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Review article

An appraisal of documented medicinal plants used for the treatment of cancer in Africa over a twenty-year period (1998–2018)

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ABSTRACT

Over the years, appreciable advancements have been made in the treatment and control of cancer incidence and progression globally. However, the conventional treatment method is often accompanied with serious and sometimes devastating side effects, besides the treatment cost, which is usually so high that it remains unaffordable to many cancer sufferers in developing countries. Some of such sufferers are left with alternative or traditional medicine involving the use of medicinal plants as the only option for meeting their health-care needs. The present review was conducted to evaluate the available published literature reporting on plant species used for the treatment of cancer over the past twenty years (1998 – 2018) in Africa. A total of 212 articles containing information on medicinal plants used for cancer treatment in Africa were retrieved from scientific databases such as Google scholar, PubMed, and Web of science. A total of 207 plant species from 70 different plant families were recorded in this review. Forty-eight percent (48%) of the documented plant species were reported with cytotoxic activity against different cancer cell lines *in vitro* and *in vivo*. The dominant plant families documented for use in cancer treatment included Asteraceae and Fabaceae. Plant species such as *Artemisia afra* Jacq., *Artemisia armeniaca* Lam., *Bidens pilosa* L., *Solanecio mannii* (Hook.f.) C. Jeffrey, and *Solanecio nandensis* (S. Moore) C. Jeffrey were reported for the treatment of different cancer types such as skin, breast, and colorectal cancer in southern Africa. Most of the studies were on breast, skin, colorectal, cervical, leukemia, and prostate cancer with less attention to other forms of cancer. While these cancer types might recieve more attention in the preliminary phase, there is a need for further in-depth studies on the promising medicinal plants against other forms of cancer. Some of the identified 'potent' medicinal plant species from *in vitro* screening need to be evaluated *in vivo* as part of the drug design pipeline. The mechanism(s) of action, other pharmacological activities including cytotoxicity against non-targeted cells and potential in cancer therapy development of the identified 'potent' extracts and isolated plant compounds are other areas that require more research attention.

1. Introduction

Cancer is one of the fastest emerging life-threatening diseases and globally listed among the top ten causes of death (Popat et al., 2013; Cheung and Delfabbro, 2016; Mbele et al., 2017). Cancer is increasing in frequency of occurrences thereby posing a great challenge in the African continent because of limited resources (Torres et al., 2012; Banydeen et al., 2015). Cancer, amongst other non-communicable diseases, has become an epidemic with an increasing global disease burden, which requires an integrative approach in order to combat this disease with minimal harm. Cancer in humans usually results from two broad processes either internally (genetically transformed abnormal cells, immune conditions) or externally (unprotected exposure to/ingestion of carcinogens, chemicals or radiations, and viruses) (Anitha et al., 2014; Chacko et al., 2015; Tariq et al., 2017). Cancer development and progression are sometimes evasive resulting in late detection, which can make treatment very difficult (Sreejaya and Santhy, 2013). Late detection of cancer is in fact the most significant reason adduced to its proliferation and morbidity (Banydeen et al., 2015).

Recent statistics estimated the global cancer disease burden at 18.1 million new cases, 9.6 million deaths and 43.8 million 5-year prevalence (total number of people who are alive within five years of a

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cancer diagnosis) in 2018 (Global Cancer Observatory, 2018). The report indicated the top five most frequent cancers (excluding non-melanoma skin cancer) to be cancers of the lung, breast, colorectum, prostate and stomach. These five cancer types accounted for 46% of the new cases and 43% of deaths in 2018 (GCO, 2018). When compared to other world regions, cancer death proportions in Asia and Africa were higher than the proportions of incident cases in the other countries of the world (Bray et al., 2018; WHO, 2018). For example, India with its proliferative growth rate has a sizeable number of individuals inflicted with a cancer diagnosis (Gandhi et al., 2017). An estimated incidence of above 1.4 million cases was recorded in 2016, and the cancer incidence is expected to reach over 1.7 million cases in 2020 (Gandhi et al., 2017). This observation was attributed to higher distribution of specific cancer types 'associated with poorer prognosis and higher mortality rates' coupled to poor early diagnosis and treatment in these regions (Gandhi et al., 2017; Bray et al., 2018; WHO, 2018). It has been projected that by 2030, the annual number of new cancer diagnoses will be around 21 million globally, with an average of 17 million deaths every year while 75 million people may be living with different types of cancer diagnoses (Banydeen et al., 2015; Ferlay et al., 2015).

The World Health Organization projected that by 2030, cancers of stomach, colon, rectal, and liver will rank among the 20 leading causes of mortality globally (WHO, 2013; Simoben and Ntie-Kang, 2017). These internal cancers are not the only cancers resulting in premature death in low - and middle - income countries (LMICs), where untreated cancer is a growing concern because of late detection (Martei et al., 2018). For example, in the low-income countries, breast and cervical cancers remain among the leading cause of cancer death in women probably due to late diagnoses or unaffordability of the treatment even if diagnosed early (Banydeen et al., 2015; WHO, 2018). In 2012, Global Cancer Observatory (GLOBOCAN) reported death resulting from lung cancer to be hovering around 1.8 million, which was about 13% of the total death due to cancer in that year (GLOBOCAN, 2012). Although effective tobacco control policies implemented in different parts of the world have been useful, smoking-related lung cancer remains a leading cause of death responsible for the largest number of cancer deaths (1.8 million deaths, 18.4% of the total) in 2018 (WHO, 2018).

At present, the common cancer treatment or therapy includes surgery, chemotherapy and radiotherapy. However, the therapeutic efficacies of these treatment methods are beset by their undesirable side-effects, some of which can be permanent. Application of chemotherapy in addition to surgery has proved advantageous in a number of different cancer types including colorectal, testicular, pancreatic, breast, osteogenic sarcoma and lung cancers (Ochwang'i et al., 2014). However, the efficiency of chemotherapy is often limited by its toxic impacts on other non-target tissues (Tariq et al., 2017; Seca and Pinto, 2018). Therefore, alternative approaches and integration of conventional natural therapies such as the use of medicinal/herbal plants, which may mitigate some adverse side effects of chemotherapy, are increasingly encouraged (Desai et al., 2008; Ochwang'i et al., 2014).

Different scholars and researchers across the globe have contributed greatly to the prevalent knowledge about cancer and reported on various medicinal plants for treating cancer with fewer side effects. Herbal/Traditional/Alternative/Complemetary medicine has gained global relevance with enormous contribution to global healthcare and international commerce through medicinal plant trade over the past few decades (Bussmann and Glenn, 2011; Kaur et al., 2011). Traditional medicine remains an integral component of healthcare in Asia and Africa particularly, sub-saharan Africa where it is often the most affordable and accessible treatment option available for cancer and other non-communicable diseases (Kaur et al., 2011; Segun et al., 2018). The history of traditional medicine in India dates to around 7000 years ago and it is still relevant and practiced now (Elahee et al., 2019) while Chinese herbal medicine practice has been established above two millennia (So et al., 2019). The vast plant biodiversity in Asia and the adoption and integration of orthodox and traditional medicines shows that there has been a reduced mortality amongst cancer sufferers (Kaur et al., 2011; Siew et al., 2019). Similarly, Africa has numerous and diverse medicinal plants coupled with rich indigenous knowledge sytems that have progressively become a vital part of ethnomedical option for treating or managing diseases such as cancer. The recorded practice has been around for a couple of centuries, though it is very likely its use began far before that (Chen et al., 2012; Sawadogo et al., 2012; Ntie-Kang et al., 2013). It must be noted that despite appreciable advancements already made in the treatment and control of cancer incidences and progression (De Angelis et al., 2014), the fact that cancer remains a leading cause of global death is an indication perhaps of the need to explore alternative treatment or management methods (Desai et al., 2008).

It is common for Africanists and traditionalists to believe medicinal plants are relatively more efficient in comparison to synthetic drugs; however, there is still a paucity of updated comprehensive compilation of promising medicinal plants from the African continent. In addition, there is no sufficient knowledge about their ability to induce apoptosis, the different types of cancer they can treat effectively, and their general cytotoxicity (Nibret et al., 2011; Patel, 2012; Tariq et al., 2017). The present review was aimed at providing a coherent synthesis and evaluation of available information in relation to published literature reporting on plant species used for the treatment of cancer over the past twenty years (1998 – 2018) in Africa. Besides providing a pool of potential medicinal plant species for bioprospecting research related to the search for alternative anticancer drugs, the identified knowledge gaps highlight opportunities for further research activities, especially from an ethnopharmacological viewpoint.

2. Methodology

This review assessed new published research papers and review articles only. Notable search engines were used such as ScienceDirect, Google scholar, Web of Science, Springerlink, Scopus, PubMed, and BioMed Central. Additional materials were retrieved by consulting books, and ethnopharmacological publications not readily available in electronic form. Keywords such as' medicinal plants used for cancer treatments in Africa',' medicinal plants and cancer' and 'medicinal uses of plants'were used for searching the literature. The focus was on literature in English. A broader search on ''ScienceDirect'' produced a total result of 26,142 articles comprising of review articles (3367), research articles (15,299), encyclopedia (633), book chapters (2767), conference abstracts (529), book reviews (46), case reports (7), conference info (19), correspondence (36), data articles (6), discussion (84), editorials (152), errata (4), mini reviews (201), news (30), patent reports (5), practice guidelines (4), product reviews (2), short communications (2059) and others (892). A narrower search on this same search engine using keywords such as 'medicinal plants and cancer in Africa' produced a total result of 5109 comprising of review articles (920), research articles (2314), encyclopedia (236), book chapters (970), conference abstracts (135), book reviews (12), case reports (1), conference info (7), correspondence (2), data articles (1), discussion (10), editorials (28), mini reviews (42), news (2), product reviews (1), short communications (191) and others (237).

