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Herbal Medicines Used in the Treatment of Typhoid in the Ga East Municipality of Ghana

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Authors' contributions

This work was carried out in collaboration among all authors. Author EOB designed and supervised the study and wrote the first draft of the manuscript. Author DD performed the market survey and analysed the data. Authors CA and JS managed the literature searches and approved the final manuscript.

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ABSTRACT

In Ghana, majority of the people patronize herbal medicines for the treatment of both chronic and acute ailments as well as infectious and non-infectious diseases. As such, the use of herbs as medicines in the treatment of enteric (typhoid) fever is very widespread.
Aims: This study therefore investigates anti-typhoidal herbal medicinal formulations that are for sale on the Ghanaian market with regards to the contents on the product labels and assesses the various active plant components in the light of documented evidence of their use in the treatment of typhoid.

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Methodology: Herbal products for the treatment of typhoid were sampled from herbal medicine shops and pharmacies and assessed for the type of formulation, plant and non-plant constituents, dosage, indications, treatment duration and contraindications.
Results: Majority of the products (87%, n=16) had registration numbers whilst 13% had none. These anti-typhoid formulations were simultaneously recommended for the treatment of malaria (56%) (9 out of 16 products), jaundice (31%), various types of pains (body pains, headache, menstrual pains) (8%), stress (8%) and fatigue (8%). All the preparations had more than one plant as its active constituent. Forty-four percent (44%) contained 2 plants species as the active ingredients, 37% contained between 3 to 5 plant species, 13% contained 6 to 10 plant species and 6% contained more than 10 plant species. The most frequently occurring active plant constituents of these products were *Carica papaya* L. (Caricaceae), *Morinda lucida* (Rubiaceae), *Citrus aurantifolia* (Rutaceae), *Vernonia amygdalina* (Compositae) and *Azadirachta indica* (Meliaceae).
Conclusion: In all, thirty-four different plant species belonging to 25 families were found to be present in these products. A literature search on the plants species showed that their traditional use in the treatment of typhoid is well documented and hence their resulting formulations may as well be very effective.

Keywords: Typhoid fever; anti-typhoid herbal medicinal formulations; active plant constituents.

ABBREVIATION

NTS : Nontyphoidal Salmonella

1. INTRODUCTION

Typhoid fever, a common and sometimes fatal infection of both adults and children that causes bacteremia and inflammatory destruction of the intestine and other organs, is endemic in countries, especially throughout Asia and Africa [1]. Chloramphenicol has been the treatment of choice for typhoid fever for 40 years, but the widespread emergence of multi-drug resistant *Salmonella typhi* (resistant to ampicillin, chloramphenicol, and trimethoprim-sulfamethoxazole) has necessitated the search for other therapeutic options [2]. Currently ciprofloxacin is the drug of choice in the treatment of enteric fever in Ghana. Alternatives such as azithromycin and ceftriazone are also recommended [3].

Typhoid fever, caused by the bacterium *Salmonella enterica* serovar typhi (*S. typhi*),has become rare in industrialized countries, yet it remains a major cause of enteric disease in children in developing countries [1], resulting in an estimated incidence of 50 cases per 100,000 persons per year, predominantly in young school-age children [4]. Globally, it is estimated that typhoid accounts for 16 million cases each year, resulting in over 600,000 deaths [5]. Typhoid fever therefore continues to be a public health problem in sub-Saharan Africa. The disease is common in developing countries and concomitant with poor public health and low socio economic indices [6]. Residents of poor communities lacking good water and sanitation system are those mostly affected. It is estimated that a total of 400,000 cases occur annually in Africa, with an incidence of 50 per 100,000 persons per year [7,8].

- In Sub-Saharan Africa invasive nontyphoidal salmonella (NTS) is also a major cause of bacteremia in adults and children; with an estimated occurrence of 175-388 cases per 100,000 in children and 200-7500 cases per 100,000 in HIV infected adults annually. In Ghana, typhoid fever ranks among the leading 20 causes of outpatient illness, accounting for 0.92 % of hospital admissions [9].

