

Original Article

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

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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

INTRODUCTION

Botanical remedies has been used to manage diseases from ancient times as they are easily accessible, affordable and over time been accepted as effective and safe (WHO, 2002). Emergence of non-communicable diseases has posed a great health challenge to countries particularly in Africa. Indeed, low and middle income economies in Africa are expected to lead with deaths arising from non-communicable diseases like diabetes by the year 2030, as a result of changes in lifestyle (Mbanya et al., 2010). Increased cases of diabetes mellitus have been reported among communities of both developed and developing countries (Onkamo et al., 1999). Sub-Saharan Africa is largely a developing region, in the year 2000, a total of 7.1 million people had diabetes; this figure is expected to rise to about 18.6 million by the year 2030 (Wild et al., 2004). In South Sudan, an upward trend of 8% to 14 % has been observed since independence while among the Tuareg and Moors indigenous communities of Mali, a prevalence of 2.61% has been recorded (IDF, 2012).

Kenya is one of the middle income economies, 43% of health facilities are provided by the government while a large

proportion of its population (78%) lives in the rural area (Yonga, 2011). It is among countries with a high prevalence of diabetes and exponential rate of increase. The first medical case of diabetes in Kenya was diagnosed in an obese patient who worked for a British employer in 1933 (Trowell and Burkitt, 1981). Notably, by 2007 diabetes prevalence had reached 1.2 million and the figure is projected to reach 1.5million by 2025, which translates to a prevalence of 4.5 % among its general population (The Nation, 30 Jun 2007). In 2012, WHO attributed 1% of the total mortality in Kenya to diabetes (WHO, 2014) as result of overweight, obesity and other lifestyle habits like smoking (Yonga, 2011). Although Kenya is among countries with a growing level of diabetes knowledge (Atieno, 2006); majority of the rural population do not have diabetes knowledge (Maina et al., 2011). Isiolo County, which is largely occupied by pastoralist community, has a prevalence of 16% with a RBS ≥ 11.1 mmol/l, out of which 37.5% are unaware of their blood sugar level status (Hemed et al., 2014). In Rift Valley region of Kenya (Karekezi et al., 2011), has reported a prevalence of 2.4% among pastoralist communities. The Maasai are a pastoral community; they occupy the Northern part of Tanzania and Southern part of Kenya. A prevalence of 22.9% and 9.9% has been recorded in the urban and rural settings respectively, in Ngorongoro, Tanzania (Masaki et al., 2015) while 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). Significant health effects due to change in dietary lifestyle that led to increased cholesterol levels have been observed among the rural and urban Maasai (Day et al., 1979). Diabetes treatment using

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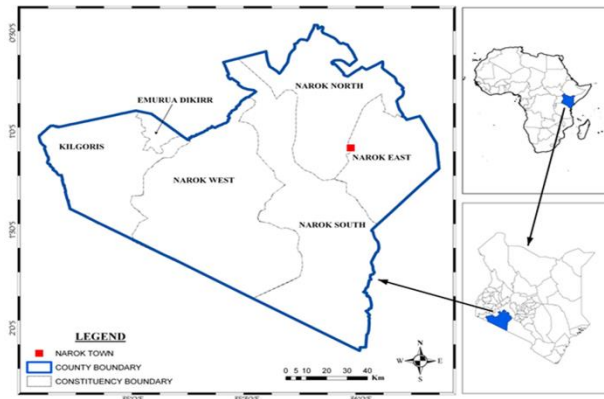


Fig. 1. Administrative map Narok County in Kenya

allopathic medicine is faced with a myriad of challenges like, high cost of the drugs, progression of the disease despite patient compliance to the prescribed regimen and undesirable side effects (DeRuiter, 2003).

However, traditional remedies have remained a mainstream source of primary healthcare in many communities. Among the Maasai people, use of traditional herbs is deeply rooted into their culture, thus a lot of knowledge on different plant resources that are of medicinal value has been retained (Sindiga, 1995). Indeed, every person in the Maasai family and by extension the entire community has basic knowledge on the use of ethno-medicine from childhood, a skill that is acquired as they grow and mature to elders (Kiringe, 2005). However, despite lifestyle changes and diabetes occurrence, the Maasai community (73%) has steadfastly considered traditional medicine their first line of treatment (Bussmann et al., 2006, Kiringe, 2006).

This study believed that, investigating medicinal plants used by the Maasai Traditional healers (TH) to treat diabetes would reveal significant plants possibly unknown to communities whose traditional knowledge has eroded with time. This study aimed at identification and documentation of; knowledge on diabetes, treatment approaches as well as demand for antidiabetic medicinal plants in Narok County.

MATERIALS AND METHODS

Study area: Historical background of the Maasai community and their habitat

The Maasai people are found in the southern and northern region of Kenya and Tanzania, respectively. In Kenya, one group of the Maasai community (which constitutes of the Ilampur (Samburu) and the Ilcamus (Njemps)), live in the northern parts of the rift valley while the other group, (the Ilarusa, Ilmoitanik, Ilwuasinkishu, Isiria, Ilpurko, Ilkeekonyokie, Ildamat, Iloitai, Isikirari, Ildalalekutuk, Iloodokilani, Ildamat, Ilkaputiei, Ilkisonko and the Ilmatapato), occupy the southern part. Both groups speak “Maa” language whose historical roots are the Eastern Sudanic language (Maa). The Maasai community originated from Chad and migrated southwards through the Great Rift Valley and before colonialism, they had occupied two-thirds of Kenya, but in 1911, after signing an agreement with the white settlers, much of their land was taken away, thereby losing their native rights. Consequently, and in addition to further encroachment from the neighboring communities, the Maasai community has been confined to Kajiado, Narok and Samburu Counties (Patrick et al., 2001).

The current study was carried out in Narok County, which 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 is 1827 meters above sea level. It borders the republic of Tanzania to the South, Nakuru County to the North, Kisii, Nyamira and Bomet Counties to the Northwest, Migori County to the West and Kajiado County to the East. Narok has 6 constituencies namely; Narok North, Narok South, Narok West, Narok East, Kilgoris and Emurua Dikirr (Fig.1). The County has a total population of 850,920 within an area of 17,921.20 km². The climate consists of a temperature range of 8-28 degrees Celcius, characterized by a bimodal rainfall pattern and an average rainfall of 500-1800 mm per year. The lowland parts of the County experiences seasonal flooding. Mt. Suswa is a major land mark of the County and is one of the tourists' attractions.

