



Re-thinking Metronidazole: Anti-microbial Synergism of Hexane Extracts of *Garcinia kola* and *Aframomum melegueta*

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Authors' contributions

This work was carried out in collaboration among all authors. Author JIO designed the study and corrected final manuscript. Author AB performed the experiments in the Laboratory and wrote the first draft. Author MS performed the experiments in the laboratory, carried out the statistical analysis and wrote the first draft of the manuscript. Author MOI wrote the laboratory protocols, also corrected final manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This research evaluates knowledge, attitudes, and practice with regard to food poisoning treatment. It compares the antimicrobial effects of *Garcinia kola* (*Gk*) and *Aframomum melegueta* (*Am*) seeds with Metronidazole and Gentamicin as standards.

Study Design: A survey with questionnaires was carried out among community Pharmacists in Lagos, Nigeria on drug of choice for suspected food poisoning and the responses analyzed. Hexane extracts of *Gk* and *Am* seeds were used on selected microbials that cause food poisoning.

Place and Duration of Study: Department of Pharmacognosy; Phytochemistry Laboratory and Department of Pharmaceutics and Pharmaceutical Technology; Pharmaceutical Microbiology Laboratory, Faculty of Pharmacy. University of Lagos.

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Methodology: Agar diffusion assays were carried out using and using *Gk* and *Am* with Metronidazole and Gentamicin as controls. Gas chromatography and Mass spectroscopy of the extracts was also carried out to ascertain the possible active phytocomponents.

Results: Our discovery on knowledge showed that 98.6% of the interviewed Pharmacists use Metronidazole for food poisoning treatment. 41.7% of the respondents prescribe Ciprofloxacin while 66.7% prescribed Tetracycline as adjunct medications. *Gk* and *Am* exerted powerful anti-microbial effects in a dose dependent manner. *Gk* on *S. typhi* showed 1.4-1.7 cm zone of inhibition (zi) at 200mg/ml and with *E. coli*, 1.2 cm at same concentration. *Am* with *S. typhi* showed 1.2-1.8 cm and *E. coli* 1.5 cm zi at same concentration too, much better than *Gk*. Their mixture for the synergistic experiments had 2.0-2.2 cm and *E. coli*, 2.4 cm zi at 200 mg/ml, the best performance of the extracts as anti-infective agents against food poisoning. 19 compounds were discovered through GC/MS in *Gk* and 31 in *Am*. They each exerted more antimicrobial effects than Metronidazole and their mixture used for synergistic experiments compared favorably with Gentamicin.

Conclusion: Hexane extracts of *Gk* and *Am* are good alternatives for the treatment of food poisoning. The study encourages further drug discovery research in order to ascertain the particular bioactive compounds in the extracts responsible for their powerful antimicrobial actions. Metronidazole is not the drug of choice for food poisoning management.

Keywords: *Aframomum melegueta*; *Garcinia kola*; Gas chromatography; Herbal medicine and Metronidazole.

1. INTRODUCTION

Food poisoning is defined as an illness caused by the consumption of food or water contaminated with bacteria and/or their toxins, or with parasites, viruses, or chemicals [1]. Food-borne diseases (FBDs) constitute a serious public health problem worldwide. There is an estimated 2 million deaths in children worldwide [2,3,4]. However, bacteria related food poisoning is the most common, but less than 20 of the many thousands of different bacteria actually are the culprits. More than 90 percent of the cases of food poisoning each year are caused by *Staphylococcus aureus*, *Salmonella*, *Clostridium perfringens*, *Campylobacter*, *Listeria monocytogenes*, *Vibrio parahaemolyticus*, *Bacillus cereus*, and Enteropathogenic *Escherichia coli*, *Proteus*. Yeasts have also been reported as contaminants from reuse of rubber bags [5]. These bacteria are commonly found on raw foods like salads, eggs, beef, vegetables, cheese, ice cream, unpasteurized milk, fish, fresh fruits, canned foods, mushrooms etc.[6,7]. Incubation periods of the various organisms causing food poisoning differ. Normally a large number of food-poisoning bacteria must be present to cause illness. There is neither racial, age nor sex predilection noted. However, some researchers have reported outbreaks of food poison involving specific group of bacteria in some areas. This depends on the source of food and method of food preparation which of course might be culture determined. In developing countries, street vending of foods is common