It is estimated that over 80 % of people in developing countries use herbal medicines for their primary healthcare [10]. As much as 70% of Ghana's population is estimated to rely on traditional medicine for their primary healthcare [11]. Correspondingly, majority of patients in Ghana patronize herbal medicines for the treatment of typhoid fever, hence the availability of a wide range of herbal medicines used in the treatment of typhoid fever. Concomitantly, these same medicines are very often used to treat other common ailments such as malaria, jaundice etc.

The widespread patronage of these herbal medicines explains the high rate of advertisements of these products on radio, television and other social media. There is an estimation of one traditional medicine practitioner for every 400 people, compared with one allopathic doctor for every 12,000 people [11].

Apparently, majority of the people patronize herbal medicines for the management of various disease conditions [11]. Most of the herbal preparations are produced and marketed by traditional medicine practitioners, they therefore have to be recommended for providing healthcare to Ghanaian indigenes long before the advent of modern medicine. This study therefore sought to determine the various types of herbal medicinal formulations used in the treatment of typhoid fever on the Ghanaian market and appraises these products via their product labels.

2. METHODS

2.1 Drug Collection

Between the periods of January – March of 2016, fifteen Pharmacies and six Herbal Medicines Retail Shops within the Ga East Municipality in the Greater Accra Region of Ghana were visited; and all herbal medicines indicated for the treatment of typhoid fever were purchased. Only herbal medicines that had Food and Drugs Authority of Ghana registration numbers were bought. Those without registration numbers were however noted. Sampling was stopped when no new anti-typhoid formulations were being found.

2.2 Sampling Site

All the herbal products were collected from Haatso, Dome and Ashongman communities, located within the Ga East Municipality of the Greater Accra Region of Ghana (5° 44′ 17″ N, 0° 11′ 42″ W5.738056, -0.195). According to the Ghana Statistical Service, 2010 Population and Housing Census on the Ga East Municipality, it is located at the northern part of the Greater Accra Region and covers a land area of about 85.7 square kilometers. The population is almost 148,000. Males constitute 49% and females represent 51%. It has 40.3% of the population below 20 years. The population density of the Ga Municipal area stands at 1,725 persons per square kilometer. Households in the Municipal Area are more of extended family (56.2%) than nuclear family (43.8%). Almost 97.5 % of the population in the Municipal Area is Ghanaians. Nearly 60% are literate. Of the employed population, 35.1% are engaged as service and sales workers while 22.6% are craft workers and traders [12].

2.3 Appraisal of Product Labels

The products were given unique identification codes and were appraised with regard to contents on their labels. Information used to assess the product labels included the presence or absence of Food and Drugs Authority of Ghana registration numbers, place of manufacture, type of formulation (solid or liquid), the plant and/or non-plant constituents present, the adult dosage per day, the various indications and duration of treatment, and their contraindications. Data were analyzed in Microsoft Excel and have been presented as graphs. The acceptable scientific names of the active plants constituents as stated on the product labels were determined by searching in online taxonomic sources such as The Plant List (TPL) (http://www.theplantlist.org/) and the International Plant Name Index (www.ipni.org).

3. RESULTS

Of all the anti-typhoidal finished formulations sampled from the market, most had been registered by the Food and Drugs Authority of Ghana, and this was indicated by the presence of registered numbers on the products. Fig. 1, displays the percentage of products that had Food and Drugs Authority of Ghana registered numbers and those that did not have them.