Socio-economic activities

Traditionally, they have been a nomadic pastoralist community but have recently, visibly metamorphosed into a sedentary agro-pastoralist community, due to rapid socio-economic changes in addition to, rural urban migration in search of jobs. The rural Maasai engages in; livestock husbandry, subsistence farming and large scale farming, major cash crops are maize, wheat and barley.

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.

Study approval and collection of data

The study was approved by the National Commission for Science, Technology and Innovation (NACOSTI). Following consultation with officer in charge, in the Ministry of sports and culture and in addition to information from the local communities, 30 traditional healers (TH) were purposively selected based on their free will consent to participate. Selection criteria were TH that were born and had been practicing within the study area. Through a cross sectional survey, interviews were carried out in Maa language but recorded in English. The information obtained included; demographic details, diabetes prevalence, knowledge, cause and prevention, name of plant(s) used to treat diabetes in the study area, dosage and route of administration besides plant status and habitat.

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 TH. 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).

Data analysis

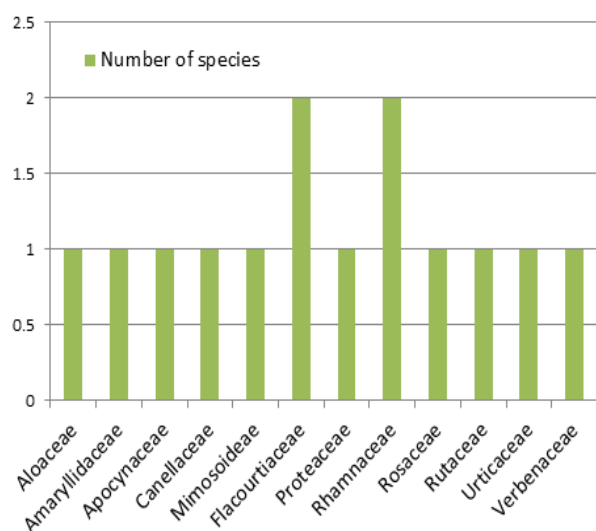
Data was summarized into themes and analyzed using content analysis and descriptive statistics such as proportions, percentages and frequencies. Ethnobotanical relevance by the traditional healers was calculated as follows; UVs (total Use Value of each species by all informants) = $(\sum UV_i) / (n_i)$; UV_i represented the Use Value of each species mentioned by each traditional healer while n_i represented number of interviews carried out in one informant (Hoffman and Gallaher, 2007; Phillips and Gentry, 1993).

Table 1 : List of antidiabetic plant species used to manage diabetes in Narok County, Kenya

Family	Scientific name Voucher number	Maasai name	Life- form	Habitat	Parts used	Preparati- on	Frequ- ency	Use value
Aloaceae	Aloe secundiflora Engl. LNM15/12	Osukuroi	Herb	Wild	Leaves	Decoc- -tion	2	0.7
Amaryllid- -aceae	Allium cepa L. LNM15/10	Kitunguu	Herb	Cultivat- ed	Leaves	Crush- ed	3	0.1
Apocynac- -ae	Carissa edulis (Forssk.) Vahl LNM15/05	Olamuriaki	Tree	Wild	Roots	Decoc- -tion	5	0.17
Canellace- -ae	Warbugia ugandensis Sprague LNM15/14	Osokonoi	Tree	Wild	Bark	Decoc- -tion	1	0.03
Mimosoid- -ae	Acacia nilotica (L.) Delile LNM15/06	Olkirorit	Shrub	Wild	Roots	Decoc- -tion	5	0.17

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.

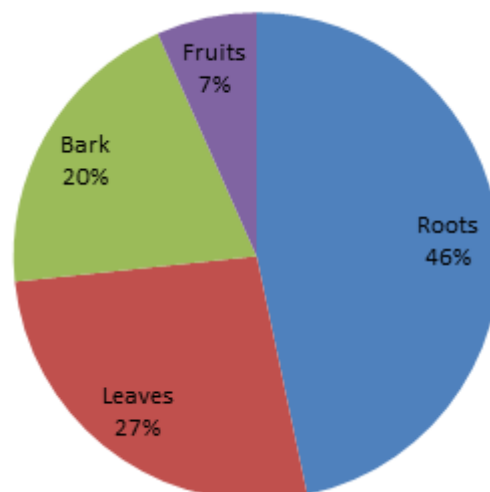
**Fig. 2.** Families of antidiabetic medicinal plants in Narok

RESULTS

It was revealed that, diabetes was locally known as engeae sukari (42%) or Emuyian esukari (58%). Eighty two percent (82%) of the TH reported its occurrence, but they (73%) added that, its prevalence was low. Additionally, 50% of the TH reported that there were cases of diabetes related deaths in the area, but morbidity was low, 67% of the TH had witnessed only 1-5 deaths and 33% 6-10 deaths. Results of the study showed that, the TH (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 TH 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 TH reported that, on average,

they treated 1-5 patients while 6% had treated 6-10 patients within the past year.

Majority of the TH understood the causes of diabetes (81%) and its symptoms (85%). Major causes included; refined foods (95%) and stress (5%). According 50% of the TH, 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 TH, 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%).

**Fig. 3.** Most used antidiabetic plant parts

The results showed that, the TH 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, 9% said conventional drugs can 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

Table 2. Cross reference of antidiabetic plant species documented in Narok County against published data

