al*., 2016). The leaves and simple, broad and are produced in clusters. The true leaves are minute scales and the plant cladodes function as leaves. Often, the cladodes are produced in clusters above each leaf scale. *Asparagus africanus* flowers are produced in small clusters made of several flowers. The flowering season is mostly in Spring and Summer. *Asparagus africanus* flowers are white. The fruits are rounded berry measuring 5-6 mm in diameter and has one seed. In the early stages, the berries are green and turns orange red as they mature. The plant is pollinated by insects specially bees which are

attracted by the flower's fragrance. After flowering the seeds are dispersed by birds and animals which feed on the red berries.

Asparagus africanus Lam is traditionally used to treat digestive problems and stomach aches in children. Besides, it is considered a tonic plant which generally improves the health of the child (Eshete & Molla, 2021). In other communities, this plant is used to treat respiratory health conditions such as coughs. In Ethiopia, the fresh leaves of this plant are pound together and mixed with other herbs for use in treatment of wounds (Megersa *et al*., 2023).

Plate 2.5: *Asparagus africanus* Lam. in Kenya

Source : *Agwata, The Herbarium Specimen Collector, Specimen. 5. *Asparagus africanus* Lam. 22 April 2023. Kenya. Nyamira County. Kenyatta University Herbarium (KUN), Accession No. 5.

2.3.6 *Aloe secundiflora* Engl.

Aloe secundiflora Engl. is a perennial herb in the family Asphodelaceae. This herb is succulent and has self-supporting growth form. *Aloe secundliflora* leaves are approximately 20 in a dense rosette. These leaves do not have stipules and petioles. Besides, the flowers are bisexual, and regular. In addition, the fruits have oblong-ovoid capsule which measures 25-14 mm. Fruits have many seeds. The seeds are blackish brown and measure 8.5 mm. It is native of Kenya, Uganda, Tanzania, Ethiopia, and Sudan. The plant thrives in an elevation ranging from 1350 m-1550 m and altitude ranging from 600-2000 m - any difference between altitude and elevation? Often, this plant thrives in terrestrial habitats especially in shrub lands and grasslands. *Aloe secundliflora* mainly grows in areas with sandy soils.

According to Wanga and Nyamboki (2023), the leaves and stems of this plant are crushed into a sap and applied topically on the affected body part. Therefore, it was used to treat various human health conditions including skin rushes, ringworms in children, pimples, wound sores and abscesses (Wanga & Nyamboki, 2023).

Plate 2.6: *Aloe secundiflora* Engl. in Kenya

Source : *Agwata, The Herbarium Specimen Collector, Specimen. 6. *Aloe secundiflora* Engl. 22 April 2023. Kenya. Nyamira County. Kenyatta University Herbarium (KUN), Accession No. 6.

2.3.7 *Oxalis corniculata* Linn.

Oxalis corniculata Linn is a plant in family oxalidaceae? The branching from the base of this plant is rooted at the nodes while the upper portion is smooth or hairy. Besides, the leaves are arranged alternatively along the stems (Tibuhwa, 2016). A single stalk of this plant arises from the axils of the leaf from which it extends to the three flower stalks, each with a single flower. The *Oxalis corniculata* flowers measures 7-11 mm wide and have five (5) yellow petals. In addition, the *Oxalis corniculata* fruit is a capsule and 1.1-5 cm long (Vasantha *et al*., 2001). The fruit is cylindrical, pointed epically and 5-ridged in cross section. The plant thrives in an altitude range of 300-2,100 m (Tibuhwa, 2016).

Additionally, *Oxalis corniculate* leaves are used to prepare poultice which are used to treat skin infections (Omwenga *et al.,* 2015a). In addition, it has been used to treat liver diseases and digestive stem challenges (Sarkar *et al*., 2020). Besides, it is used to treat skin infections such as warts, corns and swellings. Also, it is used to treat itching eye lids, conjunctivitis and in removal of the opacities in the cornea. Moreover, the leave extracts are used to treat anaemia and dyspepsia (Sarkar *et al*., 2020).

Plate 2.7: *Oxalis corniculata* Linn. in Kenya
Source: *Agwata, The Herbarium Specimen Collector, Specimen 7. *Oxalis corniculata* L. 22 April 2023. Kenya : Nyamira County. Kenyatta University Herbarium (KUN), Accession No. 7.

2.3.8 *Urtica dioica* L. (Stinging nettle)

Urtica dioica (Stinging nettle) is a perennial plant in the family Urticaceae. The plant stem is erect and green. The leaves are dark-green on the upper side and pale green on the lower side. The leaves are oblong or ovulate, opposite and a cordate at the base (De Vico *et al*., 2018). The flowers can either be green or brown and occurs in racemes in the axils of the upper leaves. The plant leaves and stems are covered by stinging trichomes. According to Adhikari *et al*. (2016), the plant grows in moderately tolerant to shade and occurs in damp, and in richly fertile soils. The soils should be weekly acidic or basic soils.

According to Omwenga *et al.* (2015), the poultice and ash from *Urtica dioica* L. are used to treat skin and stomach infections. Besides, this plant has been used in treatment of jaundice in children and rheumatism in adults (Sharma & Halder, 2017). The leaves are traditionally used as blood purifiers and treatment of the skin inflammations. Also, it is used to improve iron levels in children believed to be iron deficient (Sharma & Halder, 2017). In Himalayas, *Urtica dioica* L is used allergies, diuretics and urinary tract infections (Semalty *et al*., 2017).

Plate 2.8: *Urtica dioica* L. (Stinging nettle) in Kenya

Source: *Agwata, the Herbarium Specimen Collector, Specimen. 8. *Urtica dioica* L. 22 April 2023. Kenya: Nyamira County. Kenyatta University Herbarium (KUN), Accession No.8.

2.3.9 *Cassia didymobotrya* Fresen

Cassia didymobotrya is a plant in the family Leguminosae. This plant is a native of tropical Africa including Angola, Mozambique, Ethiopia and Sudan. Later, the plant was

introduced to other countries in Africa as an ornamental plant. The plant produces golden yellow flowers with a distinct scent (Jeruto *et al*., 2017). The flower opens from brown buds. The plant measures 0.5-5 m tall. The branches are terete, striated and subglabrous. In addition, the leaves are green and open from brown buds. The leaves measure 14-50 cm long and occur in pinnate of more than 30 leaflets. Similarly, the flowers occur in inflorescent of 10-20 flowers. The flower inflorescent are bright yellow and has long stalks. The fruits are flat and has seeds in the range of 9-16. These seeds are flat and oblong (Chukwuma & Sonibare, 2010). *Cassia didymobotrya* thrives in cool and temperate regions, evergreen bushlands, and riparian montane wooded grassland. It is common in bushlands, streams, rivers, lake shores and in damp locations. Besides, it grows in altitude range of 900-2400 and in well drained soils (Jeruto *et al*., 2017).