because it offers inexpensive foods at convenient locations. In contrast to their potential benefits, concerns over the safety and quality of these foods have been raised, because the vendors lack appreciation of basic food safety issues. A number of data confirmed the fact that *S. aureus* causes many outbreaks of food poisoning resulting from hand contact. As reported by [8] 86% of meat products, 13% of cowpea-based food products and 55% of fish products from part of eastern Nigeria were contaminated with *S. aureus*. Antimicrobial resistance associated with food and water has been a global concern [9]. It is now widely accepted that there is an association between the use of antimicrobial agents and the occurrence of resistance. Metronidazole, is largely used for food poisoning cases and it is largely ineffective. Antimicrobials exert a selective pressure on microorganisms that acts as a driving force in the development of antibiotic resistance and therefore their use is considered a key issue in epidemiological studies. Moreover, there remains the possibility that resistance may be transmitted from antibiotic resistant bacteria to the susceptible ones [4,10]. Multidrug resistant pathogens travel not only locally but also globally, with newly introduced pathogens spreading rapidly in susceptible hosts. Antimicrobial resistant bacteria in foods threaten the efficacy of human drugs if antimicrobial resistance genes become incorporated into human bacterial populations [11]. Surveillance of antimicrobial resistance is essential for providing information on the interventions, especially because the prevalence of resistance may vary

widely between and within countries and over time. Bitter kola (*Garcinia kola*) and Alligator pepper (*Aframomum melegueta*) are edible seeds widely consumed in the locality and there have been speculations that these plant products after consumption has beneficial effect in alleviating the symptoms of food poisoning but there is no scientific proof (Figs. 1,2). It is equally interesting that the seeds are usually shared at festivals where food can be cross contaminated.

The incidence of food poisoning is becoming severe in the society and the antibiotic of choice for most medical personnel is not effective maybe due to microbial drug resistance. In recent times, edible plants have increasingly become attractive alternatives to prevent or treat various types of diseases because of easy availability, accessibility, and affordability.

Modern medicines have always depended on herbal extracts from plants as fundamental source of therapeutic ingredients. Some naturally occurring substances in plants play significant role in plant disease resistance and thus most bacteria are sensitive to extract from these plants. Plants are pools of potential antimicrobial compounds for pharmaceutical need. The array of active compounds derived from them have impressive pharmaceutical properties such as analgesics, aesthetic, antibiotics, anti-parasitic, anti-inflammatory, oral contraceptive, hormones, ulcer therapeutic laxative. Seeds, herbs, vegetables, bark, roots accumulate in their cells a great variety of Phytochemical compounds such as alkaloids, tannins, saponins, phenolic compounds [4,12]. The aim of this research is to

evaluate antimicrobial effects of hexane extracts of Am and Gk seeds on known clinical bacteria isolates. Also to assess knowledge, attitudes, and practice with regard to food poisoning diseases' treatment among community Pharmacists in Lagos state, Nigeria and to investigate the individual and synergistic effect of hexane extract Am and Gk seeds on some selected bacteria that cause food poisoning (*Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis*, *Shigella* spp., *Salmonella typhi*).

2. MATERIALS AND METHODS

2.1 Materials

Am and Gk were purchased from Dubge market in Oyo state, Nigeria. Am has voucher number FHI 108876 while Gk was authenticated by Mr Oyebanji Oyetola of the Department of Botany, University of Lagos, Akoka, and assigned a voucher specimen number Lagos LUH 3688. *Garcinia kola* Heckel was checked in Plant list with the original publication details [13] while that of *Aframomum melegueta* K.Schum is in [14].

Gentamicin injections (80 mg/2ml) (Laborate Pharmaceutical, India), Metronidazole reference standard in peptone water (Acumedia, England), N-hexane, Tween 80, Tween 20, Nutrient broth, Nutrient agar, Muller Hinton agar, Eosin methylene blue agar, Salmonella shigella agar. Microorganisms were obtained from food samples left as cultures of the microbes and later each was isolated and cultured on specific media.



Fig. 1. *Aframomum melegueta* (Am) seed pods Fig. 2. *Garcinia kola* (Gk) seeds

2.2 Methods

N-hexane extraction of dried and powdered seeds of *Gk* and *Am*, Soxhlet extraction was carried out using powdered samples in analytical N-hexane (100%) for 4-5 h. They were concentrated using the Soxhlet apparatus. The different samples were collected in different sterile brown bottles and stored until needed.

Both extracts were used at different concentrations of 50 mg/ml, 100 mg/ml, 150 mg/ml, 200 mg/ml and 300 mg/ml.

