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PHYTOCHEMISTRY, PHARMACOLOGICAL ACTIVITIES AND ETHNOBOTANICAL STUDIES OF SELECTED INDIGENOUS ZAMBIAN MEDICINAL PLANTS - A REVIEW

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ABSTRACT: Medicinal plants have been used as therapeutic relief agents in many Zambian societies. Up to date, it has been statistically approximated that more than 70% of the Zambian population still relies heavily on medicinal plants as sources of pain relief, mainly because of shortage of medications in hospitals and the limited access to health care facilities. These medicinal plants are effective in the management of various illnesses owing to the secondary metabolites that offer defensive mechanism against pathogens. Aside from the fact that most medicinal plants indigenous to Zambia are yet to be profiled to affirm they potency experimentally, there still remains a limited compilation of the very few that have been profiled. This study thus, aimed to review the scientific literature on Phytochemistry, pharmacologic studies conducted and while also reviewing in detail the ethnobotanical studies carried out on some of the medicinal plants. This knowledge is of tremendous importance to future and current Zambian researchers in drug development, in their effort to identify lead or novel plant-based drugs for both the present and future. The data for this review was obtain by conducting a literature search in electronic data bases meant for professional and academic use such as google scholar, Scopus, web of Science, science direct, and PubMed as well as searching on google using key words to specifically identify peer reviewed published articles on medicinal plants that are indigenous to Zambia. This review has shown that some indigenous Zambian medicinal plants have tremendous potential as antioxidant, Uterotonic, antibacterial, antidiabetic, antihyperglycemic and antihyperlipidic agents.

INTRODUCTION: Medicinal plants have served as natural reservoirs of therapeutic agents since time immemorial. Aside from acting as providers of nutrients for both man and animals, they have been applied as sources or precursors in the development of effective plant based drugs.

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For instance, many notable drugs such as Taxol, an antimitotic agent and antimalaria drugs such as quinine, initially isolated from bark of Cinchona species have been developed from plants are still widely applied to date.

Medicinal plants are known to contain various secondary metabolites such as polyketides, saponins, tannins, phlobatannis, flavonoids, alkaloids, terpenoids, rprimarily sugars, steroids and many others that primary are marked for protecting the plants from pathogenic attacks. Most African countries, Zambia inclusive have weak

health care systems. For this reason, its encouraged and promoted that herbal medication which are easily accesible be part of the health care system [1]. From a statistical view point, 80% of world population still relies on traditional medicines to bring about therapeutic relief, while similarly about 70% of the Zambian population still uses traditional medicines as their primary health care [2, 3 4, 5]. This underscores the need to not just profile and access the various medicinal plants on the Zambian markets but also review extensively the already profiled plants in hope of piecing together those that are effective and conduct further studies on those that have shown promise. A review of the ethnobotanical studies is critical as this makes it easy for researchers to pinpoint the medicinally plants being widely used by local people and hence more attention can be drawn to these specific medicinal plants.

MATERIAL AND METHODS:

Location of Zambia: Zambia **Fig. 1** is a landlocked nation within Southern Africa, sitting on latitude 13° 08′ 25.26″ S and longitude 27° 50′57.50″ E. The nation is blessed with abundant natural forest from which people especially traditional healers are able to obtain medicinal plants. All of the plants under review are indigenous to Zambia.

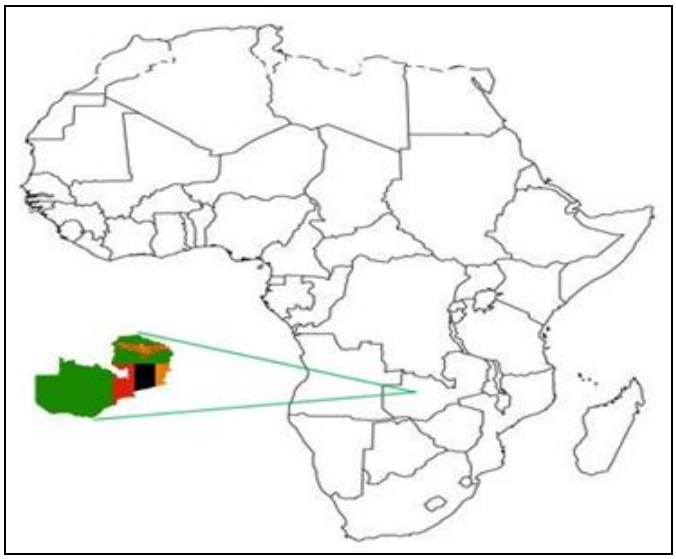

FIG. 1: MAP OF AFRICA SHOWING AN EXTRACT OF THE ZAMBIAN REGION IN GREEN

Methodology: The data for this review was obtain by conducting a literature search in electronic data bases meant for professional and academic use such as google scholar, Scopus, web of Science, science direct, and PubMed as well as searching on google using key words to specifically identify peer reviewed published articles on medicinal plants that are indigenous to Zambia.