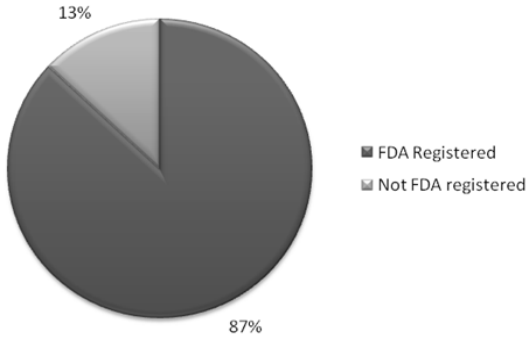

Fig. 1. Proportion of Anti-typhoidal herbal medicinal products sold within the Ga East Municipality having Food and Drugs Authority of Ghana registration numbers and those that did not have, as percentages of the number of products (n = 16)

The cost of these herbal preparations ranged from 7 to 15 Ghana Cedis, with an average cost of 10 Ghana Cedis per product. All the herbal preparations were formulated as liquid decoctions, ranging from 180 mL to 1000 mL volumes. The adult daily doses on these products ranged from 45 mL to 300 mL; with an average volume of 157 mL to be consumed daily. Measurements of the daily doses were stated as tablespoonfuls, millilitres or in most instances a

combination of both tablespoonfuls and millilitres. Fig. 2 summarizes the percentage of products labeled as such.

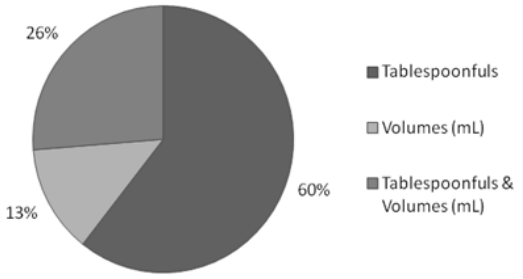

Fig. 2. Measurement of doses of anti-typhoid herbal formulations; tablespoonfuls, volumes (mL) or stated as both tablespoonfuls and volumes (mL). Results are presented as percentages of the total number of products (n = 16)

All the products encountered on the market were locally manufactured within the country (Ghana), with 71 % manufactured in Accra and the other 19 % manufactured within the Ashanti Region of Ghana.

The duration of treatment as indicated on the product label ranged from one to three weeks. The duration of treatment was not stated on 38% of the products. The herbal preparations sold for the treatment of typhoid were in all cases simultaneously used to treat at least one other disease condition, namely malaria, jaundice, pains (body pains, menstrual pains and headache), fatigue and stress. Fig. 3 displays the percentages of these products that were indicated for the simultaneous treatment of particular conditions. On 56% of the products, indications for the treatment of malaria were also made, while on 31% of the products, treatment of jaundice was also recommended.

An assessment of the contraindications for these products showed that all the products were contraindicated in pregnancy, lactating mothers and children below either 6 yrs or 12 yrs of age. No other groups of people were indicated as being contraindicated.

On all the products, the active components were stated to be plant extracts. No artificial constituents or excipients in the form of preservatives, flavours or sweeteners were indicated to be present.

The number of different plant species used to formulate these products ranged from two to twelve different plants. The products contained an average of four different plants species per formulation. Fig. 4 displays a breakdown of the percentage of products containing the different number of plant species. Some particular plant species were identified to be present in a number of these formulated products while others were unique to only one product. Table 1 contains the various plant species identified in the herbal preparations. A total of 39 plant species belonging to 25 families were identified to be used for the formulation of herbal medicines used for the treatment of typhoid fever in Ghana.

