Integration of medicinal plants into the traditional system of medicine for the treatment of cancer in Sokoto State, Nigeria

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ABSTRACT
This study was designed to explore and record various medicinal plants integrated into the traditional system of medicine for the treatment of cancer. The traditional system of medicine is a routine practiced among the indigenous ethnic groups of Sokoto state. A semi-structured questionnaire was designed and used for data collection around the selected Local Government Areas. A substantial number of plant species were identified, recorded, and collected for preservation. Data collected for each specie was analysed to assess its frequent use among the medicinal plants. A total of 67 species belonging to 31 families have been identified and recorded. Out of the 473 frequency of citation (FC), Acacia nilotica was the most frequently cited specie (32 FC, 64% FC, 0.6 RFC), followed by Guiera senegalensis (27 FC, 54% FC, 0.5 RFC), Erythrina sigmoidea (17 FC, 34% FC, 0.3 RFC), and subsequently Combretum camporum (15 FC, 30% FC, 0.3 RFC). The most common parts of the plants used include the barks (55.2%), the roots (53.2%), and the leaves (41.8%). Additionally, decoction (74.6%), powdered form (49.3%), and maceration (46.3%) are the most frequently used mode of preparation. The historical knowledge of a traditional system of medicine practiced by the native traditional healers of Sokoto for the treatment of cancer has been documented. The present study further provides a baseline for future pharmacological investigations into the beneficial effects of such medicinal plants for the treatment of cancer.

1. Introduction
Cancer is a major global disease burden with heavy morbidity and mortality affecting people around the world. Africa accounts for 7.3% of the cancer deaths and 5.8% of the total cancer incidence worldwide (Bray et al., 2018). While cancer incidence among males has varied 6-fold from 79 per 100,000 (Ferlay et al., 2015) to 95.6 per 100,000 (Bray et al., 2018) in the West African region, it was recorded in Nigeria (2012–2013) at 94.2 per 100,000 and 160.2 per 100,000 among males and females, respectively (Moroumke et al., 2017).

Medicinal plants have played an important role in the life of people across the globe. To date, traditional medicine practitioners (TMP) are primarily considered as the first-line healthcare providers in a rural community. The frequent use of traditional herbal medicine is often ascribed to the failure of orthodox treatment. Africa is one of the continent richly endowed with medicinal plants (Mgbahuruikea et al., 2019) and Nigeria is among the African region that regularly used complementary and alternative medicine (CAM) concurrently with traditional belief for the treatment of various forms of diseases (Shinkafi et al., 2015).

Nigeria is indigenously rich in plant biodiversity commonly used as medicine for the management and treatment of different forms ailments. The use of CAM by the locals across the region has been known for generations and preserved through the transmission of knowledge towards the younger generation. Furthermore, the frequent dependency on the use of herbal remedies has been attributed to the inability of patients

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access conventional therapy, thereby relying on TMP for their health care needs (Ekanem and Udoh, 2009). In Sokoto state, the traditional system of medicine has long been practiced among the indigenous ethnic groups before the advent of Usman bin Fodiyo. Historically, the state is known for traditional medicine practice and herbal trade, which attracts many people across the West African region (Shinkafi et al., 2015).

The use of herbal medicines in Sokoto state has been documented for the management of diabetes (Shinkafi et al., 2015) while for the treatment of malaria, peptic ulcer, and other ailments have been reported elsewhere (Adebisi and Alebiosu, 2014; Oluranti et al., 2012a, 2012b). On the other hand, the use of medicinal plants for the treatment of cancer has received less attention and priority over the years due to the apparent focus on tropical and communicable diseases such as malaria, diabetes, polio meningitis, HIV/AIDS, etc. At the time of writing this report, there has not been any documented information on the use of folk medicine in relation to cancer treatment. This study was designed to explore and record various medicinal plants used as folk medicines for the treatment of cancer among the indigenous ethnic groups of Sokoto state.

2. Materials and methods

2.1. Study area and survey design

The present study was conducted in Sokoto state located in the Northwest of Nigeria (Figure 1). Approximately, the region is located on the coordinates: 11°33′04″N latitude and 5°14′E longitude with a total coverage area of 25,973 km² at the extreme end of the Northern region neighbouring the Saharan Countries (Adegboyega et al., 2016). The state has over 3.6 million populations (NPC, 2013) comprising different ethnic groups including Hausa, Fulani, Zabarmawa, and Tuareg. Hausa is considered as the largest ethnic group dominated in the region. Agriculture is predominantly the most common practice among the population living in the region. On the other side of the region, Sokoto borders with Zamfara to the south and Kebbi State to the West. Among the twenty-three (23) Local Government Areas (LGAs) contained, Sokoto-North, Sokoto-South, Wamakko, Dange-Shuni, and Bodinga LGAs were selected for the study. The LGAs were selected due to the closeness to the central region where herbal trade and traditional medical practice is most prominent.