2.2.1 Evaluation of knowledge, attitude and treatment pattern of food poisoning by community pharmacists

One hundred copies of questionnaire were shared in Community pharmacies in Lagos Island and Mainland to evaluate the knowledge; attitude and practice of community Pharmacists in the treatment of food poisoning in community pharmacies in Lagos state, Nigeria. Seventy-two copies of the questionnaire were recovered.

2.2.2 Gas chromatography and mass spectroscopy

The Agilent Technologies 7890A GCMS machine with number G3170-80026 was used as the stationary phase respectively. The stationary phase had a length of 30 m, internal diameter of 0.32 mm and thickness 0.25mm. Temperature: 800°C per minute to hold for 2 min at a flow rate of 50 per min at a temperature of 1200°C to hold for 60 per min and 2400°C to hold for 6 min. The volume injected was 1 microliter of the oil sample.

2.2.3 Minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC)

The method used in this study for determination of inhibitory and bactericidal activity of both *Am* and *Gk* was similar to that of [14]. For minimum bactericidal concentration (MBC) determination, 10 µl was taken from each well (treated and untreated) after incubation and spot inoculated on BHI agar and incubated for 24 h at 37°C. The concentration at which no growth was observed on subculture was determined as the MBC.

2.2.4 Standardization of organism suspension

McFarland turbidity standard was used for optical density adjustment. The liquid culture was added

drop to drop to an already sterilized normal saline until the turbidity matches the turbidity of McFarland 0.5.

2.2.5 Preparation of assay medium (Muller Hinton agar)

Agar was dispersed in distilled water of specified volume, heated to melt in water bath. 25 ml of each melted agar was distributed in a universal sample bottle, covered, and autoclaved at 121°C for 15 min.

2.2.6 Inoculation/seeding of microorganisms

The assay medium could cool to 45°C (safe for assay organism). 1 ml of the calibrated organism was aseptically added. Mixed and pour plate into a petri dish, allowed to set. A well was created into the agar (cork boring) using a 6mm cork-borer.

2.2.7 Preparation of standard drug solutions (gentamicin and metronidazole)

2.2.7.1 For gentamicin

0.1 ml of Gentamicin injection (80 mg/2 ml) was measured into a volumetric flask and diluted to make 400 µg/ml by making up the volume with sterile distilled water to 10 ml (intermittent stock) and serially diluted

2.2.7.2 For metronidazole

0.05 g of Metronidazole reference standard was dissolved in about 10 ml sterile distilled water to make 5000 µg/ml solution (primary stock) and serially diluted

2.2.8 Statistical analysis

Data were expressed as means ± standard error of mean (SEM). Data obtained in the questionnaire were expressed in frequency and percentages, Pearson chi square was used to test for association between discrete variables using SPSS version 21.

Confidence limit was chosen at 95% ($P < 0.05$), 99% ($P < 0.01$) and 99.99% ($P < 0.001$)

3. RESULTS

Facts gathered from the questionnaire showed that all the respondents (Pharmacists) agreed that food poisoning is caused by bacteria, 43.1%

felt it is also caused by viruses, while 36.1% of respondents also attribute the cause of food poisoning to other forms of parasites [Fig. 3]. 52.8% of the respondents ascribed the cause of food poisoning to anaerobic bacteria, while 41.7% ascribed it to aerobic bacteria, although, some of the respondents felt the cause cuts across both [Fig. 3].

Metronidazole forms the core of the treatment of food poisoning as depicted in from this study. 98.6% of the respondents use metronidazole in the treatment of the disease [Fig. 4]. 41.7% of the respondents prescribed Ciprofloxacin while

66.7% prescribed tetracycline as adjunct medications [Fig. 4].

The GC/MS analysis revealed *Gk* had 19 compounds and *Am* had 31 which may be responsible for their effective anti-microbial actions. A selected number of compounds with bioactive effects were tables in Tables 1 and 2. *Am* had a high amount 14.47% [Table 1] of Spiro [5,6] dodecane- 1,7-dione, a known antibacterial compound [21]. And *Gk* had 2-butyl-2-ethyl-5-methyl-3,4-hexadienal; 15.69% and palmitic acid vinyl ester; 15.06% [Table 2] which may have contributed to the significant antimicrobial effects observed.

