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Ethno-Botanical Survey of Potential Anti-Typhoid Fever Plant Species in Akinyele Local Government Area, Ibadan, Oyo State, Nigeria

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Abstract
There is an urgent need to document the indigenous knowledge of medicinal plants used because of its dependency on oral transmission which is at the risk of extinction and the destruction of the natural habitat by anthropogenic activities causing rapid loss of the plant species. The study focuses on documenting potential Anti-typhoid fever plants among herbalists in Akinyele Local Government Area, Oyo State, Nigeria. The study was conducted during the rainy season from April to September 2019. A total number of 80 herbalists were randomly selected from eight villages within the study areas. Well-structured questionnaires administered to the respondents on an individual basis in the local language (Yoruba) were used to collect information on the medicinal plant species used in the treatment of typhoid fever. The data were analysed with descriptive statistics. The results showed a total number of twenty-three (23) plant species from 18 families used in the treatment of Typhoid fever in the study area. Apocynaceae family had the highest number of plant species. Leaves formed the major plant parts used; decoction had the highest percentage of the mode of preparation while oral administration by drinking had the highest percentage of the route of administration/ application of the recipes. The study further showed that all the plants reported had inherent secondary metabolites known as phytochemicals which makes them active against typhoid causative agents. The study concludes that medicinal plants are potent in the treatment of typhoid fever with respondents having adequate knowledge of their uses.
Keywords: Ethno-Botanical Survey, Medicinal Plants, Anti-typhoid plants, indigenous knowledge

Introduction

Plants have been an indispensable source of medicines for humans since creation (Togola *et al*, 2005; Dery and Otsyina, 2000) and constitute a major economic resource of most countries on the planet including Nigeria. Prakash (2009) stated that herbaceous plants were used to treat a wide range of diseases and are effective mainly because of the inherent secondary metabolites otherwise known as phytochemicals which they possess. Typhoid fever is a systemic infection caused by the bacterium *Salmonella enterica* subspecies enterica serotype *typhi* (Iroha *et al.,* 2010). The bacteria mostly grow in the intestine (Wain *et al*., 2015) and are life-threatening (Akomoun *et al*, 2019). Patients are usually infected by ingesting water and/or food contaminated with stool from infected persons or through direct person-to-person transmission. Symptoms begin with fever, headache, abdominal pain, vomiting (Crump and Mintz, 2010) and digestive signs (nausea, constipation or diarrhea). There are more serious forms with intestinal, cardiac or neurological complications that can be fatal without treatment (Akomoun *et al.*, 2019).

Mortality rates associated with this disease vary from one region to another, with the highest reported from Indonesia, Nigeria and India (Miller *et al.,* 1994). Each year, typhoid affects between 11 and 20 million people and causes 128,000 to 161000 deaths (WHO, 2018). The problem has become endemic in many developing countries, causing enormous childhood morbidity and high cost of treatment (Leume, 1999). Typhoid fever is still in developing countries (Asia, Africa and Latin America), where it remains a significant public health problem. In some African countries, access to safe drinking water and primary health care is unstable and the incidence of typhoid fever is high (Anita *et al*., 2022, Doughari and Okafor, 2008). Nigeria also have problems with portable water, especially in rural areas and in some urban and semi-urban areas, this has caused the incidence of Typhoid fever to be prevalent.

According to the World Health Organization, 80% of people in developing countries still depend on local medicinal plants to fulfil their primary health needs (WHO, 2002). Besides that, there is a global consensus on the benefits of phytopharmacy and at present medicinal plants occupy a key position in plant research and medicine. In many African countries, such as Ghana, Mali, Nigeria and Zambia, the first line of treatment for 60% of the children with high fevers, is the use of herbal medicines at home (WHO, 2003). The importance of plants in medicine remains even of greater relevant with the current global shift to obtain drugs from plant sources, as a result of which attention has been given to the medicinal value of herbal remedies for safety, efficacy and economy (Abubakar *et al.,* 2009).

Multidrug-resistant *Salmonella* species are being increasingly reported from the developed world. The emergence and spread of *Salmonella* resistance to many commonly used antibiotics (Ciprofloxacin, Ampicillin, Chloramphenicol, Amoxicillin) is now a subject of international concern. New avenues are therefore to be explored for the development of new antibiotics capable of eradicating *Salmonella*. Thus, the prevalence of this disease, the resistance of Salmonella to these antibiotics coupled with the high cost of treatment has resulted in the demand for the discovery of less expensive but more potent sources of drugs. In developing countries, notably in West Africa, new drugs are not often affordable. Thus, up to 80% of the population uses medicinal plants as remedies (Kirby, 1996; Hostellmann and Marston, 2002).

Plants constitute an important source of active ingredients which differ widely in terms of structure and therapeutic properties and are one of the best sources of potent drugs. For instance, leaf extracts of different plant species have been reported to show potential antimicrobial effects. *Azadirachta indica*, *Mimosa pudica*, *Chromolaena odorata,* and *Acacia nilotica* have indicated growth inhibitory effects against *Bacillus subtilis*, *Staphylococcus* spp., and *Streptococcus* spp. (Policegoudra *et al*., 2007 and Chattopadhyay *et al*., 2022). *Vernonia polyanthes* extract gave a positive inhibitory effect against Leishmania strains while alkaloid extract of *Phyllanthus discoideus* was reported to show strong inhibition against pathogenic bacteria such as *Escherichia coli*, *Enterococcus faecium*, *Pseudomonas aeruginosa*, *Staphylococcus aureus,* and *Mycobacterium smegmatis* (Tyagi *et al*., 2016). Methanolic leaf extracts of *Mentha piperita* (peppermint), *Cymbopogon citrates* (lemongrass), *Allium sativum* (garlic), *Syzygium aromaticum* (clove), and *Zingiber officinale* (ginger) have established satisfactory antimicrobial tendencies against *S. aureus*. (Tyagi *et al*., 2016)