A modified semi-structured questionnaire was adopted (Shinkafi et al., 2015) to quantitatively and qualitatively acquire different forms of information relevant to the study (Lee et al., 2018). The questionnaire used comprises personal information such as the name, age, sex, religious views, contact number, local tribe, and nationality. Additional information such as informant’s area of specialty, duration of practice, means of diagnosis, mode of preparations, route of administration, admissions, and referrals were also included. The target participants for this study were primarily the traditional healer (e.g., TMP), those with knowledge of medicinal plants (e.g., herb sellers or older inhabitant), and herbalist. A total number of fifty (50) participants residing in the selected LGAs were randomly visited for the interview.

Figure 1. A map of Nigeria (bottom left corner) located along the Gulf of Guinea retrieved from MapMaker Interactive (https://mapmaker.nationalgeographic.org/); map of Nigeria (bottom right corner) showing Sokoto province where the study was performed; only the study areas involved are presented in the map. The maps are designed using academic version of Map Maker 4 software obtainable from www.mapmaker.com.
2.2. Data collection

An ethnobotanical survey was conducted from June to October 2018. Prior to the survey, consent of the interview was requested and granted by the Sokoto branch of the National Association of Nigerian Traditional Medicine Practitioners (NANTMP) and the procedures approved by the University Ethical Committee (PTAC/MP/AL/SQ/02–20). Informants involved during the interview include TMP, herbalist, and herb sellers. Informed consent was obtained from each of the informants prior to the administration of the questionnaire. An oral interview was granted to the informants that are unable to read or write, and the questionnaire was completed on their behalf. Each medicinal plant revealed by the respondent is recorded in the local names commonly recognised in the region. During specimen collection, informants were contacted for specimen collection and processed for identification. Subsequently, local names of medicinal plants were used to identify and collect specimens for proper identification. Each specimen was identified and assigned voucher number at the Herbarium of the Department of Pharmacognosy and Ethnopharmacy, Faculty of Pharmaceutical sciences, Usmanu Danfodiyo University, Sokoto. Furthermore, each plant species was validated via the Plant List database (https://plants.jstor.org), Global Plants database (https://www.theplantlist.org), and West African Plants database (http://www.westafricanplants.senckenberg.de).

2.3. Data analysis

Data generated from the ethnobotanical study were examined in a Microsoft Office application 2013 (Excel). To assess the local importance of each of the species identified, percentage Frequency of Citation (FC) (Shinka et al., 2015), Relative Frequency of Citation (RFC) (Ahmad et al., 2014), and Informant Agreement Ration (IAR) (Heinrich et al., 1998) were used to analyse and compare the use of a single specie among the medicinal plants.

\[ FC(\%) = \frac{NC}{NI} \times 100 \]

where, \( NC \) = total number of citations, \( NI \) = total number of informants

\[ RFC = \frac{FC}{NI} \]

where, \( FC \) = frequency of citations, \( N \) = total number of informants

\[ IAR = \frac{(Nur - N)}{(Nur - 1)} \]

Where, \( Nur \) = number of used reports recorded as being used for a particular cancer type, \( Nt \) = number of plant species recorded for that type.

3. Results and discussion

3.1. Target participant for ethnobotanical studies

A total of 50 informants with knowledge of traditional medicine in the region were approached and interviewed for this study. For the period of the survey, the vast majority of the TMPs encountered were males (96%), whilst females constitute only 2% of the overall data. Culture, religious beliefs, and practices are the socio-cultural factors attributed to gender differences among the practitioners in Nigeria (Abara, 2012), which are predominantly found in most of the Northern parts of the country. A greater percentage (56%) of the respondents with substantial years of experience in practice are found ranging from 51 – 65 years of age while the least of the respondents found at the age of between 18 – 35 and 66–70 account for 4% and 6%, respectively. Furthermore, the Hausa ethnic group largely account for the highest percentage (66%) of the respondents in the survey followed by the Fulani ethnic group (32%) and both ethnic group specialised mainly in TMP and herbalism (Table 1).

| Parameters                  | Specifications | % NI |
|-----------------------------|----------------|------|
| Age                         | 18–35          | 4    |
|                             | 36–50          | 34   |
|                             | 51–65          | 56   |
|                             | 66–80          | 6    |
| Gender                      | Male           | 96   |
|                             | Female         | 2    |
|                             | Unspecified    | 2    |
| Tribe                       | Hausa          | 66   |
|                             | Fulani         | 32   |
|                             | Others         | 2    |
| Speciality                  | TMPs           | 58   |
|                             | Herbalist      | 32   |
|                             | Herb sellers   | 6    |
|                             | TMPs/Herb sellers | 2 |
|                             | Unspecified    | 2    |
| Year of practice            | 1–10 years     | 0    |
|                             | 11–20 years    | 34   |
|                             | 21–30 years    | 44   |
|                             | 31 and above   | 10   |
|                             | Unspecified    | 12   |
| Method of diagnosis         | Physical       | 96   |
|                             | Psychological  | 0    |
|                             | Biological     | 0    |
|                             | Others         | 0    |
|                             | Unspecified    | 4    |
| Admission of patients       | Yes            | 4    |
|                             | No             | 92   |
|                             | Unspecified    | 4    |
| Referral                    | Senior colleague | 48  |
|                             | Hospital       | 38   |
|                             | Senior Colleague/Hospital | 12 |
|                             | Unspecified    | 2    |