Additionally, the poultice leave preparation from *Cassia didymobotrya* F. are used to treat oral, skin and stomach infections in human (Omwenga *et al*., 2015a). The infusions obtained from the leaves and roots are made and consumed orally when treating skin diseases and ringworms (Wanga & Nyamboki, 2023). Besides, the leaves are boiled and the patient is bathed with the boiled water as a remedy for treatment of pimples, scabies, warts and measles (Njoroge & Bussmann, 2007).

Plate 2.9: *Cassia didymobotrya* Fresen in Kenya

Source: *Agwata, the Herbarium Specimen Collector, Specimen. 9. *Cassia didymobotrya* Fresen. 22 April 2023. Kenya: Nyamira County. Kenyatta University Herbarium (KUH), Accession No. 9.

2.3.10 *Solanum renschii* Vatke

Solanum renschii Vatke is a plant in the family Solanaceae. Besides, it is semi-woody shrub which is approximately 4 m tall. Leaves are simple and are closely near the end of the branches. The flowers have lateral inflorescences. The flowers can be bluish to pale violet. *Solanum renschii* fruit is globose which measures 5-10mm. Often, the fruits are brownish shinning yellow to deep red when they are ripe.

The habitat of *Solanum renschii* is mainly deciduous woodlands, rocky places and on termite moulds. The plant grows in an altitude rage of upto 1470 m (Omwenga *et al*., 2015). Omwenga *et al*. (2015) opines that decoction from *Solanum renschii* Vatke roots are used to treat stomach infections.

Plate 2.10: *Solanum renschii* Vatke in Kenya

Source: *Agwata, the Herbarium Specimen Collector, Specimen. 10. *Solanum renschii* Vatke. 22 April 2023. Kenya: Nyamira County. Kenyatta University Herbarium (KUN), Accession No. 10.

2.3.11 *Biden pilosa* Linn.

Biden pilosa is a plant in the family Asteraceae. The plant leaves are opposite, has a petiole and pinnate with 3-5 sharply serrated ovate leaflets. The leaves are slightly hairy. It has elongated budlike achenes (Xuan & Khanh, 2016). The plant branches and stems have parallel lines which are smooth and green or brown. The flowers occur in tiny inflorescence that is often in a capitulum and yellow at the centre. The achenes are blackish and narrow. The seeds are dark-brown or black (Xuan & Khanh, 2016). *Biden pilosa* plant can produce 3,000-6,000 seeds which are dispersed by wind, animal fur and human clothes (Bartolome *et al*., 2013).

According to Ribeiro *et al*. (2017), this plant is macerated and used to treat various childhood diseases including throat infections, fever, wounds and flue while in adults, it is used to treat fatigue, anaemia, malaria, dengue and kidney problems. Phytochemical

analysis of this plant has been reported to have significant biological activities including antibacterial and antifungal hence used in treatment of infections (Shandukani *et al*., 2018). Moreover, the extracts from this plant has antioxidant properties vital for treatment of human diseases.

Plate 2.11: *Biden pilosa* L. in Kenya

Source: *Agwata, the Herbarium Specimen Collector, Specimen. 11. *Bidens pilosa* L. 22 April 2023. Kenya: Nyamira County. Kenyatta University Herbarium (KUN), Accession No1. 11.

2.4 Childhood diseases

Childhood diseases remain a significant public health concern in Nyamira County, largely due to factors such as limited access to healthcare facilities, poor sanitation, malnutrition and inadequate health education (Charles & Bonareri, 2020). One of the most prevalent childhood illness in the region is respiratory infections including pneumonia and bronchitis. Similarly, malaria is a common illness affecting children due to the regions warm and humid climate which provides an ideal breeding ground for mosquitos.

Additionally, diarrhea diseases caused by poor sanitation, lack of access to clean water and unhygienic food practices are a leading cause of morbidity and mortality among children. Diarrhea, if left untreated can lead to severe dehydration which is particularly dangerous for young children (Charles & Bonareri, 2020). In addition, malnutrition, skin infections and gastrointestinal worms are widespread due to poor hygiene and sanitation practices. According to Omwenga *et al*. (2015) the persistence of these diseases highlight the need for improved healthcare access, community awareness programs and interventions such as promoting use of medicinal plants alongside conventional treatments. Given the high reliance on traditional medicine in the region, an ethnobotanical survey documenting the medicinal plants used to treat these childhood diseases is necessary

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study Area

Nyamira County is one of the 6 Counties in the formerly known Nyanza province in Kenya. The County lies between the latitude of 0° 44'59.99''North and longitude 35° 00'0. 00 East. Nyamira County borders Kericho County to North East, Kisumu to the West, Bomet County to the South East, Narok to the South West and Kisii to the West. The County covers an area of 897 km2 and it is comprised of 605, 576 persons 674.9/km2 77(KNBS, 2020; Kenya Census, 2019). The County comprises of four constituencies, namely; Borabu, Kitutu Masaba, North Mugirango and West Mugirango. Nyamira County is known well for its high crop production due to suitable ecological requirements. Approximately 75% of the soils are red volcanic soils which are deep, fertile and well drained while 25% are clay soils found in valley bottom and swampy areas suitable for brick making. Rain falls throughout the year; with an annual average of between 1200mm and 2000mm.

The County lie between 1500M and 1800M above sea level comprising ridges and hills. The low zones are swampy, wet lands and valley bottoms, while the upper zones are dominated by the hills. The high altitudes have enabled the growing of tea, which is the major cash crop and income earner for the county. There are two peak seasons of rainfall; the long and rainy season starts from March to May while the short rainy season starts from September to November.

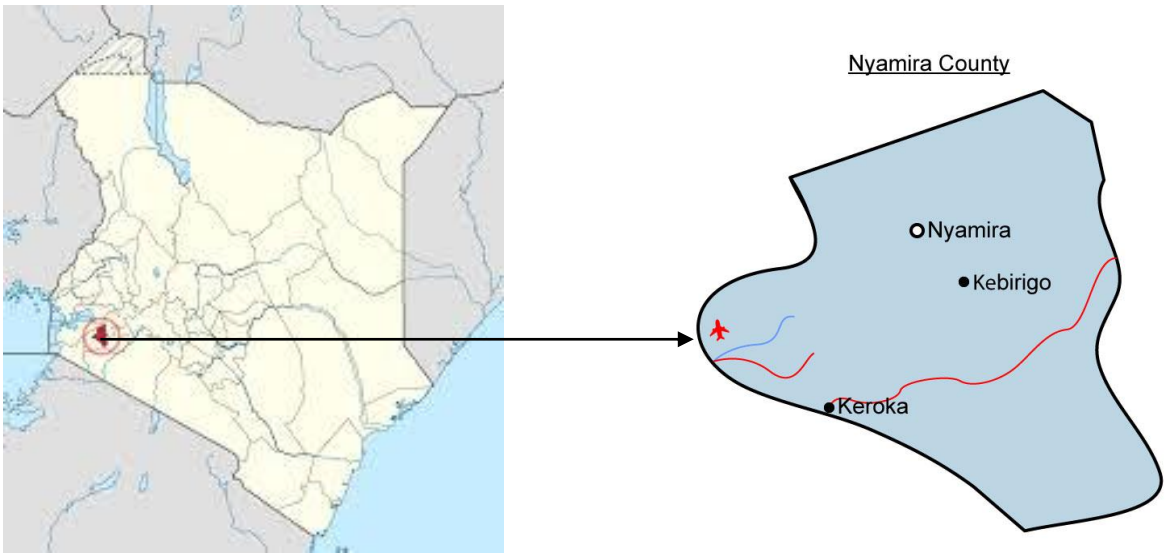

Figure 3.1: Map of Nyamira County.