Traditional medical practitioners in Nigeria use herbal preparations to treat microbial infections such as typhoid and para-typhoid infections and they claim that the primary benefit of using plant–derived medicines is that they are relatively safer than synthetic alternatives, offering profound therapeutic benefits and more affordable treatments (Iroha *et al.,* 2010). The traditional knowledge of medicinal plants that is inherent within local communities is a very important source of information that continually provides the present-day herbal remedies used for the treatment of diseases or ailments (Shahid-ud-Daula and Basher, 2009). Medicinal plants represent a rich source from which antimicrobial agents may be obtained (Kubmarawa *et al.,* 2007). Also as of today, one of the major sources of ailment treatment in Nigeria is the use of medicinal plants (Ahmed *et al*., 2018). This prompted the present study on plants used for the treatment of typhoid fever.

Materials and Methods

Study area

An ethnobotanical study was undertaken at Akinyele Local Government Area, Ibadan, Oyo State, Nigeria. The local Government has its headquarters at Moniya located on the coordinates 3^0 53` and $3^0$ 57` longitude and 7^0 28` and $7^0$ 31` latitude **(**Yekinni and Oguntade 2014). It covers an entire area of five hundred and seventy-five square kilometres (575km^2) with 297, 600 population as of 2016, projected from the 2006 national population census (NPC 2006). It has an average annual rainfall of about 1200mm and forest savanna is an ecological zone type. The Local Government is heterogeneous and metropolitan in nature because different Nigerian tribes and foreign nationals reside especially in areas such as Sasa, Ojoo, Orogun, Akinyele and Moniya. The main occupations of the inhabitants of the area are farming, carpentry, trading, marketing, food processing as well as carving work. Major crops commonly grown in the area are cucumber, maize, okra, pepper, cassava, watermelon, yam and tomatoes **(**Stella, 2009, Yekinni and Oguntade 2014**).**

Method of data collection and sampling procedures

The survey of this research was conducted during the rainy season from April to September 2019 when plants are growing luxuriantly and are very abundant. Interview methods using semi-structured questionnaires amidst informal conversation following Huntington (2000) were used to collect data from respondents in eight different villages in the study area. The villages were purposively selected based on the presence of relics of forest around the villages and the prevalence of Traditional Medical Practitioners (TMPs) or herbalists. The villages are Ijaye, Onidundu, Otunagbakin, Moniya, Idi- ose, Apapa, Aroro and Olanla. Ten TMPs were randomly selected from each village and a total number of 80 respondents as sample size were used for the study. The questionnaire was structured to capture the local names of medicinal plants used in the treatment of typhoid fever, the plant parts used, methods of preparation and mode of administration/ application and doses of the herbal recipes were collected from the respondents and documented. The questionnaire was administered to each respondent and the interview was conducted in the

local language (Yoruba) of the TMPs. The local names of the medicinal plants mentioned were supported with a recognisance survey of the plants within the environment. This led to the herbarium collection of these plants for proper identification. The plants collected were identified scientifically at the Forestry Research Institute of Nigeria (FRIN) herbarium unit through a retired taxonomist from the unit. A literature search was conducted through search engines like Google Scholar to identify the bioactive compounds in the plants mentioned and identified.

Data Analysis

Descriptive statistics

Descriptive statistics such as tables, percentages and frequency distribution were used to analyse the data collected from the respondents

Results and Discussion

Identification and classification of the enumerated plant species

The study identified a total number of twenty-three (23) plant species belonging to 18 families used in the treatment of Typhoid fever by the respondents of the study area (Table 1). These include *Mangifera indica* L., *Xylopia aethiopica* (Dunal) A., *Alstonia boonei De Wild, Funtumia elastica*, *Strophanthus gratus* (Wall. & Hook.) Baill., *Cochlospermum planchonii Hook. f. ex Planch*, *Acanthospermum hispidum D.C*, *Phoenix reclinata jacq*, *Plukenetia conophora Muell. Arg*, *Senna occidentalis* (L.) Link, *Senna siamea* (Lam.) H.S. Irwin & Barneby, *Erythrina senegalensis* DC., *Anthocleista vogelii* Planch, *Phragmanthera capitata* (Sprengel) S. balle, *Trichilia monadelpha* (Thonn.) J.J.de Wilde, *Azadirachta indica A. Juss.*, *Musa sapientum* L., *Pteris togoensis hieron*, *Sarcocephalus latifolius* (Smith) Bruce, *Citrus aurantifolia* (Christm.) Swingle, *Lecaniodiscus cupanioides* Benth. and *Zingiber officinale* Roscoe.

Akomoun *et al.*, (2019) and other authors as listed in Table 7, opined that *Zingiber officinale*, *Azadirachta indica*, *Musa sapientum*, *Xylopia aethiopica*, *Acanthospermum hispidum*, *Sarcocephalus latifolius*, *Citrus aurantiifolia*, *Mangifera indica* and *Senna siamea* are used in the treatment of Typhoid fever. The result of this study also conformed to the findings of Halimat *et al*., (2017) and other researchers on the same Table 7 who stated that *Erythrina senegalensis* and *Senna occidentalis* extracts are used in the treatment of Typhoid fever. According to Dawang and Datup, (2012), water leaf extracts of *Erythrina senegalensis* DC. (Papilionoideae), *Psidium guajava* L. (Myrtaceae), *Vitex doniana* and *Vernonia amygdalina* (Wild) Darke (Asteraceae) have been effective against *Escherichia coli* and *Salmonella typhi*. Kilani (2006) also reported that these extracts if properly enhanced and harnessed could be very useful in the healthcare delivery system for the treatment of diseases. These plants contained phytochemicals like alkaloids, glycosides and anthraquinones (Dawang and Datup, 2012).