NI: Number of informant.
internal tumours often developed from the outside tumours, e.g., the tumour from the breast can be transferred to the lung. Others believe that communicable diseases such as malaria and typhoid can lead to cancer development when they become intense. The implication of their techniques is that patients with different conditions are susceptible to misdiagnosis. For instance, we noted that almost all TMP mistakenly refers to inflammatory disorder for cancer. Generally, they defined cancer (commonly known as “ika” in Hausa) as any inflammatory disorder developed outside or inside the body. In some instances, some of the informants identified swelling and stiffness of the skin or inflammatory bowel disorders (e.g., irritable bowel syndrome) as a tumour. However, only a few of the respondents that have gone through years of experience argued to differentiate between the two inflamed characters. From our observation, these TMP diagnosed patients based on physical symptoms to commonly known disorders.

Furthermore, we noticed that 92% of the informants chose to offer outpatient care, and 4% advised their patients to reside for the duration of treatment. We asked them in what ways they handle patients beyond their capability, and we realised that 45% refer their patients to senior colleagues that have gone through years of experience. However, a significant percentage of the respondents (38%) willingly sent patients to a hospital, and the remaining respondents (12%) seek for either senior colleagues or professional assistance.

3.2. Data collection and analysis

Data obtained from the overall survey have identified a total of 67 species belonging to 32 families claimed to have been used for cancer treatment in different communities of Sokoto-South and North, Dange-Shuni, Bodinga, and Wamakko LGA. Sokoto-South LGA presented the highest percentage (25%) of the plant species identified, whereas about 47% of the species were equally distributed among Sokoto-North and Dange-Shuni LGA (Figure 2A). Further to this, Bodinga and Wamakko LGA provided 22.4 and 17.9% of the plant species, respectively. The overall plant species documented in the present study are provided alphabetically in the order of a genus (Table 2). Out of the total species identified, Leguminosae is recorded as the most commonly used family representing 19 plant species, while Malvaceae, Combretaceae, and Anacardiaceae provided 6, 5, and 4 species, respectively. Others provided to 3 or less of the remaining plant species.

For the period of data collection, we noticed that more than one local name described a single species, e.g., ‘Kayar kusa’ or ‘bera’ ascribed to Asparagus Africanus Lam., ‘Runfuu’ or ‘Runfau’ ascribed to Cassia sinuanea Delile., ‘Dany’a or ‘Nunu’ ascribed to Sclerocarya birrea (A.Rich.) Hochst., among others. The differences are attributed to different ethnic groups in the region as well as the traditional uses of the species for a different purpose. In some cases, both language and traditional use in the region mix up at least two if not more than two species having the same local name. For instance, “Gırız” ascribing to Cyperus difformis L. can also be described as Borassus aethiopum, Cyperus digitatus, and Hyphaene thebaica. There are other relevant instances, but we ensured the right plant is properly collected and identified in an appropriate manner.

In this study, we have recorded a total number of 473 FC by the informants. Acacia nilotica (L.) Delile (32 FC) was the most frequently cited, followed by Guiera senegalensis J.F.Gmel. (27 FC), Erythrina sigmoidea Hua. (17 FC), Combretum camporum Engl. (15 FC), Lannea acida A. Rich. (14 FC), Ziziphus mucronata Willd. (14 FC), Cassia sieberiana DC. (13 FC), Dichrostachys cinerea (L.) Wight & Arn (13 FC), and Ficus polita Vahl. (12 FC). Others include Leptadenia hastata Vatke., Nauclea diderrichii (De wild.) Merr., and S. birea, each having 11 FC. Furthermore, leguminosae (28.4%) has recorded the highest number of species in the families, followed by malvaceae and combretaceae, which accounted for 9% and 7.5%, respectively (Figure 2B).

On the other hand, A. nilotica (64%) has recorded the highest percentage FC with an RFC of 0.6, followed by G. senegalensis (54% FC, 0.5 RFC), E. sigmoidea (34% FC, 0.3 RFC), C. camporum (30% FC, 0.3 RFC), L. acida (28% FC, 0.3 RFC), Z. mucronata (28% FC, 0.3 RFC), C. sieberiana (26% FC, 0.3 RFC), D. cinerea (26% FC, 0.3 RFC), and F. polita (24% FC, 0.3 RFC). The most frequently cited species in this study are shown in Figure 2C and their RFC values, which appeared in Table 2.