Scientific and family name	Ethnopharmacological activity/ phytochemical components	Ethnomedicinal uses
<i>Acacia nilotica</i> (Mimosoideae)	Leaf extract has hypoglycemic activity and increases serum insulin in diabetic rats (Asad et al., 2011). Aqueous methanol pod extract lowers blood glucose levels, restores serum urea and creatinine, ameliorates diabetes complications; superoxide dismutase (SOD), lipid peroxidation (LPO), glutathione (GSH) activity (Omara et al., 2012). Contains terpenoids, tannins, alkaloids, saponins and glycosides, antimicrobial activity (Banso, 2009).	Used to treat insomnia, skin diseases and fungal infections (Olowokudejo et al., 2008). Stem bark as a stimulant and excitant (Muthee et al., 2011). The leaves, roots and stem bark in the management of chronic pain (Wambugu et al., 2011).
<i>Allium cepa</i> L.(Amaryllidaceae)	Antioxidant and hypoglycaemic activity (Campos et al., 2003). Protects against diabetes induced vasoconstriction (Mahmoud et al., 2013). Contains quercetin (Lombard et al., 2005; Singh et al., 2009), ferulic, gallic, protocatechuic acids, and kaempferol, strong anti-mutagenic and antioxidant activity (Singh et al., 2009).	Manage sprain, edema and bruise (Ugulu et al., 2009); treat erectile dysfunction and sexual impotence (Mugisha and Origa, 2005).
<i>Aloe secundiflora</i> (Aloaceae)	Exudate contains anthrones (aloinin, aloenin B, barbaloin, isobarbaloin and other aloin derivatives), phenylpyrones and chromones (Waihenya et al., 2003), antibacterial (Wagate et al., 2010) and antihyperglycemic activity (Abdirahman et al. 2015).	Leaves used to treat malaria and wounds (Muthee et al., 2011) leaves and root juice applied topically to treat injured tissue (Wambugu et al., 2011) leaf gel of taken in the management of diabetes (Keter and Mutiso 2012). Leaf decoction taken to treat HIV/AIDs and STDs in general (Njoroge and Bussman, 2009).
<i>Carissa edulis</i> (Apocynaceae)	Hypoglycemic (Fathy et al., 1996) and anti-viral activity (Tolo et al., 2006). Lignan compound nortrachelogenin from methanolic root bark extract has anti-plasmodial activity (Kebenei et al., 2011), soxhlet root bark extract has diuretic activity (Nedi et al., 2004); Contains alkaloids, saponins, terpenoids and flavonoids (Jeruto et al., 2011).	Treatment of gonorrhoea, syphilis, headache, chest complaints, rheumatism, rabies and as diuretic (Nedi et al., 2004); and treat malaria (Njoroge and Bussmann 2006).
<i>Dovyalis abyssinica</i> (Flacourtiaceae)	Dichloromethane and methanol leaf extracts shows anti-trypanosomal activity (Tadesse et al., 2015). Contains alkaloids, tannins, polyphenols, saponins, sterols, terpenes, and glycosides, antimicrobial activity (Abebe et al., 2005).	Manage wound, hemorrhoids, ulcers, throat inflammation, oral hygiene (Engidawork and Abdissa, 2011), immune booster and chest ailments or pneumonia (Amadi, 2013; Amuka et al., 2014) and treat malaria (Njoroge and Bussmann 2006). Leaves used to treat indigestion (Muthee et al., 2011) and root decoction manage postpartum weakness (Njoroge and Bussmann 2009).
<i>Faurea saligna</i> (Proteaceae)	Antimicrobial (Mthethwa, 2009) and antifungal activity against candida albicans (Mangoyi and Mukanganyama, 2011).	Manage wounds and sores (Mthethwa, 2009) treat candidiasis and fungal infections (Masevhe et al., 2015) and roots stomach problems (Muthee et al., 2011).
<i>Prunus Africana</i> (Rosaceae)	Anti-HIV-1(Rukunga et al., 2002) antifungal, antibacterial (Bii et al., 2010) hypoglycemic activity (Maina et al., 2014). Has less acute toxic effect (Nabende 2015). Contains triterpenic acid including ursolic and oleanolic acids (Fourneau et al., 1996), n-tetracosanol, fatty acids, sitosterol, sitostenone, friedelin, maslinic acid (Catalano et al., 1984).	Treat malaria (Amuka et al., 2014; Njoroge and Bussmann 2006) and pneumonia (Amadi, 2013). Infusion of stem bark and roots orally taken in the treatment of cancer (Ochwang'I et al., 2014), prostate and urinary tract infections (Wambugu et al., 2011) bark decoction management of back pain in women and treatment of HIV/AIDs (Njoroge and Bussman, 2009).

<i>Rhamnus prinoides</i> (Rhamnaceae)	Contains anthraquinones emodin, emodinanthrone, prinoidin and the flavonoid rhamnazin (Berhanu and Martin GP, 1995), tannins, alkaloids, cardiac glycosides, triterpene, saponins, phenols and resins; methanol water extract has antibacterial (Amabye, 2015) antimalarial activity (Muregi et al., 2007).	Treat malaria (Njoroge and Bussmann 2006), roots, leaves, fruits and stem bark used in the treatment of gonorrhea, prostate, malaria and brucellosis (Muthee et al., 2011), root and stem decoction in management of back pain and postpartum weakness (Njoroge and Bussman, 2009).
<i>Rhamnus staddo</i> (Rhamnaceae)	Antimalarial activity (Muregi et al., 2007) root extract in combination with some selected herbs has antifungal activity (Odhiambo et al., 2009) leaf extract has taenical activity (Desta, 1995). Methanol root extract contains tannin, flavonoids, alkaloids, steroids, terpenoids, and flavone aglycone (Onyango et al., 2014).	Treat malaria ⁴⁴ roots, stems, leaves and fruits in the management of gonorrhea, diabetes and endometritis (Wambugu et al., 2011).
<i>Rotheca</i>	Anti-mutagenic activity (Verschaeve and Van Staden, 2008). Contains alkaloids, terpenoids and flavonoids (Jeruto et al., 2011).	Used to treat malaria (Orwa et al., 2007), Njoroge and Bussmann, 2006) pneumonia (Amadi, 2013) root decoction in the management of chronic pain (Wambugu et al., 2011), STDs in general, as an aphrodisiac (Njoroge and Bussmann, 2006), leaf decoction in management of diabetes (Keter and Mutiso, 2012).
<i>Trimeria grandifolia</i> (Flacourtiaceae)	Contains idesin, lupenone and β -Sitosterol; anti-plasmodial activity ⁶⁸ .	Used to treat malaria (Orwa et al., 2007; Njoroge and Bussmann, 2006) roots in management of back pain in women and stem decoction in postpartum weakness (Njoroge and Bussmann, 2009).
<i>Urtica massaica</i> (Urticaceae)	Stems extract contains saponosides, flavonoids, anthocyanin, sterols and tannins. Hydromethanolic extract exhibits antibacterial activity against <i>Salmonella B</i> , <i>Escherichia coli</i> , and <i>Shigella flexneri</i> (Nahayo et al., 2008). Safe, with slight renal toxicity up to high dose of 5000 mg/kg (Oloro et al., 2015)	Used to treat malaria (Njoroge and Bussmann, 2006) , dried powder applied topically to treat skin cancer (Ochwang'I et al., 2014) leaf decoction taken orally to manage diabetes (Keter and Mutiso, 2012). Roots decoction is used as an aphrodisiac (Njoroge and Bussmann, 2009).
<i>Warbugia ugandensis</i> (Canellaceae)	Has antiviral activity against measles virus (Parker et al., 2007), cytotoxicity (Choi et al., 2015), antibacterial activity against <i>Staphylococcus aureus</i> (Maobe et al., 2013), Merawie et al., 2013), <i>E. coli</i> , <i>P. aeruginosa</i> , <i>S. boydii</i> , and <i>Streptococcus pneumonia</i> , antifungal activity against <i>Candida albicans</i> (Merawie et al., 2013). Contain kaempferol and galangin, naringenin, flavanone and (Yonga, 2011); coloratane sesquiterpenes demonstrates antimicrobial activity (Wube et al., 2005).	Used to manage erectile dysfunction, sexual impotence (Mugisha and Origa, 2005) and diabetes (Maobe et al., 2013), treat malaria (Njoroge and Bussmann, 2006) and stem bark respiratory diseases (Muthee et al., 2011). Bark decoction used in management of back pain in women and leaves in regulation of menstrual cycle (Njoroge and Bussmann, 2009)
<i>Zanthoxylum usambarens</i> (Rutaceae)	Anti-plasmodial activity, not toxic (Kirira et al., 2006).	Roots and fruits used to treat malaria, respiratory diseases and diarrhea (Muthee et al., 2011).