A broad search on Google scholar yielded a total result of 477,000 articles comprising of research articles, review articles and others. A narrower search from the same search engine produced a total of 18,200 articles of different types such as review and research articles. A similar search on Scopus produced a total of 137 results in web pages, books and journals and a narrow search titled ''medicinal plants and cancer in Africa'' yielded 25 documents including books and others. Furthermore, the search on ''web of science'' using the caption ''medicinal plants and cancer'' resulted in 4077 documents while a narrow search with ''medicinal plants and cancer in Africa'' as keyword produced 160 documents. It should however be noted that using the web of Science engine, the documents available were from the year 2000 till

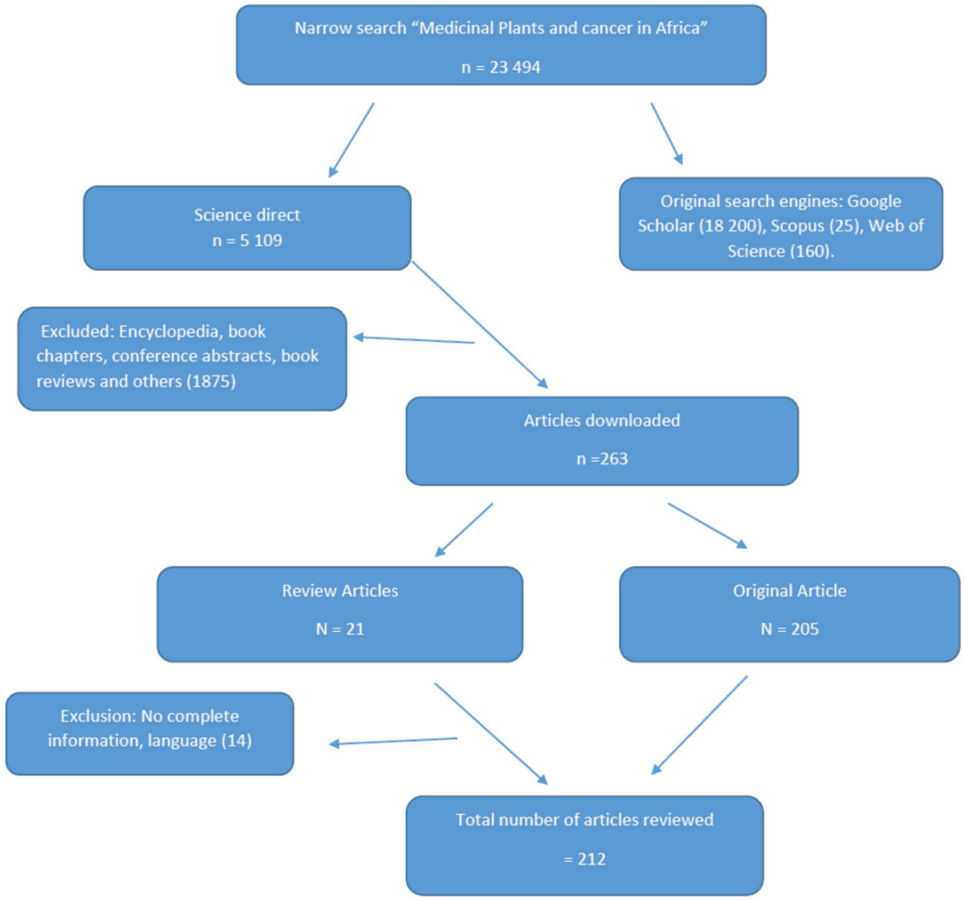

Fig. 1. Flow diagram illustrating the screening approach employed during the review process.

date. For the purpose of this review, research and review articles only retrieved from the narrow search on the aforementioned search engines and databases were considered but with focus on reported use in Africa (Fig. 1).

2.1. Exclusion and inclusion criteria

Literature searched for this current review included thesis, encyclopedia, book chapters, conference abstracts, book reviews and others **(**Fig. 1**)**. Articles excluded from this current report are those written in English Language and those with incomplete information. All of the two hundred and twelve articles (212) were comprised of only research and review articles. **(**Fig. 1**)**.

3. Results and discussion

Twenty-five percent (25%) of the world's biodiversity is reportedly found in Africa (Kakakhel, 2002). Africa is estimated to contain up to 45,000 plant species with potential for medicinal use (Klopper et al., 2007; Mahomoodally, 2013). Two hundred and seven species belonging to seventy families were documented for treating different types of cancer in this study (Table 1). Asteraceae and Fabaceae were the most dominant families with twenty-two (23) and twenty (25) different species, respectively (Fig. 2). The wide use of the two families for cancer treatment might be due to the fact that they are ubiquitous, and are among the largest terrestrial plant families throughout the world (Jansen and Palmer, 1987; Tariq et al., 2017). Furthermore, a majority of the species in these two dominant families have been reported to possess highly efficacious secondary metabolites such as flavonoids, terpenoids, saponins, tannins, alkaloids, and phenolics (Zarnowski et al., 2001; Mwine and Damme, 2011; Carvalho et al., 2013) and could be the reasons for higher reliability on these families for cancer treatment.

The highest number of documented anticancer plants was from Southern Africa followed by Eastern Africa, Western Africa while Northern Africa had the least (Fig. 3). These might be due to a number of factors. For example, Southern Africa at the top of the list has a very rich floral distribution and is reportedly the third most biologically diverse region in the world (SADC, 2012; Victor et al., 2015). Another reason could be that the majority of the population in Southern Africa deeply hold on to their traditional culture and possibly the economical conditions prohibit the use of orthodox medicine, thus use of the traditional medicinal system based on indigenous knowledge is encouraged (Khumalo et al., 2012; Mbele et al., 2017). Furthermore, the geographical region and climate of Southern Africa (summer-rainfall zone with a single rainy season) has been reported as a huge advantage to the richness of flora of this region. Also there are robust environmental laws by Department of Environmental Affairs that placed a significant sanction on illegal collection of plants from one location to the other and encourages strict biodiversity conservation (Geldenhuys and Golding, 2008). The richness in medicinal plant species in southern Africa as recorded in this review is however, contrary to the report of Ntie-Kang et al. (2014) in their review paper on molecular modelling of about 400 plant species with the potential of anticancer activity where Central Africa recorded the highest number of documented plant species in their review paper.

In Eastern Africa, countries such as Kenya and Uganda have a high incidence of cancer every year, which could have prompted an improved documented contribution in relation to traditional anticancer therapy. In Kenya, cancer is ranked as the third main cause of death after cardiovascular and infectious diseases (Tariq et al., 2017). The dependence on medicinal plant resources by rural people due to lack of,

Table 1
Medicinal plants used for treating different cancer types in Africa.

