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REVIEW

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Medicinal plants used for treating cancer in Kenya: an ethnopharmacological overview

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Abstract

Background: Cancer is one of the major causes of mortality worldwide. Though 30% of cancers can be treated when detected at early stages, their treatment has been compounded by resistance of tumor cells to anticancer drugs, side effects of the therapies, high treatment costs and limited access to medical services. In Africa, and particularly in the East African botanical plate, various ethnic groups cherish their traditions and embrace distinguished use of medicinal plants in the management of ailments like cancer. This study aimed at reviewing the ethnobotanical knowledge on the use of wild and cultivated plants as remedies for cancer treatment in Kenya as well as their phytochemical composition and reported anticancer activities.

Main body: Through extensive electronic review in PubMed, Science Direct, Scopus, Google Scholar, Web of Science, Scientific Electronic Library Online and the Google search engine, 145 plant species from 125 genera spread across 55 families were found to have been reported for cancer treatment in Kenya. The malignancies treated using the herbal remedies include squamous cell carcinoma of the gum, prostate, blood, bone, breast, colorectal, colon, oesophageal, lung, liver, skin, stomach, throat and uterine cancers. Most of the identified species have reported anticancer activities, with *Toddalia asiatica*, *Annona muricata*, *Carica papaya*, *Catharanthus roseus*, *Moringa oleifera*, *Ocimum gratissimum*, *Prunus africana* and *Zanthoxylum paracanthum* being the most studied.

Conclusions: Despite the widespread use of medicinal plants in the management of cancer in Kenya, the bioactivity, safety aspects, responsible anticancer molecules and clinical studies are required to elucidate the mechanism of action of the compounds and confirm the potential of the unstudied species.

Keywords: Cancer, Non-communicable diseases, Medicinal plants, East African botanical plate

Background

Cancer is listed among the leading causes of deaths globally and a great twenty-first century barrier to the increase in life expectancy (Chimezie and Ofure 2022; Dalmartello et al. 2021; Wekha et al. 2021). According to recent global statistics based on GLOBOCAN, about 19.3 million new cancer cases were reported in 2020. This led to at least 10 million cancer deaths (Sung et al. 2021). For this period, breast cancer was the most prevalent, with 2.3 million new cases (11.7%). The other malignances followed the order: stomach cancer (5.6%) < prostate cancer (7.3%) < colorectal cancer (10.0%) < lung cancer (11.4%). Nevertheless, lung cancer was the major cause of cancer-related mortalities accounting for about 18% (1.8 million) deaths. Colorectal (9.4%), liver (8.3%), stomach (7.7%) and breast (6.9%) cancers also made significant contributions to the estimated cancer mortalities (Sung et al. 2021).

Trickling down to the African continent, cancer has a skewed distribution and this is compounded by inadequate epidemiological expertise, diagnostic equipment and research resources, and the complex treatment seeking behavior of cancer patients (Hamdi et al. 2021). According to the National Cancer Institute of Kenya (NCI 2022), cancer is the leading cause of mortalities

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in Kenya after infectious and cardiovascular diseases. Of these, breast cancer (with 5985 new annual cases or 12.5%) of all new cases is the leading cancer in Kenya (Macharia et al. 2019). The main drivers behind the increasing cancer cases in Kenya include consumption of mycotoxin and heavy metal-contaminated foods, genetic causes and residential combustion of unprocessed solid fuels such as dung, wood, charcoal and agricultural residues (Omara et al. 2021a). Coupled with antitumor drug resistance, inaccessibility and side effects of commercial drugs, indigenous communities utilize medicinal plants for managing ailments.

The World Health Organization reported that more than 80% of the emerging world's population subsists on traditional medicine for various ailments. Medicinal plants have remained an incredible source of promising drug entities (Omara et al. 2021b). Over the years, anticancer agents have been derived from plants and currently used to treat different types of cancers in clinical practice. Thorough investigation of cytotoxic compounds in plants previously used in traditional cancer phytotherapy led to the discovery of anticancer drugs and lead compounds. For example, the chemical structure of cytotoxic phytocompound podophyllotoxin was first elucidated in 1932 (Jones 2014), followed by the discovery of the vinca alkaloids (vinblastine and vincristine) in *Catharanthus roseus* in 1958 (Sottomayor and RosBarcelo 2006). This was ensued by the identification of paclitaxel in 1971 (Barbuti and Chen 2015). Such molecules of plant origin have revolutionized cancer treatment, but more lead compounds need to be discovered as cancer cells are rapidly evolving and developing resistance to these drugs. It is argued therefore that novel therapeutic molecules will be developed from medicinal plants in close association with leads furnished by traditional knowledge and experiences (Omara et al. 2021c).

In the East African botanical plate, Kenya is known as one of the richest countries with diverse ethnic groups utilizing medicinal plants (Omara 2020). A recent review (Jaleny 2020) gave an overview of the herbal remedies for cancer used across rural Kenya. This study expands on the list through a comprehensive literature search exploring the ethnobotanical knowledge, phytochemistry and antiproliferative activities of plants used in the management of various types of cancer in Kenya, East Africa.

Main text

Materials and methods

Elaborate independent literature search in PubMed, Science Direct, Scopus, Google Scholar, Web of Science, Scientific Electronic Library Online and the Google search engine was done from September 2021 to April 2022. The keywords used were cancer, carcinoma, prostate cancer, breast cancer, lung cancer, liver cancer, anticancer plants, cancer of the blood, leukaemia, plant extract, traditional medicine, alternative medicine, natural medicine, ethnopharmacology, ethnobotany, herbal medicine, herb, decoction, infusion, macerate, cancerous, hepatocellular carcinoma, Kaposis sarcoma, Burkitt's lymphoma, cancer of the bone, cancer of the eye, cancer of the colon, cancer of the cervix uteri, skin cancer combined with Kenya. Journal articles, books, theses, dissertations, patents, and other reports covering anticancer plants in Kenya dated until April 2022 were included in the study. The retrieved studies were analyzed in Microsoft Excel. The botanical families, folk names, growth habit, part (s) used, preparation and administration mode of the different anticancer plants were captured. Further search was done to retrieve information on the anticancer activity of the extracts or isolated compounds from the claimed plants.

Inventory of plants used in the management of cancer in Kenya

The electronic search identified 24 reports with information on ethnomedicinal plants used in Kenya for preparation of herbal remedies for treatment of prostate, blood, bone, breast, colorectal, colon, oesophageal, lung, liver, skin, stomach, throat, uterine cancers and squamous cell carcinoma of the gum (Table 1). These sources reported a total of 145 botanical species claimed in traditional management of cancer in Kenya. The identified species were from 125 genera, spread across 55 families. Fabaceae (19 species, 13.1%), Asteraceae (11 species, 7.6%), Euphorbiaceae (8 species, 5.5%) and Rutaceae (7 species, 4.8%) were the most represented families (Fig. 1). Plant species from these families have been previously indicated for use in traditional treatment of different malignancies in other countries (Abu-Darwish and Efferth 2018; Ayele 2018; Bourhia et al. 2019; Kuruppu et al. 2019).

The study identified more 89 plant species (from 19 botanical families), adding onto the 55 species identified in the review by Jaleny (2020). This could be attributed to more studies reporting on ethnomedicinal plants usage in Kenya since the last review, and also the differences in the choice of the electronic databases used in the previous study and the current study. The most cited species encountered are *Prunus africana* (12 times), *Launaea cornuta* (4 times), *Tabernaemontana stapfiana*, *Maytenus obscura*, *Flueggea virosa* and *Moringa oleifera* (3 times each). Interestingly, some of the species recorded such as *Zanthoxylum chalybeum* are used in Tanzania (Matata et al. 2018), Uganda (Omara et al. 2020) and Ethiopia (Tuasha et al. 2019) for the management of cancers.

Table 1 Ethnomedicinal plants used in the management of cancer in Kenya

Family	Local name	Botanical name	Part used	Life form	Mode of preparation (administration)	Cancer treated	Author (s)
Acanthaceae	Ndakariat (Nandi)	*Acanthus pubescens* (Oliv.) Engl	L	H	Ash used	Not specified	Jeruto et al. (2008)
	Likhundu/Eshitoo	*Dicliptera laxata* C. B. Clarke	L	H	Infusion taken (4.5 g) twice daily for 1 week. Often prepared with A. *gummifera* and *S. coccinea* (leaves)	Colorectal	Ochwang'i et al. (2014)
	Shikuduli	*Justicia betonica* L	WP	H	Infusion taken. Often prepared with M. *pyrifolia* (leaves & SB), *H. africana* (leaves & Rt) and P. africana (leaves, Rt & SB)	Breast, skin colorectal	Ochwang'i et al. (2014)
	Cheptereret (*Nandi*)	*Thunbergia alata* Bojer ex Sims	Bk	H	Pressed on the site, leading to production of a thick black substance	Not specified	Kigen et al. (2014)
Aloeaceae	Linakha	*Aloe volkensii* Engl	L	S	Infusion taken half a glass daily for 2 months. Topically applied on breast cancer wounds thrice daily until recovery	Breast, colorectal, prostate, oesophageal	Ochwang'i et al. (2014)
	Kibiricha, Murucha, Sukurui (Meru)	*Aloe* species	NS	H	Not reported	Prostrate	Muriuki, (2011)
Amaranthaceae	Beetroot (*English*)	*Beta vulgaris* L	Blb	H	Not reported	Not specified	Muriuki, (2011)
	Mbogiat (Nandi)	*Amaranthus graecizans* L	L	H	Paste applied topically	Not specified	Jeruto et al. (2008)
Anacardiaceae	Mubindabindi (*Mbeere*)	*Lannea* species	NS	T	Not reported	Prostate	Muriuki, (2011)
	Liembe	*Mangifera indica* L	Rt, L, SB	T	Infusion (300 ml) taken thrice daily for 7 days. Often prepared with *H. madagascariensis* (SB), *V. lasiopus* (SB) and *S. campanulata* (SB & Rt)	Skin, breast, throat	Ochwang'i et al. (2014)
	Sungula	*Rhus vulgaris* Meikle	Rt, L, Fr	T	Pounded and boiled with *C. papaya* roots, taken 300 ml daily until recovery	Breast, skin, stomach	Ochwang'i et al. (2014)
Annonaceae	Mũtomoko (*Kikuyu*)	*Annona cherimola* Mill	Bk	T	Decoction taken	Not specified	Kamau et al. (2016)
	Not reported	*Anona muricata* L	Fr	T	Not reported	Breast, cervical	Gathura (2017)
	Ndonga (*Mbere*)	*Ovariodendron anisatum* Verdc	Rt	S	Decoction taken	Breast, prostate	Kareru et al. (2007)
Apocynaceae	Kelwo/Ng'wono (Marakweta)	*Acokanthera oppositifolia* (Lam.) Codd	Bk, Rt	S	Decoction taken. Powdered bark and roots applied topically for cancerous wounds	Not specified	Kigen et al. (2017)
	Legetetiot, Tamuryekiat (*Nandi*)	*Carissa edulis* (Forsk.) Vahl	Rt	H	Decoction	Not specified	Jeruto et al. (2008)

Table 1 (continued)

