STUDY OF EXTENT OF USE, EFFICACY AND ACUTE TOXIC EFFECTS OF SELECTED ANTIDIABETIC PLANTS IN NYERI AND NAROK COUNTIES, KENYA

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DECLARATION

I declare that this thesis is my original work and has not been presented for the award of a degree in any other University

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I dedicate this thesis to my King and Savior Jesus Christ for guiding me through my academic journey

Psalm 37:25

I have been young, and now am old; yet have I not seen the righteous forsaken, nor his seed begging bread

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ABSTRACT

Emergence of non-communicable diseases has posed a great health challenge worldwide. Particularly; prevalence of diabetes mellitus has been on the increase among communities of both developed and developing countries. In Kenya, studies carried out in 2011 rated diabetes prevalence at 29.4 % in central Kenya and as low as 2.4% in Rift Valley; an area largely inhabited by pastoral communities such as the Maasai of Narok County. Nyeri County leads in diabetes prevalence in Kenya at 12.6%. This study aimed at investigating ethnobotanical knowledge of traditional herbal practitioners (THPs) from two socio-culturally diverse communities that live in Narok and Nyeri Counties. It also sought to understand traditional antidiabetic plants that they used to treat and manage diabetes in their communities.Thirty traditional herbal practitioners were purposively selected from each County to participate in a cross-sectional survey. They were drawn from each of the six constituencies of Nyeri County (namely; Mukurwe-ini, Kieni, Tetu, Othaya, Mathira and Nyeri town) and Narok County (namely; Emurua Dikirr, Narok East, Narok South, Narok North, Narok West and Kilgoris). A specimen of each plant that was mentioned was collected, given a voucher number, and deposited at the herbarium, in the School of Biological Sciences. From the survey findings, two antidiabetic plants were selected, they included aqueous root extracts of *Dovyallis abyssinica* and leaves of *Sonchus luxurians.* They were investigated for phytochemical constituents, antidiabetic activity and acute toxicity. Doses of 25, 75 and 225mg/kg body weight were used in antidiabetic investigations. Acute toxicity was carried out based on "Organization for Economic Co-operation and Development" 2001 guidelines.

The survey findings in Nyeri County documented a total of 80 diseases. They included respiratory diseases (53.3%), malaria (50%) and gonorrhea (40%). Non-communicable diseases included; hypertension (43%) and arthritis or gout (40%). A total of 111 medicinal plant species distributed within 98 genera and 56 families and their ethnobotanical uses were documented. Plant families showing high representation of medicinal plants was Asteraceae (9.5%). *Rotheca myricoides, Prunus africana, Kigelia africana, Croton megalocarpus, Warbugia ugandensis* and *Cordia abyssinica* were most cited. Seventeen (17) plant species were documented as antidiabetic medicinal plants for the first time. They included; *Sonchus luxurians, Clematis hirsute* and *Periploca linearifolia.*

In Narok County, communicable diseases that were treated by Traditional Herbal Practitioners included; stomach ache (11.7%), malaria (10%), respiratory diseases (9 %) and syphilis (6.9 %). Non communicable diseases included, heart burn (5.8%), cancer (4.8%) and fibroids (4.2%). Plant family Mimosaceae had the highest number of plants cited. Plants with high user value included *Aloe Secundiflora*, *Warburgia salutaris, Toddalia asiatica, Rhamnus prinoides* and *Zanthozylum usambarense*. Nine antidiabetic plants were documented for the first time, for instance *Dovyalis abyssinica* and *Faurea saligna*. Phytochemicals present in both *Dovyallis abyssinica* and *Sonchus luxurians* included; alkaloids, tannins, saponins, phenols, phytosterols and glycosides. At a dose of 75 and 225mg/kg body weight, both plant extracts demonstrated antihyperglycemic activity at $P<0.05$ significant level, both in post prandial test and in diabetic mice. The extracts showed mild toxic effects at 2000mg/kg body weight.

The study concluded that, Traditional Herbal Practitioners from Nyeri and Narok County were richly endowed with traditional medicinal knowledge, however, majority were aged. There was lack of clientele and apprenticeship in Nyeri County. Aqueous extracts of the selected antidiabetic plants; roots of *Dovyallis abyssinica* and leaves of *Sonchus luxurians* were safe, possessed antidiabetic activity and antidiabetic phytochemicals. The findings validated their ethnotherapeutic use in the management of diabetes. The study recommended further survey on the use of medicinal plants among community members from Narok and Nyeri County to reinforce findings from Traditional Herbal Practitioners. It also recommended sub-acute and chronic toxicity studies of the two plants to further ascertain their safety.

Key words Narok County, Nyeri County, Antidiabetes, efficacy, acute toxicity

LIST OF ABBREVIATIONS AND ACRONYMS

CAM: Complementary and Alternative Medicine

ENT: Eye, Ear and Throat

H: Hour

i.p: Intraperitoneal

IDDM: Insulin Depedent Diabetes Mellitus

IDF: International Diabetes Federation

IEA: Institute of Economic Affairs

KDMIC: Kenya Diabetes Management and Information Centre

KEFRI: Kenya Forest Research Institute

MHRA: Medicines and Healthcare products Regulatory Agency

NACOSTI: National Commission of Science, Technology and Innovation

NCD: Non-communicable Diseases

NIDDM: Non-Isulin Dependent Diabetes Mellitus

OECD: Organisation for Economic Co-Operation and Development

STZ: Streptozotocin

THPs: Traditional Herbal Practitioners

UNDP: United Nations Development Programme

WDF: World Diabetes Foundation

WHO: World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Chronic or non-communicable diseases (NCDs) are long durational diseases known for slow progression and persistence, as a result of a combination of factors such as; genetic, physiological, behavioral and environmental. The diseases have become a serious threat to human life worldwide as they are already taking a huge toll on the health of the people and resources. According to United Nations Development Programme - UNDP (2017), NCDs are the greatest cause of preventable illness, disability, and mortality worldwide, with large impacts on social economic productivity. The NCDs account for 70% (about 40 million) deaths annually. Over 80% of these deaths are reported in the developing countries (WHO, 2014). Among the notable NCDs that have posed the greatest health challenge globally include cancer, cardiovascular diseases, chronic respiratory diseases and diabetes mellitus.

In particular diabetes mellitus is a chronic disease that has largely led to 3.7 million deaths worldwide annually, closely similar to mortality caused by HIV/AIDS (WHO, 2016). The underlying cause is a failed metabolism characterized by a chronic hyperglycemia of above 11.1 Mmol/ glucose level two hours after a glucose challenge or delayed decrease that may take 4-6 hours or, a fasting blood glucose that is higher than 7.0 Mmol/l on at least 2 occasions (International Diabetes Federation - IDF, 2010).

The symptoms include thirst, polyuria, weight loss and blurred vision (WHO, 1999). The abnormalities of protein, fat and carbohydrate metabolism are as a result of poor insulin activity

on target tissues (WHO, 2016). There are two types of diabetes mellitus: Type 1 diabetes mellitus (insulin dependent diabetes mellitus (IDDM)/ juvenile onset diabetes and, Type 2 diabetes mellitus (noninsulin dependent diabetes mellitus (NIDDM) or adult-onset diabetes (Rheeder, 2006).

Worldwide the prevalence of diabetes mellitus is growing at an alarming rate with 422 million people living with the condition as at 2014. Further, its occurence is widespread in both developed and developing countries; for instance, a prevalence of about 7.3%, 8.3%, 8.6% and 7.1% has been recorded in the European, American, Asian and Africa region, respectively (WHO, 2016). Notably, in the past decade, its incidence has rapidly risen in both low and middle income countries. Indeed, three quarters of the global burden for diabetes is contributed by the developing countries, with a projected rise to 300 million people in 2025 (King *et al.,* 1998). In Africa for example, prevalence of diabetes rose from 3.1% in 1980 to 7.1% in 2014 compared to 5.3% to 7.3% in Europe in the same period (WHO, 2014). In Kenya, IDF, (2008) reported that, the prevalence of diabetes mellitus has increased from 1% to 3.3% of the general population over the last ten years, with up to 10% of cases recorded in urban areas. Notably, there are concerns on the fact that, Kenyans have been developing Type II Diabetes at ages of 45 and 55 years compared to 64 years for people in developed countries (Mwangi *et al.,* 2011).

There has been a paradigm shift in the management of health, where treatment of major diseases including non-communicable diseases is being directed towards use of herbal medicine. Traditional health care providers account for treatment of 80% of rural population in developing countries (WHO, 2005). This is due to rising cost of conventional medicine, local availability of herbal medicine, inadequate healthcare facilities and growing list of diseases resilient to

conventional medicine (WHO, 2002a). Indeed, the potential of herbal medicine in the management of human health has received recognition from the World Health Organisation. The global WHO strategies; 2002-2005 (WHO, 2002a) and 2014-2023 (WHO, 2013a) attested their position and recognition of the use of traditional plant medicine in the management of human health. At regional level, use of herbal medicine has been part of the African Union, IDF and WHO Africa Region corporate strategy. As a result, "Diabetes Declaration and Strategy for Africa" was established to spearhead corporate endeavors to manage diabetes (IDF, 2010). Notably, the strategic route for standardization and regulation of herbal medicine is engrained in ethnobotanical surveys and study of efficacy and safety of herbal medicine.

In Kenya, it's estimated that about 80 percent (≥ 30, million individuals) of the population use traditional herbal medicine, due to its accessibility, affordability, sustainability, and cultural preference. Out of 160 herbal medicine practitioners who keep records in Kenya, nearly 80.4 million contacts are made per year (Lambert *et al.,* 2011). There has been emergence of health conditions which have defied conventional medicine, in particular diabetes. This has made patients to seek treatment from traditional healers. Consequently, with time, traditional ethnobotanical knowledge has defined the kind of herbal treatment administered to patients. Although use of traditional medicine in the treatment of various diseases may not be in doubt, its safety and efficacy has raised concerns among health authorities and the public. According to WHO (2005), major challenges facing countries in the use of herbal medicine are associated with regulatory status, quality control, assessment of safety, efficacy and lack of information.

Kenya constitutes different communities that have diverse geographical and healthcare practices including herbal medicine. Further, their cultural and socio-economic lifestyle may differ greatly.

For instance, among the Kikuyu community, the church and colonial administration to a large extent discouraged the use of ethnomedicine, and as a result, use and knowledge of herbal medicine had declined (Sindiga, 1995). However, the Maasai community is believed to be still largely rooted into their culture including use of ethnomedicine (Kiringe, 2005). Thus, it is important to evaluate the extent to which the two communities currently use herbal medicine. Particularly, in the management and treatment of diabetes which is not only expensive to treat using conventional approaches but also its resilience to conventional medicine. Various herbal practitioners have emerged, who usually administer herbs in form of concoctions or as processed herbal dietary supplements. Further, documentation of plant medicines used to treat various diseases by traditional practitioners is inevitable for reference by future generations. But, traditional medicine is faced with a myriad of challenges such as, inefficient methods of extraction, lack of standardized dosages and toxicity. Thus, it is imperative that efficacy and safety concerns be addressed through scientific investigation (Mosihuzzaman and Choudhary, 2008).

This study aimed at documenting traditional herbal medicine used by Nyeri and Narok County traditional practitioners in general and in particular identify most commonly antidiabetic plants as well as determine major group of compounds, efficacy and safety.

1.2 STATEMENT OF THE PROBLEM

Diabetes mellitus is a major non communicable disease with a projected rise to 300 million by 2025 (King *et al.,* 1998). Diabetes prevalence in Kenya is estimated at about 3.3%, with an 8.6% prevalence of impaired glucose tolerance [IDF, 2007; Maina *et al.,* 2011). Notably, diabetes has placed a heavy burden on communities due to the high cost of treatment and associated side

effects of the conventional antidiabetic drugs. As a result, some communities have turned to traditional medicine which are cheap, accessible and believed to be more effective (WHO, 2008b). However, adoption of traditional medicine is largely dependent on a community's culture and available environmental resources. Thus, health needs, disease burden and adoption to treatment practices varies widely among communities. For example, in Kenya; diabetes prevalence is estimated at 29.4% and 2.4% in Central and Rift Valley regions respectively (Karekezi *et al.,* 2011). Further, Nyeri County records one of the highest diabetes prevalence (12.6%) in Kenya. The two regions (Narok in Rift valley region and Nyeri in Central region) embrace the use of traditional medicine, however, studies to document how each of this communities had adapted use of traditional medicine to address the emergence of diabetes and other diseases was rare. Additionally, information on the current perception and attitude about the use of traditional medicine among members of Nyeri and Narok communities was lacking. Notably, traditional medicine is a rich source of affordable treatment option. It is therefore central in the treatment and management of diabetes.

1.3 OBJECTIVES

1.3.1 General Objective

To determine the extent of use, efficacy and acute toxic effects of selected antidiabetic herbal plants in Nyeri and Narok Counties

1.3.2 Specific Objectives

1. To carry out a comparative ethnobotanical survey of medicinal plants commonly used in Nyeri and Narok counties.

2. To carry out phytochemical screening of most cited antidiabetic medicinal plants occurring in Nyeri and Narok counties
3. To determine efficacy of selected antidiabetic medicinal plants used in Nyeri and Narok counties
4. To determine acute toxicity of selected antidiabetic medicinal plants used in Nyeri and Narok Counties

1.4 HYPOTHESIS

The commonly used antidiabetic herbs in Nyeri and Narok counties are effective and safe.

1.5 JUSTIFICATION AND SIGNIFICANCE

Worldwide, use of herbal medicine has been increasing exponentially despite major concerns over its quality from health practitioners, the public and international health organizations such as World Health Organization (WHO). Though death does not occur in some cases, information on effects of some herbal medicine from long term use was lacking. Notably, control and management of metabolic diseases such as diabetes requires use of effective treatment regime with minimal side effects. Lack of scientific documentation on the efficacy of antidiabetic herbs from some communities and failure to seek western medical treatment has led to unprecedented health breakdown among patients. This study, investigated the most cited antidiabetic medicinal plants in Nyeri and Narok counties. The findings forms the basis for comparison of treatment practices among these communities which have diverse socio-cultural and geographical diversity. Further, it validated efficacy, safety and mode of action of the most cited antidiabetic medicinal plants.

CHAPTER TWO

LITERATURE REVIEW

2.1 ETIOLOGY, PATHOPHYSIOLOGY AND MANAGEMENT OF DIABETES MELLITUS

2.1.1 Types and Etiologies of Diabetes

Diabetes mellitus is a metabolic disorder which is characterized by elevated blood glucose levels (hyperglycemia), due to impaired fat, carbohydrate and protein metabolism. It is caused by lack of insulin, low response of the tissues to insulin or both (Guyton & Hall, 2006). Its prevalence rose from 4.7 % in 1980 to 8.5 % in 2014 (WHO, 2013b). Pointedly, there are two types of diabetes predetermined by the cause, diagnosis and consequent mode of treatment.

2.1.1.1 Type 1 Diabetes

In the year between 1990 and 2008, Type 1 diabetes increased by 2.8 - 4.0% per year (Patterson *et al.*, 2012). About 5 - 10 % of diagnosed cases were reported in adults (Melmed *et al*., 2011). However, Type 1 diabetes is a chronic childhood disorder that mostly occurs in people below the age of 40 (Laura and Jo, 2004). Worldwide, an estimated 80 000 children under 15 years develop type 1 diabetes annually (IDF, 2013). There are several factors that cause Type 1 diabetes; inheritance of HLA genes on chromosome number six that encode immune response proteins. HLA genes occur in IDDMI regions of the genome (Laura & Jo, 2004), variations in HLA genes such as inheritance of HLA type DR3/DR4 combination predisposes an individual to autoimmune degeneration of beta cells and thus development of diabetes type 1 (Wolf *et al.*, 1983), as a result of insulin insufficiency. Other than inheritance, other factors such as viral infections with mumps or German measles, dietary exposure such as shortened period of breast feeding, premature introduction to cow's milk and malnutrition and environmental factors can

trigger autoimmune activity. Although development of type 1 diabetes is gradual, onset of the symptoms is rapid (http://www.unitedcancerfoundation.org/pdf/Document%20B%20TYPE%201.pdf, ADA 2017).

2.1.1.2 Type 2 Diabetes

About 95 % of people diagnosed with diabetes worldwide are reported to have Type 2 diabetes (Melmed *et al*., 2011). It's characterized by hyperglycemia due to insufficient insulin which is caused by gradual beta cell dysfunction. Other causes include; insulin resistance in the skeletal muscle and liver, increased production of free fatty acids in adipocytes (hyperlipidemia) and elevated synthesis of glucose in the liver. Major predisposing factors include heredity, age, obesity, physical inactivity, racial or ethnic background (Loghman, 2005) and smoking. Pathophysiologic conditions include; polycystic ovary syndrome, growth hormone (acromegaly) and excess formation of glucocorticoids (Cushing's syndrome) (Guyton and Hall, 2006). Insulin resistance arises from either a few insulin receptors in the liver, skeletal muscles and adipose tissues in obese persons, or impaired insulin signaling pathways (ibid). Clinical presentation of diabetes type 2 include, increased plasma insulin concentration (hyperinsulinemia), hyperglycemia and hypertension. Unlike diabetes Type 1, its symptoms may remain unnoticed or absent for many years until severe complications have developed (WHO, 2016)

2.1.2 Pathophysiology of Diabetes Mellitus

2.1.2.1 Type I Diabetes

Diabetes Type 1 is a chronic disease with a slow progression and if untreated it may lead to end stage complications of the kidneys, eyes, peripheral and autonomic nervous systems (Nathan, 1993). Due to lack of insulin and the subsequent unavailability of glucose to muscle cells and

adipocytes, the process of glycogenolysis and gluconeogenesis is stimulated, which leads to severe hyperglycemia. Further, there is loss of electrolytes such as potassium, sodium and magnesium accompanied by decreased blood volume, elevated hematocrit, hemoglobin concentration and white blood cell counts. Clinical presentation include; extreme weakness, fatigue, thirst (polydipsia), urination (polyuria), nausea, weight loss, increased appetite (polyphagia), glycosuria, fruity breath (diabetic ketoacidosis), abdominal pain, deep respiration (Kussmaul respiration), poor healing of wounds, blurred vision and vaginal candidiasis. (http://www.unitedcancerfoundation.org/pdf/Document%20B%20TYPE%201.pdf; ADA, 2017). Diagnostic markers include; fasting glycaemia ≥ 7.0 mmol/l (≥ 126 mg/dl), random plasma glucose level of ≥ 200 mg/dl (≥ 11.1 mmol/l) (Guyton & Hall, 2006) or elevated glycated hemoglobin - A1C ≥ 6.5% (https://www.mayoclinic.org/diseases-conditions/type-1-diabetes/diagnosis-treatment/drc-20353017).

2.1.2.2 Type 2 Diabetes

Insulin resistance leads to hyperglycaemia which causes increased enhanced leukocyte-endothelial interaction, oxidative stress, glycosylation of lipoproteins, apolipoproteins, and clotting factors. Subsequently, it leads to accumulation of advanced glycosylation end products (AGEs). Further, AGEs causes over cross-linking in the vascular walls which alters their architecture (atherosclerosis), accumulation of LDL particles and development of atherothrombosis due to endothelial cell dysfunction (Sinclair 2009). These changes leads to development of cardiovascular diseases such as cerebrovascular disease, myocardial infarction (caused by cardiac autonomic neuropath), peripheral vascular disease (PVD), coronary heart disease and microvascular disease (which is caused by atherosclerosis and damage to fine blood

vessels). Others include; peripheral neuropathy, diabetes nephropathy (renal disease), diabetes retinopathy, blindness, metabolic acidosis, rapid weight decrease, lack of energy (asthenia), eating large volumes of food (polyphagia) (Guyton and Hall, 2006). Lower limb amputation and foot problems such as neuropathic ulcers are caused by a loss of pain sensation due to peripheral neuropathy. Ischemic ulcers are caused by reduced blood supply to the feet due to peripheral vascular disease (Elizabeth & Natasha, 2009).

In 2010 diabetic retinopathy led to about 1.9 % of moderate to severe visual impairment globally and 2.6% of blindness (The Diabetes Control and Complications Trial Research Group (1993) and about 12-55% end-stage renal disease (ESRD) are caused by diabetes (WHO, 2016). People with diabetes stand a risk of developing cardiovascular disease two times higher than those without diabetes (Meigs, 2010). Moreover, one out of four diabetic cases suffer from severe peripheral vascular disease that may require amputation (Newton *et al.,* 1999). Ten percent (10 %) to 25% of these cases is due to diabetic foot ulcer (DFU) (Frykberg *et al.,* 2006). Overall, diabetes is a major contributor of deaths worldwide. In 2015, about 1.6 million diabetes - related deaths occurred, before the age of 70 years. An additional 2.2 million were attributed to hyperglycemia in 2012 (Mathers and Loncar, 2006; http://www.who.int/en/news-room/fact-sheets/detail/diabetes). Further, diabetes is estimated to be among the seventh major causes of death by 2030 (Mathers and Loncar, 2006). Thus, treatment of diabetes plays a pivotal role in preventing deaths associated with major communicable diseases.

2.1.2.3 Experimental Diabetes

Animal models are an important component in the search for effective methods of treatment and management of diabetes. Experimental diabetes is based on the type of diabetes under

investigation. For instance, Type 1 diabetes may be induced using alloxan or streptozotocin, whose aim is to destroy pancreatic beta cells similar to autoimmune activity in Type 1 diabetes patients. However, Streptozocin is preffered over alloxan which has severe effects such as extreme weight loss and mortality rate. Morever, the former can be used in combination with cotinamide to induce non-obese Type 2 diabetes (Manik *et al.*, 2017). Morever, diet-induced obesity-dependent diabetes Type 2 may be induced when F (1) hybrids of DBA/2 and C57BL/6 normal strains (BDF1 mice) are given high fat diet (Karasawa *et al.*, 2009). The present study aimed at developing Type 1 diabetes.

2.1.3Management and Treatment of Diabetes

2.1.3.1 Non-Pharmacologic Management of Diabetes

Education about intensive lifestyle interventions are an important constituent in the prevention and management of diabetes, and can therefore be used to slow down progression of impaired glucose tolerance and impaired fasting glucose to diabetes type 2. Besides, it can also prevent or slow down development of diabetes related end stage pathophysiology. Whilst being a hereditary disorder, studies have shown that it's largely caused by lack of physical exercise, which has declined world wide by 10 % (WHO, 2016). However, effective management of diabetes requires regular exercise, thus, physical activity is recommended for at least 150 minutes per week (Cynthia *et al.*, 2009). Additionally, obesity is a major cause of diabetes against the backdrop of unprecedented body weight increase globally. According to WHO (2016), about 13 % of adult population (11% of men and 15% of women) are obese, while the prevalence of obesity was three times higher compared to 1975 (http://www.who.int/mediacentre/factsheets/fs311/en/). Notably, the probability of developing

diabetes among genetically predisposed people is increased when exposed to the contributory factors. Regular exercise with a target weight loss of 7 % of baseline weight is recommended as part of diabetes prevention and management regimen (Cynthia *et al.,* 2009; WHO, 2008a). This has been proven to reduce diabetes related health risks, hyperglycemia (WHO, 2016), enhance body energy balance, prevent obesity as well as control body weight (WHO, 2008a).

Additionally, careful control of blood glucose level through healthy diet is reportedly a prerequisite in minimizing occurrence of cardiovascular risks, hyperlipidemia and other associated complications (WHO, 2016). A diet consisting of vegetables, non-fatty dairy products and proteins, whole grain (low calorie diet) and fruits is recommended (National Institute of Diabetes and Digestive and Kidney Diseases – NIDDK (2016). Notably, people diagnosed with diabetes type 1 should continue with insulin administration in addition to a healthy lifestyle (https://www.diabetes.co.uk/type1-diabetes.html)

2.1.3.2 Pharmacologic Treatment and Management of Diabetes Mellitus

Current evidence suggests that strict treatment regimen of both diabetes type 1 and type 2 prevents progression of the disease to end-stage complications and decreases morbidity (UK Prospective Diabetes Study Group –UKPDS, 1998). However, the cause and type of diabetes predetermines its mode of treatment.

2.1.3.2.1 Type 1 Antidiabetic Drugs and Associated Adverse Effects

Insulin is the main drug that is used in the treatment of Type 1 diabetes or people with diabetes type 2 that is not responding sufficiently to diet intervention and oral hypoglycemic drugs, due to beta cell dysfunction (http://samples.jbpub.com/9780763781170/81170_CH02_PASS02.pdf. Various types of insulin are administered based on the needs of an individual patient, they

include; rapid-acting insulin analogues (e.g. insulin glulisine, insulin lispro and insulin aspart), short-acting insulins (e.g. Novolin and humulin-R), intermediate-acting (humulin® -N and novolin® ge NPH) while long-acting insulin include insulin detemir, insulin glargine and insulin glargine U300 (http://guidelines.diabetes.ca/cdacpg_resources/Ch12_Table1_Types_of_Insulin_updated_Aug_5.pdf). Major associated adverse effects include allergic reaction with persisted nausea and vomiting (https://www.diabetes.co.uk/insulin/insulin-side-effects.html) and hypoglycemia (Diabetes Control and Complications Trial Research Group, 1993).

2.1.3.2.2 Commonly Available Type 2 Antidiabetic Drugs and Associated Adverse Effects

The type of treatment of diabetes Type 2 is predetermined by its cause and the mode of action of the various classes of oral hypoglycemic. Firstly, insulin secretagogues which includes sulfonylureas such as; tolbutamide, glyburide and glipizide, are used to lower blood glucose level by increasing insulin production from pancreatic β-cells. Related side effects includes "Syndrome of Inappropriate Antidiuretic Hormone secretion (SIADH)", hypoglycemia, gastrointestinal distress and dizziness.

Secondly, insulin sensitizers' act by increasing peripheral insulin sensitivity in the target tissues. They include biguanides such as Metformin, which improves glucose intolerance, inhibits gluconeogenesis and increases peripheral glucose uptake and utilization. However, they have been associated with severe side effects which is megaloblastic anemia and lactic acidosis (Lael *et al.*, 2012). Additionally, thiazolidinedione such as pioglitazone and rosiglitazone, enhance insulin-receptor sensitivity in adipocytes, skeletal muscles and liver. The associated adverse effects include, increased risk of myocardial infarction and death, hepatic failure, edema, and

hypoglycemia particularly when combined with other hypoglycemic drugs such as insulin (http://samples.jbpub.com/9780763781170/81170_CH02_PASS02.pdf).

Thirdly, alpha glucosidase inhibitors act by lowering glucose absorption from the intestines through inhibition of α-glucosidase enzyme; they include acarbose, meglitol (Sembulingam & Sembulingam, 2012) and voglibose, with therapeutic target of postprandial hyperglycemia (PPG) (Javed *et al.,* 2011). These drugs have been associated with abdominal discomfort such as diarrhea; flatulence and stomach ache (Sujoy & Andrew, (2012). Thus while on one side diabetes drugs have been effectively used to reduce diabetes related pathophysiology and morbidity, it's evident from the foregoing that, they are associated with numerous risk factors.

2.1.3.3 Traditional Antidiabetic Plants and Mechanism of Action

Diabetes treatment using conventional drugs has not been fully achieved largely due to increased poverty, bloated population, inadequate medical facilities and overstretched economy especially in the developing countries (WHO, 2005, Lambert *et al.*, 2011). Inevitably, use of antidiabetic drugs for an extended period of time has been related to pathophysiology such as hepatotoxicity, cardiac malfunction and kidney failure. Moreover, there are high chances of diabetes Type 2 progressing to a level whereby the patient must be put on insulin for survival (Ministry of Public Health and Sanitation, 2010; Cahn *et al.*, 2015). This has prompted sudden upsurge in the use of herbal medicine to treat and manage of diabetes.

Notably, some plant medicines have demonstrated antidiabetic activity for instance; Korean red ginseng has shown improved long-term glucose and insulin control safely beyond conventional treatment of type 2 diabetes (Bang *et al.,* 2014). Similarly, aqueous extracts of *Aloe vera* gel, *Ajuga iva* (Kavishankar *et al.,* 2011) and *Hypoxis hemerocallidea* (Afolayan & Sunmonu, 2010)

possess antidiabetic activity. Some plants express multiple mode of actions against a backdrop of fewer side effects. A case in point is *Gymnema sylvestre* which is commonly used in India, it lowers blood glucose through a combination of secretagogue activity of gymnemic acids and gurmarin components (Kanetkar *et al.,* 2004) and alpha glucosidase inhibitory activity (Hong *et al.,* 2001). Similarly, *Momordica charantia* reduces blood glucose levels, improves body weight and glucose tolerance. Mode of action is multifactorial, it inhibits glucose uptake in the gut brush border and enhances peripheral uptake of glucose into the skeletal muscle. Moreover, it preserves the secretory functions of pancreatic beta cells, modulates oxidative stress and normalises the systolic blood pressure (Garau *et al.,* 2003).

In Kenya, *Zanthoxylum chalybeum* has been proven to possess significant antihyperglycemic activity (Kimani *et al.,* 2015). Restoration of beta cell secretory functions and improved glucose tolerance (Agwaya *et al.,* 2016) has been suggested as a possible mode of action. Other studies have shown that; *Aspilia pluriseta*, *Bidens pilosa*, *Strychnos henningsii*, *Catha edulis* and *Erythrina abyssinica* possess antihypoglycemic property. Presence of flavonoids in these plants improves glucose tolerance, peripheral glucose uptake, secretagogue or insulin mimetic activity (Luisa *et al.,* 2008). It also has anti-hyperlipidemic effect (Xiaopo *et al.,* 2013).

2.2 ETHNOBOTANICAL KNOWLEDGE OF MEDICINAL PLANTS AND DISEASES

2.2.1 Traditional Knowledge, Treatment and Management of Diseases

Globally diverse communities use various herbs to treat different diseases depending on the knowledge on herbal medicine inherited from past members of the community. Similar to other African countries, Kenya comprises of different tribes and that have unique customs and beliefs including extensive use of plant medicine (Kigen *et al.,* 2013). In Kenya, the prevalence and

incidence of sickness among the poor and the rich are similar, however, accessibility, affordability, sustainability, and cultural preference are key determinants of health choices (Kenya Ministry of Health- MoH, 2005). Indeed, it is estimated that there are a total of 40,000 THPs in Kenya, each treating about 2,000 patients annually (nearly 80.4 million contacts per year). The common diseases treated are similar to those treated at government facilities for instance malaria, urinary tract infections, prostate cancer, STD; worms, colds, pneumonia, asthma (chest pains), tooth ache, stomach ache, headache and ulcers (Lambert *et al.,* 2011). Mostly used herbal medicine include; *Azadirachta indica*, *Prunus africana*, *Warburgia ugandensis*, *Carissa spinarum*, *Harrissonia abyssinica*, *Erythrina abyssininca*, *Tylosema fassoglensis*, *Toddalia asiatica* and *Aloe secundiflora* (Lambert *et al.,* 2011). However, published information about traditional medicinal plants used by some Kenyan communities is scanty. The old generation that are the custodian of traditional knowledge is fast aging, seemingly, the young generation is not showing much interest in advancing the trade (Kigen *et al.,* 2013).

Notably, documented information obtained from community members and practitioners about traditional plants medicine can be used as a template in scientific investigation to establish their safety and correct use and development of new drugs (WHO, 2005; Ebadi, 2006; Institute of Economic Affairs-IEA, 2011). Pointedly, the Chinese traditional medicines were recorded, and thanks to this, we now have a leading cure of malaria from the wormwood (Artemesia annua) that was used in China more than a thousand years ago (Hsu, 2006). According to Kigen *et al.,* (2013), "Databases on the ethno-medical information from every region of the country should be compiled with a view to develop centralized records for ease of reference".

2.2.2 Level of Communication in Traditional Health Care System

A successful health care system largely depends on effective communication between the patient and the medical practitioner; it determines correct diagnosis and medication. It also prevents over-dosage, synergy or drug interaction. However, cases of failure to disclose the medicatio are prevalent among elderly patients (Medicines and Healthcare products Regulatory Agency-MHRA, 2008; Barnes *et al.,* 2001). Moreover, the level of communication is also central among and between medical and traditional practitioners. It enhances referral of difficult to treat diseases and emergency cases and develops trust and confidence among traditional practitioners. Further, interaction of traditional herbal practitioners (THPs) with allopathic health workers can widen their knowledge on appropriate health practices. Moreover, major training need in traditional health practice is in health education, quality of care, and overall safety of practices (Lambert *et al.,* (2011). The study investigated level of communication between traditional health practitioners, patients and allopathic health practitioners.

2.2.3 Contemporary Challenges Facing Traditional Medicine Practices

Over the years, traditional medicine has been downgraded and faced numerous challenges. This is due to introduction of conventional medicine whose preparation and method of administration is in form of patient friendly (compliant) formulations. For example use of capsules, syrups and tablets as opposed to traditional barks, roots and leaves which are often unpalatable (Thairu, 1975). In Kenya, the elite views the practice as largely primitive, this has hindered its progress. It is also believed to be a low income earner and has therefore been relegated to the poor and illiterate people. Further, climate changes and uncontrolled human activities have negatively impacted on human lifestyles and herbal medicine (Lambert *et al.,* 2011). To conclusively

address these challenges, WHO recommends member states to take own- initiated mitigation programs (WHO, 2005). Thus, the study sought to document challenges faced by traditional practitioners in the study areas.

2.2.4 Public Awareness about Diabetes Prevalence, Causes, Morbidity, Control and Treatment Preference

Effective treatment and management of diseases and other health challenges lies within the confines of proper understanding of the symptoms, treatment, management and prevention by both the patient and health care practitioners. According to IDF (2007), diabetes prevalence in Kenya is estimated at 3.3%, with an 8.6% prevalence of impaired glucose tolerance and 13.2% among the rural and urban populations respectively (Maina *et al.,* 2011). Studies conducted in 2011 rated diabetes epidemiology at 29.4 % in central Kenya and as low as 2.4 % in Rift Valley; an area largely inhabited by pastoral communities (KDMIC, 2011). Additionally, diabetes prevalence of over 20% and 11.6% has been reported among the richer families in Kilifi in the coast region and some rural parts of Nyeri County in central Kenya, respectively (Chege, 2010).

The pandemic of diabetes is associated with rapid cultural changes, increasing urbanization, dietary lifestyles, an aging population, social economic status, genetic and behavioral patterns and lack of prevention and control preparedness (WHO, 2014). In Kenya, modifiable risk factors for diabetes include; excessive alcohol ingestion, abdominal obesity, physical inactivity and poor dietary habits while non-modifiable factors are ageing and genetic predisposition (Chege, 2010). Further, the gravity of diabetes and its complications bear enormous economic losses due to its expensive treatment and loss of productive individuals, particularly, high prevalence of morbidity. Moreover, in Sub-Saharan Africa, lack of understanding and knowledge about the

disease in both health professional and general population (WDF, 2007), insufficient supply of subsidized insulin by the government and inaccessible treatment centers and modern therapeutic services in rural areas poses major challenges (Mbanya and Ramiaya, 2006). Consequently, patients are forced to turn to herbal medicine as a last alternative; which is also perceived to be cheap and effective (WHO, 2005; WHO, 2008a).

However, the practice is characterized by diversity in and amongst different communities. For example, in Kenya, members of the Embu community use, *Bidens pilosa* (*Mucege*), *Cyathula polycephala* (*Mutegenye*), *Xerophyta spekei* (*Kianduri*) and *Ovariodendron anisatum* (*Ndonga*) (Kareru *et al.,* 2007) to treat diabetes. In Nyeri County, Canola seed oil (http://www.diabetesforecast.org/2014/09-sep/canola-oil-may-improve-blood.html; https://www.businessdailyafrica.com/magazines/Canola-farmer-oils-his-way-to-business-success-/1248928-1461364-8j5ixn/index.html.) and *Moringa oleifera* were alleged to treat diabetes (Kenya Forest Research Institute - KEFRI, 2012). According to Johns (2001), some of dietary plants used by the Maasai's possess hypoglycemic and hypolipidemic properties attributed to the antioxidant effect of phenolics (Lindhorst, 1998), cholesterol-binding effect of saponins (Chapman *et al.,* 1997, Johns, 1999) and hypolipidemic activity of gums they chew (Johns *et al.,* 2000).

Against this background, the study investigated age long practices used to treat and manage diabetes in Nyeri (within the central Kenya) and Narok counties (within the Kenya Rift Valley region), through collaboration with THPs and community members. The two regions formed suitable locale to juxtapose epidemiology, main preoccupation of inhabitants, dietary habits,

predisposing factors, as well as ethnic background due to their divergent regional and cultural set up.

2.3 EFFICACY OF ANTIDIABETIC PLANTS

Although several herbs have been reported to cure and regulate diabetes across the world due to their supposedly fewer side effects, low cost and higher potency, only some have been proven to possess significant effect, others were yet to be standardized (Wadkar *et al.,* 2008, Shojaii *et al.,* 2011). There is a strong debate worldwide about the efficacy of herbal remedies as most often, their use is justified by their long history. In Kenya, concerns have been raised over the use of some herbal medicine whose effectiveness and toxicology has not been authenticated (Gemson, 2013). But while most consumers consider reference to raw, natural or dietary supplement to mean safe, effective and ideally superior than synthetic medicine, scientific studies should continue to be conducted so as to provide evidence-based information (Mosihuzzaman and Choudhary, 2008). Similar concerns were raised by WHO Regional Office for the Western Pacific together with a group of experts (Akerele, 1993; WHO, 2005).

Reportedly, only a few among commonly used plants have demonstrated antidiabetic activity. For instance, out of ten antidiabetic herbs consumed in USA, only five (garlic, ginkgo, kava, St. John's wort and soy) have been reported to have significant effect (Barnes *et al.,* 2004). While, out of 32 plant species investigated in South Africa, only nine demonstrated significant anti-diabetic activity (Afolayan & Sunmonu, 2010). Additionally, although Asian ginseng, ren shen is popularly reported to have antidiabetic activity, it is particularly the American ginseng (yi Shang shen) that possesses significant effect (Baldwin *et al.,* 1986; D'Arcy, 1993). Therefore the findings not only underscore centrality of plant medicine in management of diabetes but also

reveal the need for scientific validation. Case in point, use of traditional medicine among the Maasai does not determine how much of the active componenst are taken by a patient (Sindiga *et al.,* 1995). Thus, Tarayia (2004) suggests that, serious research into traditional medical practices should be encouraged. Worth noting, documentation of efficacy particularly the dosage, may prevent cases of overuse or over-dosage. For instance insomnia, agitation, and elevated blood pressure which have been associated with ginseng (Baldwin *et al.,* 1986; D'Arcy, 1993).

This study sought to establish efficacy of selected antidiabetic plant medicines used by traditional practitioners in Nyeri and Narok County. Validation was carried out using diabetic white albino mice. Diabetes type one was induced using 200mg/kg bwt of streptozotocin (i.p).

2.4 PHYTOCHEMICAL SCREENING OF SELECTED ANTIDIABETIC PLANTS

Phytochemicals are responsible for therapeutic activity of plants; they have protected humans from various diseases (Kubmarawa *et al.,* 2008) over the past years. Potency of herbal formulation is largely engrained on organic chemical constituents present therein. Presence of flavonoids, flavones, flavonols, terpenoids and bound anthraquinones, has been associated with hypoglycemic activity of plant extracts (Piero *et al.,* 2011). Notably, various factors such as plant parts, species, variety and extraction methods determine the presence of bioactive chemicals in a plant extract (Shan *et al.,* 2007), thus influencing its efficacy. For instance; the hypoglycemic effect of aqueous extract of *Hypoxis hemerocallidea* in diabetic rats is attributed to its phytosterols and/or sterolin contents while in *Leonotis leonurus*, it's the different flavonoids, diterpenoids and polyphenolics (Ojewole, 2005).