Fadimu *et al*, 2014 *identified Mangifera* indica and *Alstonia boonei* as a cure for typhoid fever disease. The roots extract of *Cochlospermum planchonii* is potent in the treatment of Typhoid fever (Sam *et al.*, 2011, Abraham *et al*., 2017; Atawodi, 2005; Benoit-Vical *et al*., 2003; Kone *et al*., 2002; Igoli *et al*., 2005; Akinyemi *et al*., 2005; Gil and Akinwunmi, 1986). The effectiveness of these plants recorded in the treatment of typhoid fever was due to the presence of secondary metabolites in the plant parts such as alkaloids, phenolic glycosides, and volatile oils (Mahmoud *et al*., 2020).

Plant form of the enumerated plant species

All the twenty-three (23) plant species mentioned by the respondents were represented by all the plant forms (Table 2). Among the plant species mentioned, 13 species (56.52%) are trees, 4 species (17.39%) are shrubs and 3 species (13.04%) are herbs/forbs. Climbing shrubs, liana/ climber and fern accounted for a single species each contributing 4.35%. This reveals that plant species used in the treatment of typhoid fever are mainly represented by trees and shrubs. This agreed with the finding of Halimat *et al*., (2017) which found trees (63.34%) as the most used plant form in the treatment of typhoid fever, followed by shrubs (22.45%) and herbs (8.16%) while grass and underground stem had (4.08%) and (2.04%) respectively.

Family classification of enumerated plant species

Table 3 shows the family classifications of the enumerated plant species. The highest species (4) was found in the family of Apocynaceae which accounted for the larger percentage 17.39%. Closely followed was the Fabaceae family having 3 species and 13.05%. The Fabaceae family is subdivided into Caesalpinioidea and Papilionoideae, each having 2 and 1 species each with 8.70% and 4.35% respectively. However, Halimat *et al*. (2017) opined that Fabaceae had the highest number of medicinal plant species recorded in their study. Members of Family Fabaceae played a dominant role in terms of the number of medicinal plant species recorded, Plant species in this family are commonly used as food as well as medicine as reported in the works of Joudi and Bibalani (2010).

In this study, the Meliaceae family had 2 plant species with 9.09%. Other families such as Anacardiacee, Annonaceae, Arecaceae, Asteraceae, Euphorbiaceae, Longaniaceae, Loranthaceae, Musaceae, Pteridaeae, Rubiaceae, Rutaceae, Sapindaceae and Zingiberaceae had only one plant species each with 4.35%. Heinrich (2008) reported that families of plants used in traditional medicine are considered significant based on cultural perspective and their relationship with the effectiveness of the chemical constituents of species from these families; a combination of these factors influences and determines plant species selection by the locals for therapy (Offiah *et al*., 2011)

Plant parts used in the preparation of recipes for the treatment of Typhoid fever

The result showed that seven (7) different plant parts of

the identified plant species were used in the preparation of the recipes for the treatment of Typhoid fever (Table 4). This includes leaves, bark, roots, fruit, flowers, vines and rhizomes. Ariyo, *et al*, (2020a, 2020b, 2021) and Ariyo, (2023) reported that leaves, bark, seeds, latex, fruits, pods, roots, vines, oil, tubers, rhizome, bulbs, cobs, sticks, and bunch of alligator pepper were the plant parts used in the treatment of pile, cough, skin diseases and erectile dysfunction. Three (3) plant species such as *Acanthospermum hispidum D.C Anthocleista vogelii* Planch and *Mangifera indica* L. had more than one part used in this study. This showed that more than one part of the same plant can be used in the preparation of herbal recipes (Ariyo *et al*., 2021). This may be due to differences in the phytochemical constituent of different parts of the same plants. Also, different plant parts were combined for effective usage; this was similar to the report of Mahmoud *et al*. (2021). The Table further showed that leaves (40.00%) and bark (16.00%) had the highest percentage of plant parts used. This indicates that leaves and bark are the most used plant parts. This corroborates the findings of Francis and Sarada, (2021) which reported that leaves and bark of the trees are the major plant parts used in the treatment of typhoid fever. Mahmoud *et al*, (2021) found leaves (40.90%) as the most plant parts used to treat typhoid fever, followed by the whole plant (27.30%) and root (13.60%). Also, Ali *et al*., (2021) opined that the plant parts mostly used in the treatment of typhoid fever were leaves (66.7%), next to seeds and stems (16.7%) each. This finding was also similar to that of other researchers (Offiah *et al*., 2011 Dike *et al*., 2012). Leaves are a very important component in the treatment of typhoid fever; it is the part that appears most in many herbal recipe preparations (Halimat *et al*., 2017 Adekunle, 2008). Leaves are easily combined with different plant parts during herbal preparations (Ayannar and Ignacimuthu, 2011). Several communities have been reported to show a preference for the use of leaves in herbal remedy preparation (Ayannar and Ignacimuthu, 2011), this is because leaves are very easy to collect as compared to other plant parts (Tesfu *et al*., 1995) and serve as a depot of secondary metabolites responsible for many biological activities (Bigendako-Polygenis and Lejoly, 1990).