Family	Local name	Botanical name	Part used	Life form	Mode of preparation (administration)	Cancer treated	Author (s)
	Mukamuria (*Meru*), Mukawa (*Embu*, *Mbeere*)	*Carissa spinarum* L	L	S	Decoction taken	Breast	Mbuni et al. (2020) and Muriuki (2011)
	Olubinu	*Catharanthus roseus* (L.) G. Don	WP	H	Infusion (150 ml) taken or powder topically applied. Usually taken with *Sesbania sesban* (whole plant)	Oesophageal, stomach, throat	Ochwang'i et al. (2014)
	Kaparar (*Markweta*), Mdondo	*Tabernaemontana stapfiana* Britten	SB, Rt	T	Powder mixed with alcohol and used topically in washing the wounds once daily for 1 month. Boiled, dried, powder burnt to soot and licked. Decoction taken	Breast	Kigen et al. (2017), Mbuni et al. (2020) and Ochwang'i et al. (2014)
Asclepiadaceae	Sinendet (*Nandi*)	*Periploca linearifolia* Dill. & Rich	Rt	L	Milky latex decoction/exudate used	Not specified	Jeruto et al. (2008)
Asphodelaceae	Soap aloe (*English)*	*Aloe saponaria* (Synonym: *A. maaculata*)	NS	H	Not reported	Breast, colon, lung, liver	Gathura (2017)
Asteraceae	Chepkotiwot (*Marakwet*), Chepaswoi (*Pokot*), Ologoye (*Luhya*), Igwisi	*Bidens pilosa* L	L, Rt, St	H	Decoction drunk. Infusion (150 mL) prepared with *O. sinuatum* (Rt, leaves and stem) taken thrice a day for 2 weeks	Skin, throat	Mbuni et al. (2020) and Ochwang'i et al. (2014)
	Liposhe	*Conyza sumatrensis* (Retz.) E.H Walker	L	H	Infusion (150 mL) taken twice daily until recovery. Also used with *A. gummifera* and *M. lutea* stem barks	Breast, throat, squamous cell carcinoma of the gums	Ochwang'i et al. (2014)
	Oulfuta	*Galinsoga parviflora* Cav	L	H	Infusion (300 mL) taken twice daily for 2 weeks. Usually taken with *O. gratissimum, T. rhomboidea* and *S. didymobotyra* leaves	Colorectal	Ochwang'i et al. (2014)
	Mũthũnga (*Kikuyu, Embu*), Kipche (*Nandi*)	*Launaea cornuta* (Hochst. ex Oliv. & Hiern) C. Jeffrey	Rt, L, St, WP	H	Decoction taken. For throat cancer, Rt prepared with *R. myriocoides* and *T. asiatica* roots. Stem chewed for the same. For breast cancer, aerial parts (L & St) are boiled and steam inhaled	Throat, breast, prostate	Kamau et al. (2016), Kareru et al. (2007), Kigen et al. (2014) and Onyancha et al. (2019)

Table 1 (continued)

Family	Local name	Botanical name	Part used	Life form	Mode of preparation (administration)	Cancer treated	Author (s)
	Ingwe, Ingoyi, Enguu	*Microglossa pyrifolia* (Lam.) Kuntze	L, SB, RB	S	Leaf powder taken as an infusion (4.5 g) in hot water for a month. SB infusion (150 mL) taken twice daily until recovery. Used with *S. campanulata* (Rt & SB), *C. sumatrensis* (leaves) and *J. procera* (SB)	Breast, skin, colorectal	Ochwang'i et al. (2014)
	Muturutwa (*Meru*)	*Solanecio angulatus*	NS	T	Not reported	Prostate	Muriuki (2011)
	Livokho	*Solanecio mannii* (Hook. f) C. Jeffrey	L	S	Infusion (150 mL) taken once daily. Often taken with *M. pyrifolia* (SB & leaves), *Z. rubescens* (leaves & RB), *C. macrostachyus* (leaves) and *S. procera* (leaves)	Breast, skin, colorectal	Ochwang'i et al. (2014)
	Not reported	*Solanecio nandensis* (S. Moore) C.Jeffrey	L, St	H	Steamed in a water bath while in a nylon paper and then topically applied on breast cancer wounds by rubbing. Used with *C. serpens* (SB & leaves)	Breast, colorectal	Ochwang'i et al. (2014)
	Mũthũnga (*Kikuyu*)	*Sonchus oleraceus* L	Rt, L	H	Decoction taken	Not specified	Kamau et al. (2016)
	Not reported	*Vernonia adoensis*	WP	S	NP	Breast, cervical, prostate	Gathura (2017)
	Mucatha (*Embu*, *Mbeere*), Shiroho	*Vernonia lasiopus* O. Hoffm	SB	S	Infusion of 30 g is taken twice daily for a week. Often used with *H. madagascariensis* (SB) and *S. campanulata* (SB & Rt)	Colorectal	Muriuki (2011) and Ochwang'i et al. (2014)
Bignoniaceae	Omurabe, Morabe	*Kigelia africana* Lam. Benth	SB, L	T	Leaf powder applied topically. Infusion (300 ml) taken twice daily for 3 months	Breast, skin, uterine	Ochwang'i et al. (2014)
	Lusiola, Shisimbali	*Markhamia lutea* (Benth.) K.Schum	SB	T	Infusion (150 ml) taken twice daily until recovery. Often prepared with *A. gummifera* (SB) and *C. sumatrensis* (leaves)	Colorectal	Ochwang'i et al. (2014)

Table 1 (continued)

Family	Local name	Botanical name	Part used	Life form	Mode of preparation (administration)	Cancer treated	Author (s)
	Muthulio/Nandi flame/ Mutsuria	*Spathodea campanulata* P Beauv. ssp.nilotica (Seem)	L, Rt, SB	T	Decoction/decoction in meat soup taken/an alcohol infusion taken, 4.5 g (1 tsp) thrice daily for 4 weeks. Sometimes used with *P. africana* (Rt & SB), *M. pyrifolia* (leaves) and *H. madagascariensis* (Rt & SB)	Bone, breast, cervical, colorectal, skin	Ochwang'i et al. (2014)
Boraginaceae	Muringa (*Embu, Mbeere, Meru*)	*Cordia africana* Lam	NS	T	Not reported	Not specified	Muriuki (2011)
Canellaceae	Not reported	*Warburgia stuhlmannii* Engl	SB	T	Not reported	Colon	Gathura (2017)
	Muthiga (*Embu*, *Mbeere*), *Musunui*, *thurunui* (Meru)	*Warburgia ugandensis* Sprague	Bk, Rt, L	T	Decoction taken	Prostate	Kamau et al. (2016) and Muriuki (2011)
Capparaceae	Kiare (*Mbeere*), Muthangira (*Meru*)	*Boscia coriacea* Pax	NS	H	Not reported	Prostrate	Muriuki (2011)
Capparidaceae	Mukarakara (*Mbeere, Meru*)	*Capparis tomentose* Lam	NS	S	Not reported	Prostrate	Muriuki (2011)
Caricaceae	Lipopayi	*Carica papaya* L	L, Fr, Rt	H	Milky tree juice used to wash the wound. Leaf powder topically applied daily for 7 days. Infusion taken (300 ml) thrice daily for 1.5 months. Often prepared with *S. campanulata* (SB & Rt), *C. sumatrensis* (leaves), *B. micrantha* (SB & roots) and *Aloe* spp (leaves)	Breast, cervical, colorectal	Ochwang'i et al. (2014)
Celastraceae	Shikhalikhanga	*Hippocratea africana* (Willd.) Loes	L, Rt	S	Leaf powder mixed with root infusion (150 ml) taken once daily until recovery. Usually prepared with *Z. rubescens* (leaves & RB), *B. micrantha* (leaves & SB), *S. campanulata* (leaves & SB) and *T. emetica* (SB & Rt)	Breast, skin, colorectal	Ochwang'i et al. (2014)
	Muthuthi (*Kikuyu*), Muraga (*Mbere*, *Embu*)	*Maytenus obscura* (A. Rich)	L, Rt	S	Decoction mixed with soup drunk	Breast, prostate	Kareru et al. (2007), Kokwaro (1993), and Onyancha et al. (2019)
	Muthuthi (*Kikuyu*)	*Maytenus senegalensis* (Lam.) Exell	L	S	Not reported	Colon	Gathura (2017)
Combretaceae	Not reported	*Combretum tanaense*	R	T	Not reported	Breast	Onyancha et al. (2018)

Table 1 (continued)

Family	Local name	Botanical name	Part used	Life form	Mode of preparation (administration)	Cancer treated	Author (s)
	Kaloswet (*Nandi*), Muuku (*Kamba*)	*Terminalia brownii* Fresen	Bk	T	Pressed on the site, leading to production of a thick blacksubstance	Not specified	Kigen et al. (2014)
Convolvulaceae	Ndirande/Lilande	*Ipomoea cairica* (L.)	L, Rt	S	Powder applied topically	Breast, skin, cervical	Ochwang'i et al. (2014)
Cucurbitaceae	Marenge (*Embu*, *Mbeere*, *Meru*), Kirenge (some *Mbeere*)	*Curcubita maxima* Duschesne	NS	H	Not reported	Not specified	Muriuki (2011)
	Cheserya (*Marakwet*) Lilande (*Luhya*), Libobola	*Momordica foetida* Schumach	L, AP	C	Crushed and mixed with water used to take a bath. Infusion (4.5 g) taken daily in tea leaves until recovery. Usually prepared with *I. cairica* (Rt) and *S. aculeastrum* (Fr & Rt)	Cervical, breast	Mbuni et al. (2020) and Ochwang'i et al. (2014)
Cupressaceae	Muthithinda (*Mbeere*)	*Cupressus lusitanica*	NS	T	Not reported	Not specified	Muriuki (2011)
	Torokwo (*Marakwet*), Omusembe	*Juniperus procera* Endl	Bk, Rt, SB	T	SB made into capsules and infusion taken (1 capsule/day) for 10 days. Usually used with *C. papaya* (Rt & leaves), *C. sumatrensis* (leaves), *M. pyrifolia* (leaves) and *C. frutescens* (fruit cover)	Breast, throat, squamous carcinoma of the gum	Kigen et al. (2017) and Ochwang'i et al. (2014)
Dracaenaceae	Kithare (Embu)	*Dracaena steudneri* Engl	NS	T	Not reported	Not specified	Muriuki (2011)
Ebernaceae	Kelelwa (*Tugen*)	*Croton dichogamus* Pax	NS	S	Not reported	Not specified	Rufford (2020)
	Kapcheptuin (Marakweta)	*Euclea divinorum* Hiern	Fr	T	Chewed	Not specified	Kigen et al. (2017)
Euphorbiaceae	Mukwego (*Embu, Mbeere, Meru*), Shikangania	*Bridelia micrantha* Baill. (Hochst)	L, Rt, SB	T	Powder infusion (300 mL) taken thrice daily for 3 months. Used often with *P. africana* (SB & Rt), *S. guineense* (Bk), *S. campanulata* (SB & Rt) and *C. serpens* (SB)	Cervical, breast, skin, colorectal	Muriuki (2011) and Ochwang'i et al. (2014)
	Musutsu	*Croton macrostachyus* Delile	L, SB	T	Powder infusion (300 mL) taken thrice daily for 2 months. Taken with *Z. rubescens* (RB & leaves), *P. africana* (Rt & SB) and *H. madagascariensis* (SB)	Colorectal, skin, breast	Ochwang'i et al. (2014)
	Gikega, mukega (*Mbeere*), kariaria (*Embu*)	*Euphorbia tirucalli* L	NS	S	Not reported	Not specified	Muriuki (2011)

Table 1 (continued)

Family	Local name	Botanical name	Part used	Life form	Mode of preparation (administration)	Cancer treated	Author (s)
	Mukururu (*Embu, Mbeere*)	*Flueggea virosa* (Willd.) Voigt	Rt	T	Decoction taken	Prostate, breast	Kareru et al. (2007), Muriuki (2011), Onyancha et al. (2019)
	Mukarati	*Macaranga kilimandscharica*	NS	S	Not reported	Not specified	Muriuki (2011)
	Lusarisari	*Phyllanthus fischeri* Pax	L, SB	S	Infusion (150 mL) taken once daily until recovery. Used with *M. pyrifolia* (leaves & SB), *C. macrostachyus* (leaves), *H. madagascariensis* (SB) and *S. campanulata* (SB)	Breast, skin, colorectal	Kokwaro (1993) and Ochwang'i et al. (2014)
	Musasa	*Shirakiopsis elliptica* (Hochst.) Esser. *Synonym: Sapium ellipticum* (Hochst.krauss) Pax	Bk, L	T	Powder (4.5 g) infusion taken for a month. Often prepared with *M. azedarach* (leaves), *M. pyrifolia* (leaves), *Z. rubescens* (bark), and *S. campanulata* (bark)	Colorectal, oesophageal	Ochwang'i et al. (2014)
	Isambakhalu	*Tragia brevipes* Pax	L	S	Powder in hot water taken (900 mL) daily until recovery	Prostate, breast, leukemia	Gathura, (2017) and Ochwang'i et al. (2014)
Fabaceae	Ndirakalu	*Abrus precatorius* L. sspafricanus Verdc	Rt, Sd	T	Infusion (150 mL) taken twice daily until recovery. Often prepared together with *S. aculeastrum* leaves and fruits	Skin	Ochwang'i et al. (2014)
	Omubeli (Luo)	*Albizia coriaria* (Welw. Ex) Oliver	Bk, L	T	Poultice from leaf powder applied topically twice daily for skin cancer. Bark infusion taken (600 ml) daily for a week	Breast, skin, uterine	Ochwang'i et al. (2014)
	Musenzeri/Mukhonzuli	*Albizia gummifera* (J.F.Gmel.)	L, SB	T	Infusion (150 mL) taken twice daily until recovery. Used with *M. lutea* (SB) and *C. sumatrensis* (leaves)	Throat, skin	Dharani and Yenesew (2010) and Ochwang'i et al. (2014)
	Not reported	*Albizia schimperiana*	SB	T	Not reported	Not specified	Kokwaro (1976)
	Chuiya (Marakweta)	*Acacia hockii* De Wild	Bk, Rt	T	Decoction/ powder used	Not specified	Kigen et al. (2017)
	Not reported	*Acacia mearnsii* De Wild	WP	T	Not reported	Breast, cervical, prostate	Gathura (2017)
	Olunyili	*Aeschynomene abyssinica* (A. Rich.) Vatke	L	H	Powder applied topically at 3-day interval or infusion (75 ml) taken daily for 2 weeks. Usually boiled with leaves of *T. rhomboidei* and *S. rhombifolia*	Uterine, skin, squamous cell carcinoma of the gums	Ochwang'i et al. (2014)