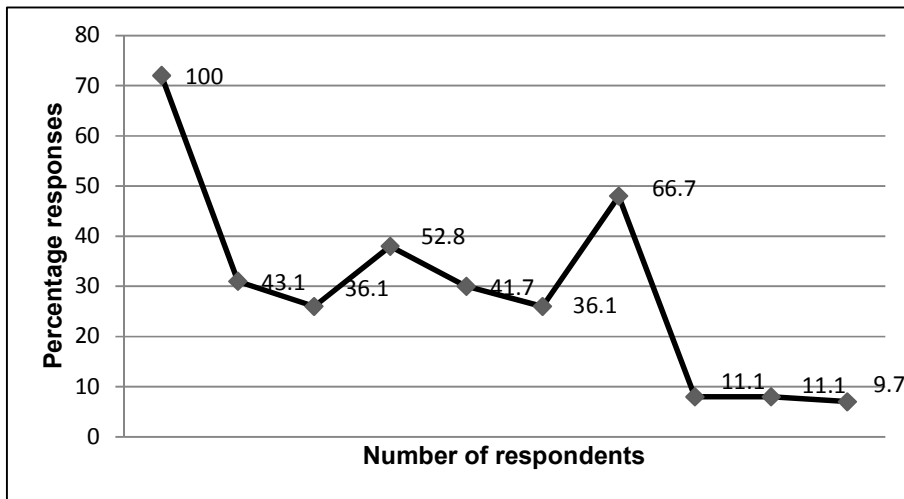


Fig. 3. Current perception of Pharmacists on microorganisms that cause food poisoning

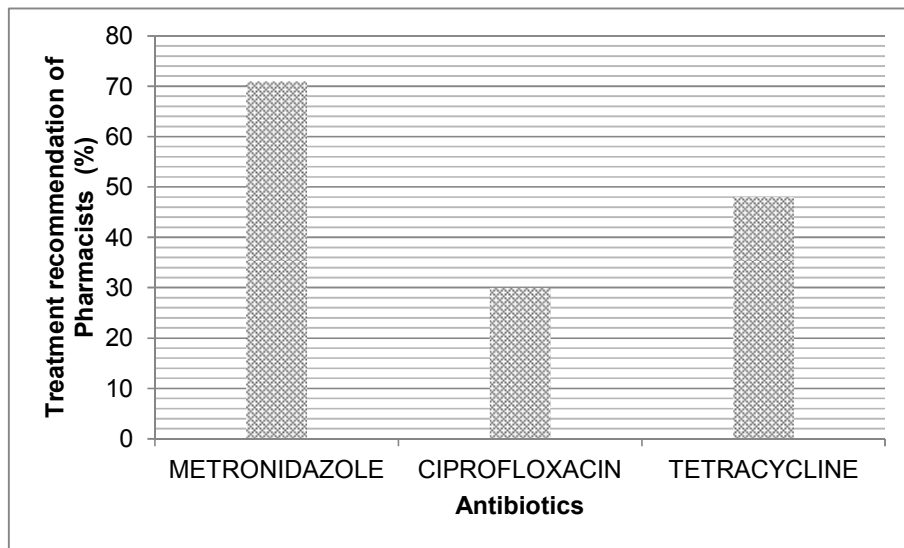


Fig. 4. Antibiotic use in the management of food poisoning

Table 1. Gas chromatography/mass spectrometry of *Am* extract showing selected compounds

Chemical Names	Retention	Reported Medicinal Uses	Total (%)
Caryophyllene	10.672	Selective agonist of cannabinoid receptor and to exert cannabimetic anti-inflammatory effects [15].	6.322
3,7,11-trimethyl-1,6,10-dodecatrien-3-ol	12.577	Bactericidal rather than bacteriostatic activity [16].	0.635
3,5-dimethylcyclohex-1-ene-4-carboxaldehyde	13.212	Aldehydes are known to possess powerful anti-microbial activity [16].	0.554
Methyl ester hexadecanoic acid	16.720	Antioxidant [17]	0.166
Methyl ester 12-octadecenoic acid	18.478	Poly saturated fatty acid already used in the clinical medicine especially in cardiology [18]	0.610
1-nonadecene	19.123	Anti-tuberculosis activity [19]	1.592
Tricosane	20.347	It has antimicrobial property [20]	0.795
Spiro[5,6]dodecane-1,7-dione	21.709	Antibacterial agents [21]	14.466

Table 2. Gas chromatography/Mass spectrometry of selected compounds from *Gk* extract