Mode of preparation of the recipes used for the treatment of Typhoid fever

The mode of preparation of the recipes used in the treatment of typhoid fever in Table 5 includes decoction, infusion squeezing in water, grinding into powder and grinding into paste. Decoction had the highest percentage 46.15% of the mode of preparation of recipes used in the treatment of typhoid fever. According to Salhi *et al*, (2010), a decoction can collect the most active ingredients and lessen or cancel the toxic effect of certain recipes. Akinmoladun *et al*. (2007) stated that in traditional usage of plants, decoction or infusions of herbs are usually made with either alcohol or water as the solvent. The use of decoction was followed by infusion having 34.62%. Squeezing in water and grinding into powder each had 7.69% while grinding into paste had 3.85%. Plant species such as *Anthocleista capitata*, *Azadirachta indica* and *Citrus aurantifolia* had more than one mode of preparation. Some of the anti-typhoid recipes were mixed with adjuvants like 7-up, palm wine, milk, sugar, palm kernel and fermented water from pap during preparation. Ariyo, (2023) reported the use of adjuvants such as honey, alcohol/ hot drinks/ gin, and fermented water from pap in the preparation of recipes for the treatment of erectile dysfunction. Kwame *et al.* (2019) stated that most of the herbal remedy preparations (57.6%) were formulated from a mixture of other plants and non-plant ingredients.

Mode of administration/ application and dosage of the recipes

The mode of administration or application of the recipes in Table 6 is mainly oral either by drinking, licking and bathing or in combination of all. The information in Table 6 further showed that oral administration by drinking had the highest percentage of 82.61%, followed by oral administration by licking, having 8.70%. Oral administration by drinking/ bathing and by drinking/ licking had an equal percentage of 4.35%. The oral prescription of typhoid recipes can be explained because the bacterial causing typhoid fever resides in the intestine which is the first contact of the recipes when administered orally. The measurement of the dosage used for the administration of anti-typhoid recipes varies from one-quarter stainless cup; to halve stainless cup, one tumbler, one gas and one teaspoon once, twice or thrice daily as the case may be. These measurements inferred that there is no standard dosage for the recipes and no information was provided on the optimization and standardization of the administration of these recipes, this is a major drawback in traditional medicine.

Plant species combinations used in the treatment of Typhoid fever

A total number of 18 herbal recipes were recorded for the treatments of typhoid fever in the study area (Table 7). 9 recipes involve the use of single plant species (single herb) with one or two plant parts such as leaves, roots and bark while 9 recipes combined different plant species (herb- herb combination) with one or more plant parts together. Teklehaymanot and Giday, (2007), and Bruschi *et al*. (2011) opined that the use of medicinal plant mixtures can provide a positive synergic effect and also improve the taste or smell of the mixture. Ariyo *et al* (2021) reported 21 different herbal recipes for the treatment of skin diseases, out of which 6 recipes are prepared from a combination of different plants and plant parts while 15 recipes use single plant species with one or many plant parts of the same plant in the preparation of the recipes.

According to Chun-Tao *et al*, (2013), the herbal product could be used as a single herb, a combination of herbs or a combination of herb (s) and drug(s) in different communities and cultures. When herbs are used in combination, various interactions may occur among the individual components to form reinforcement- (a situation in which herbs possessing similar medicinal properties are used together to produce a greater

efficacy) which can probably be interpreted to include either an additive effect- (when the combined effect of two herbs equals the sum of the effect of each agent) or synergetic effect (when the combined effect exceeds the sum of the effects of individual herbs) which can bring about additional therapeutic benefit. A synergistic relationship amongst phytochemicals has been adduced to be responsible for the overall beneficial effect derivable from plants (Liu, 2004). The use of plants in a holistic approach to treat diseases and the synergy of plant combinations can have greater effects on the treatment of infectious diseases (Ariyo *et al.,* 2021).

Phytochemical and pharmacological constituents of the enumerated plant species

The literature search was conducted to identify the active compound responsible for the medicinal value of the enumerated plants. It was found that some of the plants contain bioactive constituents such as alkaloids, saponins, tannins flavonoids, carbohydrates and phenolic compounds. However, the relative presence of these secondary metabolites in plants was reported to depend on the solvent types and the polarity of the extractants (Salama and Marraiki, 2010). Flavonoids are the most phytochemical of plants and have an antimicrobial effect on bacteria caused by typhoid fever (Lelimiska *et al*., 2020). According to the work of Chakraborty *et al*., (2004), Flavonoids influence arachidonic acid metabolism and have been known to be a good antimicrobial agent against a wide array of microorganisms. This activity may be due to the ability of flavonoids to form complexes with extracellular and soluble proteins and to complex with bacterial cell walls (Tringali, 2001 Ayoola, 2008). Mishra *et al*., (2009), have reported the propensity of flavonoids for microbial cell disturbance, inhibition of nucleic acid synthesis, and cell wall synthesis. Flavonoids are potent water-soluble antioxidants and free radical scavengers which prevent oxidative cell damage have strong anticancer activity (Okwu, 2004) and also lower the risk of heart diseases.