Table 1 (continued)

Family	Local name	Botanical name	Part used	Life form	Mode of preparation (administration)	Cancer treated	Author (s)
	Not reported	*Cassia abbreviata* Oliv	RB	T	Not reported	Breast, cervical, prostate	Gathura (2017)
	Mkithunga (*Giriama*)	*Cassia afrofistula* Brenan	Rt, B	T	Boiled and taken	Ovarian, prostate	Muniafu et al. (2014)
	Mubuti, (*Embu*, *Mbeere*), Muuti (*Meru*)	*Erythrina abyssinica* Lam. ex DC	NS	T	Not reported	Not specified	Muriuki (2011)
	Maua kulanganya	*Glycine wightii* (wight &Arn.)	L	C	Powder applied topically. Possess high preventive ability	Breast	Ochwang'i et al. (2014)
	Not reported	*Indigofera arrecta* A. Rich	L	H	Not reported	Breast, cervical, prostate	Gathura (2017)
	Not reported	*Indigofera swaziensis* Bolus	Rt	S	Decoction drunk	Throat	Onyancha et al. (2019)
	N'gechebchat (*Nandi*)	*Leucas calostachys* Oliv	Rt	S	Decoction with roots of *T. asiatica*, *R. myriocoides* and *T. grandifolia* taken	Not specified	Kigen et al. (2014)
	Mukui (*Embu*, *Mbeere*)	*Newtonia buchananii*	NS	T	Not reported	Not specified	Muriuki (2011)
	Omuvinuvinu, Luvinu	*Senna didymobotrya* (Fresen) Irwin & Barney	L	T	Infusion (300 ml) taken twice daily for 2 weeks. Used with leaves of *O. gratissimum*, *G. parviflora* and *T. rhomboidei*	Colorectal	Ochwang'i et al. (2014)
	Omukhule, Olukhulila mbusi, Lohori	*Sesbania sesban* (L.) Merr	WP	S	Powder applied topically. Concoction (150 ml) taken twice a day for 3 weeks	Throat, uterine, skin	Ochwang'i et al. (2014)
	Mkwadzu (*Swahili*)	*Tamarindus indica* L	Fr	T	Used with *Pennisetum glaucum* (grain)	Liver, prostate	Gathura (2017)
	Len'gnet (*Nandi*)	*Vachelia xanthophloea*	Bk	T	Pressed on the site, leading to production of a thick black substance	Not specified	Kigen et al. (2014)
Francoaceae	Kipset (Markwet)	*Bersama abyssinica* Fresen	Rt	T	Decoction taken	Not specified	Mbuni et al. (2020)
Hydnoraceae	Ndonga or Mutumurathi (*Embu*)	*Hydnora abyssinica* Schwein f	RZ	H	Whole RZ decoction drunk with soup	Prostate, breast	Onyancha et al. (2019)
Hypericaceae	Musila, Munamusayi	*Harunganamadagascariensis* Lam. ex Poir	SB, Rt	T	Infusion (300 ml) taken thrice daily for 3 months. Used with *Z. gilleti* (SB), *S. campanulata* (SB & Rt), *P. africana* (SB) and *V. lasiopus* (SB)	Breast, skin, colorectal	Ochwang'i et al. (2014)
Lamiaceae	Kwamatsai	*Fuerstia africana* T.C.E. Fr	L, St, Rt	S	Powder (30 g) infusion taken (75 ml) twice a day until finished. This is repeated until recovery. Powder may be applied topically	Colorectal	Ochwang'i et al. (2014)

Table 1 (continued)

Family	Local name	Botanical name	Part used	Life form	Mode of preparation (administration)	Cancer treated	Author (s)
	Ouwali	*Ocimum gratissimum* L	L	H	Infusion from shade-dried leaves (300 mL) taken twice daily for 2 weeks. Used sometimes with leaves of *G. parviflora*, *S. didymobotyra* and *T. rhomboidea*	Colorectal	Ochwang'i et al. (2014)
	Liavacado	*Persea americana* Mill	L	T	Powder (0.45 g) taken orally thrice daily until recovery or powder is licked	Prostate, breast, colorectal, skin	Muriuki (2011) and Ochwang'i et al. (2014)
	Muonyi	*Salvia coccinea* (L.) Murr	L	H	Infusion taken, twice daily for a month. Maybe dried indoors and powder applied topically. Often boiled with *D. laxata* and *A. gummifera* leaves	Breast, oesophageal, colorectal	Ochwang'i et al. (2014)
	Not reported	*Tetradenia riparia*	L	H	Not reported	Prostate	Gathura (2017)
Lauraceae	Muthaiti (*Embu, Mbeere*), Kivumba, Manyodo (*Taita*), Miseri (*Chagga*), Muura (*Meru*)	*Ocotea usambarensis* Engl	Bk, Rt	T	Paste applied on the swollen area or even to the swollen glands in the throat	Throat	Kokwaro (1993) and Muriuki (2011)
Loranthaceae	Mondoiwet (Sabot)	*Phragmanthera ussuiensis* (Oliv) M.Gilbert	Bk	S	Decoction	Not specified	Okello et al. (2010)
Malvaceae	Not reported	*Abelmoschus esculentus* (L.) Moench	Fr (pods)	H	Not reported	Breast	Gathura (2017)
	Mubuu (*Mbere*, *Embu*)	*Grewia villosa* Willd	Rt	S	Decoction taken	Breast, prostate	Kareru et al. (2007) and Onyancha et al. (2019)
	Lusatsa	*Sida cordifolia* L	L	H	Powder applied until it sticks and covers the lesions; used daily until recovery, usually with *W. indica* leaves	Skin sarcoma	Ochwang'i et al. (2014)
	Omukusa	*Sida rhombifolia* L	L	H	Powder infusion (75 ml) taken once daily for 2 weeks. Used with *A. abyssinica* and *T. rhomboidei* leaves. Maybe topically applied at 3-day intervals	Uterine, skin, squamous cell carcinoma of the gums	Ochwang'i et al. (2014)

Table 1 (continued)

Family	Local name	Botanical name	Part used	Life form	Mode of preparation (administration)	Cancer treated	Author (s)
	Likhambi/Imbululusia (male & female)/Oluyasi	*Triumfetta rhomboidea* Jacq	L	S	Powder infusion (300 mL) with *P. abyssinica* (leaves & Rt), *G. parviflora* (leaves), *O. gratissimmu* and *S. didymobotyra* (leaves) taken twice daily for 2 weeks. Topically applied at 3-day interval	Colorectal, uterine, squamous cell carcinoma of the gums	Ochwang'i et al. (2014)
	Olundu lukhasi	*Waltheria indica* L	L	H	Powder applied until it sticks and covers the lesions; used daily until recovery, usually with *S. cordifolia* leaves	Skin sarcoma, uterine, breast	Ochwang'i et al. (2014)
Meliaceae	Kerbut (*Markwet*), Eshiruma	*Ekebergia capensis* (Fresen. A. Rich)	SB, L	T	Infusion (300 ml) taken thrice a day for a week. Decoction drunk	Breast, skin, throat	Mbuni et al. (2020) and Ochwang'i et al. (2014)
	Mwarubaine	*Melia azedarach* L	L	T	Powder licked or taken orally (4.5 g in 150 ml of water)	Colorectal, oesophageal	Ochwang'i et al. (2014)
	Munyama, Irojo, Musinzi	*Trichilia emetica* Vahl	SB, RB, L	T	Infusion (150 mL) taken once daily until recovery. Used with *P. africana* (SB & Rt), *S. campanulata* (leaves & SB), *A. volkensii* (leaves) and *H. madagascariensis* (SB)		Ochwang'i et al. (2014)
Moraceae	Simotwet nebo chego (*Nandi*)	*Ficus thonningii* Blume	Bk	T	Pressed on the site, leading to production of a thick black substance	Not specified	Kigen et al. (2014)
	Mururi (*Embu*)	*Milicia excelsa*	NS	T	Not reported	Not specified	Muriuki (2011)
Moringaceae	Moringa (vera)	*Moringa oleifera* Lam	L, Sd	H	Seeds chewed; leaf decoction taken	Prostate, breast, cervical	Gathura (2017), Kamau et al. (2016) and Muriuki (2011)
Musaceae	Kiongoro kia irigu, Marigu (*Embu, Mbeere, Meru*)	*Musa* species	NS	S	Not reported	Not specified	Muriuki (2011)
Myrsinaceae	Kibabustanyiet (*Nandi*)	*Maesa lanceolata* Forssk	NS	S	Not reported	Breast, colon, lung, liver	Gathura (2017)

Table 1 (continued)

Family	Local name	Botanical name	Part used	Life form	Mode of preparation (administration)	Cancer treated	Author (s)
Myrtaceae	Lamaiwo (*Markweta*), Musiema	*Syzygium guineense* Wall	Rt, Bk	T	Bark powder taken with hot milk or in water with honey as an infusion with 4.5 g thrice a day for 3 weeks. Powder residues after extraction is used fir bathing. Taken with powders of *P. africana* (Rt & SB), *S. mauritianum* (bark), *M. tetraphylla* (bark) and S. *campanulata* (bark & Rt)	Skin	Kigen et al. (2017) and Ochwang'i et al. (2014)
Oleaceae	Emtit (*Nandi*)	*Olea africana*	Bk	T	Pressed on the site, leading to production of a thick black substance	Not specified	Kigen et al. (2014)
	Omutukuyu, Mutukuyu	*Olea hotch* spp. Hochstetteri	St	S	Infusion (150 mL) taken thrice daily until recovery. Prepared usually with *Z. gilleti* (SB), *H. madagascariensis* (SB), *S. campanulata* (SB & roots) and *P. africana* (SB)	Skin	Ochwang'i et al. (2014)
Plumbaginaceae	Not reported	*Plumbago zeylanica* L	NS	H	Not reported	Breast, colon, liver, lung	Gathura (2017)
Poaceae	Lemon grass (*English*)	*Cymbopogon citratus* (DC.) Stapf	L, St	H	Freshly boiled stem (20 g) and leaf powder taken (300 mL) taken thrice a day for a week	Colorectal	Ochwang'i et al. (2014)
	Pearl millet (*English*)	*Pennisetum glaucum*	Fr	T	Used with *Tamarindus indica* L. fruit	Liver, prostate	Gathura (2017)
	Wheat (*English*)	*Triticum aestivum* L	NS	H	Not reported	Not specified	Muriuki (2011)
Polygynaceae	Rakaro	*Oxygonum sinuatum* (Meisn.) Dammer	L, Fr, St	H	Infusion (150 mL) prepared with *B. pilosa* (Rt, leaves and stem) taken thrice a day for 2 weeks for breast, skin & throat cancers	Prostate, breast, skin, throat	Gathura, (2017) and Ochwang'i et al. (2014)
Primulaceae	Mũgaita (*Kikuyu*)	*Myrsine africana* L	Bk, Fr	S	Decoction taken	Breast, colon, lung, liver	Gathura (2017) and Kamau et al. (2016)
	Kigeta, mugeta (*Mbeere*)	*Myrsine melanophloeos*	NS	T	Not reported	Prostate	Muriuki (2011)
	Not reported	*Rapanea melanphloes* (L.) Mez	NS	T	Not reported	Breast, colon, lung, liver	Gathura (2017)

