Phytochemical Screening and Antibacterial Activity of Two Plant Extracts against Multidrug-Resistant *Stenotrophomonas maltophilia* of Clinical Origin

Agu, G. C.*[1] Agbolade, O. A.[2] Ezima, E. N.[3] Sossou, I. T.[4] Afolabi, O. T.[1] Onabanjo, M. A.[5] and Coker, M. O.[1]

1. Department of Microbiology, Faculty of Science, Olabisi Onabanjo University, P.M.B. 2002, Ago-Iwoye, Ogun State, Nigeria.
2. Department of Science Laboratory Technology, School of Science, Abraham Adesanya Polytechnic, P.M.B 1020, Ijebu-Igbo, Ogun State, Nigeria.
3. Department of Biochemistry, Faculty of Basic Medical Sciences, Obafemi Awolowo College of Health Sciences, Olabisi Onabanjo University, Sagamu, Ogun State, Nigeria.
4. Department of Medical Laboratory Sciences, Faculty of Basic Medical Sciences, Redeemers University, P.M.B. 230, Ede, Osun State, Nigeria.
5. Department of Biological Sciences, College of Science and Information Technology, Tai Solarin University of Education, Ijagun, P.M.B. 2118, Ogun State, Nigeria.

* Corresponding author: agu.georgia@oouagoiwoye.edu.ng

Abstract: New antibacterial agents are pressingly in need to combat the outgrowing incidence of bacterial resistance, which has been number one significant public health threat. The antibacterial activity and phytochemical components of *Cannabis sativa* and *Garcinia kola* against *Stenotrophomonas maltophilia* from diabetic patients with wound infection were investigated. Pure and type isolates of *S. maltophilia* (ATCC 17666) were obtained from Ogun and Lagos State hospitals, while the plants used were purchased from Ago-Iwoye market, Ogun State. Disk and agar diffusion methods were used to evaluate the antibacterial profile, and the effect of the extracts on the studied isolates, respectively. The isolates of *S. maltophilia* were resistant to all the antibiotics tested. The effect of the two extracts on the two *S. maltophilia* varied based on the plant solvent, concentration, and organisms. Ethanol extracts of *G. kola* and *C. sativa* on pure/type *S. maltophilia* had the highest diameter zones of inhibition of 24 mm/27 mm and 19 mm/22 mm at 150 mg/ml, respectively. The type isolate had the highest diameter zones of inhibition in all concentrations of the solvent extracts except for the aqueous. Minimum inhibitory and bactericidal concentration for both plants were 75 mg/ml (type isolate), 150 mg/ml (pure isolate), and 75 mg/ml for *C. Sativa* alone. Some phytochemicals such as alkaloids, flavonoids, tannins, saponins were observed in the plant extracts.In conclusion, the tested plants possess antibacterial activity, hence, could be used as substitutes in the treatment and management of *S. maltophilia* pathogens in diabetics with wound infection, and also, in the formulation of pharmaceuticals.

Key word: Antibiotics, antibacterial activity, diabetic wound infection**,** plant, extracts/phytochemicals, resistance

INTRODUCTION

Infections caused by pathogenic bacteria are a global health issue with rising mortality and morbidity (CDC, 2015). One of the examples of infections caused by these pathogenic bacteria is diabetic wound infections that frequently resulted in morbidity, hospitalization, and amputations. It has been estimated that around 15-27 % patients with diabetes require lower limb amputations, and predominantly 50 % are due to infection (Brooke, 2012). The mortality in most cases is due to most bacterial pathogens' ability to resist antimicrobials. Gram-positive cocci (especially staphylococci, streptococci), Gram-negative bacilli (*Pseudomonas aeruginosa*), and anaerobes (*Propionibacterium granulosum*) are some of the most predominant pathogens implicated in diabetic wound (Benjamin, 2004). *Stenotrophomonas maltophilia* (Xanthomonodaceae) were previously called *Pseudomonas maltophilia* (Psuedomonadaceae), and *Xanthomonas maltophilia* (Xanthomonodaceae) (Hugh and Ryschenkow, 1961; Swings *et al*., 1983). In recent times, *Stenotrophomonas maltophilia* has gained much attention due to its role as pathogenic bacteria in a quiet number of clinical symptoms. Symptoms include bacteremia, respiratory, urinary tract infections, skin and soft tissue infections,

meningitis, wound infections, conjunctivitis, endocarditis (Fisher *et al*., 1981; Robin and Janda, 1996; Denton and Kerr, 1998; Aysel *et al*., 2006).