Source:(Ruth et al., 2020)

3.2 Research Design

The study used a cross-sectional study design as proposed by Wang and Cheng (2020). The data was collected from respondents in four constituencies within Nyamira County. The data on the various medicinal plants uses especially those used to treat childhood diseases, their harvesting, preparation, application and conservation was collected. The data was collected from one hundred (100) traditional healers out of the four hundred (400) registered by the County Government using semi-structured questionnaire (Mogwasi, 2016).

The first respondent was selected purposively and was used to give direction to other herbalists they know in the area (snow balling). Prior to data collection, the selected herbalists were informed of data collection period. On the data collection date, the selected herbalists were requested to fill in the questionnaires. In an event they could not read and

write an interpreter was used to relay the information. The collected data was both qualitative and quantitative. The qualitative data was analyzed using the descriptive and inferential statistical analysis tool available in the SPSS software and output presented in form of figures and tables.

3.3 Sample Size and Sampling Design

One hundred (100) herbalists were selected as respondents in this study, and sampled purposively. The sample size was arrived at using the sample size formula developed by (Daniel & Cross, 2013). Where;

$$n=Z^2P(1-P)/d^2$$

Where;

n=Sample size

Z=Statistic level of confidence (95%)

P= Expected prevalence or proportion

d=Precision (5%)

3.3.1 Selection of the Herbalists

Purposive and snowball types of sampling were used to select the herbalists in Nyamira County. Purposive sampling was used to select herbalists who are known within the County while snowball sampling was used where one herbalist was used to lead to other herbalists. The selection of the participating herbalists was based on their willingness to voluntarily give information on the different medicinal plants that they use for their daily practice.

Table 3.1 Distribution of Respondents in Each Constituency Nyamira County

Constituency	Total Herbalist Population	Percentage of Herbalist Population	Total number of Samples
West Mugirango	145	36%	36
North Mugirango	95	24%	24
Borabu	37	9%	9
Kitutu Masaba	127	31%	31
Total	400	100%	100

3.4 Phytochemical Properties Screening

Eleven (11) fresh samples of the identified medicinal plants were randomly collected in the study area. These are the plants which were highly cited by the herbalists. The plant parts included the flower, leaf, stem and the root for those medicinal plants. After the interview, the most cited plants were sampled for subsequent identification and use in screening of the phytochemicals. After sampling, the sampled plant parts were placed between two sheets of newspaper and pressed between two pieces of cardboards. Thereafter, they were transported to Kenyatta University where they were identified by a taxonomist. The identification involved authentication where the collected samples were compared to the reference sampled in the herbarium. After identification based on the plant features such as leaf arrangement, fruit color among others, a voucher specimen number was obtained and the identified plants deposited in Kenyatta University herbarium.

The remaining samples were washed and sliced into portions then air dried under the shade for 14 days at Kenyatta University. The phytochemical extracts from the selected plants were obtained using the cold percolation method as described by Alanis *et al*. (2007). The plant parts used in extraction of the phytochemical compounds were collected and air-dried in shade. Once they were dry, the samples were cut into small pieces and ground using a laboratory mill as demonstrated by Edeoge *et al*. (2007). Fifty grams (50g) of the ground powder were soaked in 300ml of 80% methanol for 12-48 hours and shaken periodically. After soaking, the obtained extracts were filtered through Whatman filter and later evaporated. Dry weight of the extract was obtained by evaporating it in a rotary evaporator. The crude extract were subjected to qualitative phytochemical analysis using previous methods developed by Edeoga *et al*. (2005) and Álvarez and Ramírez (2007). The phytochemical compounds that were of interest in this study include, tannins, flavonoids, terpenoids, alkaloids, saponins, steroids, anthraquinones, phlobatannins and cardiac glycosides.

3.5 Test for Secondary Metabolites

3.5.1 Phytochemical Compounds Screening.

The phytochemical compounds that were screened in this study included tannins, saponins, alkaloids cardiac glycosides, steroids, phenols, anthraquinones, phlobatannins and terpenoids. The qualitative analysis of the phytochemicals were determined using methods developed by Edeoga *et al*. (2005) and Álvarez and Ramírez (2007), where (+++) reaction indicated high concentration; a (++) moderate, (+) low concentration and a (-) indicated absence of the phytochemical compound of interest.

3.5.1.1 Tannin Screening

Tannins were determined by dissolving the crude extracts obtained from the medicinal plants extract in distilled water then filtered. The obtained filtrate was added to equal volume of Iron (III) chloride solution. The formation of a blue-black precipitate showed tannins is present in the crude plant extract. A symbol of (+) was used to indicate presence of tannins and absence of tannins was indicated by (-) (Edeoga *et al*., 2005).

3.5.1.2 Test for Saponins

The presence of saponins was determined using the frothing test method. The crude sample from the selected medicinal plants was mixed with distilled water, and heated until it boiled. The mixtures were observed and presence of frothing and persistence of cream colour with a few bubbles showed that saponins was present in the crude extract samples. The results were recorded as (+) if saponin was present in the sample while (-) was used to indicate saponin was absent in the medicinal plant crude extracts (Álvarez and Ramírez, 2007).

3.5.1.3 Test for Alkaloids

In determining the alkaloids, the crude extract from medicinal plant samples were dissolved in methanol and the mixture filtered. The obtained filtrate was mixed with few drops of Wagner's reagent prepared by adding 1.27 g of Iodine and 2g of potassium Iodide in 100ml of water. Creamy precipitate, brown-red precipitate or orange precipitate indicated that alkaloid compounds were present in the medicinal plant crude extract (Obdoni & Ochuko, 2002). The results were presented as (+) if alkaloid is present while (-) indicated alkaloid was absent in the medicinal plant crude extracts.

3.5.1.4 Test for Cardiac Glycosides

When determining presence of cardiac glycosides, the Keller-Kilian's method was used. The medicinal plant crude extracts were mixed with glacial acetic acid, three drops of Iron (III) chloride and concentrated sulphuric acid. The appearance of a green colour indicated that cardiac glycosides was present in the medicinal plant extracts. The positive samples were recoded as (+) while negative was indicated as (-) as described by Obdoni and Ochuko, (2001).