Tannins were reported to form a protein complex, which is lethal to bacteria, as it alters their biochemical process (Shaimaa, 2014)**.** Tannins are also known to be effective antioxidants, antimicrobial and anti-carcinogenic agents (Lai and Roy, 2004). According to Usman *et al*., (2007), tannins and flavonoids are established microbial growth inhibitors. Phenols are generally germicidal, are usually used in formulating disinfectants and some possess estrogenic or endocrine disrupting activity. They are also the active ingredient in spices that contribute to their flavour, taste and medicinal properties (Walker and Morton, 1993). Maria *et al*., (2013) stated that phenols exhibit antioxidant and enzyme inhibitory tendencies, while alkaloids have been found to cause structural and genetic imbalance as well as bacterial DNA cell wall damage (Firempong *et al*., 2016). Alkaloids have been associated with medicinal uses for centuries, and one of their common biological properties is their cytotoxicity (Nabori, *et al*., 1994). It is the most efficient plant substance used therapeutically. Alkaloids have been documented to possess analgesic, antispasmodic and bactericidal effects which are medicinal agents (Ayoola *et al*., 2013). Terpenoids can be added to proteins to enhance their attachment to the cell membrane in a process known as isoprenylation and they also play a role in traditional herbal remedies and are active against pathogenic microorganisms (Ayoola, 2008). Saponins are capable of neutralizing some enzymes in the intestine that can become harmful, building the immune system and promoting wound healing. Tannins hasten the healing of wounds and inflamed mucous membranes (Okwu and Okwu, 2004). Cardiac steroids are widely used in the treatment of congestive heart failure. They help in increasing the force of contraction of the heart (positive inotropic activity) in heart failure patients. The presence of these phytochemicals supports the use of medicinal plants in the treatment of diseases. Steroids have been reported to have antibacterial properties (Raquel, 2007).

The phytochemical assay of methanolic leaf extracts of *A. hispidum* indicated the presence of alkaloids and anthraquinone, with higher contents of resins, tannins, flavonoids, carbohydrates, phenol and protein, and amino acids, while saponin was absent. The extracts exhibited antibacterial activities against *S. typhi*, *S. Typhimurium*, S. *gallinarum,* and *S. paratyphi* (Stephen *et al*, 2021). The phytochemical profile of *A. hispidum* obtained by Okoro *et al*., (2017) was similar to the above except for the absence of saponins. They reported the presence of carbohydrates, cardiac glycoside, saponins, alkaloids, anthraquinone, steroids, triterpene, tannins, and flavonoids and attributed the absence of saponins in acetone extract to its high hydrophilic affinity, readily dissolving in polar solvents. The result of Iroha *et al* (2010) showed the anti-typhoid activity of ethanol, hot and cold water extracts of root, bark and leaf of *Alstonia boonei* has activity against *S. typhi* strains tested. The stem bark of A. boonei has been reported to possess anti-inflammatory, analgesic and antipyretic activities (Olajide *et al*., 2000). The possible chemical compositions of the identified plants documented in literature may be responsible for the acclaimed anti-typhoid fever activities by the TMPs. The phytochemical constituents are secondary metabolites which might draw a link between modern science and the traditional use of the plant.

Conclusion

The findings of the research have revealed that medicinal plants are potent in the treatment of typhoid fever with respondents having adequate knowledge of their uses. The study recorded 23 plant species belonging to 18 families with Apocynaceae family having the highest number of species used. The presence of secondary metabolite compounds such as alkaloids, phenolic groups, flavonoids, saponins, steroids, tannins, cardiac glycosides, anthraquinones and terpenoids could be adduced to the therapeutic claims and curative ability of the identified plant species. The most used plant form and plant parts are trees and leaves while decoction is the most common method of preparation.

Oral administration by drinking is the most common method of administration of recipes by the respondents. The study recommends adequate protection and conservation of these medicinal plants to prevent their extinction. Research should be carried out on medicines derived from plants in their original state (phytomedicines) to produce synthetic drugs from all the bioactive ingredients (phytochemical compounds) present in these medicinal plants. Also, there is a need for further research in the areas of standardization of dosage, efficacy of these plants/ recipes, quality of the recipes and safe use of the plants/ recipes.

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Table 1: List of medicinal plants used in the treatment of Typhoid Fever in the study area

Family and Scientific name	Life form	Common name	Local Name	Parts used	Chemical constituents	Citation	Mode of Preparations	Mode of administration/ application
Anacardiacee								
Mangifera indica L.	Tree	Mango	Mongoro Mangora	Bark, root	Polyphenols (flavonoids, xanthones, and phenolic acids), Amino acid, Terpenes, Phenylpropenes, polyphenols, Triterpenes and triterpenoids	Berardini *et al*., 2005, Meran *et al.*, 2017	Infusion	Oral: Drinking
Annonaceae								
Xylopia aethiopica (Dunal) A.	Tree	Alligator pepper	Eeru	Fruit	Cardiac glycoside, flavonoids, phlobatannins, tannins, phenol, anthraquinones, saponin and steroids	Ilusanya *et al*., 2012	Decoction	Oral: Drinking
Apocynaceae								
Alstonia boonei De Wild	Tree	Stool wood	Ahun	Bark	Alkaloids, Saponins, Tannins, Steroids, Terpenoids, Flavonoids and Cardiac glycosides	Akinmoladun *et al*., 2007	Infusion	Oral: Drinking
Funtumia elastica	Tree	Bush rubber	Ire	Leaves	Anthocyanins, betacyanin, flavonoids, steroids, tannins saponin, Triterpenoids, Glycosides and Cardiac glycosides	Adekunle and Ikumapayi, 2006, Theophilus *et al*., 2021	Decoction	Oral: Drinking
Strophanthus gratus (Wall. & Hook.) Baill.	Liana	Climbing Oleander	Isa, Isa-godi, Isa-ogbugbu, Isa-kere (Ekiti)	Leaves	Alkaloids, Tannins, Saponins, Flavonoids, Steroids and Terpenoids, General Glycoside, Cardiac Glycoside, Anthraquinone glycoside, Cyanogenic glycosides	Daniel, 2013	Infusion	Oral: Drinking
Cochlospermum planchonii Hook.f. ex Planch	Shrub	False cotton	Gbehutu or Feru	Root	Saponins, Tannins, Flavonoids, Steroids, Essential oils and Reducing sugar	Dalziel, 1956, Dutta, 1993, Kaufman *et al*., 1989	Infusion	Oral: Drinking Bathing
Arecaceae								
Phoenix reclinata jacq	Tree	Senegal date palm	Paako (Ilorin)	Leaves	Tannins, steroid glycosides, alkaloids, reducing sugars, saponins, anthraquinones	Namuleme *et al*., 2017	Grinding to powder	Oral: Licking
Asteraceae								
Acanthospermum hispidum D.C	Forb/ Herb	Bristly starbur	Egun-igba Kayar yawo	Leaves/ vine	Alkaloids, anthraquinone, resins, tannins, flavonoids, carbohydrate, phenol, protein, and amino acids cardiac glycoside, saponins, steroids, triterpene,	Stephen *et al*., 2021, Okoro *et al*.,2017	Decoction	Oral: Drinking