Furthermore, skin cancer was recorded to have the highest IAR value of 0.82, followed by breast (0.75), head and neck (0.74), colon (0.71), lung (0.71), cervical (0.67), and scrotum (0.50). The IAR values ranging from 0 to 1 indicate the number of times any plant species use by many informants for a specific disease type (Heinrich et al., 1998). The high ranking of IAR values might be attributed to the most notable tumours.
Table 2. List of medicinal plants identified to be used for cancer treatment by the native traditional healers of Sokoto province.

| Scientific name | Family | Common name | Local name | VN | LGA | PPU | MP | RT | RFC |
|-----------------|--------|-------------|------------|----|-----|-----|----|----|-----|
| *Acacia nilotica* (L.) Delile | Leguminosae | Egyptian mimosa | Bagaruwa | PGC/UDUS/Legu/0008 | SS | L/B*R/S | P/M/D* | O/T | 0.6 |
| *Acacia sieberiana* DC. | Leguminosae | Paperbark thorn | Farar kaya | PGC/UDUS/Legu/0001 | SS | L/B* | P/M/D* | O/T | 0.1 |
| *Albizzia chevalieri* Harms | Leguminosae | Silk plant | Katsari | PGC/UDUS/Legu/0002 | SS/SN | B*R | M/D* | O | 0.2 |
| *Allium cepa* L. | Amaryllidaceae | Onion | Albasa | CG/UDUS/Amar/0001 | SS | L/B* | D* | O | 0.1 |
| *Anacardium occidentale* L. | Anacardiaceae | Cashew | Yazawa | PGC/UDUS/Anac/0002 | SN/D | B*R | M/D* | O | 0.1 |
| *Anogeissus leiocarpus* (DC.) Guill. & Perr. | Leguminosae | African birch | Marke | PGC/UDUS/Comb/0001 | D | L/B*R | P/M | O/T | 0.2 |
| *Aristolochia albida* Duch. | Aristolochiaceae | Duchman pipe | Duman Dute | PGC/UDUS/Ariz/0001 | SN | S | D* | O | 0.2 |
| *Asparagus africanus* Lam. | Asparagaceae | Asparagus | Kayar ilusa/bera | PGC/UDUS/Aspa/0001 | SN | L | D* | O | 0.0 |
| *Balantice aegyptiaca* Del. | Zygophyllaceae | Desert date | Adwa | PGC/UDUS/Zyggo/0002 | W/SN | B*R | D* | O | 0.2 |
| *Bauchinia rufescens* Lam. | Leguminosae | Silver butterfly | Jirga | PGC/UDUS/Faba/0019 | B | L/B*R | P/D* | O/T | 0.1 |
| *Boscia senegalensis* (Pers.) Lam. | Combretaceae | Basari | Anza | PGC/UDUS/Cap/0001 | W | L/R | M/D* | O | 0.2 |
| *Cadda farinosa* Forssk. | Combretaceae | herds boy fruits | Bagayi | PGC/UDUS/Cap/0002 | D | L/B*R | M/D* | O | 0.1 |
| *Cassia sieberiana* DC. | Leguminosae | African laburnum | Malga | PGC/UDUS/Legu/0004 | SS | B*R/S | P/D* | O/T | 0.3 |
| *Cassia singensis* Delile. | Leguminosae | Sticky pod | Runbus/Runfsu | PGC/UDUS/Faba/0003 | B | L/B*R | P/M | O/T | 0.1 |
| *Citrus limon* (Thunb.) Matsum. & Nakai. | Rutaceae | Water melon | Kankanana | PGC/UDUS/Curc/0001 | SN | S | P | T | 0.0 |
| *Combretum micranthum* G. Don | Combretaceae | Bush tea | Geza | PGC/UDUS/Comb/0003 | B | L/B*R | P/M | O/T | 0.0 |
| *Combretum camphonum* Engl. | Combretaceae | - | Taramniya | PGC/UDUS/Comb/0004 | SS | B*R | M/D* | O | 0.3 |
| *Combretum nolle* B.R. ex G. Don | Combretaceae | - | Wuyan damo | PGC/UDUS/Comb/0005 | B | P/M/D* | O | 0.1 |
| *Curcuma longa* L. | Zingiberaceae | Turmeric | Gangaamu | PGC/UDUS/Zing/0001 | SS | P* | O/T | 0.1 |
| *Cyprus difformis* L. | Cyperaceae | Rice sedge | Gizgiri | PGC/UDUS/Cype/0001 | B/SN | S | M | O | 0.2 |
| *Detarium senegalense* J.F.Gmel. | Leguminosae | Tallow tree | Taura | PGC/UDUS/Segu/0014 | W | L/B*R | P/D* | O/T | 0.2 |
| *Dichrostachys cindenta* (L.) Wight & Arn | Leguminosae | Sickle bush | Dundu | PGC/UDUS/Legu/0005 | D | B*R | P/D* | O/T | 0.3 |
| *Desparus mephitiformis* Hocch. ex A.DC. | Ebenaceae | Jackal berry | Kanyu/Kaiwa | PGC/UDUS/Eben/0001 | D | B*R | M/D* | O | 0.0 |
| *Entada africana* Guill. & Perr. | Leguminosae | Entada | Tawatsa | PGC/UDUS/Legu/0006 | SN | B*R | M/D* | O | 0.0 |
| *Erythrina senegalensis* Hua. | Leguminosae | Frankincense tree | Hano | PGC/UDUS/Legu/0017 | SS | R | P/D* | O/T | 0.3 |
| *Faidherbia albida* (Delile) A.Chev. | Leguminosae | Winter thorn | Dargaza | PGC/UDUS/Legu/0004 | B | B*/R | M/D* | O | 0.2 |
| *Ficus ghaphalocarpa* (Misq.) Stead ex Misq. | Moraceae | Ficus tree | Banji | PGC/UDUS/Mora/0002 | B | B*R | P/D* | O | 0.1 |
| *Ficus platyphylla* | Moraceae | Red rubber tree | Gamji | PGC/UDUS/Mora/0003 | W | B*R | P/D* | O | 0.2 |
| *Ficus polia* Vahl. | Moraceae | Heart leaved fig | Duruni | PGC/UDUS/Mora/0001 | B/D | B*R | M/D* | O | 0.2 |
| *Grewia mollis* Juss. | Malvaceae | The air potato | Kamumuwa | PGC/UDUS/Molv/0004 | B | D* | O | 0.0 |
| *Grewia villosa* Willd. | Malvaceae | Gray way | Dargaza | PGC/UDUS/Molv/0004 | B | B*/R | M/D* | O | 0.2 |
| *Guiera senegalensis* J.F.Gmel. | Combretaceae | Moishi medicine | Sabara | PGC/UDUS/Comb/0002 | SS | S*R | P/D* | O/T | 0.5 |
| *Gynandropsis gynandra* (Desr.) Roem. & Schult | Ochonaceae | Morning glory | Yadiya | PGC/UDUS/Gyn/0001 | D | W/D | P/D* | O/T | 0.2 |
| *Indigofera tinctoria* L. | Fabaceae | True indigo | Baaba | PGC/UDUS/Legu/0009 | SS | B/R | M/D* | O | 0.1 |
| *Ipomoea batatas* (Distr.) Roem. & Schult | Convolvulaceae | Morning glory | Yadiya | PGC/UDUS/Ascl/0001 | D | W/D | P/D* | O/T | 0.2 |
| *Lavandula angustifolia* (L.) Briq. | Lamiaceae | Jute | Rama | PGC/UDUS/Lami/0002 | SS | S* | O | 0.1 |
| *Lavandula stoechas* L. | Lamiaceae | Roselle | Zobo | PGC/UDUS/Lami/0003 | D | L | D* | O | 0.0 |
| *Lobelia tenuioria* L. | Lamiaceae | True indigo | Baaba | PGC/UDUS/Legu/0009 | SS | B/R | M/D* | O | 0.1 |
| *Lonicera japonica* (L.) Turcz. | Caprifoliaceae | True indigo | Baaba | PGC/UDUS/Lami/0003 | D | L | D* | O | 0.0 |
| *Mimosa pigra* L. | Leguminosae | Mimosas | Gumbi | PGC/UDUS/Legu/0013 | B/SS | L*B* | P/D* | O/T | 0.1 |
| *Moringa oleifera* L. | Moringaceae | Drum stick tree | Aduwa | PGC/UDUS/Morg/0001 | B | L/B* | D* | O/1 | 0.1 |
| *Nauclea dimorphica* (De wild.) Merr. | Rubiaceae | African peach | Tafashiya | PGC/UDUS/Rubi/0001 | SN | B* | M | O | 0.2 |
| *Ocimum basilicum* L. | Lamiaceae | African locust | Doruwa | PGC/UDUS/Lami/0002 | W/SN | D/S | S** | O/DA | 0.1 |