Stenotrophomonas maltophilia, according to Karunanidhi *et al*. (2013), is an emerging nosocomial pathogen with limited pathogenicity. However, its infections have been attributed to increased morbidity and mortality, most especially among immunosuppressed individuals. Within the hospital, *S. maltophilia* can be recovered from central venous/arterial monitors, dialysis machines, disinfectant solutions, deionized water, nebulizers, ventilation systems, and the hands of healthcare personnel and from infected wounds (Karunanidhi *et al*., 2013). Outside the hospital environment, *S. maltophilia* can be isolated in water sources like rivers, and lakes, and in soil and various plants. Despite the fact that *S. maltophilia* can be isolated from wet environments, its long-term survival in a dry environment is very uncommon (Denton and Kerr, 1998). *Stenotrophomonas maltophilia* has been reported to be intrinsically resistant to many antibiotics, hence can manifest resistance to various commonly used antibiotics, which makes infections caused by the pathogen very difficult to treat (Zer *et al*., 2009; Karunanidhi *et al*., 2013).

Cannabis sativa (Cannabinaceae), also known as marijuana and *Garcinia kola* (Guttiferae), commonly known as bitter kola due to the bitterness in its taste. These plants are useful as they present many interesting properties by reason of their rich metabolites that are very effective in treating various infectious diseases of bacterial origin. According to Cooper (2005), *C. sativa* has been used in the treatment of human ailments like allergies, burns, cuts and wounds, inflammation, leprosy, leucoderma, scabies, rabies, cholera, rheumatism, tetanus, smallpox in Northeastern India, and has become the drug of choice in the management of migraine attack in Europe and America (Mechoulam and Lander, 1980). Kabelik *et al*. (1960); Russo, (2002); Farha *et al*. (2020) observed, and reported that cases of uterine hemorrhage after birth, asthma, postpartum psychoses, various neuralgias, irrigation in diseases of the anus, sore toenails, and epilepsy were all successfully treated with cannabis extracts. Also, according to Russo (2002), cannabis extract may represent an efficacious and safe alternative for the treatment of a wide range of conditions in women, including dysmenorrheal, dysuria, hyperemesis gravid arum, and menopausal symptoms. Interestingly, different natural product constituents (phytocannabinoids) of the extracts of *C. sativa*, which have been associated with intoxication effects upon recreational usage, and medical applications far beyond the treatment of infection have been reported to have medicinal effect against many Gram-positive bacteria pathogens, including methicillin-resistant *Staphylococcus aureus* (Farha *et al*., 2020).

Garcinia kola, found mainly in tropical rainforest regions of Central and Western Africa (Olowosolu and Ibrahim, 2006). *G. kola* is traditionally used in Africa as medicine due to its purgative, anti-parasitic, antimicrobial, and aphrodisiac properties (Braide, 1993; Uko *et al*., 2001). All parts of the plant (seed, stem, bark, leaves, and root) have been found to be medicinal; hence it is often regarded as a wonder plant (Iwu *et al*., 1990; Ekene and Erhirliel, 2014). The seeds are used to treat bronchitis, throat infections, colic, head or chest colds, cough, and liver disorders and as an antidote for poison (Falang *et al*., 2014; Tcheghebe *et al*., 2016). The antimicrobial, anti-inflammatory, anti-diabetic, and antioxidant activities of *G. kola* have been long documented (Aderibigbe, 2012; Arekemase *et al*., 2012; Popoola *et al*., 2016). In the southern and western parts of Nigeria, the seed is being chewed or eaten, often it's being given to people as a sign of friendship, and respect, while the tree is usually used as a chewing stick (to brush the teeth) as it exerts

antibacterial activity on the mouth (Iwu *et al*., 2002; Agbor and Naiido, 2015).