Family	Plant species	Plant Part(s) Used	Type of cancer	Research type	Country/region	References
Acanthaceae	*Dicliptera laxata* C.B.Clarke	Leaves, Stem barks	Colon	Survey	Kenya	Ochwang'i et al., 2014
Acanthaceae	*Eremomastax speciosa speciosa* (Hochst.) Cufod.	Whole plant	Skin	Survey, *in vitro*	Eastern Africa, Sierra Leone, Nigeria, Cameroon and Ghana	Gismondi et al., 2013; Sagnia et al., 2014; Mbele et al., 2017
Acanthaceae	*Justicia betonica* L.	Leaves, Stem barks	Breast/colon/skin	Survey	Kenya	Ochwang'i et al., 2014
Amaryllidaceae	*Agapanthus africanus* (L.) Hoffmanns.	Roots	Skin	Survey	South Africa	Koduru et al., 2007
Amaryllidaceae	*Tulbaghia violacea* Harv.	Bulbs, Leaves	Cervical	Survey, *in vitro*	Southern Africa	Koduru et al., 2007; Mthembu and Motadi, 2014; Mbele et al., 2017
Amaryllidaceae	*Amaryllis belladonna* L.	Leaves, flowers, bulbs	Brain	Survey, *in vitro*	North Africa, Western Cape of South Africa	Nair et al., 1998; Botha et al., 2005; Nair and van Staden, 2013
Amaryllidaceae	*Boophone disticha* (L.f.) Herb.	Leaves, flowers, bulbs	Brain	Survey, *in vitro*	North Africa, Western Cape of South Africa	Nair et al., 1998; Botha et al., 2005; Nair and van Staden, 2013
Amaryllidaceae	*Crinum stuhlmannii subsp. delagoense* (I.Verd.) Kwembeya & Nordal Syn. *Crinum delagoense* I.Verd.	Leaves, flowers, bulbs	Brain	Survey, *in vitro*	North Africa, Southern Africa	Nair et al., 1998; Botha et al., 2005; Nair and van Staden, 2013
Amaryllidaceae	*Crinum jagus* (J.Thomps.) Dandy	Leaves, flowers, bulbs	Brain	Survey, *in vitro*	Nigeria	Soladoye et al., 2010; Nair and van Staden, 2013
Anacardiaceae	*Lannea acida* A. Rich.	Leaves, fruits	N/S	Survey	Nigeria	Soladoye et al., 2010
Anacardiaceae	*Mangifera indica* L.	Leaves, Stem barks	Skin/throat/breast	Survey	Kenya, Nigeria	Soladoye et al., 2010; Ochwang'i et al., 2014
Anacardiaceae	*Searsia pyroides* (Burch.) Moffett. Syn. *Rhus vulgaris* Meikle	Leaves, Stem barks	Stomach/skin/breast	Survey	Kenya	Ochwang'i et al., 2014
Anacardiaceae	*Tridesmostemon omphalocarpoides* Engl.	Stem barks	Leukaemia/breast/brain	Survey, *in vitro*	Cameroon, Gabon, Congo, DR Congo	Kuete et al., 2006, 2014a, 2014b, 2014d; 2016a, 2016b
Anisophylleaceae	*Anisophyllea dichostyla* R. Br.	Roots	N/S	Survey, *in vitro*	Central Africa, Democratic Republic of Congo	Khallouki et al., 2007; Mbele et al., 2017
Annonaceae	*Annona muricata* L.	Fruits, Leaves, Stem barks	Leukaemia/breast/brain/colon	Survey, *in vitro*, *in vivo*	Tropical Africa including Cameroon and Nigeria	Rajeswari et al., 2012; Kuete et al., 2013c; 2016; Paul et al., 2013; Moghadamtousi et al., 2015; Yajid et al., 2018
Annonaceae	*Annona senegalensis* Pers.	Fruits, Leaves, Stem barks	Skin/leukaemia	Survey, *in vitro*	West Africa	Potchoo et al., 2008; Ahmed et al., 2010
Annonaceae	*Anonidium mannii* (Oliv.) Engl. & Diels	Fruits, Leaves, Stem barks	Leukaemia cells/breast/colon	Survey, *in vitro*, *in vivo*	Central and West Africa, DR Congo, and Angola	Thomas et al., 2003; Betti, 2004; Noumi and Eloumou, 2011; Kuete et al., 2013a; Mbele et al., 2017
Annonaceae	*Enantia chlorantha* Oliv.	Fruits, Leaves, Stem barks	Skin	Survey, *in vitro*, *in vivo*	West Africa	Adebiyi and Abatan, 2013; Gismondi et al., 2013; Tcheghebe et al., 2016; Mbele et al., 2017
Annonaceae	*Pachypodanthium staudtii* Engl. & Diels.	Fruits, Leaves, Stem barks	Leukaemia/breast/colon/brain/liver	Survey, *in vitro*	East Africa: Kenya, Guinea, West Africa, and Cameroon	Yapi et al., 2012; Kuete et al., 2016a, 2016b
Annonaceae	*Uvaria chamea* P. Beauv.	Fruits, Leaves, Stem barks	All types	Survey	Nigeria	Soladoye et al., 2010
Annonaceae	*Xylopia aethiopica* (Dunal) A. Rich.	Fruits, Leaves, Stem barks	Leukaemia/colon/liver/brain/oral	Survey, *in vitro*, *in vivo*	Angola, Benin, Burkina Faso, Cameroon, Central African Republic, DR Congo, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Kenya, Liberia, Mozambique, Nigeria, São Tomé and Príncipe, Senegal, Sierra Leone, Sudan, South Sudan, Tanzania, Togo, and Uganda	Tatsadjieu et al., 2003; Kuete et al., 2011, 2015; Okafor et al., 2012; Adaramoye et al., 2015; Osafo and Obiri, 2016; Tcheghebe et al., 2016; Mbele et al., 2017
Apocynaceae	*Calotropis procera* (Aiton) W. T. Aiton,	Roots, Stem barks, fruits	N/S	Survey	West Africa	Moustafa et al., 2010
Apocynaceae	*Carissa edulis* Vahl.	Roots bark, Leaves	N/S	Survey, *in vitro*	Nigeria	Ngulde et al., 2015
Apocynaceae	*Catharanthus roseus* (L.) G. Don.	Roots, Leaves, Stems, flowers	Throat/stomach/oesophageal	Survey, *in vitro*, *in vivo*	Kenya	Bruneton, 1999; Hoareau and DaSilva, 1999; Van Wyk et al., 2002; Newman et al., 2003; Cragg and Newman, 2005; Wink and Van Wyk, 2008; Li-Weber, 2009; Nirmala et al., 2011; Hazarika et al., 2012; Sinhababu

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Table 1 (*continued*)

Family	Plant species	Plant Part(s) Used	Type of cancer	Research type	Country/region	References
						and Banerjee, 2013; Ntie-Kang et al., 2014; Ochwang'i et al., 2014; Yuan et al., 2016
Apocynaceae	*Raphionacme hirsuta* (E. Mey.) R.A. Dyer	Leaves, flowers	N/S	Survey, *in vitro*	Southern Africa	Moffett, 2010; Moteetee and Van Wyk, 2011
Apocynaceae	*Tabernaemontana stapfiana* Britten,	Roots, Leaves, Stem barks	Breast	Survey	Kenya	Ochwang'i et al., 2014
Apocynaceae	*Gomphocarpus fruticosus* (L.) W.T Aiton	Roots, Leaves, Fruits and Stems	breast MCF7, renal TK10 and elanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Apocynaceae	*Acokanthera oppositifolia* (Lam.)	Leaves, flowers	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Apocynaceae	*Gomphocarpus physocarpus* E. Mey.	Roots	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Araliaceae	*Cussonia paniculata* (Eckl. And Zeyh.)	Leaves	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Araliaceae	*Centella asiatica* (L.) Urb.	Leaves	N/S	Survey, *in vitro*, *in vivo*	South Africa	Steenkamp and Gouws, 2006
Araliaceae	*Polyscias fulva* (Hiern) Harms	Leaves	Leukaemia/breast/ colon/brain/liver	Survey, *in vitro*, *in vivo*	Southern, Eastern, Western, Northern and Central African outside the humid forest zone; from Mauritania and Senegal to Ethiopia and Eritrea, Namibia, Botswana, East Africa	Braca et al., 2003; Njume et al., 2009; Gouwakinnou et al., 2011; Kuete et al., 2014c, 2014e; Sagnia et al., 2014; Armentano et al., 2015; Mbele et al., 2017
Asparagaceae	*Aloe volkensii* Engl.	Leaves, Stem barks	Colon/oesophageal/ prostate	Survey	Kenya	Ochwang'i et al., 2014
Asparagaceae	*Fusifilum depressum* (Baker) U. Müll.-Doblies, J.S.Tang & D.Müll.-Doblies	Leaves, Bulbs	N/S	Survey, *in vitro*,	Southern Africa	Moffett, 2010; Mulholland et al., 2013; Seleteng et al., 2015
Asphodelaceae	*Aloe ferox* Mill.	Roots, Leaves	Skin	Survey, *in vitro*	Southern Africa	Van Wyk et al., 2000; Jia et al., 2008; Mabona and van Vuuren, 2013
Asteraceae	*Acanthaspermum hispidum* DC,	Leaves, Flowers	N/S	Survey	West Africa	Deepa and Rajendran, 2007; Chakraborty et al., 2012
Asteraceae	*Zinnia peruviana* (L.) L.	Leaves, Flowers	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Asteraceae	*Elephantopus mollis* Kunth	Leaves	Brain cancer		Cameroon	Tabopda et al., 2008
Asteraceae	*Tithonia diversifolia* (Hemsl. A. Gray)	Leaves	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Asteraceae	*Athrixia elata* Sond.	Leaves, Seeds	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Asteraceae	*Xanthium strumarium* L.	Stems	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Asteraceae	*Echinops giganteus* A. Rich. var. *lelyi* (C. D. Adams).	Leaves	Leukaemia/breast/ colon/brain/Liver	Survey, *in vitro*, *in vivo*	East Africa: Kenya, Guinea, West Africa, and Cameroon	Tene et al., 2004; Kuete et al., 2013c; Sandjo et al., 2016; Pavela et al., 2016
Asteraceae	*Microglossa pyrifolia* (Lamarck) Kuntze.	Leaves, Stem barks	N/S	Survey	Kenya	Ochwang'i et al., 2014
Asteraceae	*Artemisia afra* Jacq.	Leaves, Stems	N/S	Survey, *in vitro*	South Africa	Fouche et al., 2008; Mativandlela et al., 2008; Spies et al., 2013; Venables et al., 2016
Asteraceae	*Artemisia armeniaca* Lam.	Leaves,	N/S	Survey, *in vitro*, *in vivo*	South Africa	Mojarrab et al., 2013
Asteraceae	*Baccharoides lasiopus* (O. Hoffm.)	Leaves, Stem barks	Colon	Survey	Kenya	Ochwang'i et al., 2014
Asteraceae	*Artemisia indica* Willd.	Leaves	N/S	Survey, *in vitro*, *in vivo*	South Africa	Rashid et al., 2013
Asteraceae	*Bidens pilosa* L.,	Leaves, Flowers	Prostate/skin/throat	Survey, *in vitro*	South Africa, Kenya	Steenkamp and Gouws, 2006; Ochwang'i et al., 2014
Asteraceae	*Cnicus benedictus* L.	Leaves, Stems	N/S	Survey, *in vitro*	South Africa	Steenkamp and Gouws, 2006
Asteraceae	*Conyza sumatrensis* (Retz.) E.H. Walker	Leaves, Stem barks	Throat/breast/oral	Survey	Kenya	Ochwang'i et al., 2014
Asteraceae	*Dicoma capensis* Less.	Leaves, Stems	N/S	Survey, *in vitro*	South Africa	Steenkamp and Gouws, 2006
Asteraceae	*Galinsonga parviflora* Cav.	Leaves,	Colon	Survey	Kenya	Ochwang'i et al., 2014

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Table 1 (*continued*)