(continued on next page)
found outside the body of patients, e.g., skin cancer. The IAR values recorded ranging from 0.50 to 0.82 is tabulated in Table 3.

Collectively, the most frequently used plant species cited by the informants are A. nilotica and G. senegalensis. A. nilotica is a thorny tree native to the African region and grows wild in Nigeria particularly, in the Northern region (Alli et al., 2016). In Sokoto state, the tree is found virtually in every community around the area. The plant parts are used traditionally for different treatment of disease to include cancer. It was observed that seeds obtained from the plant are used to treat patients with breast, colon and head and neck tumours. In some cases, seeds are mixed with other herbal materials to improve effectiveness. Furthermore, the whole herbal materials can be used for treatment, but seeds are most often used by the TMP. Pharmacologically, there have been several reports validating the anticancer properties of the A. nilotica. Its potentials have been demonstrated in vitro against colorectal (Hakkim et al., 2018), breast (Barapatre et al., 2016; Sundarraj et al., 2012), lung (Sundarraj et al., 2012), cervical (Kalaivani et al., 2011), glioblastoma, and ovarian cancer (Salem et al., 2011). Similarly, in vivo pharmacological properties have been further validated against oral (Mohan et al., 2017), lymphoma (Sakthive et al., 2012), hepatocellular carcinoma (Singh et al., 2009), skin (Meena et al., 2006), and breast cancer (Kaur et al., 2002). Thus, the reported studies have backed up the traditional use of A. nilotica in the region.