Resistance and multiple resistant occurring in human pathogenic bacteria has been attributed to the indiscriminate use of commonly available antibiotics in the treatment and management of infectious diseases. The bacterial resistance, the unavoidable after effects of the antibiotics, and the occurrence of previously uncommon infections (Marchese and Shito, 2001; Poole, 2001) are some of the reasons for searching for new antibacterial substances from various sources like medicinal plants that would thwart *S. maltophilia* infections. *Stenotrophomonas maltophilia* is an uncommon and opportunistic pathogen with few reported cases of being the causative agent of infection in diabetic foot wounds. Hence, this present study investigated the antibacterial activity and bioactive compounds of the leaves and seed extracts of *C. sativa* (whose antibacterial effect has not been much explored in Nigeria), and *G. kola*, respectively, against multidrug-resistant *S. maltophilia* isolated from diabetics foot wounds.

MATERIALS AND METHODS

Study area/collection of plant materials: This work was carried out at the Laboratory unit of the Department of Medical Microbiology and Parasitology, Olabisi Onabanjo University Teaching Hospital (OOUTH) Sagamu, Ogun State, Nigeria. Fresh *C. sativa* leaves and fresh *G. kola* seeds were purchased from a dealer of herbal materials in Ago-Iwoye local market, Ogun State, Nigeria. The plants after taxonomic identification in the Department of Plant Science laboratory unit, were air-dried at laboratory temperature, and stored for further use.

Test bacteria: Pure and Type isolates of *S. maltophilia* (ATCC 17666) used in this study were obtained from stock cultures in the Department of Medical Microbiology and Parasitology Laboratory OOUTH, and from the Culture Collection Centre of the Nigerian Institute of Medical Research, Lagos Nigeria. The pure isolate was isolated from the foot wound sites of diabetic patients. The isolate was presumptively identified using Gram stain reaction, Aesculin hemolysis test, catalase test, coagulase test, indole test, lactose fermentation test, motility test, oxidase test and urease test. The cultures of the tested bacteria were maintained in nutrient agar (Difco) slants in the dark at 4°C prior to further use (Liaw *et al*., 2010).

Antibiotic susceptibility test: Antibiotic susceptibility profile of the isolates was determined by the agar disk diffusion method, also known as the Kirby-Bauer method, as described by Si *et al*. (2006) using Mueller Hinton agar. The following antibiotics (Abtek): augmentin (30 mcg), ceftazidime (30 mcg), cefuroxime (30 mcg), ciprofloxacin (10 mcg), cotrimoxazole (25 mcg), gentamicin (10 mcg), ofloxacin (30 mcg), and nitrofurantoin (300 mcg) were employed. Inoculum (0.5 ml), turbidity matched that of 0.5 McFarland standard (0.5×10^{-8} CFU/ml), was introduced on the surface of the agar plate with a sterile micropipette and evenly spread over using a sterile swab stick. The antibiotic disks were placed on the inoculated agar using sterile forceps. The plates were incubated at 37°C for 24 hours, readings were taken with a meter rule in millimeters. The diameter zone of inhibition was determined using the NCCLS standard (NCCLS, 2002).

Processing and extraction of plant materials: Dried leaves of *C. sativa* and fresh *G. kola* seeds, which were shreddred into small pieces and air-dried at laboratory temperature (27°C) for 14 days, were ground using an electric blender (Philips Bolmixer Melangeur HR 2846, Brazil). Powdered parts of each of the pulverized plants (100 g) was soaked in 1000 ml chloroform ($CHCl_3$ - 100 %), ethanol (C_2H_5OH - 50 %), and an aqueous solution. The suspended plant parts, which were allowed to stand for 72 h., were filtered using Whatman No 1 filter paper (Olowosolu and Ibrahim, 2006). After evaporation (rotary evaporator R 205D,

England), the filtrates were further concentrated to dryness using a water bath (Grant Type SUB 14). Each extract residue (10 g) was reconstituted in 100 ml of methanol.