Family	Plant species	Plant Part(s) Used	Type of cancer	Research type	Country/region	References
Asteraceae	*Microglossa pyrifolia* (Lamarck) Kuntze.	Leaves, Stem barks	Colon/skin/breast	Survey	Kenya	Ochwang'i et al., 2014
Asteraceae	*Senecio glanduloso-pilosus* Volkens & Muschl.	Leaves	N/S	Survey	Southern Africa	Moffett, 2010
Asteraceae	*Senecio incomptus* DC.	Leaves	N/S	Survey	Southern Africa	Moffett, 2010
Asteraceae	*Solanecio mannii* (Hook.f.) C. Jeffrey	Leaves, Stem barks	Skin/breast/Colon	Survey	Kenya	Ochwang'i et al., 2014
Asteraceae	*Solanecio nandensis* (S. Moore) C. Jeffrey,	Leaves, Stem barks	N/S	Survey	Kenya	Ochwang'i et al., 2014
Asteraceae	*Sonchus oleraceus* L.	Leaves, Flowers	N/S	Survey	South Africa	Jimoh et al., 2011
Bignoniaceae	*Kigelia africana* (Lam.) Benth.	Leaves, Stem barks	Breast/skin/uterine	Survey	Kenya	Ochwang'i et al., 2014
Bignoniaceae	*Markhamia lutea* (Benth.) K. Schum.	Leaves, Stem barks	Colon	Survey	Kenya	Ochwang'i et al., 2014
Bignoniaceae	*Markhamia tomentosa* (Benth.) K. Schum. ex Engl.	Leaves, Flowers, Stem barks	Cervical	Survey, *in vitro*	West Africa	Ibrahim et al., 2013
Bignoniaceae	*Spathodea campanulata* Beauv.	Leaves, Stem barks	Cervical/bone/breast/colon/skin	Survey	Kenya	Ochwang'i et al., 2014
Cannabidaceae	*Cannabis sativa* L. var. *sativa*	Leaves	N/S	Survey	Southern Africa	Koduru et al., 2007; Van Wyk et al., 2009; Moffett, 2010; Moteetee and Van Wyk, 2011; Abuhasira et al., 2018
Caricaceae	*Carica papaya* L.	Leaves	Cervical/colon/breast	Survey	East Africa: Kenya, Guinea, West Africa: Nigeria, Ghana, and Cameroon	Ochwang'i et al., 2014; Sagnia et al., 2014; Mbele et al., 2017
Celastraceae	*Loeseneriella africana* (Willd.)	Leaves, Stem barks	Colon/breast	Survey	Kenya	Ochwang'i et al., 2014
Celastraceae	*Gymnosporia tenuispina* (Sond.) Szyszyl.	Leaves, Fruits	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Celastraceae	*Catha edulis* (Khat.)	Leaves, Fruits	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Chrysobalanaceae	*Parinari curatellifolia* Planch ex. Benth	Whole plants	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Clusiaceae	*Allanblackia monticola* Staner L.C	Leaves, Seeds	Leukemia	Survey, *in vitro*	Cameroon	Azebaze et al., 2009
Clusiaceae	*Hypericum lanceolatum* Lam	Leaves, Flowers	Colon	Survey, *in vitro*	N/S	Kuete et al., 2013b, 2013d
Clusiaceae	*Garcinia punctuate* (Blume) Makino	Leaves, Flowers	Colon	Survey, *in vitro*	N/S	Kuete et al., 2013b, 2013d
Combretaceae	*Terminalia ivorensis* A. Chev.	Leaves, Stem barks, Fruits	Breast	Survey, *in vitro*	N/S	Ponou et al., 2010; Segun et al., 2018
Convolvulaceae	*Ipomoea cairica* (L.)	Leaves, Flowers	Breast/cervical/ skin	Survey	Kenya	Ochwang'i et al., 2014
Cortinariaceae	*Cortinarius rubellus* (Cooke)		Prostate	Survey	N/S	Bobach et al., 2014
Crassulaceae	*Cotyledon orbiculata spp. oblonga* (L.)	Roots	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Crassulaceae	*Kalanchoe paniculata* Harv.	Roots	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Cucurbitaceae	*Momordica foetida* Schumach.	Leaves, Stem barks	Breast/cervical	Survey	Kenya	Ochwang'i et al., 2014
Cucurbitaceae	*Momordica charantia* L.	Whole plant	Skin	Survey, *in vitro*	West Africa	Gismondi et al., 2013; Mbele et al., 2017
Cupressaceae	*Juniperus procera* Hochst. ex Endl.	Leaves, Stem barks	Breast/throat/ oral	Survey	Kenya	Ochwang'i et al., 2014
Curtisiaceae	*Curtisia dentata* (Burm.f.)	Leaves, Stem barks	All types	Survey	South Africa	Koduru et al., 2007
Dryopteridaceae	*Cyrtomium falcatum* (L.f.) C. Presl	Leaves, Roots	Prostate	Survey	N/S	Bobach et al., 2014
Ebenaceae	*Diospyros whyteana* (LC.)	Leaves, Flowers	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Euphorbiaceae	*Acalypha wilkesiana* (Muell.Arg.) Fosberg,	Leaves, Stems	Breast	Survey	West Africa	Madziga et al., 2010

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Euphorbiaceae	*Alchornea cordifolia* (Schum and Thonn) Muell. Arg.	Leaves, Fruits	Leukaemia/breast/brain	Survey, *in vitro*	Tropical Africa from Senegal to Kenya and Tanzania and throughout Central Africa to Angola	Adeneye et al., 2014; Kuete et al., 2016c
Euphorbiaceae	*Bridelia macrantha* (Hochst.) Baillon.	Leaves, Stem barks	Cervical/breast/skin/colon	Survey	Kenya	Ochwang'i et al., 2014
Euphorbiaceae	*Croton macrostachyus* Hochst. ex Delile	Leaves, Stem barks	Colon/skin	Survey	Kenya	Ochwang'i et al., 2014
Euphorbiaceae	*Elaeophorbia drupifera* (Thonn.) Stapf.	Leaves, Stem barks	Leukaemia/breast/colon/brain/liver	Survey, *in vitro*	West Africa	Eno and Azah, 2004; Ahiahonu and Goodenowe, 2007; Kuete et al., 2013b, 2013d; Voukeng et al., 2017
Euphorbiaceae	*Euphorbia ingens* E. Mey. ex Boiss.	Stems	N/S	Survey	South Africa	Koduru et al., 2007
Euphorbiaceae	*Tragia brevipes* Pax	Leaves, Stem barks	Breast/leukaemia	Survey	Kenya	Ochwang'i et al., 2014
Fabaceae	*Aeschynomene abyssinica* (A. Rich.)	Leaves, Fruits	N/S	Survey	Kenya	Ochwang'i et al., 2014
Fabaceae	*Albizia gummifera* (J. F. Gmel.) C. A. Sm.	Leaves, Fruits	Throat/skin	Survey	Kenya	Ochwang'i et al., 2014
Fabaceae	*Calliandra portoricensis* (Jacq.) Benth.	Leaves	Prostate	Survey, *in vitro*	Nigeria	Adaramoye et al., 2015; Segun et al., 2018
Fabaceae	*Detarium microcarpum* Guill. et Perr.,	Leaves	N/S	Survey	Nigeria	Ngulde et al., 2015
Fabaceae	*Albizia adianthifolia* (Schum.) W. Wight.	Leaves	Leukaemia/breast/brain/colon	Survey, *in vitro, in vivo*	Angola, Benin, Cameroon, Central African Republic, Congo, DR Congo, Ivory Coast, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Senegal, Sierra Leone, Sudan, Tanzania, Togo, Uganda	Van Wyk and Gericke, 2000; Haddad et al., 2002, 2003; Tamokou et al., 2012; Kuete et al., 2016c
Fabaceae	*Albizia coriaria* Welw. ex Oliv.,	Leaves, Seeds, Stem barks	N/S	Survey	Kenya	Ochwang'i et al., 2014
Fabaceae	*Andira inermis* (W. Wright) Kunth ex DC.	Leaves	N/S	Survey	Nigeria	Ngulde et al., 2015
Fabaceae	*Cassia alata* L. Syn. *Senna alata* (L.) Roxb.	Leaves	N/S	Survey, *in vitro*	Eastern Africa, West Africa, and Cameroon	Sagnia et al., 2014; Mbele et al., 2017
Fabaceae	*Cassia sieberiana* DC.	Leaves	N/S	Survey	Nigeria	Ngulde et al., 2015
Fabaceae	*Elephantorrhiza elephantina* (Burch.)	Leaves	Breast cancer	Survey, *in vitro,*	Southern Africa	Van Wyk and Gericke, 2000; Van Wyk et al., 2009; Moffett, 2010; Moteetee and Van Wyk, 2011; Seleteng et al., 2015
Fabaceae	*Enterolobium cyclocarpum* (Jacq.) Griesb.	Leaves	Liver	Survey, *in vitro*	West Africa	Sowemimo et al., 2015
Fabaceae	*Erythrina addisoniae* Hutch. & Dalziel	Leaves	Liver	Survey, *in vitro*	West Africa	Passreiter et al., 2015; Mbele et al., 2017
Fabaceae	*Erythrina sigmoidea* Hua	Leaves	Leukaemia/breast/colon/brain/Liver	Survey, *in vitro*	Cameroon and Chad	Mabeku et al., 2011; Kuete et al., 2016a, 2016b
Fabaceae	*Erythrophleum suaveolens* (Guill. &. Perr.)	Leaves	breast/colon/prostate/leukaemia	Survey, *in vitro*	Nigeria	Fadeyi et al., 2013; Segun et al., 2018
Fabaceae	*Neonotonia wightii* (Arn.) J.A. Lackey.	Leaves, Stem barks	N/S	Survey	Kenya	Ochwang'i et al., 2014
Fabaceae	*Pterocarpus erinaceus* Poiret.	Leaves	N/S	Survey	Nigeria	Ngulde et al., 2015
Fabaceae	*Pterocarpus erinaceus* Poir.	Leaves	N/S	Survey	Nigeria	Ngulde et al., 2015
Fabaceae	*Senna didymobotyra* (Fresenius) Irwin & Barneby.	Leaves, Stem barks	N/S	Survey	Kenya	Ochwang'i et al., 2014
Fabaceae	*Erythrina abyssinica* Lam. Ex DC.	Whole plant	Breast/Liver/Cervical cancer	Survey, *in vitro*	Sudan	Mohammed et al., 2012
Fabaceae	*Albizia grandibracteata* Taub.	Leaves	Breast/Cervical	Survey, *in vitro*	Uganda	Krief et al., 2005
Fabaceae	*Cajanus cajan* (L.) Millsp.	Whole plant	Breast/Lung/Skin	Survey, *in vitro*	Nigeria	Ashidi et al., 2010
Fabaceae	*Erythrina excels* Lam. ex DC	Leaves	Breast	Survey, *in vitro*	Cameroon	Kuete et al., 2014a, 2014b, 2014d
Fabaceae	*Erythrina senegalensis* LC.	Leaves	Leukemia/Breast	Survey, *in vitro*	Cameroon	Kuete et al., 2014a, 2014b, 2014d
Fabaceae	*Lessertia frutescens* (L.) Goldblatt & J.C. Manning	Leaves, flowers, Fruits	N/S	Survey, *in vitro, in vivo*	South Africa, Botswana, Lesotho, Namibia	Von Koene, 2001; Fernandes et al., 2004; Thring and Weitz, 2006; Koduru et al., 2007; Van Wyk and Albrecht, 2008; Korb et al., 2010; Ndhlala et al., 2013;