Table 1 (continued)

Family	Local name	Botanical name	Part used	Life form	Mode of preparation (administration)	Cancer treated	Author (s)
Proteaceae	Muyundi	*Macadamia tetraphylla* L.A.S. Johnson	B	T	Infusion of powder (4.5 g) taken with hot milk or warm water with honey, thrice a day for 3 weeks. The residues from the extraction is used for bathing. Usually used with powder of *S. guineense* bark	Skin	Ochwang'i et al. (2014)
Rhizophoraceae	Muthaguta (*Mbeere*)	*Cassipourea malosana* (Baker) Alston	NS	S	Not reported	Not specified	Muriuki (2011)
Rosaceae	Mwiria (*Embu*), Muiri (*Meru*), Timonwo (*Tugen*), Mwilitsa	*Prunus africana* (Hook.f.) Kalkman	Rt, SB, Fr	T	Infusion drunk or decoction with soup drunk. Sometimes used with *S. mauritianum* bark	Blood, breast, skin, colorectal, prostate	Gathura (2017), Jeruto et al. (2015), Kareru et al. (2007), Mbuni et al. (2020), Muriuki (2011), Ochwang'i et al. (2014), Okello et al. (2010),Onyancha et al. (2019), Otieno and Analo (2012), Rufford (2020), Shiracko et al. (2016) and Welle (2020)
	Momonio (Markweta)	*Rubus apetalus* Poir	Fr	T	Chewed	Not specified	Kigen et al. (2017)
Rubiaceae	Muchunkwa (*Meru*), Mucungwa (*Embu*, *Mbeere*)	*Citrus sinensis* (L.) Osbeck	NS	T	Not reported	Not specified	Muriuki (2011)
	Magilion (*Markweta*), Kop-ulwo (*Pokot*), Eshiuna	*Gardenia volkensii* K. Schum	Fr, Bk	S	Infusion (300 ml) taken thrice daily for 3 months	Skin, breast, uterine	Mbuni et al. (2020) and Ochwang'i et al. (2014)
	Olngeriantus (*Maa*)	*Galium aparinoides* Forssk	WP	H	Decoction/infusion given to cattle	Throat	Kigen et al. (2019) and Kok-waro (1993)
	Ombura	*Pavetta abyssinica* Fresen	L, Rt	S	Infusion (150 ml) taken daily until recovery. Often used with *R. vulgaris* (Rt, leaves & fruits) and *T. rhomboidei* leaves	Breast, skin, colorectal	Ochwang'i et al. (2014)
	Mukomari, Shekoye	*Psydrax schimperiana* (A. Rich)	SB	T	Infusion (30 g in 1 L of water) taken thrice daily until recovery. Applied topically on the wound	Breast	Ochwang'i et al. (2014)
	Vikudhuli	*Spermacoce princea* (K. Schum.) Verdc	L, AP	S	Infusion (150 ml) taken once per day. Used with leaves of *S. mannii*	Breast, colorectal, skin	Ochwang'i et al. (2014) and Onyancha et al. (2018)
Rutaceae	Mukuria Hungu (*Embu*)	*Fagaropsis angolensis* (Engl.) Dale	SB	T	Decoction taken	Breast, prostate	Onyancha et al. (2018, 2019)
	Orongoriwe (*Kuria*), Osiro (*Luo*)	*Harrisonia abbysinica* Olive	Rt	T	Decoction taken	Breast	Onyancha et al. (2018) and Schmelzer et al. (2010)

Table 1 (continued)

Family	Local name	Botanical name	Part used	Life form	Mode of preparation (administration)	Cancer treated	Author (s)
	Ketemwo (*Tugen*), Ketemwet (*Nandi*)	*Toddalia asiatica* (L.) Lam	Rt	S	Decoction taken. Sometimes used with roots of *R. myriocoides*, *L. calostachys*, and *T. grandifolia*. For throat cancer, Rt prepared with *R. myriocoides* and *L. cornuta* roots	Throat	Kigen et al. (2014) and Rufford (2020)
	Oloisuki (*Maasai*)	*Zanthoxylum chalybeum* Engl	SB	T	Not reported	Not specified	Omosa et al. (2019)
	Shihumba, Shikuma	*Zanthoxylum gilletii* (De Wild.) P.G. Waterman	SB	T	Powder infusion (150 ml) taken thrice daily for 3 months. Maybe also be applied topically. Prepared with *P. africana* (SB), *H. madagascariensis* (SB), *O. capensis* (SB) and *S. campanulata* (SB & Rt)	Skin	Ochwang'i et al. (2014)
	Not reported	*Zanthoxylum paracanthum* Kokwaro	St, Rt	T	Not reported	Not specified	Kaigongi et al. (2020)
	Shikhuma, Shigulutsu, Shughoma	*Zanthoxylum rubescens* Hook. f	L, SB, Rt	T	Infusion taken. Often prepared with *S. campanulata* (SB), *A. erasifera* stem bark, *S. ellipticum* (Bk & leaves) and *M. pyrifolia* leaves	Breast, skin, colorectal, oesophageal	Ochwang'i et al. (2014)
Salicaceae	Chepkererlong	*Trimeria grandifolia* (Hochst.) Warb	Rt	S	Decoction with roots of *R. myricoides T. asiatica*, and *L. calostachys* taken	Not specified	Kigen et al. (2014)
Santalaceae	Mutero (*Mbeere*), Muchai (*Meru*)	*Osyris lanceolata* Hochst. & Steudel	NS	T	Not reported	Prostate	Muriuki (2011)
Sapotaceae	Mukurumuru, Tsikhulumuru	*Synsepalum cerasiferum*. Synonym*: Afrosersalisia cerasifera* (Welw.) Aubrev	SB	T	Infusion taken for 1 month. Used with *S. campanulata* (SB), *S. ellipticum* (SB & Rt) and *M. pyrifolia* (leaves)	Colorectal, oesophageal	Ochwang'i et al. (2014)
Solanaceae	Pilipili (*Kiswahili*)	*Capsicum frutescens* L	Fr cover	H	Powder made into capsules and infusion taken. Sometimes prepared with *S. campanulata* (Stem bark), *M. pyrifolia* leaves, *J. procera* (SB) and *C. papaya* (leaves & Rt)	Breast, throat, squamous cell carcinoma	Ochwang'i et al. (2014)
	Indalandalua	*Solanum aculeastrum* Dunal	Fr, Rt	S	Infusion (300 mL) with *A. precatorius* roots taken thrice daily for 1.5 months	Skin, breast, cervical	Ochwang'i et al. (2014)

Table 1 (continued)

Family	Local name	Botanical name	Part used	Life form	Mode of preparation (administration)	Cancer treated	Author (s)
	Mutongu, ndongu (*Embu*, *Mbeere*)	*Solanum incanum*	NS	S	Not reported	Prostate	Muriuki (2011)
	Lifuye, Liavuya	*Solanum mauritianum* Scop	Bk	S	Powder infusion (1500–300 mL) taken thrice daily for 10 days to 1.5 months, usually after meals for appetence. Used with *P. africana* (SB & Rt)	Colorectal	Ochwang'i et al. (2014)
	Murumbae (*Kikuyu*)	*Withania somnifera* (L.) Dunal	NS	S	Not reported	Breast, prostate	Gathura (2017)
Verbenaceae	Munjugairia (*Kikuyu*), Ketbaiyat	*Rotheca myricoides* (Hochst.) Vatke	Rt	S	Decoction taken. Sometimes used with roots of *T. asiatica*, *L. calostachys*, and *T. grandifolia*. For throat cancer, Rt prepared with *T. asiatica* and *L. cornuta* roots	Prostate, throat	Kamau et al. (2016) and Kigen et al. (2014)
	Muburu (*Mbere*), Mubiru (*Embu*)	*Vitex doniana* Sweet	L	T	Decoction taken	Breast, prostate	Kareru et al. (2007) and Onyancha et al. (2019)
Vitaceae	Mukoyegoye	*Cyphostemma adenocaule* (Steud.) Desc	L, RB	H	Infusion (150 mL) taken once daily until recovery. Used with *P. fischeri* (leaves & SB), *H. africana* (leaves and Rt), leaves of *S. princea* and *S. mannii*	Skin, breast, colorectal	Ochwang'i et al. (2014)
	Lithunzune, Maombola	*Cyphostemma serpens* (A. Rich)	L, RB, SB	H	Leaf powder infusion or in porridge taken, thrice daily for 3 weeks. Powder in nylon paper bag is steamed in water and applied topically by rubbing on the wounds	Skin, breast, colorectal	Ochwang'i et al. (2014)
Urticaceae	Thabai (*Kikuyu*), Elaila	*Urtica massaica* Mildbr	L	H	Powder of leaves dried indoors applied topically on lesions (of mainly skin cancer)	Skin, breast, uterine	Ochwang'i et al. (2014)
Zygophyllaceae	Chaparral	*Larrea tridentate*	NS	H	Not reported	Not specified	Muriuki (2011)

AP, aerial parts; Bk, bark; Blb, bulb; Fr, fruit; L, leaf; Rt, root; RZ, rhizome; Sd, seed; St, stem; WP, whole plant; NS, not specified; H, herb; T, tree; S, shrub

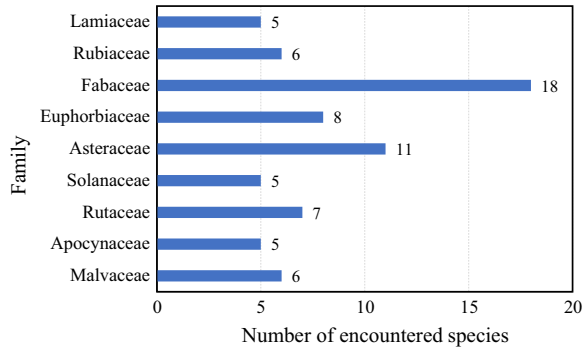


Fig. 1 Major botanical families from which antitumor remedies are obtained in Kenya

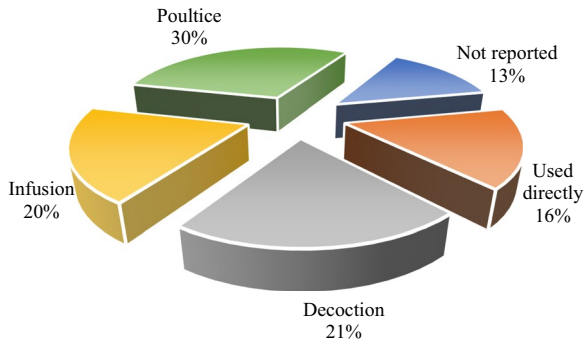


Fig. 3 Different methods used in the preparation of anticancer remedies from medicinal plants in Kenya

The identified plants are trees (63 species, 43.4%), shrubs and herbs (40 species each, 27.6%) or climbers (2 species, 1.4%). For anticancer herbal remedies, leaves (27.3%), roots (19.0%) and stem bark (12.2%) are the most commonly used (Fig. 2). The different plant parts are used for preparation of poultices (30%), decoctions (21%) and infusions (20%) as shown in Fig. 3. However, reproductive structures such as seeds, fruits and bulbs are less commonly used, similar to reports from other countries (Omara et al. 2020). In some use reports, the plant parts used were not specified and this may be explained by the top secrecy associated with herbal medicine use in Kenya (Kuria et al. 2001; Omara 2020).

Phytochemistry and antiproliferative activities of anticancer plants reported in Kenya

Many plant species have been claimed in folklore to possess anticancer properties, and some important anticancer molecules and drugs have been isolated from such plants. For example, *Camptotheca acuminata* elicited antiproliferative activity against rectal, brain, liver, gastrointestinal and breast tumors and this led to the isolation of Camptothecin, an anticancer drug (Kaur et al. 2011). In Kenya, the pioneer institution in cancer research is the Center for Traditional Medicine Research (CTMDR) of the Kenya Medical Research Institute (KEMRI), Nairobi, Kenya. To date, at least 20 species of Kenyan anticancer herbal plants have been studied extensively in the laboratory, but there is little move from bench-scale experiments to product development due to underfunding by the government (Gathura 2019). Herbal anticancer products derived from *Prunus africana*: Tadenan, Prostafx and Pygenil are widely traded in Kenya and the East African region (Nyamai et al. 2015; Omara et al. 2020).