G. senegalensis and E. sigmoidea is commonly found widely distributed in the Northern region of Nigeria. Both the Hausa and Fulani ethnic groups in the region used powdered preparation of the plant materials to treat patients, whereas in some cases, a decocted crude drug is also used for patients with suspected internal tumours. Pharmacologically, the traditional use of G. senegalensis and E. sigmoidea for cancer treatment has also been demonstrated in vitro against prostate, breast, and liver (Bello et al., 2017; Kuete et al., 2016, 2014), leukamia (Kuete et al., 2016, 2014, 2012), cervical, colon (Fiot et al., 2006; Kuete et al., 2016, 2014), and glioblastoma (Kuete et al., 2016, 2014). A quite number of plant species that have been pharmacologically validated with anticancer properties are listed in Table 4. On the contrary, over 60% of the species identified in this study have not been verified, pharmacologically. Despite the fact that some of the species such as Combretum spp, Cyperus spp, Erythrina spp., Ficus spp, Mimosa spp., among others, are widely known for their anticancer properties, yet none among the species identified in this study have been validated for similar properties.

In a similar study, the traditional use of medicinal plants for cancer treatment around Borno state in the far Eastern region of Nigeria has been reported elsewhere (Ngulde et al., 2014). In the present study, a vast number of species identified in Sokoto are consistent with that of the species documented in the region of Borno state. For instance, A. nilotica, C. sieberiana, D. cinerea, among others, have also been cited by the native people of Askira/Uba LGA of the Borno state. Culturally, Hausa and Fulani ethnic groups formed the minority in the region when compared to Sokoto state. The study reported by Ngulde and co-workers was insufficiently documented, even though both regions lie in the Sudan savanna. In the study, respondents are reported to collect herbs during the day any time between sunrise through sunset of the plant. In the present study, informants argued that leaves are actively collected from the beginning of the flowering to premature fruiting. Barks, on the other hand, are best collected during the dry season before the beginning of the rainy season. This approach, they argued, is effective in collecting medicinally active principles of the plants.

### Table 3. IAR by cancer type

| Type of cancer | Nur | Nt | IAR value |
|---------------|-----|----|----------|
| Skin          | 29  | 155 | 0.82     |
| Breast        | 32  | 127 | 0.75     |
| Head and neck | 21  | 77  | 0.74     |
| Colon         | 17  | 56  | 0.71     |
| Lung          | 13  | 42  | 0.71     |
| Cervical      | 3   | 7   | 0.67     |
| Scrotum       | 5   | 9   | 0.50     |

Nur: number of use reports; Nt: number of species.
Table 4. List of plants that were pharmacologically validated for their anticancer properties and their traditional use in the region of Sokoto state.