Antioxidative and Anti-inflammatory Potential of Indigenous Zambian Plants: Antioxidants are molecules or species that can reduce the body's oxidative damage brought on by free radicals by donating electrons to free radicals. These free radicals caused generally by metabolic processes are highly reactive species with ability to disturb the structures of important biomolecules such as body fat, membrane lipids, DNA and proteins, thus impairing the functionality of these molecules [6]. Decreased fluidity of Cell membrane has been one notable consequence of the exposure of membrane lipids to free radicals such as hydroxyl radicals or superoxide anions [6]. When the body's levels of antioxidants and free radicals are out of balance, oxidative stress usually results [7]. Commonly encountered antioxidants present in majority of medicinal plants include Curcuminoids, polyphenols, tannins, phenols, isoflavones and flavonols [8].

Recent studies conducted on indigenous Zambian medicinal plants to assess the antioxidative capacity have shown promise at preliminary level, pending further assessment. Recently, Singh and Muzyamba profiled and tested the antioxidative potential of *Paropsia brazeana* leaf ethanoic extracts. The ethanoic extracts showed promise a strong free radical scavenger, with IC_{50} values of 42.37mg/L against that of 23.19 mg/L for standard ascorbic acid. Based on classification of antioxidative strength, the lower the IC_{50} the stronger the antioxidant, and generally, an IC_{50}less than 50 for an antioxidant is classified as strong. Furthermore, through molecular docking, this research identified compounds that can for instance be used as precursors in development of anti-inflammatory drugs such as beta-sitosterol which outperformed the anti-inflammatory drug, ibuprofen when bound to the Cyclooxygenase 2 (COX2) enzyme. Beta-sitosterol exhibited stronger binding affinity with an inhibition constant of 4.18 Nm and a binding energy of -11.43 kcal/mole compared to Ibuprofen which had a binding energy of -6.88 kcal/mole and an inhibition constant of 9.10 µM [9]. In other related studies Singh and

Muzyamba profiled and assessed the root and leaf extracts of *Oldfieldia dactylophylla* (OD) another indigenous Zambian medicinal plant and found the phytochemicals in crude extracts to be acting as strong antioxidant agents with IC_{50} values of 35.71 mg/L and 44.71 mg/L for the root and leaf extract respectively [10, 11]. These tests confirmed the antioxidative capability of the plants under study and probably underscores why these plants are utilized by the locals for medicinal related functions. By successfully quantifying the flavonoid and phenolic content in *Paropsia Brazeana* ethanoic leaf extracts and the root and leaf extracts of *Oldfieldia dactylophylla*, the pair thus solidified claim of existence of such therapeutic compounds in the leaves and root part of the said plants.

Diplorhynchus condylocarpon (Müll. Arg.) belonging to the family *Apocyanaceae* is another indigenous Zambian medicinal plant that is multifaceted in its usage as a medicinal plant. In Zambia and other surrounding nations, the leaf, stem bark and root part is widely used to manage numerous chronic wounds, diarrhea, tuberculosis, venereal diseases, persistent coughs, anorexia, vomiting, inflammation of testicles, diabetes mellitus, malaria and many others [12-21]. In a recent study Chibuye *et al.* demonstrated the antioxidative potential of *Diplorhynchus condylocarpon* by applying the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay at 517 nm. Through this study, the researchers showed that at concentrations of 20-100 µg/mL, the leaf methanoic extract showed strong antioxidant potential with IC_{50} value of 19.973 µg/mL while root and stem bark showed radical scavenging potential with IC_{50} values of 60.867 and 107.150 µg/mL [22]. In another recent related study, Chibuye *et al* analyzed the antioxidant potential of *Adenia panduriformis*, a Zambian medicinal plant belonging to the family *Passifloraceae* and showed that the leaf extract was stronger or more effective antioxidant with relatively lower IC_{50} value of 53.48 µg/mL against 74.47 µg/mL for the standard antioxidant ascorbic acid [23].

Antimicrobial Potential of Some Selected Indigenous Zambian Medicinal Plants: Globally, infectious diseases have been known to cause a great deal of pain and death and provide a shared threat to both humans and animals [24] and unsurprisingly with weak health care system in place, African country's shoulders much of the burden. Infectious diseases are a common occurrence in impoverished nations, particularly in Africa, these illnesses are frequently brought on by pathogenic microbes such as bacteria, viruses, parasites, and fungi [25]. Medicinal plants have been known to be effective in inhibiting growth of microorganisms [26]. With over 80% of world population still depending on medicinal plants as therapeutic agents [2], and multidrug resistant pathogens (MRPs) having being reported around the world, there is need to quickly identify more alternative sources of antibiotics that can be used to make synergies or new drugs altogether.