Chemical Names	Retention	Medicinal Uses	Total [%]
n-Hexadecanoic acid	17.154	n-Hexadecanoic acid has larvicidal effect, [22]	1.658
1-(4-hydroxyl-3-methoxyphenyl)-3-decanone	19.775	suppress proliferation of human cancer cells through the induction of apoptosis [23]	2.881
2,6,10,15,19,23-hexamethyl-2,6,10,14,18,22-tetracosahexaene	29.623	Strengthen the body's resistance, and improve human immunity [24].	2.438
Palmitic acid vinyl ester	36.769	Antioxidant [17]	15.063
2,6,10-trimethyl dodecane	36.924	anti-tumour activity [25]	6.889
2-butyl-2-ethyl-5-methyl-3,4-hexadienal	39.596	Powerful anti-microbial activity [16]	15.691

We ascertained from the agar diffusion assays that the oils exerted powerful anti-microbial effects in a dose dependent manner. *Gk* on *S. typhi* showed 1.4-1.7 cm zone of inhibition (zi) at 200 mg/ml and with *E. coli*, 1.2 cm at same concentration. *Am* on *S. typhi* showed 1.2-1.8 cm better than *Gk* and on *E. coli* 1.5 cm (zi) at same concentration too, much better than *Gk* again. Their mixture showed 2.0-2.4 cm on *E. coli*, 2.4 cm (zi) at 200 mg/ml, the best performance of the oils as anti-infective agents against food poisoning.

Metronidazole did not kill any of the test microorganisms as proven by the zero area of inhibition observed from the tests [Table 3]. *Gk* compared to Gentamicin, the standard drug for food poisoning management showed significant results on *B. subtilis* but not on *E.coli*, *S. aureus* and *S. typhi* [Table 4] while *Am* also achieved

significant inhibition on application of the oils [Table 4]. *Am* showed significant microbe inhibition in a dose dependent manner too [Table 5] on *B. sub* but not on *E. coli*, *S. aureus* and *S. typhi*.

The combination of *Am* and *Gk* at different concentrations [Table 6] shows what appears to be a potentiation of antimicrobial effects on *B. subtilis* and *S. aureus* in a dose dependent manner. The Minimum Inhibitory Concentration: (MIC) Table 7 showed *Am* with 0.4 mg/ml on *B. subtilis*. *Gk* showed 0.8 mg/ml on *S. aureus*, same as the mixture of the two extracts. The Minimum Bactericidal Concentration (MBC). of the extracts [Table 8] showed *Gk* on *S. aureus* to be 3.2 mg/ml, *Am* on *B. subtilis* is 12.8 mg/ml, *Am+Gk* on *S. aureus* is 12.8 mg/ml and *Am+Gk* on *B. subtilis* is 6.4 mg/ml.

Table 3. Antimicrobial activities of extracts expressed in means of zones of inhibition

Concentration (mg/ml)	Zones of inhibition (cm)						
	<i>GK extract</i>		<i>Am extract</i>		<i>GK + Am</i>		<i>Metronidazole</i>
	<i>Salmonella typhi</i>	<i>Escherichia coli</i>	<i>Salmonella typhi</i>	<i>Escherichia coli</i>	<i>Salmonella typhi</i>	<i>Escherichia coli</i>	<i>Both organisms</i>
200	1.7	1.2	1.8	1.5	2.1	2.2	-
200	1.2	1.1	1.6	1.4	2.2	2.4	-
200	1.0	1.2			1.6	2.0	-
100	1.2	0.9	1.5	1.2	1.8	1.9	-
100	1.0	0.8	1.4	1.3	1.8	2.0	-
100	0.8	0.9			1.3	1.8	-
50	-	-	1.3	1.0	1.3	1.6	-
50	0.8	-	1.2	1.0	1.0	1.6	-
50	-	0.6			1.2	1.5	-

Table 4. Comparison of the inhibition of food poisoning-causing microbes by gentamicin and Gk

Organisms	Gentamicin 50 ug/ml	Gk 300 mg/ml	Gk 150 mg/ml
<i>B. subtilis</i>	18.17±0.17	19.33±0.17a	12.33±0.17b
<i>Shigella</i>	13.83±0.17	-	-
<i>E. coli</i>	17.67±0.17	-	-
<i>S. aureus</i>	16±1.0	-	-
<i>S. typhi</i>	-	-	-