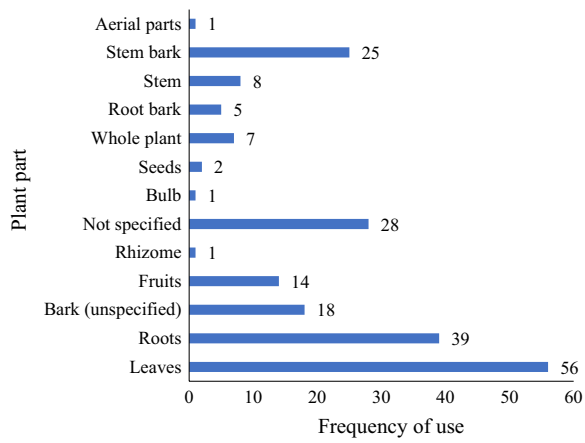


Fig. 2 Frequency of use of plant parts utilized in the management of cancer in Kenyan herbal medicine

A review of the identified plants used for treatment of malignancies that have been reported to possess antiproliferative activities was undertaken. The most studied anticancer plants included *Toddalia asiatica*, *Annona muricata*, *Carica papaya*, *Catharanthus roseus, Moringa oleifera*, *Ocimum gratissimum*, *Prunus africana* and *Zanthoxylum paracanthum* (Table 2) and have various compounds reported in them (Fig. 4). However, some of the most utilized plant species such as *Tabernaemontana stapfiana* and *Flueggea virosa* have hardly been studied or have given conflicting results. For example, some potentially bioactive compounds isolated from *Flueggea virosa* (fluevirines E and F) elicited no appreciable antiproliferative effect against human cancer cell lines: SW480, A549, SMMC-7721, HL-60 and MCF-7 (Yang et al. 2020).

Phytochemicals elicit anticancer activity through various pathways such as inducing cleavages that yield reactive oxygen species (thereby inducing oxidative stress), inducing apoptosis, reducing cell proliferation through cell cycle arrest, inhibiting angiogenesis and tissue invasion of the tumor and cancer metastasis (Lichota and Gwozdzinski 2018). For example,

Table 2 Anticancer activity of some medicinal plant species reported in Kenya for cancer treatment

Plant	Active phytochemicals	Molecular targets and/or effects on cancer cells
Toddalia asiatica	8-Methoxynorchelerythrine (**1**), 11-demethylrhoifoline B (**2**)**,** 8-methoxynitidine (**3**), 8-acetylnorchelerythrine (**4**), 8,9,10,12-tetramethoxynorchelerythrine (**5**), isointegriamide (**6**); 1-demethyl dicentrinone (**7**), 11-hydroxy-10-methoxy-(2,3)-methylenedioxytetrahydroprotoberberine (**8**), rhoifoline B (**9**), pancorine (**10**), 8-methoxychelerythrine (**11**), arnottianamide (**12**), oxynitidine (**13**), oxysanguinarine (**14**), dicentrinone (**15**), (2,3,10,11)-dimethylenedioxytetrahydroprotoberberine (**16**), skimmianine (**17**), 5-methoxydictamnine (**18**) (Hu et al. 2014), benzo[c]phenanthridine derivatives: dihydronitidine **(19),** nitidine (**20**) and demethylnitidine (**21**) (Iwasaki et al. 2009), 6-(3-methyl-2-butenyl)-5,7-Dimethoxycoumarin (toddaculin) (**22**), 6-(2,3-Epoxy-3-methylbutyl)-5,7-dimethoxycoumarin (aculeatin) (**23**), 6-(3-Methyl-2-butenyloxy)-5,7-dimethoxycoumarin (**24**), 8-(3-Methyl-2-butenyl)-6,7-dimethoxycoumarin (O-methylcedrelopsin) (**25**), 6-(2-Hydroxy-3-methyl-3-butenyl)-5,7-dimethoxycoumarin (toddanol) (**26**), 6-(2,3-Dihydroxy-3-methylbutyl)-5,7-dimethoxycoumarin (toddalactone) (**27**), 5,7-Dimethoxy-4-methylcoumarin (**28**) (Vázquez et al. 2012), 8S-10-Odemethylbocconoline (**29**), oxynorchelerythrine (**30**), phellopterin (**31**), O-methylcedrelopsin (**32**), toddanone (**33**) (Sukieum et al. 2017)	Cytotoxicity recorded against human A549 (lung cancer), BGC-823 cells (gastric carcinoma), HCT15 (colon cancer), HeLa cells (cervical cancer), HepG2 (hepatocellular carcinoma), MCF-7 (breast cancer), SK-MEL-2 (skin cancer), and SGC-7901 (gastric adenocarcinoma) cell lines (Hu et al. 2014). Benzo[c]phenanthridine alkaloids (**1–5)** and secobenzo [c]phenantridine alkaloids showed cytotoxicity against the cancer cell lines; **4** was the most potent with IC_{50} values ranging from 1.3 to 2.5 lg/mL. The aporphine-type alkaloids had moderate cytotoxicity on the tested cell lines, while berberine-type and indole-type alkaloids had modest activities (Hu et al. 2014) Derivatives **20** and **21** selectively reduced proliferation of murine (LLC) and human lung adenocarcinoma (A549) cells in vitro, while **19** inhibited proliferation of in a subcutaneous A549 xenograft model (Iwasaki et al. 2009). Coumarins (**22–27**) had potential cytotoxicity and antiproliferative activity against U-937 cells with $IC_{50} = 51.38 \pm 4.39$ (**22**), 92.44 ± 2.82 (**23**), 190.5 ± 3.18 (**24**), 99.74 ± 2.34 (**25**), > 100 (**26**), 165.0 ± 4.06 (**27**), > 1000 µM (**28**) and $CC_{50} = 138.90 \pm 3.50$, 459.10 ± 3.42, 548.60 ± 5.20, 154.90 ± 3.34, > 100, 320.40 ± 3.38, > 1000 µM, respectively. Toddaculin (**22**) induced cell differentiation effects and apoptosis (Vázquez et al. 2012) Alkaloids (**29**, **30**) from root extract fractions had cytotoxic effects against human epidermoid carcinoma of oral cavity (KB) cells with $IC_{50} = 21.69$ and 43.77 µg/mL, respectively. For human small cell lung cancer (NCI-H187) cells, **30–33** had weak cytotoxicity with IC_{50} from 21 to 35 µg/mL (Sukieum et al. 2017)
Abelmoschus esculentus	Isoquercitrin (**34**), quercetin (**35**), hyperoside (hyperin), coumarin scopoletin and uridine (Chaemsawang et al. 2019)	Cytotoxicity of extracts reported against breast cancer (MCF-7), hepatocellular carcinoma (HepG2) and cervical carcinoma (HeLa) cell lines (Chaemsawang et al. 2019). Isoquercitrin inhibited urinary bladder, pancreatic and colon cancer progress (Amado et al. 2014; Chen et al. 2015, 2016) Extracts induced significant cell growth inhibition (63%) in human breast cancer (MCF-7) and skin fibroblast (CCD-1059 sk) cells. The expression of pro-apoptotic caspase-3, caspase-9, and p21 genes was increased in MCF-7 cells (Monte et al. 2014)
Albizia coriaria	Triterpenoid saponins: coriarioside A (**36**) and coriarioside B, gummiferaoside C (**37**), acacic acid glycosides, lupeol (**38**), lupenone, betulinic acid, acacic acid lactone, (+)–catechin and benzyl alcohol (Byamukama et al. 2015; Noté et al. 2009, 2010; Omara et al. 2022)	Coriarioside A and gummiferaoside C from root bark showed cytotoxicity against two colorectal human cancer cells: HCT-116 (with IC_{50} of 4.2 µM for Coriarioside A and 2.7 µM for gummiferaoside C) and HT-29 (with IC_{50} 6.7 µM for Coriarioside A and 7.9 µM for gummiferaoside C) cell lines (Note et al. 2009)

Table 2 (continued)

Plant	Active phytochemicals	Molecular targets and/or effects on cancer cells
Annona muricata L	Annonaceous acetogenins (muricin J, muricin K, muricin L) (Sun et al. 2014), annonacin (**39**), annomuricin A, annomuricin E (**40**), annomuricin C, annomutacin, gigantetronin (Wu et al. 1995; Yuan et al. 2003), quercetin, luteolin 3′7-di-o-glucoside, gallic acid, apigenin-6-c-glucoside, taxifolin (+) (George et al. 2012)	Aqueous leaf extracts exhibited anticancer activity with IC_{50} values of 220, 350 and 250 µg/mL for breast cancer cell lines: MCF-7, MDA-MB231 and 4T1, respectively (Najmuddin et al. 2016). Leaf extracts recorded cytotoxicity against human bladder cancer (K562) and leukemia cancer (ECV304) cell lines (Oviedo et al. 2009) Annonaceous acetogenins exhibited antiproliferative activity against human prostate cancer PC-3 cells (Sun et al. 2014). Fruit extracts cytotoxic against U937 histiocytic lymphoma cell line with IC_{50} of 10.5, 18.2 and 60.9 µg/ml for ethyl acetate, hexane and methanol extracts, respectively (Valencia et al. 2011) Annonacin caused complete suppression of 7, 12-dimethylbenz[a]anthracene (DMBA) induced and 12–0-tetradecaboylphorbol-13-acetate (TPA) promoted skin tumorigenesis in mice (Roduan et al. 2017). At 0.1 µM, annonacin induced growth arrest and apoptosis in breast cancer (MCF-7) cells (Ko et al. 2011) Annomuricin E was cytotoxic to HT-29 colon carcinoma and CCD841 normal colon cell lines with IC_{50} values of 5.72, 3.49 and 1.62 µg/mL for HT-29 cells at time intervals of 12, 24, and 48 h of administration, respectively (Moghadamtousi et al. 2015) Stem extracts suppressed the expression of molecules associated to hypoxia and glycolysis in CD18/HPAF (pancreatic) cancer cells (IC_{50} of 73.0 µg/mL) (Torres et al. 2012) Cytotoxicity recorded against Raji cells with IC_{50} values of 90.6, 407.2 and 260.2 µg/mL. Cytotoxic effect of chloroform and n-hexane extracts on Hela cell line gave IC_{50} values of 127.3 and 169.2 µg/mL, respectively (Artanti et al. 2016) Leaf extracts inhibited cell proliferation in pancreatic cancer cells (Capan-1) (Rosdi et al. 2015) Ethanol extract of seeds showed cytotoxic effect on MDBK and HEp-2 cells (IC_{50} values:34.5 and 55 mg/mL, respectively) at 24 h, and an IC_{50} value of 49.6×10^{-3} mg/mL toward HEp-2 cells at 72 h (Betancur-Galvis et al. 1999) Cytotoxic against kidney epithelial (VERO), stomach cancer (C-678) and human large lung cell carcinoma (H-460) cell lines with IC_{50} values lower than 0.00022 mg/mL for all the cell lines (Quispe et al. 2006). Cytotoxicity reported against histiocytic lymphoma cell line (U937), pancreatic cancer cells (FG/COLO357), breast cancer cells (MDA-MB-435S), immortalized human keratinocytes (HaCat), normal human liver cells (WRL-68) and human skin malignant melanoma (A375) (George et al. 2012; Ménan et al. 2006; Nawwar et al. 2012; Osorio et al. 2007; Torres et al. 2012). In histiocytic lymphoma cell line, the extract had IC_{50} value of 7.8 µg/mL. Toxicity toward FG/COLO357 with an IC_{50} value of 200 µg/mL (Torres et al. 2012). Cytotoxic effect of *n*-butanolic extract of leaves against MDA-MB-435S (human breast carcinoma), HaCaT (human immortalized keratinocyte) and WRL-68 (normal human hepatic) cell lines with IC_{50} values of 29.2, 30.1 and 52.4 µg/mL, respectively (George et al. 2012) Ethanol extracts of leaves cytotoxic to Ehrlich Ascites Carcinoma (EACC) and breast cancer (MDA and SKBR3) cell lines with IC_{50} values of 335.85, 248.77, and 202.33 µg/mL (Gavamukulya et al. 2014). Fruit extracts had substantial repression of breast cancer cells (MDAMB-468) growth as well as selective suppression of epidermal growth factor receptor (EGFR) with IC_{50} of 4.8 µg/mL (Dai et al. 2011)

Table 2 (continued)