A study at the University Teaching Hospital (UTH) revealed that occurrence of Methicillin Resistant *Staphylococcus aureus* more than doubled from 2003 to 2014 [27]. Adissemination of current trends in field of pharmacognosy is there of paramount importance.

Antibacterial Activity of *Solanum aculeastrum* growing on the Zambian Terrain: In Zambia, one among the many indigenous plants that has held a rich tradition history is a plant called *Solanum aculeastrum*, a member of the *Solanum* genus. In a recent study, Hikaambo *et al.* investigated the antimicrobial activities of *S. aculeastrum* fruit extracts grown in Zambia against Escherichia coli (*E. coli*) (ATCC 25922), *Staphylococcus aureus* (*S. aureus*) (ATCC 25923), and *Candida albicans* (C. albicans). The researchers showed **Fig. 2** and **3** that the crude methanolic and aqueous fruit extracts of *S. aculeastrum* were able to inhibit the growth of *S. aureus* and *C. albicans* with an exception to *E. coli* [28].

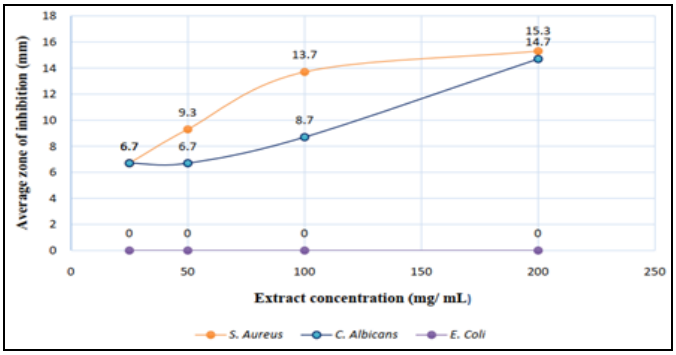

FIG. 2: ANTIMICROBIAL ACTIVITY OF *S. ACULEASTRUM* METHANOLIC [28].

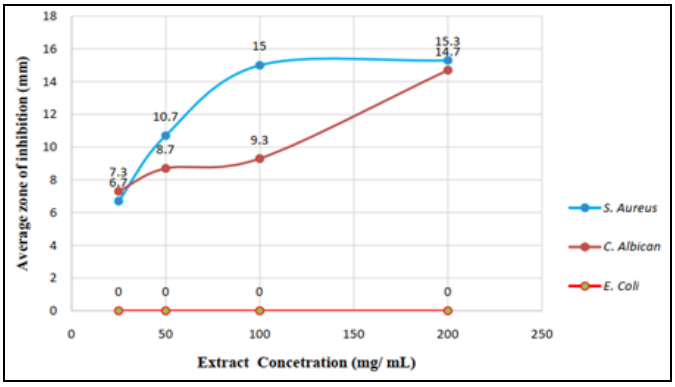

FIG. 3: ANTIMICROBIAL ACTIVITY OF *S. ACULEASTRUM AQUEOUS* EXTRACT [28]

Conclusively, Hikaambo *et al.* showed that this indigenous medicinal plant has antimicrobial potential against two bacterial strains *S. aureus* and *C. albicans*. Having preliminarily shown the antibacterial potential of *S. aculeastrum*, future focus can thus be placed on isolation of bioactive compounds and then conducting both *in-vivo* and *in-vitro* activities.

Antibacterial Activity of *Azadira chtaindica* (*A. Indica*) and *Tamarindus indica* growing on the Zambian Terrain: *Azadira chtaindica* (*A. indica*) popularly known as neem plant, a plant falling under the Meliaceae family. The plant has been previously reported to have numerous therapeutic benefits to humans to varying degrees. Aside from a growing in tropical regious such as India, the plant is also indigenous to Zambian terrain. Preliminary screen on the neem leaves growing in Zambia was indicative of the presence of phenolics and tannins in both ethanolic and aqueous extracts, while saponins, flavonoids and alkaloids in indicatively present in aqueous extracts [29]. Antimicrobial activity of the ethanol and water extracts of neem leaves showed results to varying degrees. For, example, Hikaambo *et al.* previously tested the sensitivity of ethanolic and aqueous extracts against the bacterial strain *Escherichia coli* using disc diffusion method and observed that there was an increase in zones of inhibitions with increasing concentrations of the extracts **Fig. 4**.

The mean inhibitory concentration (MIC) for aqueous extract was 10 mg/mL and 20 mg/mL for the ethanolic extract against *E. coli* [29]. In another separate study, Mudenda *et al.* showed that aqueous and ethanolic of Neem leaf possess antibacterial activity against *Enterococcus faecalis (E. faecalis)*. The study showed that both extracts (aqueous and ethanolic) recorded a minimum inhibitory zone of 20 mg/mL. The zone of inhibitions were observed to increase with increasing concentrations with maximum values obtained at 9.60 mm ± 0.57 and 9.40 mm ± 1.13 for the aqueous and ethanolic extract respectively compared to 30.0 mm ± 0 for the standard drug Ciprofloxacin [30]. These findings place Neem leaves as potential sources of novel antimicrobial agents.