3.5.1.5 Test for Terpenoids

Terpenoids was tested by mixing the medicinal plant crude extracts with chloroform and filtered. In the filtrate, a drop of concentrated sulphuric acid was added carefully to form two layers. Formation of a reddish-brown coloration interface indicated that terpenoids were present in the medicinal plant crude extracts. The samples which had terpenoids were recorded as (+) and if absent, it was presented as (-) as described by (Edeoga *et al*., 2005).

3.5.1.6 Test for steroids

Steroids in the sampled plants was determined using the Salkowsi test where 2 ml of chloroform was added to the extract and 2 ml of concentrated sulphuric acid added as described by (Noormazlinah *et al.*, 2019). Formation of reddish-brown ring at the surface interface indicates presence of steroids.

3.5.1.7 Test for Anthraquinones

Anthraquinones was tested using Borbtrager test where 5 ml of chloroform was added to the extract, shaken well and filtered. Thereafter, equal volume of 10% ammonia solution was added to the filtrate as described by (Ramya *et al.*, 2019).

3.5.1.8 Test for phenols

A ferric chloride test was used to test for phenols. A few drops of neutral 5% ferric chloride solution was added to the extract. Formation of a deep green or purple color showed presence of phenolic compounds (Nabavi *et al.*, 2008).

3.5.1.9 Test for Phlobatannins

A small amount of the extract was boiled in distilled water and a few tops of 1% hydrochloric acid was added. Formation of a red precipitate showed Phlobatannins presence as described by (Lemino & Bag, 2013).

3.6 Data Analysis

The data from the questionnaires were coded an excel sheet and imported to SPSS version 20. The data was checked for normality and qualitative data was analyzed using the descriptive and inferential statistics available in the SPSS software. Relationship between the respondent's sociodemographic characteristics and the medicinal plants harvesting and preparation was determined using spearman correlation. The output was generated and presented as tables and figures.

CHAPTER FOUR: RESULTS

4.1 Sociodemographic Information of the Respondents

The respondents in this study were from four constituencies in Nyamira County, Kenya. Out of the 100 sampled herbalists, their social demographic data is presented in Table 1. Out of the sampled study participants, 34% were from Kitutu Masaba, West Mogirango (32%), North Mogirango (18%), and Borabu (16%). Besides, 56% of the sampled respondents were female while 44% were male. Similarly, 30% of the respondents were aged between 51-60, (30%) and 61-70 (30%) years while 26% aged above 70 years. A few of the respondents (14%) were below 50 years. These includes 21-30 years (4%), 31-40 years (6%) and 41-50 (4%).

Based on the level of education, 54% of the sampled herbalists in Nyamira County had attained primary level of education, followed by non-formal education with 26%. In contrast, the respondents who had attained secondary and college level of education were 6% each. However, none of the sampled herbalists had attained university level. Moreover, 48% of the herbalists had practiced use of medicinal plants to treat different human ailments for more than 20 years while 8% of the respondents had practiced for 11-20 years, (6%) 6-10 years and (4%)1-5 years (Table 1).

Table 4.1: Sociodemographic Information of the Selected Herbalists in Nyamira County

Location	**Frequency (N)**	**Percentage (%)**
West Mogirango	16	32
North Mogirango	9	18
Borabu	8	16
Kitutu Masaba	17	34
Gender		
Male	22	44
Female	28	56
Age (years)		
20-30	2	4
31-40	3	6
41-50	2	4
51-60	15	30
61-70	15	30
Above 70	13	26
Level of education		
Primary	27	54
Secondary	3	6
College	3	6
University	0	0
Nonformal	17	34
Experience of the herbalists		
1-5 years	2	4
6-10 years	4	8
11-20 years	19	38
Above 20 years	24	48

4.2 Diversity of the Medicinal Plants

The medicinal plants identified in this study were from (21) different families and divisions (Table 4.2). The most cited family was Lamiaceae. The herbalist indicated they used different medicinal plants to cure different diseases. However, the citation of each medicinal plant differed with some of the medicinal plants cited by all the herbalists while some were cited by only one herbalist. The uses of the medicinal plants were different.

Table 4.2: Medicinal Plants Used by the Abagusii Community to Treat Childhood Diseases

Medicinal Plants	Local Name (Ekegusii)	Family Name	Parts Used	No. of Citations	Uses
Asparagus africanus Lam.	*Ekerobo ekiagarori*	Asparagaceae	roots	45	Fever, Skin disease and Malaria
Acacia gerrardii Beuth.	*Omokonge*	Mimosaceae	Bark	13	Stomach infections
Urtica dioica L.	*Rise*	Urticaceae	Leaves	48	Liver diseases
Acacia nilotica (L) Delile.	*Omonyenya*	Mimosaceae	Bark	38	Malaria
Aloe secundiflora Engl.	*Omogaka*	Aloeceae	Leaves	41	Malaria
Amaranthus Spp. L.	*Emboga*	Amaranthaceae	Seeds	40	Rashes, eczema and measles
*Azadirachta indica (*A) Juss.	*Omwarobaine*	Maliaceae	Bark	39	Eczema, ringworm and chickenpox
Biden Pilosa L.	*Ekemogamogi*	Compositae		50	Snake bites
Bischofia savanica Blume.	*Omonyagesagane*	Eunphordiaceae	Roots	27	Tootache, wound and diarrhea
Cassia didymobotrya Fresen.	*Omobeno*	Fabaceae	leaves	42	Constipation
Caesalpinia clecapetala (Roth) Alston.	*Ekenagwa*	Caesalpineniaceae	Roots	27	Skin infections
Carissa edulis Valh.	*Omonyangateti*	Apocynaceae	Fruits and Roots	50	Diarrhea, epilepsy and cough
Commelina benghalensis L.	*Rikongiro*	Combretaceae	Leaves	43	Boils and skin related diseases
Cleome gynadra L.	*Chinsaga*	Chenopodiaceae	Flowers and leaves	18	Stomach pains
Croton macrostachyus Hochst.ex Delile	*Omosocho*	Euphorbaceae	Bark	47	Oral and skin infections
Cyathula uncinulata Schrad.	*Riramata*	Amaranthaceae	Leaves	15	Skin infections
Dichrocephala integrifolia Kuntze.	*Ekengenta mbori*	Asteraceae	Leaves and Bark	46	Oral infections