Plant	Active phytochemicals	Molecular targets and/or effects on cancer cells
Acokanthera oppositifolia	Not reported	DCM and DCM: MeOH root and stem extracts had moderate in vitro anticancer activity against breast (MCF-7) and Melanoma (UACC62) cells with total growth inhibition (TGI) at 6.25–15.0 µg/mL but no activity against Renal (TK10) cells (Fouche et al. 2008)
Beta vulgaris L	Not reported	Ethanolic extract exhibited significant anticancer activity against lung cancer (A549) cell line but only a slight effect against colorectal adenocarcinoma (Caco-2) cell line at 800 µg/ml (El-Beltagi et al. 2018). Cytotoxicity against PC-3 cells led to decrease in the growth rate of the cells (3.7% in 3 days) at 29 µg/mL. Comparative cytotoxicity tests in normal human skin (FC) and liver (HC) cell lines showed that the extract were cytotoxic on the cells, though activity were lower than that of doxorubicin (8.6% compared to 100%, respectively, at 29 µg/ml concentration in a 3-day test period) (Kapadia et al. 2011)
Capsicum frutescens L	Capsaicin (**41**) and quercetin (Shaimaa et al. 2016)	Aqueous fruit extracts exhibited anticancer activity, (though lower than capsaicin standard) when tested against prostate (PC-3) and breast (MCF-7) cancer cell lines in vitro (Shaimaa et al. 2016)

Table 2 (continued)

Plant	Active phytochemicals	Molecular targets and/or effects on cancer cells
Carica papaya L	Lycopene (**42**), ferulic acid, benzyl isothiocyanate, kaempferol, quercetin, chlorogenic acid, caffeic acid, beta carotene and *p*-coumaric acid (Melariri et al. 2011; Teng et al. 2019)	Pure lycopene and papaya juice inhibited viability of liver cancer (HepG2) cell line with IC_{50} of 22.8 µg/mL and 20 mg/mL (Rahmat et al. 2002). Aqueous leaf extracts inhibited by apoptosis the proliferation of human breast cancer (MCF-7) cells with IC_{50} = 1319.25 µg/mL (Nisa et al. 2017) *n*-hexane seed extract dose dependently inhibited superoxide generation (IC_{50} = 10 µg/mL) and the viability of acute promyelocytic leukemia (HL-60) cells (IC_{50} = 20 µg/mL), comparable to that of pure benzyl isothiocyanate (Nakamura et al. 2007) Aqueous extract of flesh (0.01– 4% v/v) inhibited the proliferation of breast cancer cell line (MCF-7) (Garcia-Solis et al. 2009). Ethanolic extract of pericarp (50–640 µg/mL) inhibited the growth of Breast cancer cell line (MCF-7) treated with sodium nitroprusside, a nitric oxide donor (Jayakumar and Kanthimathi 2011). Breast cancer cell line (T47D) was inhibited by leaf protein fraction with IC_{50} = 2.8 mg/mL); induced apoptosis by regulation of protein expression (Hirose et al. 1998) Aqueous extracts of leaves (1.25–27 mg/mL) exhibited a concentration-dependent anticancer effect on stomach cancer cell line (AGS), pancreatic cancer cell line (Capan-1), colon cancer cell line (DLD-1), ovarian cancer cell line (Dov-13), lymphoma cell line (Karpas), breast cancer cell line (MCF-7), neuroblastoma cell line (T98G), uterine cancer cell line (Hela), T cell leukemia cell line (CD26 negative or negative Jurkat) cell lines and suppressed DNA synthesis by suppressing the incorporation of 3H-thymidine (Morimoto et al. 2008) Aqueous extract of leaves (0.625–20 mg/mL) inhibited the proliferative responses of both haematopoietic and solid tumor cell lines (T cell lines, H9, Jurkat, Molt-4, CCRF-CEM and HPB-ALL), Burkitt's lymphoma cell lines (Ramos and Raji), chronic myelogenous leukemia cell line (K562), cervical carcinoma cell line (Hela), hepatocellular carcinoma cell lines (HepG2 and Huh-7), lung adenocarcinoma cell line (PC-14), pancreatic epithelioid carcinoma cell line (Panc-1), mesothelioma cell lines (H2452, H226, and MESO-4), plasma cell leukemia cell line (ARH77), anaplastic large cell lymphoma cell line (Karpas-299), breast adenocarcinoma cell line (MCF-7), mesothelioma cell line (JMN) and pancreatic adenocarcinoma cell line (Capan-1). In peripheral blood mononuclear cells, the extract reduced the production of IL-2 and IL-4, whereas increased the production of Th1 types cytokines such as IL-12p40, IL-12p70, INF-γ and TNF-α. The expression of 23 immunomodulatory genes was enhanced by the addition of papaya extract (Otsuki et al. 2010) Leaf juice not only exhibited a stronger cytotoxic effect on human squamous cell carcinoma (SCC25 cancer) cells, but also produced a significant cancer-selective effect as shown by tests on non-cancerous human keratinocyte HaCaT cells (Nguyen et al. 2016)

Table 2 (continued)

Plant	Active phytochemicals	Molecular targets and/or effects on cancer cells
Catharanthus roseus (L.) G. Don	Terpenoid alkaloids: vinblastine (**43**) and vincristine (**44**), serpentine, catharanthine, ajmalicine, akuammine, lochnerine, lochnericine, tetrahydroalstonine, 3′,4′-anhydrovinblastine, serpentine, vincaleukoblastine, leurocristine, vincaleurocristine, vincarodine, vincoline, leurocolombine, viramidine, vincathicine, vincubine, isositsirikine, vincolidine, catharanthine, vindoline (**45**), tetrahydroalstonine, vindolinine, reserpine, coronaridine, 11-methoxy tabersonine, tetrahydroalstonine, vindorosidine, hydroxytyrosol, ferulic acid, chlorogenic acid, kaempferol, trisaccharides, quercetin and petunidin 3-O-(6-O-p-coumaroyl) (Mustafa and Verpoor 2007; Hisiger and Jolicoeur 2007)	Vindoline from leaf extracts was cytotoxic to HCT-116 colorectal carcinoma cell line at 200 µg/mL
Erythrina abbysinica	Erythrina alkaloids: erythraline, erysodine, erysotrine, 8-oxoerythraline and 11-methoxyerysodine, Abyssinones A-D (**46–48**) and abyssaponins: A and B (**49, 50**)	Cytotoxicity with LC_{50} value > 240 µg/ml (Kapingu et al. 2006). In vitro cytotoxicity of the crude alkaloidal fraction reported against HeLa, HepG2, HEP-2, HCT-116, MCF-7 and HFB4 cell lines with IC_{50} values of 13.8, 10.1, 8.16, 13.9, 11.4 and 12.2 µg/mL Abyssinones A-D and abyssaponins (A and B) isolated from *E. abyssinica* stem bark exhibited considerable cytotoxicity against MCF-7 and MDA-MB-231 breast adenocarcinoma cell lines with IC_{50} ranging between 12.9 and 74 µM as compared to resveratrol (IC_{50} = 13.9–19.3 µM) (Pérez et al. 2015)
Hydnora abyssinica	None reported	Aqueous and methanolic rhizome extracts had $IC_{50} = 499.3 \pm 1.3$ and 27.20 ± 1.1 µg/mL against HCC 1395 cells with selectivity indices of 0.37 and 3.10, respectively, (Onyancha et al. 2018)
Kigelia africana Lam. Benth	Lapachol, 3-(2′- hydroxyethyl)-5-(2″-hydroxypropyl) dihydrofuran-2-(3H) one, specioside, verminoside and minecoside, kigelin, β-sitosterol, 1,3-dimethylkigelin and ferulic acid	DCM and DCM: MeOH root and leaf extracts had moderate in vitro anticancer activity against breast (MCF-7), renal (TK10) cells and melanoma (UACC62) cells with TGI at 8.02–42.88 µg/mL (Fouche et al. 2008). MeOH and DCM: MeOH extracts had cytotoxicity against human breast cancer (HCC 1937) cells with IC_{50} values of 26.02 µg/ml and 55.01 µg/ml, respectively, (Mukavi et al. 2020). Seed oil suppressed human colon adenocarcinoma (Caco-2) and human embryonic kidney (HEK-293) cell growth in a dose-dependent manner (Chivandi et al. 2012). Fruit extracts increased the sub-G1 phase (apoptosis) population in HCT116 human colon cancer cells (Guon and Chung 2016)
Markhamia lutea (Benth) K. Schum	Cycloartane triterpenoids, musambins A–C and their 3-Oxyloside derivatives musambiosides A–C (Lacroix et al. 2011), oleanolic acid, pomolic acid, 2-epitormentic acid, musambin A, b-sitosterol-3-O-b-D-glucopyranoside (Lacroix et al. 2009; Rajendran et al. 2014)	Anticancer activity against Ehrlich Ascites Carcinoma cells with an IC_{50} value of 27.0 µg/mL (Rajendran et al. 2014). Cytotoxicity against KB (mouth epidermoid carcinoma) and the human diploid embryonic lung cells (MRC5) though most IC_{50} values were > 50 µg/mL (Lacroix et al. 2009)

Table 2 (continued)

Plant	Active phytochemicals	Molecular targets and/or effects on cancer cells
Moringa oleifera Lam	Quercetin, kaempferol, β-D-glucopyranoside tetradecanoate, β-sitosterol, β -sitosterol glucoside (Kaur & Shantanu 2015), isothiocyanate, hexadecanoic acid and eugenol (Al-Asmari et al. 2015)	Cytotoxic against colon cancer (Colo-320 DM), Breast cancer (MCF-7), Ovary cancer (PA-1) and oral cancer (KB-403) cell lines with IC_{90} value of 3.98, 17.60,12.86 and 8.40 µg/mL, respectively (Kaur and Shantanu 2015). Methanol extracts were cytotoxic to human B-lymphocyte plasmacytoma (U266B1) cell line with IC_{50} of 0.32 µg/ml (Parvathy and Umamaheshwari 2007). Aqueous leaf extract caused a dose-dependent decrease in HeLa cell viability with IC_{50} of 70 µg/ml (Nair and Varalakshmi 2011). Leaf extracts displayed significant anti-proliferative activity ($p < 0.05$) against Human liver (hepatocellular carcinoma, HepG2) and muscular (rhabdomyosarcoma, RD) cell lines (Milugo et al. 2016). The IC_{50} of leaf extracts cytotoxicity on cisplatin-resistant ovarian cancer (A2780CP20) and prostate cancer (PC3) cell lines in a study were 0.27 and 0.17 mg/ml, respectively (Zayas-Viera et al. 2016) Apoptosis assay performed using leaf and bark extracts on breast and colorectal cancer lines showed a remarkable increase in the number of apoptotic cells with a seven-fold increase in breast (MD-MB-231) cell line to an increase of several folds in colorectal cancer (HCT-8) cell line (Al-Asmari et al. 2016) Leaf extracts inhibited the growth of hepatocarcinoma (HepG2), colorectal adenocarcinoma (Caco-2) and breast adenocarcinoma (MCF-7) cell lines with dichloromethane leaf extract having IC_{50} between 112 and 133 µg/ml (Suphachai 2014). Leaf extracts caused death of 72–82% of acute myeloid leukemia cells and 77–86% of acute lymphoblastic leukemia cells after 24 h of incubation with 20 µg/ml of the extract. In the same time, 69–81% of HepG2 cells died after treatment with ethanol extract (Khalafalla et al. 2010). Leaf extracts also showed in vitro anticancer activity on human hepatocellular carcinoma (HepG2) cells. At a maximum dose of 200 mg/kg, the survival of HepG2 and non-small cell lung cancer (A549) cells were reported to decrease by 60% and 50%, respectively (Jung et al. 2015) Leaf extract had anticancer activity against human epidermoid cancer (Hep-2) cell line with IC_{50} of 12.5 µg/ml in the most active fraction (Krishnamurthy et al. 2015). Cytoxicity of water-soluble leaf extract reported against human alveolar epithelial cells derived from the lung cancer (A549) cell line with IC_{50} of 166.7 µg/ml (Tiloke et al. 2013). Cell viability of leaf extract-treated A549, HepG2, CaCo2, Hek293 and Jurkat cells were reported to be reduced with IC_{50} from 0.05 to 0.4% (Madi et al. 2016). Human pancreatic cancer cells (Panc-1, p34 and COLO-357) were inhibited by leaf extracts with IC_{50} of 1.1, 1.5 and 1.8 mg/ml (Berkovich et al. 2013) Seed extracts had cytotoxic potential against A549, Hep-2, HT-29 and IMR-32 cancer cell lines (Rajesh et al. 2012). β-sitosterol-3-O-glucopyranoside, 4-(α-L-rhamnosyloxy) benzyl isothiocyanate and niazimicin prevented the induction of Epstein Barr-Virus genome in Raji cells. Niazimicin delayed the formation of tumors and reduced the number of tumors in vivo (Guevara et al. 1999)