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						Street and Prinsloo, 2013; Aboyade et al., 2014; Leisching et al., 2015
Fabaceae	*Tetrapleura tetraptera* (Schum. & Thonn.) Taub.	Leaves, Fruits	Leukaemia	Survey	Nigeria	Fadeyi et al., 2013; Segun et al., 2018
Gunneraceae	*Gunnera perpensa* L.	Rhizome	N/S	Survey	South Africa	Koduru et al., 2007
Guttiferae	*Harungana madagascariensis* Lam. ex Poir.	Leaves, Fruits, Stem barks	Colon/skin/breast	Survey	Kenya	Ochwang'i et al., 2014
Guttiferae	*Hypericum riparium* A.Chev.	Leaves, Flowers	Gastric cancer	Survey, *in vitro*	N/S	Tala et al., 2013
Hyacinthaceae	*Drimia sphaerocephala* Baker	Leaves, Bulbs	N/S	Survey, *in vitro*	Southern Africa	Moffett, 2010
Hyacinthaceae	*Eucomis autumnalis* (Mill.)	Leaves, Fruits	N/S	Survey	South Africa	Koduru et al., 2007
Hyacinthaceae	*Merwilla plumbea* (Lindley) Speta.	Leaves, Bulbs	N/S	Survey, *in vitro*, *in vivo*	South Africa, Lesotho, Swaziland	Van Wyk et al., 2009; Moffett, 2010; Street and Prinsloo, 2013
Hypoxidaceae	*Hypoxis argentea* Harv. ex Baker	Corms	N/S	Survey	South Africa	Koduru et al., 2007
Hypoxidaceae	*Hypoxis colchicifolia* Baker	Corms	N/S	Survey	South Africa	Koduru et al., 2007
Hypoxidaceae	*Hypoxis hemerocallidea* Fisch., C.A. Mey.	Corms	N/S	Survey, *in vitro*,	South Africa, Lesotho, Swaziland, Mozambique, Zimbabwe	Koduru et al., 2007; Moffett, 2010; Steenkamp and Gouws, 2006; Van Wyk et al., 2009; Seleteng et al., 2015; Street and Prinsloo, 2013; Drewes et al., 2008; Madikizela et al., 2017
Hypoxidaceae	*Hypoxis obtusa* Burch. ex Ker Gawl.	Corms	N/S	Survey, *in vitro*	South Africa	Koduru et al., 2007; Moffett, 2010; Steenkamp and Gouws, 2006; Van Wyk et al., 2009; Seleteng et al., 2015; Street and Prinsloo, 2013; Drewes et al., 2008; Madikizela et al., 2017
Hypoxidaceae	*Hypoxis rigidula spp. pilosissima* Baker	Leaves, Bulbs	breast MCF7, renal TK10 and elanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Iridaceae	*Gladiolus quartinianus* A. Rich.	Whole plant	Leukaemia cells/breast/colon/brain	Survey, *in vitro*, *in vivo*	Cameroon, Senegal to Ethiopia	Tcheghebe et al., 2016; Mbele et al., 2017
Lamiaceae	*Fuerstia africana* Th. Fr.	Leaves, Stem barks	Colon	Survey	Kenya	Ochwang'i et al., 2014
Lamiaceae	*Ocimum gratissimum* Linn	Leaves, Stem barks	Colon	Survey	Kenya	Ochwang'i et al., 2014
Lamiaceae	*Ocimum labiatum* (N.E.Br.) A.J. Paton. LC. *formerly Orthosiphon labiatus*	Aerial parts	N/S	Survey, *in vitro*, *in vivo*	Southern Africa	Hussein et al., 2007; Mbele et al., 2017
Lamiaceae	*Persea americana* Mill.	Leaves, Stem barks	Colon/skin/breast	Survey, *in vitro*	Kenya	Ochwang'i et al., 2014
Lamiaceae	*Salvia africana* L.	Aerial parts	N/S	Survey, *in vitro*	South Africa	Hussein et al., 2007; Mbele et al., 2017
Lamiaceae	*Salvia coccinea* Buc'hoz ex Etl.	Leaves, Stem barks	Breast/oesophageal/colon	Survey	Kenya	Ochwang'i et al., 2014
Lamiaceae	*Salvia miltiorrhiza* Bunge	Aerial parts	Prostate	Survey	N/S	Bobach et al., 2014
Lamiaceae	*Plectranthus verticillatus* (L.f.) Druce.	Leaves, Stems	breast MCF7, renal TK10 and elanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Lauraceae	*Beilschmiedia acuta* Benth. ex Hook. f.	Barks, Leaves	Leukaemia/breast/colon/brain	Survey, *in vitro*	Cameroon, Central African Republic	Kuete et al., 2014a, 2014b, 2014d, 2014e; Mbele et al., 2017
Loganiaceae	*Anthocleista schweinfurthii* Gilg,	Stem Barks, Leaves	Leukaemia/breast/colon	Survey, *in vitro*	Tropical Africa—Nigeria to Ethiopia, south to Angola, Zambia and Tanzania	Mbouangouere et al., 2007; Kuete et al., 2014a, 2014b, 2014d, 2016a, 2016b; Ngbolua et al., 2014
Malpighiaceae	*Heteropterys chrysophylla* (Lam.) Kunth.	Leaves	Prostate	Survey, *in vitro*	N/S	Bobach et al., 2014
Malvaceae	*Hibiscus cannabinus* L.	Leaves, Stems	Skin/breast	Survey, *in vitro*	North Africa (Egypt); West Africa	Khaghani et al., 2011; Gismondi et al., 2013; Mbele et al., 2017
Malvaceae	*Hibiscus Sabdariffa* L.	Leaves	N/S	Survey	South Africa, Sudan, Benin, Cote D'ivore, Ghana, Niger, Nigeria, Burkina Faso	El-Sherif and Sarwat, 2007; Oyewole and Mera, 2010
Malvaceae	*Sida cordifolia* (Linn)	Leaves, Stem barks	Skin	Survey	Kenya	Ochwang'i et al., 2014
Meliaceae	*Ekebergia capensis* Sparrman.	Leaves, Stem barks	Skin/Throat/breast	Survey	Kenya	Ochwang'i et al., 2014