Antibacterial assay: Agar diffusion technique, as described by NCCLS (2002) using Mueller Hinton agar, was employed to determine the antibacterial effects of the plant extracts against the tested isolates. The reconstituted extracts were serially diluted to obtain different concentrations from 50 mg/ml to 200 mg/ml. Standardized suspensions of the isolates (0.2 ml) were introduced onto freshly prepared Mueller Hinton agar. After drying the plates, five holes (wells) were bored in each of the plates using a 6 mm sterile cork borer, to which an equal volume of each of the concentrations was added, with a well containing one of the solvents (negative control). The plates in duplicates stood for 30 minutes for pre-diffusion before incubating at 37℃. Readings were taken after 24 hours in millimeters using a meter rule. All organic solvents used for extraction were also used as controls.

Determination of the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC): Minimum inhibitory concentration (MIC) and minimum bactericidal oncentration (MBC) of the extracts against the tested organisms were determined by tube dilution method as described by Reyhan and koruglogu (2007) and recommended by the Clinical and Laboratory Standards Institute (CLSI, 2011). Two-fold serial dilutions of the extracts was prepared in tubes that contained Mueller-Hinton broth, different concentrations from 600 to 4.68 mg/ml were obtained. Overnight cultures (0.2 ml each) that had been diluted to 5×10^5 cfu/ml were added into tubes, labeled correctly and incubated at 37℃ for 24 h. Dimethyl sulfoxide (10%) was used as a negative control. The MIC was defined as the lowest concentration of the extract that showed no turbidity (no visible growth of microorganisms) when compared with the control. Suspensions (0.5 ml) from the tubes with no visible growth were poured onto Mueller Hinton agar plates and incubated overnight at 37℃. The MBC was defined as the lowest concentration of extracts at which the bacteria did not grow on agar media. The experiment was in duplicates.

Phytochemical screening of the plant extracts: Qualitative examination was carried out on both plants (*C. sativa* and *G. kola*) extracts used in the study. Chemical tests were carried out on the aqueous extracts and powdered plant specimens using standard procedures to identify the constituents as described by Ibedu *et al*. (2018).

RESULTS

The outcome of the biochemical tests used to re-affirm the identity of the isolates is presented (Table 1). In contrast, the antibiotics sensitivity of both the pure and type isolates of *S. maltophilia* revealed that the isolates were resistant to all the antibiotics tested in this study (Table 2). Some of the standard antibiotics frequently recommended in treatment of infections due to *S. maltophilia* did not inhibit the growth of the organisms.

Table 1: Gram staining and biochemical characteristics of the tested bacterial isolates

Organism	Tests									
	Gra	**S**	**Mot**	**Cat**	**Coa**	**Aes**	**Lac**	**Ind**	**Urease**	**Oxi**
SM	-ve	rod	+ve	-ve	-ve	-ve	-ve	+ve	+ve	-ve

Key: **sm**= *Stenotrophomonas maltophilia* ,**-ve**=negative, **+ve**= positive, **gra**=gram staining reaction, s= shape, **mot**=motility, **cat**=catalase test, **coa**= coagulase test, **aes**= aesculin hydrolysis test, **lac**= lactose fermentation test, **ind**= indole test, **urease**= urease test, **oxi**= oxidase test.

In this study, the antibacterial activities of three different concentrations of extracts of ethanol, chloroform, and aqueous solvents of the two tested plants are presented (Table 3). The presence or absence of diameter zones of inhibition were used to assess their effects on the isolates quantitatively. The inhibitory effect of the ethanolic extracts of *G. kola* and *C. sativa* on both the pure and type isolates of *S. maltophilia* was concentration dependent as the highest effects of 24 mm, 19 mm, and 27 mm, 22 mm were observed at 150 mg/ml respectively. At the three concentrations of 50, 75, and 150 mg/ml, of the ethanolic extract of *G. kola* showed the highest inhibition zones of 16 mm, 19 mm, and 27 mm, respectively) against the type isolate than the zones of inhibition exhibited by the ethanolic extract of *C. sativa* (15 mm, 18 mm, and, 22 mm) (Table 3).