TABLE 1: MEAN ZONE OF INHIBITION OF AQUEOUS AND ETHANOLIC EXTRACTS AGAINST *E. COLI* [29]

Concentrations of Extracts	Aqueous extract Mean Zone of Inhibition	Ethanolic extract Mean Zone of Inhibition	Ciprofloxacin (Control) mean Zone of Inhibition
1 mg/mL	0 mm	0 mm	
10 mg/mL	2.33* mm ± 2.08	0 mm	
20 mg/mL	5.7 mm ± 0.58	6.67* mm ± 0.58	
30 mg/mL	8.78 mm ± 0.58	5.67 mm ± 0.56	34.67 mm ± 0.58
40 mg/mL	10.00 mm ± 1.00	7.67 mm ± 0.58	
50 mg/mL	10.67 mm ± 0.58	8.7 mm ± 0.58	

*- MIC of aqueous and ethanolic extracts against *E. coli.*

In another related study, aimed at assessing the sensitivity of *Tamarindus indica* against *Staphylococcus aureus* and *Escherichia coli*, Phiri *et al.* observed that the ethanolic and aqueous fruits extracts of *T. Indica* inhibited the growth of *Staphylococcus aureus* and *Escherichia coli* in a dose dependent fashion with minimum inhibitory concentrations of 0.5 mg/mL for both extracts [31]. Specifically, Phiri *et al*. observed that the ethanolic and aqueous fruit extract of *T. indica* showed more potency towards the microbial strain *E. coli* with a 100 mg/mL of dose giving maximum inhibitory zones of 14.8 mm ± 0.5 and 13.5 mm ± 0.3 for aqueous and ethanolic fruit extracts respectively compared to maximum zones of inhibition of 29.0 mm ± 0.5 for the positive control drug Levofloxacin. At similar dose of *T. indica*, the maximum zones of inhibitions were recorded at roughly 8.5 mm ± 0.5 for both extracts against the strain *S. aureus* compared to the zone of inhibition

of 30.0 mm ± 0.5 for positive control drug Cloxacillin. In both cases, negative control (dimethyl sulphoxide) recorded 0.00 mm zones of inhibition [31]. Conclusively, this research provided primary evidence of the antibacterial potential of fruit extracts *Tamarindus indica*, an indigenous plant found on the Zambian terrain and can be good drug candidate in development of future antibiotics subject to more *in-vivo* and *in-vitro* activities.

Antibacterial Activity of *Ficus sycomorus* growing on the Zambian Terrain: *Ficus sycomorus* also forms a part of indigenous Zambian medicinal plants that has been and has still been used to manage various ailments. The plant belongs to the family Moraceae [32]. *Ficus sycomorus* extracts have been previously reported to exhibit antimicrobial activity against different types of bacteria strains including drug-resistant pathogens and fungal species [33]. In a recent related study, Masaiti *et al.* conducted disc diffusion method to assess the antibacterial potential of *F. sycomorus* bark aqueous and ethanolic extract against *Staphyloccocus aureus* and *Escherichia coli* at varying concentrations. At concentrations of 20 – 500 mg/mL, the researchers noticed a gradual increase in zones of inhibition starting from 50 mg/mL dose all the way to 500 mg/mL. specifically, a 50 mg/mL dose of aqueous extract of F. *sycomorus* gave a zone of 3 mm through to a maximum value of 6.1 mm at 500 mg/mL against *Escherichia coli* compared to 7.5 mm for the positive control drug Ciprofloxacin (5 µg), while the same aqueous extract tested on *Staphyloccocus aureus* strain, showed inhibition zones starting from a 50 mg/mL dose which recorded 2.2 mg/mL to maximum value of 5 mm at 500 mg/mL compared to 5.8 mm for Ciprofloxacin (5µg) [34].

Ethanolic extracts of the bark of F. *sycomorus* at concentrations 20 –500 mg/ml showed zones of inhibitions starting from dose of 50 mg/mL giving 3.1 mm through to maximum value of 7.0 mm at 500 mg/mL against *Escherichia coli* compared to 9.5 mm for the positive control drug Ciprofloxacin (5 µg). The same extract at similar concentrations tested on *Staphyloccocus aureus* strain, showed inhibition zones starting from a 50 mg/mL dose which recorded 4.5 mg/mL through to a maximum value of 6.8 mm at 500 mg/mL dose compared to 10.0 mm for Ciprofloxacin (5µg) [34].

This study on this indigenous Zambian medicinal plant showed potential as an antibacterial agent, and thus could be considered for future tests in hope developing antibiotics especially with drug resistant strain having being reported in certain Zambian hospitals.