All values expressed as Mean±SEM. a represents significant increased inhibition of *Bacillus sub* by Gk (300mg/ml) when compared to Gentamicin (50ug/ml), P=0.01 b represents significant decreased inhibition of *B. subtilis* by Gk (150mg/ml) when compared to Gentamicin (50ug/ml), P<0.01

Table 5. Comparison of the inhibition of food poisoning causing microbes by gentamicin and Am

Organisms	Gentamicin 50 µg/ml	Am 200 mg/ml	Am 150 mg/ml	Am 100 mg/ml
<i>B. subtilis</i>	18.17±0.17	11.17±0.17 ^c	9.83±0.17 ^d	8.5 ^d
<i>E. coli</i>	17.67±0.17	-	-	-
<i>S. aureus</i>	16±1.0	-	-	-
<i>S. typhi</i>	-	-	-	-

All values are expressed as Mean±SEM. ^c and ^d represent significant inhibition of *B. subtilis* by Am when compared to Gentamicin (50ug/ml), P<0.01 and P<0.001.

Table 6. Comparison of the inhibition of food poisoning causing microbes by gentamicin and Am and Gk

Organisms	Gentamicin 50ug/ml	Am + Gk [50:50]	Am+Gk [25:75]	Am+Gk [12.5:87.5]
<i>B. subtilis</i>	18.17±0.17	20.33±0.17 ^a	14.03±0.03 ^b	9.17±0.17 ^c
<i>Shigella</i>	13.83±0.17	-	-	-
<i>E. coli</i>	17.67±0.17	-	-	-
<i>S. aureus</i>	16±1.0	15.2±0.2 ^d	18.17±0.17 ^e	-
<i>S. typhi</i>	-	-	-	-

^a represents significant increased inhibition of *B. subtilis* by Am + Gk [50:50] ^b and ^c represent significant inhibition of *B. subtilis* by Am+Gk [25:75] and ^c represent significant inhibition of *B. subtilis* by Am+Gk [12.5:87.5] ^d represents significant increased inhibition of *S. aureus* by Am + Gk [50:50] and ^e represent significant inhibition of Am+Gk [25:75] when all are compared to Gentamicin (50ug/ml), P<0.01 and P<0.001

Table 7. Minimum inhibitory concentration (MIC)

Conc. (mg/ml)	0.1	0.2	0.4	0.8	1.6	3.2	6.4
Gk on <i>S. aureus</i>	+	+	+	-	-	-	-
Am on <i>B. subtilis</i>	+	+	-	-	-	-	-
Am+Gk on <i>S. aureus</i>	+	+	+	-	-	-	-
Am+Gk on <i>B. subtilis</i>	+	+	-	-	-	-	-

+ = presence of growth - = No growth

Table 8. Minimum bactericidal concentration (MBC)

Conc. (mg/ml)	0.4	0.8	1.6	3.2	6.4	12.8	25.6	51.2
Gk on <i>S. aureus</i>	nt	+	+	-	-	-	-	-
Am on <i>B. subtilis</i>	+	+	+	+	+	-	-	-
Am+Gk on <i>S. aureus</i>	nt	+	+	+	+	-	-	-
Am+Gk on <i>B. subtilis</i>	+	+	+	+	-	-	-	-

+ = presence of growth - = No growth nt= not tested

4. DISCUSSION

The fact that Metronidazole did not achieve zones of inhibition in this study is very worrisome considering the rate at which the drug is indiscriminately taken for food poisoning in Nigeria even in diarrheal cases that should resolve on their own. Its also on the other hand not surprising as the drug is effective against protozoa and anaerobic microorganisms but not effective on gram negative bacteria. Indiscriminate use of antibiotics has led to the emergence of drug-resistant strains which have a significant impact on patient's morbidity and mortality [26]. It is hoped that this study would lead to the development of antibacterial drugs of natural origin for the management of infections caused by the test organisms considering the significant results observed.

The antibacterial activity in the study were expressed as a measure of the diameter of the inhibition of growth in centimeters. Table 3 shows the antibacterial activity (mean zones of inhibition of the different concentrations) of Am, Gk and mixture of Gk and Am. The results of this work show that the Gk, Am and the mixture of Gk and Am had significant antibacterial property by preventing the growth of the test organisms in a dose dependent manner.

Am was most active against *S. typhi* with zones of inhibition ranging from 1.8 cm at of 200 mg/ml to 1.2 cm at 50 mg/ml. This result is similar to the work of [27] who reported that the crude extract of Gk exhibited antimicrobial activities *In vitro* against Gram negative organisms. Gk has been medicinally used as an antimicrobial for many years.