Euphorbiaceae								
Plukenetia conophora Muell. Arg	Climbing shrub	African walnut	Awusako	Leaves	Alkaloids, saponins, tannins, anthraquinones and gallic acid, Glycosides, Steroids, Polyphenols, flavonoids, carbohydrates and cardiac glycosides	Ayoola *et al*., 2013 Neji and Agwupuye, 2019, Olugbemi *et al*., 2018	Squeeze	Oral: Drinking
Fabaceae- Caesalpinioidea								
Senna occidentalis (L.) Link	Shrub	Negro Coffee	Iya omo, Rere	Leaves	Alkaloids, tannins, saponins, glycosides, Terpenoids, Flavonoids, Steroids, Phenols	Innocent *et al*., 2022	Decoction	Oral: Drinking
Senna siamea (Lam.) H.S. Irwin & Barneby	Tree	Kassod tree, Siamese cassia, Yellow cassia	Kasia	Root	Saponins, anthraquinones, Phytobatannins, alkaloids, tannins, Oxalate, Phytate, Resin, Steroids	Ali-Smith, 2009, Bukar *et al*, 2009	Infusion	Oral: Drinking
Fabaceae- Papilionoideae								
Erythrina senegalensis DC.	Tree	Senegal coral tree	Ologboser e, Ologbons ese	Bark	Alkaloids, flavonoids, Steroids, tannins, phenols, quinones, saponins, terpenoides, anthraquinones, xanthoproteins	Bioltif *et al*, 2022	Decoction	Oral: Drinking
Longaniaceae								
Anthocleista vogelii Planch	Tree	Cabbage tree	Sapo	Root, leaves	Saponins, flavonoids, alkaloids, terpenes, steroids, phenols	Jegede *et al*, 2011	Infusion, Decoction	Oral: Drinking
Loranthaceae								
Phragmanthera capitata (Sprengel) S. balle	Shrub	Misletoe	Afomo	Flower	Phenols and polyphenols, Flavonoids, Tannins, Anthocyanins, Coumarins, Limonoids, Saponins, Sterols	Ladoh-Yemeda *et al*., 2021	Decoction	Oral: Drinking
Meliaceae								
Trichilia monadelpha (Thonn.) J.J.de Wilde	Tree		Ako rere, Rere, Ajanrere	Bark	Tannins and phenolic compounds, alkaloids, Phytosterols/ triterpenoids, carbohydrates, flavonoids, coumarins, cardiac glycosides, anthraquinones, saponins	Ben *et al*., 2013	Decoction	Oral: Drinking
Azadirachta indica A. Juss.	Tree	Neem tree	Dogoyaro	Leaves	Alkaloids, saponins, tannins, steroids, terpenoids, glycosides, flavonoids, Phenol, oxalic acid	Innocent *et al*., 2021	Squeeze Decoction	Oral: Drinking
Musaceae								
Musa sapientum L.	Herb	Plantain	Ogede agbagba	Leaves	Alkaloids, cardiac glycosides, flavonoid, saponins, steroids, tannins, Phenols,	Repon *et al*., 2013,Oyeyemi *et al*., 2019	Decoction	Oral: Drinking

Pteridaeae								
Pteris togoensis hieron	Fern	Terrestrial fern	Imo osun	Leaves	Tannins, saponin, flavonoid, terpenoids, phenols	Awadhesh *et al*., 2014	Grinding to paste	Oral: Licking
Polygalaceae								
Securidaca longependunculata Fres.	Tree	Violet Tree	Kyiritoo, Ofodo	Leaves	Alkaloids, flavonoids, saponins, cardiac glycosides, tannins, steroids, triterpenes, Carbohydrate	Namadina *et al*., 2020	Grinding to powder	Oral: Drinking
Rubiaceae								
Sarcocephalus latifolius (Smith) Bruce	Tree	African peach	Egbesi	Root	Alkaloids, anthraquinone, glycosides, flavonoids, saponins, tannins, terpenoids	Oluremi *et al*., 2018	Decoction	Oral: Drinking
Rutaceae								
Citrus aurantifolia (Christm.) Swingle	Shrub	Key lime	Osan were	Fruit	Essential oil, Flavonoids, Terpenoids, Phenolic, Limonoids, Alkaloids, Tannins, Terpenoids	Indriyani *et al*., 2023, Bukola *et al*., 2016	Decoction, Infusion	Oral: Drinking, Licking
Sapindaceae								
Lecaniodiscus cupanioides Benth.	Tree		Aaka, Akika	Root	Tannins, Phlobatannins, Flavonoids, Saponins, Steroids, Terpenoids, Cardiac glycoside, Alkaloids, Phenol, Anthraquinone	Bright and Soliu, 2022 Mikhail *et a*l., 2013	Infusion	Oral: Drinking
Zingiberaceae								
Zingiber officinale Roscoe	Herb	Ginger	Ata-ile	Rhizome	essential oils, phenolic compounds, flavonoids, carbohydrates, proteins, alkaloids, glycosides, saponins, steroids, terpenoids and tannin	Gaurav *et al*., 2011	Infusion	Oral: Drinking