Antimicrobial Activity of *Cassia Abbreviata* Growing on the Zambian Terrain: According to the WHO, roughly around 340 million new cases of *Neisseria gonorrhoeae* and *chlamydia* are reported globally, of which a staggering 85% are from developing nations [35]. Similarly, the WHO also estimates that 500 million new STIs are reported globally every year out of which over 100 million cases are recorded from Sub-Saharan nations of which Zambia is a part of [36]. In Zambia alone, over 200, 000 new infections of STIs are reported annually of which 50% falls to Young adults under the age of 29 years old [37]. These figures translate into an already existing problem that is in need of urgent attention.

STIs are a class of infectious diseases whose primarily medium of spread is through sexual intercourse [38]. Most STIs are curable, however, this effort is hampered by emergence of reported multi-drug resistant pathogens. For instance, the pathogen *Neisseria gonorrhoeae* has reportedly developed resistance to its fine line of treatment as recommended by WHO thus, possessing a serious challenge to health practitioner [39]. This therefore calls for the need to develop new drugs all together or find alternatives that can be used to come up with supra-additivity or synergism in an effort to combat this vice. As history would have it, one effective option is to turn to nature and ask if medicinal plants may once again be our guide. A simple survey among local people has revealed that medicinal plants have long been used effectively to treat various microorganisms and may thus be effective in treatment of contagious diseases [40, 41].

One such plant that has been utilized to manage STIs is *Cassia abbreviata* (*C. abbreviate).* A recent study by Mudenda *et al* indicate that *C. abbreviate* oliv roots exhibited *in-vitro* antibacterial activity against *N. gonorrhoeae* in both aqueous and ethanol extracts. The ethanol and aqueous extracts had measured minimum inhibitory concentrations (MICs) of 125 µg/ml and 62.5 µg/ml, respectively.

Conclusively, the aqueous extract exhibited greater activity than the ethanol extract [41]. The study also found that ethanolic extracts at various concentrations from 125 µg/mL to 1000 µg/mL exhibited lower antibacterial activity compared to the standard drug tetracycline (positive control), with mean zones of inhibition at 125 µg/mL found to be 4.4 mm through to 12.5 mm at 1000 µg/mL dose. Tetracycline alone showed slightly greater mean inhibition zones (18.0 mm) compared to a mixture with ethanolic extract at 1000 µg/mL dose (17.4mm). Thus, combining ethanol extracts of C. *abbreviate* oliv roots with tetracycline did not yield in supra-additivity, as tetracycline's effectiveness appeared diminished in the presence of the ethanolic extract [41].

Unlike ethanolic extracts of *C. abbreviate* that failed to yield any synergism when combined with tetracycline, the study by Mudenda *et al.* also showed that significant improvement in supra-additivity when aqueous extracts of *C. abbreviate* were combined with tetracycline (standard drug), mean zone of inhibition were recorded at 25 mm compared to mean zone of inhibition of 18 mm for tetracycline alone, while aqueous extracts alone at different concentrations of 6.25 µg/mL to 1000 µg/mL recorded mean zones of inhibitions of 3.4 mm (minimum) through to 14.0 mm 1000 µg/mL i.e an increase in zones of inhibitions was noticed to be dose dependent [41].

Therefore, these results provide primary evidence that the aqueous root extract of this indigenous Zambia medicinal plant is can be good option for development of drugs to combat or treat *Neisseria gonorrhoeae*. In another related study, Mulubwa and Prakash also showed the antimicrobial potential of *Cassia abbreviata* (*C. abbreviate)* against various clinical isolates such as Neisseria *gonorrhoeae (NG), Pseudomonas aeruginosa (PA), Klebsiella pneumoniae (KP) and Candida albicans (CA).* In this study, the researchers prepared 6 different extracts of *Cassia abbreviate Oliv* stem bark out of which 4 extracts were prepared *via* Soxhlet extraction using solvents such as ethanol, water, trichloromethane (TCM) and dichloromethane (DCM)+ethanol (1:1) as solvents, respectively with the other two soaked in ethanol and water [42]. The researchers observed that aside from trichloromethane extracts, all the other extracts showed antimicrobial Activity against *Neisseria gonorrhoeae* and *Pseudomonas aeruginosa* with an average MIC of 78.8 µg/ml. The least MIC (46.88) µg/mL was recorded against *Pseudomonas aeruginosa* from the cold aqueous extract of *C. abbreviate* while both hot and cold ethanol extracts of *C. abbreviate* recorded least MIC of 46.88 µg/ml against *Neisseria gonorrhoeae* [42]. The extracts also showed antimicrobial activity against the strain *Candida albicans.* From all the prepared extracts, only hot extracts of *C. abbreviate* (ethanol, dichloromethane +ethanol (1:1) and trichloromethane) showed activity against *Klebsiella pneumonia* trichloromethane extract giving the least MIC of 46.88 µg/mL [42].