| Medicinal plant | Reference | Traditional use for type of cancer |
|-----------------|-----------|-----------------------------------|
| A. nilotica     | Hakkim et al. (2018); Mohan et al. (2017); Revathi et al. (2017); Barapatre et al. (2016); Sakthive et al. (2012); Sundarraj et al. (2012); Kalaivani et al. (2011); Kalaivani et al. (2011) | breast, skin, head and neck, scrotum |
| A. cepa         | Pan et al. (2018); Nile et al. (2018); Fredotovi et al. (2017); Abdelrahman et al. (2017); Lee et al. (2014); Wang et al. (2012); Shirvantanava and Ganesh (2010) | skin, and colon |
| A. occidentalis | Santos et al. (2018); Taiwo et al. (2017); Ashraf and Rathi (2017); Shilpa et al. (2015) | head and neck |
| A. leiocarpus   | Hassan et al. (2018); Olugbami et al. (2017b); Salau et al. (2013) | head and neck, skin |
| B. oegypscas    | Yassin et al. (2017); Hassan et al. (2016); Saleh and Enara (2016); Isma et al. (2015) | breast, lung, skin |
| B. rufescens    | Garbi et al. (2015) | skin |
| B. senegalensis | Elkhateeb et al. (2019) | breast, colon |
| C. longa        | Li et al. (2018); Coker-Gurk et al. (2018); Li et al. (2018); Zhao et al. (2018); Frossova and Rudia -Kucerova, 2018; Arumria Selvan et al. (2018); Perna et al. (2018); Naqui et al. (2017); Mou et al. (2017); Wang et al. (2017); Zang et al. (2017); Zhou et al. (2017); de Campos et al. (2017); Rivera et al. (2017); Wang et al. (2017); Zhou et al. (2016); Santos et al. (2016); Liu et al. (2016); Mishra et al. (2016); Abdel-Lateef et al. (2016) | breast, lung, head and neck, skin, cervical, scrotum, colon |
| D. cinerea      | Long et al. (2009) | skin |
| E. Africana     | Cioffii et al. (2006) | skin, breast |
| E. sigmoidea    | Kuete et al. (2016); Kuete et al. (2014) | breast, colon, skin |
| G. senegalensis | Bello et al. (2017); Abubakar et al. (2013); Kuete et al. (2012); Fist et al. (2006) | breast, lung, skin, colon |
| G. gymandra     | Pettit et al. (2005) | skin |
| H. cannabinus   | Wong et al. (2014) | lung, colon |
| H. sabdariffa   | Hassan et al. (2016); Tsai et al. (2014); Lin et al. (2011); Hou et al. (2005); Lin et al. (2005); Lin et al. (2002); Tseng et al. (2000) | breast, lung, skin |
| L. tintoria     | Renkudevi and Shuhani Sultana (2011); Kameswaran and Ramanibai (2008) | breast, head and neck |
| K. senegalensis | Olugbami et al. (2017a); Rabadeaux et al. (2017); Androulakis et al. (2006); Zhang et al. (2007) | breast, head and neck, skin |
| M. indica       | Bai et al. (2018); Tan et al. (2018); Deng et al. (2018); Fernández-Ponce et al. (2017); Gangopadhyay et al. (2017); Edhruiwara et al. (2017); Nemec et al. (2017); Nemec et al. (2016); Nguyen et al. (2016); Abdullah et al. (2014); Ramos et al. (2014); Kim et al. (2012); Garcia-Rivera et al. (2011); Wilkinson et al. (2011); Noratto et al. (2010) | breast, skin, lung, colon |
| M. oliefera     | Antonini et al. (2018); Tlaka et al. (2018); Guell-Guiriz et al. (2018); Jafaraf et al. (2018); Abdel-Rabou et al. (2017); de Andrade Luz et al. (2017); Giacoppo et al. (2017); Adebayo et al. (2017); Abd-Rabou et al. (2016); Charlet et al. (2016); Michut et al. (2016); Jung et al. (2015); Al-Asmari et al. (2015); Elsayed et al. (2015); Krishnamurthy et al. (2014); Belal et al. (2016); El-Ashmawy et al. (2016) | lung, breast |
| O. basilicum    | Minari et al. (2018); Torres et al. (2018); Bayala et al. (2014); Bebbahani et al. (2014); Shirazi et al. (2014); Al-Ali et al. (2013); Kathirvel and Ravi (2012) | skin, head and neck |
| O. gratissimum  | Lin et al. (2014); Ilkumwe et al. (2014); Nangia-Makker et al. (2013); Chen et al. (2011); Ekmurue et al. (2010); Ye et al. (2010); Nangia-Makker et al. (2007) | skin |
| P. biglobosa    | Fadey et al. (2013); Adetutu et al. (2012) | breast, skin |
| P. guajava      | dos Santos et al. (2018); Qin et al. (2017); Ashraf et al. (2016); Rizzo et al. (2014); Lery and Carley (2012); Montempi et al. (2012); Lee and Park (2010) | colon, head and neck |
| S. hirta        | Armentano et al. (2015); Tanah and Ndjip (2013) | head and neck |
| S. occidentalis | Qin et al. (2016); Yang et al. (2016); Bhagat and Saxena (2010) | breast, head and neck |
| S. spinosa      | Isu et al. (2014) | skin |
| T. indica       | Lim and Song (2013); Aravind et al. (2012); Shivshankar and Shyamala Devi (2004) | lung, colon |
| V. paradoxus    | Zhang et al. (2015); Tague et al. (2014); Mabung et al. (2011) | skin, head and neck |
| W. indica       | Monetier et al. (2017); | breast, skin |
| X. Americana    | Murtaza et al. (2018); Pervaz et al. (2016); Pervaz et al. (2015); Bayer et al. (2012) | breast, skin |
| Z. officinale   | Al-Otaibi et al. (2018); Fuher et al. (2018); Morimoto et al. (2018); Oh et al. (2018); Mannihg et al. (2018); Luo et al. (2018); Li et al. (2018); Wang et al. (2018); Muhammad et al. (2018); El-Asissemy et al. (2018); Li and Chiang (2017); Liu et al. (2017); Jakevicius et al. (2017); Pashari-Ael et al. (2017); Elkady et al. (2017); Al-Tamimi et al. (2016); Ansari et al. (2016); Lee (2016); Rubila et al. (2016); Cojocaru et al. (2015); Das et al. (2015); Woe et al. (2015); Marrelli et al. (2015); Akimoto et al. (2015); Tahir et al. (2015); Elkady et al. (2014); Park et al. (2014) | lung, breast, colon, cervical |
| Z. mucronata    | Beg et al. (2016); Sigidi et al. (2016); Bhatia et al. (2011) | skin, head and neck |
of leaves from the plant is justified and, this will limit the exploitation, thereby preserving the extinction of the plant species from the area.