2.5 ACUTE TOXICITY TEST

Acute toxicity is characterized by adverse change(s) that occurs immediately or shortly after exposure to a substance(s) within 24 hour. The observations provides basic information about toxic nature of a material, herbal medicine and related dietary food supplements, on target organs (Gad and Chengelis, 1988). Rats or mice are most often used as the animal model (Litchfield and Wilcoxon, 1949). Major methods used to investigate toxicity include the "classical" LD_{50} test, which is intended to estimate the mean lethal dose of the test material. However, it uses high number of animals, therefore other methods such as “Limit Test” are preferred. They involve few animals, reduced cost and provide reliable lethal estimates of a material (Gad and Chengelis, 1988). The study aimed at investigating acute toxicity of selected medicinal plants. The information was used to establish their safety as well as estimate the dosage with minimal adverse effects.

CHAPTER THREE

COMPARATIVE ETHNOBOTANICAL SURVEY OF MEDICINAL PLANTS COMMONLY USED IN NYERI AND NAROK COUNTIES

3.1 INTRODUCTION

In the recent past, humanity has faced a growing and overwhelming healthcare challenge due to the devastating burden of non-communicable diseases (NCDs). Particularly, diabetes has become one of the leading NCDs in both the developed and currently developing countries. Its complications reduce a person's productivity with consequent loss of economic growth whilst placing a very heavy social-economic and health care burden on the community (IDF, 2013; Michael and Alethea, 2006). About 415 million and 14.2 million adults have diabetes worldwide and Africa, respectively. About 50% of all adult hospital admissions in Kenya have been related to NCDs which accounts for 55% of hospital deaths, diabetes being among the leading (El-busaidy *et al.,* 2014). Currently, Kenya has 478 thousand persons estimated to have diabetes (IDF, 2015) and a treatment expenditure of USD 61 per person (IDF, 2013). In Kenya, studies have recorded a prevalence of 4.2%, 2.2% and 12.2% in the general population, rural areas and urban areas, respectively (Dirk *et al.,* 2009). Impaired glucose tolerance affects 60.3% women compared to 19.5% men in the urban areas and 22.6% and 10% in women and men in the rural areas, respectively (Christensen *et al.,* 2009).

According to WHO (2002b); old age, cigarettes, excessive consumption of alcohol or refined foods and lack of regular physical activity are significant determinants of diabetes. Moreover, disparities in predisposing factors are determined by location or region, due to variations in demographic and social-economic pattern (Laakso *et al.,* 1988). For instance, while Central

Kenya has a diabetes prevalence of 29.4%, only 2.4% accounts for Rift Valley region (Karekezi *et al.,* 2011); in particular, Nyeri County has a high prevalence of diabetes among HIV infected individuals (13.5%) as compared to HIV negative population (6.18%) (Njagi, 2012). Further, it has the highest prevalence (12.6%) compared to the country's prevalence of 5.6%, Kirinyaga County at 6.8%, and both Murang'a and Nyandarua at 10%. This has prompted the need to establish a Diabetes Specialist Unit that would serve as the coordination Centre for all the 259 community health units (Nyawira, 2013).

Conversely, Karekezi *et al.,* (2011), has reported low diabetes prevalence in Rift Valley region of Kenya (2.4%) among pastoralist communities, such as the Maasai. However, like in many other pastoralist communities (Hemed *et al.,* 2014; IDF, 2012), an upward trend of diabetes prevalence has been reported among the urban (22.9%) and the rural (9.9 %) Maasai of Ngorongoro, in Tanzania (Masaki *et al.,* 2015). In Simanjiro, a prevalence of 0.9% and 2.4 % type 2 diabetes and impaired fasting glucose tolerance has been reported, respectively (Mandha *et al.,* 2015). Moreover, there has been a significant difference in levels of cholesterol among the rural and urban Maasai (Day *et al.,* 1979). The foregoing was a strong indicator of presence of diabetes among communities that were previously unaffected.

Notably, diabetic patients and health care professionals continue to seek alternative treatment approaches related to antihyperglycemic medicinal herbs as they are believed to cause few side effects compared to synthetic drugs (Huang, 1992; Dey *et al.,* 2002). While traditional knowledge on herbal medicine has remained a mainstream source of maintaining wellbeing for generations in many communities (Kamboj, 2000); choices about treatment and management approaches related to the health and well-being of people with diabetes is neither made by their

physician or health professional but themselves (Anderson and Funnell, 1999). Moreover, for an individual to make rationally correct choices, adequate background information is necessary. Consequently, diabetes education aiming at improving knowledge, attitudes and skills is a widely accepted integral part of comprehensive diabetes care (Maina *et al.*, 2011). Further, prior information on attitude, past behavior, affective believes of a community have been shown to play a crucial role during awareness campaigns and patient counseling (Conner and Armitage, 1998; Norris *et al.,* 2001; Nejad *et al.,* 2004). Thus, effective use of traditional medicine as an alternative approach towards treatment and management of any disease is largely influenced by individuals or community's background knowledge, understanding, attitude, perception and treatment prevalence.

Notably, many tribes in Africa are custodian of sophisticated plant knowledge (Barrow, 1996), but adoption of western culture has caused rapid erosion of traditional knowledge (Fratkin, 1997). For example, during the pre-colonial era, the Kikuyu community was inclined towards traditional treatment, conversely, this traditional practice together with the passing down of traditional knowledge to the younger generation had retrogressed in the post-colonial period (Kamenju, 2013; Sankan, 1995). Currently, the community is faced with the burden of NCDs (http://integratepc.org/hospitals/kenya-only/) whose treatment is loaded with serious challenges such as high cost, unbearable side effects and drug resistance of communicable diseases (Laxminarayan and Heymann, 2012; Lucado *et al.*, 2008).

On the contrary, the Maasai community has especially received scholarly attention on use of herbal medicine attributed to their strong adherence to traditional culture (Sankan, 1995) and systematic passage of ethno medicine from generation to generation (Ochieng' and Odera, 1995;

Njau, 2001). Also notable is reliance on therapeutic plants as first line of treatment (Kiringe, 2006) and significant retention of their culture despite introduction of western education and Christianity (Sindiga, 1995; Bussman, 2006). As a result Maasai plant therapeutics has dominated documentation of medicinal plants in Kenya as posted in survey studies by Bussman (2006), Sindiga (1995), Kiringe (2006) and Ochieng' and Odera (1995) to mention a few.

According to WHO (2008; 2013a), plant herbal treatment accounts for primary health care of 75-80 % of the world population. Moreover, traditional knowledge on plant herbs endowed in different cultures has been used to prevent, diagnose, improve and even treat both physical and mental illnesses for ages (WHO, 2011; WHO, 2013a). The same knowledge is reported to form the cradle of modern medicine (Rishton, 2008; Schmidt *et al.,* 2008). Additionally, the multifaceted approach in the study of therapeutic plants; ethnobotanical, phytochemical, biological and molecular techniques have virtually been informed by the ethnobotanical knowledge engrained in the traditional communities (Balunas and Kinghorn, 2005). Thus, WHO (2013a), has expressed the need for member countries to develop programs for conserving cultural medicinal knowledge (Eloff, 1998), mainly through documentation of traditional plant medicine. Worth noting, there was lack of information from the foregoing about medicinal plants adapted by the current Kikuyu and their Maasai counterparts to treat and manage diseases, in the face of rising need for traditional medicine due to emergence of difficult to treat communicable and NCDs. Therefore, the current study sought to comparatively investigate traditional medicinal plants that were being used by the current cohort of Maasai and Kikuyu THPs, attitude and perception of traditional medicine and level of traditional knowledge about causes, prevention and management NCDs diseases; particularly diabetes.

3.2 MATERIALS AND METHODS

3.2.1 Description of Nyeri County

3.2.1.1 Study Area and Ethnographic Background

Nyeri County is in Central Kenya and it borders; Laikipia County to the North, Nyandarua to the West, Murang'a to the South, Meru to the North East and Kirinyaga to the East (Figure 1). It is located between latitude 0.4167° S, 36.9500° E. It has a population of 693,558 (Male – 49 %, Female – 51 %) occupying an area of about 3,337km^2. It is divided into six constituencies; Tetu, Kieni, Othaya, Mathira, Mukurwe-ini, and Nyeri town. The temperature ranges from a mean of 12°C to 27°C; mean rainfall received ranges from 550-1,500 mm per annum. There are two rainfall seasons, long rains starts in March and ends in May whereas, short rains starts in October to December. Nyeri County leads nationally with a forest cover of 38.5% as compared to a national cover of 6.99**%.** The major geographical landscapes of the County are Mount Kenya (5,199 m) and the Aberdare ranges (3,999 m) to the east and west, respectively; both are densely forested with rich plant species diversity.

3.2.1.2 Socio-Economic Activities

Agricultural activities are a source of livelihood while the most predominant economic activities include; tea and coffee which are grown for exports, large scale horticultural flower farming, greenhouse farming by small scale vegetable farmers and dairy farming. The most predominant tribe is the Kikuyu community; others include the Kamba, Luo, Meru, Embu, Somali, and Borana. Most of the people living in Nyeri County are of Christian faith.

3.2.1.3 Social Amenities

Nyeri County has a high number of hospitals including; one level 5, 3 level 4, 18 level 3 and 75 level 2 health facilities. It also has three private and three mission hospitals; one nursing home, one hospice and 228 private clinics distributed across the County. The doctor/population ratio is about 1:6459 and the nurse/population ratio is 1:143.

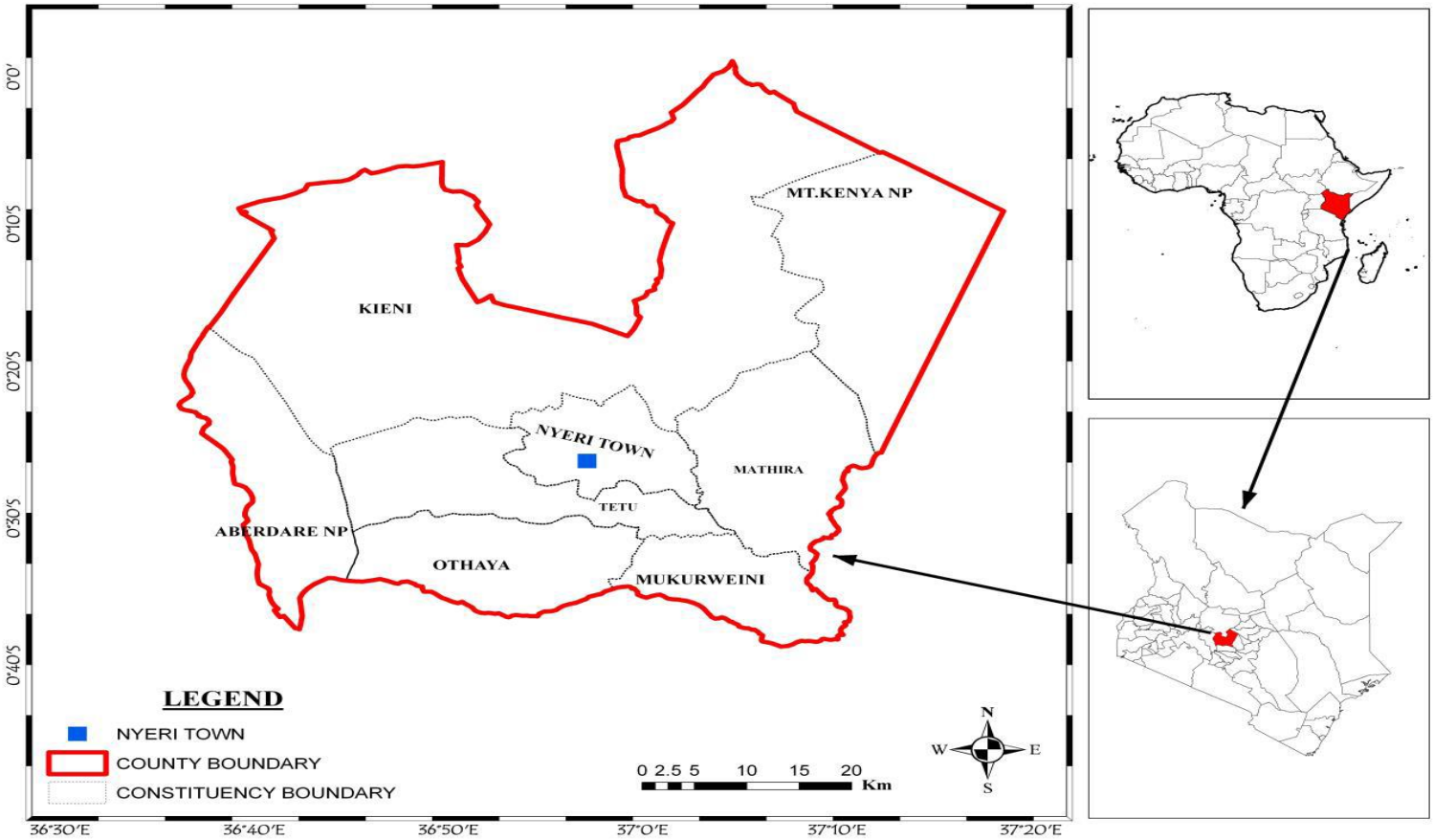

Figure 1: Map of Africa Indicating the Location of the Study Area, Nyeri County, Kenya

3.2.2 Description of Narok County

3.2.2.1 Study Area and Ethnographic Background

The Maasai are primarily nomadic pastoralists who inhabit the southern part of Kenya. They are reported to have originated from Sudan and Ethiopia before settling in East Africa (Hughes, 2006). In the precolonial period; they occupied the Savanna plains from Lake Turkana in Northern Kenya to the Maasai steppe of Central Tanzania. In 1911, the community was evicted by colonialist from their original land and restricted largely to the present day Kajiado and Narok. The community is composed of northern dialect and southern dialect. The northern dialect of the Maasai occupy Baringo and Samburu Counties; the Njemps and Samburu, respectively (Fratkin, 1997). The Southern dialect occupies Kajiado and Narok Districts (Bussman, 2006). This is composed of clans; Ildalaletuk, Isiria, Ilpurko, Iloodokilani, Ilmoitanik, Ilwuasinkishu, Ilkeekonyokie, Ilkisonko, Ilkaputiei, Iloitai, Sikirari, Ildamat and Ilmatapato (Vossen, 1988).

The current study was done in Narok County (Figure 2). The county was specifically chosen because unlike Kajiado which has become heavily urbanized as result of its close range to Nairobi City, Narok County is largely rural. The rural set up is likely to favor retention of culture including ethno medicine due to limited urban influence and lack of adequate modern health care facilities. Moreover, Narok County enjoys natural ecosystems such as Maasai Mara Game Reserve and Mau forests which may ascertain significant supply of traditional medicinal plants. Narok County is situated in Kenya along the Great Rift Valley. It lies between; 0° 16' S 34° 39' E and 2° 09' S, 36° 15' E coordinates and height above sea level is 1827 meters. To the south it borders the republic of Tanzania, Nakuru County to the North, Migori County to the

west, and Nyamira, Kisii, and Bomet counties to the Northwest. The County has six constituencies; namely; Emurua Dikirr, Narok East, Narok South, Narok North, Narok West and Kilgoris (Figure 2). The County's total population is 850,920 within a geographical area of 17,921.20 km^2. The main inhabitants are the Maasai, with pockets of Kisii, Kikuyu and Kalenjin communities. The climatic conditions include a temperature range of 8-28 degrees Celcius, a bimodal rainfall pattern which amounts to average rainfall of 500-1800mm per year. The lowlands parts of the County experience seasonal flooding.

3.2.2.2 Social Economic Activities

The economic activities include farming, tourism in Maasai Mara, commercial farming such as wheat, maize and potatoes and livestock farming. Currently, majority of the Maasai no longer practice nomadic pastoralism, instead they lead a sedentary lifestyle, due to land fragmentation. Moreover, they have adapted other social economic activities such as farming and trading (CRA, 2012). However, the social economic activities have often been affected by unpredictable weather patterns resulting to drought and food insecurity. The drought has resulted to loss of livestock, displacement of communities in search of water and pasture. The dynamic weather patterns and changing social economic life style may pose a threat to conservation of plants which may lead to loss of ethnobotanical knowledge.

3.2.2.3 Social Amenities

There are a total of 104 health facilities, 3 level four, 1 level three, 16 level two, and 84 level one hospitals distributed within the County. There are 571 primary schools, 61 secondary schools and 1 university (CRA, 2012)

3.2.3 Study Approval

The study was approved by the National Commission for Science, Technology and Innovation (NACOSTI).

3.2.4 Data Collection

The study was carried out in the month of April to July, 2014. Respondents were assured of confidentiality (Appendix 1). Those who willingly consented were selected to participate in the study by signing consent of agreement form (Appendix 11). The study design was a cross sectional survey, 30 respondents were recruited for the study. Recruitment was done in consultation with the Ministry of Culture and Social Services. Data was collected through interviews; transect walk and administration of semi-structured questionnaires (Appendix 111). The questionnaires constituted open - ended and closed - ended items, aimed at obtaining a detailed account of ethno-therapeutic approaches in treatment and management of diabetes. They were pilot tested and thereafter used by the researchers and a team of trained research assistants to gather the information on; diabetes prevalence, control and treatment approaches, demand for the services and traditional knowledge about antidiabetic herbal medicine. The interviews were conducted in the vernacular language and translated by the research team. Medicinal plants cited during the interviews were observed from the study field, identified, photographed and collected through the assistance of THPs and the taxonomist from the University of Nairobi. Voucher specimens were deposited in the University of Nairobi Herbarium - in the School of Biological Sciences.

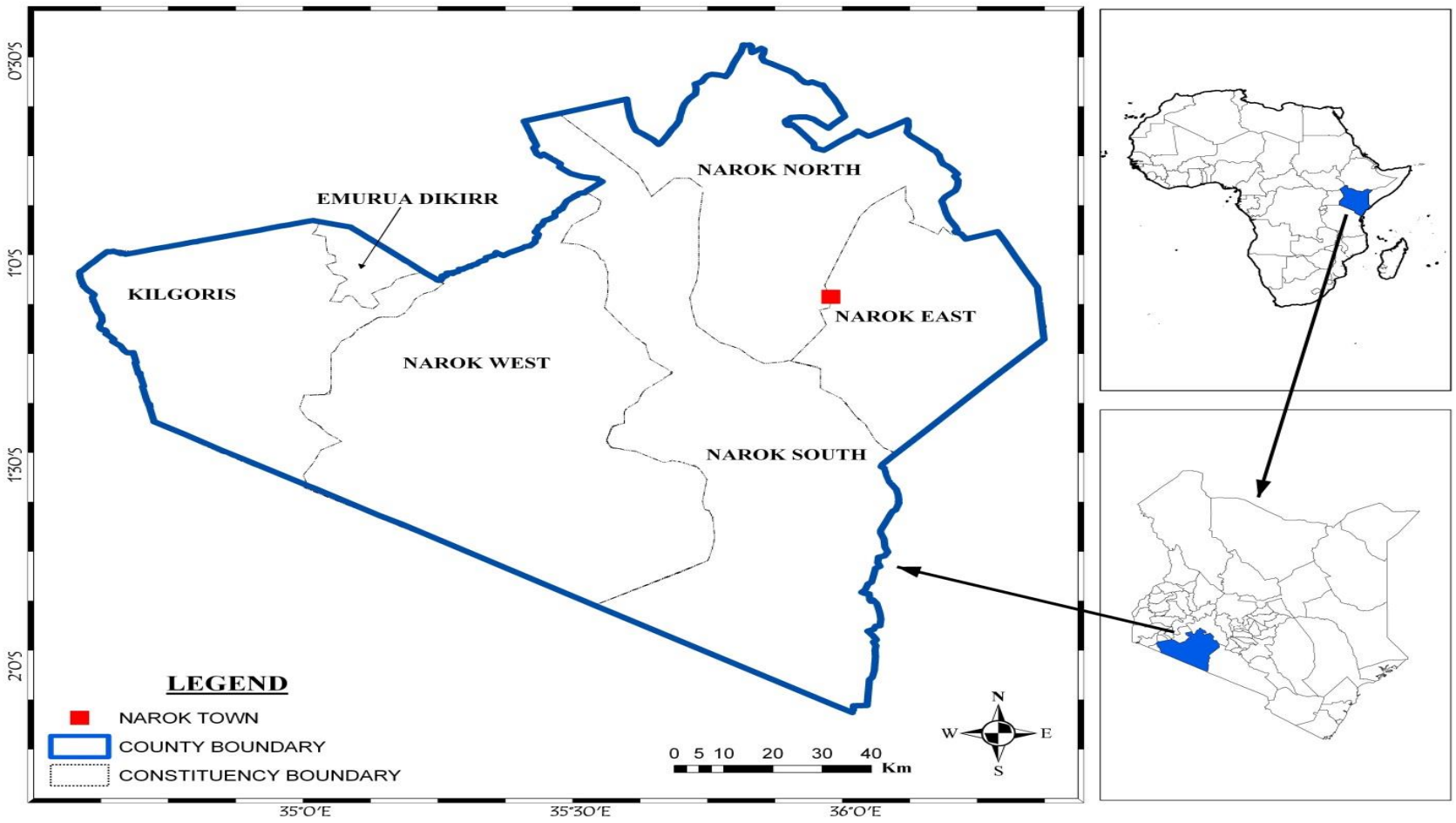

Figure 2: Administrative Map of the Study Area, Narok County, Kenya

Although most of the plants were identified in the field, a few were identified from the University of Nairobi Herbarium using taxonomic records and existing literature.

3.2.5 Voucher Specimen

After analysis of the survey data, the researchers undertook a follow up visit to the study area to identify and collect samples of plants that were used to manage diabetes as mentioned by the THPs. The plant samples were given a voucher identification number and each plant specimen was deposited at the School of Biological Sciences- Herbarium (University of Nairobi).

3.2.6 Statistical Data Analysis

The data was analyzed and summarized into proportions and percentages using descriptive statistics. Some responses were quoted verbatim and content analyzed. Relative importance of antidiabetic plant species among traditional medicine practitioners in Nyeri and Narok County was calculated as $UVs = (\Sigma\ UV_{is}) / (n_i)$, where UVs is the total Use Value of the species for all informants, UV_{is} is the Use Value of the species for a single informant, while n_{is} is the number of interviews by the informant (in this study, one interview was conducted per respondent) (Hoffman and Gallaher, 2007; Phillips and Gentry, 1993).

3.2.7 Cross Referencing With Existing Literature

Information on ethnotherapeutic uses, pharmacological activity, and phytochemical components was obtained through content analysis on all antidiabetic plant species that were cited and documented during the survey.

3.3. RESULTS

3.3.1 Ethnobotanical Survey and Threats to Medicinal Plants Traditionally used for the Management of Human Diseases in Nyeri County, Kenya

Majority of the Traditional Herbal Practitioners (THPs) were over 57 years (87%) and were of Christian faith (89%). Seventy seven percent (77%) had formal education out of which 55.6% had undergone professional training and worked in the formal sector; however, 20% had since retired. Sixty seven percent (67%) combined herbal practice with other income generating activities such as; business, farming, masonry and formal employment, the other 33% of the practitioners earned their living from herbalism. The THPs had long standing experience; 89% had practiced for over 20 years, the other 11% between 6-10 years. They mainly practiced from their homes (78%); the other 22% had established a clinic at Karatina, Mweiga and Nyeri town. They had acquired their skills in herbal medicine through inheritance from parents and long-standing experience. Notably, there was no evidence of apprenticeship or organized structures of passing down knowledge which they possessed. However, 67% had acquired additional information from books, media and internet. Fifty six percent (56%) had no formal training on herbal medicine while 44% had attended a government and World Bank sponsored seminar. The attendees displayed a deep mastery of appropriate herbal medicine practices during plant harvesting, preparation, storage, and dosage administration. They were aware of the group of patients that should be referred to medical practitioners for specialized treatment based on age, sex and magnitude of sickness. They learned management skills which included record keeping and financial management from the workshop from the conveners of the workshop. Besides uplifting their confidence and self-esteem in the profession, the workshop had driven out fear

among them. Eighty percent (80%) had registered as members of the Nyeri Herbalists Association (NYETIPA) under the Ministry of Culture and Social Services.

A total of 80 ailments treated by herbalists were recorded. Common communicable (infectious) diseases included; colds (53.3%), malaria (50%), gonorrhea (40%), respiratory infections (33.3%), intestinal worms (33.3%), and amoebiasis (10.0%) while non-communicable diseases were; high blood pressure (43%), arthritis/gout (40%), wounds (40%), joint pain (33.3%), ulcers/hyperacidity (33.3%), stomach ache (33.3%), male sexual dysfunction (33.3%) and constipation/indigestion (33.3%). Some diseases were treated as one, like arthritis and gout and, ulcers and hyperacidity (Table 1). For the THPs to achieve a wholesome effect they used a holistic treatment approach which included several herbs like; blood purifiers, appetizers, digestives, revitalizers and nutritional vegetables such as stinging nettle and Macdonald's eye. They combined 4-5 herbs in the treatment of one disease. Some acknowledged using a cocktail of up to 20 herbs, thus the saying "*gũtirĩ mũtĩ wa mũmwe*", which means "plant species never grow in isolation".

Table 1 Plants Traditionally used in the Management of Human Diseases by Traditional Herbal Practitioners in Nyeri County, Kenya

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Acanthaceae	*Thunbergia alata* Bojer ex Sims LNM14/103	Tonsils, hemorrhagia and postpartum bleeding	Kanyanja	Leaves	Decoction	Vine /Herb	Bu	2	0.06
Acanthaceae	*Justicia diclipteroides* Lindau LNM14/76	Pain	Numa	Leaves	decoction	Herb	Bu, Cp	1	0.03
Aloaceae	*Aloe kedongensis* Reynolds LNM14/84	Clear pimples, acne	Mũgwanũgũ	Leaves	Sap	Herb	Cp, Bu	3	0.1
Aloaceae	*Aloe lateritia* Engl. LNM14/32	Muscle inflammation or elephantiasis	Kĩĩruma	Leaves	Sap	Herb	Cp, Bm, Bu	1	0.03

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Amaranthaceae	*Achyranthes aspera* L. LNM14/117	Used to clean wounds (enhances blood coagulation)	Mũtegenye /Kamũtegenye	Leaf	Use sap or pound to obtain the juice	Shrub	Bu	1	0.03
Anacardiaceae	*Rhus natalensis* Bernh. ex Kraus LNM14/96	STDs, fibroids and colds	Mũthigiũ	Stems Roots Leaves Bark	Infusion	Tree	Bu, Cp,	2	0.06
Annonaceae	*Annona cherimola* Mill. LNM14/53	Cancer	Mũtomoko	Bark	Decoction	Tree	Cf	1	0.03

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Apocynaceae	*Carissa edulis* (Forssk.)Vahl LNM14/24	STD, polio, arthritis/ gouts, energizer, stomach ache, malaria, coughing / cold, male sexual stimulant	Mũkawa	Leaves Bark	Decoction	Shrub	Bu, Cp	8	0.27
Araliaceae	*Cussonia holostii Engl.* LNM14/45	Wounds, high blood pressure, irregular menstrual cycle, uterine cleansing, fibroids	Mũroha	Bark	Decoction	Tree	Bu, Cf, Cp, Bm	6	0.2

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Asclepiadaceae	*Mondia whitei* (Hook f.) Skeels LNM14/44	Appetizer, stomach problems, deworming, hyperacidity/ ulcers, male sexual stimulant, kidney cleansing, malaria	Mũhukũra	Roots Bark	Decoction added to soup	Liana	Bu, Cf, Cp,	6	0.2
Asclepiadaceae	*Periploca linearifolia* Dill. and A. Rich. LNM14/06	Colds and STDs	Mwemba-igũrũ	Roots	Sap	Liana	Bu, Bm	2	0.06

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Asteraceae	*Sonchus oleraceus* L. LNM14/02	Constipation, stimulate digestive system, cancer	Mũthũnga	Roots Leaves	Decoction	Herb	Cf	3	0.1
Asteraceae	*Tagetes minuta* L. LNM14/48	Wounds, toothe ache, insect bite	Mũbangi	Root Stem Leaves	Crushed, Chew	Herb	Cf	5	0.17
Asteraceae	*Bidens pilosa L.* LNM14/49	Conjunctivitis, malaria, kidney cleansing	Mũhehenje /Mũcheege	Root	decoction	Herb	Cf	5	0.17
Asteraceae	*Vernonia auriculifera* LNM14/40	Stomach ailments, insect repellant, intestinal worms, dysentery	Mũthakwa	Roots Leaves	Decoction, whole leaves	Shrub	Bu, Cf, Cp,	5	0.17

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Asteraceae	*Galinsonga parviflora Cav.* LNM14/08	Measles, tonsils, colds, asthma	Mũng'ei	Whole plant	Chew leaves Decoction	Herb	Cf	4	0.13
Asteraceae	*Launaea cornuta* (Hochst. ex Oliv. and Hiern) C. Jeffrey LNM14/03	Constipation, cancer	Mũthũnga	Roots Leaves	Decoction	Herb	Cf	3	0.1
Asteraceae	*Vernonia lasiopus* O.Hoffm. LNM14/23	Malaria, deworming, male stimulant, restore periods in women	Mũchatha	Roots	decoction	Shrub	Bu	3	0.1

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Asteraceae	*Psiadia punctulata* (DC.) Oliv. and Hiern LNM14/90	Male sexual stimulant	Mũbai or mũenda ngueko	Roots	Decoction	Shrub	Bu, Cf,	5	0.06
Asteraceae	*Bersama abyssinica* Fresen. LNM14/95	Epilepsy and male sexual stimulant	Mũrumandũ	Leaves Root	Chew Decoction	Tree	Bu, Cp	2	0.06
Asteraceae	*Aspilia pluriseta* Schweinf. ex Engl. LNM14/110	Diarrhea	Mũũtĩ	Roots	Decoction	Herb	Bu	1	0.03

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Asteraceae	*Vernonia brachycalyx* O. Hoffm. LNM14/111	Stomach evacuation	Kagutu	Leaf	decoction			1	0.03
Asteraceae	*Spilanthes mauritiana* (A.Rich. ex Pers.) DC. LNM14/30	Toothache	Gatharia ita	Flowers Roots	Chew	Herb	Bu	1	0.03

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Bignoniaceae	*Kigelia africana* (Lam.) Benth. LNM14/33	Gonorrhea, sphyllis, drugs / bhang addiction, jaundice, madness, cataract, blood cleanser, high blood pressure, hydrocephalus, measles, hemorrhagia, postpartum bleeding	Mũratina	Leaves Bark Fruit	Decoction	Tree	Bu Cf, Cp Bm	15	0.5
Bignoniaceae	*Markhamia lutea* (Benth.) K. Schum. LNM14/120	Toothe ache (mouth wash before bed)	Mũũ	Bark	Chew	Tree	BM, Bu, Cp, Cf	1	0.03

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Boraginaceae	*Cordia africana Lam.* LNM14/123	Joints, typhoid, high blood pressure, antitumor, chest infection, cardiac stimulant.	Mũringa	Bark	Decoction	Tree	Bu, Cf, Cp, Bm	12	0.4
Boraginaceae	*Ehretia cymosa* Thonn. LNM14/94	Wounds, male sexual stimulant.	Mũrembu	Bark	Decoction Sap	Tree	Bu, Cf, Cp,	2	0.06
Burseraceae	*Commiphora eminii* Engl. LNM14/74	Clean teeth, snake bite	Mũkũngũgũ	Bark Stem Root	Decoction	Tree	Cf, Cp,	3	0.1

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Caesalpinaceae	*Senna didymobotrya* (Fresen.) Irwin and Barneby LNM14/39	Intestinal worms, antifungal, burns, bleeding gums, tooth ache, typhoid, amoebiasis, stomach ache evacuation.	Mwĩnũ / Mũĩnũ	Leaves	Decoction	Shrub	Cp, Bu	9	0.3
Caesalpiniaceae	*Caesalpinia volkensii* Harms LNM14/43	Headache/ migraine energizer, malaria, joints	Mũchũthĩ (Njũthĩ)/ mũbũthĩ	Seeds Roots	crush to form a paste	Liana	Bu, Cf, Cp,	6	0.2

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Caesalpiniaceae	*Senna septemtrionalis* (Viv.) H. Irwin and Barneby LNM14/70	Gonorrhea, syphilis, intestinal worms	Mũchingiri	Root	Decoction	shrub	Bu	3	0.1
Caesalpiniaceae	*Caesalpinia decapetala* (Roth) Alston LNM14/112	Clean teeth	Mũbaage	Stem	Stem cutting	Shrub	Bu	1	0.03

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Canellaceae	*Warburgia ugandensis* Sprague LNM14/34	Arthritis/ gouts, tooth ache, stomach problems, malaria, respiratory diseases e.g. colds, asthma and chest pain, AIDs, cancer, anthrax	Mũthĩga	Bark Root Leaves	Decoction	Tree	Bu, Cf, Cp, Bm	14	0.47
Capparaceae	*Maerua triphylla* LNM14/81	Headache, migraine	Mũkũri-ũndũ	Root	Decoction	Shrub	Bu	3	0.1

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Capparaceae	*Capparis tomentosa* Lam. LNM14/71	Arthritis, inflammation/ elephantiasis, joint pains	Mũri ũmwe	Bark	Decoction or cover the inflamed tissue with bark for 15 minutes).	Tree	Bu	1	0.03
Caricaceae	*Carica papaya* L. LNM14/46	Skin fungal infection	Mũbabae	Unripe fruit	Juice	Tree	Cf	1	0.03
Celastraceae	*Hippocratea africana* Loes. ex Engl. LNM14/93	Sexual stimulant in men, drying of wounds, STDs	Mũng'aang'a	Bark Roots	Decoction	Liana	Bu	2	0.06
Celastraceae	*Maytenus heterophylla* (Eckl. and Zeyh.) LNM14/104	Diarrhea	Mũthuthi	Roots	Decoction	Tree	Bu	2	0.06

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Celastraceae	*Elaeodendron buchananii* Loes. LNM14/116	Wounds	Mũtanga	Roots	Grinded	Tree	Bu	1	0.03
Chenopodiaceae	*Chenopodium opulifolium* Schrad. ex W.D.J. Koch and Ziz LNM14/109	Gonorrhea	Mũiganjo	Bark Root	Decoction	Herb	Bu, Cp	1	0.03
Crassulaceae	*Kalanchoe marmorata* Baker *or K. densiflora* Rolfe. LNM14/31	Tooth ache	Mahũithia / Mũkondori	Leaves	Heat over the fire and place on the inflamed or swollen muscle	Shrub	Bu	1	0.03

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Cucurbitaceae	*Coccinia trilobata* (Cogn.) C. Jeffrey LNM14/108	Syphilis	Kagerema	Leaves	Decoction	Vine	Bu	1	0.03
Dracaenaceae	*Dracaena steudneri* Schweinf. ex Engl. LNM14/11	High blood pressure	Ithare	Bark Root	Decoction	Tree	Bu, Cp	2	0.06
Ebenaceae	*Euclea divinorum Hiern* LNM14/73	Diarrhea, typhoid, stroke	Mũkinyai	Root	Infusion Decoction	Tree	Bu, Cf, Cp,	3	0.1

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Euphorbiaceae	*Croton megalocarpus* Del. LNM14/35	Influenza, pneumonia, wounds, family planning, amoeba/ protozoa, typhoid, menorrhagia, postpartum haemorrhage	Mũkindũri	Bark Leaves	Decoction	Tree	Bu, Cf, Cp, Bm	12	0.4

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Euphorbiaceae	*Neoboutonia macrocalyx Pax* LNM14/38	Coughing/ cold, chest pain, wounds, family planning, high blood pressure, cardiac problem/ hypertrophy, cholesterol and chicken pox	Mũtũndũ	Bark Roots	Decoction	Tree	Bu, Cf, Cp, Bm	9	0.3
Euphorbiaceae	*Synedenium compactum* N. E. Br. LNM14/77	AIDs, warts, joint pain	Watha	Leaves	Decoction or Milky sap, Ash from the bark	Shrub	Bu, Bm	3	0.1
Euphorbiaceae	*Ricinus communis* L. LNM14/98	Gouts, family planning	Mwarĩki /Mbarĩki	Root Seeds	Root decoction 3 drops of oil	Shrub	Cf	2	0.06

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Euphorbiaceae	*Tragia brevipes* Pax. LNM14/100	Male sexual stimulant, parturition	Njegeni	Roots	Roots sap applied on penis Decoction	Herb	Bu,	2	0.06
Euphorbiaceae	*Bridelia micrantha* (Hochst.) Baill. LNM14/106	Gastrointestinal worms	Mũkoigo	Bark	Decoction	Tree	Bu	2	0.06
Euphorbiaceae	*Acalypha Volkensii* Pax LNM14/115	Wounds	Mũng'aria	Roots	Sap	Shrub	Bu	1	0.03

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Euphorbiceae	*Euphorbia gossypina* (Pax) LNM14/86	Respiratory diseases, leukemia, energizer	Kariaria	Roots Stem Leaves	Decoction	Shrub	Bu, Cp, Bm	2	0.06
Flacourtiaceae	*Trimeria grandifolia* (Hochst.) Warb. LNM14/56	Arthritis/ gouts, hyperacidity/ ulcers, joints	Mũhĩndahĩndi	Roots	Decoction	Shrub	Bu, Cp	4	0.13
Flacourtiaceae	*Dovyalis abyssinica* A. Rich LNM14/58	Gonorrhea syphilis, constipation/ indigestion, fibroids	Mũkambura	Bark Leaves Roots	Decoction	Shrub	Bu, Cf, Cp,	4	0.13

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Gramineae	*Digitaria scalarum* Chiov. LNM14/102	Gonorrhea, candidiasis	Thangari	Root	Decoction	Herb	Cf, Cp, Bu	2	0.06
Gramineae	*Saccharum officinarum* L.	Fibroids	Kĩgwa	Stem	Juice	Herb	Cf	1	0.03
Gramineae	*Pennisetum clandestinum* Hochst. Ex Chiov. LNM14/78	Kidney cleansing	Wĩtima	Roots	Decoction	Herb	Cp, Bu,	1	0.03
Guttiferae	*Hypericum revolutum* Vahl. LNM14/40	AIDs	Mũthathumwa	Leaves	Decoction	Tree	Bu	1	0.03

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Hydnoraceae	*Hydnora abyssinica* Schweinf. LNM14/17	High blood pressure, diarrhea, expel after birth, hemorrhagia and postpartum bleeding	Mũthigira	Roots Rhizome	Decoction	Herb	Bu, Cf, Cp,	4	0.13
Hypericaceae	*Harungana madagascariensis* Lam. ex Poir. LNM14/92	Malaria and stimulate growth of mammary glands	Mũitathũa	Roots	Decoction	Shrub	Bu,	2	0.06
Hypocreaceae	*Engleromyces goetzei* P.Henn. LNM14/87	Colds and pneumonia	Kĩeha kia mũrangi	Whole plant	Decoction	Fungi	Bu, Bm	2	0.06