The same trend was also observed for the chloroform and aqueous extracts of the two tested plants. The zones of inhibition varied according to the type of plant, solvent used in the extraction, concentrations of the extracts, and the strain of *S. maltophilia*. On the other hand, the diameter zones of inhibition at the three concentrations of the *G. kola* extracts were higher with the type isolate than the pure isolate of *S. Maltophilia* (Table 3). Similarly, all extracts showed different antibacterial activities, but the differences were inconsiderable.

Table 2: The zone of inhibition zones in (mm) of the antibiotics against the two isolates

Antibiotics	Concentration (MCG)	*S. maltophilia*	*S. maltophilia* (ATCC 17666)
GEN	10	-	-
COT	25	-	-
CRX	30	-	-
CXM	30	-	-
OFL	30	-	-
AUG	30	-	-
NIT	30	-	-
CPR	10	-	-

Key: **gen**=gentamicin, **cot**= cotrimoxazole, **crx** = cefuroxime, **cxm**= ceftaxidime, **ofl**= ofloxacin, **aug**= augmentin, **nit**= nitrofurantoin ,**cpr** =ciprofloxacin, - = negative (no inhibition of growth)

However, the highest diameter zones of inhibition (10 and 16 mm, 17 and 19 mm, 24 mm, and 27 mm) were obtained at three concentrations (50 mg/ml, 75 mg/ml, and 150 mg/ml) respectively of the ethanolic extract of *G. kola* against both the pure and type isolates of the tested bacteria. This was followed by the aqueous extract (10 and 12 mm, 1 8 and 19 mm, 19 and 21 mm), while the chloroform extract had the least zones (10 and 12 mm, 13 and 18 mm, 15 and 19 mm) against the tested bacteria (Table 3). However, the highest diameter zones (15 and 17 mm, 17 and 20 mm, 19 and 21 mm) were observed at the three concentrations of the chloroform extract of *C. sativa* for the pure and type isolates, respectively (Table 3). This was followed by the ethanolic extract (13 and 15 mm, 15 and 18 mm, 19 and 22 mm) and lastly by the aqueous extract in which the following diameter zones of inhibition (12 and 14 mm, 17 and 15 mm, 19 and 17 mm) were observed at the three concentrations of 50 mg/ml, 75 mg/ml, 150 mg/ml for the tested bacteria respectively (Table 3).

The minimum inhibitory concentration and minimum bactericidal concentration (values) of the tested plant extracts against the bacterial isolates were concentration-dependent. The MICs ranged from 37.5 mg/ml to 150 mg/ml, in which the pure isolate was inhibited at 150 mg/ml and 75 mg/ml for *G. kola* and *C. sativa*, respectively. The type isolate was inhibited

at 75 mg/ml for both *G. kola* and *C. sativa* (Table 4). Meanwhile, the MBCs of the pure and type isolates for both plants were the same: 150 mg/ml and 75 mg/ ml, respectively (Table 4). Out of the two plant extracts tested against the two isolates, *C. sativa* was found to be more effective than *G. kola* as it inhibited the tested bacteria at a lower concentration (75 mg/ml). Moreover, both plants were more active against the type isolates than the pure isolate of *S. maltophilia* (Table 4). The phytochemical constituents of the plants extrcats were alkaloids, flavonoids, glycosides, tannins, saponins, anthraquinones, and phlobotannins (absent in *G. kola*) (Table 5).