Furthermore, Mulubwa and Prakash also noticed that cold ethanolic extracts of *C. abbreviate* and dichloromethane +ethanol showcased activities against *Candida albicans* although cold ethanolic extracts had the least MIC of 93.75 µg/mL [42]. These studies provided evidence once more of the antibacterial potential of this indigenous Zambia medicinal plant.

Antidiabetic Potential of Selected Indigenous Zambian Medicinal Plant's: Diabetes mellitus (DM) is a complex illness that is exacerbated by dietary choices, microbial infections, the environment, and genetics in the family, and is generally characterized by hyperglycemia [43, 44]. According to the International Diabetes Federation (IDF)218,200 cases of Diabetes mellitus were reported in 2015 alone with as many as 8,232 deaths being associated to diabetes, while over 14 million cases have been reported in Africa and projected to double by year 2040 [45].

Various treatment plans options are available, such as synthetic drugs, however, these have been reported to have several side effects. This and the alarming numbers projected to be reached by 2040 call urgent scientific innovation in search for more cable drugs which at heart of it are safer. Thousands of plant species have been reported worldwide to be in use to manage DM cases [46]. Of the thousands of plants used to manage DM, numerous indigenous Zambian plant such as *Cassia abbreviate, Lanneaedulis (Sond.) Engl*and *Oldfieldia dactylophylla* have being assessed.

In a recent study on antidiabetic potential of Zambia indigenous medicinal plants, Musenge *et al.* assessed the potential of *Cassia abbreviate (C. abbreviate)* crude extracts and noticed that the root bark ethanolic extract (381 mg/kg) had a noteworthy hypoglycemic impact at both 60 and 180 minutes, however the 381 mg/kg n-hexane fraction only demonstrated a substantial hypoglycemic effect at 180 minutes. At 60 minutes, sitagliptin 10 mg/kg only slightly decreased blood glucose levels [47].

Furthermore, all groups showed no mortality in the acute toxicity test of the extracts, with the exception of the phase two leaf ethanolic and methanolic crude extracts at a dose of 5000 mg/kg [47]. In another related study to assess the potential of *Lanneaedulis* (L. *edulis*), an indigenous Zambian medicinal plant, Banda *et al.* induced diabetes in albino rats using alloxan monohydrate. In this study, Banda and co administered 100, 300 and 500 mg/kg positive control group doses to 3 groups for two weeks, while 5 mg/kg of glibenclamide was administered to positive control group and distilled water to normal and negative control groups [48].

The researchers observed that in comparison between the groups' day 0 and day 3 mean blood glucose levels, the 300 mg/kg *L. edulis* group showed a 23.3% decline while the 500 mg/kg *L. edulis* group recorded a drop of 52.6% in mean blood glucose levels. By day five, the 100 mg/kg *L. edulis* diabetic positive control group had dropped by 25.1%, reaching statistical significance ($P < 0.05$) in comparison to the diabetic control group. Furthermore, giving *L. edulis* aqueous extracts to diabetic rats for a period of 14 days [48].

The study also revealed that by day five, the 100 mg/kg *L. edulis* diabetic positive control group had dropped by 25.1%, reaching statistical significance ($P < 0.05$) in comparison to the diabetic control group. Furthermore, when compared to the diabetic control group, the administration of aqueous extracts of *L. edulis* to diabetic rats for a period of 14 days resulted in a significant ($P < 0.05$) decrease in the levels of serum total cholesterol, triglycerides, Low Density Lipoprotein (LDL) and Very Low-Density Lipoprotein (VLDL) and an increase in the levels of High Density Lipoprotein (HDL) [48]. These findings primarily show that *L. edulis* an indigenous medicinal plant growing on the Zambian terrain does possess antihyperglycemic and antihyperlipidemic effects in a dose dependent manner. Consequently, this effect is brought on by the phytocompounds found in this plant. The plant therefore makes a good candidate for drug development.

Oxytocic Activities of Selected Indigenous Zambian Medicinal Plants: In Zambia, traditional medicine holds significant value in healthcare system. It is claimed that there are over 40,000 traditional healers or herbalists compared to 1500 medical doctors [49]. These figures show the important place that indigenous medicinal plants in the Zambian communities.

Traditional medicine usage in the context of maternity care has garnered interest from the clinical, public health, policy, and research communities. Some studies have indicated that roughly around 32% of women in Zambia use traditional medicine during their pregnancy for one reason or another [50]. Different types of Zambian indigenous medicinal plants have been used to induce labor in pregnant women. One such plant that is locally used is *Steganotaenia araliacea* (*S. araliacea*) otherwise known as herbal Pitocin. In a previous study *L. wiindi et al.*, 2015 assessed the ecbolic potential of *S. araliacea* aqueous root extracts. In this *in-vitro* study the researchers examined the contractile stimulatory effects of the cruderoot extract of *S. araliacea* on isolated smooth muscle preparations of the uterus of both pregnant and non-pregnant rats as well as the contractile effects of reference antagonists such as Atropine, Indomethacin, Salbutamol and agonists such as Oxytocin and Acetylcholine [51].