Table 2: Distribution of the Plant Species into Plant Forms

Plant Form	Frequency	Percentage
Tree	13	56.52
Shrub	4	17.39
Climbing shrub	1	4.35
Herb/Forb	3	13.04
Liana/ Climber	1	4.35
Fern	1	4.35
Total	**23**	**100**

Table 3: Family Classification of Enumerated Plant Species

Family	Frequency	Percentages
Anacardiacee	1	4.35
Annonaceae	1	4.35
Apocynaceae	4	17.39
Arecaceae	1	4.35
Asteraceae	1	4.35
Euphorbiaceae	1	4.35
Fabaceae- Caesalpinioidea	2	8.70
Fabaceae- Papilionoideae	1	4.35
Longaniaceae	1	4.35
Loranthaceae	1	4.35
Meliaceae	2	8.70
Musaceae	1	4.35
Polygalaceae	1	4.35
Pteridaeae	1	4.35
Rubiaceae	1	4.35
Rutaceae	1	4.35
Sapindaceae	1	4.35
Zingiberaceae	1	4.35
Total	**23**	**100**

Table 4: Plant Parts Used in the Preparation of Typhoid Fever Recipes

Plant Part	Frequency	Percentage
Leaves	10	40
Bark	4	16
Root	6	24
Fruit	2	8
Flower	1	4
Vine	1	4
Rhizome	1	4
Total	**25**	**100**

Table 5: Distribution of the mode of preparation of typhoid fever recipes

Mode of preparation	Frequency	Percentage
Decoction	12	46.15
Infusion	9	34.62
Squeezing	2	7.69
Grinding into powder	2	7.69
Grinding into paste	1	3.85
Total	**26**	**100**

Table 6: Distribution of mode of administration/ application of the recipes

Mode of Administration	Frequency	Percentage
Oral by drinking	19	82.61
Oral by Licking	2	8.70
Oral by drinking/ bathing	1	4.35
Oral by drinking/ licking	1	4.35
Total	**23**	**100**

Table 7: Plant species combinations used to treat Typhoid Fever in the study area

S/n	Plant species combination	Part used	Method of preparation	Dosage	Revised literature
1	*Trichilia monadelphous*	Fresh bark	Cook the fresh bark of *Trichilia monadelpha* with clean water and add a small quantity of potash to it.	Drink half a stainless cup twice daily	Ariyo, 2018
2	*Senna siamea*	Fresh or dry roots	Cut fresh or dry roots of cassia into pieces and put seven up in a clean plastic-covered container	Drink half a stainless cup twice daily	Akomoun *et al*, 2019, Simeon *et al.*, 2020
3	*Lecaniodiscus cupanioides*	Fresh roots	Wash the fresh root of *Lecaniodiscus cupanioides* cut it into pieces and put it in a plastic bottle, add clean water and a small quantity of potash to it. Leave it for a day.	Drink one gas twice daily	Ariyo, 2018
4	*Anthocleista vogelii*	Fresh roots	Fresh roots are cut into pieces and soaked in undiluted palm wine with potash	Drink one tumbler 5-6 am in the morning	Maltida, 2016
5	*Securidaca longependunculata* Fres.	Dried leaves	The leaves are sun-dried and ground to powder then mixed with a small amount of water, before administering Boil the leaves for a long time; allow the colour to change then use to bath.	Use water to drink a teaspoon of the powder Drink ½ stainless cup twice daily	Halimat *et al*., 2017,
6	*Senna occidentalis*	Leaves	The leaves are selected and washed before boiling, boil for 10 minutes allow to cool, decoction is given orally.	Drink half a stainless cup twice daily	Ali *et al*., 2021, Simeon *et al.*, 2020, Halimat *et al*., 2017
7	*Cochlospermum planchonii*	Root	Soak the root in clean water for 3 days and allow the colour to change	Use the water to bath and drink half a stainless cup 3 times daily	Sam *et al*, 2011, Abraham *et al*., 2017, Atawodi, 2005, Benoit-Vical *et al*., 2003, Kone *et al*., 2002, Igoli *et al*., 2005, Akinyemi *et al*., 2005, Gil and Akinwunmi, 1986
8	*Mangifera indica*	Leaves	The leaves are selected and washed before boiling in water for a long time. Allow it to cool and add milk to it before taking it.	Drink one small stainless cup three times daily	Akomoun *et al*, 2019, Ali *et al*., 2021, Igberaese and Ogbole, 2018, Fadimu *et al*, 2014, Faleyimu *et al*, 2010, Simeon *et al.*, 2020, Halimat *et al*., 2017, Aguoru and Ogaba, (2010), Sodipo and Wannang, (2015)
9	*Phoenix reclinata jacq*	Dried leaves	Grind the leaves, make sure they are smooth then add palm kernel oil and mix it thoroughly.	Take one teaspoon daily	Maltida, 2016
10	*Phragmanthera capitata* + *Citrus aurantiifolia*	Flower and leaves + Fruit	Boil both flower and leaves in water until the colour changes, add lime orange to it,	Drink half a stainless cup three times daily	Maltida, 2016 + Akomoun *et al*, 2019, Ali *et al*., 2021, Igberaese and Ogbole, 2018, Fadimu *et al*, 2014, Ighere *et al*, 2012, Simeon *et al.*, 2020, Halimat *et al*., 2017, Francis and Sarada, 2021, Lelimiska *et al*., 2020. Aguoru and Ogaba, (2010), Sodipo and Wannang, (2015)