Elaedendron buchanii Loes.	*Rikanda*	Celastraceae	Roots	23	Diarrhea, Malaria and eye infections.
Enseta venticosum (Welw) Cheeseman.	*Engoma*	Ebenaceae	Fruit	33	Bone fractures and internal parasites
Ertangea marganata S Moore.	*Omonyaiboba*	Asteraceae	Leaves	23	Obesity
Erythrina abyssinica Lam.	*Omotembe*	Fabaceae	Bark	25	Tuberculosis, Diarrhea and cough
Lantana camara L.	*Riuga rirоro*	Lamiaceae	Buds	48	Liver diseases
Leonotis nepetiforia (L) R.B.	*Risibi*	Lamiaceae	Leaves	45	Kidney problems
Myricoides (Hoshst) R.Br.and Vatke.	*Omonyasese*	Lamiaceae	Roots	46	Dry coughs
Musa autralimusa	*Rigoma*	Musaceae	Leaves	35	Mouth ulcers
Orhosiphon hildebranditii Baker.	*Ekebunga baiseke*	Lamiaceae	Bark	23	Skin
Rhoicissus tridentata (L.F) Wild and drumon.	*Omosubo*	Vitaceae	Buds	25	Malaria
Rhus natalensis Bernh Ex Krauss.	*Obosangora*	Anacardiaceae	Bark	20	Diarrhea, skin diseases and fever
Solanum rencshii Vatke.	*Omotobo*	Solanaceae	Leaves	45	Mouth ulcers
Solanum nigrum Linn.	*Rinogu*	Solanaceae	Seeds and Fruits	40	Breathing complication
Spilanthes mauritania DC.	*Ekanyunyuntamonwa*	Asteraceae	leaves	40	Mouth wounds
Toddalia asiatica (L) Lam.	*Ekenawa ekiagaroi*	Rotaceae	Roots	41	Digestive problems and fever
Vernonia auriculifera Hiern.	*Omosabakwa*	Compositae	Buds	20	Stomach pains
Swarbugia ugandensis W.	*Esoko*	Canellaceae	Bark	39	Headaches and malaria

4.3 Plant Parts Used

In this, study, the most cited plant part used as medicinal were the leaves with 40.3% followed by roots (29.6%), barks (13.3% and fruits (10.3%). In addition, the herbalists indicated to use other plant parts such as the fruits, whole plant, and stem (Table 4.3). Flowers were cited by 1.9% of the respondents while whole plant and stem were cited by 0.9% and 3.7% respectively.

Table 4.3: Plant Parts Used for Medicinal Purposes

Plant part	Number of citations	Percentage (N)
Leaves	876	40.3
Roots	430	29.6
Barks	234	13.3
Fruits	223	10.3
Stem	81	3.7
Flowers	42	1.9
Whole plant	19	0.9

4.4 Methods of Preparation

In Nyamira County, the herbalists use diverse methods of herbal preparation. The most cited and common method used by the herbalists was soaking in hot water (84%), then boiling (36%) followed by soaking in cold water with (34%) and pounding with 30% (Table 4.4). The herbalists indicated to boil the plants parts of the medicinal plants to obtain a concoction which is highly effective. In contrast, the least cited methods included heating (8%) and roasting with (4%).

Table 4.4: Method of Preparation

Preparation method	Frequency	Percentage (%)
Soaking in hot water	42	84
Boiling	18	36
Soaking in cold water	17	34
Pounding	15	30
Chewing	14	28
Burning	8	16
Heating	4	8
Roasting	2	4

4.5 Methods of Administration

In this study, the most cited methods of herbal administration were drinking and bathing with 96%, followed by rubbing of the plant extract to the affected area with 72%, and poulticing (58) (Table 4.5). The least cited methods include steaming with 32%, taken with food 32% and a combination of drinking and bathing with 20%.

Table 4.5: Methods of Herbal Administration

Administration Method	Frequency (N)	Percentage (%)
Drinking	48	96
Bathing	48	96
Rubbing	36	72
Steaming	16	32
Poulticing	29	58
Taken with food	16	32
Bathing and drinking	10	20

4.6 Threats to Medicinal Plants in Nyamira County

In Nyamira County, the medicinal plants are threatened by diverse human factors. According to the respondents in this study area, the most cited threat is overexploitation (94%), habitat destruction (76%), population pressure (72%), gene erosion (72%), global trade (18), commercial exploitation (8%) and flooding (2%) (Table 4.6).

Table 4.6: Threats to Medicinal Plants in Nyamira County

Threats to medicinal	Frequency	Percentage (%)
Over exploitation	47	94
Habitat destruction	38	76
Gene erosion	36	72
Population pressure	36	72
Global trade	9	18
Commercial exploitation	4	8
Flooding	1	2

4.7 Management Methods

The management methods used in study area were diverse. The most preferred management method by the respondents in study area was biological and ecological issues (82%) followed by documentation of the medicinal plants (66%), indigenous intellectual property rights (30%), adequate positions and quality healthcare (28%) and management strategies ensuring livelihood security (22%) (Table 4.7). In contrast, the least cited

management methods include policy formulations (16%) and building knowledge systems learning and information (22%).

Table 4.7: Management Methods

Management method	Frequency (N)	Percentage (%)
Biological and ecological issues	41	82
Documentation	33	66
Indigenous intellectual property rights	15	30
Adequate positions and quality healthcare	14	28
Management strategies which ensure livelihood security	11	22
Building knowledge systems learning and information	11	22
Policy formulations	8	16

4.8 Protection of the Medicinal Plants

The herbalists in the study area indicated that medicinal plants in use by the Abagusii community are threatened by human activities. The most cited human activity that is a threat to the medicinal plants was cultivation cited by 94% of the respondents followed by *in-situ* (36), while commercial activities, and *ex-situ* was cited by 34% of the respondents (Table 4.8). Similarly, 28% of the respondents indicated that the medicinal plants used by Abagusii community can be protected through awareness in the community on the importance of the medicinal plants.

Table 4.8: Protection of the Medicinal Plants

Threats to Medicinal Plants	Frequency	Percentage (N)
Cultivation	47	94

In-situ	18	36
Commercial	17	34
Ex-situ	17	34
Awareness	14	28

Relationships between the Respondents Sociodemographic and the Herbal Preparation

Based on Spearman Order Rank Correlation, there was significant positive correlation between plant parts used, gender, and the herbalists' experience (Table 4.9). Besides, there was a positive significant correlation between the herbalist's level of education and the medicinal plant harvesting methods. The medicinal plant preparation significantly correlated with the herbalist age and experience.

Table 4.9: Relationships between the Respondents Sociodemographic and the Herbal Preparation

	Age	**Gender**	**Education Level**	**Experience**	**Plant parts used**	**Harvesting methods**	**Preparation methods**	**Administration methods**
Age	1							
Gender	.000	1						
Education level	.837	.000	1					
Experience	.888	.526	.000	1				
Plant parts used	.-107	.-133**	.769	-.125*	1			
Harvesting methods	.372	.000	.0133**	.011	.769	1		
Preparation methods	.107**	.072	.821	.001*	.588	.628	1	
Administration methods	.018**	.102**	.778	.122**	.705	.705	.770	1

Key: *Correlation significant at 0.05, ** correlation is significant at the 0.01 level (2-tailed)

Relationship between the Herbalist Sociodemographic and Knowledge on Cause of Plant Depletion, Management and Protection Methods

In this study, there was significant relationship between the herbalist experience and age. Also, there was significant relationship between the herbalist age, gender and their knowledge and the causes of medicinal plant depletion, management and protection methods (Table 4.10).