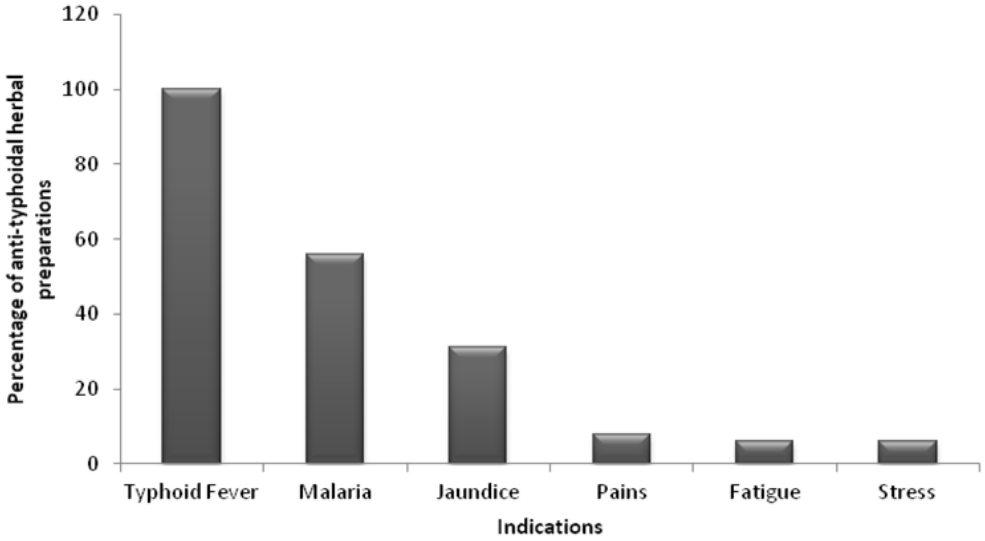

Fig. 3. Indications for which anti-typhoidal herbal medicinal preparations were recommended

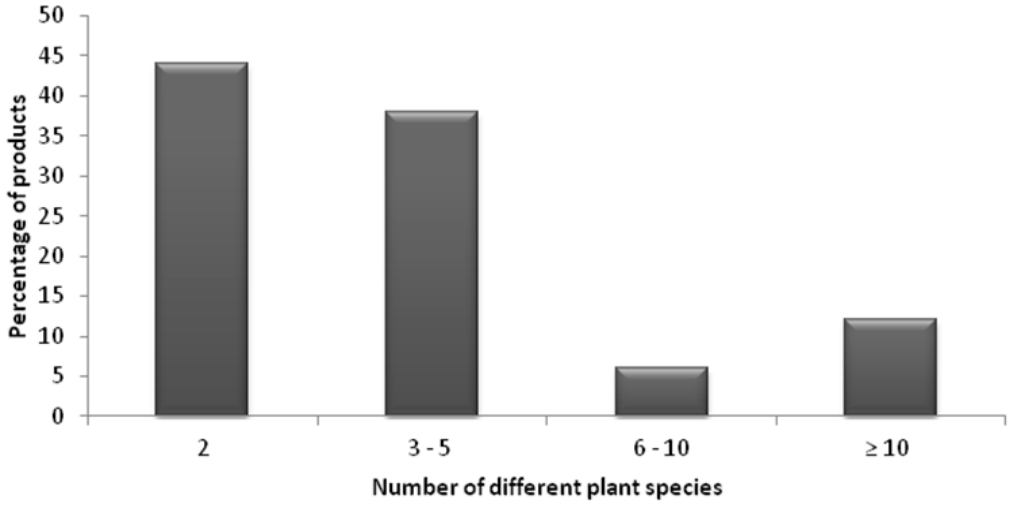

Fig. 4. Distribution of number of plant species in products

Table 1. Active plant constituents in anti-typhoid herbal medicinal formulations. Group I (very frequently occurring plant species, recorded more than 3 - 6 times on the products) and Group II (less frequently occurring plant species, recorded 1-2 times on the products)