Similarly, in another related study, Goma *et al.*, 2017 also provided scientific backing towards the traditional use *S. araliaceahochst* as uterotonic agents. In this study the frequency (number of contractions per minute) and force of contraction were measured from the uterine muscle contractions caused by varying doses of the hot and cold crude aqueous extracts [52]. The results showed that cold aqueous root extracts of *S. araliacea* had higher potency (EC50 of 0.54 mg/mL) than potency of hot aqueous extract (EC50 of 2.09 mg/mL) [52]. Similarly, Chanda *et al.*, 2020 showed

that *Azanza garckeana (A. garckeana)* crude root extracts possess Uterotonic Activity, laying claim to the traditional use of the plant to induce labor. In this study, Chanda and collegues obtained hot aqueous crude root extract, cold root extract and methanolic crude extracts and assessed the potential of the extracts as Uterotonic agents on uterine smooth muscles isolated from estrogenised adult nongravid female wistar rats [53]. The results showed that methanolic crude root extracts of *A. garckeana* was the most potent of all tested extracts with EC50 of 1.28×10^{-2} mg/mL closely followed by hot crude root extracts and cold extracts with EC50 values of 2.79×10^{-2} mg/mL and 4.88×10^{-1} mg/mL [53].

ADMET and Molecular Docking Studies Carried out on Selected Zambian Medicinal Plants: Research on drug metabolism is essential for the identification and creation of novel chemical entities. These investigations offer a comprehensive grasp of a drug's absorption, distribution, metabolism, and excretion (ADME) characteristics [54]. For example, ADMET analysis is important in evaluating a molecule's pharmacodynamic properties, this and many other reasons make ADMET analysis on selected molecules or potential drug candidates critical in pre-clinical analysis of drugs [10].

In a recent study, Singh *et al,* successfully carried out physicochemical, lipophilicity, solubility, drug likness, pharmacokinetics and medicinal properties analysis of selected molecules (L1, L2, L3 and L4) from *Oldfieldia dactylophylla* root while using anti-diabetic drug metformin [10].

Furthermore, all the molecules being analyzed showed high Gastrointestinal absorption (GI) values. Only CYP2C 19 exhibits inhibition in the case of L3, whereas five well-known isozymes (CYP1A 2, CYP2C 19, CYP2C 9, CYP2D 6, and CYP3A 4) exhibit negative inhibition in the case of metformin. The CYP1A 2, CYP2D 6, and CYP3A 4 isozymes did not inhibit L1. In the presence of ligand L2, isozyme CYP2D 6 is not an inhibitor. In the case of ligand L3, the isozymes CYP1A 2 and CYP2C 9 exhibit an inhibitory characteristic, while the values L1(3.99), L2 (3.21), L3 (3.65), L4 (2.92), and reference drug metformin (3.02) showing the ease of synthesis or favorability of the drug was demonstrated through synthetic accessibility [10]. Furthermore, the Ligands L1, L2, and L4 showed zero violations on the Lipinski scale and high GI values hinting drugs to be good candidates. The ADMET parameters for ligands L1, L2, and L4 compared favorably to the control drug metformin with high GI and zero Lipinski violations. However, ligand L3 with one Lipinski violation (MLOGP>4.15) and two violations for drug likeness make it potentially unsuitable as a drug candidate. When it came to hydrogen bond requirements, candidate L4 scored the highest[10]. It has been noted that molecules with a more favorable profile as therapeutic candidates are those that include more hydrogen bond acceptors (HBAs) and less hydrogen bond donors (HBDs) [49].

In another recent study, Singh *et al*, carried out *in-silico* molecular docking and ADMET analysis of 5 phytocompounds (L1, L2, L3, L4 and L5) from *Pseudolachnostylis maprouneifolia* as a potential cancer drug for cancer developmentcancer drug and a control drugimatinib 4-[(4-methylpiperazin-1-yl) methyl]-N-[4-methyl-3-[(4-pyridin-3-ylpyrimidine-2-yl) amino] phenyl] benzamide and a tyrosine kinase inhibitor [55].

The result showed highest binding energy of-9.01 Kcal/mol for L2, high gastrointestinal absorption (GI) and the lowest inhibition constant of 249.88 nM while L5 had binding affinity score of -6.15 kcal/mol. The binding energy of L2 was compared to that of the reference drug (-9.22), however inhibition constant of L2 (249.88 nM) was much lower than the reference drug (666.57 µM) [55].