Table 4.10: Relationship between the herbalist sociodemographic and knowledge on cause of plant depletion, management and protection methods

	Age	Gender	Education Level	Experience	Causes of depletion	Management methods	Protections methods
Age	1						
Gender	.000	1					
Education level	.556	.749	1				
Experience	.001*	.790	.825	1			
Causes of depletion	.028**	.008*	.217	.899	1		
Management methods	.247	.065	.373**	.656	.344**	1	
Protection methods	.004*	.104**	.441	.725	.725	1	1

Key: *Correlation significant at 0.05, ** correlation is significant at the 0.01 level (2-tailed)

4.9 Phytochemical Screening

In this study, phytochemicals in the chemical classes terpenoids and phenols were identified in all the selected medicinal plants. However, some of the phytochemicals were specific to the medicinal plant.

In this study, all the selected plants were positive for the phytochemical tannins except *Cassia didymobotrya*. On flavonoids, all the selected plants were positive except *Uritica dioica* and *Asparagus africanus*. Besides, all the selected plats were positive for terpenoids. Comparison based on phenols showed that all the plants were positive for phenol except *Asparagus africanus* (Table 4.11). Additionally, all the selected plants were negative for saponin phytochemical except S*olanum nigrum, Asparagus africanus, Croton macrostachyus, Carissa edulis* and *Bidens pilosa*. Similarly, steroids are negative - majority of the selected plants except *Uritica dioica, Croton macrostachyrus, Lantana camara, Solanum nigrum* and *Carissa edulis* which were positive for steroids. Alkaloids were negative in majority of the selected plants except *Aloe secundiflora*, *Lantana camara, Solanum nigrum* and *Carissa edulis*. (Table 4.11). In this study, all the selected plants were negative for the phytochemicals Cardiac Glycosides, Phlobatannins and Anthraquinones.

Table 4.11: Phytochemicals Screened in the Selected Medicinal Plants

Phytochemicals	*A. sec undifl ora*	*A. afri canus*	*B.pilo sa*	*C. ed ulis*	*C.didym obotrya*	*Croton macrostach yus*	*Oxalis corniculate*	*Uritica dioica*	*Lantana camara*	*Solanum nigrum*	*Solanum renschii*
Tannins	+	+	+	+	-	+	+	+	+	+	+
Flavanoids	+	-	+	+	+	+	-	-	+	+	+
Terpenoids	+	+	+	+	+	+	+	+	+	+	+
Saponins	-	+	+	+	-	+	-	-	-	+	-
Steroids	+		+	+	-	+	-	+	+	+	-
Anthraquinones	+	-	-	-	-	-	-	-	-	-	-
Cardiac Glycosides	-	-	-	-	-	-	-	-	-	-	-
Phlobatannins	-	-	-	-	-	-	-	-	-	-	-
Alkaloids	+	-	+	+	+	+	+	+	+	+	-
Phenols	+	-	+	+	+	+	+	+	+	+	+

Key: -

\+ = present

\- = absent

CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

In this study, all the respondents treated human diseases. The herbalist ages ranged from 29 to 80 years. Majority of the herbalists were female. The high number of herbalists who were women could be due to their family roles. Women are responsible for providing food to their families and as they do so, they get to learn the medicinal value of the different plants in the region. This finding agrees with Bussmann *et al*. (2018) who indicated that many herbalists are women because of their family roles of providing food which is often plant based. As they gather the plants, they learn the medicinal value of each plant and its role in treatment of human diseases.

Additionally, majority of the respondents had primary education with a few having attained secondary and college education. This demonstrates that knowledge of herbal medicinal is not necessarily learned through schooling but it is passed from one generation to another. The older herbalists share the medicinal knowledge with the younger herbalists. This finding is in agreement with Kigen *et al*. (2013), who established that the traditional medicine knowledge is shared from one generation to another. The experienced and older herbalists share the traditional medicine with the younger generation who practice until old age.

All plant parts are important source of medicine to many communities. However, the herbalists in the study area were specific on the plant parts used in preparation of the herbal therapies. Leaf was the most cited plant part compared to the roots and barks. This can be

attributed to easy harvesting of the leaves more than the roots. In addition, leaves can be chewed so were the roots while other plant parts such as, barks, fruits and the whole plant may require further preparations. Also, the herbalists cited the use of the leaves as a strategy of protecting the medicinal plants. The leaves are produced every season hence available. The use of roots and barks requires cutting the entire plant which is destructive and cutting trees especially in government gazette forests is illegal. This finding is in agreement with previous study by Tangjitman *et al*. (2015) where leaves were the most cited plant parts because of their potency and their ability to regenerate fast. Besides, this finding corroborates with Ahmad *et al*. (2014) who indicate that the leaves are the photosynthetic part of the plant hence act a storage organ for exudates and photosynthetic which are of medicinal value. Other plant parts were the least cited because preparation involving these plant parts is believed to be hectic and more destructive to the plant (Tugume & Nyakoojo, 2019).

Herbalists in Nyamira County use diverse methods of herbal preparation. The most cited methods included soaking in hot and cold water, boiling and pounding. The use of these methods more than other methods such as roasting, heating and burning to ashes can be attributed to the ability of these methods to extract the active compounds from the medicinal plants. The active compounds from these plants are vital in healing the various childhood different human diseases. This finding is in agreement with Kamatenesi *et al*. (2011) and Mutai *et al.* (2021) where boiling of medicinal plants to make decoctions was the most cited method by herbalists because of their ability to extract the active compounds required to heal human diseases. According to Tugume and Nyakoojo (2019), boiling of

different medicinal plant parts to decoction significantly increases the effectiveness of the decoction because active compounds work synergistically to heal the diseases.

Additionally, drinking was the most cited method of the herbal administration. According to the herbalists, drinking is the most preferred method because it is easier to administer. Some of the herbal preparations are bitter and drinking is better than other methods such as chewing the leaves, barks or the roots. This finding is in agreement with Appiah *et al*. (2018) where herbalists in Ghana preferred drinking method of herbal administration due to the fact that it is easier to administer. Pounding was also preferred by the herbalists especially on the plant parts such as the leaves. Bathing, rubbing and soaking in either warm or cold water was common when the target ailment was external and mostly skin infection. This finding is in agreement with *Agyare et al*. (2014) who indicated that bathing, rubbing and soaking in warm water was common methods of herbal preparation for external body infections especially the skin.

Additionally, this study established that the availability of medicinal plants in Nyamira County was constantly diminishing because of constant threat of these plants in their natural habitats. Agricultural activities were the most cited threat to the medicinal plants in the study area. This finding corroborates with Appiah *et al*., (2018) who established those agricultural activities and encroachment of the medicinal plants natural habitats significantly threaten the availability of these plants in the future. Similarly, deforestation and overharvesting of the medicinal plants was reported as threats to the availability of medicinal plants (Chekole *et al*., 2015). Contrary to this finding is a study by Wodah and

Asase (2012) who indicated that drought, and bush fires were the major threats to medicinal plants availability.