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Meliaceae	*Khaya ivorensis* A. Chev.	Leaves, Stem barks	N/S	Survey	Nigeria, Southern Africa	Segun et al., 2018
Meliaceae	*Melia azedarach* L.	Leaves, Stem barks	Colon, oesophagus	Survey	Kenya	Ochwang'i et al., 2014
Meliaceae	*Pseudocedrela kotschyi* (Schweinf.) Harms,	Leaves, Stem barks	N/S	Survey	Nigeria	Segun et al., 2018
Meliaceae	*Trichilia emetica* Vahl,	Leaves, Stem barks	Breast/skin/colon, Prostate cancer.	Survey,*in vitro*	Tropical Africa including Angola, Cameroon, Uganda, Tanzania, Malawi, Mozambique, Kenya	Bobach et al., 2014; Ochwang'i et al., 2014
Moraceae	*Dorstenia psilurus* (DOJPS)	Roots, Leaves	Leukaemia/Pancreatic	Survey, *in vitro*	Tropical Africa including Angola, Cameroon, Uganda, Tanzania, Malawi, Mozambique	Dimo et al., 2001; Pieme et al., 2013
Moraceae	*Morus mesozygia* Linnaeus.	Leaves	Leukaemia/breast/colon/ Liver/brain	Survey, *in vitro, in vivo*	Tropical Africa, from Senegal eastward to Ethiopia and Southward to Zambia, Angola, Mozambique, Central Africa.	Kapche et al., 2009; Nicolle et al., 2009; Kuete and Efferth, 2010, 2011; Kuete et al., 2009a, 2009b, 2014a, 2014b, 2014d, 2016a, 2016b
Moraceae	*Antiaris Africana* Engl.	Stem barks	Prostate/Liver	Survey, *in vitro*	Cameroon	Kuete et al., 2009a, 2009b
Moringaceae	*Moringa oleifera* Lam.	Leaves, Stems	N/S	Survey, *in vitro, in vivo*	Sierra Leone, Nigeria	Gismondi et al., 2013; Jafarain et al., 2014; Mbele et al., 2017
Myrsinaceae	*Rapanea melanophloeos* (L.) Mez.	Leaves	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Myrsinaceae	*Myrsine africana* L.	Leaves	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Myrsinaceae	*Ardisia kivuensis*	Leaves, Fruits	Breast/Cervical	Survey, *in vitro*	N/S	Ndonsta et al., 2011; 2012
Myrtaceae	*Syzygium guineense* (Willd.) DC.	Leaves, Stem barks	Skin	Survey	Kenya	Ochwang'i et al., 2014
Nephrolepidaceae	*Nephrolepis exaltata* (L.) H.W. Schott.	Leaves	Prostate	Survey, *in vitro*	South Africa	Bobach et al., 2014
Nyssaceae	*Camptotheca acuminata* Decne.	Leaves, Stem Barks	N/S	Survey	Southern, Eastern, Northern, Central and Western Africa	Shi et al., 2010; Yuan et al., 2016
Olacaceae	*Olax subscorpioidea* Oliv.	Leaves	N/S	Survey	Nigeria	Segun et al., 2018
Olacaceae	*Ximenia americana* L.	Leaves	N/S	Survey, *in vitro*	East Africa	Voss et al., 2006; Mbele et al., 2017
Oleaceae	*Olea capensis* L.	Leaves, Stem barks	Skin	Survey	Kenya	Ochwang'i et al., 2014
Oleaceae	*Olea hotcsh spp. Hochstetteri* Pavetta abyssinica Fresen.,	Leaves, Stem barks	N/S	Survey	Kenya	Ochwang'i et al., 2014
Passifloraceae	*Passiflora edulis* Sims.	Leaves, Fruits	Leukaemia	Survey, *in vitro, in vivo*	Central Africa and East including Cameroon, Tanzania, Uganda	Rowe et al., 2004; Ichimura et al., 2006; Kuete et al., 2016a, 2016b
Petiveriaceae	*Petiveria alliacea* L.	Leaves	Breast	Survey, *in vitro*	Nigeria	Uruena et al., 2008; Hernandez et al., 2014; Segun et al., 2018
Phyllanthaceae	*Phyllanthus fischeri Pax,*	Leaves, Fruits, Stem barks	N/S	Survey	Kenya	Ochwang'i et al., 2014
Phyllanthaceae	*Uapaca togoensis* Pax.	Leaves, Fruits, Stem barks	Leukaemia/breast/colon	Survey, *in vitro, in vivo*	Tropical Africa from Sierra Leone to DR Congo; Predominant in Cameroon.	Kone et al., 2004, 2006; Mengome et al., 2010; Kuete et al., 2015a, 2015d, 2015b; Mbele et al., 2017
Piperaceae	*Piper capense* L.f.	Leaves, Fruits	Leukaemia/breast/colon/ Liver/brain	Survey, *in vitro*	Guinea to Ethiopia and South Africa to Angola, Mozambique	Rowe et al., 2004; Ichimura et al., 2006; Kannan et al., 2011; Kuete et al., 2013c, 2016a, Pavela et al., 2016
Piperaceae	*Piper guineense* Schumach. & Thonn.	Leaves, Fruits	N/S	Survey	Nigeria	Soladoye et al., 2010
Pittosporaceae	*Pittosporum viridiflorum* Sims.	Barks, Roots	N/S	Survey	South Africa	Koduru et al., 2007
Plumbaginaceae	*Plumbago zeylanica* L.	Roots, Leaves	Pancreatic, breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro, in vivo*	Nigeria, South Africa	Lin et al., 2003; Fouche et al., 2008; Chen et al., 2009; Segun et al., 2018
Poaceae	*Cymbopogon citratus* (D.C.) Stapf.	Leaves	Colon	Survey	Kenya	Ochwang'i et al., 2014
Poaceae	*Eleusine indica* (L.)	Leaves	N/S	Survey	West Africa, Cameroon and Eastern Africa	Sagnia et al., 2014; Mbele et al., 2017
Poaceae	*Imperata cylindrica* (Linnaeus)	Leaves	Leukaemia/breast/colon/ brain	Survey, *in vitro, in vivo*	Benin, Burkina Faso, DR Congo, Ivory Coast, Gambia, Ghana, Guinea, Kenya, Liberia, Mali, Mozambique, Niger, Nigeria, Senegal, Tanzania, Togo, Uganda	Mohamed et al., 2009; Kuete et al., 2013c; Keshava et al., 2016; Kwok et al., 2016
Polygalaceae	*Securidaca longipedunculata* Fresen	Whole plant	HepLa/pancreatic	Survey, *in vitro*	Nigeria	Runyoro et al., 2005; Dibwe et al., 2012; Ngulde et al., 2015; Segun et al., 2018

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Ranunculaceae	*Aconitum napellus* L.	Leaves	N/S	Survey, *in vitro*	Southern Africa	Bruneton, 1999; Van Wyk et al., 2002;
Ranunculaceae	*Knowltonia capensis* (L.) Huth.	Leaves, Roots	N/S	Survey	South Africa	Koduru et al., 2007
Rosaceae	*Prunus africana* (Hook.f.)	Leaves	N/S	Survey	Kenya	Ochwang'i et al., 2014
Rubiaceae	*Gardenia volkensii K. Schum.*	Leaves, Fruits	N/S	Survey	Kenya, West Africa	Ochwang'i et al., 2014
Rubiaceae	*Nauclea latifolia* Sm.	Leaves, Fruits	Leukaemia/breast/colon	Survey, *in vitro*	West tropical Africa—from Ghana to Gabon and DR Congo	Shigemori et al., 2003; Anowi et al., 2012; Kuete et al., 2014a, 2014b, 2014d, 2015a, 2015d; 2016a, 2016b
Rubiaceae	*Nauclea pobeguinii* L.	Leaves, Fruits	Leukaemia/breast/colon/ brain	Survey, *in vitro*	South Tropical Africa: Angola, Zambia, West Tropical Africa: Burkina Faso, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Nigeria, Senegal, Sierra Leone, West-Central Tropical Africa: Cameroon, Central African Republic, Congo Brazzaville, DR Congo, Gabon	Mesia et al., 2005; Kadiri et al., 2007; Karou et al., 2011; Kuete et al., 2015c
Rubiaceae	*Pausinystalia johimbe* (K. Schum) Pierre ex Beille	Leaves, Fruits, Stem barks	N/S	Survey, *in vitro*	West Africa	Gismondi et al., 2013; Mbele et al., 2017
Rubiaceae	*Pavetta abyssinica* L.	Leaves	N/S	Survey	Kenya	Ochwang'i et al., 2014
Rubiaceae	*Psydrax schimperiana* (A. Rich),	Leaves	N/S	Survey	Kenya	Ochwang'i et al., 2014
Rubiaceae	*Sarcocephalus latifolius* (Smith)	Leaves, Fruits	N/S	Survey, *in vitro*	Nigeria, Cameroon	Soladoye et al., 2010; Oise et al., 2014
Rubiaceae	*Spermacoce princea* (K. Schum.) Verdc.	Leaves	N/S	Survey	Kenya	Ochwang'i et al., 2014
Rutaceae	*Vepris soyauxii* (Engl.) Mziray	Leaves	Leukaemia/breast/colon/ brain/liver	Survey, *in vitro*	West Africa: from Sierra Leone, Liberia, Ivory Cost, Mali, Ghana to Nigeria and Cameroon	Momeni et al., 2010; Tcheghebe et al., 2016; Mbele et al., 2017
Rutaceae	*Araliopsis synopsis* Engl.	Stem barks	Prostate	Survey,*in vitro, in vivo*	Cameroon	Happi et al., 2012
Rutaceae	*Zanthoxylum gilletii* (De Wild.) Waterm.	Leaves, Stem barks	N/S	Survey	Kenya	Ochwang'i et al., 2014
Rutaceae	*Zanthoxylum usambarense* (Engl.).	Leaves, Roots	Breast	Survey, *in vitro*	East tropical Africa - Ethiopia, Kenya, Tanzania, Eastern DR Congo	Ozkan et al., 2013; He et al., 2017
Salicaceae	*Sideroxylon obtusifolium* (Humb. ex Roem.) Penn.	Leaves, Fruits	Prostate	Survey	Southern Africa	Bobach et al., 2014
Salicaceae	*Trimeria grandifolia* (Hochst.) Warb.	Leaves, Fruits	Prostate	Survey	South Africa	Bobach et al., 2014
Sapindaceae	*Lecaniodiscus cupanioides* Planch. ex Benth.; Bulola; mt	Leaves, Stem bark, Fruits	colon/lung	Survey, *in vitro*	Nigeria	Adesegun et al., 2014; Segun et al., 2018
Sapotaceae	*Synsepalum cerasifera* (Welw.)	Leaves, Fruits	N/S	Survey	Kenya	Ochwang'i et al., 2014
Scrophulariaceae	*Phygelius capensis* E. Mey. ex Benth.	Leaves	N/S	Survey, *in vitro*	Southern Africa	Moffett, 2010; Moteetee and Van Wyk, 2011; Seleteng et al., 2015
Solanaceae	*Solanum aculeastrum* Dunal	Leaves, Fruits, Stem barks, Roots	N/S	Survey, *in vitro*	South Africa	Koduru et al., 2007; Fouche et al., 2008
Solanaceae	*Solanum erianthum* D. Don	Leaves	Skin cancer/lung cancer	Survey, *in vitro*	N/S	Chen et al., 2013
Solanaceae	*Solanum mauritianum* Scop.	Leaves	N/S	Survey	Kenya	Ochwang'i et al., 2014
Solanaceae	*Solanum panduriforme* E. Mey.	Whole plant	breast MCF7, renal TK10 and melanoma UACC62	Survey, *in vitro*	South Africa	Fouche et al., 2008
Solanaceae	*Solanum tomentosum* L.	Stems	breast MCF7, renal TK10 and melanoma UACC62	Traditional, *in vitro*	South Africa	Fouche et al., 2008
Taxaceae	*Taxus baccata* L.	Fruits, Leaves	Breast/ovarian/ lung	Survey, *in vitro*	Southern Africa	Newman et al., 2003; Li-Weber, 2009; Yuan et al., 2016
Taxaceae	*Taxus brevifolia* (Nuttall) Pilger	Fruits, Leaves	Breast/ ovarian/lung	Survey, *in vitro*	Southern Africa	Jing et al., 2006; Wani and Horwitz, 2014; Yuan et al., 2016
Ulmaceae	*Celtis africana* Burm. f.	Leaves	N/S	Survey	South Africa	Koduru et al., 2007
Umbelliferae	*Ferula hermonis* Boiss.	Leaves	N/S	Survey, *in vitro*	North Africa (Egypt)	Kuete and Efferth, 2015; Mbele et al., 2017
Vitaceae	*Cyphostemma serpens* (Hochst. ex A.Rich.) Desc.	Leaves	Cervical/skin/breast	Survey	Kenya	Ochwang'i et al., 2014
Zingiberaceae	*Aframomum arundinaceum* (Oliv. & D.Hanb.) K.Schum.	Leaves, Fruits	Leukaemia/breast/brain	Survey, *in vitro*	Western and Central Africa	Tane et al., 2005; Kuete et al., 2014a, 2014b, 2014d; Mbele et al., 2017
Zingiberaceae	*Aframomum melegueta* K.Schum	Leaves, Fruits	Skin	Survey, *in vitro*	Sierra Leone, Nigeria and Eastern Africa (Ethiopia)	