Group I	
Carica papaya L. (family Caricaceae)	*Morinda lucida Benth. (family Rubiaceae)*
Citrus aurantifolia (family Rutaceae)	*Vernonia amygdalina Delile. (family Compositae)*
Azadirachta indica A. Juss (family Meliaceae)	*Cassia alata L.(family Caesalpiniaceae)*
Khaya senegalensis (Desv.) A. Juss (family Meliaceae)	*Momordica charantia L. (family Curcubitaceae)*
Group II	
Persea americana Mill. (family Lauraceae)	*Cocos nucifera L. (family Araceae)*
Phyllanthus fratenus G.L. Webster (family Phyllantiaceae)	*Khaya ivorensis A. Cheo (family Meliaceae)*
Trema orientalis L. Blume (family Cannabeceae)	*Cryptolepis sanguinolenta (Lindl.) Schltr (family Apocynaceae)*
Psidium guajava L. (family Myrtaceae)	*Cymbopogon citrates DC. (family Apocynaceae)*
Pycnanthus angolensis (Welw.) Warb, (family Myristicaceae)	*Lantana camara L. (family Verbanaceae)*
Rauwolfia vomitoria Afzel (family Anarcadiaceae)	*Mangifera indica L. (family Anarcadiaceae)*
Spondiasis mombin L.(family Anacardiaceae)	*Cassia sieberiana DC. (family Leguminosae)*
Carapa procera DC. (family Meliaceae)	*Nauclea latifolia Sm. (family Rubiaceae)*
Bidens pilosa L. (family Asteraceae)	*Paullinia pinnata (family Sapindaceae)*
Alstonia boonei De Wild (family Apocynaceae)	*Zingiber officinale Roscoe (family Zingiberaceae)*
Aloe schweinfurthii Baker (family Aloaceae)	*Cnestis ferruginea Vahl ex DC.(family Connarceae)*
Ocimum gratissimum (family Lamiaceae)	*Vitex grandifolia Gürke (family Lamiaceae)*
Cassia siamea Lam.(family Caesalpiniaceae)	*Anthocleista nobilis G. Don (family Gentianaceae)*

Several errors in the names of the active plant constituents were discovered. A number of plant names on the product labels could not be readily identified or were wrongly spelt. Some labels mentioned only the plant genus but failed to state the particular species. After online verification of the plant names, literature search showed that out of the 39 plants identified, anti-typhoid activity has been documented for at least 89% (32), (Table 2).

Table 2. Literature review on plants

Species	Cross-reference
Aloe schweinfurthii	No reference found.
Alstonia boonei	The ethanol extract of this plant showed better antibacterial activity than the water, methanol and hexane extracts against *S. typhi* [13].
Anthocleista nobilis G. Don	*A. nobilis is* commonly used for treating typhoid fever, amongst several other diseases in North-Central Nigeria [14].
Anthocleista vogelii	Both the ethanol and aqueous extracts of the leaves had good antibacterial effect against *S. typhi* when compared with Chloramphenicol [15].
Azadirachta indica	When the antibacterial activity of *A. indica* (Neem) was evaluated, the methanolic leaf extracts showed the highest zone of inhibition against salmonella as compared with other extracts [16].
Bidens pilosa	*B. pilosa* is part of a number of plant species traditionally used in the management of typhoid fever in the Bamboutos Division of the West Region of Cameroon [17].
Carapa procera	*C. procera* is part of the Cameroonian pharmacopeia which when evaluated against gastroenteritis-causing bacteria including *S. typhi*, the crude extracts and methanolic fractions of the leaves and bark were active against four (4) bacterial species including *S. typhi* and *S. paratyphi*. Active extracts and fractions gave MICs ranging from 2.5 to 10 mg/mL [18].
Carica papaya	The seeds of *C. papaya* are effective against *E. coli, Salmonella* and *Staphylococcus* infections, where the leaf and stem extracts have demonstrated high activities against Gram negative bacteria and Gram positive bacteria, with the highest activity demonstrated against *S. typhi*. This study therefore recommended that *C. papaya* may be used for the treatment of gastroenteritis, urethritis, otitis media, typhoid fever and wound infections [19].
Cassia alata (Senna alata)	The Bamboutos division in Cameroon uses this plant in the treatment of typhoid. This plant showed the highest zones of inhibition with diameter of 24, 22.5 and 20.5 mm against *S. paratyphi A, S. paratyphi B and S. typhi* respectively at 160 mg/mL concentration [20].
Cassia siamea (Senna siamea)	The ethanol and ethyl acetate extracts showed inhibition against *S. typhi* [21].
Cassia sieberiana	The leaves or bark are boiled in water or alcohol, and drunk over a period of time depending on the severity to treat typhoid fever [14].
Citrus aurantifolia	This plant is widely used in West Africa for its antimicrobial activity against gastrointestinal pathogens including *Salmonella* [22,23].
Cnestis ferruginea	The ethanol extracts of the stem of *C. ferruginea* demonstrated activity against various bacteria including *Salmonella*. MIC and MBC against the bacterial isolates were in the range of 3.2 – 6.3 mg/mL [24].
Cocos nucifera	*C. nucifera* mesocarp powder showed very high activity against *Salmonella typhi* [25].
Cryptolepis sanguinolenta	A 2 mg/mL each of 70% ethanol, hot and cold aqueous extract of *C. sanguinolenta* exhibited activity against *S. typhimurium,* three strains each of *Salmonella typhi* and several other microorganisms [26].
Cymbopogon citratus	*C. citrates* was documented in an ethnomedicinal survey of plants used for the treatment of typhoid fever in Ijebu Ode Local Government Area of Ogun State Nigeria [27]. It was also observed in another study to possess high antimicrobial activity against *S. typhi* [28].
Khaya senegalensis	The ethanol and aqueous extracts of the stem bark extracts of *K. senegalensis* showed activity against *S. typhi* at a concentration of 50 mg/mL with an inhibition zone of 15 mm respectively [29].
Khaya ivorensis	It was observed that when mixed with black peppercorns it can be used to treat diarrhea and dysentery. A bark concoction is used as a drink or bath for back pains and as a lotion for rheumatism [30].