Selected Ethnomedicinal Plants used to Manage HIV/AIDS in Zambia: A lot of progress has been made in combating HIV/AIDS in Zambia; however, Zambia still remains as one of the top ranked nations with regards to prevalence rates of HIV/AIDS. For instance, according to the Central statistical office (2015) as many as 1.2 million Zambians are living with HIV/AIDS with as many as 21000 HIV/AIDS related deaths recorded in 2016 [56]. One of the main challenges in winning the fight against HIV/AIDS in Zambia is that most individuals still refuse to get tested [57]. Many patients have been reported to use medicinal plants in managing various opportunistic diseases such as persistent cough, malaria, oral candidiasis,

tuberculosis (TB), diarrhea and cancer [58]. In a recent study, Chinsembu *et al.,* 2019 looked at 84 indigenous plant species from 38 different families. The study showed that traditional healers used medicinal plants to treat numerous aliments such as STI (68%), skin infections (10%) and diarrhea (7%). The study further showed that 43% of the medicinal plants studied were being used to treat *gonorrhea* while 27% of the plants were being used to manage genital ulcerative diseases and 11 % for *Lymphogranuloma verereum* (LGV) [59]. The table below shows some elected medicinal plants used to treat HIV related infections.

TABLE 2: SELECTED PLANTS USED TO TREAT HIV RELATED DISEASE

Botanical name	local name	Disease treated	Part [s] Used	Ref.
Agave sisalana Perrineex Engelm	Vukuka	Diarrhea	Leaves	59
Aloe chabaudii Schönland	Mupozo	Genital sores, herpes zoster	Leaves	59
Lanneas chweinfurthii Engl	Chilusa	Gonorrhea	Roots	59
Sclerocaryabirrea Hochst	Musewe	Bacterial vaginosis	Roots	59
Cissusqua drangularis L	Chisaula-nkhunda	Malaria, gonorrhea	whole plant	59
Ziziphusmauritiana	Musau	Gonorrhea, genital ulcers	Fruit eaten raw	59
Strychnosspinose Lam.	Mutamba /Sansa	lymphogranuloma, Gonorrhea	fruits/root	59,19
*Mimosa pigra*L	Kalikalula	Diarrhea, genital ulcers, gonorrhea	Leaves	59
Acacia nigrescens Oliv	Nyamaponondwe	Herpes zoster	stem bark	59
Solanum panduriforme Drège ex Dunal	Mutuntula	HIV	Roots	59
Solanum incanum L	Muhnundurwa	lymphogranuloma	Roots	19
Kigelia africana (*Lam.*) Benth	Muveve/Muvungula	Genital ulcers/lymphogranuloma	Stem bark	59,19
Rauvolfia caffra Sond	Mukashu	Genital sores, gonorrhea	Roots	19
Flueggea virosa (Willd.) Voigt	Lukuswaula	HIV, skin rashes, boils	Roots	59

Limitations, Gaps and Future Perspectives: Although most of the studies documented in this paper offers insightful information about the antibacterial and antidiabetic potential of native medicinal plants in Zambia, it is important to recognize a number of limitations that need to be addressed in future research studies:

Standardization of Extracts: The composition of plant extracts can vary due to factors such as extraction methods, plant growth conditions, and storage. Most of the published work does not provide sufficient information on the standardization of extracts used in the studies, different reseacher's have gone about extracting secondary metabolites using various methods. Implementing standardized extraction protocols and characterizing the chemical composition of extracts would enhance the consistency and reproducibility of results.

Lack of *In-vivo* Studies: Majority of the plant based studies primarily centers on *in-vitro* effects of botanical extracts, supported by limited data from *in-vivo* research. It is imperative to carry out animal trials in order to substantiate the effectiveness and safety of these botanical extracts in organisms and to establish a connection between *in-vitro* results and practical medical uses. Subsequent investigations ought to incorporate meticulously planned *in-vivo* experiments to evaluate the drug's metabolism, effects, and possible adverse reactions. Secondly, most if not all of the studies have centered on use of crude extracts and little to no attention has paid to isolation, characterization of phytocomounds to test their therapeutic potential.

Challenges in Clinical Translation: Transposing *in-vitro* observations to clinical practice presents notable obstacles. Most if not all of the existing research fails to examine the potential hindrances in clinical translational research, including the necessity for additional investigations on the pharmacokinetics, pharmacodynamics, and safety in human participants.

The performance of clinical trials is imperative for assessing the effectiveness and safety of these botanical treatments in practical clinical environments.

CONCLUSION: Zambia possess numerous Indigenous medicinal plants. These plants have been used for years, however most of these are yet to be profiled or reviewed. This review brings out a collection of some of the widely used medicinal plants in Zambian communities. The plant reviewed have shown tremendous potential as therapeutic agents such antioxidants, antimicrobial, anti-inflammatory, antidiabetic and uterotonic agents. ADMET studies conducted on some these plants have shown them to have strong potential to act as anticancer and antidiabetic agents even when compared to standard drugs. This review thus, brings out the need to conduct further research on some of the indigenous Zambian plants that have shown early promise in an effort to develop novel plant based drugs.

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