The seeds are used in the treatment of bronchitis and throat infections [28]. The antimicrobial properties of have very good antibacterial and antiviral properties [29,30,31].

The mixture of *Gk* and *Am* produced greater zone of inhibition signifying synergistic effect on the test organisms. The mixture showed better antibacterial activity against the test organisms when compared with the standard antibiotic as shown in Tables 3 and 5 comparing favorably with Gentamicin, a powerful antibiotic. To the best of knowledge, the innovation of mixing these extracts was carried out for the first time in the current research, contributing positively to the search for Lead drugs to be used as antibiotics to combat the current drug resistance issue.

The MIC, and MBC suggest that the extracts are good candidates for broad spectrum antibiotics.

From these observations, *Gk* extract, *Am* extract and their mixture compared favorably with the standard antibiotic; Gentamicin. The broad spectrum of activity displayed by the samples in this study appears to justify and explain the scientific basis for their uses in traditional medicine.

5. CONCLUSION

Metronidazole is not the drug of choice for food poisoning treatment and management. Hexane extracts of *Am* and *Gk* have powerful antimicrobial effects and therefore can be good alternatives for the treatment of food poisoning. The study encourages further drug discovery work to ascertain the bioactive compounds in the extracts responsible for their effective bioactivity. The extracts mixture could be further explored as solution to Methicilin resistant *S. aureus*.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Logan NA. Bacillus and relatives in foodborne illness. J Appl Microbiol. 2012; 112(3):417-429.
2. Miller MA, Sentz J, Rabaa MA, Mintz ED. Global epidemiology of infections due to *Shigella*, Salmonella serotype typhi, and enterotoxigenic *Escherichia coli*. Epidemiol. Infect. 2008;136(4):433-5.
3. Koepke R, Sobel J, Arnon SS. Global occurrence of infant botulism; 1976-2006. Pediatrics. 2008;122(1):73-82.
4. Ullah F, Ayaz M, Sadiq A, Ullah F, Hussain I, Shahid M, Yessimbekov Z, Adhikari-Devkota A, Devkota HP. Potential role of Plant extracts and phytochemicals against