Species	Cross-reference
Lantana camara	*L. camara* has activity against *S. gallinarum* with MIC starting at 5 mg/mL [31].
Mangifera indica	Aqueous extract of *M. indica* showed good anti-salmonella activity against clinical isolates of *S. typhus,* with 98.8% inhibition at 200 µg/mL concentration. IC50 required for killing Salmonella ranged from 101.3 to 800 µg/mL [32], other studies have also supported the anti-typhoid activity of this plant [33].
Momordica charantia	Marked reduction in infection level was observed in rats treated with extracts from *M. charantia* when compared to standard drugs [34].
Morinda lucida	The water and chloroform extracts of leaves of *M. lucida* has produced antibacterial effects comparable to those of standard antibiotics against *S. typhi* and other microorganism [35]. The stem bark, roots and leaves infusions are also documented to be used as an anti-dysentery [36].
Nauclea latifolia	The aqueous and alcoholic extracts of the leaves and roots of *N. latifolia* showed no appreciable inhibitory effect against *S. typhi* [37].
Ocimum gratissimum (Ocimum viride)	The steam distillation extract of *O. gratissimum* has shown activity at 0.01% against *S. typhimurium* and 0.001% against *S. typhi*. The cold water, hot water (100^{o}C), ethanol and chloroform extracts of *Ocimum gratisssimum* leaves also showed antibacterial potential against some pathogenic bacteria known to cause diaorrhoea; *Staphylococcus aureus, Escherichia coli, Shigella sp.* and *Salmonella sp*. [38,39].
Paullinia pinnata	No reference found for hypertension. This plant is however useful in traditional medicine for prophylaxis and cure of several diseases [40,41].
Persea americana	The ethyl acetate, chloroform and methanol extracts did not demonstrate pronounced activity against *S. typhi* [42].
Phylanthus fratenus	The methanol extract of the root of *P. fraternus* showed maximum antibacterial activity against *S. typhi* B with a zone of inhibition of 11 mm and minimum activity against *S. typhi* A, with a zone of inhibition of 10 mm [43].
Psidium guajava	The administration of 10-30 mg/100g of the aqueous extract of *P. guajava* to *S. typhi* infected rats over 12 h through the oral route produced a recovery within seven days [44].
Pycnanthus angolensis	Methanol leaf extract caused inhibition against *Salmonella* [45].
Rauwolfia vomitoria	*R. vomitoria* has a lot of medical potential in curing and preventing ailments including typhoid [46].
Spondiasis mombin	The aqueous and organic solvent extracts of fresh leaves of *S. mombin* exhibited anti-microbial activity against *S. typhi* [47].
Trema orientalis	Ethnomedicinal studies on *Trema orientalis* Linn. Blume (Ulmaceae) have shown that it is used by traditional practitioners to treat several ailments viz. diabetes mellitus, respiratory diseases, oliguria, and malaria [48,49].
Vernonia amygdalina	Aqueous, ethanol and acetone extracts of *V. amygdalina* leaf, stem and roots were tested at a concentration of 100 mg/mL against antibiotic-resistant *Salmonella* species. Aqueous extracts of the leaf, stem and roots showed no activity against antibiotic resistant *Salmonella* isolate, while the ethanol and acetone extracts showed activity rates of 20% and 17% for roots, 14.3% and 12.9% for stem, and, 15.7% and 11.4% for leaf [44]. The anti-Salmonella activity has been further confirmed by the ethanolic extract [50,51].
Vitex grandifolia	Ethanol extracts demonstrated broad spectrum antibacterial activity against Salmonella [52].
Zingiber officinale	Soybean oil extract of ginger showed high zone of inhibition (11.67±1.53 mm) against *Salmonella* spp [53]