11	*Pteris togoensis* + *Citrus aurantiifolia*	Leaves + Juice	Grind the leaves of *Pteris togoensis* into powder and add a little sugar or lime for taste then administer.	Lick 1 teaspoon three times daily	Maltida, 2016 + Ali *et al*., 2021, Halimat *et al*., 2017, Sodipo and Wannang, (2015), Aguoru and Ogaba, (2010)
12	*Funtumia elastica* + *Sarcocephalus latifolius*	Leaves + Root	The leaves are boiled together with the root of *Sarcocephalus latifolius*, and then allowed to cool	Drink half a stainless cup two times daily	Maltida, 2016 + Halimat *et al*., 2017, Akomoun *et al*, 2019, Igberaese and Ogbole, 2018
13	*Erythrina senegalensis* + *Citrus aurantiifolia*	Bark + Fruit	The bark is boiled with clean water together with *Citrus aurantiifolia* and allowed to cool.	Drink half a stainless cup two times daily	Simeon *et al.*, 2020, Halimat *et al*., 2017 + Ali *et al*., 2021, Halimat *et al*., 2017, Sodipo and Wannang, (2015), Aguoru and Ogaba, (2010)
14	*Strophanthus gratus* + *Citrus aurantiifolia*	Leaves + Juice of C. a	Soak leaves for some time (4hr) then add lime orange to it.	Drink one-quarter of a stainless cup daily	Maltida, 2016 + Ali *et al*., 2021, Halimat *et al*., 2017, Sodipo and Wannang, (2015), Aguoru and Ogaba, (2010)
15	*Acanthospermum hispidum* + *Citrus aurantiifolia*	Leaves, Vine + Fruit	Boil both leaves and vine of *Acanthospermum hispidum* and fruit of lime orange together and then allow it to cool.	Drink half a stainless cup three times daily	Akomoun *et al*, 2019, Fadimu *et al*, 2014, Sam *et al*, 2011, Francis and Sarada, 2021, + Ali *et al*., 2021, Halimat *et al*., 2017, Sodipo and Wannang, (2015), Aguoru and Ogaba, (2010)
16	*Xylopia aethiopica* + *Musa sapientum* + *Anthocleista vogelii*	Fruit + Leaves + Leaves	Collect dropped dried leaves of *Anthocleista vogelii* and dropped dried leaves of *Musa sapientum* and (*Xylopia aethiopica*) 9 for male and 7 for female and one white stone or "he stone" (*ako okuta*) and cook with water.	Drink one stainless cup 2 times daily.	Akomoun *et al*, 2019, Fadimu *et al*, 2014, Faleyimu *et al*, 2010. + Akomoun *et al*, 2019, Igberaese and Ogbole, 2018, Simeon *et al.*, 2020, Francis and Sarada, 2021 + Maltida, 2016
17	*Azadirachta indica* + *Plukenetia conophora*	Leaves + Leaves	Squeeze the leaves of the two plants together in equal proportion with small quantity of water	Drink half stainless cup twice daily	Akomoun *et al*, 2019, Igberaese and Ogbole, 2018, Ighere *et al*, 2012, Simeon *et al.*, 2020, Halimat *et al*., 2017, Lelimiska *et al*., 2020, Aguoru and Ogaba, (2010) +

18	*Alstonia boonei* + *Mangifera indica* + *Citrus aurantiifolia* + *Zingiber officinale* + *Cochlospermum planchonii*	Bark and Root + Bark and Root + Fruit + Rhizome + Root	Cut the fruit of *Citrus aurantiifolia* into pieces squeeze and soak with all the other herbs in *omi ogi* (maize processed palp water). Add more omi ogi as it finishes	Drink halve stainless cup three times daily	Fadimu *et al*, 2014, Ighere *et al*, 2012, Halimat *et al*., 2017, Francis and Sarada, 2021, Iroha *et al*., 2010 + Akomoun *et al*, 2019, Ali *et al*., 2021, Igberaese and Ogbole, 2018, Fadimu *et al*, 2014, Faleyimu *et al*, 2010, Simeon *et al*., 2020, Halimat *et al*., 2017, Aguoru and Ogaba, (2010), Sodipo and Wannang, (2015) + Akomoun *et al*, 2019, Ali *et al*., 2021, Igberaese and Ogbole, 2018, Fadimu *et al*, 2014, Ighere *et al*, 2012, Simeon *et al*., 2020, Halimat *et al*., 2017, Francis and Sarada, 2021, Lelimiska *et al*., 2020. Aguoru and Ogaba, (2010), Sodipo and Wannang, (2015) + Francis and Sarada, 2021, Lelimiska *et al*., 2020, Aguoru and Ogaba, (2010), Sodipo and Wannang, (2015), Ali *et al*., 2021, Halimat *et al*., 2017, Aguoru and Ogaba, (2010), Sodipo and Wannang, (2015) + Sam *et al*, 2011, Abraham *et al*., 2017, Atawodi, 2005, Benoit-Vical *et al*., 2003, Kone *et al*., 2002, Igoli *et al*., 2005, Akinyemi *et al*., 2005, Gil and Akinwunmi, 1986, Ariyo, 2018