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Labiatae	*Ajuga remota*. Benth LNM14/42	Colds, malaria AIDs tooth ache, high blood pressure and amoeba / protozoa	Wanjirũ wa kĩeni	Leaves Roots	Decoction	Herb	Bu, Cp	7	0.23
Labiatae	*Leonotis nepetifolia* (L.) R. Br. LNM14/63	Goiter, intestinal worms, conjunctivitis, irregular menstrual cycle	Mũchii	Leaves	Decoction	Shrub	Bu	4	0.13
Labiatae	*Plectranthus barbatus* Andrews forskohlii LNM14/67	Stomach problem, tooth ache, constipation	Maigoya	Leaves	Decoction	Shrub	Bu, Cf, Cp, Bm	3	0.1

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Labiatae	*Ocimum kilimandschari cum* Guaerke LNM14/68	Respiratory diseases, insect repellant	Makũri	Leaves	Decoction	Shrub	Bu, Cf, Cp,	3	0.1
Labiatae	*Ocimum gratissimum L.* LNM14/80	Headache/ migraine, Gonorrhea, colds	Mũkandu	Bark Leaves	Decoction, Infusion	Shrub	Bu	3	0.1
Labiatae	*Fuerstia africana* T.C.E.Fr. LNM14/105	Gonorrhea	Gathĩrĩga	Leaves	Decoction	Herb	Bu	1	0.03
Lauraceae	*Persea Americana* Mill. LNM14/19	Bleeding gums, diarrhea, high blood pressure, diuretic, typhoid	Mũkorobia	Seed Leaves Fruit peels	Seed (infusion, Leaf decoction Peel decoction	Tree	Cp Cf	4	0.13

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Liliaceae	*Aloe secundiflora Engl.* LNM14/36	Pneumonia, constipation, malaria, fibroids, AIDs, wounds (apply sap)	Thukũrũi	Leaves	3 drops per glass	Herb	Bu, Cp	10	0.33
Loganiaceae	*Strychnos henningsii* Gilg LNM14/47	Arthritis/ gouts, back or joint pain, fatigue, malaria and respiratory diseases	Mũteta	Root Bark	decoction	Shrub	Bu, Cf, Cp, Bm	6	0.2
Malvaceae	*Sida tenuicarpa Vollesen* LNM14/57	Gonorrhea, diarrhea and toothache.	Kahĩnga	Roots	Decoction	Shrub	Bu, Cf, Cp,	4	0.13

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Malvaceae	*Pavonia urens* Cav. LNM14/89	Hyperacidity, tooth ache	Machũna	Leaves	Decoction	Shrub	Bu, Cp,	2	0.06
Malvaceae	*Hibiscus fuscus* Garcke	Stomach evacuation due to food poisoning/ afflatoxins	Mũgere	Roots	Decoction	Shrub	Bu	1	
Meliaceae	*Ekebergia capensis Sparrm.* LNM14/75	Pneumonia, induce aggressive actions, colds, coughing	Mũnunga	Bark Leaves	Decoction	Tree	Bu, Cf,	3	0.1
Meliaceae	*Melia volkensii* Gürke LNM14/59	Malaria	Mwarubainĩ	Bark Leaves	Decoction	Tree	Bu, Cp,	1	0.03

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Mimosaceae	*Mimosa pudica* L. LNM14/113	Asthma	Mũkua-tũhũ / Mwĩkuithia	Root	decoction	Herb	Cf, Cp, Bu	1	0.03
Moraceae	*Ficus thonningii Blume* LNM14/55	Intestinal worms, colds, dysentery	Mũgumo	Bark Leaves	decoction	Tree	Cf	4	0.13
Moraceae	*Ficus lutea* Vahl LNM14/83	Skin fungal infection	Mũmbũ	Leaves	Milky sap	Tree	Bu	1	0.03
Moringaceae	*Moringa oleifera Lam.* LNM 14/28	Arthritis/ gouts, loss of memory, prostate cancer, high blood pressure	Moringa	Seeds Leaves	Chew seed, Leaf decoction	Tree	Cf, Cp	4	0.13

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Musaceae	*Musa sapientum* L. LNM14/107	Gonorrhea	Ngoro ya irigũ	Inflorescence (flower)	Decoction	Tree	Cf	1	0.03
Myricaceae	*Myrica salicifolia* Boj. ex Baker LNM14/99	AIDs	Mũthongoya	Bark Roots	decoction	Shrub	Bu	1	0.03
Myrsinaceae	*Myrsine africanum L.* LNM14/26	Intestinal worms, cancer	Mũgaita	Fruits Bark	Decoction	Shrub	Bu,	4	0.13
Myrtaceae	*Eucalyptus globilus* Labil. LNM14/82	Asthma, pneumonia, cold, sinuses, epilepsy, high blood pressure (bark)	Mũbao wa white	Bark Leaves	Decoction, Infusion	Tree	BuCpBM	3	0.1

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Myrtaceae	*Callistemon viminalis* (Gaertn.) G.Don ex Loudon LNM14/119	Tooth ache	Bottle brush (exotic)	Leaves	Boil	Tree	Cp	1	0.03
Oleaceae	*Olea africana* L. LNM14/27	Intestinal worms, high blood pressure, amoeba/ protozoa, joints	Mũtero/ Mũtamaiyo	Stem Root Bark	Decoction	Tree	Bu, Cf, Cp, Bm	6	0.2
Oleaceae	*Olea hochstetteri Bak.* LNM14/69	Gonorrhea, syphilis, Colds, intestinal worms	Mũcharage	Bark Stem	Decoction	Tree	Bu	3	0.1

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Oleaceae	*Schrebera alata* (Hochst.) Welw. LNM14/41	Tooth ache	Muga nyoni	Bark Twig	Chew	Tree	Bu, Cp	1	0.03
Papilionaceae	*Erythrina abyssinia* DC LNM14/72	Gonorrhea, sphyllis, arthritis/ gouts	Mũhũtĩ	Roots Bark	Decoction	Tree	Bu, Cf, Cp,	3	0.1
Phytolacaceae	*Phytolacca dodecandra* L Hér. LNM14/91	Hyperacidity, jigger repellant	Mũhoko	Leaves	Powder Decocotion	Liana	Bu,	2	0.06
Polygonaceae	*Oxinum sinuatum* LNM14/52	STDs, candidiasis	Cong'e	Roots	Decoction	Herb	Cf, Cp	4	0.13

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Polygonaceae	*Rumex abyssinicus* Jacq. LNM14/114	Pneumonia	Mũgũagũa /Mũgagatio	Stem	Crushed/chew	Herb	Bu, Cf	1	0.03
Ranunculaceae	*Clematis hirsuta Guill. and Perr.* LNM14/10	Colds, kidney cleanser	Mũgaya-ng'ũndũ	Leaves Roots	Inhale crushed leaves or roots	Shrub	Bu	3	0.1

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Rhamnaceae	*Rhamnus prinoides* L. He'rit LNM14/18	Arthritis, gouts, appetizer, constipation/ digestive system, hyperacidity/ ulcers, high blood pressure, male sexual stimulant, anthrax	Mũkarakinga	Leaves Roots Bark	Decoction	Shrub	Bu, Cp	7	0.23
Rhamnaceae	*Rhamnus staddo* A. Rich LNM14/101	Kidney cleansing, malaria	Ngukura	Roots	Decoction added to soup	Shrub	Bu	2	0.06

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Rosaceae	*Prunus africana* (Hook F.) Kalkm. LNM14/20	Animal protein allergy, STD, arthritis/ gouts, blood purifier/ cleanse, appetizer, prostate, arthritis, stomach problems, constipation, malaria hyperacidity/ ulcers, fibroids, joints and renew memory	Mũiri	Bark Leaves	Decoction	Tree	Bu Cf Cp Bm	17	0.57

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Rubiaceae	*Galium aparine* L. LNM14/85	STDs, kidney cleansing	Gakarakũ	Leaves	Decoction	Herb	Cf, Bu	2	0.06
Rubiaceae	*Vangueria madagascariensis* J. F. Gmel. LNM14/61	Stimulate digestion	Mũbirũ	Roots	Decoction	Tree	Bu	1	0.03
Rutaceae	*Zanthoxylum usambarense (Engl.)* LNM14/37	Toothache and cleaning teeth, malaria, chest problems: colds, coughing and asthma	Mũheheti	Bark, Stem	Decoction, Chew	Tree	Bu, Cf, Cp, Bm	9	0.3

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Rutaceae	*Toddalia asiatica* (L.) Lam. LNM14/60	Colds, respiratory diseases, e.g. cold, asthma and chest pain, tooth ache	Mũrũrũe	Leaves	Decoction	Tree	Bu, Cf, Cp, Bm	4	0.13
Rutaceae	*Clausena anisata* Hook.f. De Wild. and Staner LNM14/121	Toothe ache (mouth wash before bed)	Mũtathi	Leaf Root	Decoction	Tree	Bu	1	0.03
Solanaceae	*Solanum aculeastrum* Dunal LNM14/51	Whooping cough, wounds, male sexual stimulant	Mũtũra (mũgandũra anake) (Ndũra/fruit)	Roots Fruits	Decoction	Shrub	Bu, Cf, Cp, Bm	5	0.17

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Solanaceae	*Solanum incanum L.* LNM14/62	Anti-vomiting, stomach problems, hyperacidity, dyspepsia	Mũtongu	Roots	Decoction	Shrub	Bu, Cf, Cp,	4	0.13
Solanaceae	*Solanum nigrum* L. LNM14/29	Nausea, high blood pressure, arthritis/gouts	Managu	Leaves	Decoction	Herb	Cf	3	0.1
Solanaceae	*Withania somnifera* (L.) Dunal LNM14/97	Hyperacidity/ ulcers	Mũrumbae	Flower	Decoction	Shrub	Bu, Cf, Cp,	2	0.06
Solanaceae	*Physalis peruviana* L. LNM14/65	Hyperacidity	Mũnathi	Whole plant	Decoction	Herb	Bu	1	0.03

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Sterculiaceae	*Dombeya burgessiae* Gerr. Ex. Harv. LNM14/118	Stops bleeding of wounds (blood clotting effect)	Mũkeũ	Leaves Stem	Sap	Shrub	Bu	1	0.03
Ulmaceae	*Trema orientalis* (L.) Blume. LNM14/64	Asthma	Mũhethũ	Roots	Decoction	Tree	Bu	1	0.03
Urticaceae	*Urtica masaica Mildbr.* LNM14/12	Arthritis/ gouts, high blood pressure, sexual stimulant and joint pain	Hatha /Thabai	Roots, Leaves	Decoction	Herb	Cf, Bu	3	0.1

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Verbenaceae	*Rotheca myricoides* (Hochst.) Vatke LNM14/09	Kidney cleansing, gonorrhea, syphilis, STD, headache/ migraine, pneumonia, prostate cancer, constipation/ indigestion, malaria, hyperacidity ulcers, amoeba, typhoid, joints, brucellosis	Munjuga-iria	Roots	Decoction (Boil)	Shrub	Bu, Cf, Cp, Bm	15	0.5

Plant Family	Botanical name and Voucher number	Therapeutic uses	Local name	Pspu[a]	Preparation	Growth forms	Habitat	Ncs[b]	Use Value (UVs)
Verbenaceae	*Lantana camara* L. LNM14/66	Headache/ migraine, athletes foot and sun burn	Karendi/ Mũkigĩ	Leaves	Crush sniff decoction	Shrub	Bu Cf, Cp Bm	3	0.1
Vitaceae	*Rhoicissus 75tridentata* (L.f.) Wild and Drummond LNM14/54	Remove after birth	Ndurutua	Roots	Decoction	Liana	Bu	1	0.03

Key: Bu-bush, Cf- Crop field, Cp-Compound, Bm-Boundary marker Sma – Semi Arid and Mkt – Bought in the market

Ppu[a]- *Part of plant used, Ncs[b]- Number of citations*

The plants occurred in diverse habitats, 23.8% of the herbs were harvested either from the; bush, crop farms, compound or boundary. The highest proportion of species growth form was trees (36%) followed by shrubs (32%), herbs (24%), liana (7%) and fungi (1%). Regularly harvested plant parts were the roots (34.1%), leaves (25%), bark (20%) and whole plant (9%) (Figure 3). In order to conserve medicinal plants, the THPs obtained the bark by cutting longitudinal strips or harvested a third of the roots per plant; others had developed botanical gardens in their farms where they grew trees such as, *Prunus africana* and *Azadirachta indica*.

Plant materials were washed and dried before grinding and stored in water proof containers. Plant medicine was prepared by boiling (80%), as an infusion (15%), inhalant or through dermal or nasal application (5%). Frequently used measurement unit was a glass/cup (equivalent to 250ml) of herbal decoction or infusion taken twice or thrice daily, children took half the adult dose. Preparation was done by the THPs and therefore cases of over dosage were rarely reported. But when such cases occured, the effects included; constipation/indigestion and vomiting which were treated by administering a laxative and anti-vomiting herb respectively. Notably, THPs did not treat infants, pregnant women, very old people and emergency cases but referred them to hospital for specialized treatment.

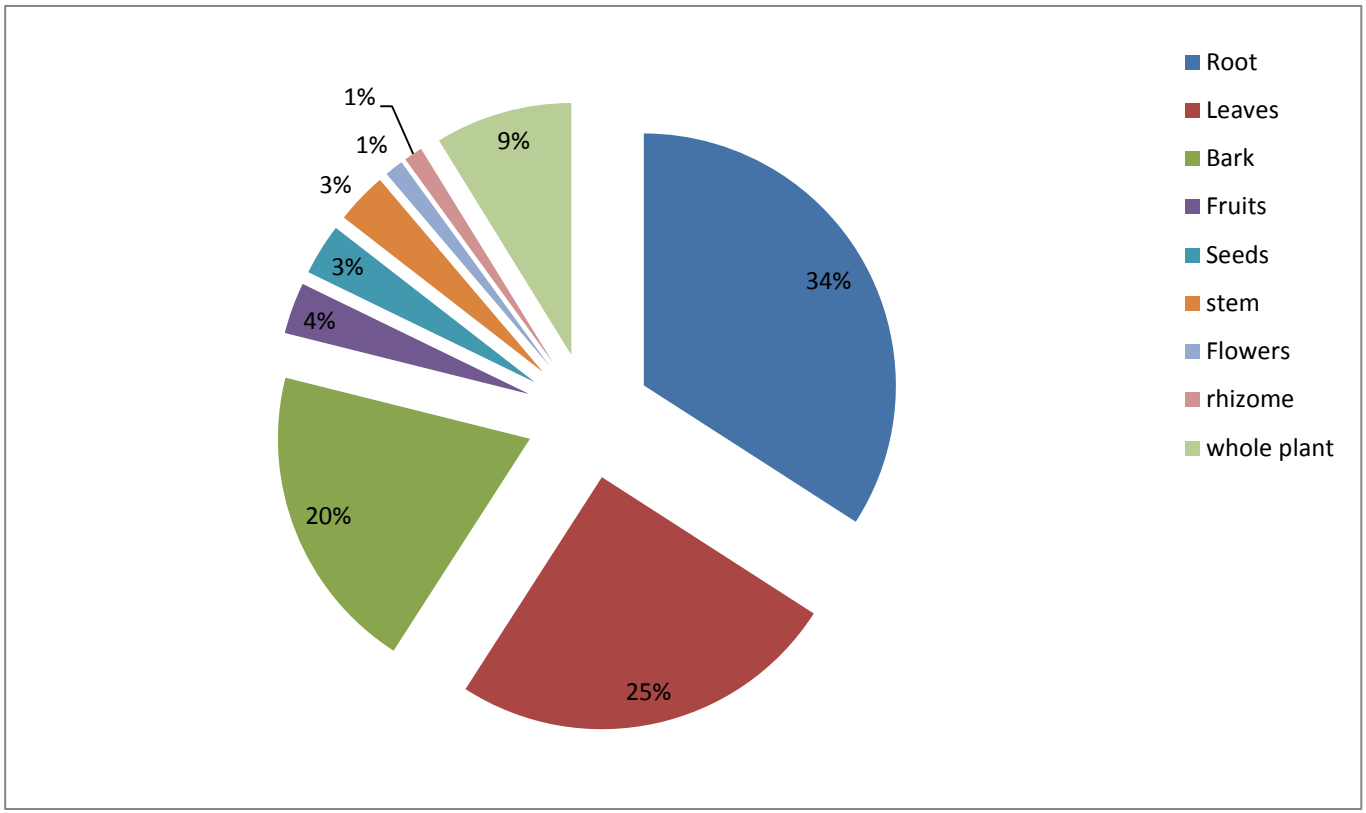

Figure 3: Commonly Harvested Parts of Plants used by Traditional Herbal Practitioners in Nyeri County in the Treatment and Management of General Diseases

Plant toxicity was reportedly rare, however, 11% of THPs acknowledged that, some herbs like; *Annona cherimola, Warbugia ugandensis*, *Aloe* spp. and *Senna didymobotrya* caused toxic effects such as diarrhea, mild headache, stomach ache and general body weakness. In particular, *Neoboutonia macrocalyx* caused kidney problems, *Caesalpina volkensii* and *Acacia nilotica* (L. Wild) had blood thinning effect while *Rhamnus prinoides* and *Prunus africana* demonstrated diuretic effect. The THPs neutralized plant toxicity by adding milk, fats, and bone soup. They also combined medicinal plants with other plants such as, *Rhamnus prinoides, Periploca linearifolia, Carissa edulis, Rotheca myricoides, Prunus africana, Acasia nilotica* or *Tremma orientalis* depending on the plant type. Also, ½ a glass of *Achyranthes aspera* leaves and *Ficus natalensis* (roots or bark) was added to the root preparation of *Euclea divinorum, Senna didymobotrya* and *Cyathula polycephala* leaves to counteract their laxative effect.

Notably, high level of knowledge in plants that are toxic to both man and animals was observed among the THPs. Plant(s) that were not eaten by goats or those that produced a milky sap were considered to be poisonous to humans or animals. At least each TMP mentioned 3-5 toxic plants. This finding explained why plant toxicity due to adulteration was reportedly rare. A total of 12 toxic plants were identified and documented (Figure 4)**.**

The THPs displayed an in-depth knowledge on herbal medicine used to manage diseases in the Kikuyu community. Majority (67%) mentioned over 20 medicinal plants without reference to their records. However, there was no significant relationship between level of education ($p = 0.070$) or age ($p = 0.889$) and traditional knowledge of herbal medicine. A total of 111 medicinal plant species distributed within 98 genera and 56 families were documented (Table 1). Plant families with high numbers of medicinal plants were;

Asteraceae (9.5%), Euphorbiaceae (7.2%), Labiatae (6.3%), Solanaceae (5.4%) and Caesalpinaceae (4.5%) (Figure 5). Plants that showed a high "User Value" among the THPs included; *Prunus africana*, *Rotheca myricoides*, *Kigelia africana*, *Warbugia ugandensis*, *Croton megalocarpus* and *Cordia abyssinica* (Table 1). The THPs from drier parts of the County in particular Kieni sub-county, possessed more information on traditional herbal medicine used by the traditional Kikuyu community and relied more on knowledge inherited from their parents.

Despite their deep knowledge in traditional medicine, the practice faced several challenges; 70% of the THPs acknowledged that, there was a general belief among members of the community that taking herbal medicine causes resistance to modern drugs. Failure to complete prescribed dose was also reported, especially when a large quantity of herb decoction was administered. This was caused by presumption by patients that it was an overdose. Other challenges included poor payment for services provided by the THPs and very high expectation from the patients for immediate healing.

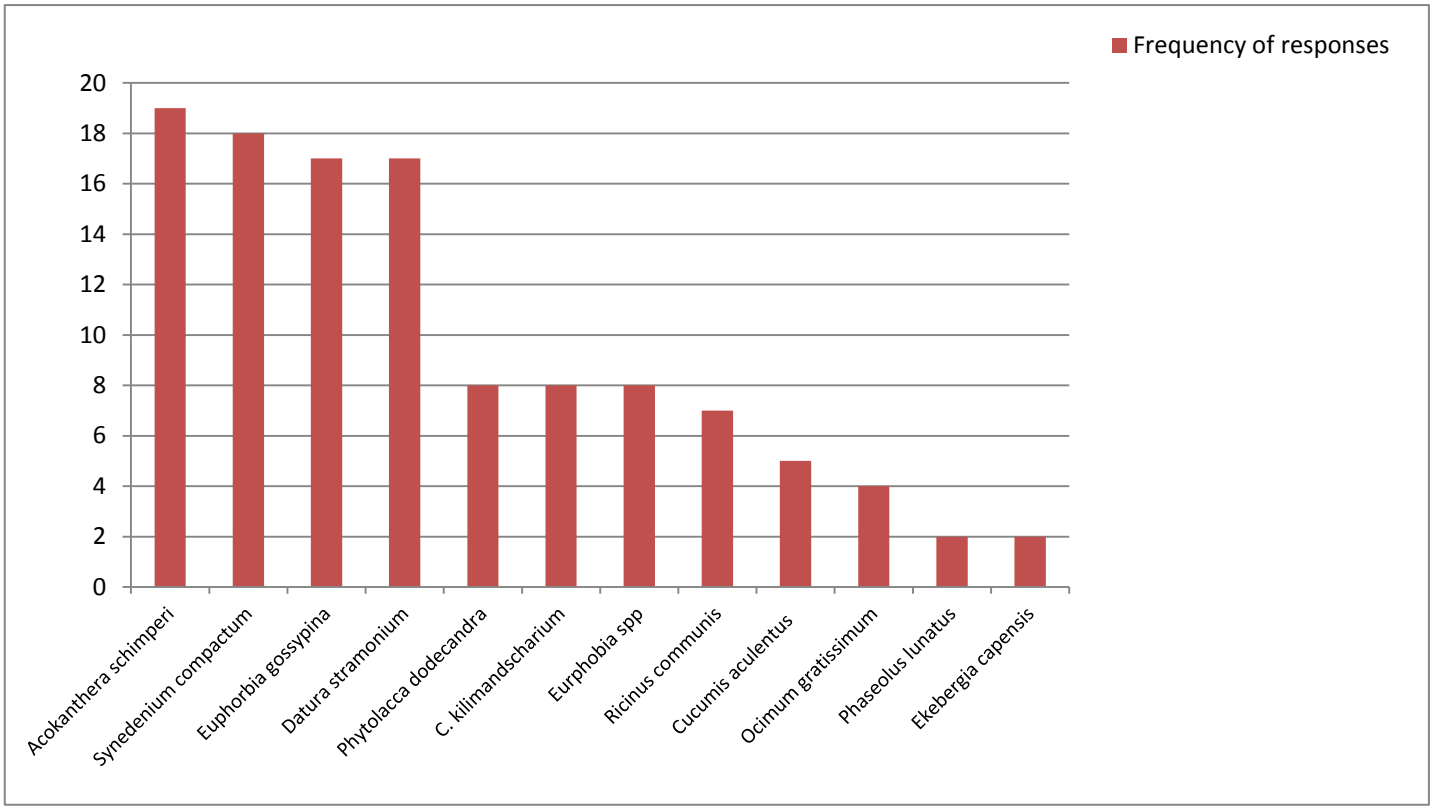

Figure 4: Toxic Plant Species Known to Traditional Herbal Practitioners in Nyeri County, they are Avoided during Harvesting of Plant Medicine

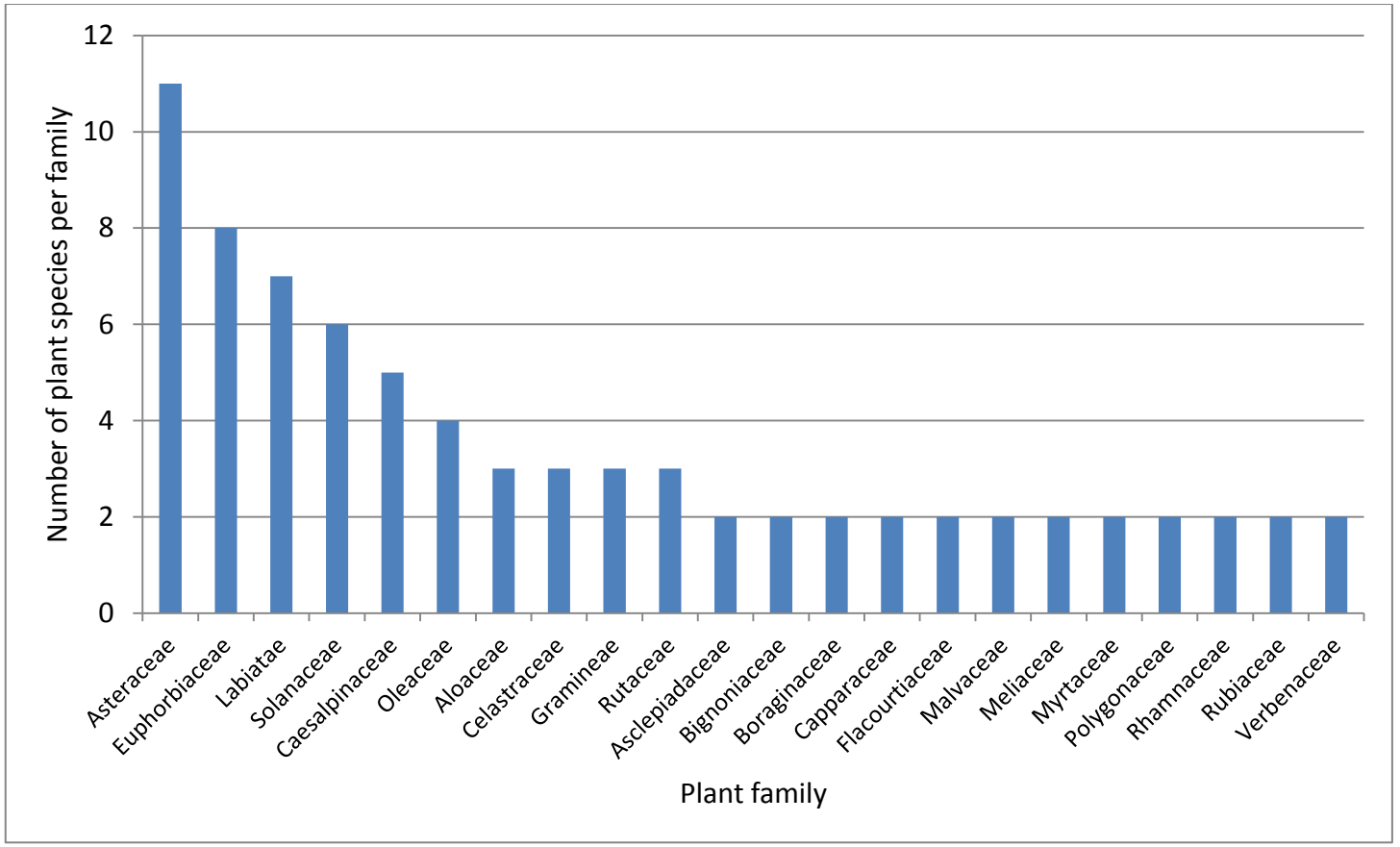

Figure 5: Families of Medicinal Plants Cited by Traditional Herbal Practitioners in Nyeri County. The Bars Represent the Proportion of Number of Plant Species per Plant Family

3.3.2 Knowledge and Demand for Medicinal Plants used in the Treatment and Management of Diabetes in Nyeri County, Kenya

Diabetes in Nyeri County was described as "Mũrimũ wa cukari", 30 THPs (100%) acknowledged that diabetes was very common and they were aware of its occurrence. Each cited at least 1-5 diabetic persons within their local area and 1-5 deaths related to diabetes complication(s). Eighty nine percent (89%) of THPs understood what diabetes was and gave a valid explanation of its cause(s). The other 11% in particular those that were old or illiterate did not understand the disease. About 67% and 33% of the THPs reported that diabetes was common among the old people and adults, respectively. Seventy eight (78%) of THPs reported that most of diabetic persons within their locality were men, the other 22% reported a high prevalence in women.

Concerning causes of diabetes in Nyeri County, 89% of THPs related it to diet, obesity, inactivity and stress, only 11% believed that, it was caused by inheritance. In particular, diet was highly cited as a major contributor (95%), due to consumption of refined foods such as; sugar, maize, wheat and fats in addition to meat.

About 89% of the THPs cited personal responsibility and commitment as a prerequisite in the control and prevention of diabetes. They advocated for reduced consumption of meat, refined foods and fats, and supplementation with a diet consisting of traditional foods and vegetables. The THPs emphasized that, local herbs were superior to conventional drugs as they rarely produced side effects. Further, the THPs in the current study recommended assimilation of modern technology in order to enhance correct diagnosis. Before administering any antidiabetic herbs and during subsequent review visits, 88% of the THPs requested the patient to obtain a medical laboratory test report about the level of their blood sugar. Further, the current study revealed challenges faced by the THPS in their practice such as; although

diabetic patients sought conventional medical services from the time of diagnosis, rarely did the medical practitioners refer these cases to THPs. Only one herbalist acknowledged of having treated a case of diabetes referred to him by a medical practitioner. Moreover, unless probed by the TMP, the patients were unwilling to disclose any previous medical treatment. Therefore, to avoid double treatment, the THPs had to inquire from the patients about use of any other form of medication, before they administered any treatment. The major reasons that were given about why patients switched from conventional therapy to herbal medicine included; the patient realizing that their condition had become chronic, onset of side effects from the conventional drugs and therefore lost faith in them and lack of any other treatment option.

The THPs reported that, patients did combine conventional and herbal medicine but they rarely informed the herbalist. Nevertheless, the THPs always advised them to switch from conventional drugs to herbal medicine. Others preferred the patient to take herbal medicine for some period of time, like one week / month, and if there was no noticeable improvement, revert back to conventional medicine.

The present study showed that, 78% of the THPs treated diabetes; and in a year, 67% had treated a diabetic case. However, the numbers of diabetic patients that had sought THPs services was low compared to the high diabetes occurrence in the area. In a month, 11% of the THPs had treated a diabetic patient, the other 89% had not. The average number of diabetic patients both per month and year ranged from 1-5 patients indicating low demand for their services in the treatment and management of diabetes.

The THPs used a variety of treatment practices to improve efficiency of herbal medicine. Ninety percent (90%) administered more than one antidiabetic herb in addition to other forms

of treatment approaches. They included; recommending change of diet to one that included traditional and none fatty foods. They also administered herbs that enhanced digestive and blood circulatory system. One TMP included herbs that rejuvenated the nervous system; he believed that, diabetes was partly caused by nervous communication breakdown. He added that, "*to effectively treat diabetes one should treat stress"* which according to him was *"a major diabetes contributing factor".* The most preferred method of administering herbal medicine as a decoction was the oral route.

The THPs displayed extensive knowledge on antidiabetic herbs; each cited 1-5 herbs and, those that referred to other sources of information named 6-10 plants. However, the main challenge that faced the present study was the THPs unwillingness to disclose the dosage. The THPs acknowledged that, they combined more than one antidiabetic herb in addition to other therapeutic approaches. However, only three were willing to disclose the constituent herbs within the combination (Table 2). Notably, literate THPs regularly referred to other sources of information purposely to understand the most appropriate herb to administer, its efficacy and side effects.

Table 2 : Commonly used Antidiabetic Medicinal Plant Combination used by Traditional Herbal Practitioners in Nyeri County

Combination	Name of the herbs	Part(s) used	Preparation and dosage
1	*Mangifera indica*	Leaves	Decoction
	Persea americana		
	Sonchus luxurians/ Launaea cornuta / Lactuca inermis (Mũthũnga)		
2	*Rotheca myricoides*	Leaves or bark	Decoction. Take one cup three times a day for 2months
	Prunus africana	bark	
3	*Rhamnus prinoides*	Root or bark	Decoction
	Acacia nilotica	Bark or root	
	Myrsine africana	Fruits	
	Dracaena steudneri	Bark, root	

A total of 30 plant species within 23 plant families and 28 genera believed to possess antidiabetic property were documented (Figure 6; Table 3). The plant family with the highest proportion of antidiabetic species was Asteraceae (8); interestingly, from the interviews, an herb locally known as "Mũthũnga" had the highest citation (13.9%), however, during specimen identification in the field with the THPs, the researchers together with the botanist identified it as botanically different herbs which comprised of five species namely; *Launaea cornuta, Lactuca inermis, Sonchus luxurians, Sonchus oleraceus and Sonchus asper*. In practice, it was *Launaea cornuta, Lactuca inermis,* and *Sonchus luxurians* that were prescribed during treatment depending on the availability of the species. *Sonchus oleraceus* and *Sonchus asper* were used as a nutritional supplement in the management of diabetes. Other antidiabetic herbs included; *Mangifera indica* (8.3%), *Galinsonga parviflora* (5.6%), *Rotheca myricoides* (5.6%), *Prunus africana* (5.6%), *Persea americana* (5.6%), *Hydnora abyssinica* (5.6%), *Periploca linearifolia* (5.6%), *Dracaena steudneri* (5.6%), *Rhamnus prinoides* (5.6%) and *Clematis hirsuta* (5.6%). From the foregoing survey report, it was evident that diverse ecological regions provided a unique variety of medicinal plants which met the therapeutic needs of each community in the treatment and management of diabetes. A high prevalence of diabetes in the study area could explain why the present study revealed a large number of medicinal plants used to treat and manage diabetes.

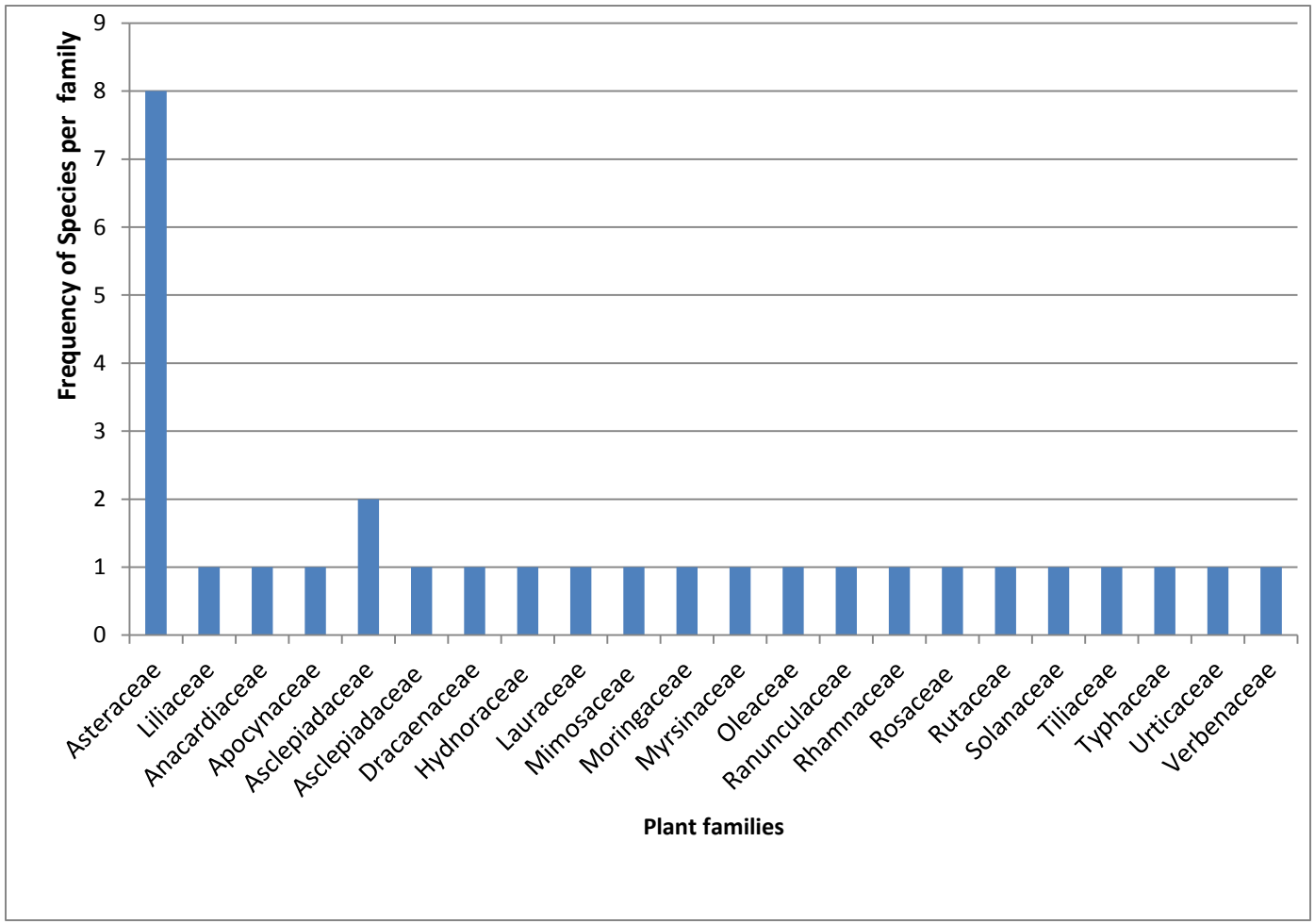

Figure 6: Families of Medicinal Plants Commonly used in the Treatment and Management of Diabetes in Nyeri County

Table 3 : **Medicinal Plants used in the Treatment and Management of Diabetes by Traditional Herbal Practitioners in Nyeri County**

Family	Botanical name and voucher number	Local Name	Growth form	Habitat	Part used	Preparation and Dosage	Citations	Use Value (UVs)
Anacardiaceae	*Mangifera indica* L. LNM14/07	Mũembe	Tree	Cf Cp	Leaves	Slice the leaves and then prepare an infusion for 24 hours (tea color) Take 1 glass per day for 28days	*3*	0.1
Apocynaceae	*Carissa edulis* (Forssk.) Vahl. LNM14/24	Mũkawa	Shrub	Bu	Leaves Bark Root	Decoction	1	0.03
Asclepiadaceae	*Periploca linearifolia* Quart.-Dill. LNM14/06	Mwemba-igũrũ	Liana	Bu	Stem Leaves	Decoction	2	0.07
Asclepiadaceae	*Gomphocarpus fruticosus* (L.) W.T.	Mũkangarithi	Herb	Cf Bu	Seeds Roots	Prepare a decoction, take 250ml twice	1	0.03

Family	Botanical name and voucher number	Local Name	Growth form	Habitat	Part used	Preparation and Dosage	Citations	Use Value (UVs)
	Aiton LNM14/14			Cp		daily for 2 months		
Asteraceae	*Sonchus luxurians* (R. E. Fries)C. Jeffrey LNM14/04	Mũthũnga	Herb	Cf Bu Cp	Leaves	Chew the leaves or boil the whole plant. Take one cup for one month	5	0.17
Asteraceae	*Launaea cornuta* (Hochst. ex Oliv. and Hiern) C. Jeffrey. LNM14/03	Mũthũnga	Herb	Cf Bu Cp	Leaves	Chew the leaves or boil the whole plant. Take a cup for one month	5	0.17
Asteraceae	*Lactuca inermis Forssk* LNM14/01	Mũthũnga	Herb	Cf Bu Cp	Leaves	Chew the leaves or boil the whole plant. Take a cup for one month	5	0.17
Asteraceae	*Sonchus oleraceus* L. LNM14/02	Mũthũnga		Cf Bu Cp	Leaves	Chew the leaves or boil the whole plant. Take a cup for one	5	0.17

Family	Botanical name and voucher number	Local Name	Growth form	Habitat	Part used	Preparation and Dosage	Citations	Use Value (UVs)
						month		
Asteraceae	*Galinsonga parviflora* Cavanilles. LNM14/08	Mũng'ei	Herb	Cf	Leaves Roots	Decoction taken for a month	2	0.07
Asteraceae	*Vernonia lasiopus* O.Hoffm. LNM14/23	Mũchatha	Shrub	Bu	Leaf	Decoction	1	0.03
Asteraceae	*Spilanthes mauritiana* (A.Rich. ex Pers.) DC. LNM14/30	Gatharia ita	Herb	Bu Cf	Whole plant	Decoction	1	0.03
Dracaenaceae	*Dracaena steudneri* Schweinf. Ex. Engl. LNM14/11	Ithare	Tree	Cp	Bark Root	Decoction	2	0.07
Hyacinthaceae	*Ornithogalum tenuifolium* F. Delaroche	Mũgwace	Herb	Sma	Rhizome	Decoction	1	0.03

Family	Botanical name and voucher number	Local Name	Growth form	Habitat	Part used	Preparation and Dosage	Citations	Use Value (UVs)
	LNM14/22							
Hydnoraceae	*Hydnora abyssinica* A. Braun ex Schweinf. LNM14/17	Mũthigira	Herb	Sma	Stem	Decoction	2	0.07
Lauraceae	*Persea americana* Mill. LNM14/19	Mũkũrobia	Tree	Cf Cp	Leaves Bark	Decoction	*2*	0.07
Liliaceae	*Allium sativum* L. LNM14/13	Caumu	Herb	Mkt	cloves	Decoction	1	0.03
Mimosaceae	*Acacia nilotica* (L.) Delile LNM14/16	Ngirũriti	Shrub	Bu	Bark Root	Decoction	1	0.03
Moringaceae	*Moringa oleifera* Lam. LNM 14/28	Moringa	Tree	Cf Cp	Seeds	Chew 2 seeds per day for a month	1	0.03
Myrsinaceae	*Myrsine africana* L. LNM14/26	Mũgaita	Shrub	Bu	Fruits	Decoction	1	0.03
Oleaceae	*Olea africana* Mill.	Mũtero	Tree	Bu	Leaf	Decoction	1	0.03

Family	Botanical name and voucher number	Local Name	Growth form	Habitat	Part used	Preparation and Dosage	Citations	Use Value (UVs)
	LNM14/27			Cp	Root			
Ranunculaceae	*Clematis hirsuta* Guill. and Perr. LNM14/10	Mũgaya ng'ũndũ	Shrub	Bu	Leaves Roots	Decoction	2	0.07
Rhamnaceae	*Rhamnus prinoides* L Hér. LNM14/18	Mũkarakinga	Shrub	Bu	Roots Bark	Decoction	2	0.07
Rosaceae	*Prunus africana* Hook.f.) Kalkman LNM14/20	Mũiri	Tree	Cf Bu Cp	Leaves Bark	Decoction	*2*	0.07
Rutaceae	*Teclea simplicifolia* (Engl.) Verdoorn LNM14/25	Mũnderendu		Bu	Leaves	Decoction	1	0.03
Solanaceae	*Solanum nigrum* L. LNM14/29	Managu	Herb	Cf	Leaves	Infusion	1	0.03
Tiliaceae	*Grewia similis* K.Schum. LNM14/21	Mũtheregendu	Shrub	Bu	Leaves	Decoction	1	0.03

Family	Botanical name and voucher number	Local Name	Growth form	Habitat	Part used	Preparation and Dosage	Citations	Use Value (UVs)
Typhaceae	*Typha domingensis* Pers. LNM14/15	Ndothua	Herb	Wld	Rhizomes	Decoction	1	0.03
Urticaceae	*Urtica massaica* Mildbr. LNM14/12	Thabai /Hatha	Herb	Cf Bu	Leaves	Decoction	1	0.03
Verbenaceae	*Rotheca myricoides* (Hochst.) Steane and Mabb. LNM14/09	Munjuga-iria	Shrub	Bu	Leaves Roots Bark	Decoction taken for a month	2	0.07

Key: Bu-bush, Cf- Crop field, Cp-Compound, Bm-Boundary marker Sma – Semi Arid and Mkt – Bought in the market

Ppu[a]- *Part of plant used, Ncs[b]- Number of citations*

3.3.3 Plants used by Traditional Herbal Practitioners of Narok County in the Management of Human Health

3.3.3.1 Demographic Information of the Respondents

The first objective sought to examine the demographic characteristic of the respondents. The description was important because of the perceived link between demographic characteristics and ethnobotanical knowledge. The characteristics covered in this section included; gender, level of education, major source of income, professional qualification, main source of ethno-medicine knowledge, in-service training and attendance to seminars and workshop. The findings indicate that among the 30 THPS, 94% were males while 6% were females. Majority of respondents (48.1%) were mature adults of over, 57 years old while 25.9% and 18.5% were aged between 48-57 and 37- 48, respectively. Majority (56%) had no formal education while 36% and 8% had primary and secondary education, respectively. Majority (54.5%) did not have professional qualification while 45.5% had. Majority (57.1%) acquired their ethnobotanical knowledge from apprenticeship and (52. %) from elders. Majority (72%) had not attended any form of formal training, while the remaining had attended a World Bank sponsored workshop. Majority of the attendants (80%) agreed that, the training workshops had improved their skills on record keeping, appropriate methods of harvesting, extraction and storage of plant extracts. Majority (86.4%) did not belong to any organized group. However, majority (66.7%) of those belonging to a group were members of National Traditional Health Practitioners of Kenya (NATHEPA) registered under the Ministry of Culture and Sports.