(46%) had had previous contact with a medical practitioner. They all (100%) reported that, major reasons why patients had sought herbal besides conventional treatment was because they believed that former was more effective than the latter.

About 14 antidiabetic medicinal plants occurring in 13 genera and 12 families 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* (Olkiroir), *Faurea saligna* (Olorote), *Rhamnus prinoides* (Orkonyiel) and *Urtica massaica* (Entantamenjoi), 16.7% each (Table 1). 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 (Fig. 2). The most preferred plant parts were roots (46%) and leaves (27%) (Fig. 3). The plants species were mainly trees (50%) and shrubs (29%) while herbs were not

frequently used (21%). The plants mainly 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 method of administration while dosage was rarely disclosed.

Ethno therapeutic uses of antidiabetic plants that were documented and identified in Narok have been reported in various surveys in treatment and management of various diseases; as anti-inflammatory agents (18%), reproductive (17%), antiprotozoal (malaria in particular) (15%) anti-respiratory disease agent (7%) and others (21%). Interestingly, very few plants have been cited as antidiabetic agents (7%) in these studies. No phytochemical study has been carried out on two of the plant species namely; *Faurea saligna* and *Zanthoxylum usambarense*. Various studies have established presence of major phytochemicals in all the other antidiabetic plants: terpenoids occurred in 11 plants; flavonoids (11), alkaloids (7), phenolics (6), saponins (5), tannins (4), glycosides and steroids, each four plants (Table 2).

DISCUSSION

Encounter with diabetes patients and related deaths in the area as reported by the TH had largely contributed to the increased diabetes knowledge observed among them. Further, diabetes awareness campaigns country wide by the ministry of health had additionally played a major role (Nicolai et al., 2014). The low prevalence of diabetes could be attributed to its 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 TH 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 TH; WHO 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 TH 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 (<https://www.pcrm.org>). Notably, despite the low diabetes prevalence recorded in the study area, the number of diabetic clients seeking herbal treatment was relatively high; this is 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 Massai* 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 Massai*, *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 TH, they harvest a third of the roots or from plants that have not been previously/recently harvested. Preparation of the medicine as a decoction has also been reported (ibid).

Although, studies to establish their antidiabetic efficacy have been carried out, very few plants (43%) (Table 2) have been scientifically validated, 57% have not been investigated, they included; *Dovyalis abyssinica*, *Faurea saligna*, *Rhamnus prinoides*, *Rhamnus staddo*, *Rotheca myricoides*, *Trimeria grandifolia*, *Urtica massaica*, *Warbugia ugandensis* and *Zanthoxylum usambarense*. Although *Acacia nilotica* leaf and pod extract have been studied, antidiabetic efficacy of the roots which were mentioned by Narok TH have not been scientifically validated.

Terpenoids have known anti-hyperlipidemic, anti-obesity and Type 2 antidiabetic activity (Goto et al., 2010; Uma et al., 2011). Alkaloids express their antidiabetic activity through increasing insulin sensitivity (Uma et al., 2011); glucose uptake, antioxidant activity (Tiong et al., 2013) and reduction of glucose-6-phosphatase activity, triglyceride (TG) and total cholesterol (TC) content (Sharma et al., 2010). Phenolics antidiabetic activity (Uma et al., 2011), is attributed to its antioxidant (Chen et al., 2011; Rafehi et al., 2012) and antiglycation activity (Chen et al., 2011) decreasing of total cholesterol, triglyceride, LDL-cholesterol, serum glucose and body weight (Yin et al., 2011). Flavonoids increases glucose uptake (Granados et al., 2015), insulin secretion (Mohan and Nandhakumar, 2014), prevent Beta-cell apoptosis (Pinent et al., 2008) possess antioxidant activity and modulate renal glucose reabsorption (Lukačínová et al., 2008). Saponin hypoglycemic activity associated with increased insulin secretion by rejuvenating β -cells, modulating calcium channels (Koneri et al., 2014), antiglycation, antioxidant (Chen et al., 2011), anti-obesity activity (Park et al., 2005) and amelioration of diabetes complications related to liver and kidney function, and glucose metabolism (Patel et al., 2012). Tannins has antihyperlipidemic and hepatoprotective activity (Babby, 2014). Reported bioactivity of phytochemicals present in the antidiabetic plants used by TH from Narok confirms their reported use in the management of diabetes by the TH. However, further studies on efficacy of their antidiabetic activity, as well as potential toxic effect are inevitable, to form basis as future candidates for antidiabetic drug extraction.