(*continued on next page*)

Table 1 (*continued*)

Family	Plant species	Plant Part(s) Used	Type of cancer	Research type	Country/region	References
						Gismondi et al., 2013; Sagnia et al., 2014; Mbele et al., 2017
Zingiberaceae	*Aframomum polyanthum* (K.Schum.) K.Schum.	Leaves, Fruits	Leukaemia/breast/brain	Survey, *in vitro*	West Africa: Cameroon, Tropical Africa	Kuete et al., 2014a, 2014b, 2014d, 2015a, 2015d; Mbele et al., 2017
Zingiberaceae	*Aframomum pruinosum* Gagnep.	Leaves, Fruits	Skin	Survey, *in vitro*	West Africa	Gismondi et al., 2013; Mbele et al., 2017
Zingiberaceae	*Curcuma longa* L.	Rhizome, Leaves,	N/S	Survey	Nigeria	Soladoye et al., 2010
Zingiberaceae	*Zingiber officinale* Rosc.	Rhizome, Leaves,	Leukaemia/cervical/bile duct	Survey, *in vitro, in vivo*	Tropical Africa, West Africa, Cameroon	Akoachere et al., 2002; Chrubasik et al., 2005; Kato et al., 2006; Singh, 2007; Ali et al., 2008; Kim et al., 2008; Sakpakdeejaroen and Itharat, 2009; Soladoye et al., 2010; Kuete et al., 2011; Kurapati et al., 2012; Plengsuriyakarn et al., 2012; Gismondi et al., 2013; Ochwang'i et al., 2014; Santos et al., 2016; Mbaveng and Kuete, 2017; Mbele et al., 2017

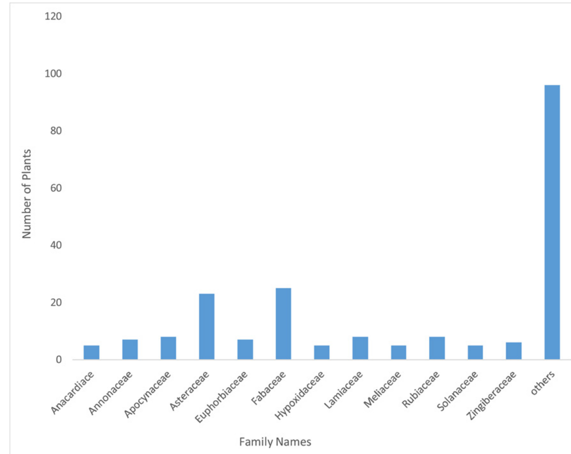

Fig. 2. Family distribution of documented plant species for cancer treatment in Africa.

or poor access to modern medical services, the high costs of these services and orthodox medicines, as well as the cultural values that rural communities attach to traditional plant remedies may be other contributing factors. A report by Witt et al. (2018) posited that alien species were deliberately introduced by the Government of Eastern Africa countries many decades ago which had possibly increased plant species diversity of Eastern Africa. Geographically, land degradation or disturbances, a common occurrence in most Eastern Africa countries are among the main drivers of plant invasions which ultimately decrease total species diversity of the region (Dregne, 2002; Witt et al., 2018).

In Western Africa, the climatic condition is favourable and most of the countries in this region are rich in plant species of economic importance (Segun et al., 2018). Perhaps, Western Africa would have recorded more documented anticancer plants, but due to war crisis in this region which may have damaged vegetations and also hampered science development/researches with outlook for anticancer plants, therefore reducing documented anticancer plants. Renn and Zwick (2008) in their paper on impact of civil unrest reported that destruction of vegetation and other components of human life are indirect consequences of civil unrest. The direct impact may be the loss of property, health or even life (Renn and Zwick, 2008). Moreover, in addition to orthodox medicine, many diseases are still mostly managed by traditional medical practitioners, who employ varieties of medicinal plants (Ajao et al., 2017).

Based on the literature reviewed, Northern Africa contribution to documentation of plants traditionally used for cancer treatment appeared to be relatively poor, this may be due to the geographical location and climatic condition of this zone largely a desert, therefore, the population tend to focus more on fungi and corals or even animals for traditional medicine, hence, the reduced documentation. Northern Africa is enveloped in the the world's largest desert, and this has been reported as the most probable reason for poor species (Linder, 2014). Hence, there is a high need for more ethnobotanical studies documenting potential anticancer plants in this region.

3.1. Cancer types and prevalence in Africa

Africa generally has low cancer incidence compared to the developed countries. This might be due to poor prognosis, late diagnosis and/or lack of sufficient medical facilities and personnel in many African countries (Brandão et al., 2018). However, documented cancer incidence is expected to rise exponentially in the next few decades (Brandão et al., 2018) partly due to changing lifestyle and current ongoing industrial revolution in some African countries (Simoben and

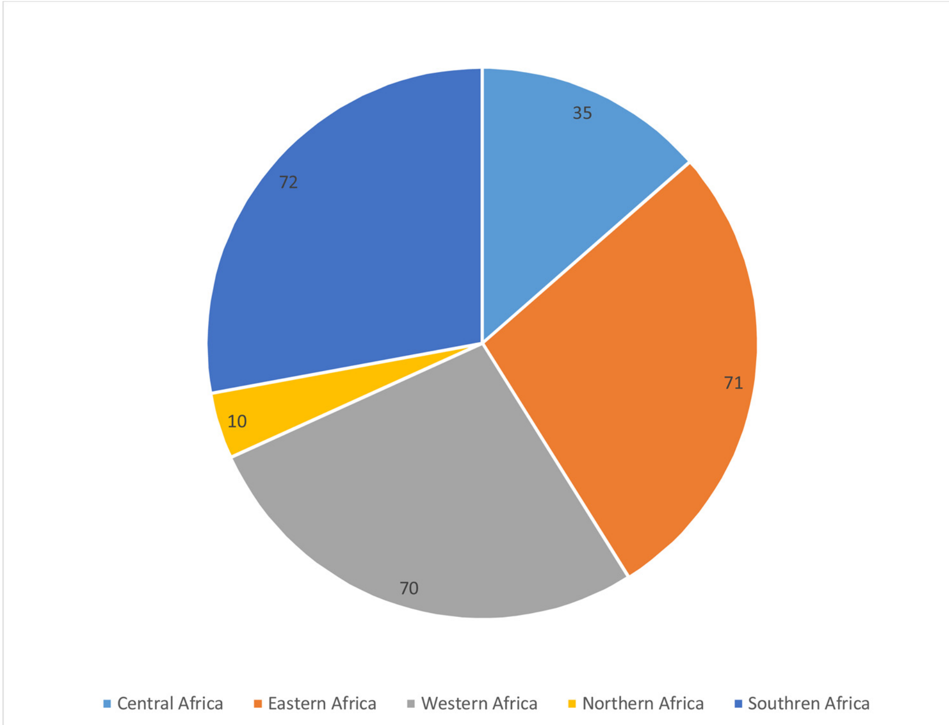

Fig. 3. Percentage distribution of documented plants that are traditionally used for cancer treatment across Africa regions.

Ntie-Kang, 2017). There is no general consensus in regard to the most prevalent type of cancer in Africa as different reports suggest different type of cancer for different countries. For example, cervical cancer is reportedly the most prevalent cancer type and the leading cause of cancer morbidity and mortality among women in sub-Saharan Africa (Denny et al., 2013; Stewart et al., 2018). In many African countries, esophageal squamous cell carcinoma is the leading histological subtype of esophageal cancer, with an elevated incidence rate in many Eastern and Southern African countries (Middleton et al., 2018).