3.3.3.2 Plants used in the Management of Human Diseases

Data on medicinal plants was analyzed based on its therapeutic uses preparation, growth form, habitat and user value, parts of the plant harvested, types of toxic plants, toxic effects of overdosage and plants used to check toxicity of herbal concoctions. Data were also analyzed on diseases and groups of people not treated as well as referral cases.

Data analysis was also carried out on common ailments and conditions treated using therapeatic plants. Frequency of citation was used to present data; the results are presented in Table 4. A total of 27 ailments and conditions were mentioned; most cited communicable diseases included; stomach ache (11.7%), malaria (10%), respiratory diseases (9 %), and syphilis (6.9 %), skin diseases (4.2%), gonorrhea (4.2 %) and diarrhea (3.7 %). Non communicable diseases included, heart burn (5.8%), cancer (4.8%), fibroids (4.2%) and diabetes (3.7%). Ailments were treated using several herbs individually or in combination. For example, malaria, respiratory diseases and joints were treated using a cocktail of herbs. One of the traditional healers elaborated; *our treatment is holistic because besides addressing the specific ailments, it seeks to address other concerns associated with sicknesses such as general body weaknesses and poor appetite, hence the need for multiple therapeutic approaches.*

Medicinal plants used by the Maasai community to manage health included thirty five plants distributed in 26 families and 35 genera (Table 5; Fig 7). Mimosaceae family had the highest representation (3) while Rhamnaceae, Apocynaceae, Solanaceae, Myrsinaceae and Euphorbiaceae had two medicinal plants each as indicated in (Fig. 7). The most important medicinal plants in decreasing order of user value included; *Aloe Secundiflora* (0.1), *Warburgia salutaris* and *Toddalia asiatica* (0.09), *Rhamnus prinoides and Zanthozylum*

usambarense (0.08), *Albizia anthelmintica* and *Rhamnus staddo* (0.07), *Trimeria grandifolia* (0.06), *Carissa edulis* and *Senna didymobotrya* (0.05), *Solanum indicum* and *Myrsine africana (0.04)* as indicated in (Table 5). Moreover, all of them have been cited in one or more other studies for their medicinal uses and chemical constituents.

Table 4: **Ailments Treated using Plants by the Maasai Traditional Herbal Practitioners in Narok County**

Name of disease (English)	**Local name**	**Therapeutic herbs**	Frequency
Stomach ache	Enkoshekea engoshoke/naporsesen	*Acacia nilotica (L.) Olea europaea , Juniperus procera, Periploca linearifolia*	22
Malaria	Enkojongoni/oltikana	*Toddalia asiatica, Rapanea melanophloeos, Ekebergia capensis, Trimeria grandifolia*	19
Respiratory diseases	Orkirobi	*Toddalia asiatica , Rhamnus staddo, Rhamnus prinoides, Zanthozylum usambarense*	17
Syphilis	Orbae	*Rotheca myricoides*	13
Heart burn	Emakit/olodwa	*Olea europaea, Aloe secundiflora,*	11
cancer	oseriki	*Toddalia asiatica, Olea europaea, Sarcostemma stolonifera, Synadenium grantii*	9
Skin disease/rashes	Enkeea ochani	*Toddalia asiatica , Tarchonanthus camphoratus, Warbugia ugadensis*	8
Gonorrhea	Ormakutkut	*Rhamnus staddo, Cucumis* spp.	8
Fibroids	oseriki	*Toddalia asiatica , Olea europaea , Sarcostemma spp, Synadenium* grantii	8
Diarrhea	Nkiriata	*Ekebergia capensis*	7
Diabetes	Emuyian esukari	*Rhamnus staddo*	7

Name of disease (English)	**Local name**	**Therapeutic herbs**	Frequency
Backache	Enkoriong	*Rhamnus staddo , Carissa edulis*	6
Headache	Endukuya/enkea ekwe	*Rhamnus prinoides, Rhamnus staddo*	6
Wounds	Orbae	*Maytenus heterophylla, Croton megalocarpus*	6
Typhoid	Maleria engare/ elototo engoshoke	*Rhamnus prinoides, Myrsine 98africana*	6
Arthritis	Nangida	*Barleria spp , Periploca linearifolia, Carissa edulis*	6
Respiratory/ Chest	orgoo	*Ekebergia capensis , Acokanthera schimperi*	6
Amoeba	Olong'o ng'wen,ng'wensho	*Albizia anthelmintica*	6
Joints pain	Eno orbat	*Vernonia brachycarlyx, Barleria spp , Combretum molle, Rhamnus prinoides, Rhamnus staddo*	5
Eye problem	Emwoyian o nkanyeki	*Acacia kirkii*	4
Madness	ormilo	*Trimeria grandifolia*	4
Asthma	Asma / Engea orgoo	*Zanthozylum usambarense*	3
Energizer	elopa	*Trimeria grandifolia*	2
Boils	Emorloo/Oldututai	*Chenopodium opulifolium, Rapanea melanophloeos*	2
Breast cancer	Enaoyinyie	*Solanum nigrum*	1
Detoxification		*Rhamnus prinoides, Rapanea melanophloeos,Prunus africana*	1
Dizziness		*Trimeria grandifolia*	1

Table 5 : Therapeutic Plants used in Treatment and Management of Diseases by Traditional Herbal Practitioners in Narok County

Plant Family	Botanical name/ voucher specimen	Local name	Therapeutic use	Preparation	Plant Part used	Growth form	Habitat	NCs	Use Value Index
Liliaceae	*Aloe secundiflora* Engl. LNM15/15	Osuguroi	Malaria, stomach ache, ulcers, gonorrhea, headache, wound, skin diseases, diabetes, cold fever	Decoction	leaves	Shrub	Wild	15	0.1
Canellaceae	*Warburgia salutaris* Sprague LNM15/16	Osokonoi	Headache, stomach ache, eye problem, constipation, gouts, gingivitis, tooth ache	Decoction	Bark	Tree	Wild	13	0.09
Rutaceae	*Toddalia asiatica* (L.) Lam. LNM15/17	Oleparmuny o	Chest, cold, cough, malaria, whooping cough,	Decoction	Roots/ bark	Shrub	Wild	13	0.09

Plant Family	Botanical name/ voucher specimen	Local name	Therapeutic use	Preparation	Plant Part used	Growth form	Habitat	NCs	Use Value Index
			cancer						
Rhamnaceae	*Rhamnus prinoides* L'Hérit. LNM15/18	Orkonyiel	Sore throat, weight loss, fatigue, backache, stomach ache, digestion, malaria, colds, headache, typhoid, joint pain, detoxification	Decoction	roots	Shrub	Wild	12	0.08
Rutaceae	*Zanthozylum usambarense* (Engl.) Kokwaro LNM15/19	Oloisiki	Cold, nourish the children, sore throat	Decoction	Fruits, Roots/ bark	Shrub	Wild	11	0.08
Mimosaceae	*Albizia anthelmintica*	Ormukutan	Malaria, ulcers, Amoeba	Decoction	roots bark	Shrub	Wild	9	0.07

Plant Family	Botanical name/ voucher specimen	Local name	Therapeutic use	Preparation	Plant Part used	Growth form	Habitat	NCs	Use Value Index
	A.Rich. LNM15/20								
Rhamnaceae	*Rhamnus staddo* A. Rich LNM15/22	Orkokola	Cold, pneumonia, backache, diabetes, malaria, joint pain	Decoction	roots	Shrub	Wild	9	0.07
Flacourtiaceae	*Trimeria grandifolia* (Hochst.) Warb. LNM15/21	Oledat	Malaria, cold, typhoid	Decoction	Roots/ bark	Shrub	Wild	8	0.06
Apocynaceae	*Carissa edulis* (Forssk.) Vahl. LNM15/25	Olamuriaki	Malaria, common cold, cough rickets, blood diseases	Decoction	roots	Shrub	Wild	7	0.05
Myrsinaceae	*Myrsine africana*	Iseketet	Worms, stomach	Decoction	Fruits	Shrub	Wild	*7*	0.05

Plant Family	Botanical name/ voucher specimen	Local name	Therapeutic use	Preparation	Plant Part used	Growth form	Habitat	NCs	Use Value Index
	L. LNM15/20		ache, heart burn		seeds				
Caesalpinaceae	*Senna didymobotrya* (Fresen.) Irwin and Barneby LNM15/23	Osenetoi	Malaria, deworming, diarrhea, stomach ache	Decoction	leaves	Shrub	Wild	6	0.04
Solanaceae	*Solanum indicum* L. LNM15/29	Entemelua	Cough, allergy, chicken pox	Decoction	roots	Shrub	Wild	6	0.04
Mimosaceae	*Acacia nilotica* (L.) Willd. ex Delile LNM15/27	Orkiloriti	Constipation, stomach ache, cleaning wounds	Decoction	Bark	Tree	Wild	5	0.03
Meliaceae	*Azadirachta indica* A. Juss. LNM15/25	Omwaarobaini	Bloating, malaria, cough, malaria	Decoction	leaves	Tree	Wild	5	0.03
Rosaceae	*Rubus steudneri* Schweinf. LNM15/24	Oremit	Cold, fever	Decoction	Roots/ bark	Scrambler	Wild	4	0.03

Plant Family	Botanical name/ voucher specimen	Local name	Therapeutic use	Preparation	Plant Part used	Growth form	Habitat	NCs	Use Value Index
Fabaceae	*Acacia robusta* Burch. LNM15/26	Ormumunyi	Remove placenta, ease delivery	Decotion	roots	Shrub	Wild	4	0.03
Urticaceae	*Urtica massaica* Mildbr. LNM15/28	Entamenjoi	Blood pressure, injury, typhoid, gouts	Decoction	Roots/ leaves	Herb	Wild/ Farms/R iverine	4	0.03
Anacardiaceae	*Rhus natalensis* Bernh. ex Kraus LNM15/ LNM15/40	Ormisigioi	Cold, fatigue, stomach ache	Decoction	Bark/s tem	Shrub	Wild	3	0.02
Asphodelaceae	*Bulbine abyssinica* A.Rich. LNM15/38	Oloikine	Malaria	Decoction	bark	Herb	Wild	3	0.02
Portulacaceae	*Talinum portulacifolium* (Forssk.) Asch. Ex Schweinf. LNM15/36	Ormame	Injury, diuretic, STD	Decoction	roots	Shrub	Wild	3	0.02

Plant Family	Botanical name/ voucher specimen	Local name	Therapeutic use	Preparation	Plant Part used	Growth form	Habitat	NCs	Use Value Index
Myrsinaceae	*Rapanea melanophloeos* LNM15/34		Malaria, boils, detoxification	Decoction	Root/ bark	Shrub	Wild	3	
Oleaceae	*Olea europaea* LNM15/32	Oloirien	Cancer, stomach problems, heart burn, fibroids	Decoction	Root/ Bark	Tree	Wild	3	
Euphorbiaceae	*Synadenium grantii* Hook f. LNM15/30	Olkorbobit	Laxative, cancer	Decoction	roots	Shrub	Wild	2	0.01
Lamiaceae	*Rotheca myricoides* (Hochst.) Steane and Mabb. LNM15/31	ormakutkut	Gonorrhea, Syphilis, libido	Decoction	roots	Shrub	Wild	2	0.01
Acanthaceae	Barleria spp LNM15/33	Olerubat	Joint pain, arthritis	Decoction	Bark/ leaves	Shrub	Wild	2	
Asclepiadaceae	*Sarcostemma*		Cancer	Decoction	Root	Shrub	Wild	1	

Plant Family	Botanical name/ voucher specimen	Local name	Therapeutic use	Preparation	Plant Part used	Growth form	Habitat	NCs	Use Value Index
	stolonifera LNM15/35								
Mimosoideae	Acacia kirkii LNM15/37	Olerai	Eye problem	Decoction	Roots	Shrub	Wild	1	
Apocynaceae	Acokanthera schimperi LNM15/39	ormorijoi	Respiratory diseases	Decoction	Leaves	Shrub	Wild	1	
Asteraceae	*Vernonia brachycarlyx* LNM15/41	Ologumati	Joint pain	Decoction	Leaves	Shrub	Wild	1	
Chenopodiaceae	Chenopodium opulifolium LNM15/43	Enaboi	Boils	Sap	Stem	Shrub	Wild	1	
Solanaceae	*Solanum nigrum* LNM15/45	Ormomoi	Breast cancer	Decoction	Root	Herb	Farms	1	
Celastraceae	*Maytenus*		Wounds	sap	Leaves	Shrub	Wild	1	

Plant Family	Botanical name/ voucher specimen	Local name	Therapeutic use	Preparation	Plant Part used	Growth form	Habitat	NCs	Use Value Index
	heterophylla LNM15/47								
Euphorbiaceae	*Croton megalocarpus* LNM15/49		Wounds	Sap	Stem	Shrub	Wild	1	
Combretaceae	*Combretum molle* LNM15/48		Joint pain	Decoction	Roots	Shrub	Wild	1	

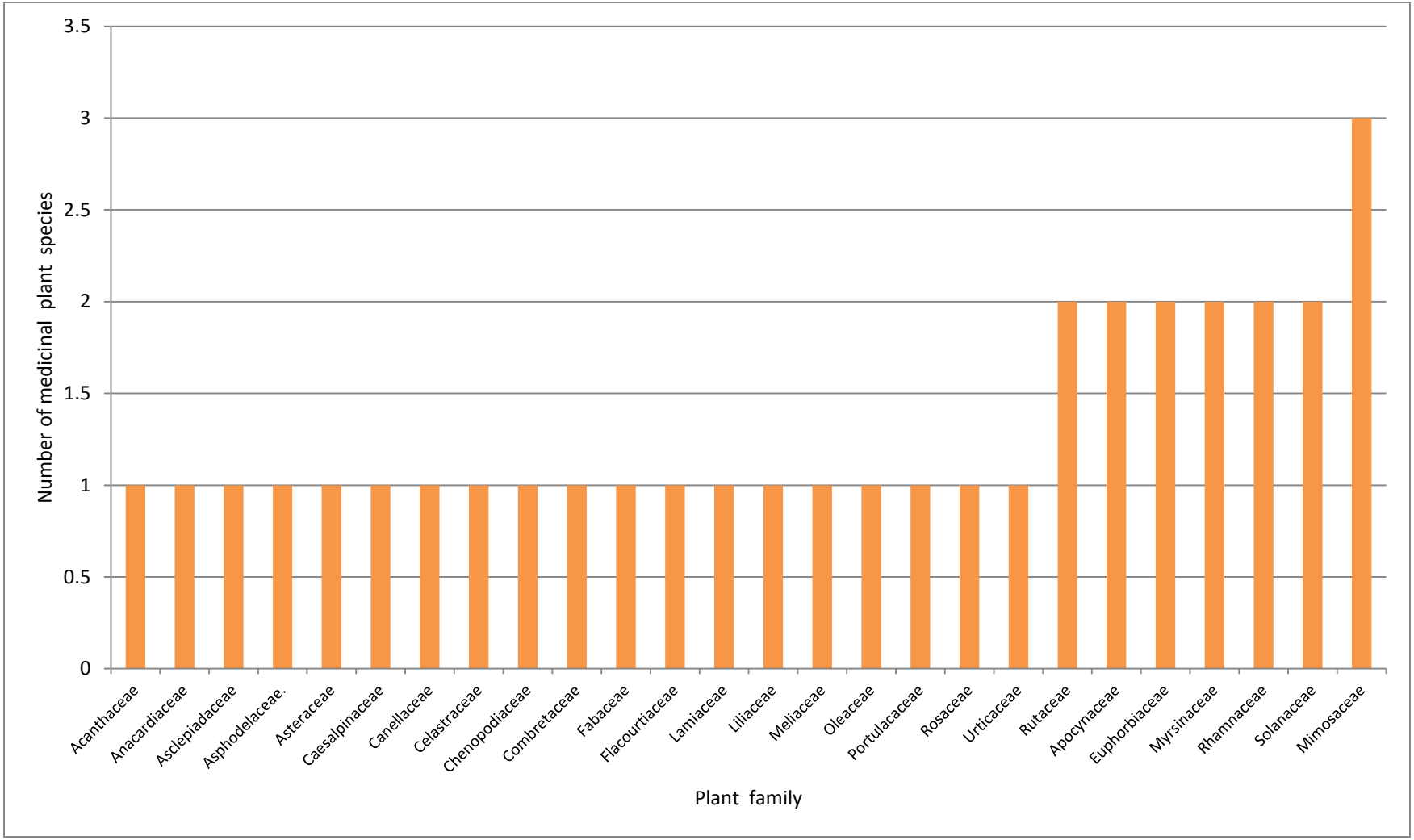

Figure 7: Families of Therapeutic Plants used to Treat General Ailments by Traditional Herbal Practitioners in Narok County

The commonly used types of medicinal plants were shrubs (76%) and trees (12%) as indicated in (Figure 8). The most common parts harvested for medicine were roots (44%) and barks (24%) as outlined in (Figure 9). One of the THPs expounded that roots are believed to have higher concentrations of medicinal substances. The traditional healers also reported conservation measures of the medicinal plants. Due to the sensitivity of the removal of roots and barks to the survival of the medicinal plants, two roots are picked if they are five while one is picked out of two or three. For the bark, a section is cut without ringing. Harvested plant parts were dried, boiled or soaked to make decoctions which were taken orally per cup periodically in a day. Analyses on habitat from which medicinal plants were sourced indicated that, majority were from the wild (92%) as indicated in (Figure 10). One of the THPs explained that the traditional pastoral life of the Maasai community exposed them to wild ecosystems which provided a rich source of medicinal herbs.

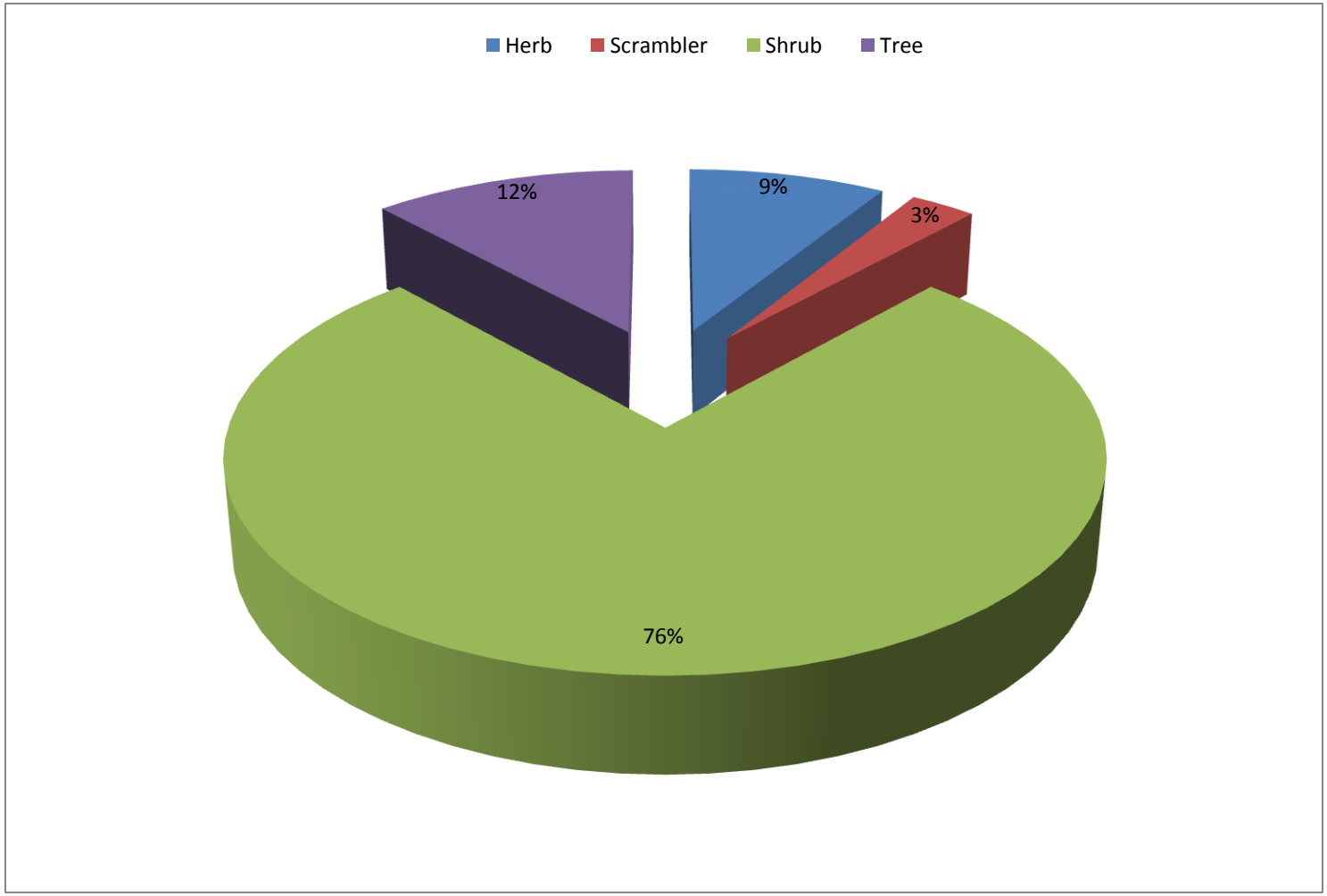

Figure 8 : **Growth Form of Plants used to Treat and Manage Diseases by Traditional Herbal Practitioners in Narok County**

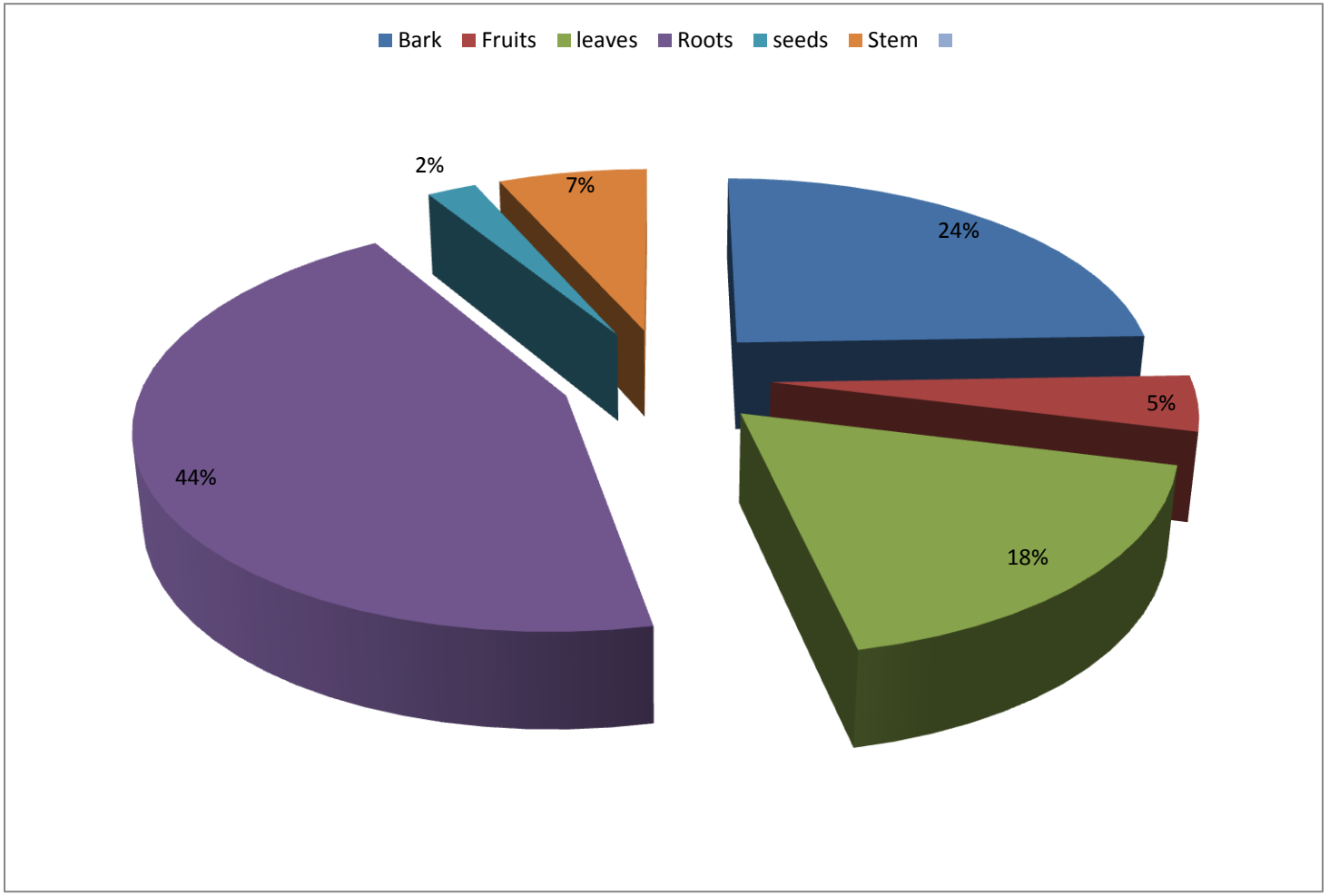

Figure 9: Commonly Harvested Plant Parts used to Treat and Manage Diseases by the Traditional Herbal Practitioners in Narok County

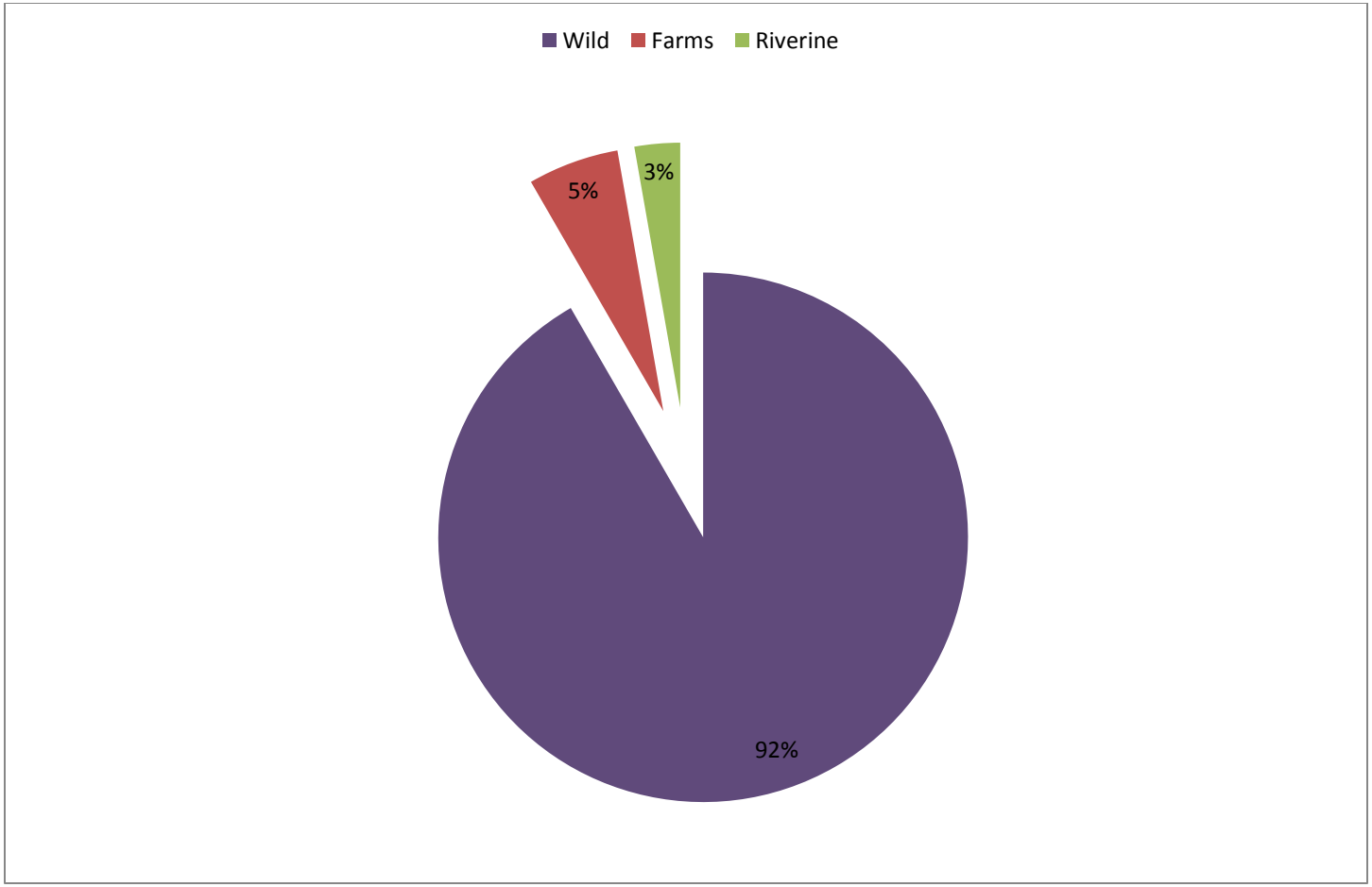

Figure 10: Habitats where Plants were Harvested for use in the Treatment and Management of Diseases by Traditional Herbal Practitioners in Narok County

Analysis on toxic plants indicates that herbalists are aware of toxic plants. One of the traditional healers explained; *Among the Maasai, both at community and family level as well as markedly in the herbalist apprenticeship the issue of toxic plants is taken very seriously due to safety of both the people and livestock.* A total of six plants distributed in three families; Euphorbiaceae, Apocynaceae, Flacourtiaceae and Asteraceae; and six genera were named. Majority of toxic plants commonly cited were from Euphorbiacee family. The most common toxic plants are Ricinus *communis, Acokanthera schimperi,* and *Dovyalis abyssinica* as they can cause death among other effects. The most cited toxic plants include Ricinus *communis* (8) *Acokanthera schimperi* (7), *Euphorbia candelabrum* (8) as indicated in Table 6. Respondents further explained that *Ricinus communis* is particularly associated with animal deaths.

Table 6: Plants that are Toxic to both Man and Livestock as Reported by the Traditional Herbal Practitioners in Narok County

local name	Scientific name	Effect	Frequency
Orpaleki	*Ricinus communis* *Family:* Euphorbiaceae	Death	8
Olmorijoi	*Acokanthera schimperi* *Family: A*pocynaceae	Blood circulatory system, digestive system, death	7
Orpopong'i	*Euphorbia candelabrum* *Family* Euphorbiaceae	Blisters on the skin, digestive and blood circulatory system	7
Olkorbobit	*Synadenium sp.* *F*amily Euphorbiacee	Stomach problem	*4*
Orbang'i	*Tagetes minuta* Family: Asteraceae	Breathing system, Digestive system	4
Olmorogi	*Dovyalis abyssinica* *Family* Flacourtiaceae	Stomach problem	3

Further analysis was done to examine the knowledge of THPs about medicinal plants that could cause undesired effects when excess dosage was used. The most common cited included *Senna didymobotrya* (5), *Warbugia ugadensis* (4) and *Zanthozylum usambarense* (4). The most common effects included; diarrhea, vomiting and stomach ache as a result of taking excess dosage of *Senna didymobotrya, Aloe secundiflora, Clutia abyssinica, Senna didymobotrya* and *Zanthozylum usambarense.* Notably, *Acokanthera schimperi* was potentially is known to cause death. To counteract toxicity and mask the bitter taste, the concoctions and decoctions were mixed with excipients like soup, milk, fat, egg yolk, oil, soup or blood. The same were used to reverse toxicity in case of over dosage (Table 7). However, according to the respondents, poisoning due to over dosage was rare; one respondent elaborated; *we take serious precautionary measures because we know these medicinal plants can be toxic*.

Further, knowledge of medicinal plants used to reduce or neutralize toxicity of medicinal plants was also sought. The results are presented in (Table 8). *Carissa edulis* (3) was the most commonly used plant to manage toxicity having been mentioned three times followed by plants; *Prunus africana, Toddalia asiatica, Rhus natalensis* and *Rhamnus staddo* which were mentioned two times each. Roots were the plants parts used to neutralize toxicity. One of the traditional healers elaborated; the traditional herbs are hardly taken singly; herbs, notably *Carissa edulis and Prunus africana* formed a critical component of medicinal concoctions to alleviate toxic effects. Moreover, it was reported that some medicinal plants were brewed with honey, boiled in bone soup or mixed with milk so as to manage toxicity.

Table 7 : **Medicinal Plants that were Known Cause Side Effects when Dosage is exceeded as Reported by the Traditional Herbal Practitioners in Narok County**

Plants	**Toxic effect**	**Frequency**	**antidote**
Senna didymobotrya	Diarrhea	5	milk
Zanthozylum usambarense	Diarrhea and vomiting	4	1 glass of milk
Warbugia ugadensis	Fainting, severe headache, excessive sweating, drowsiness	*4*	milk
Aloe secundiflora	Diarrhea/fever	3	milk
Rhamnus prinoides	dehydration	2	milk
Acokanthera schimperi	death	2	Milk, egg yolk
Clutia abyssinica	Vomiting, stomach ache	1	milk

Table 8: Medicinal Plants used by the Traditional Herbal Practitioners to Neutralize Plant Toxicity and Prevent Side Effects in Narok County

Plant Family	Scientific name	Local name	Plant part	Preparation	Frequency
Apocynaceae	*Carissa edulis*	Olamuriaki	Roots	Boil	3
Rosaceae	*Prunus africana*	Olkujuk	bark	Soak in water	2
Rutaceae	*Toddalia asiatica*	Oleparmunyu	bark	Boil	2
Anacardiaceae	*Rhus natalensis*	Olmisigiyoi	Roots	Boil	2
Rhamnaceae	*Rhamnus staddo*	Orkokola	roots	Boil	2
Leguminosae	*Acacia kirkii*	Olngwenyingwenyi	roots	Boil	1
Flacourtiaceae	*Trimeria grandifolia*	Oledat	roots	Boil	1
Combretaceae	*Combretum molle*	Ormororoi	*Roots*	Boil	1
Acanthaceae	*Barleria spp*	Olerubat	roots	Boil	1
Solanaceae	*Solanum incanum*	Ontulelei	roots	Boil	1
Flacourtiaceae	*Dovyalis abyssinica*	Olmorogi	roots	Boil	1

Results showed that there were diseases and groups of patients that were neither treated nor handled by the THPs; there was also referral cases as presented in Table 9, 10 and 11. Diseases that were not treated included; HIV/AIDS (22), Diabetes (10), tuberculosis (TB) (7) and cancer (3). Groups of patients that were not treated included the elderly (4) and young children (3). Reasons given by THPs about referral were such as; lack of improvement after along period of treatment (12), diseases that were difficult to test or diagnose (7) and emergency cases (4). Similarly, diseases most cited for referral included HIV/AIDs and diabetes. Notable comment from one of THPs was that patients sought conventional treatment only when traditional medicine failed. Moreover, emergence of diseases such as HIV/ AIDS and diabetes was reported to have challenged traditional medicine leading to referrals to THPs believed to be more specialized in handling such diseases. Lack of adequate diagnostic methods was reported as one of the major cause of referrals. In particular, young children and old people were not in a position to explain the nature of the sickness.