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CONFLICT OF INTEREST

All authors declare no conflict of interest

REFERENCES

- Abdirahman YA, Juma KK, Nyamai DW, Njagi JM, Agyirifo DS, Ngugi MP, Gathumbi PK, Ngeranwa JJN, Njagi ENM. In-Vivo Anti-hyperglycemic Activity and Safety of The Aqueous Stem Bark Extracts of *Aloe secundiflora*. *Med Aromat Plants*. 2015;S1:003.
- Abebe D, Debell A, Makonnen Z, Abera F, Teka F Kebede T, Urga K, Yersaw K, Biza T, Mariam BH, Guta M.. Screening of some medicinal plants of Ethiopia for their anti-microbial properties and chemical profiles. *J Ethnopharmacol*. 2005;97:421-427.
- Amabye TG. Evaluation of Phytochemical, Chemical Composition, Antioxidant and Antimicrobial Screening Parameters of *Rhamnus prinoides* (Gesho) Available in the Market of Mekelle, Tigray, Ethiopia. *Nat Prod Chem Res*. 2015;41.
- Amadi EK. Evaluation of herbal drugs used to treat fungal and bacterial diseases in Mbeere, Eastern Kenya. *Int J Herbal Med*. 2013;1:85-87.
- Amuka O, Okemo PO, Machochi AK, Mbugua PK. Ethnobotanical Survey of Selected Medicinal Plants used by Ogiek Communities in Kenya against Microbial Infections. *Ethnobot Res Appl*. 2014;12:627-641.
- Asad Mu, Munir TA, Afzal N. *Acacia Nilotica* Leave Extract and Glyburide: Comparison of Fasting Blood Glucose, Serum Insulin, β -Thromboglobulin Levels and Platelet Aggregation in Streptozotocin Induced Diabetic Rats. *JPM*. 2011;61:247.
- Atieno JO. Diabetes management in a primary care setting: Kenyatta national hospital. *Diabetes Voice*. 2006;5:27-29.
- Babby A, Elanchezhian C, Suhasini S. Current Antihyperlipidemic and Hepatoprotective activity of Tannic acid in Streptozotocin induced diabetic rats. *Res Med Med Sci*. 2014;4:9-12.
- Banso A. Phytochemical and antibacterial investigation of bark extracts of *Acacia nilotica*. *J med plants res*. 2009;3:82-85.
- Berg PI. The Maasai keep healthy despite a high-fat diet. *ScienceNordic: Research and Study*; 2012. Available at: <http://scienordic.com/maasai-keep-healthy-despite-high-fat-diet>. Accessed on May 20th, 2017.
- Berhanu MA, Martin GP. Emodin and emodinanthrone rhamnoside acetates from fruits of *Rhamnus prinoides*. *Phytochemistry*. 1995;39:1411-1414.
- Bii C, Korir KR, Rugutt J, Mutai C. The potential use of *Prunus Africana* for the control, treatment and management of common fungal and bacterial infections. *J Med Plants Res*. 2010; 4:995-998.
- Bussmann RW, Gilbreath GG, Solio J, Lutura M, Lutuluo R, Kunguru K, Wood N, Mathenge SG. Plant use of the Maasai of Sekenani Valley, Maasai Mara, Kenya. *J Ethnobot Ethnomed*. 2006;2:22.
- Campbell DJ, Gichohi H, Mwangi A, Chege L. Land use conflict in Kajiado District, Kenya. *Land Use Pol-icy*. 2000;17:337-438.
- Campos KE, Diniz YS, Cataneo AC, Faine LA, Alves MJQF, Novelli ELB. Hypoglycaemic and antioxidant effects of onion, *Allium cepa*: dietary onion addition, antioxidant activity and hypoglycaemic effects on diabetic rats. *Int J Food Sci and Nutr*. 2003;54:241-246.
- Catalano S, Ferretti M, Marsili A, Morelli I. New Constituents of *Prunus africana* Bark Extract. *J Nat Prod*. 1984;47:910.
- Chen YF, Roan HY, Lii CK, Huang YC, Wang TS. Relationship between antioxidant and antiglycationability of saponins, polyphenols, and polysaccharides in Chinese herbal medicines used to treat diabetes. *J Med Plants Res*. 2011;5:2322-2331.
- Choi CW, Song SB, Oh JS, Kim YH. Antiproliferation effects of selected Tanzania plants. *Afr J Trad Complement Altern Med*. 2015;12:96-102.
- Christensen DL, Friis H, Mwaniki DL, Kilonzo B, Tetens I, Boit MK, Omondi B, Kaduka L, Borch-Johnsen K. Prevalence of glucose intolerance and associated risk factors in rural and urban populations of different ethnic groups in Kenya. *Diabetes Res Clin Pract*. 2009;84:303-310.
- Cochrane K, Nkedianye D, Partoip E, Sumare S, Kiruswa S, Kaelo D, Onetu L, Nesele M, Said M, Homewood K, Trench P, Reid RS, Herrero M. Family Fortunes: Analysis of Changing Livelihoods in Maasai land. Final Project Report ZC0275. (Whitehall, United Kingdom: Department for International Development), pp. 261, 2005.
- Day J, Bailey A, Robinson D. Biological variations associated with change in lifestyle among the pastoral and nomadic tribes of East Africa. *Ann Hum Biol*. 1979;6:1.
- DeRuiter J. Overview of the Antidiabetic Agents: Oral Hypoglycemics/Antidiabetics: Learning Objectives. *Endocrine Pharmacotherapy Module*. (Spring), 2003.
- Desta B. Ethiopian traditional herbal drugs. Part I: Studies on the toxicity and therapeutic activity of local taenicidal medications. *J Ethnopharmacol*. 1995;45:27-33.
- Diet and Diabetes: Recipes for success. Physicians committee for responsible medicine. Available at: <http://www.pcrm.org/health/health-topics/diet-and-diabetes-recipes-for-success>. Accessed on May 20th, 2017.
- Engidawork E, Abdissa H. Evaluation of anti-inflammatory and wound healing activities of the 80% methanol fruit extracts of *Dovyalis abyssinica* A. Rich. in mice. (Addis Ababa, Ethiopia: Addis Ababa University), 2011.