4. DISCUSSION

The wide spread use of herbal medicines in the treatment of typhoid in Ghana gives a little indication of how widespread herbal medicines are used in Ghana. An estimated 80 % of rural villagers in southern Ghana rely on plants as their main medicinal source [54]. The widespread use of herbal medicines in the coastal areas of Ghana, which includes Accra is attributed to

rapid urbanization in an area with a high level of endemic plant taxa and a population heavily dependent on herbal medicines for their primary health care [55].

The fact that all these products were manufactured locally could be indications of how traditional herbal medicines are widely used within this area and the widespread belief in the efficacy of these herbs. This may also indicate the high level of patronage of these products and the availability of the various plant species used in the production of these products. All the products were formulated as liquid decoctions. This could be indicative of probably the preference for liquid formulation by the consumers or as a result of the manufacturers lacking sophisticated techniques to produce the other dosage forms. Most manufacturers of herbal medicines in Ghana are believed to be small to medium scale businesses.

The daily dosage of these products ranged from 45 to 300 mL. These daily volumes are quite high, and may be an indication that the products can be better formulated so that the daily doses are smaller in volumes. This may require standardization of the preparation to increase the concentration of the active ingredients in the final products resulting in improvements in the quality [56]. This will result in a decrease in the final product volumes which currently ranges from 180 – 1000 mL. Only two out of the 16 products provided measuring cups. A lack of standardized measuring instruments will promote inaccurate measurement of the medicines. Measuring spoons and cups can probably be included in all the products and the dosage stated in millilitres to enhance accurate measurement of doses [57].

The cost of these herbal preparations ranged from 7 to 15 Ghana Cedis, with an average cost of 10 Ghana Cedis per product. It is generally believed that herbal medicines are inexpensive [58], however, for most of these products more than one bottle of medication will need to be taken before one can complete the recommended duration of treatment. Hence a critical cost analysis will need to be made to really determine whether the costs of these herbal preparations are lower or higher when compared with the available alternative orthodox drugs such as ciprofloxacin which is the drug of choice for treating typhoid in Ghana [3].

The duration of treatment as indicated on the product labels ranged from one to three weeks. On 38 % of the products, the duration of treatment was not stated at all. This puts the patient at a high risk of either under dosage or over dosage of the medicine. Under dosage could lead to treatment failure and over dosage may increase the chance of toxicity. An assessment of the duration of treatment and the daily dosage showed that majority of these products will need more than one product to be able to complete the recommended duration of treatment.

The anti-typhoid herbal formulations were simultaneously used for the treatment of malaria, jaundice, pains (body pains, menstrual pains and headache), fatigue and stress. A lot of Ghanaians accept that one herbal medicine could be the cure for many ailments and this notion may be the reason for which high numbers of plant species (up to 12) is found in each formulation. An average of 4 different plant species were used in formulating these products. The inclusion of several plants could mean that the products were probably formulated to multipurposely treat several ailments. Some plants on their own are also multi-purpose medicinal plants [59]. *Azadirachta indica* [54], *Vernonia amygdalina* [60], *Momordica charantia* [61] etc., are all plants documented to have multipurpose medicinal actions and available in these preparations.