Table 2 (continued)

Plant	Active phytochemicals	Molecular targets and/or effects on cancer cells
Prunus africana (Hook.f.) Kalkman	Ursolic acid, oleanolic acid, β-amyrin, atraric acid, N-butylbenzene-sulfonamide, β-sitosterol, β-sitosterol-3-O-glucoside, ferulic acid and lauric acid (Jena et al. 2016; Ngule et al. 2014; Nyamai et al. 2015)	Anti-prostate cancer activity targets fast dividing cells by impairing mitosis or by causing target cells to undergo apoptosis (Nyamai et al. 2015; Ochwang'i et al. 2014). Growth inhibition of a human prostate cancer cell line (PC-3) and epithelial cells derived from a lymph-node carcinoma of the prostate (LNCaP) by 50% at 2.5 µL/mL and also induced significant apoptosis in both cell lines (PC-3 and LNCaP) at 2.5 µL/mL compared to untreated cells. Ethanolic extract had an antimitogenic effect on prostate cancer cells by inhibiting the mitogenic action of epidermal growth factor which resulted in a decreased number of cells entering the S-phase of the cell cycle (Margalef et al. 2003). Aqueous and methanolic bark extracts had $IC_{50} = 81.9 \pm 8.04$ and 10.6 ± 0.7 µg/mL against human breast cancer (HCC 1395) cells with selectivity indices of 2.39 and 1.93, respectively (Onyancha et al. 2018)
Ovariodendron anisatum	Not reported	Aqueous and methanolic root extracts had $IC_{50} = 248.0 \pm 5.8$ and 50.6 ± 2.9 µg/mL against HCC 1395 cells with selectivity indices of 0.6 and 0.06, respectively (Onyancha et al. 2018)
Ocimum gratissimum	Phenolic compounds including procyanidin, carboxystrictosinedine, isoferullic acid, hydroxyplorentin, isoquercetin, diadzin, hyperin (Nassazi et al. 2020)	Antiproliferative activity of crude leaf extracts and methanolic fractions against human prostate (DU145), colon (CT26) and cervical (HeLa 229) cancer cells with IC_{50} between 104.84 ± 0.44 and 2874.81 ± 0.33 µg/mL for crude (methanolic, ethyl acetate, DCM and hexane) extracts and 16.16 ± 0.14 to 1019.26 ± 0.28 µg/mL for methanolic fractions (Nassazi et al. 2020). Partially purified fractions (1.61 mg/mL) were effective in inhibiting the proliferation of prostate adenocarcinoma (PC-3) in a in a concentration-dependent manner (Ekunwe et al. 2013, 2010). Unfractionated aqueous leaf extracts presented cytostatic effects with an 80% decrease in human breast cancer cell line (MCF-7) growth at 1 mg/mL (Torres et al. 2018) Crude extracts, its hydrophobic and hydrophilic fractions differentially inhibited breast cancer cell chemotaxis and chemoinvasion in vitro and retarded tumor growth and temporal progression of MCF10ADCIS.com xenografts (Nangia-Makker et al. 2013). Aqueous extract decreased the viability of human pulmonary adenocarcinoma (A549) cells (Chen et al. 2011). Further, leaf extracts decreased the cell viability of hepatocellular carcinoma (HCC SK-Hep1 and HA22T) cells in a dose-dependent manner (from 400 to 800 µg/mL) while there was little effect on Chang liver cells (Huang et al. 2020)
Launaea cornuta	Not reported	Aqueous and methanolic leaf extracts had $IC_{50} = 365.0 \pm 15.3$ and 231.7 ± 2.0 µg/mL HCC 1395 cells with selectivity indices of > 2.7 and 1.7, respectively (Onyancha et al. 2018)
Indigofera swaziensis	Not reported	Cytotoxicity reported (Hostettmann et al. 2000)
Spermacoce princeae	Not reported	Aqueous and methanolic aerial part extracts had $IC_{50} = 365.0 \pm 15.3$ and 231.7 ± 2.0 µg/mL against HCC 1395 cells with selectivity indices of > 2.7 and 1.7, respectively (Onyancha et al. 2018)
Fagaropsis angolensis	Not reported	Aqueous and methanolic bark extracts had $IC_{50} = 553.6 \pm 15.4$ and 59.4 ± 5.6 µg/mL against HCC 1395 cells with selectivity indices of 0.5 and 0.36, respectively (Onyancha et al. 2018)

Table 2 (continued)

Plant	Active phytochemicals	Molecular targets and/or effects on cancer cells
Combretum tanaense	Not reported	Aqueous and methanolic root extracts had $IC_{50} = > 1000$ µg/mL (inactive) and 193.0 ± 13.2 µg/mL against HCC 1395 cells with selectivity indices of > 1 and 0.19, respectively (Onyancha et al. 2018)
Oxygonum sinuatum	Not reported	MeOH: DCM (1:1) extracts of leaves, stem and fruits had antiproliferative activity against mouse breast cancer (4T1l), human breast cancer (Hcc 1395), human prostate (22Rv1) and metastatic prostate (DU 145) cancer cell lines with IC_{50} ranging between 181.48–867.06 µg/mL, 114.87–956.97 µg/mL and 35.84 to > 1000 µg/mL, respectively (Njuguna et al. 2018)
Maytenus senegalensis	Not reported	Methanolic root fraction was cytotoxic to Caco-2 and HepG2 cells with IC_{50} of < 40 µg/mL. The cell deaths were mediated by apoptosis (Bah et al. 2020)
Maytenus obscura	Not reported	Aqueous extract of its stem bark elicited moderate antitumor activityagainst DU145, 22RV1 and HeLa cancer cell lines with IC_{50} values of 25.03, 30.88 and 23.11 µg/mL (Kimani 2022)
Zanthoxylum chalybeum Engl	Skimmianine, furoquinoline alkaloid skimmianine, the benzophenanthidine alkaloids chelerythrine and nitidine, the aporphine alkaloids tembetarine, magnoflorine, N-methylcorydine, N-methylisocorydine (menisperine) and berberine and the phenylethyamine candicine, alkamide, fagaramide, dihydrocheleryth-rine, lupeol and sesamin (Omosa et al. 2019)	Extracts showed moderate cytotoxicity with IC_{50} values below 50 µM against the drug sensitive CCRF-CEM and multidrug-resistant CEM/ADR5000 leukemia cell lines (Omosa et al. 2019). Cytotoxicity reported against human cancer cell line HL-60 cells with IC_{50} of 137.31 µg/ml and selectivity index of 3.81 (Nibret et al. 2010). Cytotoxicity against Human gingival fibroblasts cells with IC_{50} of 26 ± 3 µg/ml (Ocheng et al. 2016)
Zanthoxylum paracanthum	Myristic acid (**50**), stigmasterol (**51**), sesamin, 8-acetonyldihydrochelerythrine, arnottianamide, 10-methoxycanthin-6-one, canthin-6-one (**52**), 8-oxocheler-ythrine	Root bark extract showed cytotoxicity at 8.12 µg/mL against HCC 1395 cells. All the compounds were cytotoxic to HCC 1395 and DU 145 cancer cells but stigmasterol and canthin-6-one had the lowest IC_{50} values of 7.2 and 0.42 µg/mL against HCC 1395 cells. Out of the chemical isolates, 10-methoxycanthin-6-one and canthin-6-one showed the strongest inhibition of the DU 145 cells (Kaigongi et al. 2020)

IC_{50}-median inhibitory concentration/ half maximal inhibitory concentration, LC_{50}-median lethal concentration, IC_{90}-concentration inhibiting 90% of cellular growth

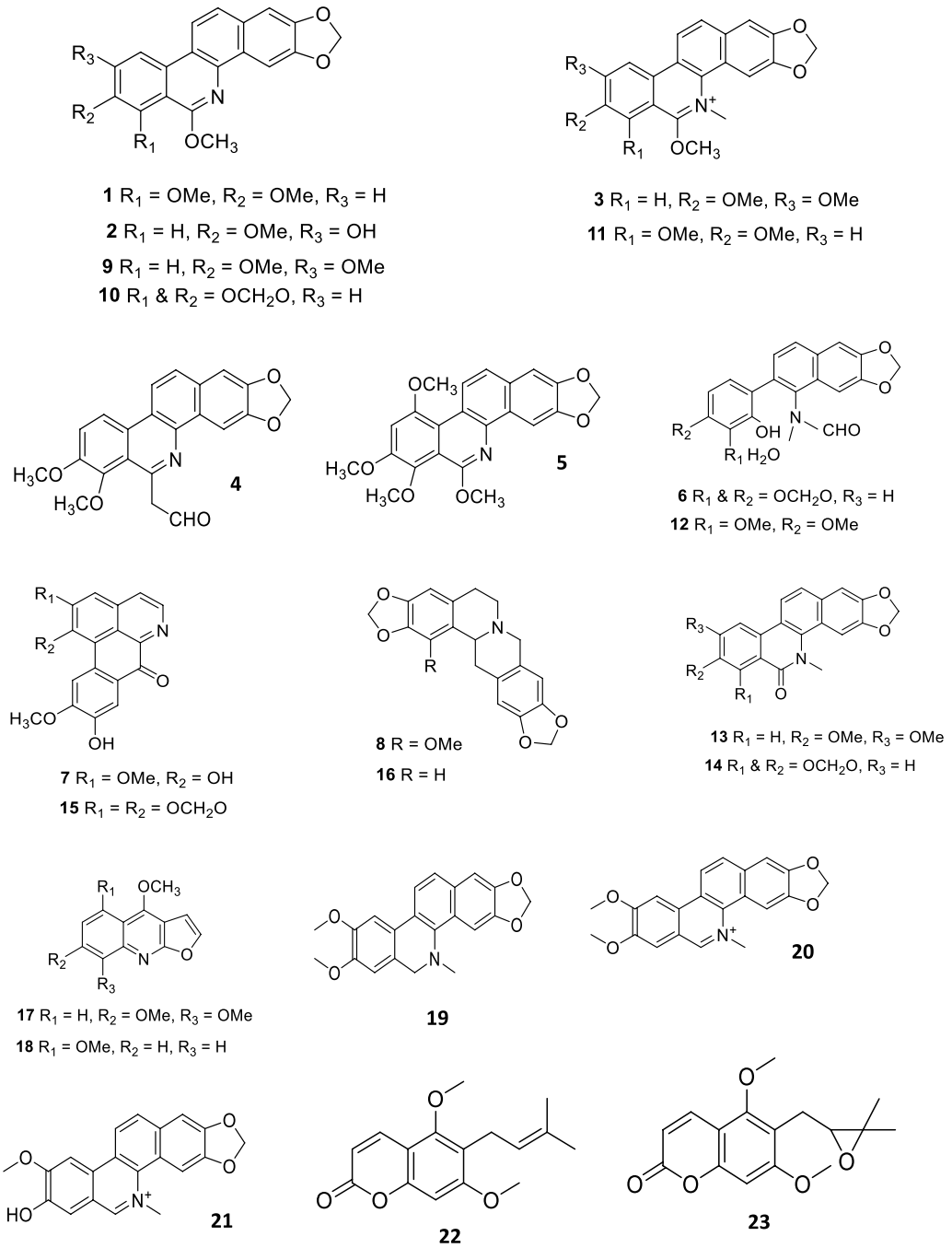


Fig. 4 Some of the anticancer molecules reported in anticancer plants used in Kenya. The compounds numbered **1–52** correspond to the molecules mentioned in Table 2