Table 9: Types of Diseases that were not Treated by the Traditional Herbal Practitioners in Narok County

Disease	Frequency
HIV/AIDS	22
Diabetes	10
TB	7
Cancer	3
Abortion	2
Sexually transmitted diseases	2
Curses	1
Syphilis	1
Gonorrhea	1
Asthma	1
Typhoid	1
Eye problems	1
polio	1
Goiter	1
Abortion	1
Deep cuts	1

Table 10: Cases of Illnesses that were referred by the Traditional Herbal Practitioners for Further Treatment in Hospital, in Narok County

Cause of referral	Frequency
Did not show signs of improvement	12
Testing and diagnosis difficult	7
Emergencies	4
HIV	4
Diabetes	4
Serious injuries	2
Chronic diseases	2
Cancer	1
Brain damage	1
When directed by the oloiboni	1

Table 11: **Groups of Patients that were not Treated by the Traditional Herbal Practitioners, in Narok County**

Group of patients not treated	Frequency
Elderly	4
Young children	3
Pregnant women	2

3.3.3.3 Challenges in Conservation of Medicinal Plants

The respondents pointed out that despite their traditional way of conserving medicinal plants; limited removal of roots and barks, traditional therapy was facing a serious challenge due to deforestation. It was reported that, massive clearing of bushes for large scale farming, charcoal burning, human encroachment of forest such as Mau forest, had endangered medicinal plants. The situation had been exaggerated by the gradual shift from pastoral to sedentary life of the Maasai community. Moreover, the effect of this clearing of bushes was reported to render soils prone to flashfloods, which further devastated vegetative establishment. As a result, the THPs had to travel to distant forests in search of medicinal plants. In other cases, they had to pay a small fee to private land owners to access medicinal plants. Reportedly, this denied their clients real-time therapeutic attention.

3.3.4 Medicinal Plants used in the Management of Diabetes by Traditional Herbal Practitioners of Narok County, Kenya

It was revealed that, diabetes was locally known as *engea e sukari* (42%) or *Emuyian esukari* (58%). Eighty two percent (82%) of the THPs reported its occurrence, but they (73%) added that its prevalence was low. Additionally, 50 % of the THPs reported that there were cases of diabetes - related deaths in the area. However, morbidity was low, 67% of the THPs had witnessed only 1-5 deaths and 33% 6-10 deaths. Results of the study showed that, the THPs (33%) demonstrated possession of knowledge on medicinal plants traditionally used to manage and treat diabetes. Demand for traditional antidiabetic plants was high. Reportedly, 27% of the THPs had treated at least one diabetic patient in the past week, 9% in the past month while 36%

in the past year. Forty one percent (41%) of the THPs reported that, on average, they treated 1-5 patients while 6% had treated 6-10 patients within the past year.

Majority of the THPs understood the causes of diabetes (81%) and its symptoms (85%). Major causes included; refined foods (95%) and stress (5%). According to 50% of the THPs, diabetes was common among old people while 29% and 8% said middle aged and youths, respectively. Additionally, it was more prevalent among men (46%) than women (37%) while 17% said both gender. According to the THPs, the main predisposing factors in the area were; inheritance (18 %), stress in women (12%), inactivity among men (53%), or a combination of various factors (18 %). Modifiable factors included; in-activity (5%), diet (11%), obesity (5%), refined foods (5%), or a combination of factors (74%).

The results showed that, the THPs well understood how to control and treat diabetes. Forty two percent (42%) believed that diabetes could be controlled by avoiding meat, sugary and refined foods, and eating traditional foods and vegetables (13%). Ninety one percent (91%) believed in the use of herbs to treat diabetes. Nine percent 9% said conventional drugs could also be used. Forty two percent (42 %) incorporated modern methods of laboratory testing of blood sugar level to confirm diagnosis. Twenty five percent (25%) had treated a diabetic case referred to them by a medical practitioner while some of the clients (46%) had had previous contact with a medical practitioner. They all (100%) reported that, major reasons why patients sought for traditional medicine instead of conventional treatment was because the former was believed to be more effective than the latter.

About 14 antidiabetic medicinal plants occurring in 13 genera and 12 families (Figure 11) were documented and identified as herbal medicine traditionally used in Narok County to treat and

manage diabetes. The most frequently used plant species was *Dovyalis abyssinica* (20%), locally known as Olmorogi, followed by *Carissa edulis* (Olamuriaki), *Acacia nilotica* (Olkirorit), *Faurea saligna* (Olorte), *Rhamnus prinoides* (Orkonyiel) and *Urtica massaica* (Entamenjoi), 16.7% each (Table 12). Plant families with a higher proportion of antidiabetic plant species were Flacourtiaceae and Rhamnaceae (2 plant species each); other families were represented by one plant species (Figure 11). The most preferred plant parts were roots (46%) and leaves (27%) (Figure 12).

Table 12 : Plant Species used by Traditional Herbal Practitioners to Manage Diabetes in Narok County, Kenya

Family	Scientific name Voucher number	Maasai name	Life form	Habitat	Parts used	Preparation	Frequency	Use value
Aloaceae	*Aloe secundiflora* Engl. LNM15/12	Osukuroi	Herb	Wild	Leaves	Decoction	2	0.7
Amaryllidaceae	*Allium cepa* L. LNM15/10	Kitunguu	Herb	Cultivated	Leaves	Crushed	3	0.1
Apocynaceae	*Carissa edulis* (Forssk.) Vahl LNM15/05	Olamuriaki	Tree	Wild	Roots	Decoction	5	0.17
Canellaceae	*Warbugia ugandensis* Sprague LNM15/14	Osokonoi	Tree	Wild	Bark	Decoction	1	0.03
Mimosoideae	*Acacia nilotica* (L.) Delile LNM15/06	Olkirorit	Shrub	Wild	Roots	Decoction	5	0.17
Flacourtiaceae	*Dovyalis abyssinica* A. Rich. LNM15/01	Olmorogi	Tree	Wild	Roots	Decoction	6	0.2
Flacourtiaceae	*Trimeria grandifolia* (Hochst.) Warb. LNM15/08	Oledat	Tree	Wild	Roots	Decoction	4	0.13

Family	Scientific name Voucher number	Maasai name	Life form	Habitat	Parts used	Preparation	Frequency	Use value
Proteaceae	*Faurea saligna* Harv. LNM15/03	Olorte	Tree	Wild	Leaves	Decoction	5	0.17
Rhamnaceae	*Rhamnus prinoides* L. He'rit LNM15/02	Orkonyiel	Shrub	Wild	Bark	Decoction	5	0.17
Rhamnaceae	*Rhamnus staddo* A. Rich LNM15/07	Orkokola	Shrub	Wild	Roots	Decoction	4	0.13
Rosaceae	*Prunus africana* (Hook .F.) Kalkm. LNM15/11	Olkujuk	Tree	Wild	Bark	Decoction	3	0.1
Rutaceae	*Zanthozylum usambarense* Engl. LNM15/13	Oloisiki	Tree	Wild	Fruits	Chewing	2	0.7
Urticaceae	*Urtica massaica* Mildbr. LNM1 5/04	Entamenjoi	Herb	Wild	Roots and Leaves	Decoction	5	0.17
Lamiaceae	*Rotheca myricoides* Hochst. LNM15/09	Ormakutkut	Shrub	Wild	Roots	Decoction	3	0.1

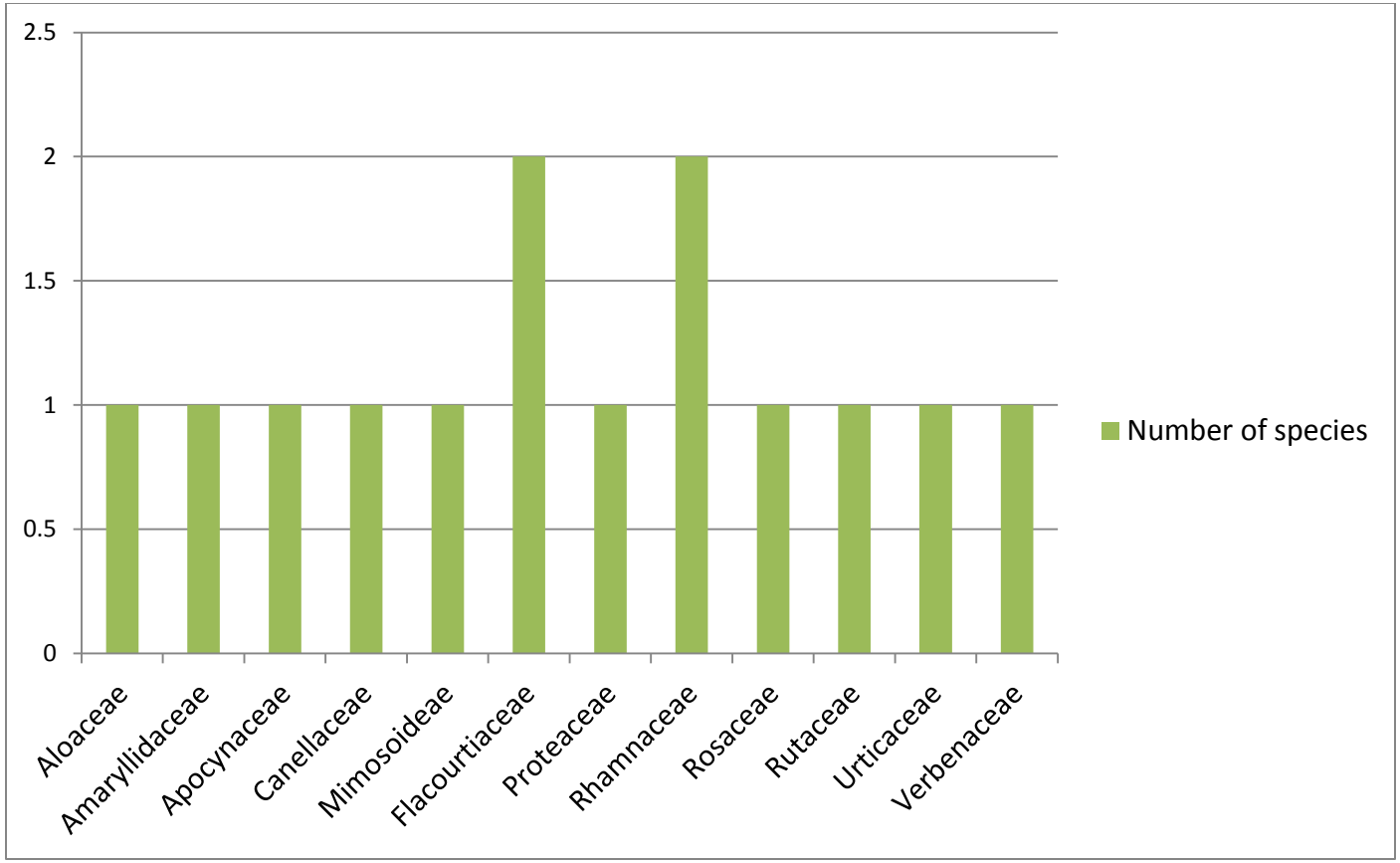

Figure 11 : Families of Antidiabetic Plant Species used by Traditional Herbal Practitioners in Narok County

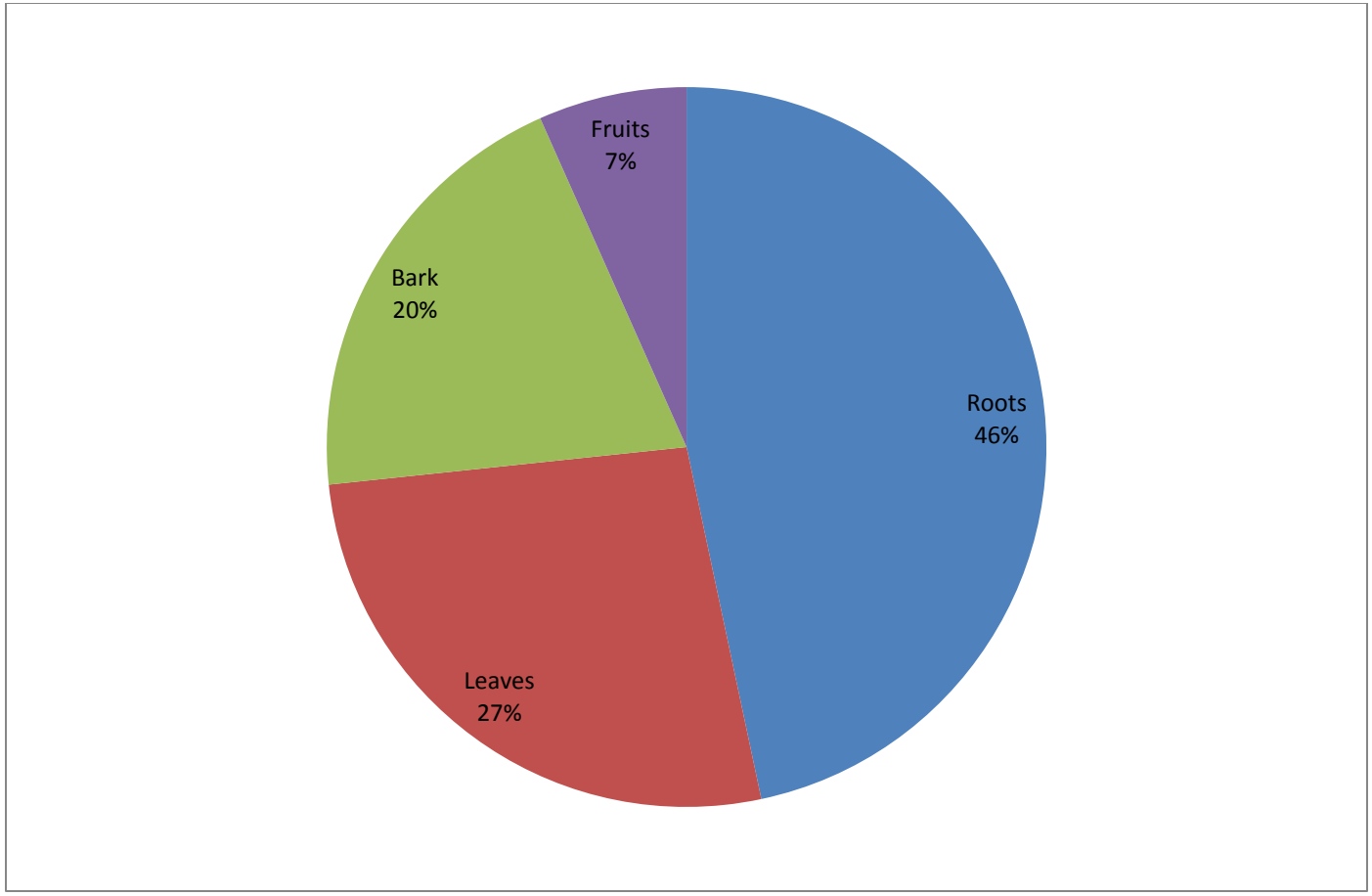

Figure 12: Commonly Harvested Parts of Plants used by Traditional Herbal Practitioners in Narok County to Treat and Manage Diabetes

Medicinal plants species were mainly trees (50%), shrubs (29%) and herbs (21%). The plants largely occurred in the wild/bush (93%) but a few in crop farms (7%). Eighty six percent (86%) of the plants were prepared as decoction, the remaining were by either chewing or crushing. Oral route was the preferred route of administration, dosage was rarely disclosed.

3.4 DISCUSSION

3.4.1 Ethnobotanical Survey and Threats to Medicinal Plants Traditionally used for the Management of Human Diseases in Nyeri County, Kenya

Majority of the herbalist were old, an indication that the practice was not being passed on to the young generation. This is similar to what was reported in other studies in Kenya (Muthee *et al.*, 2011; Wambugu *et al.*, 2011). Most herbalists were of Christian faith; similar observation was made by Muthee *et al.*, (2011) in Loitoktok. High level of education among the THPs was attributed to early introduction of education and Christianity by the missionaries (Sindiga *et al.*, 1995). Lack of laid down structures to pass down knowledge contradicted Kamenju (2013) report which showed that, during the precolonial period, Kikuyu traditional herbalists undertook the practice as a profession and a means of livelihood and, they routinely passed the knowledge to the young generation. Besides uplifting their confidence and self-esteem in the profession, information acquired from organized seminar had driven out fear among those that had it instilled in them during the colonial period (Sindiga *et al.*, 1995). Additionally, high rate of registration with herbalists' association was observed in other parts of Kenya, as reported by Muthee *et al.*, (2011) among the Maasai THPs who were practicing in Loitoktok, Kajiado County.

The current study documented treatment of respiratory infections and arthritis by the THPs, which was also cited in Tana River County (Kaluwa *et al.*, 2014). Similarly, a study carried out by Bussman *et al.*, (2006) mentioned a high prevalence of sexually transmitted diseases, malaria, gastro-intestinal disorders, parasitic ailments and wounds among the Maasai of Sekenani, which confirmed their documentation in the current study. Use of polyherbals in the treatment of

diseases was in agreement with Kamenju (2013) view that, Kikuyu THPS treatment approach aimed at addressing the root cause of the disease.

Njoroge and Bussmann (2006) reported high usage of herbs and shrubs in the management of ear, nose and throat conditions in Central Kenya; these concurred with findings from the current study. Further, the present study revealed increased use of roots, similarly, a high prevalence in harvesting of roots and bark was reported among the Ilkisonko Maasai community (Kimondo *et al.,* 2015). However, in a study carried out in India by Kumar and Bharati (2014), it was observed that, leaves (33 instances) were the most frequently used plant part. Although root harvesting threatens plants species, conservation measures undertaken by the herbalists in the present study area were significant towards protection of the ecosystem.

Measurement of the plant medicine using a glass/cup was also observed by Muthee *et al.,* (2011). THPs in the present study did not treat some groups of patients, these finding contradicted perception and attitude by pregnant women in Nigeria who believes that, herbal medicine is safe (Fakeye *et al.,* 2009) however, it was in agreement with report by Muthee *et al.,* (2011).

The present study revealed that the THPs possessed in-depth knowledge on herbal medicine; similar findings were reported from Samburu County and Sekenani valley in Maasai Mara (Bussman, *et al.,* 2006; Nanyingi *et al.,* 2008). In the present study, family Asteraceae had the highest citations of medicinal plants. These findings concurred with that of Malik *et al.,* (2015) in a study carried out in Northern Punjab. As indicated in the present study, Njoroge (2012) had reported *Prunus africana* and *Strychnos henningsii* as frequently used herbs in Central Kenya. THPs from drier parts of Nyeri County demonstrated deeper knowledge in medicinal plants. They also reported increased use of herbal medicine by the community. Over reliance on

medicinal plants was reported in other drier regions like Samburu and Tana River counties which have fewer medical facilities (Nanyingi *et al.,* 2008, Kaluwa *et al.,* 2014).

Major challenges facing demand for the services from THPs in Nyeri County was attributed to poor perception towards herbal medicine. A study carried out in Thika and Nairobi by Njoroge (2012), showed that, "*part of the local populations still holds herbalists with suspicion, erroneously perceiving them as "witchdoctors".* In a study carried out in Murang'a, 20% of patients didn't believe that herbal medicine work. Another 16% said that they didn't like it (Mwangi and Gitonga, 2014). This was in contradiction with the upward trend in the use of traditional herbal medicines observed in other parts of Kenya (Kigen *et al.,* 2013).

3.4.2 Knowledge and Demand for Medicinal Plants used in The Treatment and Management of Diabetes in Nyeri County, Kenya

High diabetes prevalence cited in Nyeri County corroborates previous studies which classified Central Kenya as one of the regions with the highest record of diabetes (31%) (Maina *et al.,* 2011). High diabetes level reported by the THPs among the old, was in agreement with Kibachio *et al.,* (2013) that documented a mean age of 57 ± 12 years among diabetic patients from Nyeri County, with some being as old as 93 years of age. Other studies have shown high diabetes prevalence in men (9.8%) compared to 9.2% in women (Danaei *et al.,* 2011).

Findings in Nyeri revealed that diabetes was closely associated with diet particularly refined food and lifestyle; these observations concurred with other findings (Mehta *et al.,* 2006; WHO, 2007a; Ziraba *et al.,* 2009). Moreover, related findings established that, poor dietary habits were major predisposing factors in diabetes (WHO, 2007a; Mehta *et al.,* 2006). Similarly, high fat diet (59.4%), abdominal obesity 43.7% and sedentary lifestyle (46.8%) were linked to predisposing

factors for diabetes (Chege, 2010; El-busaidy *et al.*, 2014). Conversely, in Murang'a County, inheritance was cited by 50.4% of diabetic patients as a major predisposing factor. Notably, the County has lower diabetes prevalence than Nyeri (Mwangi and Gitonga, 2014). Considering that only a small percentage of diabetes in Nyeri County was caused by inheritance as reported by the THPs, it was evident that, inheritance was not a major predisposing factor among Nyeri community. Doubtlessly, diabetes prevalence in Nyeri County could be significantly lowered by managing diet and body weight through proper lifestyle practices. Indeed, WHO, emphasizes that although overweight and obesity are common factors underlying NCDs, they can be preventable through dietary lifestyles (WHO, 2009).

In the current study, consumption of traditional foods and vegetables was mentioned as one method of preventing occurrence of diabetes. This was in agreement with other reports; which underscored the centrality of traditional lifestyle which consisted of whole grain, vegetables and fruits, because they contained high fiber content (Christensen *et al.*, 2009; IDF, 2009). Further, the THPs emphasized on the superiority of herbs over conventional drugs, similarly, a cross-sectional survey among some Palestinian diabetic patients showed that, 70% confessed that use of Complementary and Alternative Medicine - CAM therapy - had demonstrated greater efficacy than the allopathic remedies. Additionally, CAM had slowed down the disease progression, reduced both the disease symptoms as well as pathological effects caused by the allopathic therapies (Ali-Shtayeh *et al.*, 2012). Inclusion of modern technology in diagnosis and review of diabetes by the THPs in the current study contradicted IDF (2006) which reported that, THPs rarely refers their patients to public health facilities due to ignorance.

Moreover, the THPs reported that patients combine traditional and conventional medicine; similar findings from Murang'a showed that, 7% of diabetic patients combined both herbal and conventional medicine as their diabetes management regime (Mwangi and Gitonga, 2014). According to the THPs, patients shy off from disclosing use of herbs and drugs; on similar vein, out of 17% of patients that used both herbs and drugs, 73% did not inform their doctors (Al-Rowais, 2002). Additionally, 68% of patients attending outpatient clinic in 7 Palestine government hospitals declined to declare to the medical practitioner that they had used Complementary and Alternative Medicine (CAM) (Ali-Shtayeh *et al.,* 2012). This contradicted a study carried out in Jordan which revealed that, most patients (80.2%) had willingly disclosed information on CAM use to their physicians (Otoom *et al.,* 2006). In the present study, the THPs strongly believed that combining of medicine, could result in herb- drug interaction which could to a dangerous state of hypoglycemia, toxicity and serious physiological side effects. Indeed, herb-drug interactions have been cited as a potential physiological risk factor (Fugh-Berman, 2000; Izzo, 2005). The major challenge faced by the THPs was low turnout of clientele; it was attributed to factors such as; association of THPs with witchcraft (Mwangi and Gitonga, 2014) and easy access to medical health facilities (http://www.kenya-information-guide.com/nyeri-county.html).

Reportedly, the THPs preferred combinational therapy; polyherbal therapy has been proven to produce a higher antidiabetic effect than single herb therapy (Ebong *et al.,* 2008). Moreover, the use of herbs to rejuvenate the nerves as reported in this study is supported by evidence which indicated that there is a relationship between regeneration of the pancreas and the neural activity (Takayoshi, 2004). Additionally, there exists a strong link between depression and poor hyperglycemic control (Lustman *et al.,* 2000); which validated the approach undertaken by this

particular TMP. The most preferred method of administering herbal medicine as a decoction was the oral route. This was attributed to ease of administrating the mixture.

Notably, literate THPs regularly referred to other sources of information purposely to understand; the most appropriate herb to administer, its efficacy and side effects. That revelation underscored the importance of documenting therapeutic uses of traditional herbs and the need to validate their efficacy and safety using scientific methods. The plant family with the highest proportion of antidiabetic species was Asteraceae (8); a similar trend was observed elsewhere (Heinrich *et al.*, 1998). The study documented seventeen antidiabetic herbs. A study carried out in Israel, documented 16 hypoglycemic plants (Yaniv *et al.,* 1987), but none was similar to what is used in the present study area, possibly due to ecological diversity. A similar report carried out in South - eastern Morocco documented 45 medicinal plants used to manage diabetes (El-Hilaly *et al.,* 2007). It included *Olea europoea* which was also cited in the current study. In South-western Nigeria, Abo *et al.,* (2008) documented 31 antidiabetic plants and only *Rutaceae* family was similarly cited in the present study. Keter and Mutiso (2012), identified 39 plant species used to manage diabetes in the lower eastern region of Kenya which included; *Allium sativum*, *Olea africana*, *Urtica massaica* and *Rotheca myricoides,* which were also cited in the present study. From the foregoing survey report, it was evident that diverse ecological regions provided a unique variety of medicinal plants which met the therapeutic needs of each community in the treatment and management of diabetes. A high prevalence of diabetes in the study area could explain why the present study revealed a large number of medicinal plants used to treat and manage diabetes.

Analysis of the antidiabetic medicinal plants through cross referencing with existing literature revealed that, some of the plants used to manage various diseases possessed antidiabetic activity. The antidiabetic effect of most of the plants was attributed to their hypoglycemic (El-Fiky *et al.,* 1996; Ferheen *et al.,* 2009; Ranilla *et al.,* 2010)), α-amylase inhibitory **(**Odhav *et al.,* 2010), antiglucosidase (Ferheen *et al.,* 2009; Ranilla *et al.,* 2010; Gallardo-Williams *et al.,* 2002), hypolipidemic (Ashraf *et al.,* 2011; Eidi *et al.,* 2006; Arulmozhi *et al.,* 2010), lipid peroxidation inhibition, antioxidant (Jaiswal *et al.,* 2009; Arulmozhi *et al.,* 2010) and anti-inflammatory activity (Koko *et al.,* 2015) and, improved insulin resistance (Mohamed *et al.,* 2014).

Seventeen (17) plant species which included; *Clematis hirsuta, Dracaena steudneri, Gomphocarpus fruticosus, Grewia similis, Hydnora abyssinica, Lactuca inermis, Myrsine africana, Ornithogalum tenuifolium, Periploca linearifolia, Rhamnus prinoides, Rotheca myricoides, Sonchus asper, Sonchus luxurians, Spilanthes mauritiana, Teclea simplicifolia, Urtica massaica* and *Vernonia lasiopus,* had not been investigated for their antidiabetic activity in previous studies and were therefore mentioned for the first time in the present study as potential antidiabetic herbs. This confirmed the importance of having carried out the survey in particular Nyeri County.

3.4.3 Therapeutic Plants used by Traditional Herbal Practitioners of Narok County in the Management of Human Health

The traditional healers were mixed gender with men being the majority. This indicates the importance of women in the management of health in the Maasai community. The findings are consistent to that reported by Muthee *et al.,* (2011) and Kamanja et *al.,* (2015) among the Maasai of Loitoktok and the Samburu community, respectively. However, the report from the Maasai in

Narok contradicted that from Nyeri County which showed that the traditional healers sampled among the Kikuyu of Nyeri County were men. In Narok County, the herbalists were distributed across the old, middle and young ages which indicated evidence of passing knowledge from one generation to another. The findings contradicted those documented from Nyeri County in this thesis, in which herbal practitioners were entirely old or in middle ages. The THPs lacked formal education and professional training; they acquired ethnobotanical knowledge from apprenticeship. This contends with findings of Muthee *et al.,* (2011) from the Maasai of Loitoktok district.

However, the THPs who had attended in-service training outlined its benefits such as acquisition of knowledge and skills based on record keeping, extraction methods and appropriate storage methods. The same benefits were reported by THPs in Nyeri County. The reported failure of the majority to register in groups was explained by the small number that had attended in-service training. This may limit sharing of ethnobotanical knowledge in the face of efforts to perpetuate and regulate ethnobotanical knowledge. To the contrary, findings from Nyeri County showed that majority of THPs belonged to formal groups and had undergone in-service training. This indicated a significant step towards documentation and standardization of traditional medicine.

Diseases that were mainly treated using herbs included stomach disorders, malaria, sexually transmitted diseases, colds, skin diseases and fibroids. The same diseases have been reported by Bussman *et al.,* (2006) and Mutiso *et al.,* (2016) in their ethnobotanical surveys among the Maasai of Sekenani Valley and Losho, in Narok County. Muthee *et al.,* (2011) and Kiringe (2006) have reported similar findings in Kajiado County. However, a notable finding in the present study that had hardly been mentioned in the ethno medicine studies among the

Maasai is treatment of diabetes and cancer. This is a pointer that non communicable diseases have slowly creeped into the lives of the Maasai community. Findings from the current study showed that, gradual changes in the Maasai community from pastoral to sedentary lifestyles due to urban influence was a potential opportunity for the emergence of non-communicable diseases.

The reported wholesome treatment using multiple herbs has also been reported in studies done among the Kikuyu community (Njoroge and Bussman, 2006). According to Gessler *et al.,* (1994) drugs may only be active in combination due to synergistic effects of several compounds that are active singly. The most popular families reported in the present study in decreasing order included Mimosaceae, Rhamnaceae, Apocynaceae, Solanaceae, Myrsinaceae, Euphorbiaceae and Rhamnaceae. Family Rhamnaceae, Mimosaceae, and Euphorbiaceae had also been reported as dominant medicinal plants among the Maasai (Mutiso *et al.,* 2016). The reported additional important plant families in the present study rationalized the need to undertake research for documentation of plant herbs among traditional communities. The recounted dominance of some plant herbs in the management of health among the Maasai community in the present study have been reported in other studies. For example, *Warburgia salutaris, Rhamnus prinoides Toddalia asiatica, Carissa edulis* have been reported to be salient in the management of diseases among the Maasai of Loita and Kajiado (Nankaya, 2014; Kiringe, 2005). *Zanthozylum usambarense* have been cited as dominant by Muthee *et al.,* (2011) and Mutiso *et al.,* (2016) among the Maasai of Loitoktok and Losho in Kajiado and Narok counties, respectively. *Aloe Secundiflora,* most dominant plant in the management of health was reported in the present study. It has also been cited as one of the dominant medicinal plants among the Ilkisonko Maasai of Kajiado County (Kimondo *et al.,*

2015). In the present study, *Toddalia asiatica*, *Olea europaea*, *Sarcostemma stolonifera* and *Synadenium grantii* was used in the treatment of cancer. This was the first time they had been mentioned in the existing ethnobotanical studies in Kenya; more fundamentally, the use, *Sarcostemma stolonifera.* Treatment of cancer had not been mentioned before. However, extracts from *Toddalia asiatica* (Vishnu, 2012), *Olea europaea* (Chloe *et al.,* 2015) and *Synadenium grantii* (de Oliveira, *et al.,* 2013) had been reported outside Kenya.

The reported wider use of shrubs compared to trees and herbs as medicinal plants in the present study has also been cited in other studies (Kiringe, 2006; Kimondo *et al.,* 2015). This is perhaps due to semi-arid nature of the Maasai land ecosystem (Bussman, 2006). The indicated dominant use of roots followed by barks as sources of medicine has been reported by Mutiso *et al.,* (2016) and Muthee *et al.,* (2011). The superior use of roots for medicinal purposes is a potential threat to survival plant use (Jeruto *et al.,* 2010). To overcome this challenge the Maasai community had adopted cultural methods of sustainable use of plant herb resources, notably selective removal of roots. This conservation measure has also been reported by Nankaya (2014). The dominant use of wild plants as medicinal herbs has also been mentioned in the current study. This can be traced to the traditional pastoral life of the Maasai which exposed the community to a wide range of wild habitats. The reported preparation by drying, crushing, soaking and boiling to make decoctions which are taken periodically in a day have been reported in other studies (Kiringe, 2006; Jeruto *et al.*, 2010).

The present study revealed indepth knowledge of poisonous plant species to both plants and animals, among the Maasai community. Effects of excess dosages and how to remedy toxicity using plant species and additives were observed. The same was observed among the Kikuyu of

Nyeri in this thesis. Moreover, salient toxic plants such as *Ricinus communis Acokanthera schimperi, Euphorbia candelabrum* and *Tagetes minutas* were mentioned by the THPs in Nyeri County. Toxicity of *Ricinus communis* and *Acokanthera Schimperi* has also been reported in Samburu County especially in regard to causing death in livestock (Kamanja *et al.,* 2015). *Acokanthera Schimperi* has also been reported as arrow poison (Wanzala *et al.,* 2016). Medicinal plants that produced toxic effects when taken in excess included; *Senna didymobotrya, Warbugia ugadensis* and *Zanthozylum usambarense*. They were associated with diarrhea, vomiting and stomach ache. The findings corroborates Kamanja *et al.,* (2015) report among the Samburu community. Similarly, the reported mixing of the concoctions and decoctions with soup, milk, fat, egg yolk, oil, and even blood to reduce toxicity and mask the bitter taste of the product has been reported by Njau (2001). Further, the use of medicinal plants mainly *Carissa edulis, Rhamnus staddo, Prunus africana, Toddalia asiatica* and *Rhus natalensis* to manage toxicity had also been reported by Kamanja *et al.,* (2015) and Njau (2001) among the Samburu and the Maasai of Tanzania. In this study, use of multiple herbs in treatment of ailments was used to manage toxicity. Diseases such as HIV/AIDS, TB and cancer, and groups of patients such as children and very old people were not treated using ethnnomedine by the THPs in Narok County. Similar report was documented among the THPs from Nyeri County in this thesis. However, the general health of pregnant women and children was managed by the midwives.

THPs from Narok County only referred patients to hospital after ethno medicine failed. The findings contrast findings from Nyeri County in this thesis where patients sought ethno medicine after conventional medicine failed (Njoroge and Bussman, 2006). The major challenge facing THPs in Narok County was the potential threat to survival of medicinal plants, as a result of

charcoal burning and human encroachment of forest. Similar findings have been reported among the Samburu and Maasai of Loita (Kamanja *et al.,* 2015; Nankaya, 2014).

3.4.4 Medicinal Plants used in the Management of Diabetes by Traditional Herbal Practitioners of Narok County, Kenya

Encounter with diabetes patients and related deaths in the area as reported by the TH had largely contributed to the increased diabetes awareness observed among the THPs. Further, diabetes awareness campaigns countrywide by the Ministry of Health had also played a major role (Nicolai *et al.,* 2014). The low prevalence of diabetes could be attributed the predominantly rural set up; a similar trend has been observed elsewhere (Dirk *et al.,* 2009). Occurrence of diabetes among the Maasai community of Narok County which had no such previous record during the pre-colonial era is associated with sociocultural changes facing it in the post-colonial era (Karekezi *et al.,* 2011; Mandha *et al.,* 2015; Masaki *et al.,* 2014). This explains why most of the reported causes of diabetes by the THPs in Narok were attributed to; diet, stress and inactivity. These findings corroborate previous reports (Berg, 2012; Campbell *et al.,* 2000; Cochrane *et al.,* 2005). Similarly, Hemed *et al.,* (2014) attributes diabetes to sedentary lifestyle (46.8%), abdominal obesity (43.7%) and high fat diet (59.4%). Notably, occurrence of diabetes related deaths in this community was a clear indicator that such changes have been engrained within their lifestyle for over a long period of time. The current study revealed a high prevalence of diabetes among men and old people as reported by the THPs. WHO (2000a) has reported a similar trend. Further, Yang *et al.,* (2010) recorded a diabetes prevalence of 10.6% in men compared to 8.8% in women and 20.4% among old people compared to 3.2% among young people.

To treat and manage diabetes, the THPs in the present study recommended use of traditional diet and vegetables both of which are rich in fiber. These foods have been shown to manage and reverse diabetes type 2 (http://www.pcrm.org/health). Notably, despite the low diabetes prevalence recorded in the present study, the number of diabetic clients seeking herbal treatment was relatively high; this was attributed to the positive attitude and faith in herbal medicine over conventional therapy by this community (Bussmann *et al.,* 2006; Kiringe, 2006; Sankan, 1995; Sindiga *et al.,* 1995)

The present study documented *Urtica massaica* as one of the most used plants in Narok; which is similarly cited in a study carried out in the lower eastern region of Kenya, together with other plants like *Aloe spp.* and *Rotheca myricoides* (Keter and Mutiso, 2012). But a comparative analysis of other studies reveals that, plants used to manage diabetes in Narok were different from those from other communities such as Peru (Rainer *et al.,* 2013), Trinidad and Tobago, except for *aloe spp* (Lans, 2006), and Embu County of Kenya (Kareru *et al.,* 2007) and lower eastern region of Kenya, except for *Urtica massaica*, *Rotheca myricoides* and *Aloe spp.* (Keter and Mutiso, 2012).

In the present study, roots were most preferred plant part compared to leaves in Lower Eastern Region (ibid) while effort of cultivating medicinal plants for ethno therapeutic use was reportedly rare. This raised the question of plant conservation. But according to the THPs, they harvested a third of the roots or from plants that had not been previously/recently harvested. Preparation of the medicine as a decoction has also been reported (Keter and Mutiso, 2012).
Although, studies to establish their antidiabetic efficacy have been carried out, very few plants (43%) had been scientifically validated, 57% had not been investigated, they included; *Dovyalis*

abyssinica, Faurea saligna, Rhamnus prinoides, Rhamnus staddo, Rotheca myricoides, Trimeria grandifolia, Urtica massaica, Warbugia ugandensis and *Zanthozylum usambarense.* Although *Acacia nilotica* leaf and pod extract had been studied, antidiabetic efficacy of the roots which were mentioned in this study by Narok THPs had not been scientifically validated.

3.5 CONCLUSION

Ethnobotanical survey revealed that the current cohort of herbalists from Nyeri County was richly endowed with traditional knowledge on herbal medicine that was used to treat various ailments affecting its community; despite lack of clientele.

Seventeen (17) plants were identified and documented for the first time as potential antidiabetic medicine.

Polyherbal treatment was the preferred mode of treatment, which promotes synergistic activity of herbal medicines.