- Fathy KE, Mohamed AA, Elham AA. Effect of *Luffa aegyptiaca* (seeds) and *Carissa edulis* (leaves) extracts on blood glucose level of normal and streptozotocin diabetic rats. *J Ethnopharmacol.* 1996;50:43-47.
- Fourneau C, Hocquemiller R, Cavé A. Triterpenes from *Prunus africana* bark. *Phytochemistry.* 1996;42:1387-1389.
- Goto T, Takahashi N, Hirai S, Kawada T. Various Terpenoids Derived from Herbal and Dietary Plants Function as PPAR Modulators and Regulate Carbohydrate and Lipid Metabolism. *PPAR Res.* 2010;2010:9.
- Granados S, Balcázar N, Guillén A and Echeverri F. Evaluation of the Hypoglycemic Effects of Flavonoids and Extracts from *Jatropha gossypifolia* L. *Molecules.* 2015;20:6181-6193.
- Hemed E, Mariam D, Ahmed K, Changambi M, Nahida K, Hafsa P. How serious is the Impact of Type II Diabetes in Rural Kenya? *The Open Diabetes J* 2014;7:1-4.
- Hoffman B, Gallaher T. Importance Indices in Ethnobotany. *Ethnobot Res Appl.* 2007;5:201-218.
- International Diabetes Federation. Expert Meeting on Indigenous Peoples, Diabetes and Development. (Copenhagen, Denmark: world diabetes foundation), 2012.
- Jeruto P, Mutai C, Lukhoba C, Ouma G. Phytochemical constituents of some medicinal plants used by the Nandis of South Nandi district, Kenya. *J Anim Plant Sci.* 2011;9:1201-1210.
- Karekezi C, Ngugi NN, Njenga E, Ngugi P, Muchemi E, Karugu L, Kabutu J, Mbugua V, Mwangi J, Gathiru M, Muchoki B. Regional Differences in Prevalence of Diabetes among Medical Attendees in Kenya. Kenya Diabetes Management and Information Centre. In: IDF World Diabetes Congress, Dubai, 4-8 December, 2011 (Nairobi, Kenya), 2011. Available at: <http://www.ncdinfo-kenya.org/knowledge-portal/publications/1157/regional-differences-in-prevalence-of-diabetes-among-medical-attendees-in-kenya> Accessed on May 20th, 2017.
- Kareru PG, Kenji GM, Gachanja AN, Keriko JM, Mungai G. Traditional Medicines among the Embu and Mbeere Peoples of Kenya. *Afr J Trad Complement Altern Med.* 2007;4:75- 86.
- Kebenei JS, Ndalt PK, Sabah AO. Anti-plasmodial activity of Nortrachelogenin from the root bark of *Carissa edulis* (vahl). *Int J Appl Res Nat Prod.* 2011;4:1-5.
- Keter LK, Mutiso PC. Ethnobotanical studies of medicinal plants used by Traditional Health Practitioners in the management of diabetes in Lower Eastern Province, Kenya. *J Ethnopharmacol.* 2012;139:74-80.
- Kiringe JW. A Survey of Traditional Health Remedies Used by the Maasai of Southern Kaijido District, Kenya. *Ethnobot Res Appl.* 2006;4:61-73.
- Kiringe JW. Ecological and Anthropological Threats to Ethno-Medicinal Plant Resources and their Utilization in Maasai Communal Ranches in the Amboseli Region of Kenya. *Ethnobotany Research & Applications.* 2005;3:231-241.
- Kirira PG, Rukunga GM, Wanyonyi AW, Muregi FM, Gathirwa JW, Muthaura CN, Omar SA, Tolo F, Mungai GM, Ndiege IO. Anti-plasmodial activity and toxicity of extracts of plants used in traditional malaria therapy in Meru and Kilifi Districts of Kenya. *J Ethnopharmacol.* 2006;106:403-407.
- Koneri RB, Samaddah S, Ramaiah CT. Antidiabetic activity of triterpenoid saponin isolated from *Momordica cymbalaria* Fenzl. *Ind J of Exp Biol.* 2014;52:46-52.
- Lans CA. Ethnomedicines used in Trinidad and Tobago for urinary problems and diabetes mellitus. *J Ethnobiol Ethnomed.* 2006;2:45.
- Lombard K, Peffley E, Geoffriau E, Thompson L, Herring A. Quercetin in onion (*Allium cepa* L.) after heat-treatment simulating home preparation. *J Food Composition Anal.* 2005;18:571-581.
- Lukačinová A, Mojžiš J, Beňačka R, Rácz O, Ništár F. Structure-activity relationships of preventive effects of flavonoids in alloxan-induced diabetes mellitus in rats. *J Anim and Feed Sci.* 2008;17:411-421.
- Mahmoud MF, Noura AH, El Bassossy HM, Fahmy A. Quercetin Protects against Diabetes-Induced Exaggerated Vasoconstriction in Rats: Effect on Low Grade Inflammation. *PLoS One.* 2013;8:e63784.
- Maina JK, Kareru PG, Gatebe EG, Rotich H, Githira PN, Njonge F, Kimani D, Mutembei JK. Hypoglycemic effects of selected herbal drug formulations from the Kenyan market. *J Na Prod Plant Resour.* 2014;4:10-17.
- Maina W, Ndegwa M, Njenga E, Muchemi E. Knowledge, attitude, and practices related to diabetes among community members in four provinces in Kenya: a cross-sectional study. *Afr J Diabetes Med.* 2011;19:15-18.
- Mandha J, Joram B, Kassimu N, Petrucka P. Risk Factors of Type 2 Diabetes among Maasai Pastoral Communities in Simanjiro, Tanzania. *Open Access Library J.* 2015;2:e2079.
- Mangoyi R, Mukanganyama S. In Vitro Antifungal Activities of Selected Medicinal Plants from Zimbabwe against *Candida albicans* and *Candida krusei*. *Afr J Plant Sci Biotech.* 2011;5:8-14.
- Maobe MAG, Gitu L, Gatebe E, Rotich H, Karanja PN, Votha DM, Wambugu J, Muingai C. Antimicrobial Activities of Eight Selected Medicinal Herbs Used for the Treatment of Diabetes, Malaria and Pneumonia in Kisii Region, Southwest Kenya. *Global J Pharmacol.* 2013;7:25-33.
- Maobe MAG, Gitu L, Gatebe E, Rotich H. Phytochemical Analysis of Phenol and Flavonoid in Eight Selected Medicinal Herbs Used for the Treatment of Diabetes, Malaria and Pneumonia in Kisii, Kenya. *Acad J Cancer Res.* 2012;5:31-39.
- Masaki S, Ngoye A, Petrucka P, Buza J. Type 2 Diabetes Prevalence and Risk Factors of Urban Maasai in Arusha Municipality and Rural Maasai in Ngorongoro Crater. *J Appl Lif Sci Int.* 2015;3:157-168.
- Masevhe NA, McGaw LJ, Eloff JN. The traditional use of plants to manage candidiasis and related infections in Venda,

South Africa. *J Ethnopharmacol.* 2015;168:364-372.