The presence of a wide range of plant species [40] give a snapshot of the country's medicinal flora and, reflect the concerns about health and illness and the importance of traditional medicine among Ghanaians [62]. However, mistakes in the names of the plant species will need to be critically checked to aid in correct identification of the components.

In Ghana, typhoid fever ranks among the leading 20 causes of outpatient illness, accounting for 0.92% of hospital admissions [9]. Malaria on the other hand remains hyper endemic in Ghana and is the single most important cause of mortality and morbidity especially among children under five years, pregnant women and the poor [63]. These are therefore two prevalent infections in Ghana. The rationale to combine several active plants extracts is in itself not a bad idea since some plant species may also have been combined in these preparations to enable the individual components work synergistically to increase the overall effectiveness of the preparation. In traditional medicine, whole plant extracts or mixtures of plants are used rather than isolated compounds. There is the evidence that some

crude plant extracts have greater *in vitro* or/and *in vivo* activities than isolated constituents at an equivalent dose [64]. Studies will however have to be conducted on these herbal formulations to ascertain stability of the active components, physical and chemical interactions between the various components, and safety in consuming such high numbers of different extracts (compounds). On the average, each plant extract may contain several of chemical compounds.

From another perspective, these plants extracts may be combined because the manufacturers may have very little or no clue as to the active components of the extracts. It may therefore be recommended that bioactivity-guided isolation and characterization be performed on these formulations to identify the possible active plant fractions or compounds. This will result in the exclusion of unnecessary or harmful compounds or fractions from the formulation. This will make the resulting formulation safer for consumers to use and even more effective in the treatment of typhoid due to higher concentrations of the active ingredients.

An assessment of the contraindications showed that all the products were contraindicated in pregnancy, lactating mothers and children below either 6 yrs or 12 yrs old. This is very useful in preventing possible toxicity in such vulnerable groups since very little or no toxicity studies may have been conducted in these sensitive groups of patients to ascertain the product safety. However due to the wide patronage of these products, both acute and chronic toxicity studies may need to be conducted in other groups of patients. This will also ascertain the safety of these products when used in other co-morbid conditions and age groups.

No artificial constituents whether in the form of active constituents and inactive constituents such as preservatives, flavours or sweeteners were indicated to be present in the products. This may raise the question as to whether the components of these formulations are anti-microbially active enough to preserve the products for their respective shelf lives and during the usage period. All the products were aqueous based and hence the high concentration of water makes them very prone to microbiological contamination not to mention the high incidence of the presence of several microbial pathogens in herbal products and their toxins [65].

A literature search performed on documented anti-typhoid activity of the plants used in formulating these preparations such as (*Carica papaya* [66], *Vernonia amygdalina* [67-69], *Morinda lucida* [35,36], *Azadirachter indica* [16] and *Citrus aurantifolia* [23] etc.) showed that their inclusion as active ingredients may be well justified.

A further literature search on the phytochemical constituents of the plants with the highest frequency *Carica papaya*, *Morinda lucida*, *Citrus aurantifolia*, *Vernonia amygdalina*, *Azadirachta indica*, *Khaya senegalensis*, *Cassia alata* and *Momordica charantia* (Group I, Table 1) showed that all the 8 plants contained flavonoids, while 7 contained alkaloids, 6 out of the eight plants contained tannins, saponins and glycosides as secondary metabolites [70-77]. The antityphoid activity may well be due to the presence of these phytoconstituents, but further studies may need to be done to ascertain this.

5. CONCLUSIONS

The active plant components of the anti-typhoidal formulations seem to be well justified and probably indicate that the resulting products could be highly active. The labeling of these products can also be improved in respect of the names of the active components and directive for dosage. Improvement can also be made in terms of formulation of the products to reduce the daily dosage and product volumes.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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