The THPs in Nyeri County demonstrated extensive conventional knowledge about diabetes occurrence, symptoms, prevention and control. They also appreciated the need to assimilate modern medical laboratory technology in the treatment of diabetes.

Notably, services from the THPs were rarely sought because of the low attitude among members of the community; indicating that, herbal medicine was not well accepted. The revelations confirmed why it was necessary for this study to have documented traditional knowledge from the THPs from Nyeri County, so that it does not become eroded due to natural attrition of the present custodians.

Analysis of background information from Narok indicated the importance of both gender in managing the health of the Maasai community. Distribution of THPs at various age groups revealed that, ethnobotanical knowledge was being passed from one generation to another and training helped to improve ethnobotanical health care. The wide ethnobotanical knowledge revealed in this study pointed at the importance of traditional medicine in managing health in the face of escalating costs of conventional medicine and growing number of diseases resistant to modern medicine.

The study revealed the potential of ethnobotanical knowledge to respond to respond to emerging diseases in the Maasai community such as HIV/AIDs, cancer and diabetes. However, diagnosis of these diseases such as HIV/AIDs, cancer and diabetes in the Maasai community remained a challenge.

Diabetes was cited to be rare, however, the THPs from Narok demonstrated their potential to treat and manage the disease.

Survey findings from Nyeri and Narok counties have provided the base for the study of efficacy of the documented medicinal plants. Moreover, the reported toxicity of some medicinal plants revealed the need for safety standards to be set based on laboratory research. This would guide the THPs to safely and efficaciously administer the traditional herbal remedies.

Further, it was concluded that the reported threat to existence of therapeutic plants pointed at the fact that traditional methods of conservation were not effective in the face of aggressive bush clearing for cultivation and forest encroachment in the Maasai communities. However, the study observed efforts by THPs from Nyeri County to conserve traditional medicinal plants through

agroforestry and establishment of botanical gardens. There was also need to adopt new mechanism to sustain traditional herbs if the ethnobotanical knowledge is to suffice.

This work has been published in peer reviewed journals (Appendix 1X)

CHAPTER FOUR

PHYTOCHEMICAL SCREENING OF *Dovyallis abyssinica* AND *Sonchus luxurians*

4.1 INTRODUCTION

Different medical conditions are treated with various plant species; which have been harvested from geographical areas that possess multiple variations in soil chemicals and climatic factors; which could determine their phytochemistry (Rotblatt and Ziment, 2002). Phytochemicals are responsible for medicinal effects of plants and have protected humans from various diseases from time immemorial (Kubmarawa *et al.*, 2008). However, some of the chemicals could cause toxic effects; attributed to the source, deliberate adulteration or inherent toxicity of plant constituents (Mosihuzzaman and Choudhary, 2008). For instance, the irritant constituent of the volatile oil of parsley known as apiole is believed to possess its abortifacient and hepatotoxic activity, upon prolonged and excessive ingestion (Williamson, 2006).

In addition, herb-drug interactions may occur due to pharmacodynamics or pharmacokinetic activities of chemical components present in medicinal herbs. However, the rationale for such interactions is often hard to understand without adequate information regarding the phytochemical elements of the herbal product, their pharmacological effect and metabolism. Therefore, unless medicinal components are identified, it may become difficult (if not impossible) to understand mechanism of action, adverse reaction or possible interaction of herbal medicine during the process of establishing efficacy and safety (Dubber and Kanfer, 2004; Special Programme for Research and Training in Tropical Diseases - TDR, 2005).

Although there are several herbal plants believed to treat diabetes, only a few have scientific information about their chemical composition. Presence of flavonoids, flavones, flavonols,

terpenoids and bound anthraquinones in plants have been shown to cause hypoglycemia (Piero *et al.,* 2011). However, composition may vary in relation to plant parts, species or variety and extraction methods (Shan *et al.,* 2007), thus influencing the final quality of the herbal product. For instance; the hypoglycemic activity of aqueous extract of *Hypoxis hemerocallidea* in fasted normal and STZ-induced diabetic rats is attributed to its phytosterols and/or sterolin contents (Mahomed and Ojewole, 2003). But in *Leonotis leonurus,* it's attributed to the different flavonoids, diterpenoids and polyphenolics (Ojewole, 2005). Further, the antidiabetic effect of aqueous leaf extract of *P. guajava* in rats is attributed to the presence of tannins, flavonoids, pentacyclic triterpenoids, guiajaverin and quercetin (Mukhtar *et al.,* 2004; Ojewole, 2005).

Herbal preparation is obtained by subjecting plant samples to extraction (WHO, 2007b), importantly, presence of therapeutic phytochemicals is largely determined by the method of extraction among other factors. Although the first generations of medicinal plants were simple botanical materials administered in more or less crude form by traditional practitioners (Iwu *et al.,* 1999), the third generation is based on scientific studies (Akerele, 1993; Petrovick *et al.,* 1999). Accordingly, over the years, preparation of herbal medicine has evolved significantly from simple concoctions of boiled plant material to refined formulations; this makes the process of dosage determination and method of administration easy. Moreover, use of conventional method of harvesting, preparation and extraction makes investigation of chemical constituents, efficacy and safety of medicinal plants authentic and easy.

Notably, different extraction methods and plant samples (dried or fresh forms), may yield different active ingredients (Shan, 2007) which influences the final quality of the herbal product (Mosihuzzaman and Choudhary, 2008). Extraction methods vary from percolating, boiling,

mechanical disruption, macerating the herb in water, or solvent extraction (organic solvent, e.g., ethanol) (Rotblatt and Ziment, 2002). Further, elimination or reduced use of organic solvents, improved or shortened extraction process is encouraged. For example, use of newer sample preparation methods, such as microwave-assisted extraction, supercritical fluid extraction, and accelerated solvent extraction or pressurized liquid extraction (Huie, 2002). However, in instances where such equipment are unavailable or there is need to validate traditional method of extraction, then, extraction by decoction may be adapted with a few conventional modifications, such as, regulated temperature and storage method.

This study aimed at validating THPs method of extraction through decoction. In addition, it qualitatively investigated major groups of phytochemicals present in aqueous extracts of selected antidiabetic medicinal plants using simple laboratory chemical tests. Extracts of leaves of *Sonchus luxurians* and root of *Dovyallis abyssinica* were the most preffered antidiabetic therapeutic plants used by the THPs in Nyeri and Narok County, respectively. Thus they were selected for phytochemicals screening.

4.2 MATERIALS AND METHODS

4.2.1 Plant Collection, Extraction and Screening

Roots of *Dovyallis abyssinica* and leaves of *Sonchus luxurians* were collected from Narok and Nyeri County, respectively, the plants were transported within 24 hours. While still fresh, the plant materials were sorted, cleaned in running water and chopped into small portions. They were dried in an airy chamber for two weeks. But being a cold and rainy season, the process was enhanced by use of a ventilator fan (Fanli Isitici: Luxell, Turkey) for 12 hours per day. They were turned daily to avoid development of moldy growth or decay. The dried material was pulverized using an electric grinder. Hot water extraction was carried out by boiling the ground material in distilled water in the ratio of 1:10 for 20 minutes, to simulate traditional method of preparing a decoction. After cooling, the mixture was strained using muslin cloth, the filtrate was placed in test tubes and then centrifuged at 3000 RPM for five minutes. The supernatant was freeze dried ((Mondulyo-UK) to remove water. The dried powder was stored at -20^0C awaiting phytochemical, efficacy and acute toxicity tests.

The dried plant powder was screened for major groups of chemical compounds using standard procedures according to Trease and Evans (2000) and Sofowora (1993).

4.2.2 Qualitative Phytochemical Tests

Test for Alkaloids

A few drops of Wagners Reagent (Iodine in Potassium Iodide) was added to 3ml extract solution A Brown reddish precipitate was confirmation of presence of alkaloids

Tests for Flavonoids: Alkaline Reagent Test

2ml of 2% solution of NaOH was added to the plant extract solution. Formation of intense yellow colour demonstrated presence of flavonoids. Upon addition of few drops of diluted acid, the solution became colorless which further confirmed presence of flavonoids.

Test for Coumarins

0.5g of the extract was added in test tube which was covered with filter paper (moistened with 1N NaOH). The tube was put in a hot water bath and then cooled. Yellow fluorescence colour was an indication of coumarins

Test for Tannns

0.5% of sample was boiled in 20ml of water and filtered. 0.1% of ferric Chloride was added to the filtrate. Formation of brownish green or blue black colour was indication of presence of tannins

Test for Phenols: Ferric Oxide Test

Three to four drops of ferric oxide was added to the extract. Formation of bluish black colour was confirmation of presence of phenols

Test for Saponins

Crude extract was dissolved in 5ml of distilled water in a test tube and shaken vigorously. Frothing for 20 minutes was indication of presence of saponins. Three drops of olive oil was added to the mixture. Formation of an emulsion was further proof of presence of saponin

Test for Glycosides

10ml of 50% H_2SO_4 was added to 1ml extract and boiled in a hot water bath. Fehling's reagent was added to the mixture. Brick red precipitate indicated presence of glycosides

Test for Phytosterol: **Libbermann-Buchard's Test**

2ml dry acetic acid was added to 2mg of the extract and heated to boil in a hot water bath. The mixture was allowed to cool, 1ml H_2SO_4 was added. Bluish green color was an indication of presence of phytosterol

4.3 RESULTS

Phytochemical analysis carried out in aqueous extract of *D. abyssinica* roots and *S. luxurians* leaves demonstrated that they possessed bioactive plant compounds which included; alkaloids, flavonoids, tannins, saponins, phenols, phytosterols, coumarins and glycosides. However, coumarins and flavonoids were absent in aqueous leaf extract of *S. luxurians* (Table 13).

Table 13: **Phytochemical Present in Aqueous Extract of The *Dovyallis abyssinica* Roots and *Sonchus luxurians* Leaves**

Type of phytochemical	**Aqueous root extract of *Dovyallis abyssinica***	**Aqueous leaf of *Sonchus luxurians***
Alkaloids	+	+
Flavonoids	+	-
Tannins	+	+
Saponins	+	+
Phenols	+	+
Phytosterols	+	+
Coumarins	+	-
Glycosides	+	+

4.4: DISCUSSION

Alkaloids, flavonoids, tannins, saponins, phenols, phytosterols, glycosides and coumarins were identified in aqueous root extract of *D. abyssinica*. Notably, chemical analysis of methanolic root extract by Nyang'au *et al.,* (2017) and Geyid *et al.,* (2005) demonstrated presence of similar phytochemicals, however, flavonoids were found to be absent. According to Chirchir *et al.,* 2014, methanolic fruit extract of *D. abyssinica* showed presence of phytochemicals similar to the present study.

Phytochemical analysis of aqueous extract of *S. luxurians* showed that saponins, alkaloids, tannins, phenols, glycosides and phytosterols, were present, the results corroborate the findings of Kindiki *et al.,* (2016). However, in the present study, flavonoids and coumarins were absent, supporting Waiganjo *et al.,* (2013) who showed absence of flavonoids and flavones in both hexane and water extracts. Contrary, presence of flavonoids is used as chemotaxonomic markers of asteraceae family (Emerenciano *et al.,* 2001) to which *S. luxurians* belongs. Absence of some phytochemicals may be attributed to variations in the soils of the two areas, climate, latitude, and time of harvest, method of extraction or storage, among other factors (Kokwaro, 1993).

Presence of bioactive plant chemicals has been the basis of medicinal activity of plant products. Thus, many studies have in the recent past coupled efficacy of medicinal plants with their phytochemical constituents. For example, anticancer (Jin-Jian *et al.,* 2012), antidiabetic and antioxidant (Tiong *et al.,* 2013), cardiovascular (Mugabo *et al.,* 2012; Andraws *et al.,* 2005) and antibacterial (Shachi *et al.,* 2011) activity of alkaloids have been reported.

Investigation on the bioactivity of flavonoids indicate that they possess antioxidant (Pietta, 2000), antibacterial (Cushnie & Lamb, 2005) activity and decreased serum cholesterol and triglycerides levels (Ramulu and Goverdhan, 2012). Futher, they have been associated with improved insulin secretion, prevention of beta-cell apoptosis (Montserrat *et al.,* 2008), potentiated glucose-induced insulin secretion, inhibition of α-amylase and α-glucosidase activity and glucose uptake from the intestines and, hypoglycemic effect (Mohan and Nandhakumar, 2014). Terpenes have been shown to inhibit α-amylase activity (Ljiljana *et al.,* 2014) and ameliorated the alterations of cardiomyopathy (Gong *et al.,* 2012).

Saponins have antimicrobial and antifungal (Pinarosa *et al.,* 2006), anticancer (Thu *et al.,* 2016), antioxidant, antiglycation (Gülçin *et al.,* 2004; Yun-Fang *et al.,* 2011), antiperoxidative, hypoglycemic and antihyperlipidemic (Elekofehinti *et al.,* 2013), hypocholesterolemic and anti-obesity effect (Olusola *et al.,* 2014). Tannins possess antioxidant (Amarowicz, 2007; Kunyanga *et al.,* 2011), antimicrobial (Scalbert, 1991), antidiabetic (Kunyanga *et al.,* 2011) and anticancer (Cai *et al.,* 2017) activity. The antidiabetic activity is attributed to α-glucosidase and α-amylase inhibition (Kunyanga *et al.,* 2011).

Alkaloids possess hypoglycemic and hypolipidemic activity (Sharma *et al.,* 2010; Zhou *et al.,* 2012). Phenols, are reported to have antioxidant (Javanmardi *et al.,* 2003) and antibacterial (Aldulaimi, 2017) activity. Additionally, phenolic compounds such as thymol, carvacrol and eugenol possess antimicrobial, inflammatory, anticancer, analgesic and antioxidant (Rajput *et al.,* 2017) activity. The inhibitory activity against α-glucosidase and pancreatic lipase has been the basis for their antidiabetic effect (Qi *et al.,* 2012).

Phytosterols and its components; stigmasterol, β-sitosterol and campesterol have hypocholesterolemic properties which are demonstrated through the antioxidant, radical scavenging and membrane stabilizing effect (Yoshida & Etsuo, 2003), besides enhancing their anticancer activity (Atif & Carol, 2000). Additionally, phytosterols; lophenol, cycloartanol, 24-ethyl-lophenol, 24-methyl-lophenol and 24-methylene-cycloartanol have antidiabetic activity (Miyuki *et al.,* 2006)

Coumarins are phytochemicals with various medicinal properties; anti-inflammatory, antioxidants, anticoagulant, hypolipidaemic, hypotensive, decreased ventricular fibrillation (Hoult and Miguel, 1996), besides; they inhibit postprandial hyperglycemia (Sung *et al.*, 2004). Glycosides possess antidiabetic activity through inhibition of glucose-uptake in the small intestine and gastric emptying (Masayuki & Hisashi, 2000), and antioxidative activity (Ivan *et al.,* 2001). The glycosidic residues enhance the activity and pharmacokinetic parameters of phytochemical compounds (Kren & Martinkova, 2001). The pharmacological activities of the chemicals isolated from the cited plants validated the traditional use of most of the medicinal herbs used by the THPs to manage diabetes.

4.5 CONCLUSION

From the foregoing, the phytochemical screening confirmed presence of therapeutic phytochemicals in *D. abyssinica* and *S. luxurians.* They included; alkaloids, saponins, tannins, phenols, phytosterols, glycosides. Additionally, presence of flavonoids and coumarins was demonstrated in *D. abyssinica.* The findings demonstrated presence of bioactive compounds thus validating use of *D. abyssinica* ans *S. luxurians* as ethnotherapeutic plants.

CHAPTER FIVE

ANTIDIABETIC EFFECT OF AQUEOUS LEAF EXTRACT OF S*onchus luxurians* AND *Dovyallis abyssinica*

5.1 INTRODUCTION

Diabetes mellitus is an endocrine disease related to genetic predisposition and lifestyle change. Beta cells of the pancreas secrete insulin which regulates blood glucose level in healthy individuals by increasing glucose uptake and metabolism in cells, ultimately lowering its concentration in blood. In some persons, the body's autoimmune activity destroys pancreatic β-cells, resulting into type 1 Diabetes Mellitus (Shrayyef and Gerich, 2010). Additionally, obesity, intake of a diet rich in processed carbohydrates and fats, stress and sedentary lifestyle increases blood glucose level which causes insulin resistance. As result, glucose regulatory mechanism is compromised leading to type 2 diabetes mellitus (T2DM) (WHO, 2002a)

Diabetes cases have been on the rise globally, Mauritius is among the most affected in South East Asia with about 22% of the population in 2017 estimated to be diabetic (IDF, 2017). According to National Diabetes Statistics Report (2017), U.S has 30.3 million, South Africa 2.28million (7.6% of the population), Ethiopia in East Africa 1.3 million and Kenya 478 000 (2.2%) diabetic people. Nyeri County leads in diabetes prevalence (12.6%) in Kenya (https://www.standardmedia.co.ke). Notably, Rift Valley region has the lowest diabetes prevalence (KDMIC, 2011).

Escalated diabetes cases has placed unbearable treatment and management burden on the affected communities due to unprecedented health complications such as cardiovascular diseases, retinopathy, nephropathy, neuropathy, ketoacidosis and high blood pressure. In

addition, high cost of the drugs compromises patient's adherence to the recommended treatment schedule which is closely related to diabetes progression (Petra, 2015)

Nonetheless, communities have turned to traditional and complementary therapeutic plants which are considered cheap and safe (WHO, 2008). According to WHO (2013a), such plants should be subjected to scientific investigation for validation. Consequently, scientific surveys have been carried out to document medicinal plants and investigate their efficacy and safety. Noteworthy, most of the findings have positively established efficacy and safety of medicinal plants. For example, studies in India have shown that *Allium cepa* and *Allium sativum* possess antidiabetic activity and are safe as well (Grover *et al.*, 2002). *Anacardium occidentale* from Cameroon, *Annona muricata* South and North America and *Coccinia indica* in Sub Saharan Africa (Neelesh *et al.*, 2010), aqueous extracts of *Bidens pilosa*, *Aspilia pluriseta* and *Erythrina abyssinica* from Eastern Kenya (Piero *et al.*, 2011) have also demonstrated antidiabetic activity. Further, most plant materials possess secondary metabolites with antidiabetic activity such as saponins, flavonoids, terpenes and alkaloids (Firdous, 2014).

The present study documented *Sonchus luxurians* (Appendix 1V, V, V1 and V11) and *Dovyallis abyssinica* (Appendix V111) as the most preffered antidiabetic plants. *Sonchus luxurians* (R. E.Fries) C.Jeffrey., family: Asteraceae, is a wild succulent, erect or trailing herbaceous perennial plant that grows to a height of about 1-2 meters tall, its hardy, produces white latex, mature stems are hollow and often woody at the base. It's native to tropical East African countries namely; Uganda, Kenya, Burundi, Tanzania. It grows on mountain sides, grasslands, and roadsides in highland areas, thickets or dense vegetation along the forest margins or stream banks and in disturbed ground. The leaves are used as a vegetable and medicine to treat fever and

stomach upsets. (http://tropical.theferns.info/viewtropical.php?id=Sonchus+luxurians). From the study findings, *S. luxurians* is known as Muthunga in Nyeri County. From other studies, it's known as Kimogit in Nandi, its root decoction is used to treat malaria (Jeruto *et al.,* 2011).

Dovyallis abyssinica (A. Rich) Warb. Family: Flacourtiaceae, is commonly known as Abyssinian gooseberry and "olmorogi" among the Maasai community of Narok County. In Nyeri, it's known as "Mukambura", the leaves, bark and roots are used to cure gonorrhea, syphilis, constipation / indigestion and fibroids as reported in the present study. Among the Nandi, it is known as Nukchat; the leaves and roots decoction is used to treat malaria (Jeruto *et al.*, 2011). *D. abyssinica* is a spiny evergreen shrub, can grow up to 10 meters. It inhabits highland forest, dry evergreen forest; rocky limestone slopes; rain-forest to riparian forest and scrub; semi-evergreen or deciduous bushland or open wooded grassland (http://tropical.theferns.info/viewtropical.php?id=Dovyalis+abyssinica). The study investigated antidiabetic activity and safety of these plants using white albino mice (*Mus musculus*) to validate their traditional use.

5.2 MATERIALS AND METHODS

5.2.1 Ethical Approval

Permission to undertake the research was obtained from the University of Nairobi (UoN) "Biosafety, Animal Use and Ethics Committee", in the College of Agriculture and Veterinary Sciences-CAVs.

5.2.2 Plant Collection and Identification

Data from ethnobotanical survey carried out in Nyeri and Narok Counties (refer to section 3.3.2 and 3.3.4, respectively) was analyzed and the most commonly cited antidiabetic plant species *Sonchus luxurians* and *Dovyallis abyssinica,* respectively, were selected for efficacy studies. The plant materials were collected in June and July 2016 with the assistance of two herbalists and a botanist. The process of identification was carried out in the School of Biological Sciences and a voucher specimen placed in the herbarium; *Sonchus luxurians*: LNM14/04 and *Dovyallis abyssinica*: LNM15/01.

5.2.3 Preparation of Plant Material and Extraction

Preparation and extraction was carried out as described in section 4.2.1

5.2.4 Study Design and Treatment

Thirty six, 6 week old, male white albino mice (*Mus musculus*) were purchased from Vetlab at the University of Nairobi. The mice were kept in plastic cages with stainless steel covers in groups of six. They were acclimatized for 2 weeks at room temperature and 12h light and dark cycle. They were fed with standard rat chow (Unga feeds) and provided with water *ad libitum* throughout the study period. The mice were randomly divided into groups of six animals (Table 14 and 15).

The dried powder of *Sonchus luxurians* and *Dovyallis abyssinica* was reconstituted in normal saline in doses of 25, 75 and 225mg/Kg body weight (bwt). The extract was administered daily at 9 a.m for 28 days, orally using gastric intubation. Mice in groups 1 and 2 received normal saline, those in group 3, 4 and 5 plant extract while those in group 6 received Glibenclamide (5mg/kg bwt).

5.2.5 Induction of Diabetes

Experimental diabetes type 1 can be induced by injecting streptozotocin (STZ) intraperitoneally (i.p) (Masiello *et al.*, 1998). According to Akbarzaden *et al.,* (2007), streptozotocin causes decreased body function, weight, level of insulin and C- peptide. Also, the pancreas swells resulting in degeneration of Langerhans islet beta cells with subsequent increase in blood glucose, urine production, water and food intake, mortality rate and action potential duration (in the heart).

In this study, streptozotocin (STZ) was used to induce diabetes mellitus, using standard procedure (Naoaki *et al.*, 2012) with a few modifications. STZ was prepared and administered in a relatively dark room, 2 ml tubes containing STZ were placed in ice cubes, immersed in ice cold water to provide uniform cooling. This was found to be more effective in protecting STZ from degradation compared to using only ice cubes. Due to the small size of the mice; a fixed needle 0.5ml insulin syringe with a 30g needle was used; to avoid injecting the drug into the internal organs. The mice were fasted for 12 hours, a dose of 200mg/kg bwt was administered i.p from 4 p.m. Plasma glucose level was recorded at 9 a.m. daily, for three days after induction and weekly thereafter. Mice that showed a blood glucose level of 11 mmol/l or more were categorized as diabetic.

5.2.6 Determination of Blood Glucose Level

A drop of blood was obtained through a tail vein puncture and plasma glucose level recorded using Acuchek glucometer, the results were expressed in mmol/l.

5.2.7 Determination of the Activity of Aqueous Extract on Postprandial Blood Glucose Level

Normal mice were fasted overnight; they were administered orally with the extract or standard drug at the start of the experiment (0 min). Thirty minutes later, they were given 2gms/kg bwt of glucose solution at dosage volume not exceeding 0.1ml. Plasma glucose was then recorded at 0, 30, 60 and 120minutes. Diabetic mice received plant extract or standard drug daily, orally using gastric intubation.

Table 14: Experimental Design of Antihyperglycemic Activity of Aqueous Plant Extract of *Sonchus luxurians* Collected from Nyeri County

Group	Six Male White albino mice	Extract Dosage (mg/kg body weight)
1	Normal control	Vehicle (normal saline)
2	Untreated diabetic	Vehicle (normal saline)
3	Diabetic rats	25
4	Diabetic rats	75
5	Diabetic rats	225
6	Diabetic rats	Glibenclamide (5mg/kg bwt)

Table 15: Experimental Design of Anti-Diabetic Activity of Aqueous Extract of *Dovyalis abyssinica* Collected from Narok County

Group	Six Male White albino mice	Extract Dosage (mg/kg body weight)
1	Normal control	Vehicle (normal saline)
2	Untreated diabetic	Vehicle (normal saline)
3	Diabetic rats	25
4	Diabetic rats	75
5	Diabetic rats	225
6	Diabetic rats	Glibenclamide (5mg/kg bwt)

5.2.8 Measurement of Body Weight

Weight of the mice was measured in grams at the beginning of the experiment and weekly thereafter using a weighing balance (Sartorius, GMBH GOTTINGEN, and Type L2200P Germany).

5.2.9 Data Analysis

Statistical significance of the difference among means was determined using one way analysis of variance (ANOVA, GraphPad Prism 7) at $P<0.05$ significance level.

5.3 RESULTS

5.3.1 General Behavior of the Animals Post Induction

Three days after administration of streptozotocin (200mg/kg bwt IP) the mice appeared weak, movement was limited, fed poorly, water intake decreased and crowded at one place (Fig. 13). Notably, the observed signs gradually disappeared once treatment was started. The mice had a pre-induction mean blood glucose concentration of 7.3mmol/l, which increased to a mean of 15.7mmol/l (115%) three days post induction. The mice that recorded a blood glucose level of ≥ 11mmol/l were considered diabetic.

Normal control (non-diabetic) rats were active throughout the study period, however, high mortality rate (50%) was observed among the untreated diabetic mice, all the untreated animals had died by the beginning of the fourth week.

Figure 13: A Photograph showing the Behavior of Mice Crowding Post-Injection with (200mg/Kg Bwt) Streptozotocin

5.3.2 Antidiabetic Effect of *Dovyallis abyssinica*

5.3.2.1 Activity of Aqueous Root Extract of *Dovyallis abyssinica* on Post Prandial Blood Glucose Level

Results of *Dovyallis abyssinica* aqueous root extract are presented in Figure 14. The mean fasting blood glucose level of normoglycemic mice was 7.2mmol/l. Aqueous root extract of *D. abyssinica* at a dose of 75 and 225mg/kg bwt inhibited hyperglycaemia when administered to glucose loaded (2mg/kg bwt) mice. At a dose of 75mg/kg bwt, the increase after 1 hour was 14.3%, but 2 hours thereafter, it decreased significantly (P = 0.0084) by 24.65%. One hour after administration of 225mg/kg bwt and glucose loading blood glucose level increased by 17.2% but decreased significantly (P = 0.048) 2 hours thereafter, by 37.6%. One hour after administration of 25mg/kg bwt of the extract to glucose loaded mice, plasma glucose increased by 12.9%, however, it decreased by 25.8% 2 hours thereafter. The difference among the mean was insignificant (P value = 0.2425). Across the doses, glucose increased in the first hour but had decreased by the end of the second hour to a level below the baseline. Contrary, a gradual increase was observed among the control, to a level above the baseline. The antihyperglycemic activity of the extracts post prandial was dose related.

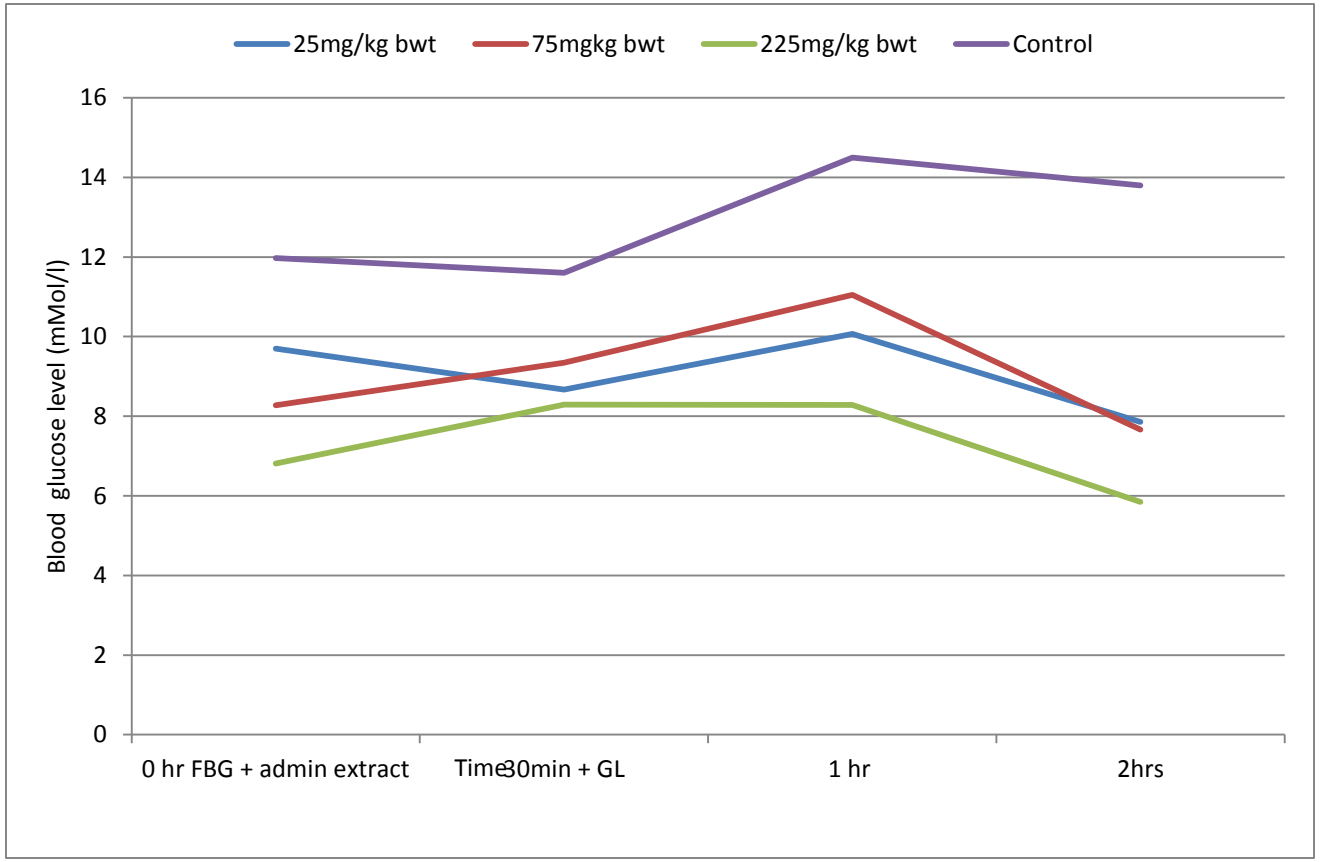

Figure 14 : Glucose Lowering Effect of Aqueous Root Extract of *Dovyallis abyssinica* Administered at Doses of 25, 75 and 225mg/Kg Bwt to Glucose (2gms/Kg Bwt) Loaded Normoglycemic White Albino Mice

Key: FBG – Fasting blood glucose, Gl – Glucose loading

5.3.2.2 Antihyperglycaemic Effect of *Dovyallis abyssinica* Aqueous Root Extract on Diabetic Mice

D. abyssinica demonstrated a decrease in glucose level four hours after administration of 25mg/kg bwt (Fig.15) and 75mg/kg bwt (Fig. 16), however, the difference among the means was not significant(P = 0.9166 and P=0.5636, respectively). At a dose of 225mg/kg bwt, blood glucose level decreased significantly (P = 0.0325) (Fig.17), to near similar to that of the standard drug (5mg/kg bwt).

Increased plasma glucose level was recorded across all the dose level during the first week of treatment of the diabetic mice as compared to the standard drug group; the increase was inversely related to the dose (Table 16). However, after administration of *D. abyssinica* aqueous root extract for four weeks, there was substantial gradual reduction in blood glucose (P = 0.0089) compared to the standard group (Fig**.** 18), the decrease was dose related.

There was no significant weight loss at a dose of 75 (2.2%) and 225mg/kg bwt (4.2%) compared to those that received 25mg/kg bwt (13.8%) and the untreated diabetic mice (14.75), while the standard drug group showed an 8.8% decrease.

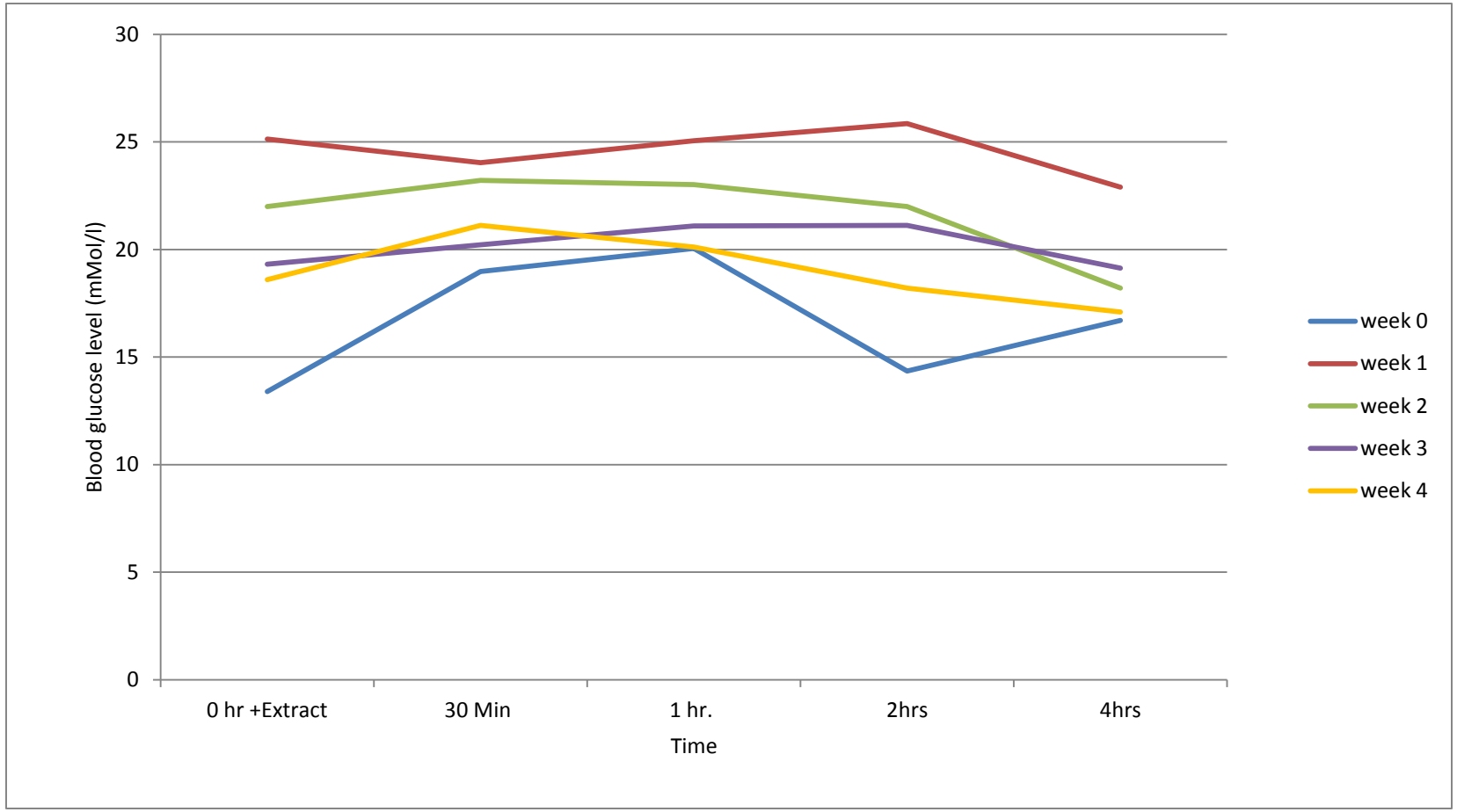

Figure 15: Antihyperglycaemic Activity of 25 Mg/Kg Bwt of Aqueous Root Extract of *Dovyallis abyssinica*, Administered to Diabetic White Albino Mice for 28 Days

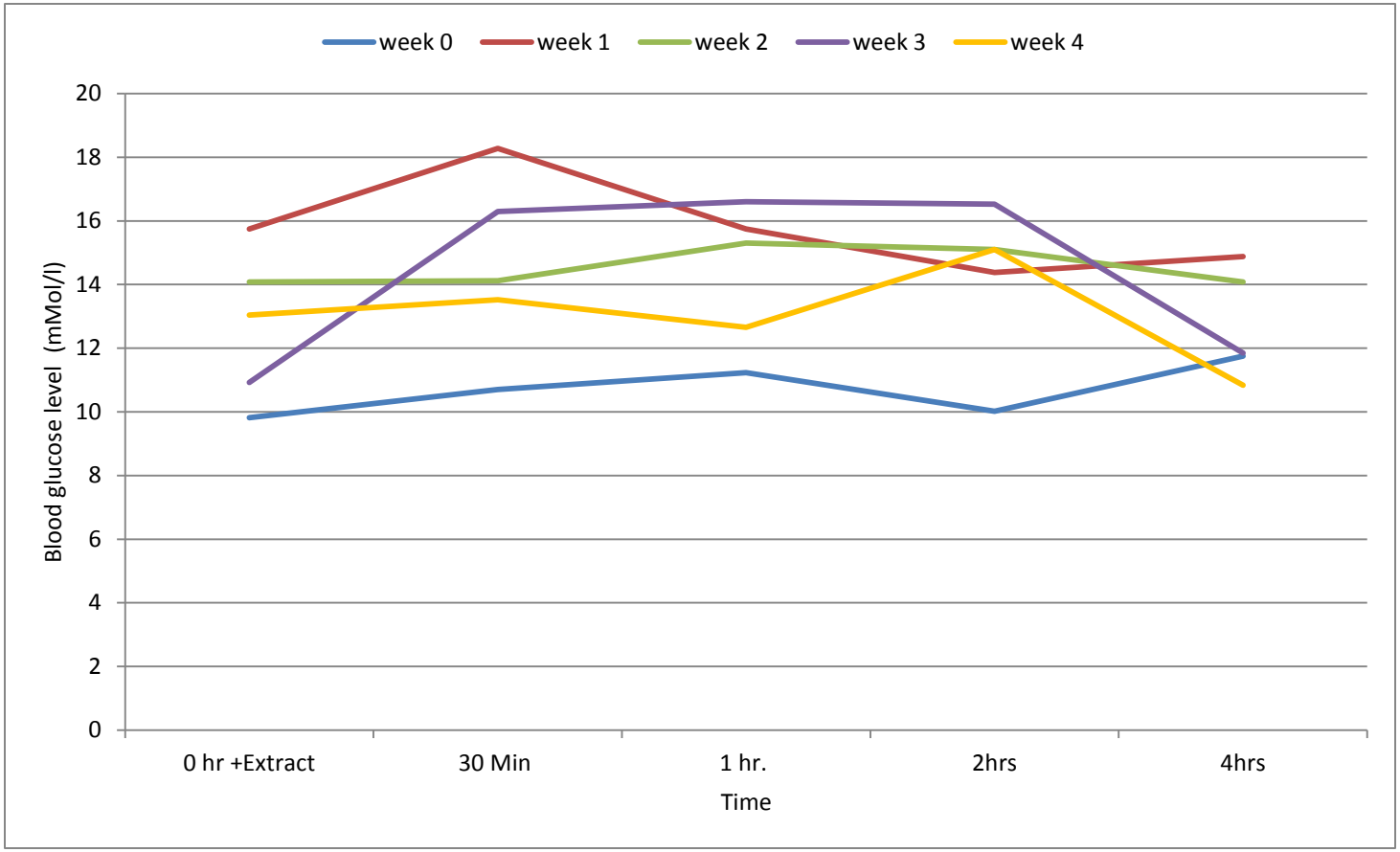

Figure 16: Antihyperglycaemic Activity of 75 Mg/Kg Bwt of Aqueous Root Extract of *Dovyallis abyssinica*, Administered to Diabetic White Albino Mice for 28 Days