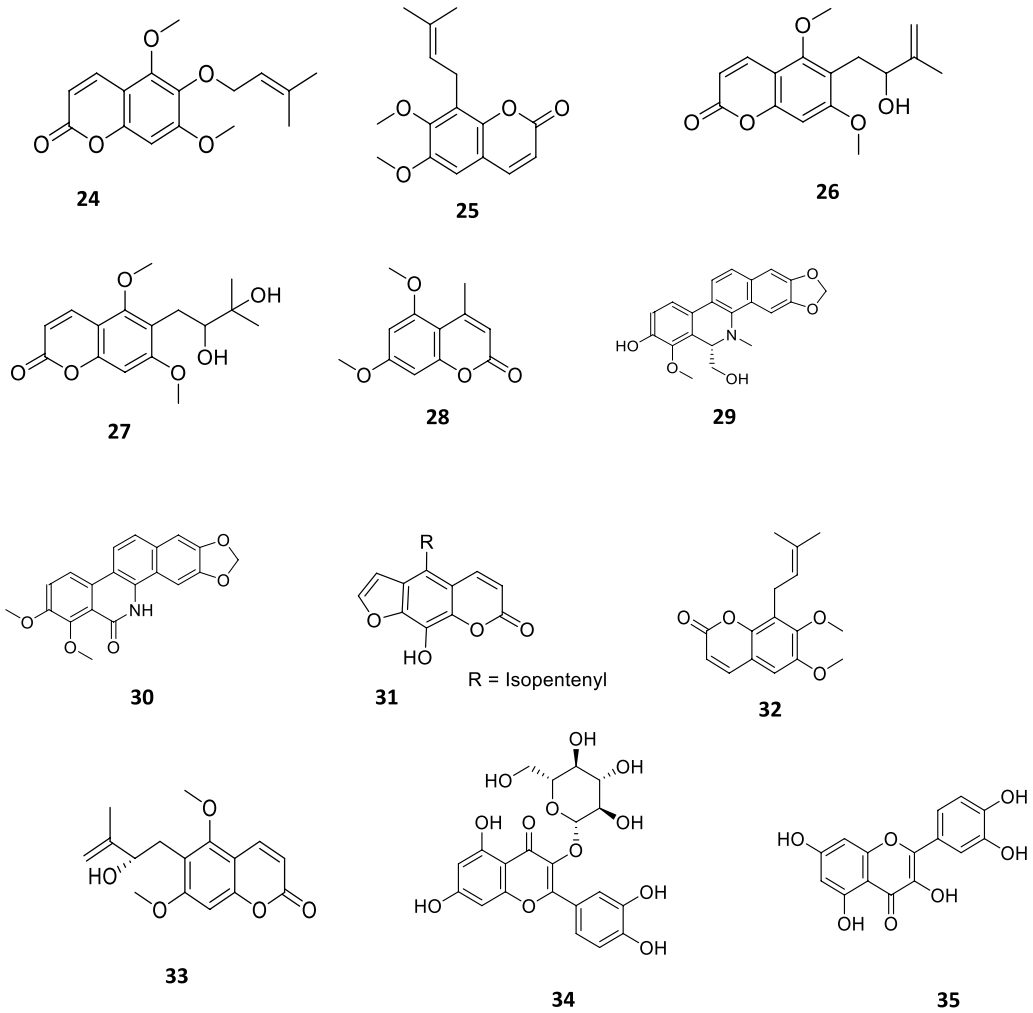
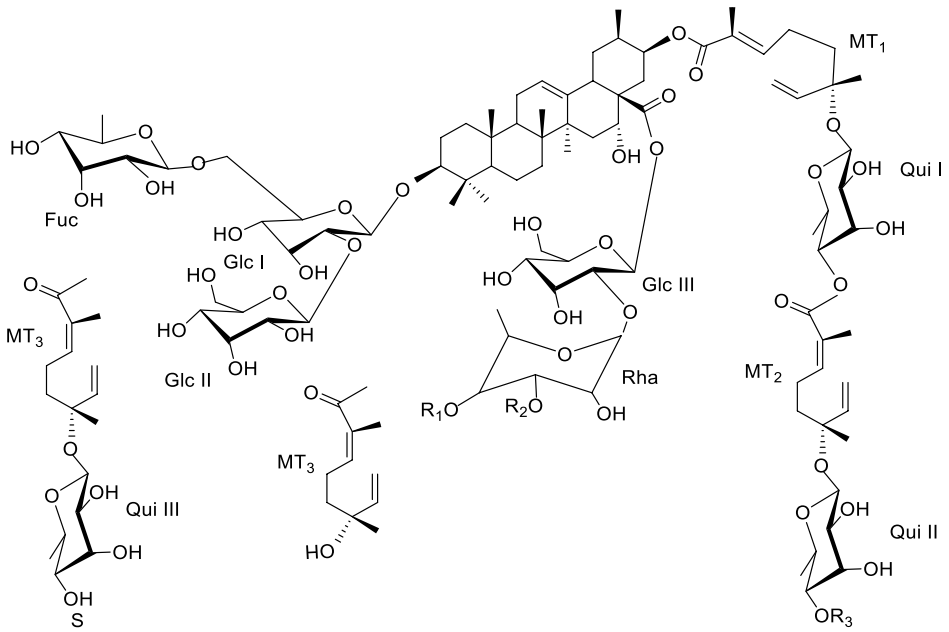
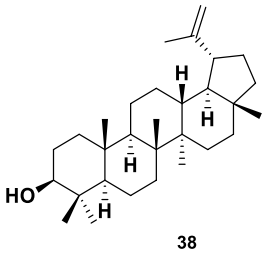


Fig. 4 continued



Molecule	R_1	R_2	R_3
Coriarioside A (**36**)	Ara*f*	Glc	S
Coriarioside B	Xyl	H	MT_3
Gummiferaoside C (**37**)	Xyl	H	S

Ara*f* = α-arabinofuranosyl, Fuc = β-fucopyranosyl, Glc = β-glucopyranosyl, MT = monoterpenyl moiety (labelled 1 to 3), Rha = α-rhamnopyranosyl, Xyl = β-xylopyranosyl, Qui = Quinovose.



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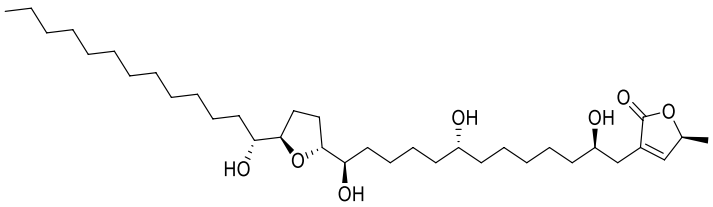

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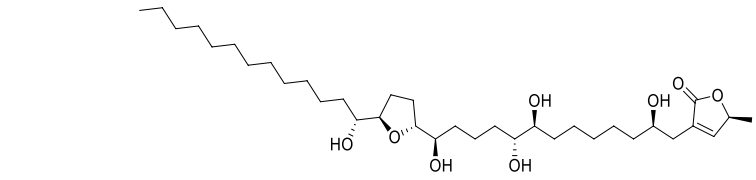
Fig. 4 continued



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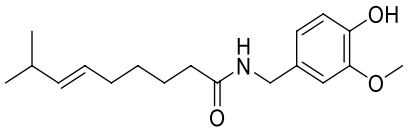

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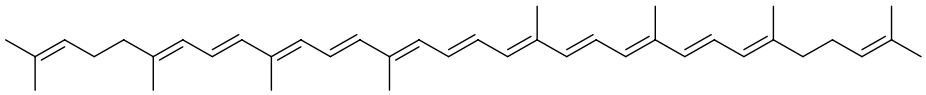

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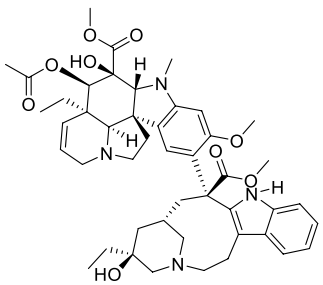

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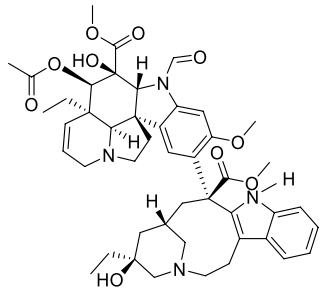

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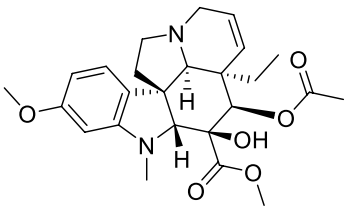

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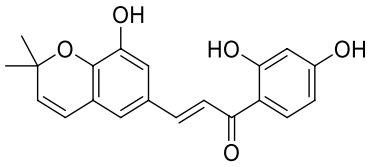

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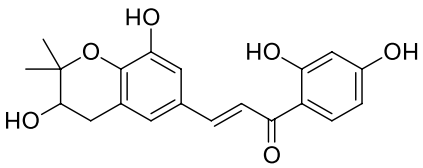

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Fig. 4 continued

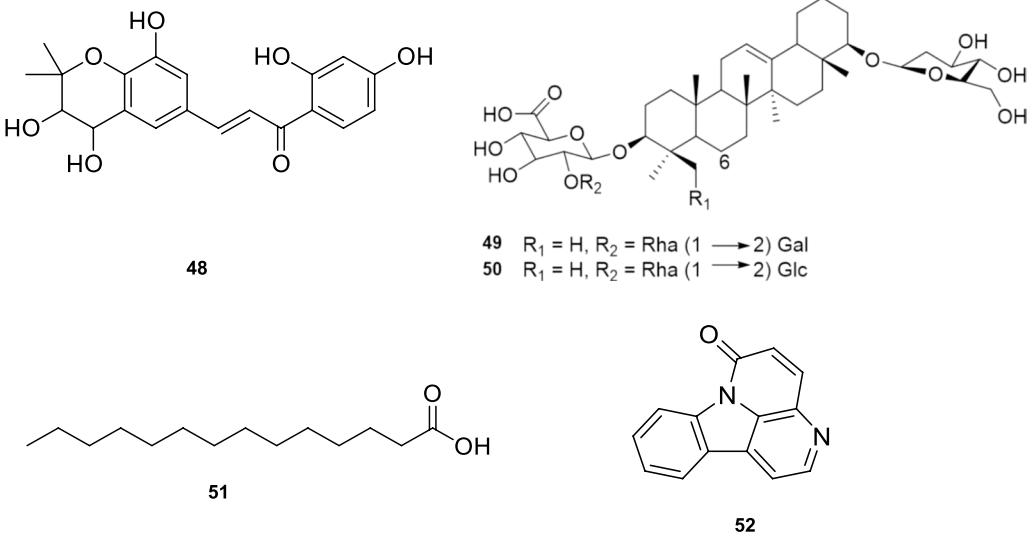

Fig. 4 continued

β-amyrin and β-sitosterol-3-O-glucoside from *Prunus africana* elicited anticancer activity against Caco-2 cell line through induction of apoptosis (Chepkoech 2014). In addition, some of the compounds demonstrate different mechanisms of anticancer action contingent on their doses. For example, the *Catharanthus* alkaloids at low concentrations (< 1 μmol) inhibit microtubule dynamics and stabilize them, while at high concentrations (> 1–2 μmol), they disintegrate the microtubules and damage the mitotic spindle, triggering apoptosis by inhibition of mitosis (Lee et al. 2015). Other than the isolated compounds, it is important to note that various compounds that may be present in a plant extract can synergistically induce anticancer activity through the different mechanistic pathways.

Clinical trials utilizing standardized extracts or compounds from anticancer plants reported in Kenya are yet to be done. However, extracts and compounds from species such as *Catharanthus roseus* and *Prunus africana* have previously been subjected to clinical trials in other countries (Grace et al. 2003; Kumar et al. 2013). Thus, there is need to investigate the anticancer activity of the unstudied species identified in Kenya, along with phytochemical analysis and elucidation of their mechanism of action. This review emphasizes the need for increased budgetary allocation for investigation of Kenyan anticancer plants from laboratories to clinical trials.

Study limitations

The current review had the following limitations: (1) direct studies pertaining to toxicity of the plant extracts or the isolated cytotoxic compounds were not reviewed, (2) though major abstracting and indexing databases were used for retrieving the reports reviewed in this study, some reports may have not been encountered and therefore not included in this review.

Conclusions

Ethnobotanical knowledge on the use of herbal remedies in the management of cancer in Kenya is immense. However, investigation of bioactivity, safety aspects, anticancer molecules, pre-clinical and clinical studies are required to elucidate the mechanism of action of the compounds and confirm the potential of the unstudied species.

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Author contributions

TO designed the study, TO, MPO and SBO collected and analyzed the data. TO wrote the first draft of the manuscript. All the authors revised and approved the final manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

This is a review study and no raw data were collected. Any data collected or analyzed are within this article.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

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

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