In this study, breast cancer appears to be the leading cancer type in the literature reviewed, followed closely by colon/colorectal cancer, and then skin cancer while the least mentioned cancer type is lung cancer (Fig. 4). Breast cancer is globally recognised as the most diagnosed cancer type and leading cause of cancer death in women (WHO, 2018). The submission of breast cancer being the most diagnosed and leading cause of death as recorded in this review is in line with findings documented in a similar review article in India (Asia) where breast cancer is reported as the most prevalent and aggressive cancer among women in India (Thakur et al., 2018). Among the factors for breast cancer prevalence are hereditary (mutation in BRCA1 and BRCA2) genes, exposure of chest area during radiation therapy, possession of more glandular tissues in the breast, birth control pills, obesity, alcohol abuse, and induced abortions (Page and Dupont, 1992; Collaborative Group on Hormonal Factors in Breast Cancer (CGHFBC), 1996; Boyd et al., 1998; Nelson et al., 2002; Sasco et al., 2003; Thakur et al., 2018). According to the American Cancer Society, half of the breast cancer cases globally are found in developing countries of which African countries take a huge chunk (American Cancer Society, 2016). The literature reviewed revealed that the majority of the plant species documented were mostly used for the treatment of breast cancer, skin cancer, colon/colorectal cancer, prostate cancer, internal organs cancer, cervical cancer, leukaemia, and womb cancer in the following order: skin cancer > breast cancer > colon cancer > uterus cancer > stomach cancer > cervical cancer > throat cancer > prostate cancer > leukaemia > lung cancer (Tariq et al., 2017).

Skin cancer is among the top 10 cancer types affecting both men and women (American Cancer Society, 2012; WHO, 2014; Global Cancer Observatory, 2018). According to the American Cancer Society, light-skinned individuals are more vulnerable to skin cancer than dark-skinned individuals (American Cancer Society, 2012; WHO, 2014). Exposure to highly intense sunlight of inhabitants of Africa may be the reason for the proliferation of skin cancer in Africa despite the dark-skinned condition (Tariq et al., 2017). In separate studies conducted in South Africa, Australia and New Zealand, skin cancer prevalence was attributable to the high radiation from sunlight in these countries (CANSA, 2017; Tariq et al., 2017). There is a constant need for concerted efforts and in-depth studies with respect to the discovery of potent anticancer plants and subsequent pharmacological studies in order to abate the dire consequences of cancer in Africa, especially since orthodox medicine remains elusive and expensive for the larger populace of African descent.

3.2. Phytochemicals and cytotoxicity of anti-cancer plants

The use of medicinal plants could be a viable alternative in the search for more effective cancer therapy, if the phytochemistry and the mode of action of these medicinal plant extracts or isolated active principles can be ascertained. The use of natural products derived from medicinal plants is gaining more attention, becoming more favourable and subsequently bringing succour for cancer patients (Liang et al., 2017). The majority of chemotherapeutic drugs for cancer treatment are molecules identified and isolated from plants or their synthetic derivatives (George et al., 2010; Ntie-Kang et al., 2014; Simoben and Ntie-Kang 2017). However, in spite of the large numbers of plants reported in this review with medicinal values, only few of the valorization studies outlined their cytotoxicity against different cancer cell lines. Ninety-nine plant species (i.e. 48%) out of the total two hundred and seven plants documented in this review were reported to demonstrate cytotoxic activity against different cancer cell lines (Table 1)

Several researchers have highlighted the importance of phytochemicals from medicinal plants and their capacity to induce apoptosis in different cancer cell lines (Solowey et al., 2014). For example,

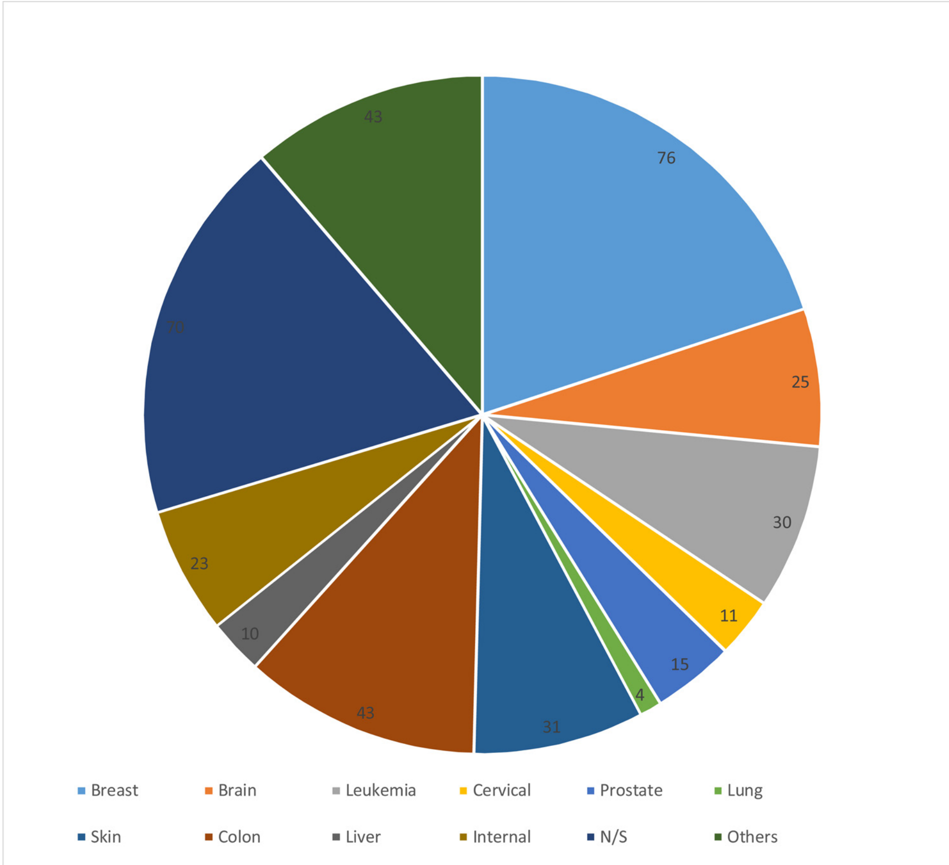

Fig. 4. Pie chart showing frequency of cancer types.

vinblastine, vincristine, camptothecin, topotecan, irinotecan, etoposide, paclitaxel, vinca alkaloids, *Taxus* diterpenes, *Camptotheca* alkaloids, and *Podophyllum* lignans found in different medicinal plants are known to demonstrate anticancer activity (Ntie-Kang et al., 2014). Ntie-Kang et al. (2014) in their molecular modelling of potential anticancer agents study reported different chemical compounds found in about 400 African medicinal plants *in vitro* and *in vivo* with evidence of anticancer, cytotoxicity and antiproliferative activities. Also, the active compound, asiatic acid, found in *Centella asiatica* (L.) Urb. induced apoptosis and decreased viability in human melanoma SK-MEL-2 cells (Park et al., 2005). *Centella asiatica* was also reported to effectively inhibited lung cancer cell growth (Wu et al., 2017). Gu et al. (2002), Fouche et al. (2008) reported growth inhibition and apoptotic induction for most species from the Asteraceae family. *Tithonia diversifolia* (Helms. A. Gray) extract was reportedly the most active species against different cancer cells among over thirty-two plants tested for cytotoxic activity against different cell lines (Fouche et al., 2008). Vaishnav et al. (2015) similarly reported growth inhibition of human cervical cancer cells (HeLa) by *Xanthium strumarium* L., another species in the Asteraceae family.

Generally, *in vitro* cytotoxicity of plant extracts is usually the first step in bioprospecting research for anticancer compounds from natural sources (Erel et al., 2014). Further studies validating *in vitro* activity through *in vivo* testing are much limited. More in-depth studies are required using mechanism-based assays and *in vivo* systems on promising species from *in vitro* screening assays in order to provide valid and strong scientific background for the ethnomedicinal use of these plant species and for the development of potentially novel anti-cancer drugs.

3.3. Limitations of the study

One of the limitations of this present study was the unavailability of full text of some articles i.e. only abstracts were provided online. Also, some articles were written in languages without English translation which made them difficult for use. Lastly, the non-presentation of vital medicinal plants information in thesis format which makes them unreliable as reproducibility of such findings have not been peer-reviewed. Future research on medicinal plants should focus on documenting more plants from the folkmedicine, thereafter, scientific evaluation/investigation and clinical trials and lastly mass production of drugs after thorough and rigorous evaluation of such plants.

4. Conclusions and recommendations

This review provided information on a large number of medicinal plants across numerous families with the potential for treating different types of cancer. Based on the documented traditional use, Asteraceae, Fabaceae, Rubiaceae, and Euphorbiaceae families contain several plant species with the potential for cancer treatment. Forty-eight (48%) percent of the plants documented in this review have been evaluated scientifically with respect to their cytotoxic activities and showed good potential for apoptosis induction against different cancer cell lines. From the foregoing, it was observed that detailed ethnomedicinal records were lacking for many plants used traditionally for cancer treatment. Most of the studies lacked complete and detailed information about the sources of plants, formulating recipes and doses, and most importantly the exact type of cancer treated by each plant. Yet these factors can be critical in getting to the right information in the search for potent alternative cancer therapy. Most of the plant species documented in the literature reviewed were mostly used for treating breast, skin, colon, cervical, prostate cancer and leukaemia with less documented record for traditional treatment of other forms of cancer. Isolation (perhaps bioassay-guided) of active principles as well as *in vivo* and clinical evaluation of potent extracts and/or isolated compounds require more vigourous research effort in order to establish efficacy against different cancer types as there are limited clinical studies on medicinal plants and more need to be conducted. Bearing in mind the possibility of drug-drug interactions and in the case of medicinal plant extracts, which contain an array of compounds, detailed cytological and holistic pharmacological studies would be critical to ensure that their potential use in any form of cancer therapy does not result in negative side effects.

Declaration of Competing Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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