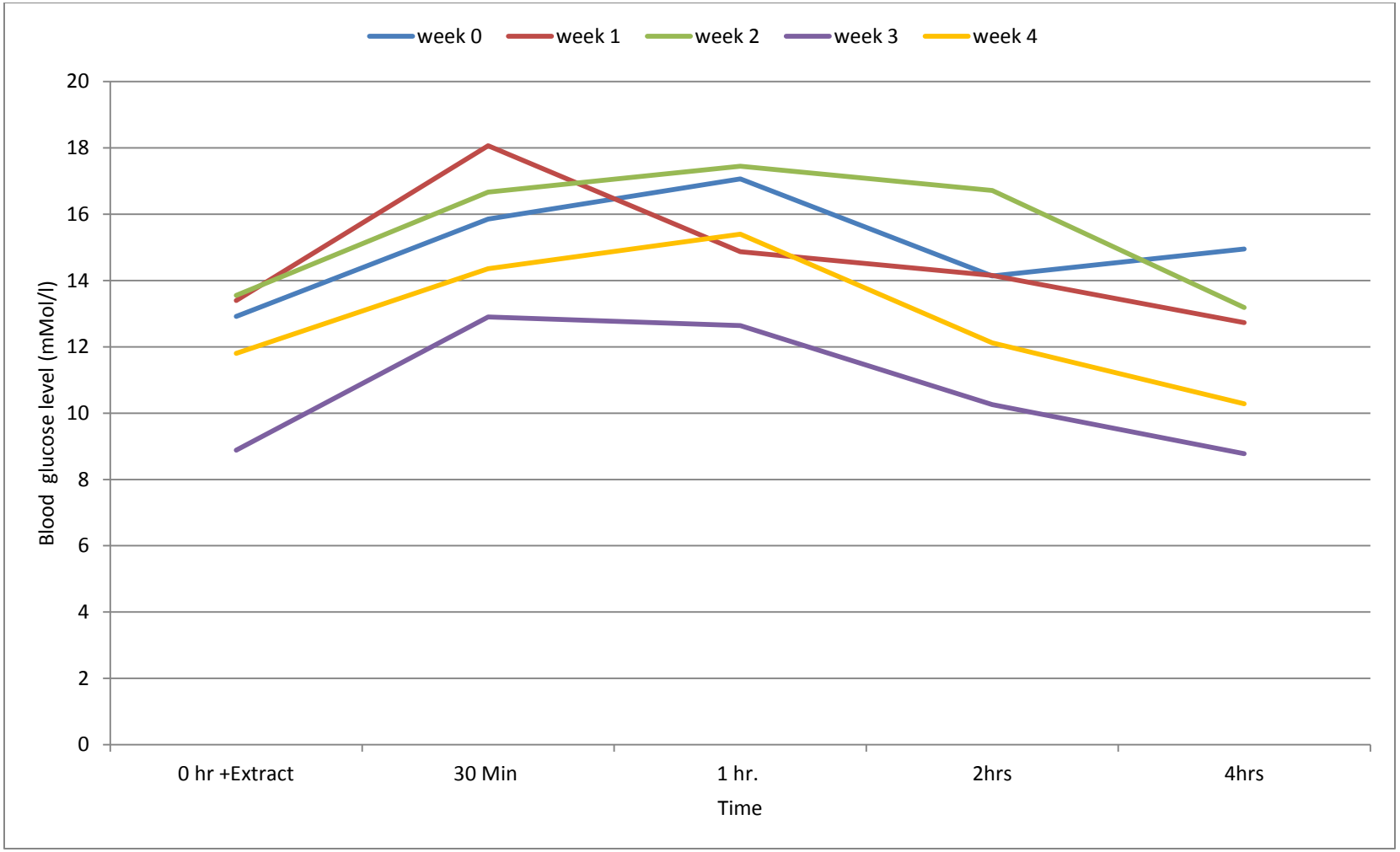

Figure 17: Antihyperglycaemic Activity of 225 Mg/Kg Bwt of Aqueous Root Extract of *Dovyallis abyssinica*, Administered to Diabetic White Albino Mice for 28 Days

Table 16: Change in Blood Glucose Level in Diabetic Mice Treated with *Dovyallis abyssinica*

Change in mean blood glucose level post induction	25mg/kg bwt	75mg/kg bwt	225mg/kgbwt	Standard Drug
Week 1(increase)	11.73(87.5%)	5.93(60.4%)	0.48(3.72%)	None
Week 4(decrease)	6.53(35.1%)	2.71(20.78%	1.6(13.6%)	2.6(18.03%)

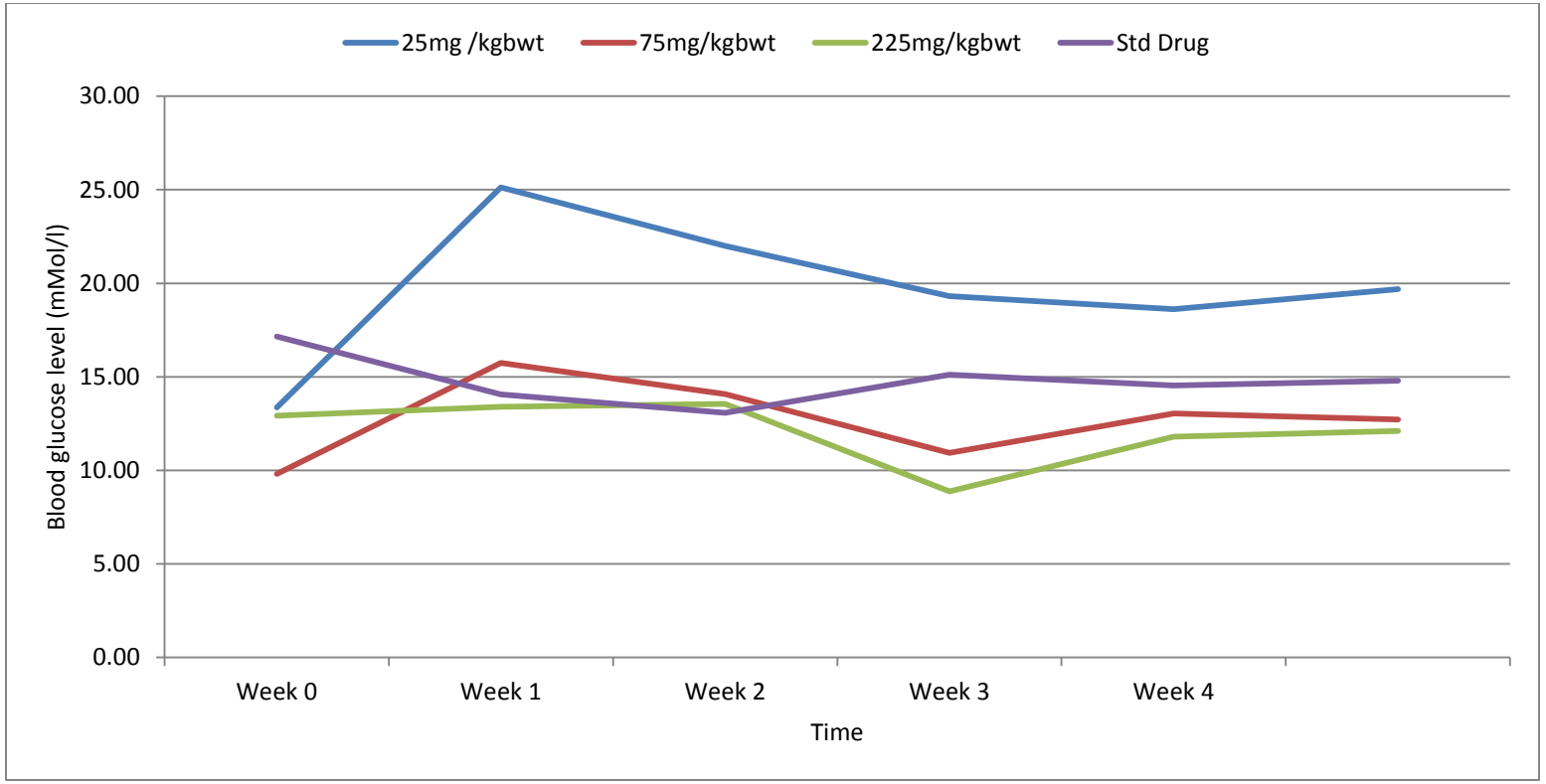

Figure 18: Antihyperglycaemic Activity of Aqueous Root Extract of *Dovyallis abyssinica*, Compared to the Control and Glibenclamide (Standard Drug) at a Dose of 5 Mg/Kg wt Administered to Diabetic White Albino Mice for 28 Days

5.3.3 Antidiabetic Effect of *Sonchus luxurians*

5.3.3.1 Effect of *Sonchus luxurians* Aqueous Plant Extract on Post Prandial Blood Glucose Level

Sonchus luxurians demonstrated a decrease in blood glucose level when administered concurrently with the 2mg/kg bwt (Fig. 19). The difference among the means was significant at doses of 75Mg/kg bwt (P = 0.0218) and 225mg/kg bwt (P = 0. 0015), but was insignificant at 25mg/kg bwt (P = 0.4104). The post prandial effect was dose related.

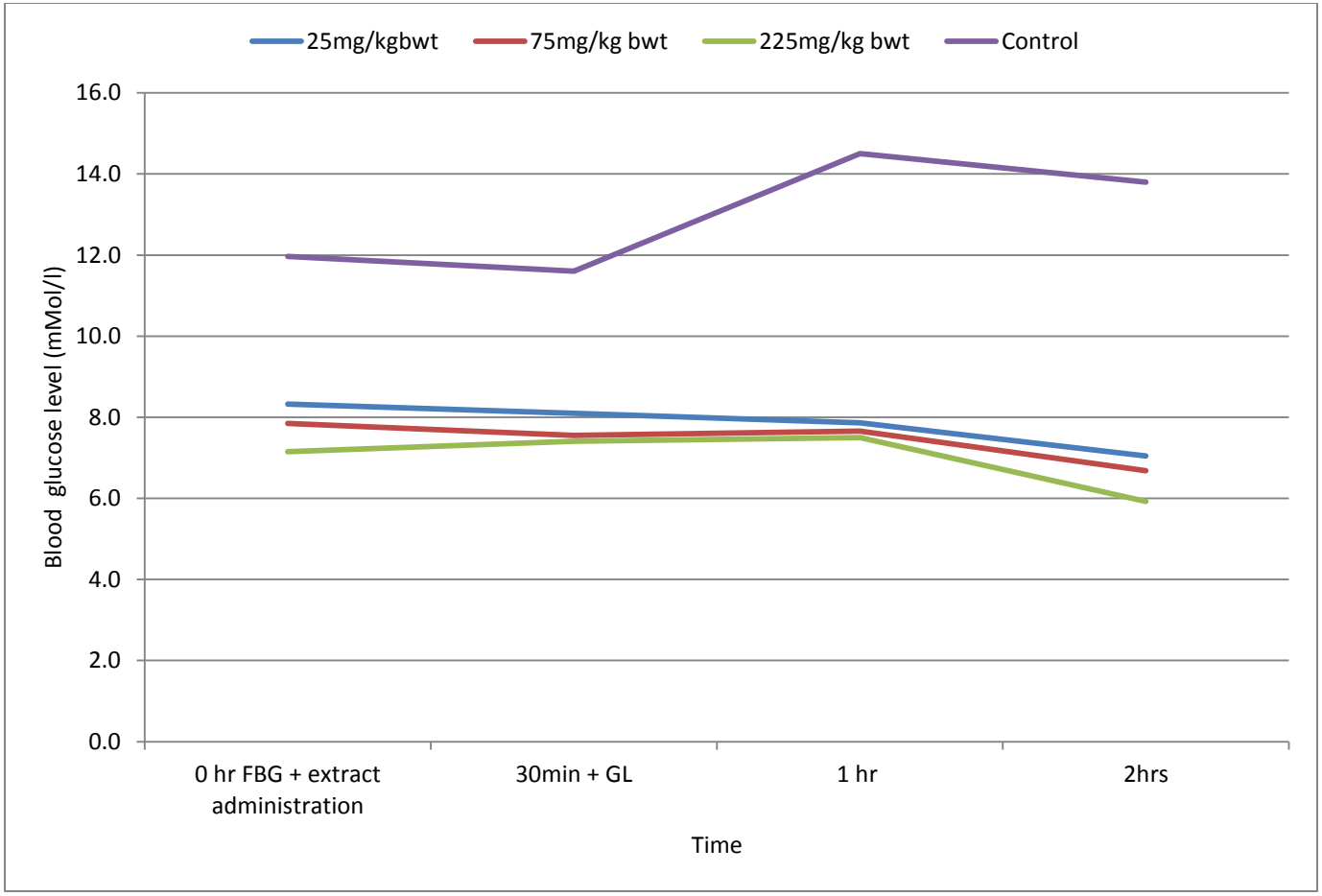

Figure 19: Effect of Aqueous Leaf Extract of *Sonchus luxurians* Administered at Doses of 25, 75 and 225mg/Kg Bwt to Glucose Loaded Normoglycemic White Albino Mice in Post Prandial Test

5.3.3.2 Antihyperglycaemic Effect of *Sonchus luxurians* Aqueous Leaf Extract on Diabetic Mice

Sonchus luxurians leaf extract demonstrated antihyperglycaemic effect (Fig. 20, 21, 22). Although increased blood glucose level was observed one week post induction (Table 17), there was significant long term decrease ($P = 0.0368$) of plasma glucose level after administration of the plant extract for four weeks (Fig. 23). The difference among the means was close to that of the standard drug (5mg/kg bwt of glibenclamide; $P = 0.0136$).

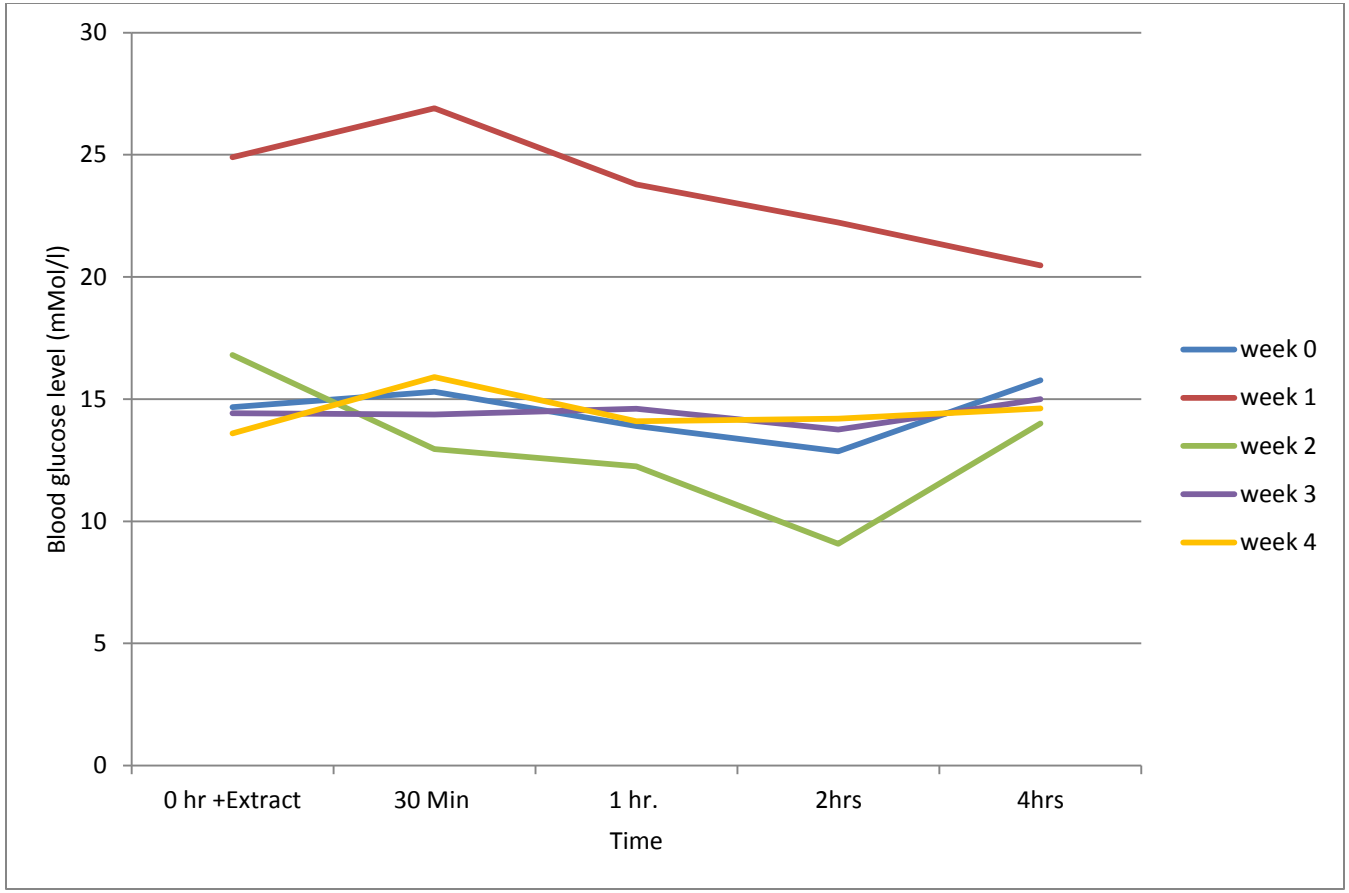

Figure 20: Antihyperglycaemic Activity of 25 Mg/Kg Bwt of Aqueous Leaf Extract of *Sonchus luxurians*, Administered to Diabetic White Albino Mice for 28 Days

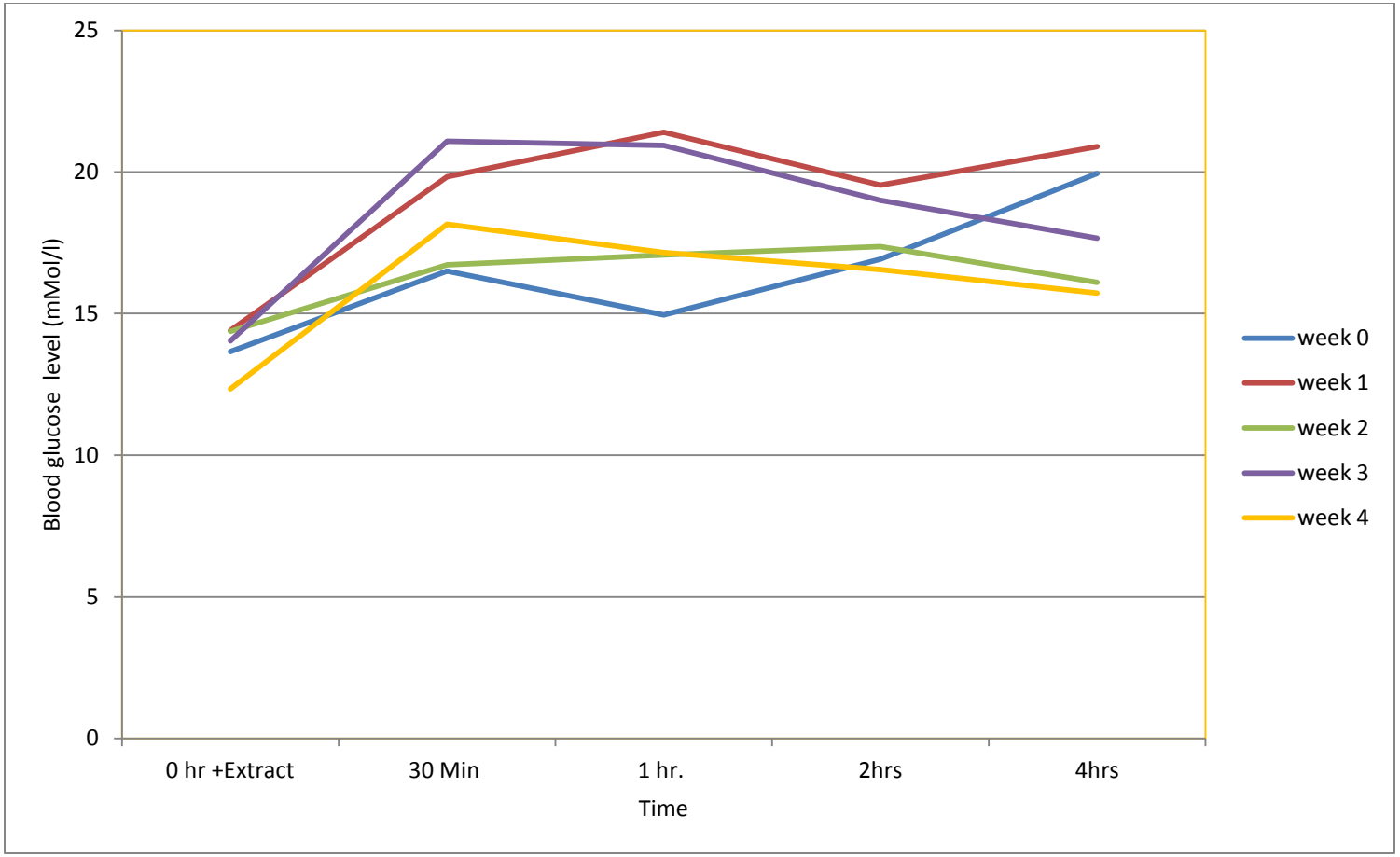

Figure 21: Antihyperglycaemic Activity of 75 Mg/Kg Bwt of Aqueous Leaf Extract of *Sonchus luxurians*, Administered to Diabetic White Albino Mice for 28 Days

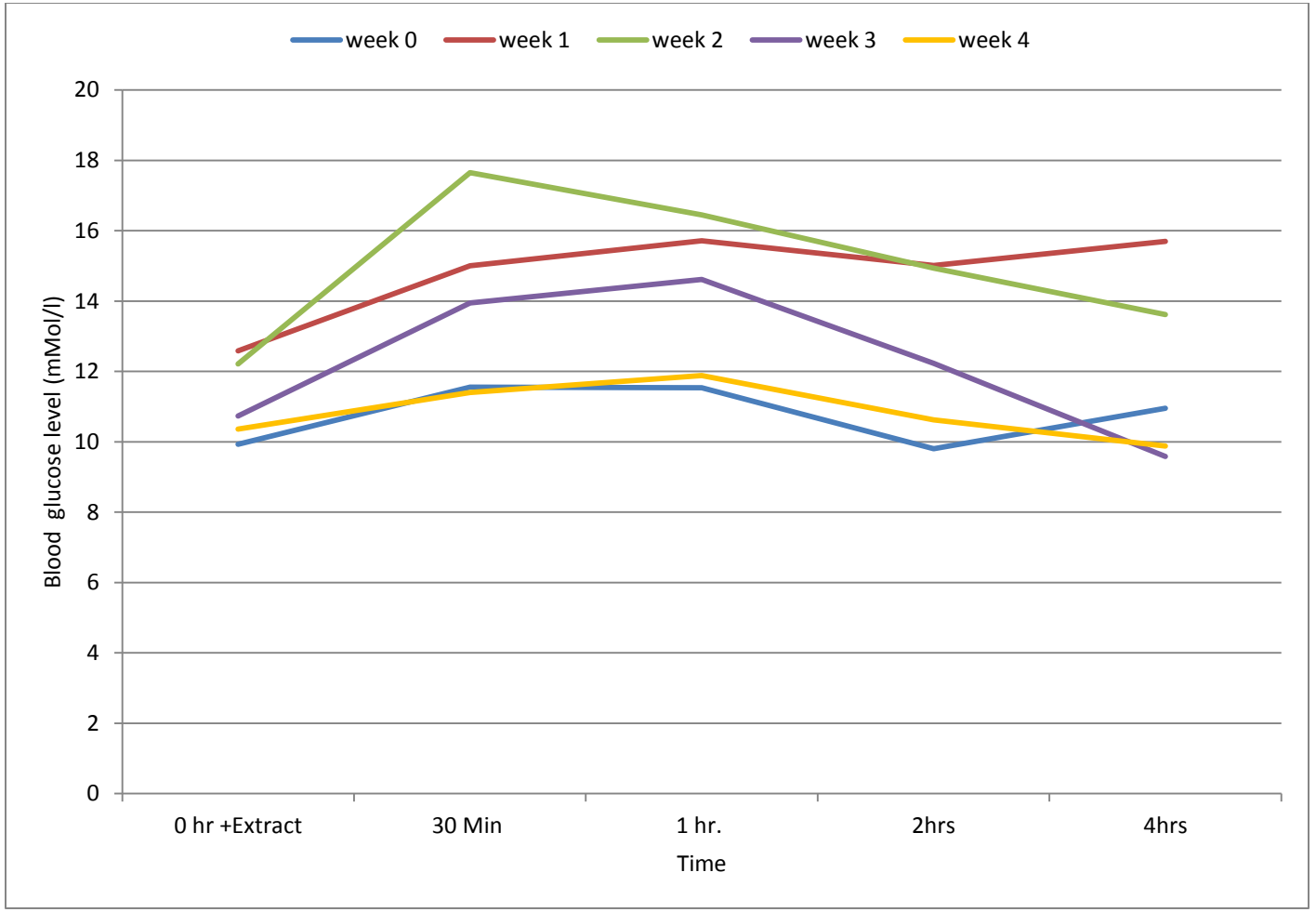

Figure 22: Antihyperglycaemic Activity of 225 Mg/Kg Bwt of Aqueous Leaf Extract of *Sonchus luxurians*, Administered to Diabetic White Albino Mice for 28 Days

Table 17: Change in Plasma Glucose Level Compared to the Baseline, in Diabetic Mice Treated with *Sonchus luxurians* at Doses of 25, 75 and 225mg/Kg Bwt for 28 Days

Change in mean blood glucose level post induction	25mg/kg bwt	75mg/kg bwt	225mg/kgbwt	Standard Drug
Week 1(increase)	10.3(75.5%)	0.8(5.9%)	2.6(26.2%)	None
Week 4(decrease)	11.3(45.3%)	2.0(13.9%)	2.2(17.6%)	2.6(18.03%)

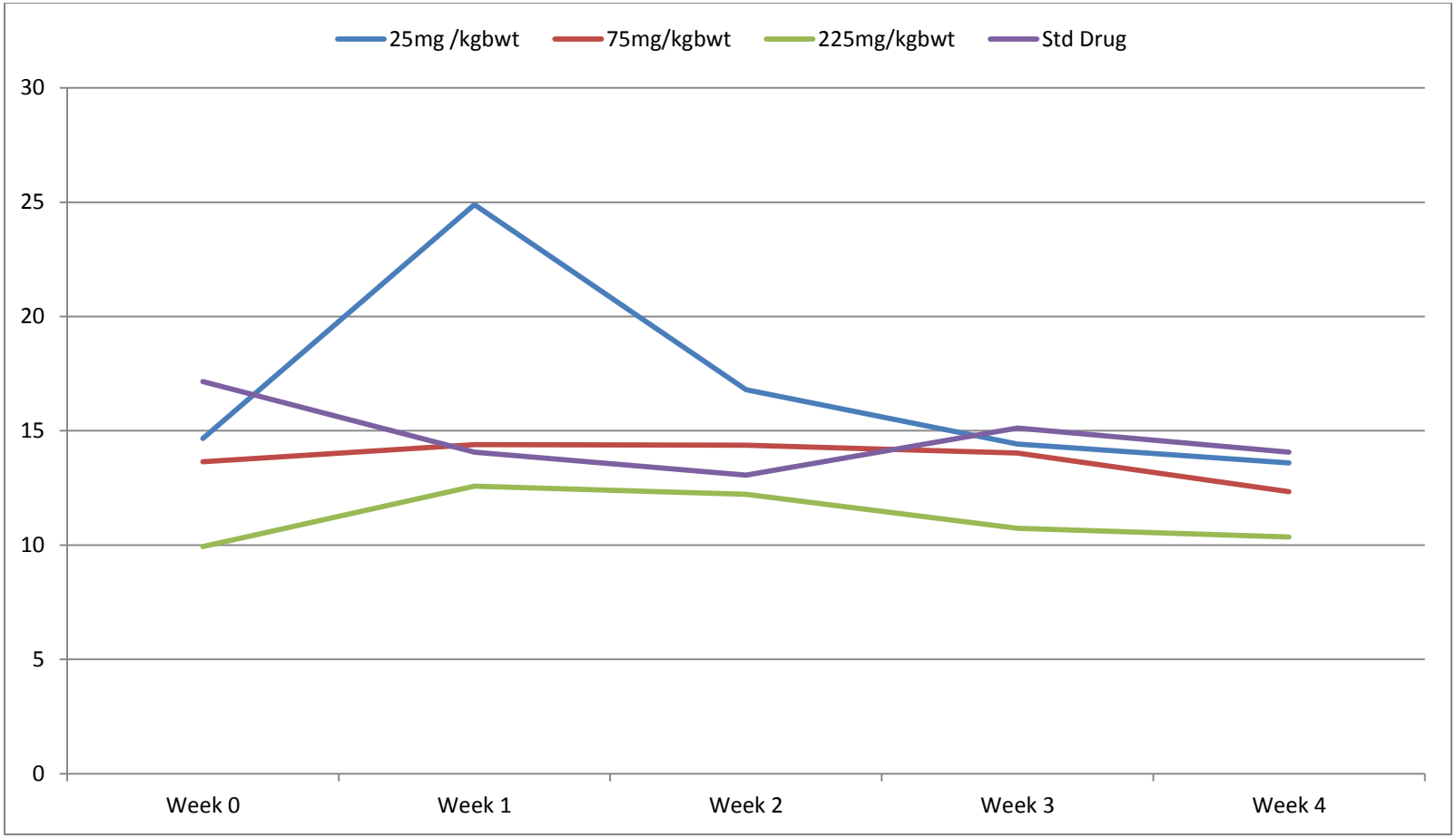

Figure 23: Antihyperglycaemic Effect of Aqueous Leaf Extract of *Sonchus luxurians* Compared to the Control and Glibenclamide (Standard Drug) at a Dose of 5 Mg/Kg Bwt, Administered to Diabetic White Albino Mice for 28 Days

5.3.4 Activity of Aqueous Extract of *D. Abyssinica* and *S. luxurians* on Body Weight

There was no significant weight loss at a dose of 75 (8.7%) and 225mg/kg bwt (-1.2%) compared to those that received 25mg/kg bwt (12.7%) and the untreated diabetic mice (14.75), the standard drug group showed an 8.8% decrease similar to mice receiving 75mg/kg bwt (Fig. 24; Figure 25).

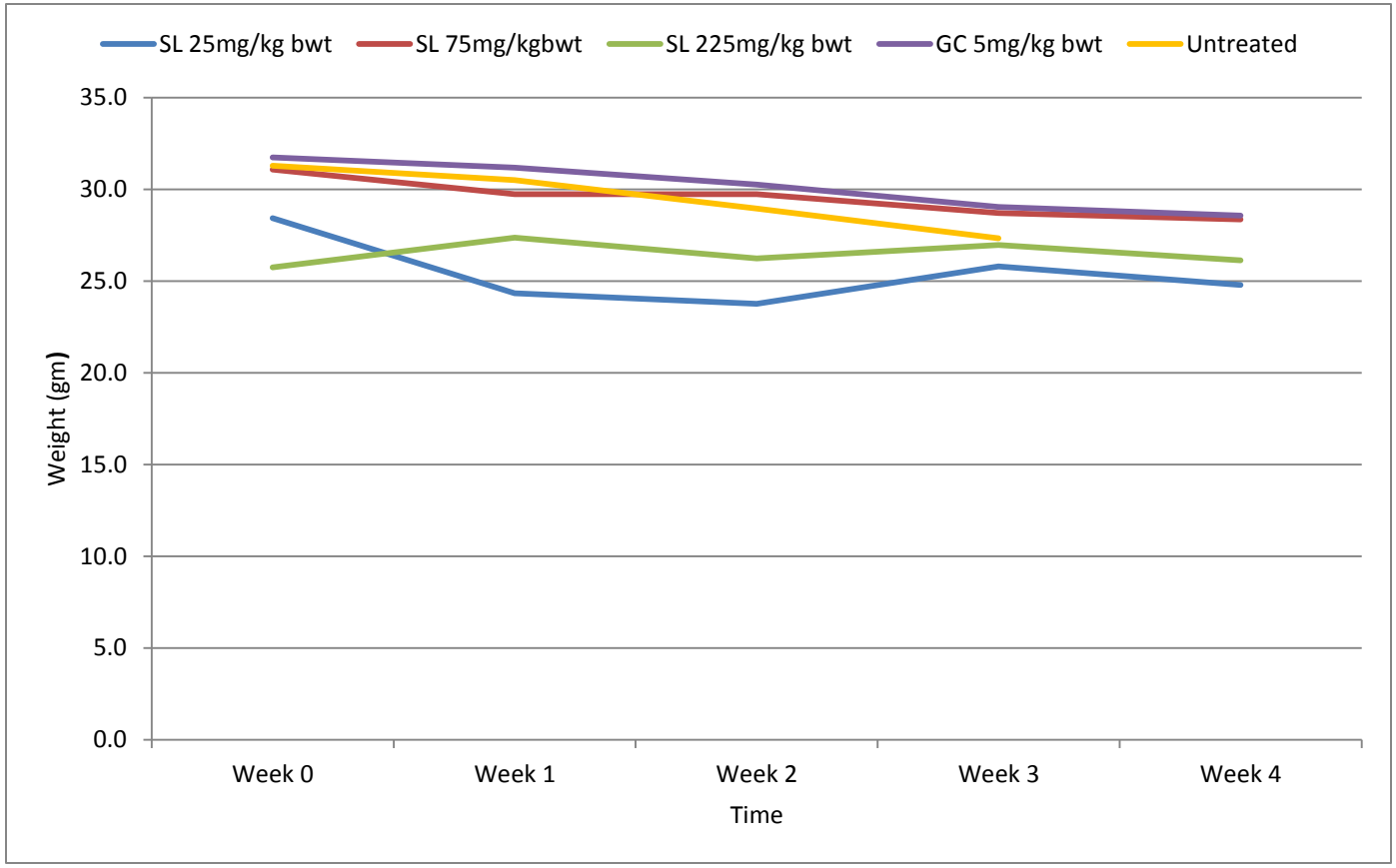

Figure 24: Weight Changes in Diabetic White Albino Mice Post Induction with 200mg/kg bwt of STZ and Treatment with *Sonchus luxurians* for 28 Days

Key: SL - *Sonchus luxurians* GC - Glibenclamide (5mg/kg bwt)

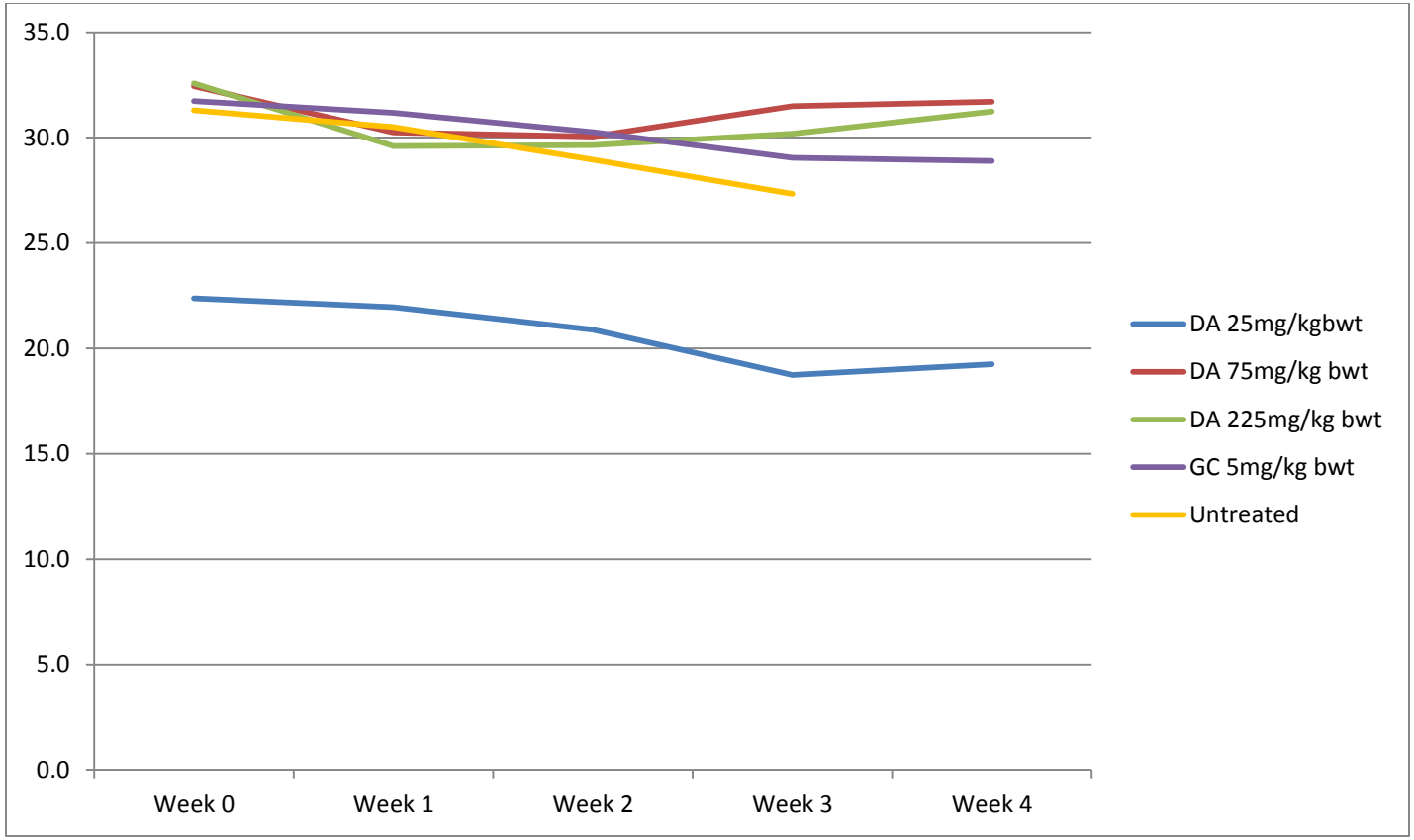

Figure 25: Body Weight Changes in Diabetic White Albino Mice Post Induction with 200mg/kg bwt of STZ and Treatment with *Dovyallis abyssinica* for 28 Days

Key: DA - *Dovyallis abyssinica* GC- Glibenclamide (5 mg/kg bwt)

5.4 DISCUSSION

The observed mean fasting blood glucose level of 7.2mmol/l in the experimental mice corroborates that of other studies (Mukundi *et al.,* 2015). *D. abyssinica* aqueous root extract at doses of 75 and 225mg/kgbwt prevented hyperglycemia two hours after glucose loading. Although this study did not study the mechanism of action, other studies have reported that increased glucose uptake caused by alkaloids (Tiong *et al.,* 2013) and flavonoids (Granados *et al.,* 2015) or increased insulin secretion as an effect of flavonoids (Mohan & Nandhakumar, 2014) might explain the hypoglycemic activity in the present study.