Table 3: Mean antibacterial effect of clinical bacterial isolates with two plant extract

Plant used zone (mm)		Solvent concentration in mg/ml	Mean diameter zone of inhibition
Bacterial tested		*S. maltophilia*	*S. maltphilia* (ATCC17666)
G. kola			
Ethanol	50	10	16
	75	17	19
	150	24	27
Chloroform	50	10	12
	75	13	18
	150	15	19
Aqueous	50	10	12
	75	18	19
	150	19	21
C. sativa			
Ethanol	50	13	15
	75	15	18
	150	19	22
Chloroform	50	15	17
	75	17	20
	150	19	21
Aqueous	50	12	14
	75	17	15
	150	19	17

Average of 2 replicates: Mean diameter inhibition zone=>15 sensitive: 14-15: = intermediate; < 14 = resistant

Table 4: Minimum inhibitory concentration and bactericidal concentration of the bacterial isolates

	MIC Mg/ml		MBC Mg/ml	
Test Organism	**GK**	**CS**	**GK**	**CS**
S. maltophilia	150	75	150	150
S. maltophilia (ATCC17666)	75	75	75	75

Key: mic: minimum inhibitory concentration; mbc= minimum bactericidal concentration; gk= *garcinia kola*; cs = *cannabis sativa.*

Table 5: Phytochemical constituents of *Garcinia kola* and *Cannabis sativa* extracts

Components	GK	CS
Alkaloid	+	+
Flavonoids	+	+
Glycosides	+	+
Tannins	+	+
Saponin	+	+
Anthraquinone	+	+
Phlobatannins	+	+

Key: GK = *Garcinia kola*, **CS** = *Cannabis sativa*, + positive = present, - negative = absent

DISCUSSION

One of the most significant threats to public health is the global spread of bacterial resistance against readily available antibiotics. Hence, substitutes are urgently needed to combat the increasing rates of bacterial resistance. The ethanol, chloroform, and aqueous extracts of *C. sativa* leaf and the *G. kola* seed of the families Cannabinaceae and Guttiferae, respectively, were screened for their antibacterial activities against *S. maltophilia* organisms. The test bacteria were resistant to all the antibiotics employed in this study. This is in line with most findings who reported multidrug resistance of *S. maltophilia* to commonly available antibiotics (Karunanidhi *et al*., 2013; Cikman *et al*., 2016).

The resistance of *S. maltophilia* to the tested antibiotics could be due to its numerous mechanisms of resistance. It was reported that the drug resistance mechanisms of the organism are acquired via horizontal transfer such as through plasmids, transposons, integrons, efflux pumps, melanin-like pigment and bio-film formation (Avison *et al*., 2000; Avison *et al*., 2001; Liaw *et al*.,2010; Hu *et al*., 2011). According to Crossman *et al*. (1998), the genome sequence of *S. maltophilia* revealed many resistance genes like genes encoding for multidrug efflux pumps, β-lactamases, and aminoglycoside-modifying enzymes contribute to the organism's reduced antibiotic sensitivity. In the work of Karunanidhi *et al*. (2013) and Cikman *et al*. (2016), *S. maltophilia* has intrinsic resistance to different classes of antimicrobials. Furthermore, nosocomial *S. maltophilia* are multiple-drug resistant, and are usually less sensitive to carbapenems, cephalosporins, penicillins, chloramphenicol, and quinolones, thereby complicating the treatment option (Karunanidhi *et al*., 2013). Ramakant *et al*. (2011) reported the occurrence of multidrug-resistant organisms among patients with diabetic foot infection. According to the findings of Huchital *et al.* (2020), *S. maltophilia* which is an opportunistic pathogen, may complicate the treatment of diabetic foot infections.

The various extracts of the tested plants have shown antibacterial activity (especially at higher concentrations) against *S. maltophilia* pathogens that were resistant to different antibiotics employed in this study. It was observed that the ethanol extract of *C. sativa* had the highest antibacterial activity compared with the other extracts tested, whereas the chloroform extract showed the lowest activity. This finding supports the observations made by some other researchers, that *C. sativa* has antibacterial properties on some other pathogens. So,Wasim *et al.* (1995), reported the antimicrobial activity of ethanol and petroleum ether extracts of *C. sativa* (leaf) against multiple microorganisms. Also, Appendino *et al*. (2008) reported antibacterial cannabinoids from *Cannabis*;

Ali *et al*. (2012), reported the antimicrobial activity of *C. sativa*. Muhammad *et al*. (2014), and Sarmadyan *et al*.(2014). Sarmadyan *et al*. (2014) reported the *in-vitro* antibacterial activity of *C. sativa* leaf extracts on some selected pathogenic bacterial strains and the antimicrobial effect of hydro-alcoholic extract of *C. sativa* on multiple drug resistance bacteria isolated from nosocomial infections respectively.