- foodborne pathogens. Appl. Sci. 2020;10: 4597.
5. World Health Organization. Informe Estimación de la carga mundial de las enfermedades de transmisión alimentaria. Ginebra [Internet]; 2015. [Updated: 2017]. Available: <http://www.who.int/mediacentre/news/releases/2015/foodborne-disease-estimates/es/> [Accessed: July, 2020]
 6. Noah N. Food poisoning from raw fruit and vegetables. Introduction. Epidemiol Infect. 2009;137(3):305-6.
 7. Ilomuanya, M. O., Mbaneme N. A., Okubanjo O.O., Ofokansi, K.C. (2015) In vitro equivalence studies / comparative assessment of generic metronidazole tablets commercially available in Lagos, Nigeria. British Journal of Pharmaceutical Research 2015; 7(3): 196-205 DOI : 10.9734/BJPR/2015/18572
 8. Kumar HS, Parvathi A, Karunasagar I. Prevalence and antibiotic resistance of *Escherichia coli* in tropical seafood. World J. Microbiol. Biotechnol. 2005;21:619-623.
 9. Kessie GM, Ettayebi AM, Haddad AM, Shibi FJ, Al-Shammery AF, Tawfik, Al-Ahdal MN. Plasmid profiles and antibiotic resistance in coagulase negative staphylococci isolated from polluted water. J. Appl. Microbiol. 1998;84:417-422.
 10. Smith DL, Harris AD, Johnson JA, Silbergeld EK, Morris JG Jr. Animal antibiotic use has an early but important impact on the emergence of antibiotic resistance in human commensal bacteria. Proc. Nat. Acad. Sci. 2002; 99:6434-6439.
 11. Okwu DE, Phytochemicals and vitamin content of indigenous spices of South Eastern Nigeria. J. Sustain Agric. Environ. 2004;6:30-34.
 12. *Garcinia kola* Heckel. Bull. Soc. Bot. France 1883;30(150).
 13. *Aframomum melegueta* Pflanzenr. IV. 1904;46:204.
 14. Adukwu EC, Allen SC, Phillips CA, The anti-biofilm activity of lemongrass (*Cymbopogon flexuosus*) and grapefruit (*Citrus paradisi*) essential oils against five strains of *Staphylococcus aureus*. J. Appl. Microbiol. 2012;113(5):1217-27
 15. Jürg Gertsch, Marco Leonti, Stefan Raduner, Ildiko Racz, Jian-Zhong Chen, Xiang-Qun Xie, Karl-Heinz Altmann, Meliha Karsak, Andreas Zimmer. Beta-caryophyllene is a dietary cannabinoid PNAS. 2008;105:9099-9104.
 16. Muthuchelian KJ, Teijsm Binn. Raja Rajeswari N, Rama Lakshmi S. GC-MS Analysis of bioactive components from the ethanolic leaf extract of *Canthium dicoccum* (Gaertn.) Chem. Pharm. Res. 2011;3(3):792-798.
 17. Sermakkani MV, Thangapandian. GC-MS Analysis of *Cassia italica* Leaf methanol extract. Asian J. Pharma. Clin. Res. 2012; 5(2).
 18. Grzegorz Gajos, Pawel Rostoff, Anetta Undas, Wiesława Piwowarska. Effects of Polyunsaturated Omega-3 Fatty Acids on Responsiveness to Dual Antiplatelet Therapy in Patients Undergoing Percutaneous Coronary. Interven. J. Am. Col. Cardiol. 2010;55(16):1671-1678.
 19. Rukachaisirikul, Prabpai S, Kongsaree P, Suksamrarn A. (+)-Bornyl piperate, a new monoterpene ester from *Piperaff pedicellatum* roots. Chem. Pharma.I Bull. 2004;52(6):760-761
 20. Agnihotri S, Wakode S, Ali M, Essential oil of *Myrica esculenta* Buch. Ham. composition, antimicrobial and topical anti-inflammatory activities. Nat. Prod. Res. 2012;26(23):2266-9.
 21. van der Sar AM, Stockhammer OW, van der Laan C, Spaink HP, Bitter W, Meijer AH. MyD88 innate immune function in a zebrafish embryo infection model. Infect. Immun. 2006;74:2436–2441.
 22. Copping LG. Crop protection agents from nature. The Royal Society of Chemistry. 1996.
 23. Lee E, Surh YJ. Induction of apoptosis in HL-60 cells by pungent vanilloids, [6]-gingerol and [6]-paradol. Cancer Lett. 1998; 134(2):163-8.
 24. Kim Y, Ponomarenko J, Zhu Z, Tamang D, Wang P, Greenbaum J, Lundegaard, C, Sette A, Lund O, Bourne PE, Nielsen M, Peters B. Immune epitope database analysis resource. Nucleic Acids Res. 2012;40:525-30
 25. Atolani Olubunmi, Gabriel Olatunji A. "Epicuticular Wax and Volatiles of *Kigelia pinnata* Leaf Extract. Ethnobotanical Leaflets. 2010;7:10.
 26. Ilomuanya M.O., Billa N., Ifudu N. D., Igwilo C. (2017) The effect of pore size and morphology of activated charcoal prepared from midribs of *Elaeis Guineensis* on adsorption of poisons using metronidazole and *Escherichia coli* O157:H7 as a case

- study. Journal of Microscopy and Ultrastructure 5 : 32–35
<http://dx.doi.org/10.1016/j.jmau.2016.05.0>
27. Adegboye MF, Akinpelu DA, Okoh AI. The bioactive and phytochemical properties of *Garcinia kola* (Heckel) seed extract on some pathogens. Afr. J. Biotechnol. 2008; 7(21):3934-3938
28. Mboto CI, Eja ME, Adegoke AA, Iwatt GD, Asikong BE, Takon I, Udo SM, Akeh M. Phytochemical properties and antimicrobial activities of combined effect of extracts of the leaves of *Garcinia kola*, *Vernonia amygdalina* and honey on some medically important microorganisms. Afr. J. Microbiol. Res. 2009;3(9):557-559.
29. Adesuyi AO, Elumm IK, Adaramola FB, Nwokocho AGM. Nutritional and phytochemical screening of *Garcinia kola*. Adv. J. Food Sci. Technol. 2011;4(1):9-14.
30. Terashima K, Takaya Y, Niwa M. Powerful antioxidative agents based on garcinoic acid from *Garcinia kola*. Bioorganic Med. Chem. 2002;10(5):1619-1625.
31. Sermakkani M, Thangapandian V. GC-MS analysis of *Cassia italica* leaf methanol extract. Asian J. Pharma. Clin. Res. 2012; 5:(2).

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