Furthermore, there are different methods of herbal preparation observed by the informants. In this study, decoction (74.6%) is the most frequently used mode of preparation by the informants followed by powder (49.3%) and subsequently maceration (46.3%). The least among the methods include soup (4.5%) and smoking (3%) mode of herbal preparation (Figure 3B). To obtain an herbal extract, it was observed that the TMP constantly boils water containing herbal material for at least two hours. Alternatively, the herbal material is allowed to macerate in water for a period of time, typically two to three days. Either way, the resultant herbal preparation is administered to patients at the dose recommended by the informant. In contrast, an herbal powdered drug is prepared from the dried herbs and pulverised into a fine powder. The powdered drug is then mixed with either water, milk, or any locally made drink (e.g., ‘kuru’ or ‘kunu’) at the dose recommended by the informants. Interestingly, it was further observed that a few of the TMP used the method of smoking to treat patients. In this method, herbal material is placed on the burning charcoal and allowed smoke from the burning herbs to spread directly on the patient. Their argument was that by allowing smoke to spread through the patient’s skin is quite effective in treating outside tumours.

The most common routes of administration cited by the informants are the oral route (82.1%) and topical application (32.8%) (Figure 3C). Sometimes, oral route and topical applications are concurrently applied to treat patients. Additionally, 1.5% of the informants treat patients either by smoke inhalation or dermal absorption (a process where smoke is absorbed through the patient’s skin). During our discussion, it is interesting to document that patients are given an herbal drug such as O. oleifera to sniffs through the nostril in case of suspected lung cancer. In a similar treatment, smoke burnt from the aerial parts of the herbal material is inhaled by the patient through the nasal cavity to treat lung cancer.

3.4. Toxicological risk associated with the use of herbal medicines in the province

The ethical implications for the use of herbal medicines in the region have also been considered in the present study. The frequent use of herbal medicines has been implicated in cases of acute renal failure in other regions of the country (Akpan and Ekrkpo, 2015; Bamgbuye et al., 1993; Kadiri et al., 1999; S. Kadiri et al., 1991). For the period of discussions, informants were asked the implications of prescribed herbal medicines, as a result, it is alarming to know that none among the informants could account for any side effects from the patients. They argued that herbal medicines are natural and therefore, considered safe for use ascribing to the long history of use. However, few of the experienced TMP are aware of the implications and, thus, recommends a minimal dose, e.g., a cup of decocted herbal material daily. In severe cases, patients were prescribed to a higher dose disregarding the toxicological implications for their therapeutic use.

For instance, Aristolochia albida Duch (0.2 RFC) has been prescribed for cancer treatment. While a species of Aristolochia have been documented in a similar study (Ngulde et al., 2014), its toxic side effects have yet to be established. Generally, Aristolochia and one of its chief components aristolochic acid have been known for its carcinogenic, and nephrotoxic effects for a very long time (Michael et al., 2009). Recently, several toxicological risks associated with a history of using herbal medicines containing aristolochic acid amongst cancer patients have been reported (Aydin et al., 2017; Ban et al., 2018; Chen et al., 2018; Hoang et al., 2016; Hung et al., 2016; Kanaan et al., 2016; Popovska-Jankovic et al., 2016; Xiong et al., 2018; Zhong et al., 2017). Despite the reported cases on the use of herbs containing aristolochic acid around the world, a similar effect associated with the use of Aristolochia spp has yet to be reported in Nigeria.

Herb-drug interaction is another major risk factor implicated in a widespread form of adverse effects (Amadi and Orisakwe, 2018). In the present study, we noted that patients with cancer cases recourse to traditional healers at the same time receiving orthodox treatment. These patients are desperate for treatment, which subject them to various forms of adverse drug reactions. For instance, we noticed a case of a patient undergoing chemotherapy for colorectal cancer at the same time the patient is receiving treatment from a traditional healer. The patient is administered a very high dose of decocted herbal medicine disregarding the effects of herb-drug interaction. There are several unknown similar cases of this type found most often in the region, an approach that requires government urgent attention.

Figure 3. Percentage number of: A. parts of plant used; B. methods of herbal preparation used; and C. routes of administration used.
4. Conclusions

Concisely, we have documented for the first time traditional knowledge of medicinal plants integrated into the traditional system of medicine for the treatment of cancer in Sokoto state. In the present study, a total of 67 species of medicinal plants belonging to 31 families have been documented. Out of which, *A. nilotica* recorded the highest use-reports, followed by *G. senegalensis*, and subsequently *E. sigmoidea*. Additionally, various forms of diagnosis, the plants parts used, their modes of preparation, and different routes of administration have also been documented. The present study provides a baseline for future pharmacological investigations into the beneficial effects of local medicinal plants for the treatment of cancer.

Declarations

**Author contribution statement**

I. Malami: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

N. Jagaba: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data.

A. Muhammad and A. Alhassan: Conceived and designed the experiments; Wrote the paper.

I. Abubakar: Analyzed and interpreted the data.

P. Waziri, H. Mshelia, I. Yahaya and S. Mathias: Contributed reagents, materials, analysis tools or data.

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**Competing interest statement**

The authors declare no conflict of interest.

**Additional information**

No additional information is available for this paper.

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