Mbanya JC, Ayesha N, Motala A, Sobngwi E, Assah FK, Enoru ST. Diabetes in sub-Saharan Africa. *The Lancet.* 2010;375:2254-2266.

Merawie Y, Sahile S, Moges F, Husen A. Antimicrobial activity of crude and semi-purified fractions of *Warburgia ugandensis* against some pathogens. *J Coastal Life Med.* 2013;1:233-240.

Mohan S, Nandhakumar L. Role of various flavonoids: Hypotheses on novel approach to treat diabetes. *J Med Hypotheses and Ideas.* 2014;8:1-6.

Mthethwa, NS. Antimicrobial activity testing of traditionally used plants for treating wounds and sores at Ongoye area KwaZulu-Natal, South Africa. (KwaDlangezwa, South Africa: University of Zululand), 2009.

Mugisha MK, Origa HO. Traditional herbal remedies used in the management of sexual impotence and erectile dysfunction in western Uganda. *Afr Health Sci.* 2005;5:40-49.

Muregi FW, Ishih A, Miyase T, Suzuki T, Kino H, Amano T, Mkoji GM, Terada M. Antimalarial activity of methanolic extracts from plants used in Kenyan ethnomedicine and their interactions with chloroquine (CQ) against a CQ-tolerant rodent parasite, in mice. *J Ethnopharmacol.* 2007; 111:190-195.

Muthee JK, Gakuya DW, Mbaria, JM, Kareru PG, Mulei CM, Njonge FK. Ethnobotanical study of anthelmintic and other medicinal plants traditionally used in Loitokitok district of Kenya. *J Ethnopharmacol.* 2011;135:15-21.

Mwaniki M. Kenya: Experts sound alert over rising cases of diabetes among youth. (Nairobi, Kenya: The Nation), 2007.

Nahayo A, Bigendako MJ, Fawcett K, Nkusi H, Nkurikiyimfura JB, Yansheng G. Chemical study of the stems of *Urtica massaica*, a medicinal plant eaten by the mountain Gorillas (*Gorilla beringei beringei*) in Parc National des Volcans, Rwanda. *Res J Appl Sci.* 2008;3:514-520.

Nedi T, Mekonnen N, Urga K. Diuretic effect of the crude extracts of *Carissa edulis* in rats. *J Ethnopharmacol.* 2004;95:57-61.

Nicolai S, Prizzon A, Hine S. Beyond Basic: The growth of post-primary education in Kenya. *Development progress.* 2014.

Njoroge GN, Bussman RW. Ethnotherapeutic management of sexually transmitted diseases (STDs) and reproductive health conditions in central province of Kenya. *Indian J Trad Med.* 2009;8:255-261.

Njoroge GN, Bussmann RW. Diversity and utilization of antimalarial ethnophytotherapeutic remedies among the Kikuyus (Central Kenya). *J Ethnobiol Ethnomed.* 2006;2:8.

Ochwang'i DO, Kimwele CN, Oduma JA, Gathumbi PK., Mbaria JM., Kiama SG. Medicinal plants used in treatment and management of cancer in Kakamega County, Kenya. *J Ethnopharmacol.* 2014;151:1040-1055.

Odhiambo JA, Siboe GM, Lukhoba CW, Dossaji SF. Antifungal Activity Of Crude Extracts Of Selected Medicinal

Plants Used In Combinations In Lake Victoria Basin, Kenya. *Plant Prod Res J.* 2009;13:35 -43.

Oloro J, Tanayen JK, Barbra K, LI, Paul W, Francis B and Amon AG. Toxicity of four herbs used in erectile dysfunction; *Mondia whitei*, *Cola acuminata*, *Urtica massaica*, and *Tarenna graveolens* in male rats. *Afr J Pharm Pharmacol.* 2015;9:756-763.

Olowokudejo JD, Kadiri AB, Travih VA. An Ethnobotanical Survey of Herbal Markets and Medicinal Plants in Lagos State of Nigeria. *Ethnobot Leaflets.* 2008;12:851-865.

Omara EA, Somaia AN, Abdel RHF, Walid MS, Sayed AE. Therapeutic effect of *Acacia nilotica* pods extract on streptozotocin induced diabetic nephropathy in rat. *Phytomedicine.* 2012;19:1059-1067.

Omollo CO. The Anti-malarial and Biochemical Studies of *Microglossa pyrifolia* (Lam.) Ktze and *Trimeria grandifolia* (Hochst.) Warb from Lake Victoria Basin, Kenya. 2011. Available at: <http://ir.jkuat.ac.ke/bitstream/handle/123456789/883/Omollo%20C.%20O.%202011%20MSc%20Medicinal%20chemistry.pdf?sequence=1&isAllowed=y>. Accessed on May 20th, 2017.

Onkamo P, S. Vaananen S, Karvonen M, Tuomilehto J. Worldwide increase in incidence of Type I diabetes ± the analysis of the data on published incidence trends. *Diabetologia.* 1999;42:1395-1403.

Onyango CA, Gakuya LW, Mathooko FM, Maina JM, Nyaberi M.O, Makobe M, Mwaura F. Phytochemical studies on herbal plants commonly used for processing and preserving meat and milk. *J Appl Biosci.* 2014;73:5942- 5948.

Orwa JA, Mwitari PG, Mtu E, Rukunga GM. TH and the management of Malaria in Kisumu District, Kenya. *East Afri Med J.* 2007;84:51-55.

Park JD, Rhee DK, Lee YH, Biological activities and chemistry of saponins from *Panax ginseng* C. A. Meyer. *Phytochem Rev.* 2005;4:159-175.

Parker ME, Chabot S, Ward BJ, Johns T. Traditional dietary additives of the Maasai are antiviral against the measles virus. *J Ethnopharmacol.* 2007;114:146-152.

Patel SB, Santani D, Shah MB, Patel VS. Antihyperglycemic and anti-hyperlipidemic effects of *Bryonia laciniosa* seed extract and its saponin fraction in streptozotocin-induced diabetes in rats. *J Young Pharmacists.* 2012;4:171-176.

Patrick M, Dhyani B, Charles ole S, Joyce N, Moses K, Simon M, Yasuyuki M, Robert H. Ethnobotany of the Loita Maasai, Towards Community Management of the Forest of the Lost Child. Experiences from the Loita Ethnobotany Project. 2001. Available at: <http://unesdoc.unesco.org/images/0012/001266/126660e.pdf>. Accessed on May 20th, 2017.