Blood glucose level increased by 115% post induction in all diabetic mice. STZ and its aglucone derivative *N*-nitrosomethylurea are known to possess cytotoxic effect on insulin-producing beta cells of the pancreas through NAD+ depletion (Rolf *et al.,* 1974), while its genotoxic effect leads to beta cell death (Alejandro & Martha, 2002), thus decreased insulin secretion.

Increased blood glucose level that was recorded across all the study groups during the first week of treatment post induction may be explained by decreased insulin secretion as a effect of destruction of pancreatic beta cells by STZ (Rolf *et al.,* 1974; Alejandro and Martha, 2002). However, by the end of the treatment period (fourth week), blood glucose level had decreased to below the baseline post induction. This may be explained by the fact that, phytochemicals present in the extract such as flavonoids, could have stopped further apoptosis of beta cells (Pinent *et al.,* 2008). Saponins might have activated regeneration of the beta cells and activity of calcium ion channels (Koneri *et al.,* 2014). Also, bioactivity of flavonoids and saponins are known to increase insulin secretion (Mohan and Nandhakumar, 2014) thus increased glucose metabolism.

At doses of 75 and 225mg/kg bwt, both *S. luxurians* and *D. abyssinica* demonstrated hypoglycemic activity in glucose loaded normogycemic mice, this may be explained by the increased glucose uptake activity of alkaloids as reported by Tiong *et al.,* (2013). Moreover, the present study observed an overall reduction in blood glucose level 28 days after treatment with the extracts. Beta cell regenerating activity of saponin (Koneri *et al.,* 2014) was suggested as a possible mechanism of action. As compared to 225mg/kg bwt of aqueous root extract of *D. abyssinica,* a similar dose of *S. luxurians* did not demonstrate antihyperglycaemic effect across the fourth hour. Additionally, after 28 days of treatment, *S. luxurians* demonstrated a lower effect ($P = 0.0368$) compared to that of *D. abyssinica* ($P = 0.0089$). The study suggested absence of flavonoid and coumarins in *S. luxurians* as a possible cause of the observed difference.

Further, the study suggests response of beta cells to *D. abyssinica* and *S.luxurians*, and the potential of saponins to ameliorate the effects of diabetes on the kidney, liver and glucose metabolism (Patel *et al.,* 2012) as some of the factors that may have prevented mortality as well as significant weight change at doses of 75 and 225mg/kg bwt.

From the study findings, both *D. abyssinica* and *S. luxurians* possessed hypoglycaemic activities in glucose loaded animals; thus, the bioactive chemicals present in these plants may have the potential to prevent hyperglycaemia after meals. This validates their use by the traditional healers from Narok and Nyeri County, respectively. Notably, both extracts did not reduce blood glucose level substantially across the hours after administration in diabetic mice; however, they did ameliorate the effects of STZ (Type 1 diabetes) after administration for 28 days. This property may slow onset of diabetes related etiologies which more often than not, lead to premature diabetes related deaths. Further, it demonstrates that, the two plants have the potential of

regulating and managing diabetes long term, either as a nutritional supplement or inclusion in holistic treatment approach by the practitioners. It also validates use of *S. luxurians* as a vegetable by the Kikuyu and other East African communities (Newmark, 2002; Gowele *et al.*, 2017) and thus its role in preventing onset of diabetes among the communities. Further, use of fruits of *D. abyssinica* and its roots in meat including other traditional herbs may explain the low prevalence of diabetes reported in Narok County.

CONCLUSION

The study concluded that, *S. luxurians* and *D. abyssinica* possessed antihyperglycaemic activity. The findings validated their use in the management and treatment of diabetes by THPs in Nyeri and Narok counties, respectively.

CHAPTER SIX

ACUTE TOXICITY STUDY OF *Dovyallis abyssinica* AND *Sonchus luxurians*

6.1 INTRODUCTION

Herbal medicine is a main stream form of treatment in use by traditional practitioners for centuries to counter health challenges facing community members. In USA, herbs are classified as dietary supplements, and therefore manufacturers are no longer required to obtain premarket approval; this has doubled its consumption (https://dash.harvard.edu/bitstream/handle/1/8852135/Doogan.pdf?sequence=1). Eighty per cent of African people use some form of traditional plant medicine, whose worldwide annual market is about US$ 60 billion (WHO, 2002b), a similar proportion of Kenyan population use herbal medicine (Lambert *et al.*, 2011), without understanding its potential to cause undesired effects. Noteworthy, a long history in use of an herbal medicine may not qualify it as safe. Contrary, there is a strong belief in majority of consumers and physicians that it's safe and healthy (Gesler, 1992; Winslow & Kroll, 1998).

Currently there are easy to follow procedures used to investigate safety of medicinal plants or chemicals. Acute toxicity tests aim to identify adverse change(s) occurring shortly after administration or exposure to a chemical on target organs (Gad & Chengelis, 1988), thus categorize herbal medicine and related dietary food supplements based on their degree of safety. The rat and mouse is the preferred animal model, but other animals could also be considered (Litchfield & Wilcoxon, 1949). Toxicity tests are a premarket requirement which should be firmly engrained in a country's National Health Policy. But according to WHO (2005) report,

Kenya lacks a national policy to regulate marketing of herbal medicine. Most consumers use herbal medicine believing that, plant based medicine is naturally safe compared to conventional drugs. Therefore, they ignorantly underestimate the inherent potential of plant materials to directly or indirectly cause health damage. According to Nyamwamu *et al.,* (2015), *Senna didymobotrya* is used to treat intestinal worm, diarrhea, ringworm, malaria and jaundice. However, acute toxicity tests of the root extracts demonstrated 80% mortality of the mice within 14 days. Additionally, plant based medicine possess, toxic chemicals that trigger multiple undesirable responses (Swanepoel *et al.,* 2008). The foregoing report underscores the need to carry out toxicity tests on plant based materials or chemicals to establish their safety. This study aimed at investigating acute toxicity of *D. abyssinica* and *S. luxurians* which were reportedly used by THPs in Narok and Nyeri County, respectively, to treat and manage diabetes.

D. abyssinica A. Rich Warb., as established in this study, was a medicinal plant used to treat diabetes by the THPs in Narok County and, syphilis, gonorrhea, fibroids and constipation in Nyeri County. It is also used to manage colic pain in infants, headache, eye infections and wounds in Marakwet County (Kigen *et al.,* 2014). In the present study, *S. luxurians* (R. E.Fries) C. Jeffrey were reportedly used by THPs in Nyeri County to treat diabetes. But in Nandi County, it used to treat fever, tonsils and stomach upsets (Jeruto *et al.,* 2010). In Tanzania, it is used to treat stomach problems and fever besides being used as vegetable (Ruffo *et al.,* 2002). Information on their toxicity was scanty, thus the current study investigated the potential toxic effect of aqueous extract of roots of *D. abyssinica* and leaves of *Sonchus luxurians* on female mice. The information was used to establish their safety for human consumption. It was also used to estimate the upper limit dose that may not cause adverse effects or death.

There are several methods of assessing acute toxicity of a substance including; the "classical" LD_{50} test designed to establish the mean lethal dose of the test substance. However, its disadvantage is that it uses high number of animals. Other methods such as “Limit Test” involve reduced number of animals and cost of the procedure while at the same time achieving reliable lethal estimates of a material (Gad & Chengelis, 1988).

6.2 MATERIALS AND METHODS

6.2.1 Acute Oral Test

In this study, acute oral test was carried out based on OECD guidelines 423 (OECD, 2001). Female white albino mice 6-8 weeks old with a body weight variance of 10% were obtained from the Central Veterinary Investigation Laboratories, Kabete, Kenya. The animals were randomly selected into three groups of three animals each including the control group; they were marked for easier identification. The room was maintained at 12h light and 12h darkness cycle, optimum temperature (22-25^{0}C) and humidity (48-50 %). They were allowed to acclimatize to laboratory conditions for 7 days, allowed free access to water and fed with rat chow from “Unga Group Limited”.

6.2.2 Administration of the Extract

The animals were fasted before dosing; but received feed 3 hours thereafter. A pink white, fluffy dry powder of *D. abyssinica* and dark green crystals of *S. luxurians* were dissolved in normal saline as a vehicle. The extract solutions were administered orally, at doses not exceeding volume of 0.1ml (https://iqconsortium.org/images/lG-3Rs/IQ-CRO_Recommended_Dose_Volumes_for_Common_Laboratory_Animals_June_2016_ (2).pdf).

The starting dose was 300 mg/kg bwt; if no deaths occurred at 300 mg/kg bwt, the test would be repeated at 2000 mg/bwt. However, if deaths occurred at 300mg/kg the test would be repeated at 50mg/kg. The animals were observed separately once during the first 30 minutes, periodically for the first 24 hours, and daily thereafter for a maximum of 14 days (EHSC, 2001). Toxicity signs and the time they occurred and disappeared were noted. Dead or moribund animals were to be subjected to gross necropsy and representative samples preserved in 10% formalin for histopathology. Based on the outcome of the acute toxicity test, LD_{50} (24h) was estimated as category 1, 2, 3, 4, or 5 according to OECD guidelines (OECD, 2001) annex 2c. At the close of the experiment, the animals were sacrificed under anaesthesia (16mg/kg bwt + 60mg/kg bwt i.m (xylazine +ketamine) (Parasuraman *et al.,* 2010).

6.2.3 Data Analysis

Qualitative statistics was used to describe the behavior of the mice post treatment.

6.3 RESULTS

6.3.1 Acute Toxic Effects of Aqueous Extracts of *Dovyallis abyssinica* and *Sonchus luxurians*

The animals did not show major clinical signs; however, general fur loss (alopecia) and piloerection and seeking for shade, among group two (2000mg/kg bwt) animals were observed (Fig 26, Fig 27). No death was recorded among the three groups. Both plants were therefore placed at category 5 at a dose of 2000mg/kg bwt, with an estimated LD 50 of 2500 mg/kgbwt based on OECD (2001) annex 2c.

Figure 26: Photograph of White Albino Mice showing Piloerection after Treatment with 2000mg/kg bwt of *Dovyallis abysinica* and *Sonchus luxurians*

Figure 27: Photograph of White Albino Mice showing Fur Loss after Treatment with 2000mg/kg bwt of *Dovyallis abysinica* and *Sonchus luxurians*

6.4 DISCUSSION

Human health determines physical activity and level of contribution to economic growth. Worth noting, the body's interaction with foods or chemicals can trigger responses whose effect is undesirable. This study showed that *D. abyssinica* and *S. luxurians* produced mild toxic effects; no morbidity or mortality were recorded in mice, they survived throughout the study period. According to OECD (2001) guidelines, respiratory, circulatory, nervous, somatomotor and behaviorial changes are major physiological indicators of toxicity of a substance. Other changes that require considerable attention include convulsions, tremors, salivation, lethargy, diarrhoea, sleep and coma. Notably, none of these signs were seen in the present study with the exception of fur loss and piloerection. The findings suggested that the plants were non-toxic at low doses when administered orally and thus validated the use of *D. abyssinica* by the Maasai and *S. luxurians* by the Kikuyu communities, respectively.

6.5 CONCLUSIONS

The study concluded that, *D. abyssinica* and *S. luxurians* had an estimated LD 50 of 2500mg/kgbwt, this suggests that, at low doses, the plants may not cause undesired effects sufficient enough to prevent its use as an antidiabetic medicinal plant.

CHAPTER SEVEN

GENERAL DISCUSSION, CONCLUSION AND RECOMMENDATION

7. 1 GENERAL DISCUSSION

World wide, traditional practices in various communities have developed and progressed gradually from divergent and most often than not, convergent set points. This has led to emergence of sociocultural changes brought about by migrations and globalization. Additionally, new communicable and non communicable diseases predispose the inhabitants to unprecedent health challenges (Napier *et al.,* 2014). But, faced with such changes and needs, research has shown that, environmental resources become the key factor that shapes communities' traditional knowledge and understanding. They also determine rate of adoption to a new traditional health management paradigm shift (https://www.sciencedaily.com/releases/2014/02/140213103517.htm). Pointedly, African culture has seen an expontential transformation. Its culture is gradually being replaced with western culture due to globalization (Kabiru, 2013). And, existence of satellite information (Scott & Marshall, 2005) and pressure from governments and missionaries who perceived such practices as witchcraft (Young *et al.,* 1988)

Thus, although use of traditional medicine is widespread, the reasons are divergent; communities from developed world use it in the management of chronic diseases (Molassiotis *et al,* 2005), but, in rural or low income communities it's their primary source of treatment (WHO, 2008a, 2013a). Currently, anthropological documentation about traditional health practices among divergent communities is the basis for ethnopharmacological research. The research has proven

to be a fundamental resource in the discovery of new drugs against resistant and chronic ailments, and its validation. Kenya is a multi-cultural country; it's a constituted of communities from divergent socio-economic and cultural background. A case in point is the Maasai and the Kikuyu communities who co-existed during the precolonial period. But migration of the former to the far southern part of the country has seen the two communitites go through divergent socio-cultural evolution.

From a convergent point of view, the survey revealed that, there were some diseases that were not treated by THPs from both commuinities, such as tuberculosis, accidents and emergency cases. Groups that were not treated included children and the elderly. Contrary to THPs from Nyeri County, pregnant women were treated in Narok County by mid wives who doubled as paediatrician. The study revealed that, similar to the the Kikuyu community in the precolonial period, there was evident ranking of Maasai THPs. They comprised of the the midwives, medicine man, the seer (oloibon) and the witch. Difficult to treat cases were referred to the seer who would attempt to explain the spiritual cause of the disease. It was presumed to have been caused by witchcraft or curse. This hierarchy explains why the study recorded presence of both gender in practice in Narok County.

Further, the Maasai THPs passed down their trade to younger members of the community or family through apprenticeship. This was lacking among their Nyeri counterparts; the study ascribed it to the high level of literacy, strong belief in conventional medicine and negative attitude towards traditional practices. Notably, majority of the THPs from both counties were elderly with most having been in the practice for over 20 years. However, the source of their traditional knowledge was contrasting; the Kikuyu THPs relied on both their elders as well as

formal sources like internet and books. However, rarely did the Maasai refer to modern sources of information. Instead, they mostly consulted community elders, family members or friends. The study attributed it to the strong adherence to traditional cultures by the Maasai's.

In contrast, the Maasai THPS held their traditional knowledge with high secrecy. Culturally such information could only be divulged to an aprenticee or after one has paid a token as required by their customs. This explained why despite rich traditions, the number of medicinal plants cited by THPs from Narok were fewer compared to Nyeri County. Evidently, THPS from Nyeri County had higher education and most were employed in the formal sector. This explained why majority of them refered to formal sources of information. Contrary, majority of THPs from Narok were illiterate and relied on herbalism as a source of income. Level of education among THPs in Nyeri County directly reflected on the educational level of their clients. This could explain the low level of clientele and the perceived negative attitude towards traditional medicine; which was a major challenge. Comparatively, majority of the clients in Nyeri were those suffering from chronic diseases. Reportedly, they resorted to traditional medicine as a last option. However, according to the THPs from Narok County, their clients' preffered herbal medicine as a first choice of treatment. They only turned to conventional medicine when the former failed. The strong belief in herbal medicine among the clients explained why some THPs claimed that they had treated cases referred to them by medical practitioners.

The major challenge that faced THPs from Narok was accessibity of herbs due to destruction of vegetation. But efforts to grow their own through agroforestry were not evident. On the contrary, conservation efforts through establishment of botanical gardens or agroforestry were observed among THPs from Nyeri.

Notably, most of the THPs from both Narok and Nyeri County had attended a workshop sponsored by the World Bank. According to THPs, the benefits were immense and the outcome underscored the benefits of such training. In particular, they learned about the preparation and administration of medicines, patient care and diagnosis through incorporation of modern techniques. Most of the THPs from Nyeri County were registered in the Ministry of Culture and Sports. The study attributed this to the belief that, their practice was more of a trade than community service, as was the case in Narok County.

Despite geographical isolation, the two communities had some similarities in traditional medicine. In both counties, the THPs demonstrated a deep knowledge of traditional medicine and also believed in combinational therapy. Moreover, they acknowledged that the main cause of diabetes was related to unhealthy diet and sedentary lifestyle. However, the prevalence of diabetes and diabetes related deaths were reportedly higher in Nyeri County compared to Narok. THPs from both counties demonstrated deep traditional knowledge on toxic plants. Both mentioned plants such as *Acokanthera schimperi*, *Ricinus communis* and *Synedenim compactum*. This information revealed why cases of poisoning or adulteration were rare among THPs despite the low level of education. Further, they were aware of medicinal plants that could be used to reduce or neutralize toxicity. For example, *Prunus africana* and *Carissa edulis.* In addition, they understood that some plants could possess toxic effects if dosage was exceeded, for example *Warbugia* and *Aloe Spp.* Pointedly, there was close similarity in the type of plants cited by the THPs from the two counties. This included; *Warbugia spp., Aloe spp., Prunus africana, R. myricoides, R. staddo, R. prinoides* and *U. massaica*. The most preffered method of preparation was decoction and parts harvested were the roots. However, the most common plant form was

shrubs and trees in Narok and Nyeri, respectively. The study attributed this disparity to geographical variations.

From Nyeri County, seventeen (17) antidiabetic plant species were documented which had not been investigated for their antidiabetic effect in previous studies. They were therefore cited for the first time in the current study as potential antidiabetic herbs. They included; *Dracaena steudneri*, *Clematis hirsuta*, *Gomphocarpus fruticosus, Periploca linearifolia*, *Lactuca inermis, Hydnora abyssinica*, *Myrsine africana*, *Spilanthes mauritiana, Ornithogalum tenuifolium*, *Grewia similis, Rhamnus prinoides, Rotheca myricoides, Sonchus luxurians, Sonchus asper, Teclea simplicifolia*, *Urtica massaica* and *Vernonia lasiopus*.

From the survey findings in Narok County nine (9) medicinal plants were for the first time cited to be antidiabetic. They included; *Dovyalis abyssinica, Faurea saligna, Rhamnus prinoides, Rhamnus staddo, Rotheca myricoides, Trimeria grandifolia, Urtica massaica, Warbugia ugandensis* and *Zanthozylum usambarensis. Acacia nilotica* leaf and pod extract had been investigated in other studies. However, administration of its roots as antidiabetic plant medicine was mentioned by Narok THPs, it was therefore documented for the first time.

The differences in traditional knowledge and practice among the Kikuyu from Nyeri and Maasai from Narok observed in the survey, was attributed to geographical isolation in the post colonial period. Reportedly, there were some aspects of their traditional cultures that they share todate due to their co-existence in the precolonial period. However, others have been acquired as a result socio-economic convergence in the 21st century.

Dovyallis abyssinica and *Sonchus luxurians* were among most cited antidiabetic medicinal plants in Narok and Nyeri County, respectively. Phytochemical screening identified presence of phytochemicals such as flavonoids, saponins, tannins, glycosides among others; which have known antidiabetic activities. This validated their therapeutic use in the treatment and managenent of diabetes by the THPs. However, absence of some phytochemicals such as flavonoids in *S. luxurians* underscored the need for phytochemical screening to elucidate efficacy of individual plant species.

Further investigation revealed that both *D. abyssinica* and *S. luxurians* possessed hypoglycemic activity. Postprandial test results showed that the extracts can prevent glucose overshoot after a meal. The findings suggest their use in management of diabetes. This study suggested increased glucose uptake and metabolism in the tissues as the possible mode of action.

Although there was no significant decrease across the hours, the two plants demonstrated significant antihyperglycemic activity when administered for 28 days. These findings further suggested their use in long term management of diabetes mellitus. Notably, efficacy of *S. luxurians* was comparatively lower than for *D. abyssinica*. This could be explained by the absence of some phytochemicals such as flavonoids; or difference in plant parts. It further answers the question on whether roots possess more phytochemicals as claimed by the herbalists. The most active doses were 75 and 225mg/kg bwt, notably; there were no related deaths. This confirmed the antidiabetic use of these plants and method of extraction by the THPs. The current study reported for the first time the antidiabetic activity of *D. abyssinica* and *S. luxurians.*

Findings from acute toxicity tests showed that *D. abyysinica* and *S. luxurians* did not possess deleterious effects 24 hours after administration of 2000mgs/kg bwt and no deaths were

recorded. Estimated LD50 was set at 2500mg/kg which further confirmed usage of these plants by THPs in the treatment of diabetes.

7.2 CONCLUSIONS

Based on the results, the present study established that;

i. THPs from Nyeri had a higher level of education compared to THPs from Narok County
ii. THPs from Nyeri cited more medicinal plants than THPs from Narok County
iii. Contrary to THPs from Nyeri County, THPs from Narok passed down traditional knowledge to the younger generation through apprenticeship
iv. Traditional herbal practice was prevalent among both men and women in Narok County, but was majorly among men in Nyeri County.
v. Low level of clientele and perceived negative attitude towards traditional medicine was a major challenge facing THPs in Nyeri County
vi. Poor or lack of conservation measures was common in Narok County
vii. THPs from both Narok and Nyeri County possessed indepth knowledge of the cause and prevention of diabetes, in addition to, treatment and management using traditional medicinal plants.
viii. *Dovyallis abyssinica* and *Sonchus luxurians* possessed antidiabetic phytochemicals
ix. *Dovyallis abyssinica* and *Sonchus luxurians* possessed antidiabetic activity, which confirmed their use as antidiabetic plants in Narok and Nyeri County, respectively.
x. *Dovyallis abyssinica* and *Sonchus luxurians* possessed mild toxic effects, and was therefore considered safe as antidiabetic medicicinal plants

7.3 RECOMMENDATION

The study investigated traditional medicinal knowledge among THPs from two diverse commnunities, and antidiabetic activity of selected medicinal plants. From the findings, the study recommended the following:

i. Public education in Nyeri County aimed at developing positive attitude and perceptions of the community members about importance of medicinal plants.

ii. Public education in Narok County about the importance of conservation of forests and vegetation as a community resource, the study advocated for agroforestry, and reduction in charcoal burning.

iii. Seminars and workshops between medical health stakeholders and THPs, to promote level of communication, aimed at infusing modern health technologies in traditional medicine practices as well as develop trust.

iv. Carry out quantitative analysis of phytochemicals present in *D. abbysinica* and *S. luxurians*

v. Investigate antidiabetic activity of *D. abbysinica* and *S. luxurians* using a different animal model such Wister rats

vi. Investigate antidiabetic activity of other parts of *D. abbysinica* and *S. luxurians* that were not investigated in this study.

vii. Investigate other antidiabetic medicinal plants cited in Narok and Nyeri County whose activity was not carried out in the present study.

viii. Sub-acute tests of aqueous extracts of the root of *D. abbysinica* and shoot of *S. luxurians* to further validate their safety

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This thesis was subjected to TURNITIN software (Appendix 1X)

APPENDICES

Appendix 1: Researchers Declaration

Research Project: Investigating the Efficacy and Safety of Antidiabetic Herbal Medicine from Selected Plants in Nyeri and Narok Counties, Kenya.

1. The above research will be undertaken with respect to the indigenous knowledge and intellectual property rights of the herbal practitioners/local community.

2. The researcher will at no given time initiate or conduct practices that are deemed to obtain information from the respondents by intimidation, coercion or false pretence.

3. That the respondent will be informed of the objectives of the project prior to questionnaire administration and in confidence to eliminate any degree of conspiracy.

4. That the researcher will be under no obligation to edit or tamper the information provided by the respondent.

5. That the herbalists and local community of Nyeri and Narok Counties are the owners of the traditional knowledge that will be presented in this questionnaire. Consequently, any benefits that may accrue from the use of this knowledge will be shared with them.

6. That the information to be collected will be used for described research purpose (for documentation of plants used by the Nyeri and Narok Counties' communities to treat diabetes and their related toxic effects) and not for other undisclosed intention.

Signatory researchers

1. Dr. M. Mbaabu

2. Prof. J. M. Mbaria

3. Prof Kiama

4. Prof Gathumbi

5. Loice Kamau

Principal researcher,

Signature……. Date……..

Appendix 11: Informed Consent of Agreement (To Be Administered To the Herbalist)

Title: Investigating the Efficacy and Safety of Antidiabetic Herbal Medicine from Selected Plants in Nyeri and Narok Counties.

Principal Investigator: Loice Njeri Kamau

Purpose of the study: The study findings may help stakeholder in the health sector to regulate and standardize use of herbal medicine in the treatment of diabetes. This study may lead to appreciation of our cultural heritage which is critical to preservation and conservation of indigenous knowledge and herbs, respectively. More importantly, generalization about the impact of cultural and socio-economic variance on current and future approaches towards diabetes treatment and management can be made. Lastly the study may also make contributions to the seldom research and scholarly efforts to document plant herbs besides validation of their quality and safety

Procedures to be followed: Registered herbalists and community members will be purposively sampled, an interview date shall be set, and thereafter, questionnaires shall be administered.

Duration: The interview shall take approximately 15 minutes

The risks involved in the study: participating in this study shall not expose you to any risks.

Statement of confidentiality: The information given and the particulars of the participant shall be held with utmost confidentiality.

Right to ask questions: After the interview may ask any question concerning the study or may contact the researcher for any clarification thereafter.

Benefits of participants: The information obtained in this study shall be documented for future reference by the public including the participants for use in their practice. Moreover, efficacy and safety of herbal medicine has been a major issue of concern, thus validation of antidiabetic herbs and determination of their safety shall greatly assist the herbalists in administering the herbs appropriately while safeguarding the safety of their clients.

Voluntary Participation: Your decision to participate is voluntary; you do not have to answer the questions you don't want to.

Declaration: If you agree with the above information please sign below;

Signature…….. Date……

I---------- hereby agree to participate in this study/project with my full consent and declare that to the best of my knowledge, the information that I am going to provide on the use of medicinal plants used to treat diabetes in Nyeri/Narok County is true, accurate and complete.

Appendix 111: A Questionnaire Administered to Traditional Herbal Practitioners, in Ethnobotanical Survey of Antidiabetic plants used in Nyeri and Narok County, Kenya

Section A: Demographic Information

Enumerator (Name)…… Signature…… Date of interview…… Serial number…… Name of respondent…… Division……..Location……Sub-location…… Village……Telephone……Gender

Answer by ticking (√) in the appropriate box in the following

1. What is your age?

a) Below 18 years { } b) 18-27 years { } c) 28-37 years { }

d) 38-47 years { } e) 48-57 years { } g) over 57 years { }

2. What is your highest level of education?

a) Primary { } b) Secondary { } c) College { }

d) University { } e) others (please specify)……

3. What is your religion? .....

4).What is your professional training? .....

5. Are you currently practicing in your profession? a) Yes { } b) No { }

6. If no, please explain ……

7. Are you employed? a) Yes { } b) No { }

8. If yes, what is the nature of employment? .....

9. What is your major source of income? .....

10. For how long have you practiced as a traditional herbalist? .....

11. Where do you practice as a traditional herbalist (location)? .....

12. How did you acquire your skills as an herbalist? ……

13. Have you attended any training in your practice? a) Yes { } b. No { }

14. If yes, please explain ……

a) If yes where did the training take place……

b) Was the training facilitated yes { }. No { }

c.) If yes, who was the facilitator a) the government { }, b) NGO { }, c) the church { }, d) herbalists' association { } e) ministry of health { } f) any other (please explain)…

b) Level of training ……

15. How else do you obtain information about the practice? a) Elders { } b) Friend(s) { } c) Radio { } d) T.V { } e) Internet { } f) Books { } g) Any other Please explain ……

16. Do you attend seminars/workshops? a) Yes { } b) No { }

17. If yes what was the main topic.....

18. Was the seminar beneficial to your profession a) Yes { } b) No { }

19. If yes, please explain ……

19. Do you belong to any form of group owned by herbalists? a) Yes { } b) No { }

20. If yes, what is the name of your group? .....

21. Is the group registered? a)Yes { } b) { }

Name the registering institution----

Section B: Traditional Knowledge on Herbal Medicine

22. a) List in order of priority list of diseases that you treat with herbs

Serial No.	Name of disease	Maasai (Local name)	Kiswahili	English
1				

b) I) Are there some diseases that you do not treat? Yes ( ) No ( )

ii) If Yes, which ones?

c) i) Are there some age groups that you do treat? Yes ( ) No ( )

ii) If yes, which ones? …….

d) i)Are there some cases that you refer to hospitals? Yes ( ) No ( )

ii) If yes, which ones? ……

Section C: Traditional Knowledge about Diabetes

Part 1: Diabetes Morbidity

23**.** Does diabetes occur in this area ( ) a) Yes { } b) No { }

24**.** What is the local name for diabetes in this area? .....

25 i) Do you know people that have died of diabetes in your area? Yes ( ) No ( ) If

ii) If Yes how many

Part 2: Demand for your service

26i) Have you treated any case(s) of diabetes for the last one year? A) Yes { } b) No { }

ii) If yes, how many cases of diabetes did you treat for the last one year? ……

27**.** When did you last treat the last diabetic patient? .....……

28. Please tell me, what's the total number of patients you have treatment for diabetes;

a) Last week ……

b) Last month……

C) Last year…….

Part 3: Factors Responsible For Causing Diabetes

29**.** How do you know that someone has diabetes (What are the signs and symptoms of diabetes), Please explain…….....

30. What causes diabetes? Please explain……

31. What age group is commonly affected by diabetes? .....……..

32. Which gender is most affected a) male { } b) Female { } Please explain why? …….....**...**

33. How common are diabetes cases in this area (Tick as necessary) a) Very common { } b) Common { } c) Rare { } d) None { }

34. Other than age and gender, are there other conditions that are likely to increase the chances of getting diabetes? Please explain ……

35. In your own opinion, what factors do you associate with diabetes in this area? Please list them

i. ……..

ii. …….

36. i) Do you associate diabetes with diet**?** a) Yes { } b) No { }

ii) If yes, please explain……

Part 4: Diabetes Control and Treatment

37) In your own opinion what measures would you take to prevent diabetes? ……

38. Please tell me how you treat diabetes ……

39. What modern methods of managing diabetes do you incorporate in your treatment regime? .....

40. Do you prefer herbal medicine to drugs from hospital? a) Yes { } b) No { }

41. Have you treated a case of diabetes referred to you by a medical practitioner from hospital? a)Yes{ } No { }

42 (i)**.** Have you treated cases which are already seeing medical practitioner? a).Yes { } b) No { }

ii) If yes, what reason(s) do they give? ……

43(i). Do the patients combine herbs and medicine from the hospital? a) Yes { } b) No { }

ii) If yes, do they inform you about the medication from the hospital? a) Yes { } b) No { }

iii) If no, do you ask them about the medicine a) Yes { } b) No { }

iv What advice do you give them? Please explain ……

44. What is your opinion concerning combining of herbal and hospital medicines?, please explain

Section D: Challenges in Herbal Medicine Practice

45. What are the major challenges you face in treating and managing diabetes? Please list them……

Section E: Harvesting, processing and administration of herbal medicines from medicinal plants

46 Which medicinal plants do you use to treat diabetes and how do you use them? Please fill in the table below.

Plant (vernacular Name)	**Other name(s)**	**Status e.g.** **Cv=cultivated;** **We=weed;** **Wi=Wild;** **Sw=semi wild, or both**	**Habitat e.g.** **Bm=Boundary** **Marker;** **Bu=bush;** **Cf=crop field;** **Cp=compound**	**Part used e.g.** **R=root;** **Bk=bark;** **L=leaves;** **T=tuber;** **F==fruit**	**How is it prepared**
1					

Section F: Dosage, preparation and administration

47. Among all plants that you have just mentioned, which plants do you commonly use to prepare herbal remedies for the treatment of diabetes in order of their efficacy? Please fill the table below.

Name of the plant(vernacular)	**Part used(roots, tubers, bark, leaves, fruits, stem, bulb, others(specify)**	**Preparation (powder, boil single, mixture, soaked in water-how much of plant in how much water?**	**Administration(oral, rectal, inhalation, bathed, others(please specify)**	**Dosage (how much is given, after how long and for how long?)**	**Side effects reported/ remedy**

48. i) Are the doses different for the different groups of people a) Yes { } b) No { }

ii) If yes how are they different? Please explain ……

49. How long does your medicine take before being spoiled? ……

50. How many patients out of ten recover fully? ……

51. How do you tell that a patient has recovered? ……

Section G: Toxicity

52(i) Can some plants cause other effects besides treating diabetes? Yes { } b) No { }

ii) If Yes, please explain……

53i) Can some plants cause problems if the dosage is exceeded? a)Yes { }b) No{ }

ii). If yes, can you tell me the risks associated with too much dosage in the mixture you consider most risky. Please fill in the table below.

Names of the most risky mixture (Name plants used in the mixture	**Plants associated with the risk**	**Risk of overdose**	**Antidote (What herb do you use to neutralize)**
1			

54. Have you ever experienced a case of over dosage? A) Yes { } b) No { }

55. If yes what happened and how did you respond to the side effects?

56. Do you use some plants to reduce toxicity (if at all) in the preparation of herbal medicine to treat diabetes case? A) Yes { } b) No { }

57. If yes, please fill in the table below

Name of plant to reduce toxicity	**Part used**	**Amount used in the mixture for diabetes treatment e.g handful, half Kg, etc…..**	**What is done to he Plant part before mixing**

58**.** Which plants do you consider to be toxic to both animals and humans? Please fill the table below.

Name of toxic plant (Vernacular name)	**Toxic effects/system affected**

Appendix 1V: Photograph showing closed flower buds of *Sonchus luxurians*

Appendix V: Photograph showing a young shoot of *Sonchus luxurians*

Appendix VI: Photograph of open flowers of *Sonchus luxurians*

Appendix VII: Photograph of Mature woody stem of *Sonchus luxurians*

Appendix V111: Photograph of leaves of *Dovyallis abyssinica*

Appendix 1X: Publications

TANG [HUMANITAS MEDICINE]

Original Article

Ethnobotanical survey and threats to medicinal plants traditionally used for the management of human diseases in Nyeri County, Kenya

Loice Njeri Kamau[1,*], Peter Mathiu Mbaabu[1], James Mucunu Mbaria[2], Peter Karuri Gathumbi[3], Stephen Gitahi Kiama[1]

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ABSTRACT

In Kenya, traditional knowledge on herbal medicine has remained a mainstream source of maintaining wellbeing for generations in many communities. However, the knowledge has been eroded in the course of time due to sociocultural dynamics virtually advanced by Christianity and formal education especially in the Kikuyu community. The study documented current ethnobotanical knowledge and threat to the traditional knowledge on medicinal plants among the Kikuyu community. A survey was carried out in Mathira, Tetu, Kieni, Othaya, Mukurweini, and Nyeri Town constituencies. Thirty practicing herbalists were purposively sampled; 5 per constituency. Data was obtained through semi - structured questionnaires and analyzed both qualitatively and quantitatively. A total of 80 ailments treated using 111 medicinal plant species distributed within 98 genera and 56 families were documented. Prevalent communicable diseases treated using herbal medicine included; gonorrhea (17.5%), malaria (15%), respiratory infections (12%), colds (10%) and amoebiasis (10%). Non-communicable diseases were; joint pains (11.1%), ulcers/hyperacidity (8.7%), high blood pressure (8.7%), intestinal worms (11.1%) and arthritis/gout (10%). Frequently harvested plant materials were; roots, barks and leaves. The study concluded that, traditional medicine practitioners in Nyeri County possessed wide knowledge of herbal medicine but this knowledge was on the verge of disappearing as it was largely a preserve of the aged generation. The study recommended massive campaign about the benefits of using herbal medicine in the study area. Further pharmacological studies are recommended on the mentioned plant species aimed at establishing their efficacy and safety as well as standardization as potential drugs.

Keywords traditional medicine, Kikuyu comunity, Nyeri County, Kenya

TANG [HUMANITAS MEDICINE]

Original Article

Medicinal plants used in the management of diabetes by traditional healers of Narok County, Kenya

Loice Njeri Kamau[1*], Peter Mathiu Mbaabu[1*], Peter Gathumbi Karuri[3*], James Mucunu Mbaria[2*], Stephen Gitahi Kiama[1]

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ABSTRACT

The Maasai community from Kenya is highly esteemed for their strong adherence to traditional cultures and ethno medicine. This is attributed to their age-old traditional mechanisms of passing down knowledge to the younger generation. Adoption to new socio-economic lifestyle and urbanization has been associated with development of diabetes, which has been reported among some indigenous pastoral communities in Kenya. Documentation of traditional methods of treatment and management of diabetes by the Maasai has not yet been reported, yet it is noteworthy. Thirty traditional healers from Narok County were purposively selected and interviewed about traditional knowledge of antidiabetic medicinal plants, parts used, preparation dosage and administration. A total of 14 antidiabetic plant species distributed within 13 genera and 12 families were identified and documented as herbal medicine used in the management of diabetes. The most highly cited plant species was Dovyalis abyssinica (20%), the plant family Flacourtiaceae and Rhamnaceae (2 plant species each) recorded the highest number of plant species while the most frequently used plant part was the roots (46%). Literature review revealed that some of the cited plants have known phytochemicals with antidiabetic activity; the study recommends further scientific investigation to validate their efficacy and safety.

Keywords diabetes, traditional medicine, Narok County, Kenya

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Knowledge and demand for medicinal plants used in the treatment and management of diabetes in Nyeri County, Kenya

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ABSTRACT

Ethnopharmacological relevance: Non communicable diseases are currently a major health challenge facing humanity. Nyeri County has one of the highest diabetes prevalence in Kenya (12.6%), compared to the country's prevalence of 5.6%. The purpose of the study was to document; diabetes knowledge, medicinal plants and demand for the services of traditional medicine practitioners, in the management and treatment of diabetes.

Methods: A cross-sectional study was carried out in the six constituencies in Nyeri, using pre-tested semi-structured questionnaires. Thirty practicing traditional medicine practitioners were purposively selected for the study. Field observation and identification was carried out on all plants that were cited during the interview. Plant samples were collected and voucher specimen deposited in the University of Nairobi Herbarium in the – School of Biological Sciences.

Results: The study revealed 30 plant species in 28 genera and 23 families that are used by the traditional medicine practitioners to treat and manage diabetes. Demand for traditional medicine practitioners' services in the treatment of diabetes is low and often occurs when conventional drugs fail.

Conclusion: Interaction with the TMPs unveiled significant diversity of potential anti diabetic medicinal plants and in-depth ethnobotanical knowledge that they possessed. Preference for traditional herbal medicine was low despite wide ethnobotanical knowledge in the face of high prevalence of diabetes in

APPENDIX X: TURNITIN ORIGINALITY REPORT

STUDY OF EXTENT OF USE, EFFICACY AND ACUTE TOXIC EFFECTS OF SELECTED ANTIDIABETIC PLANTS IN NYERI AND NAROK COUNTIES, KENYA BY Loice Kamau

From PhD Thesis (Vet Anatomy and Physiology)

Processed on 03-Feb-2018

ID: 904322218

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