More also, the findings of this study is similar to that reported by Farha et *al.* (2020), who uncovered the hidden antibiotic potential of *Cannabis*, and that of Blaskovich *et al.* (2021). The authors reported that cannabinoids have selective activity against a subset of Gram-negative bacteria, including *Neisseria gonorrhoeae*. However, the antibacterial activities of some other extracts against *S.maltophilia* have been reported: the antibacterial activity of the ethanolic extracts of *Zuccagnia punctate* Cav.; antibacterial properties of *Senecios andrasicus* on multi-resistant *S. maltophilia*; *in-vitro* antibacterial activity of chlorogenic acid against clinical isolates of *S. maltophilia* and the inhibitory effects of eugenol and pulegone on *S. maltophilia* (Karunanidhi *et al*., 2013, Baygar *et al*., 2019). According to Langezaal *et al*. (1992), the antibacterial activity of *C. sativa* could be due to the presence of sesquiterpenes or the presence of cannabidiol. Besides, antioxidant properties, and chemical constituents could be responsible for the antibacterial effect of *C. sativa*, as reported by Esimone *et al*. (2007) and Prafulla *et al*. (2012), respectively. Prafulla et *al*. (2012) established the fact that traditional medicines contain chemical constituents that make them useful in wound healing, and in treating diseases caused by bacteria.

The antibacterial effect of *G. kola* in this study, especially the ethanol extract, is in agreement with the work of many researchers. Okoye *et al.* (2014) and Afolabi *et al.* (2020) reported that the ethanol extract of *G. kola* had the highest inhibitory diameter zone against *Staphylococcus aureus*, hence, concluded that the best solvent for the extraction of *G. kola* nut was ethanol. Ajayi *et al*. (2014) also reported the antibacterial activity of *G. kola* against dental caries-causing bacteria. *Garcinia. kola* has been useful in treating cough, laryngitis, and liver diseases (Malu and Ojabo, 2007; Xu *et al*., 2013).The highest zone of inhibition observed in the ethanol extracts of both plants studied could mean that their active constituents have more ability to dissolve in ethanol than other solvents used in this study (Jeyaseelan *et al*., 2011). The findings of this study, however, is in disagreement with the work of Dickson *et al*. (2011), who stated that aqueous extract was more potent in terms of activity compared to ethanol and chloroform extracts and stated that ethanol was not a good solvent for extraction of the active component. Despite the antibacterial activities observed among the three extracts, there were no significant differences. This translates to the fact that the amount of yield does not always influence the antibacterial activities, but the active ingredients present in the extract (Ekam and Ebong, 2007). Thus, it could be said that both plants tested have antibacterial effects but with different sensitivities. In addition, different concentrations of the extracts had different antibacterial effects on the isolates.

Flavonoid, one of the active ingredients present in the studied plants, has been observed to play an important role in the modification of the body reactions to allergens, viruses, and carcinogens, and its anti-inflammatory activity. On the other hand, alkaloids have been found to contain nitrogen and are physiologically active with sedative and analgesic properties (Ekam and Ebong, 2007). Glycoside is reported to contain carbohydrate and non-carbohydrate residue and are important in medicine because of their action on the heart, and has been used in cardiac insufficiency (Balch and Balch, 2000).

CONCLUSION

Findings of this study could mean that the phytochemicals present in the studied plants could be utilized in management and treatment of diabetic patients with wound infection. However, more studies would be needed to ascertain the exact resistance mechanisms of the plant extracts on *S. maltophilia,* and to isolate potent active phytochemical constituents that might be responsible for inhibiting *S. maltophilia* isolated from diabetic patients with wound infections and type culture.

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