Phillips O, Gentry AH. The useful plants of Tambopata Peru: I. Statistical hypotheses tests with a new quantitative technique. *Econ Bot.* 1993;47:15-32.

Pinent M, Castell A, Baiges I, Montagut G, Arola L, Ard'evol

- A. Bioactivity of Flavonoids on Insulin-Secreting Cells. *Comprehensive Reviews Food Sci Food Safety*. 2008;7:299-308.
- Rafehi H, Ververis K, Karagiannis TC. Mechanisms of action of phenolic compounds in olive. *J Diet Suppl*. 2012;9:96-109.
- Rainer WB, Narel PZ, Marinoli RC, Natalia MM, Peril in the market-classification and dosage of species used as anti-diabetics in Lima, Peru. *J Ethnobiol Ethnomed*. 2013;9:37.
- Rukunga GM, Kofi-Tsekpo MW, Kurokawa M, Kageyama S, Mungai GM, Muli JM, Tolo FM, Kibaya RM, Muthaura CN, Kanyara JN, Tukei PM, Shiraki K. Evaluation of the HIV-1 reverse transcriptase inhibitory properties of extracts from some medicinal plants in Kenya. *Afr J Health Sci*. 2002;9:81-90.
- Sankan SS. *The Maasai*. (Nairobi, Kenya: Kenya Literature Bureau), 1995.
- Sharma B, Salunke R, Balomajumder C, Daniel S, Roy P. Anti-diabetic potential of alkaloid rich fraction from *Capparis decidua* on diabetic mice. *J Ethnopharmacol*. 2010;127:457-462.
- Sindiga I, Nyaigotti-Chacha C, Kanunah MP. *Traditional Medicine in Africa*. (Nairobi, Kenya: East African Educational Publishers Ltd), 1995.
- Singh BN, Singh BR, Singh RL, Prakash D, Singh DP, Sarma BK, Upadhyay G, Singh HB. Polyphenolics from various extracts/fractions of red onion (*Allium cepa*) peel with potent antioxidant and antimutagenic activities. *Food Chem Toxicol*. 2009;47:1161-1167.
- Tadesse B, Terefe G, Kebede N, Shibeshi W. In Vivo anti-trypanosomal activity of dichloromethane and methanol crude leaf extracts of *Dovyalis abyssinica* (Salicaceae) against *Trypanosoma congolense*. *BMC Complement Alt Med*. 2015;15:278.
- Tiong SH, Looi CY, Hazni H, Arya A, Paydar M, Wong WF, Cheah SC, Mustafa MR, Awang K. Antidiabetic and Antioxidant Properties of Alkaloids from *Catharanthus roseus* (L.) G. Don. *Molecules*. 2013;18:9770-9784.
- Tolo FM, Rukunga GM, Muli FW, Njagi ENM, Njue W, Kumon K, Mungai GM, Muthaura CN, Muli JM, Keter LK, Oishi E, Kofi-Tsekpo MW. Anti-viral activity of the extracts of a Kenyan medicinal plant *Carissa edulis* against herpes simplex virus. *J Ethnopharmacol*. 2006;104:92-99.
- Trowell HC, Burkitt DP. *Western Diseases, Their Emergence and Prevention*. (Massachusetts, USA: Harvard University Press), 1981.
- Ugulu I, Baslar S, Yorek N, Dogan Y. The investigation and quantitative ethnobotanical evaluation of medicinal plants used around Izmir province, Turkey. *J Med Plants Res*. 2009;3:345-367.
- Uma MM, Sudarsanam D. *Phytomedicine for Diabetes mellitus: An overview*. *Res Pharmacy*. 2011;1:28-37.
- Verschaeve L, Van Staden J. Mutagenic and antimutagenic properties of extracts from South African traditional medicinal plants. *J Ethnopharmacol*. 2008;119:575-587.
- Wagate CG, Mbaria JM, Gakuya DW, Nanyingi MO, Kareru PG, Njuguna A. Screening of some kenyan medicinal plants for antibacterial activity. *Phytother Res*. 2010;24:150-153.
- Waihenya R, Kayser O, Hagels H, Zessin K, Madundo M, Gamba N. The phytochemical profile and identification of main phenolic compounds from the leaf exudate of *Aloe secundiflora* by high-performance liquid chromatography-mass spectroscopy. *Phytochem Anal*. 2003;14:83-86.
- Wambugu SN, Mathiu PM, Gakuya DW, Kanui TI, Kabasa, JD, Kiama SG. Medicinal plants used in the management of chronic joint pains in Machakos and Makuani counties, Kenya. *J Ethnopharmacol*. 2011;137:945-955.
- WHO. *Traditional Medicine Strategy (2002-2005)*. (Geneva, Swiss: WHO), 2002.
- Wild S, Roglic G, Green A, Sicree R and King H. Global Prevalence of Diabetes Estimates for the year 2000 and projections for 2030. *Diabetes Care*. 2004;27:1047-1053.
- World Health organization. *Non-communicable Diseases (NCD): Country Profiles*. (Geneva, Swiss: WHO), 2014.
- Wube AA, Bucar F, Gibbons S, Asres K. Sesquiterpenes from *Warburgia ugandensis* and their antimycobacterial activity. *Phytochemistry*. 2005;66:2309-2315.
- Yang W, Lu J, Weng J, Jia W, Ji L, Xiao J, Shan Z, Liu J, Tian H, Ji Q, Zhu D, Ge J, Lin L, Chen L, Guo X, Zhao Z, Li Q, Zhou Z, Shan G, He J. Prevalence of Diabetes among Men and Women in China. *N Engl J Med*. 2010;362:12.
- Yin P, Zhao S, Chen S, Liu J, Shi L, Wang X, Liu Y, Ma C. Hypoglycemic and Hypolipidemic Effects of Polyphenols from *Burs of Castanea mollissima* Blume. *Molecules*. 2011;16:9764-9774.
- Yonga G. *Workshop on Country-Level Decision Making for Control of Chronic Diseases*. The Institute of Medicine: The National Academies of Sciences, Engineering and medicine, 2011. Available at: <http://iom.nationalacademies.org/Activities/Global/ControlChronicDiseases/2011-JUL-19/Day-2/Day-2-Part-1/Video17.aspx#sthash.BKorklnf.dpuf>. Accessed on May 20th, 2017.