The existence of diverse threats to the availability of medicinal plants in the study area calls for better management methods. The respondents cited that documentation of the medicinal plant's information will aid in protection of these plants. In addition, the government should formulate policies which will aid in the protection of the natural habitats of the medicinal plants. The public should be educated on the importance of protecting the natural forest. According to Chekole *et al*. (2015), protection of medicinal plants involves formulation of policies, documentation of the indigenous knowledge of each medicinal plant and educating the users of the medicinal plants on the need of domestication of the plants to prevent overharvesting in natural habitats.

Additionally, the herbalist's knowledge on the medicinal plant's methods of preparation, administration and the plant parts related differently with the herbalists sociodemographic. The herbalists who were aged had more knowledge on these plants because they have been practicing over time. Traditional knowledge on medicinal plants is highly valued and it is passed from one generation to another. This is in agreement to previous study by Kigen *et al*. (2017) and Mutai *et al*. (2021) who reported that knowledge on medicinal plants is highly guarded by the herbalists. The aged are believed to have experience and can share with the younger and most trusted persons in the family lineage. Despite the significance of traditional knowledge in use of herbal medicine, the herbalist level of education impacted their knowledge on the most suitable harvesting and conservation methods.

According to Khurm *et al.* (2021), preliminary screening of crude from *Cassia didymobotrya* roots showed presence of various compounds including flavonoids, glycosides, terpenes, phenolics, saponins, tannins and anthraquinones. Similarly, Oladeji *et al.* (2021) identified flavonoids, terpenoids, anthraquinones, alkaloids and phenols from the methanol, ethyl acetate and dichloromethane extracts of *Cassia didymobotrya*. These compounds have been previously established to have antimicrobial properties against pathogenic bacterial such as Methicillin Resistant *Staphylococcus aureus* and *Pseudomonas aeruginosa*.

Additionally, *Solanum nigrum, Solanum renschii* Vatke were positive for phytochemicals tannins, flavonoids, terpenoids, alkaloids, saponins, steroids and phenols while negative for anthraquinones, phlobotannin and cardiac glycosides. This finding is in agreement with Chen *et al*. (2022) and Ling *et al*. (2019) who reported that the major bioactive constituents in *Solanum nigrum* include alkaloids, phenols, and steroidal saponins (Yuan *et al.*, 2020). These compounds have significant therapeutic potentials and can be used as antitumor, antibacterial, antioxidant and anti-inflammatory (Peraman & Nachimuthu, 2019). Traditionally, the plant has been used as an essential dietary fiber with an important source of such elements as zinc, calcium and vitamins C and E (Sangija *et al*., 2021).

Carissa edulis has been in use as a medicinal plant since time immemorial. Traditionally, it is used to treat tooth decay and prevent skin premature. In this study, the phytochemistry analysis showed that this plant has tannins, flavonoids, terpenoids, alkaloids, saponins, steroids and phenols while negative for anthraquinones, phlorotannin and cardiac

glycosides. This is in agreement with Fowsiya and Madhumitha (2017) who established that *Carissa edulis* has a number of phytochemicals including flavonoids, tannins, phenols and terpenes. According to Opande (2022), *Carissa edulis* root contains rutin, pinitol, amyrin, carissone and carissin. These compounds have various biological activities including antiviral, antimicrobial, anti-inflammatory and anticonvulsant (Fowsiya & Madhumitha, 2017). Similarly, *C. edulis* tea has high phenolic contents which are vital in the treatment of viruses such as Herpes simplex virus disease. According to Kaunda *et al*. (2020), the aerial parts of *C. edulis* has vitamins C, B1, B2 and A also, it has macro elements such as calcium, iron, magnesium and potassium.

In the study, *Croton macrostachyrus* was positive for the phytochemical's tannins, flavonoids, alkaloids, steroids, phenols, terpenoids and saponins while negative for the phytochemicals anthraquinones, phlorotannin and cardiac glycosides. This finding agrees with previous study by Degu *et al*. (2016) where multiple classes of phytochemicals including phytochemical's tannins, flavonoids, alkaloids, steroids, phenols, terpenoids, anthraquinones, phlorotannins, cardiac glycosides and saponins were extracted from the leaves, stem barks, fruits, and twigs of *Croton macrostachyrus*. The phytochemicals from *Croton macrostachyrus* have had several pharmacological activities including antibacterial (Sendeku *et al*., 2015), anti-inflammatory (Nguelefack *et al.,* 2015), antidiabetic (Abdirahman *et al*., 2015), antidiarrhea (Abdirahman *et al*., 2015), sedative and anticonvulsant (Abdirahman *et al*., 2015), anthelmintic (Aleme & Awetahegne, 2015), antimycobacterial (Gemechu *et al*., 2013), antispasmodic (Mohammed *et al*., 2014) and cytotoxicity (Omosa *et al*., 2016). These properties justify the ethnomedicinal uses of this

plant to cure various diseases in humans and animals by different communities globally (Maroyi, 2017).

Additionally, *Asparagus africanus* selected in this study was positive for the phytochemicals; tannins, terpenoids and saponins. This finding is in agreement with El-Ishaq *et al*. (2019), who reported that extracts from *Asparagus africanus* root were positive for steroidal saponins phytochemicals. Traditionally, the *Asparagus africanus* is used to treat various human diseases including headache, throat infections, tuberculosis, hemorrhages, abortion, cough and ladder irritations (Kebede *et al*., 2016).

Aloe secundiflora selected in this study was positive for tannins, flavonoids, terpenoids, phenols and Anthraquinones. This corroborates with previous studies within the same region where methanolic extracts of *Aloe secundiflora* was positive for phenols, alkaloids and terpenoids. However, this was contrary to that which reported positive results in cardiac glycosides in methanolic extracts of *Aloe secundiflora* which was not reported in any plant selected in this study (Mariita *et al*., 2011). *Aloe secundiflora* leaf extracts have antibacterial, antiviral and antihelminth medicinal properties (Bjorå *et al*., 2015). In Kenya, herbalists living around lake victoria use the *Aloe secundiflora* to treat various ailments including stomachache, polio, malaria and chest related problems (Mariita *et al*., 2011).

In *Bidens pilosa*, the positive phytochemicals were tannins, flavonoids, terpenoids and phenols and absent for alkaloids, cardiac glycosides, Anthraquinones and phlorotannin.

This is in agreement with Bartolome *et al*. (2013) who established that *Bidens pilosa* has a range of phytochemicals including terpenoids, flavonoids, compounds of aromatics and aliphatic origins. These phytochemicals have significant biological activities in humans including antidiabetic Chien *et al*. (2009), antimalaria, anti-ulcerative, antibacterial, antifungal, antioxidant (Yuan *et al*., 2010) and ant-inflammatory. Similarly, extracts from this plant have a history of use as antitumor, ant-immunomodulatory and antihyperglycemic (Yshida *et al*., 2006). In Kenya, *Bidens pilosa* is traditionally used to improve general human health and heal early childhood diseases and globally used to treat infections such as ear infections, kidney problems, headaches, diarrhea and stomach pains (Xuan & Khanh, 2016).

5.1 Conclusions

i. Herbalists in Nyamira County use different medicinal plants to treat different childhood diseases. These includes colic pains, diarrhea and stomach pains and mouth ulcers.

ii. The harvesting, preparation, conservation methods of medicinal plants by herbalists in Nyamaira County are diverse and are related to the herbalist sociodemographics.

iii. Some medicinal plants are available within Nyamira County while the availability of some is threatened by human activities such as farming and overharvesting. Therefore, there is a need to document these plants and protect the forests to reduce encroachment and overharvesting of the existing medicinal plants.

iv. Selected medicinal plants from Nyamira County produce diverse phytochemicals such as flavonoids, phenols, monoterpenoids, glycosides, saponins, tannins and

steroids. These phytochemical properties have been documented to have diverse biological properties such as antimicrobial, antioxidants, and antimalarial.

5.2 Recommendations

i. This study documented a few different medicinal plants that are used in Nyamira County; therefore, documentation should be done on other plants which were not documented in this study.

ii. Further research should be done to identify active ingredients in phytochemical compounds for future drug formulation.

iii. There is a need to enforce policies that will aid in conservation of medicinal plants in Nyamira County.

iv. Further research should be done to screen the phytochemicals from the medicinal plants for future use in treatment of diseases.

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APPENDIX 1: QUESTIONNAIRE FOR MEDICINAL PLANT PRACTITIONERS

SECTION A: GENERAL INFORMATION

What is the name of your Constituency?

Kindly Tick (√) as appropriate.

Constituency	**(√)**
West Mugirango	
North Mugirango	
Borabu	
Kitutu Masaba	

2.Kindly state your gender. Fill as appropriate.

Male ( )

Female ( )

3.Kindly state the number of years you have practiced herbalism.

Practicing experience	5-10 years
Below 1 year	10-20 years
1-5 years	Over 20 years

4.How many patients do you treat in a day?

5. Are you a member of any herbalist association?

6. How did you acquire the knowledge to use medicinal plants?

7.What is your age?

AGE	
20-30 years	50-60 years
30-40 years	60-70 years

40-50 years	Over 70 years

8.What is your level of education? Fill as appropriate.

EDUCATION LEVEL	
Primary	Non-formal education
Secondary	Other specifications
Tertiary	

SECTION C: CHILDHOOD DISEASES.

9. What are the plants that treat the common childhood diseases?

Disease	**Name of plant (Local name)**	**Family name of plant**
Asthma		
Baby fever		
Body rashes		
Diabetes		
Pepys		
Pneumonia		
Cancer		
Ear ache		
Fresh wound		
Diarrhea		
Kidney diseases		
Liver diseases		
Measles		

Mouth sours		
Heart diseases		
Malaria		

SECTION C: MEDICINAL PLANTS

9. What plants do you use for treating the following childhood diseases? Fill as appropriate.

Disease treated	**Name of plant (Local name)**	**Plant part used (Roots, Stem, Bark, Leaves, Buds, Flowers, Fruits)**	**Harvesting method (Uprooting, Picking, Cutting, Peeling)**	**Preparation method (Boiling, Burning, Pounding, , Chewing, Roasting)**	**Application Method (Drinking, inhaling, bath, rubbing)**	**Storage (dry, fresh)**	**Availability (Abundant, Rare, Frequent)**	**Domestication (wild, cultivated)**	**Other uses (Food, fodder, firewood, Aesthetic value)**
Asthma									
Baby Fever									
Body rashes									
Diabetes									
Pepys									

Pneumonia									
Cancer									
Common cold									

Disease treated	**Name of plant (Local name)**	**Plant part used** **(Roots, Stem, Bark,** **Leaves, Buds, Flowers, Fruits)**	**Harvesting method** **(Uprooting,** **Picking,** **Cutting, Peeling)**	**Preparation method** **(Boiling, Burning, Pounding,** **, Chewing, Roasting)**	**Application** **Method (Drinking, inhaling, bath, rubbing)**	**Storage (dry, fresh)**	**Availability (Abundant, Rare, Frequent)**	**Domestication (wild, cultivated)**	**Other uses (Food, fodder, firewood, Aesthetic value)**

Ear ach									
Fresh wound									
Diarrhea									
Kidney diseases									
Liver diseases									
Malaria									
Measles									
Mouth souls									

SECTION D: GENERAL VIEWS

10.In your opinion, what should be done to conserve medicinal plants in Nyamira County?

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Thank you for participating

APPENDIX 2: RESEARCH AUTHORIZATION

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 020-8704150

Our Ref: I56/CE/34256/2016 DATE: 12th May, 2022

Director General,
National Commission for Science, Technology
and Innovation
P.O. Box 30623-00100
NAIROBI

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR MS. AGWATA NYABATE DELFINE – REG. NO. 156/CE/34256/16

I write to introduce Ms. Agwata Nyabate Delfine who is a Postgraduate Student of this University. She is registered for M.Sc. degree programme in the **Department of Plant Sciences.**

Ms. Agwata intends to conduct research for a M.Sc. thesis Proposal entitled, **"Ethnobotanical Survey and Profiling of Phytochemicals from Medicinal Plants Used to Treat Childhood Diseases in Nyamira County, Kenya"**

Any assistance given will be highly appreciated.

Yours faithfully,

PROF. ELISHIBA KIMANI
DEAN, GRADUATE SCHOOL

APPENDIX 3: RESEARCH PERMIT

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 812606

Date of Issue: 20/January/2023

RESEARCH LICENSE

This is to Certify that Ms.. Delfine Nyabate Agwata of Kenyatta University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Nyamira on the topic: ETHNOBOTANICAL SURVEY AND PROFILING OF PHYTOCHEMICALS FROM MEDICINAL PLANTS USED TO TREAT CHILDHOOD DISEASES IN NYAMIRA COUNTY, KENYA for the period ending : 20/January/2024.

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THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013 (Rev. 2014)
Legal Notice No. 108: The Science, Technology and Innovation (Research Licensing) Regulations, 2014

The National Commission for Science, Technology and Innovation, hereafter referred to as the Commission, was the established under the Science, Technology and Innovation Act 2013 (Revised 2014) herein after referred to as the Act. The objective of the Commission shall be to regulate and assure quality in the science, technology and innovation sector and advise the Government in matters related thereto.

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2. The research and its related activities as well as outcomes shall be beneficial to the country and shall not in any way;
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    ii. Adversely affect the lives of Kenyans
    iii. Be in contravention of Kenya's international obligations including Biological Weapons Convention (BWC), Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), Chemical, Biological, Radiological and Nuclear (CBRN).
    iv. Result in exploitation of intellectual property rights of communities in Kenya
    v. Adversely affect the environment
    vi. Adversely affect the rights of communities
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    viii. Plagiarize someone else's work
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14. The Commission shall have powers to acquire from any person the right in, or to, any scientific innovation, invention or patent of strategic importance to the country.
15. Relevant Institutional Scientific and Ethical Review Committee shall monitor and evaluate the research periodically, and make a report of its findings to the Commission for necessary action.

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